COMMUNITY ASSISTANCE
PLANNING REPORT NO. 53
(2nd Edition)

A WATER QUALITY MANAGEMENT PLAN FOR OKAUCHEE LAKE

WAUKESHA COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

KENOSHA COUNTY
Leon T. Dreger
Thomas J. Gorlinski
Sheila M. Siegler

RACINE COUNTY
Richard A. Hansen, Secretary
Jean M. Jacobson
James E. Moyer

MILWAUKEE COUNTY
Daniel J. Diliberti
William R. Drew, Vice-Chairman
Linda J. Seemeyer

WALWORTH COUNTY
Anthony F. Balestrieri
Gregory L. Holden
Allen L. Morrison

OZAUKEE COUNTY
Robert A. Brooks
Thomas H. Buestrin Chairman
Gus W. Wirth, Jr.

WASHINGTON COUNTY
Kenneth F. Miller
Daniel S. Schmidt

WAUKESHA COUNTY
Duane H. Bluemke, Treasurer
Kenneth C. Herro
Paul G. Vrakas

OKAUCHEE LAKE MANAGEMENT DISTRICT COMMISSIONERS

James G. Hemmerich, Chairperson

COMMISSIONERS

Dennis W. Johnson
Gregory W. Hirt
Robert G. Thelen II, Waukesha County Representative
Patricia T. Napgezek, Town of Oconomowoc Representative

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION STAFF

Philip C. Evenson, AICP ..... Executive Director
Kenneth R. Yunker, PE ..... Deputy Director
Nancy M. Anderson, AICP ..... Chief Community Assistance Planner
Robert E. Beglinger ..... Chief Transportation Engineer
Robert P. Biebel, PE, PH ..... Chief Environmental Engineer
Leland H. Kreblin, RLS ..... Chief Planning Illustrator
Elizabeth A. Larsen ..... Business Manager
John G. McDougall ..... Geographic Information Systems Manager
John R. Meland ..... Chief Economic Development Planner
Dr. Donald M. Reed ..... Chief Biologist
William J. Stauber, AICP ..... Chief Land Use Planner

Special acknowledgement is due to Dr. Jeffrey A. Thornton, CLM, PH, SEWRPC Principal Planner, Dr. Thomas M. Slawski, SEWRPC Senior Planner; Ms. Christine M. Hinz, former SEWRPC Planner; Ms. Rachel E. Lang, former SEWRPC Senior Biologist; and Mr. Edward J. Schmidt, SEWRPC Research Analyst, for their contributions to the conduct of this study and the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 53, 2nd Edition

A WATER QUALITY MANAGEMENT PLAN FOR OKAUCHEE LAKE WAUKESHA COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin 53187-1607
www.sewrpc.org

The preparation of this publication was financed in part through a grant from the Wisconsin Department of Natural Resources Lake Management Planning Grant Program.

December 2003

Inside Region $ 10.00
Outside Region $ 20.00

(This page intentionally left blank)

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

Chapter I

INTRODUCTION

Okauchee Lake is a 1,187-acre lake located within U.S. Public Land Survey Sections 23, 24, 25, 26, 35, and 36, Town 8 North, Range 17 East, Town of Oconomowoc, and U.S. Public Land Survey Sections 19, 30, and 31, Town 8 North, Range 18 East, Town of Merton, all in Waukesha County. The Lake is a natural lake basin. However, portions of the Lake were created by the construction of low head dams downstream of the natural basin of Okauchee Lake, creating the embayments locally known as Lower Okauchee[1] and Upper Oconomowoc Lakes. These portions of the Lake are 47 acres and 36 acres in size, respectively, and both are located entirely within Township 8 North, Range 17 East, Town of Oconomowoc. All three "lakes" are fed by, and drain to, the Oconomowoc River. Okauchee Lake is the third lake in a chain of six lakes situated along the Oconomowoc River—Friess Lake in Washington County and North Lake in Waukesha County are situated upstream of Okauchee Lake, and Oconomowoc Lake, Fowler Lake, and Lac La Belle, all in Waukesha County, are located downstream of Okauchee Lake.[2] These lakes are important assets for the residents of their riparian communities, and for the residents of the Counties and of the Region of which the Counties are an integral part.

During recent years, Okauchee Lake has experienced various management problems, the symptoms of which have included excessive plant growth, recreational user conflicts and limitations, and variations in water quality. In addition, concerns have been raised regarding the need to protect environmentally sensitive areas within and adjacent to the Lake and to prevent the invasion of exotic species.

The previous water quality management plan for Okauchee Lake was completed by the Southeastern Wisconsin Regional Planning Commission during 1981, and was prepared under a cooperative agreement with the

---

[1] *Lower Okauchee Lake is also referred to as Little Okauchee Lake by some residents.*

[2] *Lake management plans have been prepared by the Southeastern Wisconsin Regional Planning Commission for each of these six waterbodies: see SEWRPC Community Assistance Planning Report No. 98, 2nd Edition,* A Lake Management Plan for Friess Lake, Washington County, Wisconsin, *November 1997; SEWRPC Community Assistance Planning Report No. 54,* A Water Quality Management Plan for North Lake, Waukesha County, Wisconsin, *July 1982; SEWRPC Community Assistance Planning Report No. 53,* A Water Quality Management Plan for Okauchee Lake, Waukesha County, Wisconsin, *August 1981; SEWRPC Community Assistance Planning Report No. 181,* A Water Quality Management Plan for Oconomowoc Lake, Waukesha County Wisconsin, *March 1990; SEWRPC Community Assistance Planning Report No. 187,* A Management Plan for Fowler Lake, Waukesha County, Wisconsin, *March 1994; SEWRPC Community Assistance Planning Report No. 47,* A Water Quality Management Plan for Lac La Belle, Waukesha County, Wisconsin, *December 1980.*

Wisconsin Department of Natural Resources (WDNR).[3] This plan was adopted as an amendment to the regional water quality management plan and formed the basis for the implementation of actions to protect and enhance lake water quality. The lake water quality management plan was also used in the preparation of the nonpoint source pollution control plan adopted for the Oconomowoc River Basin during 1986 under the Oconomowoc River Priority Watershed Project.[4] The implementation period for this priority watershed project ended in 1994. These efforts have contributed to an apparent maintenance of the then-preexisting water quality conditions in the Lake, as demonstrated through the findings of the WDNR Long-term Trend Water Quality Monitoring Program, documenting water quality conditions in Okauchee Lake between 1973 and 1980, and of the U.S. Geological Survey trophic state water quality monitoring program, documenting water quality conditions in Okauchee Lake between 1984 and 2002. Additional data were reported by the Lake's citizen volunteer monitor, who conducted water quality monitoring under the auspices of the WDNR Self-Help Monitoring Program from 1995 through 2002.

Seeking to improve the usability of Okauchee Lake and its natural assets and recreational use potential, the Okauchee Lake Management District requested the Southeastern Wisconsin Regional Planning Commission to update and refine the current water quality management plan for the Lake. For this purpose, the Okauchee Lake Management District applied for and received cost-share funding for plan preparation through the Chapter NR 190 Lake Management Planning Grant Program, administered by the WDNR. Pursuant to the objectives of the proposed planning program, the water use and related lake use objectives for Okauchee Lake would be reviewed and refined within this lake management plan for Okauchee Lake. To this end, this lake management plan represents part of the ongoing commitment of the Okauchee Lake Management District, and the Towns of Merton and Oconomowoc, to sound environmental planning with respect to the Lake. This plan was prepared during 2001 and 2002, by the Regional Planning Commission in cooperation with the Okauchee Lake Management District, and represents one of several actions taken to manage Okauchee Lake and its natural resources.

This report discusses the physical, chemical, and biological characteristics of the lakes together with pertinent related characteristics of the tributary drainage area; evaluates the feasibility of various water quality management alternatives which may enhance water quality conditions in the lakes; and, presents a refined management plan for the Lake. The primary management objectives of this plan for Okauchee Lake include: 1) providing water quality suitable for the maintenance of fish and other aquatic life, 2) reducing the severity of existing nuisance problems due to excessive macrophyte growths which constrain or preclude intended water uses, and 3) improving opportunities for water-based recreational activities. The recommended management plan for the Lake, presented herein, conforms to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes*,[5] and, accordingly, should constitute a practical, as well as technically sound, guide for the management of Okauchee Lake and its tributary drainage basin.

---

[3]*SEWRPC Community Assistance Planning Report No. 53,* A Water Quality Management Plan for Okauchee Lake, Waukesha County, Wisconsin, *August 1981.*

[4]*WDNR Publication No. WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

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

Chapter II

PHYSICAL DESCRIPTION

INTRODUCTION

The physical characteristics of a lake and its watershed are important factors in any evaluation of existing and probable future water quality conditions and lake uses, including recreational uses. Characteristics such as watershed topography, lake morphometry, and local hydrology ultimately influence water quality conditions and the composition of the plant and fish communities within a lake. Therefore, these characteristics must be considered during the lake management planning process. Accordingly, this chapter provides pertinent information on the physical characteristics of Okauchee Lake, its watershed, climate, and hydrology. Subsequent chapters deal with the land use conditions and the chemical and biological environments of the Lake.

WATERBODY CHARACTERISTICS

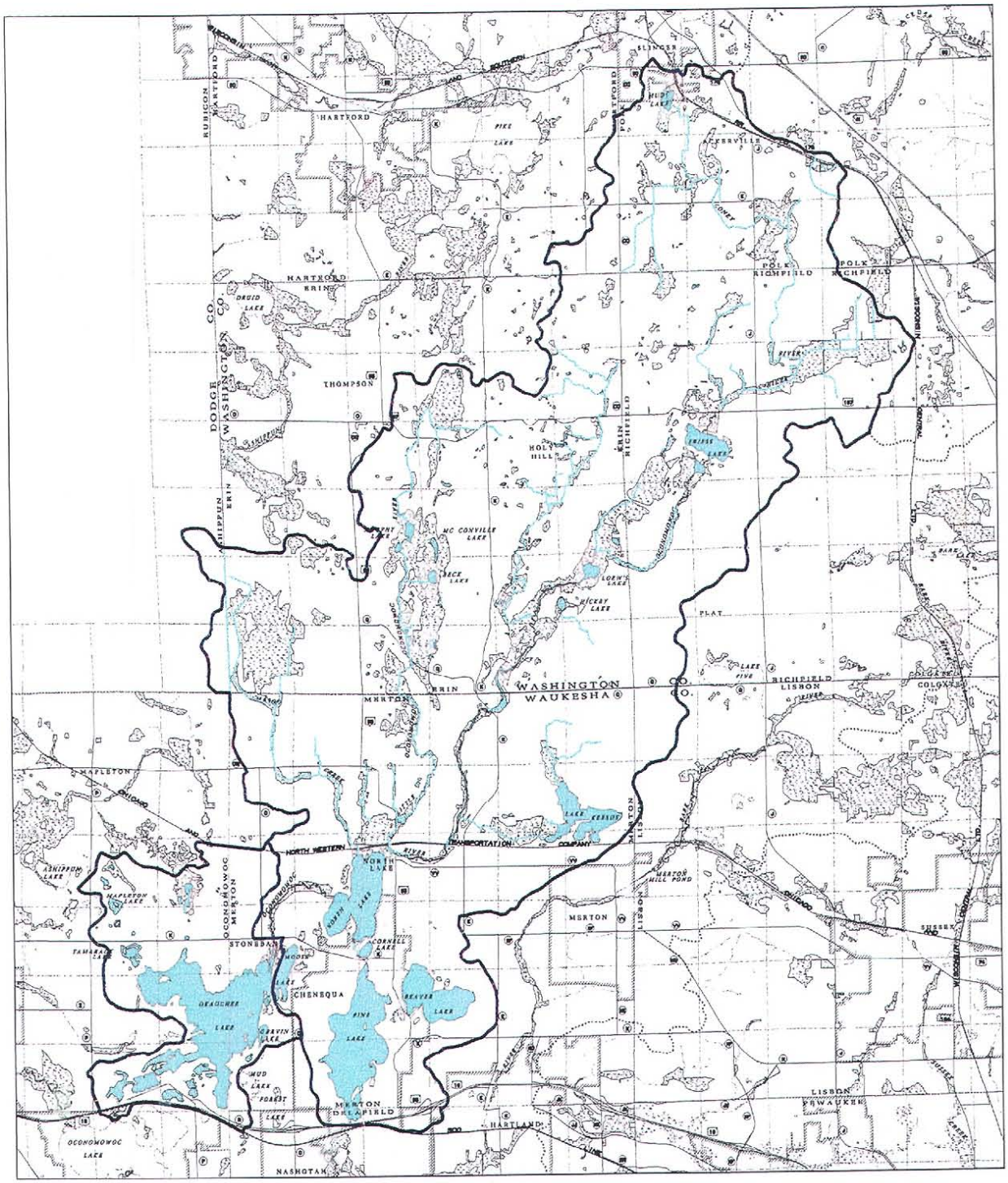
Okauchee Lake is located within the Towns of Merton and Oconomowoc in Waukesha County, as shown on Map 1. Okauchee Lake is fed by and drained to the Oconomowoc River. The Lake lies within a depression created by glacial outwash deposits and is bordered by a terminal moraine deposited during the Wisconsin Period of glaciation of about 12,500 years ago. Basic hydrographic and morphometric data for the Lake are presented in Table 1. The morphometry of the Lake basin is illustrated in Map 2.

Okauchee Lake has a surface area of about 1,190 acres, and a volume of approximately 30,000 acre-feet. About 7 percent of Okauchee Lake has a water depth less than five feet, 41 percent has a water depth between five and 10 feet, 22 percent has a water depth between 10 and 40 feet, and 30 percent of the Lake has a water depth of more than 40 feet. The maximum depth of Okauchee Lake is reported to be approximately 95 feet, and the mean depth is about 25 feet. Okauchee Lake is 3.0 miles long and 1.4 miles wide at its widest point. The major axis of the Lake lies in a generally northeasterly-southwesterly direction. The shoreline of the Lake is about 18.5 miles length, resulting in a shoreline development factor of about 3.1, which indicates that the Okauchee Lake shoreline is approximately three times as long as the circumference of a circular lake of the same area.

Okauchee Lake is a natural lake that was originally created by the melting of at least two ice blocks entrapped in glacial deposits. The Lake level was naturally controlled until about 1838, when a dam was constructed at the Lake outlet, raising the Lake level by about nine feet. This initial dam provided power for a sawmill, which operated until about 1870. This mill was subsequently converted into a flour mill operation until about 1878, after which it was converted to a feed mill operation until 1911. In that year, a new dam was built about 2,000 feet downstream from the original structure, which was partially removed to assure navigability. The embayment thus created is locally known as Lower Okauchee Lake.

Map 1

LOCATION MAP OF OKAUCHEE LAKE



Source: SEWRPC.

Table 1

HYDROGRAPHY AND MORPHOMETRY OF OKAUCHEE LAKE

Parameter	Measurement
Size (total)	
Surface Area	1,187 acres
Total Drainage Area	52,371 acres
Direct Tributary Drainage Area	5,562 acres
Volume	30,412 acre-feet
Residence Time[a]	0.9 years
Shape	
Maximum Length of Lake	3.0 miles
Length of Shoreline	18.5 miles
Maximum Width	1.4 miles
Shoreline Development Factor[b]	3.1
Depth	
Area of Lake Less than 5 Feet	7 percent
Area of Lake 5 to 10 Feet	41 percent
Area of Lake 10 to 40 Feet	22 percent
Area of Lake Greater than 40 Feet	30 percent
Mean Depth	25 feet
Maximum Depth	94 feet

[a] *Residence Time: Time required for a volume equivalent to the full volume of the lake to enter the lake as inflowing waters.*

[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.

The 1911 dam was constructed of reinforced concrete and initially used to generate electricity. Lake levels were controlled by the impoundment at this site until 1961, when, because of the need to repair the then-existing dam, a new dam was constructed about 1,800 feet downstream from the 1911 dam. As previously, the old structure was partially removed by the Lake Shore Development Corporation, creating yet another embayment, locally known as Upper Oconomowoc Lake.

These successive impoundments inundated the low-lying areas within the Lake basin, and, as a result, there are now numerous submerged stumps and several islands within the Lake. Both Lower Okauchee and Upper Oconomowoc Lakes were formed over what were once primarily marshlands.

As of 2001, Lake levels were controlled by a reinforced concrete dam with a 46-foot-wide spillway and two lift-gates. The Lake surface was maintained at normal operating elevations varying from 872.60 to 873.71 feet National Geodetic Vertical Datum of 1929 (NGVD-29). The top of the weir controlling the water level was located at an elevation of 873.71 feet NGVD-29, and the top of the dam sill is at an elevation of 877.50 feet NGVD-29. The Town of Oconomowoc is responsible for the continued operation and maintenance of this dam.

The shoreline of Okauchee Lake is almost entirely developed for residential and some commercial uses. Erosion of shorelines results in a loss of riparian land, damage to shoreland infrastructure, and interference with access and lake uses. Such erosion is caused by wind-wave action, ice movement, and wakes from motorized boat traffic. A survey of the Okauchee Lake shoreline, conducted during the summer of 2001 by the Commission staff, identified existing shoreline protection condition around the Lakes, as shown on Map 3. About 3.3 miles, or 18 percent of the shoreline of the Lakes, were found to be in a natural condition, while the remaining 15.2 miles, or 82 percent, were found to be protected by some type of shore protection structure. Typical structures used to stabilize the shoreline included bulkheads or vertical walls, revetments or sloping walls, and riprap. Most of the shoreline protection structures appeared to be in a good state of repair.

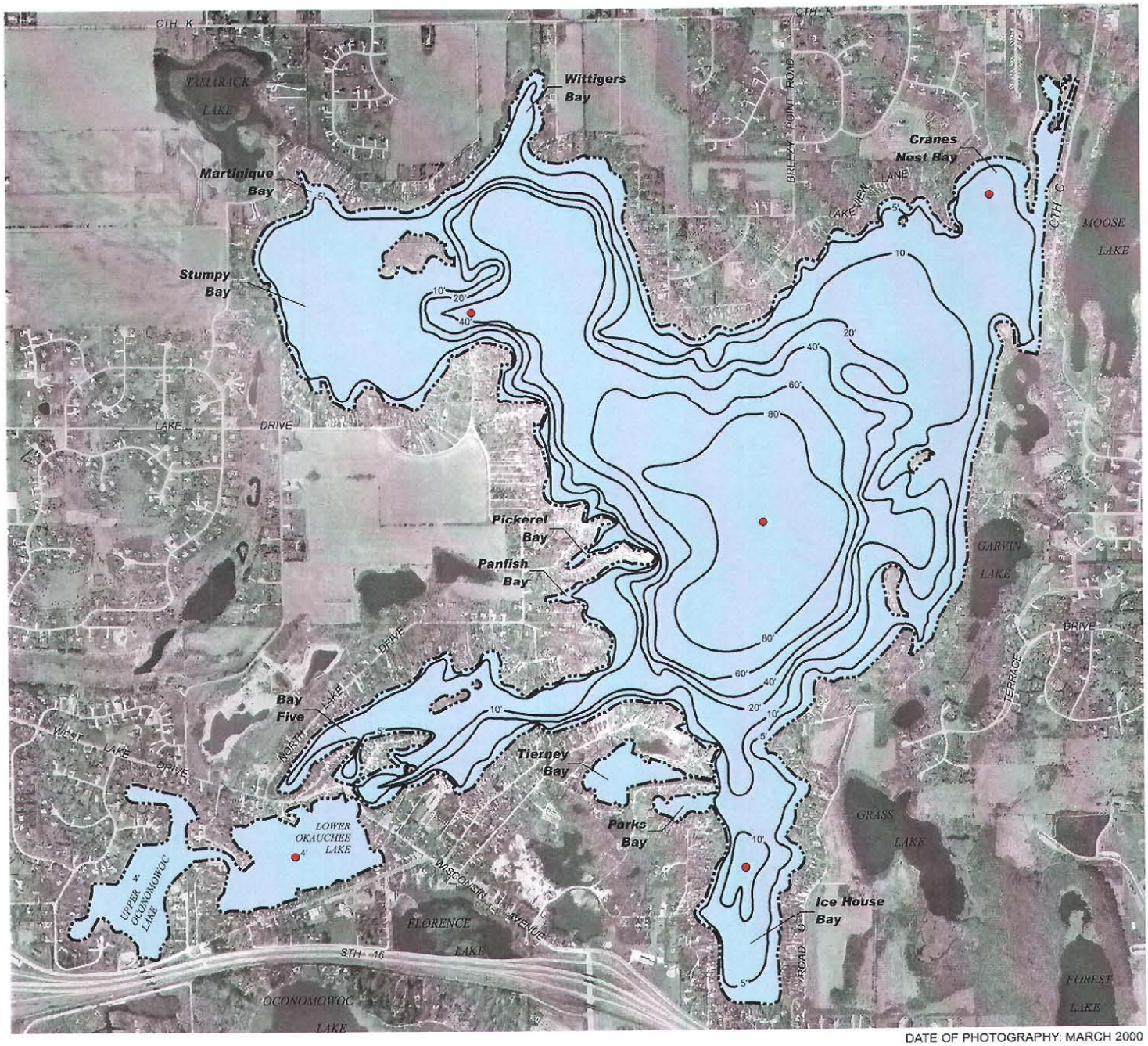
Okauchee Lake has a variety of bottom sediment types. Lake bottom sediment types are shown on Map 4. While silt forms the dominant substrate type within the Okauchee Lake basin, substantial areas of silt and sand, and sand and gravel, exist in the Lake. These latter substrates occur in isolated areas along the shoreline, particularly along the western shoreline of the Lake proper, along the east central shoreline south to the embayment known as Ice House Bay, and along portions of the shoreline within Ice House Bay at the southern extreme of the Lake.

WATERSHED CHARACTERISTICS

Okauchee Lake is part of the Oconomowoc River watershed, and tributary to the Rock River system. This system extends through western and northern Waukesha County into portions of Washington County and Dodge County, as shown on Map 5. The drainage area tributary to Okauchee Lake is about 52,400 acres in areal extent. Of this area, the portion of the drainage area directly tributary to Okauchee Lake, that is, that land area which drains

Map 2

BATHYMETRIC MAP OF OKAUCHEE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

MONITORING SITE

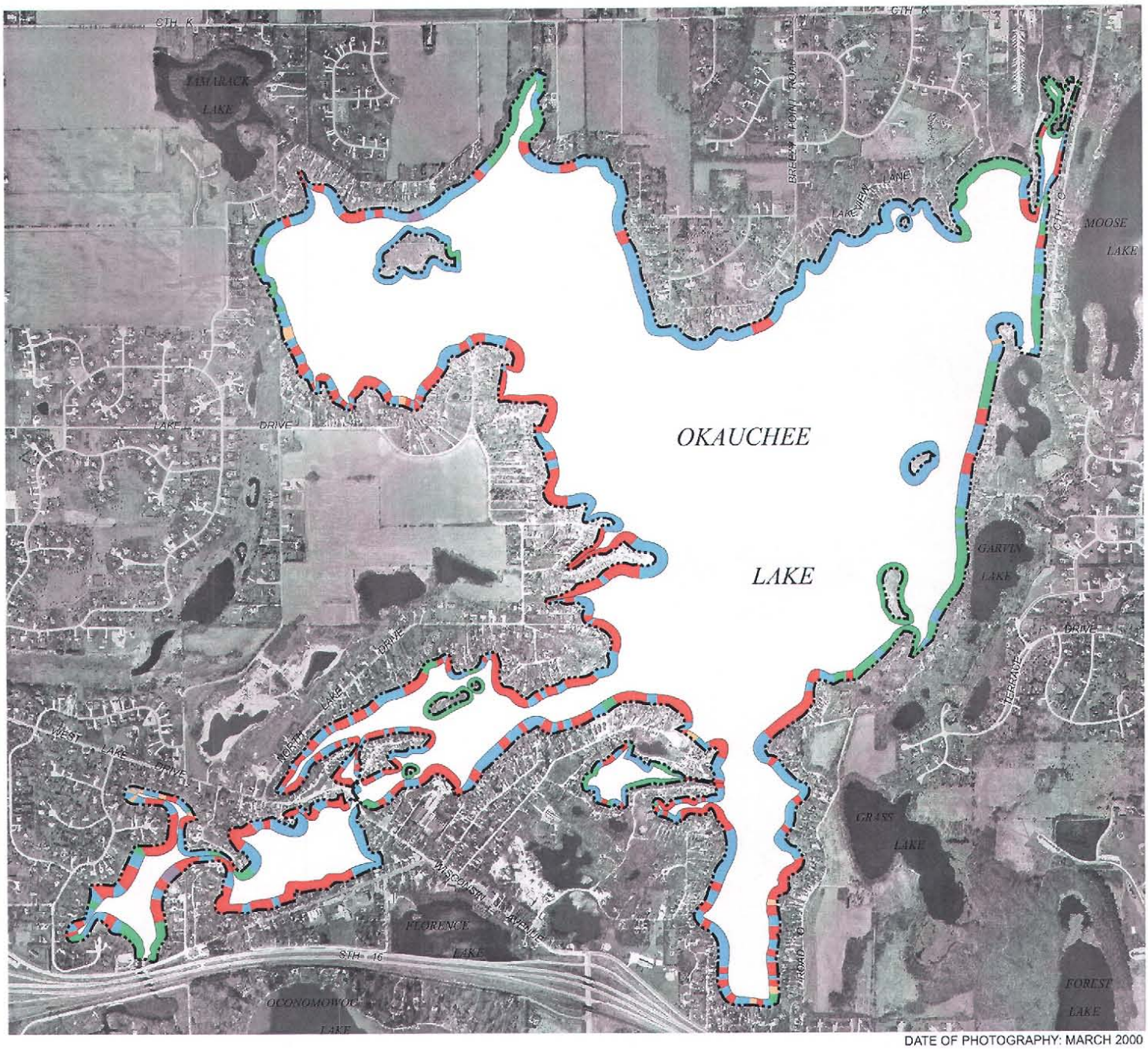
GRAPHIC SCALE

0 1000 2000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 3

SHORELINE PROTECTION STRUCTURES ON OKAUCHEE LAKE: 2000



DATE OF PHOTOGRAPHY: MARCH 2000

RIPRAP

BULKHEAD

BEACH

REVETMENT

NATURAL

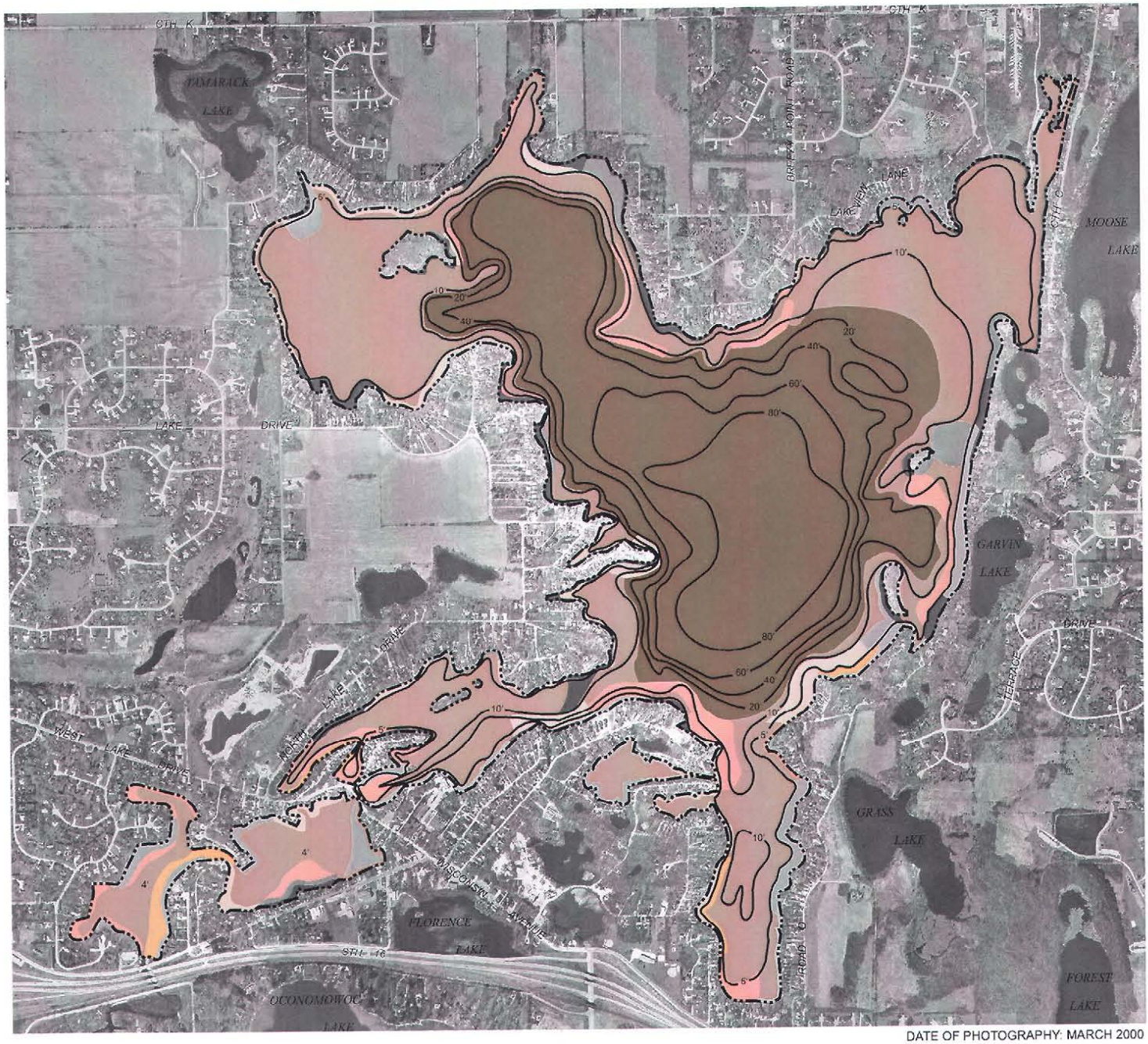
GRAPHIC SCALE

0 1000 2000 FEET

Source: SEWRPC.

Map 4

SEDIMENT SUBSTRATES DISTRIBUTION IN OKAUCHEE LAKE: 2000



DATE OF PHOTOGRAPHY: MARCH 2000

--20'— WATER DEPTH CONTOUR IN FEET

SAND AND ROCK

ROCK

SILT AND GRAVEL

GRAVEL

SAND AND GRAVEL

SAND

SILT AND SAND

SILT

MUCK

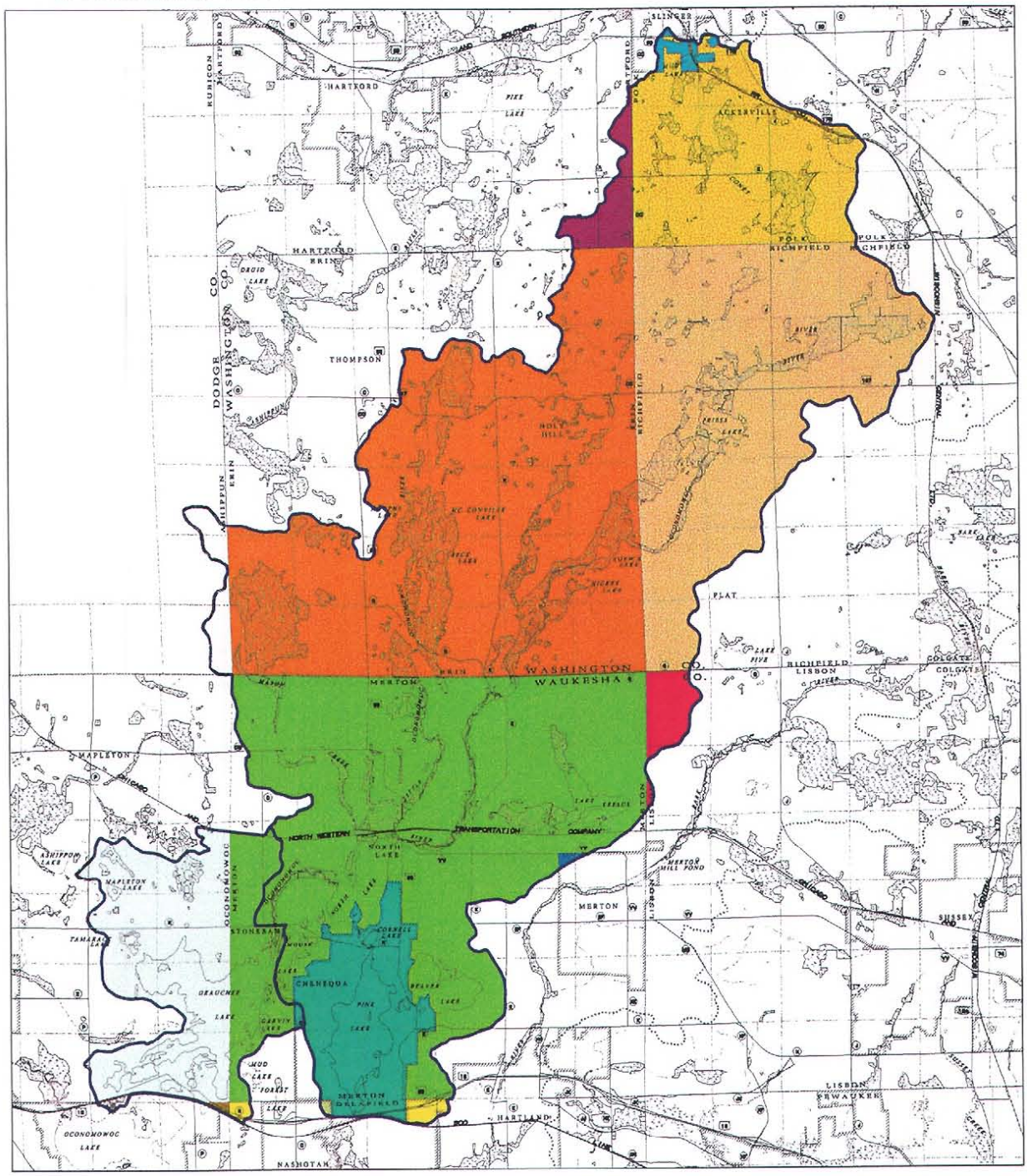
GRAPHIC SCALE

0 1000 2000 FEET

Source: SEWRPC.

Map 5

CIVIL DIVISION BOUNDARIES IN THE TOTAL DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE



Source: SEWRPC.

directly into the Lake without passing through any of the upstream waterbodies, totals about 5,600 acres in areal extent, as shown on Map 2. The drainage basin directly tributary to Okauchee Lake extends into the civil divisions of the City of Delafield; the Villages of Oconomowoc Lake and Chenequa; and the Towns of Oconomowoc, Merton and Summit, all within Waukesha County. The Lake has a watershed-to-lake surface area ratio of 44:1, which ratio is relatively low for lakes within Wisconsin which are reported to have an average watershed-to-lake surface area ratio of about 110:1.[1] The Oconomowoc River is the only perennial inlet to the Lake. Outflow from Okauchee Lake flows to the Oconomowoc River, which discharges into Oconomowoc Lake about one mile downstream from the Okauchee Lake outlet. The Oconomowoc River joins the Rock River about 18 miles downstream from Okauchee Lake, within Jefferson County.

The lands riparian to Okauchee Lake are largely developed for urban residential use, with some scattered commercial land use. The lands situated to the north of Lakes consist of primarily agricultural and open space lands, although some further conversion of these lands to urban residential lands uses is envisioned.

SOIL TYPES AND CONDITIONS

Soil type, land slope, and land use management 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 soil texture and soil particle structure influences the permeability, infiltration rate, and erodibility of soils. Land slopes, too, are important determinants of stormwater runoff rates and of the susceptibility of soils to erosion.

The U.S. Natural Resources Conservation Service, formerly the U.S. Soil Conservation Service, under contract to the Southeastern Wisconsin Regional Planning Commission, completed a detailed soil survey of the Okauchee Lake area in 1966.[2] The soil survey contained interpretations for planning and engineering applications, as well as for agricultural applications. Based upon this soil survey, an assessment was made of hydrologic characteristics of the soils within the drainage area tributary to Okauchee Lake. The suitability of the soils for urban residential development was assessed using three common development scenarios. These ratings reflected the requirements of Chapter Comm 83 of the *Wisconsin Administrative Code* governing onsite sewage disposal systems as it existed through the year 2000. During 2000, the Wisconsin Legislature amended Chapter Comm 83 and adopted new rules governing onsite sewage disposal systems. These rules, which had an effective date of July 1, 2000, significantly altered the existing regulatory framework and have effectively increased the area in which onsite sewage disposal systems may be utilized.

Soils within the tributary drainage area to Okauchee Lake were categorized into four main hydrologic groups, as well as an "other" category, as indicated in Table 2. The areal extent of these soils and their locations within the watershed are shown of Map 6. About 60 percent of the total drainage area is covered by moderately drained soils, while about 30 percent of the total drainage area is covered by approximately equal areas of poorly-drained or very poorly-drained soils. Less than 1 percent of the total drainage area is covered by well-drained soils. The remainder is covered by water or is comprised of disturbed soils that could not be classified and for which no determination has been made. The major soil groups present within the drainage area tributary to Okauchee Lake include: Fox silt loam, Theresa silt loam, Casco loam, Casco-Rodman complex, Hochheim loam, St. Charles silt loam, Brookston silt loam, and marsh soils.

---

[1] *Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *1983.*

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

Table 2

GENERAL HYDROLOGIC SOIL TYPES WITHIN THE DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE

Group	Soil Characteristics	Direct Tributary Drainage Area (acres)	Percent of Total	Total Tributary Drainage Area (acres)	Percent of Total
A	Well drained; very rapidly to rapid permeability; low shrink-swell potential	--	--	158	<1
B	Moderately well drained; texture intermediate between coarse and fine; moderately rapid to moderate permeability; low to moderate shrink-swell potential	3,434	62	31,499	60
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	506	9	8,447	16
D	Very poorly drained; high water table for most of the year; organic or clay soils; clay soils having high shrink-swell potential	123	2	7,971	15
Other	Group not determined	76	1	652	1
--	Water	1,423	26	3,644	7
--	Total	5,562	100	52,371	100

Source: SEWRPC.

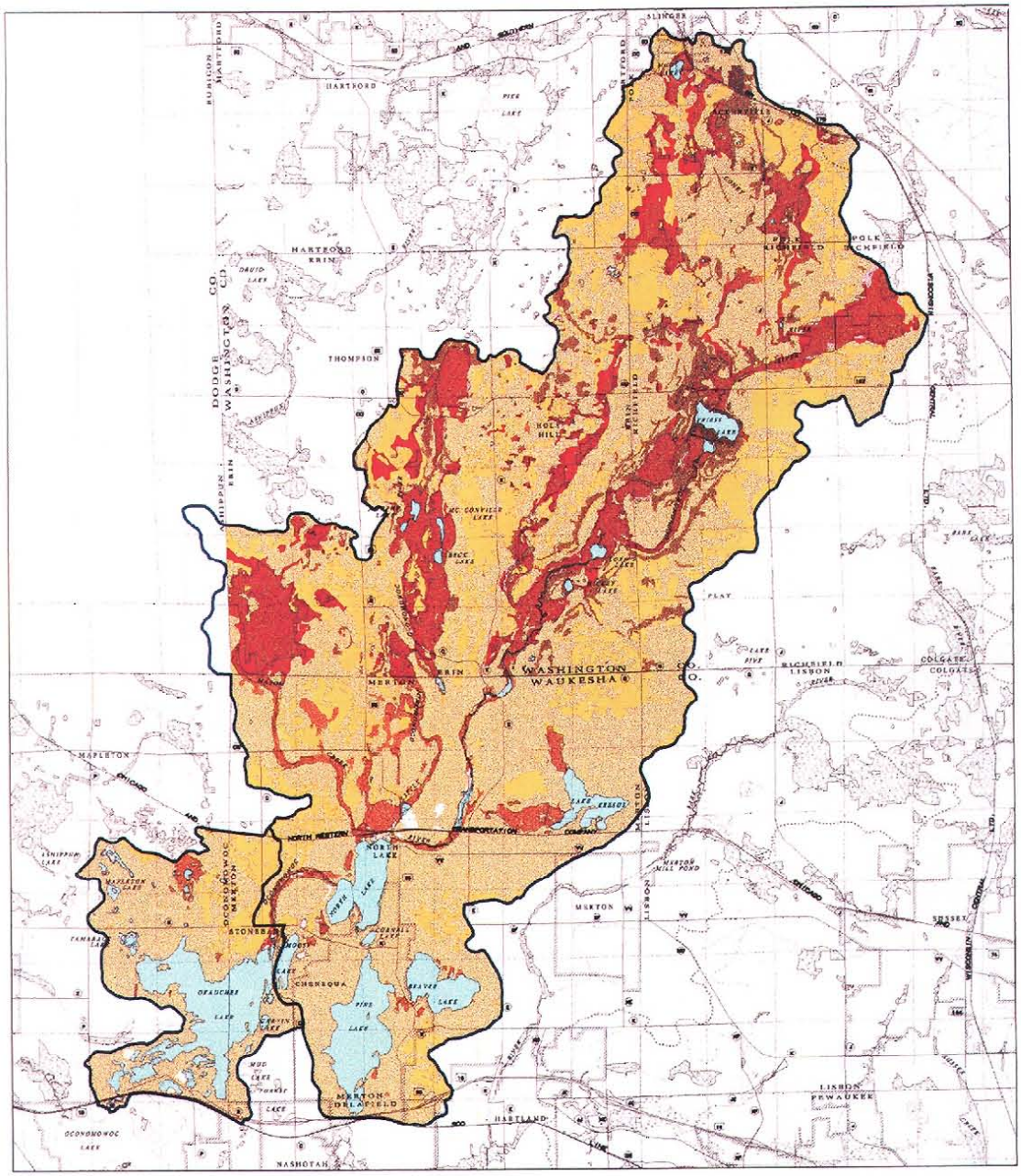
As noted above, the soils within the drainage area tributary to Okauchee Lake were classified with respect to suitability for various types of urban and rural development under the Regional soil survey. The suitability for use for onsite sewage disposal systems was updated by the Regional Planning Commission, based upon soil characteristics provided by the detailed soil surveys and the field experience of County and State technicians responsible for overseeing the location and design of such systems. The classifications reflected the then-existing soil and site specifications set forth in Chapter Comm 83 of the *Wisconsin Administrative Code*, as it was prior to June 2000. Notwithstanding, the interpretations associated with the soil survey are such that they continue to provide insights into the potential for land-based sources of pollution to affect the Lake water quality either as a consequence of overland flows during storm events or through groundwater interflows in the Lake. It is useful to note that about one-quarter of the lands within the total drainage area tributary to Okauchee Lake, as shown on Map 7, are covered by soils that are categorized as having few limitations for onsite sewage disposal systems. However, approximately a further one-quarter of the lands had severe limitations, suggesting a potential sensitivity to disturbance and likelihood of being permeable to pollutants. The balance of the total drainage area was covered by soils for which a determination could not be made, or by surface water.

Climate and Hydrology

Long-term average monthly air temperature and precipitation values for the Okauchee Lake area are set forth in Table 3. These averages were taken from official National Oceanic and Atmospheric Administration (NOAA) records for the weather recording station at Oconomowoc. The records of this station may be considered typical of the lake area. Table 3 also sets forth runoff values derived from U.S. Geological Survey (USGS) flow records for the Rock River at Afton, in Jefferson County, Wisconsin. The mean annual temperature of 45.2°F at Oconomowoc is quite similar to that of other recording locations in Southeastern Wisconsin. The mean annual precipitation at Oconomowoc is about 30.9 inches. More than half the yearly precipitation normally occurs during the growing season, from May to September. Runoff rates are generally low during this period, since

Map 6

HYDROLOGIC SOIL GROUPS IN THE TOTAL DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE



GROUP A: Well–drained

GROUP A/B: Well–drained soil/Moderately drained[1]

GROUP A/D: Well–drained soil/Very poorly drained soil[2]

GROUP B: Moderately drained soil

GROUP B/D: Moderately drained soil/Very poorly drained soil[3]

GROUP C: Poorly drained soil

GROUP C/D: Poorly drained soil/Very poorly drained soil[4]

GROUP D: Very poorly drained soil

Surface Water

Hydrologic soil group not determined

1 Well–drained soil if water table is lowered through provision of a drainage system. Moderately drained soil if water table is not lowered.

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

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

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

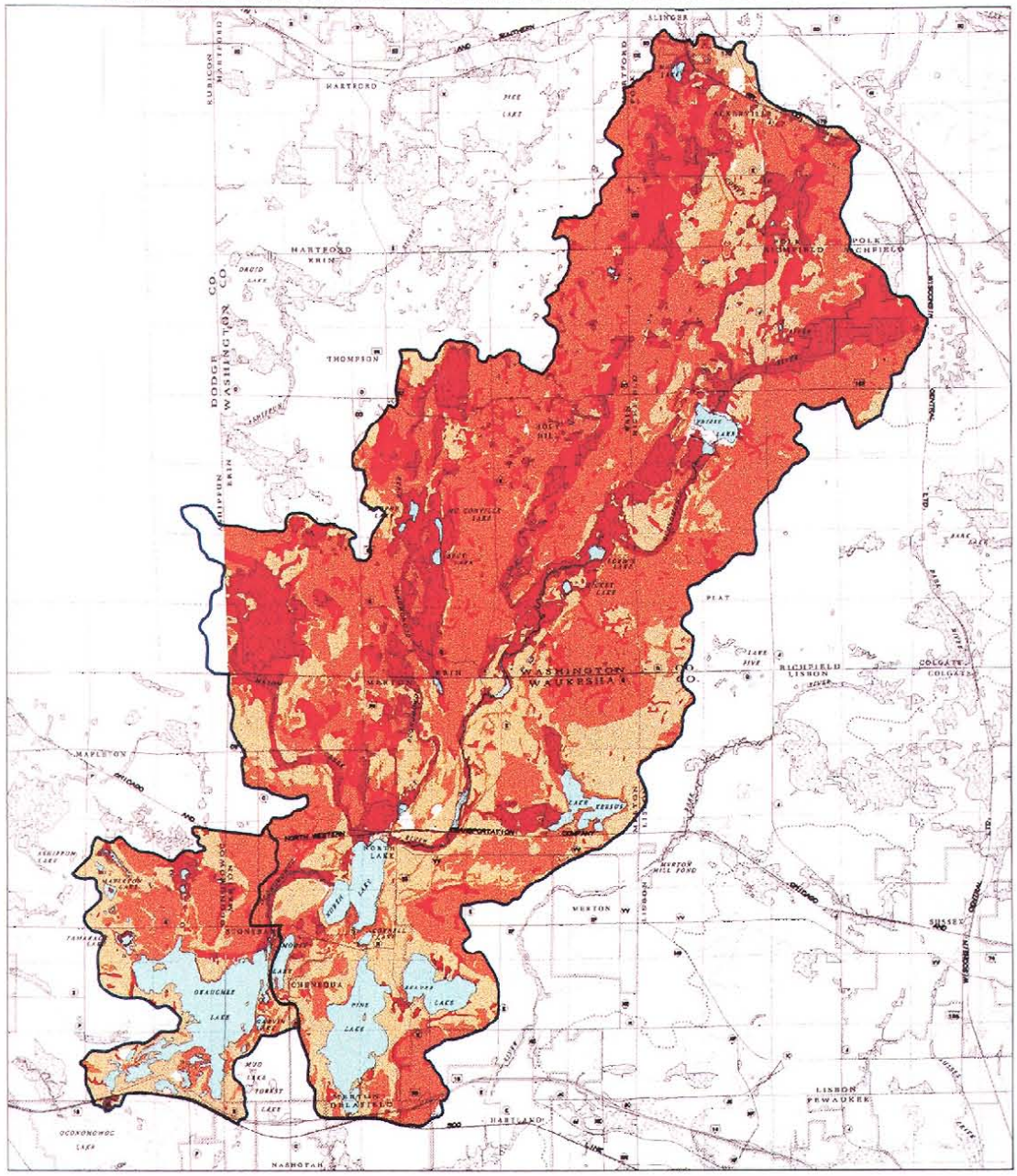
0 .5 1

Scale in miles

Source: U.S. Department of Agriculture, National Resource Conservation Service; and SEWRPC.

Map 7

SUITABILITY OF SOILS WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE FOR CONVENTIONAL ONSITE SEWAGE DISPOSAL SYSTEMS



UNSUITABLE: Areas covered by soils which have a high probability of not meeting the 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 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 criteria of Chapter Comm 83 of the Wisconsin Administrative 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

0 .5 1
Scale in miles

Source: U.S. Department of Agriculture, National Resources Conservation Service; and SEWRPC.

Table 3

LONG-TERM AND 1999 STUDY YEAR TEMPERATURE, PRECIPITATION, AND RUNOFF DATA FOR THE OKAUCHEE LAKE AREA

Temperature													
Air Temperature Data (°F)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	15.2	19.4	31.9	45.4	57.5	66.7	71.7	68.8	60.1	49.0	35.5	21.4	45.2
1999 Mean Monthly	15.9	31.4	33.9	48.8	59.9	67.8	75.0	67.8	60.7	49.2	43.0	26.5	48.3
Departure from Long-Term Mean	0.7	12.0	2.0	3.4	2.4	1.1	3.3	-1.0	0.6	0.2	7.5	5.1	3.1

Precipitation														
Precipitation Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean	Total
Long-Term Mean Monthly	0.99	0.94	1.87	2.76	2.86	3.60	3.76	3.93	3.88	2.52	2.12	1.67	2.58	30.90
1999 Mean Monthly	3.46	0.73	0.73	6.38	5.23	6.10	5.72	1.82	3.48	0.92	1.39	1.96	3.16	37.92
Departure from Long-Term Mean	2.47	-0.21	-1.14	3.62	2.37	2.50	1.96	-2.11	-0.40	-1.60	-0.73	0.29	0.59	7.02

Runoff													
Runoff Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Total
Long-Term Mean Monthly	0.45	0.49	1.15	1.38	0.89	0.58	0.49	0.39	0.40	0.48	0.52	0.51	7.73
1999 Mean Monthly	0.44	1.03	0.74	1.24	1.78	1.19	0.74	0.95	0.38	0.48	0.39	0.49	9.85
Departure from Mean Monthly	-0.01	0.54	-0.41	-0.14	0.89	0.61	0.25	0.56	-0.02	0.00	-0.13	-0.02	2.12

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

evapotranspiration rates are high, vegetative cover is good, and soils are not frozen. Normally, less than 15 percent of the summer precipitation is converted to surface runoff, but intense summer storms may occasionally produce high rates and amounts of runoff. Approximately 40 percent of the annual precipitation normally occurs during the winter or early spring when the ground is frozen, resulting in high rates and amounts of surface runoff during those seasons. Impervious areas, such as street surfaces, parking lots, and rooftops, increase the amount of surface runoff and decrease soil infiltration.

The 12-month period over which the Okauchee Lake water quality sampling study was carried out, January 1999 through December 1999, was a period of above average temperatures and higher-than-average amounts of precipitation in Southeastern Wisconsin, as indicated in Table 3. Temperatures were generally above normal during the winter months of 1999, slightly above normal in the spring of 1999, and slightly above normal for the summer and fall months. Precipitation at Oconomowoc during the sampling period was about 37.9 inches, or about 7.0 inches above normal, with the greatest increased amounts occurring during the period from April through July 1999.

Lake Stage
The water level of Okauchee Lake is primarily determined by the level of the dam located at the Lake outlet. The dam has a normal operating level, as established by the Wisconsin Department of Natural Resources, within the range of elevations between 872.60 feet and 873.71 feet NGVD-29.

Water Budget
A water budget for Okauchee Lake was estimated from precipitation and evaporation data, Oconomowoc River inflows and outflows, surface runoff data for the drainage area directly tributary to the Lake, groundwater inflows and outflows, and lake level data for the period 1976 through 1977. During the initial planning project, it was estimated that 35,900 acre-feet of water entered the Lake. Of this total, about 24,300 acre-feet of water, or 68 percent, was contributed by the Oconomowoc River; about 6,500 acre-feet, or 18 percent, by groundwater; about 3,600 acre-feet, or 10 percent, by direct precipitation onto the lake surface; and about 1,450 acre-feet, or 4 percent, by surface runoff from the drainage area directly tributary to the Lake. The total water outflow from Okauchee Lake during this period was estimated to be 35,900 acre-feet, about 21,000 acre-feet, or 59 percent, of which was discharged to the Oconomowoc River. A further volume of about 10,900 acre-feet, or 30 percent of the outflow volume, was discharged as groundwater outflow; about 2,900 acre-feet, or 8 percent, as evaporation from the Lake surface; and, about 1,200 acre-feet, or 3 percent, by an increase in Lake storage and the resulting, higher Lake level.

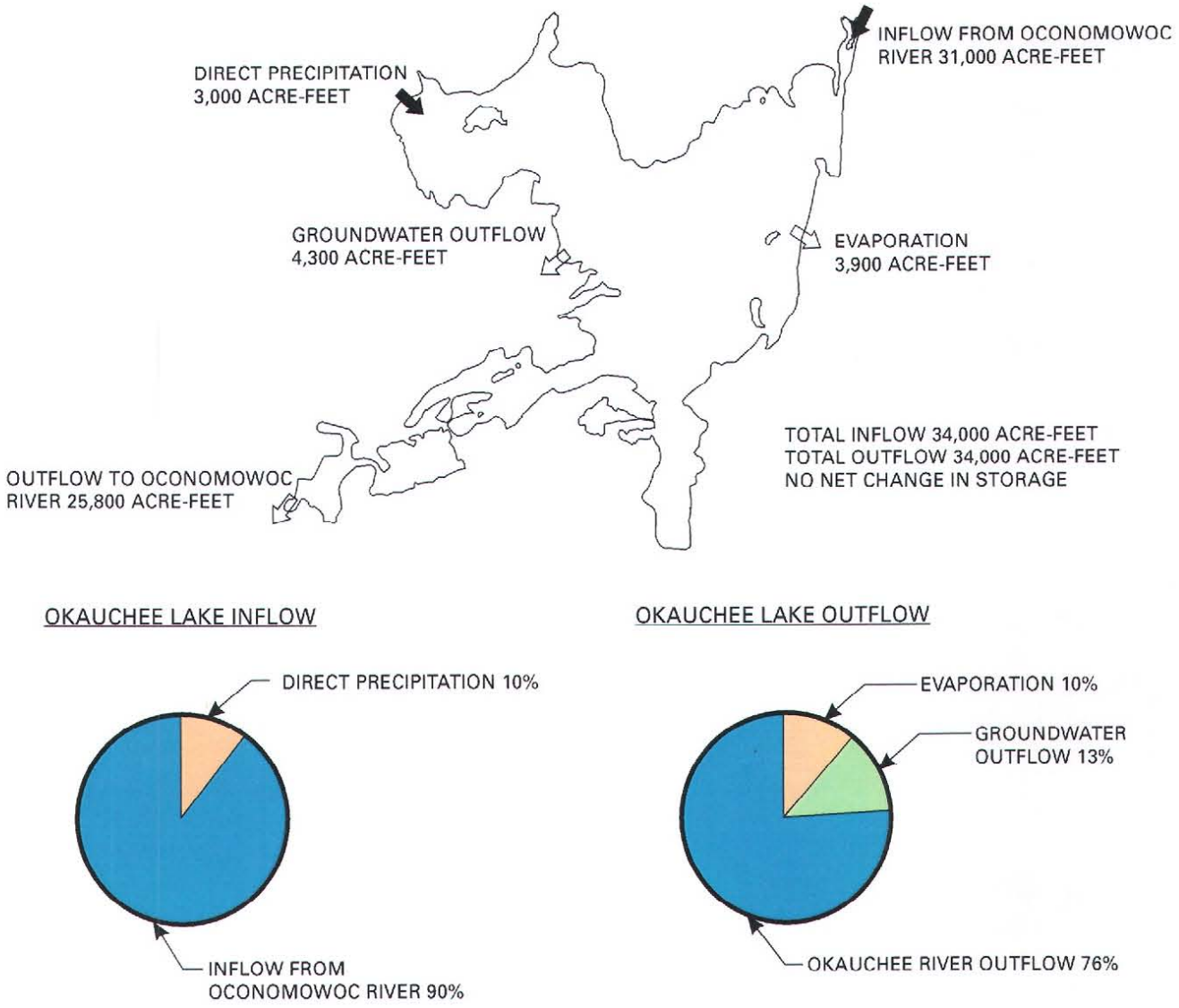
In addition to the surface water quantity measurements conducted during 1976 and 1977, groundwater flows also were estimated using 23 pairs of groundwater sampling wells. These wells were used to measure the direction and flow of groundwater in the vicinity of Okauchee Lake. Inflows of groundwater to Okauchee Lake were found to occur only along the northeastern shore of the Lake, near the Oconomowoc River inlet, with much of the northern and eastern shore serving as transition zones where groundwater sometimes flowed into, and sometimes out of, the Lake. Groundwater levels were reported to be low during this study period.

A long-term water budget for Okauchee Lake was computed from estimated precipitation and inflow volumes from the tributary streams, and estimated outflows through the Oconomowoc River, based upon data collected by the U.S. Geological Survey at Watertown, Wisconsin, between 1931 and 2001, and is set forth in Figure 1. An average of about 31,000 acre-feet, or about 90 percent of the water entering the Lake, is contributed by surface runoff, and about 3,000 acre-feet, or about 10 percent, is contributed by precipitation directly onto the Lake surface. Of this total long-term annual inflow, it is estimated that 3,900 acre-feet, or about 11 percent of the inflow volume, is lost to evaporation from the Lake surface; 4,300 acre-feet, or about 13 percent, estimated as the net groundwater loss from the Lake measured in the initial plan, is lost as groundwater outflow from the Lake, and 25,800 acre-feet, 76 percent, is discharged from the Lake to the Oconomowoc River. The long-term water balance for Okauchee Lake assumes no significant net change in Lake water level.

The hydraulic residence time is important in determining the expected response time of the lake to increased or reduced nutrient and other pollutant loadings. The hydraulic residence time for Okauchee Lake during the initial study period of December 1976 through November 1977, a year of slightly above average precipitation, was estimated to be 0.8 year. During years of average climatological conditions, the hydraulic residence time is estimated to be 0.9 year, as suggested for the long-term average water balance for the Lake.

Figure 1

HYDROLOGIC BUDGET FOR OKAUCHEE LAKE: 1914-2001



Source: U.S. Geological Survey and SEWRPC.

Chapter III

HISTORICAL, EXISTING, AND FORECAST LAND USE AND POPULATION LEVELS

INTRODUCTION

Water pollution problems, recreational use conflicts, and deterioration of the natural environment are all primarily a function of the human activities within the drainage area of a waterbody, as are the ultimate solutions to these problems. This is especially true with respect to lakes that are highly susceptible to deterioration by human activities, because of their relatively long pollutant retention times and variety of often-conflicting uses to which lakes are subjected. Furthermore, urban development is often concentrated in the direct drainage areas and around the shorelines of the lakes, where there are no intermediate stream segments to attenuate pollution runoff and loadings. Accordingly, the population levels and the land use management in the tributary drainage area of a lake are important considerations in any lake management efforts.

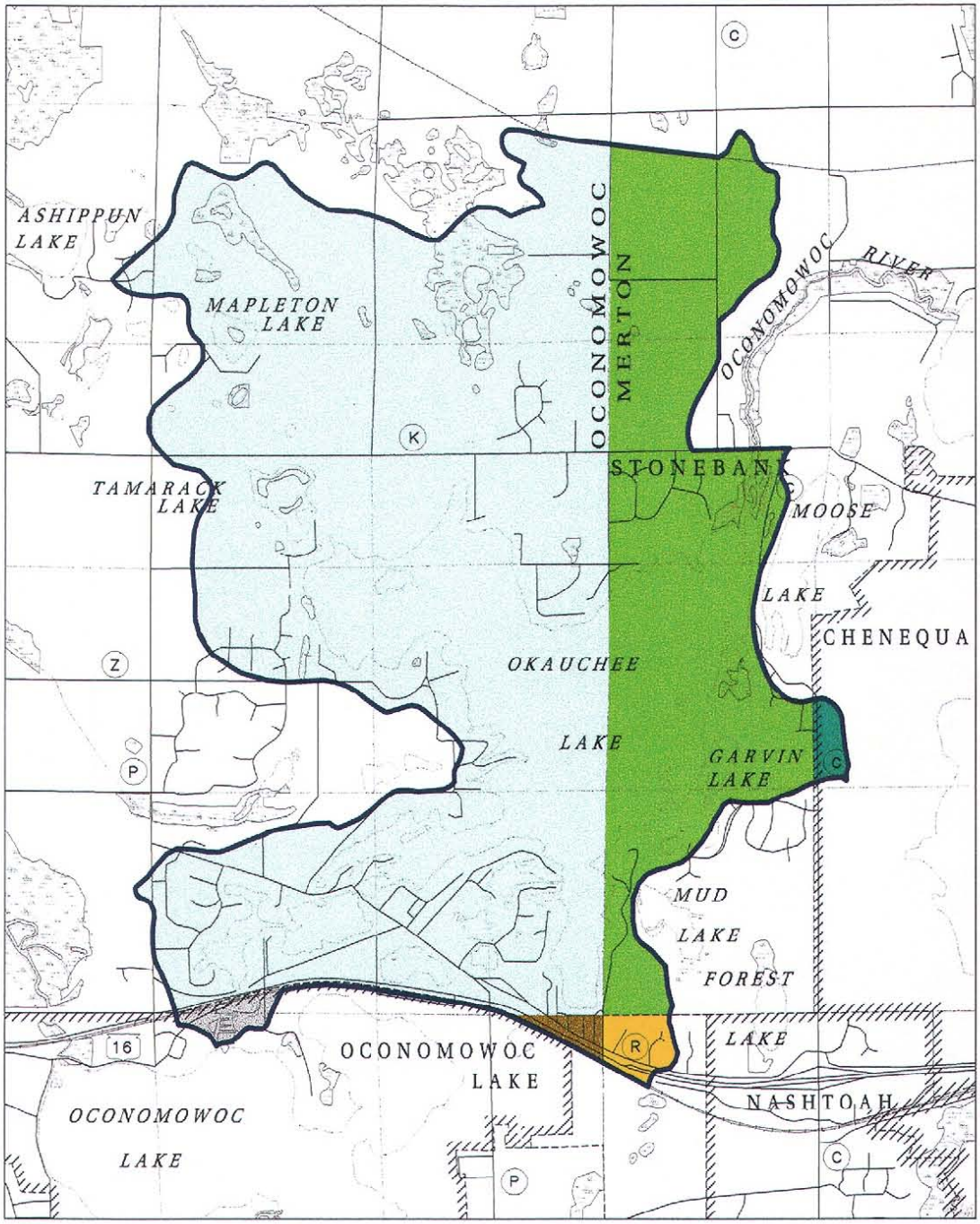
CIVIL DIVISIONS

The geographic extent and functional responsibilities of civil divisions and special-purpose units of government are important factors which must be considered in any water quality management planning effort, since these local units of government provide the basic structure of the decision-making framework within which environmental problems must be addressed. Superimposed on the irregular boundary of the drainage area tributary to Okauchee Lake is a generally rectilinear pattern of local civil division boundaries, as shown on Map 8. The governmental units within the drainage area directly tributary to Okauchee Lake include portions of the City of Delafield, the Villages of Chenequa and Oconomowoc Lake, and the Towns of Merton, Oconomowoc, and Summit, all in Waukesha County. None of these civil divisions lies entirely within the direct tributary drainage area. Within the total drainage area tributary to the Lake are a number of other civil divisions, including: the Town of Ashippun in Dodge County; the Villages of Hartland, Merton, and Nashotah and Town of Lisbon in Waukesha County; and, the Village of Slinger and Towns of Erin, Hartford, Polk, and Richfield in Washington County. The area and proportion of the drainage area lying within the jurisdiction of each civil division, as of 2000, are set forth in Table 4. The geographic boundaries of the civil divisions are an important factor which must be considered in any water quality management planning effort for a lake, since these local units of government provide the basic structure of the decision-making framework within which intergovernmental environmental problems must be addressed.

In addition to these general purpose units of government, the Okauchee Lake Management District 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 1975 and encompasses the properties riparian to the Lake. Public inland lake protection and rehabilitation districts, or lake management districts, may undertake

Map 8

CIVIL DIVISION BOUNDARIES WITHIN THE DIRECT DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE



Source: SEWRPC.

Table 4

AREAL EXTENT OF CIVIL DIVISION BOUNDARIES WITHIN THE DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE

Civil Division	Direct Drainage Area		Total Tributary Drainage Area	
	Civil Division Area within Area (acres)	Percent of Area within Civil Division	Civil Division Area within Area (acres)	Percent of Area within Civil Division
City of Delafield	52	1	172	<1
Village of Chenequa	30	1	2,754	5
Village of Oconomowoc Lake	50	1	50	<1
Village of Hartland	--	--	6	<1
Village of Merton	--	--	30	<1
Village of Nashotah	--	--	21	<1
Village of Slinger	--	--	164	<1
Town of Merton	1,433	26	14,401	28
Town of Oconomowoc	3,973	71	3,973	8
Town of Summit	25	<1	25	<1
Town of Erin	--	--	14,927	29
Town of Hartford	--	--	586	1
Town of Lisbon	--	--	485	1
Town of Polk	--	--	4,791	9
Town of Richfield	--	--	9,563	18
Town of Ashippun	--	--	423	1
Total	5,563	100	52,371	100

Source: SEWRPC.

programs of lake protection or rehabilitation including water quality, 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]

POPULATION

As indicated in Table 5, the resident population of the drainage area directly tributary to Okauchee Lake has increased steadily since 1950. The 1995 resident population of the drainage area was estimated at 4,000 persons, or approximately double the estimated 1950 population. This population level has remained relatively stable since about 1975. However, as set forth in Table 5, population forecasts prepared by the Regional Planning Commission on the basis for the preparation of a normative regional land use plan[2] suggest that the population of the drainage area directly tributary to Okauchee Lake is expected to increase to about 6,000 persons by the year 2020. This population growth may be expected to place a steadily increasing stress on the natural resource base of the Lake's drainage area, and both water resource demands and use conflicts may be expected to increase.

LAND USE

The type, intensity, and spatial distribution of the various land uses within the drainage area tributary Okauchee Lake are important determinants of lake water quality and recreational use demands. The current and planned land

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

[2] *SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin 2020, *December 1997.*

Table 5

HISTORIC AND FORECAST RESIDENT POPULATION OF THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OKAUCHEE LAKE: 1950-2020

Year	Population
1950	2,080
1960	2,640
1970	3,920
1975	4,160
1980	4,000
1990	3,918
2000	4,096
2020	6,000

Source: SEWRPC.

use patterns placed in the context of the historical development of the area are, therefore, important considerations in any lake management planning effort for Okauchee Lake.

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 subsequent sale of public lands brought a rapid influx of settlers into the area. Map 9 shows the original plat of the U.S. Public Land Survey for the Okauchee Lake area. Land division in the Okauchee Lake area began in the 1830s. Map 10 and Table 6 indicate the historic urban growth pattern since 1920 in the drainage area directly tributary to Okauchee Lake.[3] The largest increase in urban development within the drainage area directly tributary to Okauchee Lake occurred between 1920 and 1940. While this period also saw extensive urban development in the total drainage area tributary to Okauchee Lake, the greatest increases in urban lands within the wider watershed have occurred since 1975, as shown in Table 6.

The existing land use pattern in the drainage area directly tributary to Okauchee Lake, as of 1995, is shown on Map 11 and quantified in Table 7. As indicated in Table 7, about 30 percent of the drainage area directly tributary to Okauchee Lake was in urban land uses, with the dominant urban land use being residential, encompassing about 70 percent of the urban land area. Most of the residential development along the immediate shoreline of the Lake is indicated to be single family residential land uses, although some multi-family residential development occurs in the southeastern extreme of the drainage basin. About one-third, 34 percent, of the drainage area directly tributary to the Lake was in agricultural use, such uses being primarily located north of Okauchee Lake. Open lands and woodland areas comprised about 5 percent of the drainage area; wetlands and water accounted for balance of the rural lands in the tributary drainage area, comprising about one-third of the drainage area, as shown in Table 7.

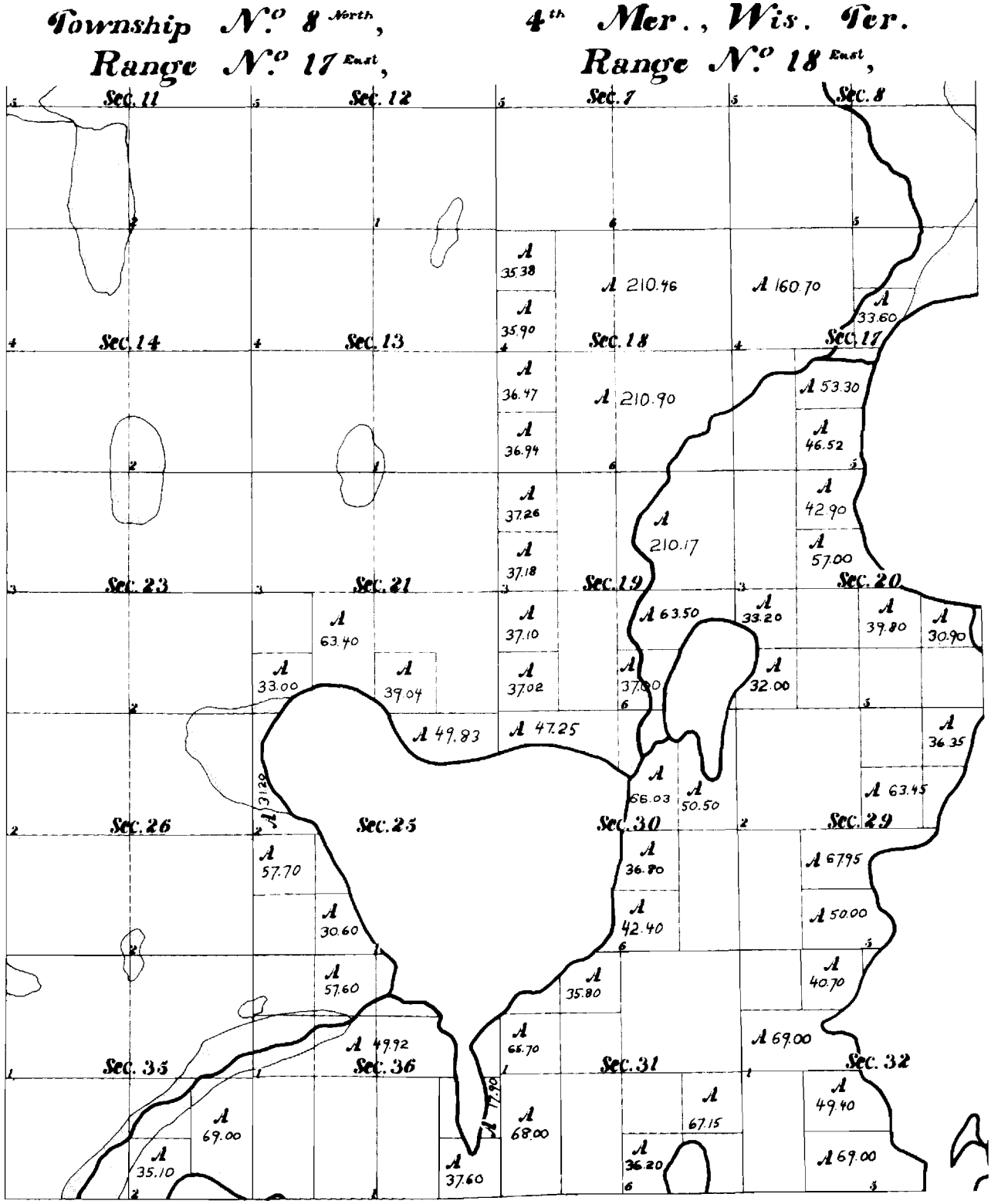
Within the total drainage area tributary to Okauchee Lake, urban land uses accounted for less than 20 percent of the land area, comprising about 16 percent of the drainage area, as shown in Table 8. Rural land uses accounted for about 83 percent of the total land area within the drainage basin, with agricultural uses comprising about 60 percent of this total.

The extent of residential development within the urban areas of the drainage area tributary to Okauchee Lake is expected to increase. Within the drainage area directly tributary to the Lake, urban residential uses are expected to increase by about 400 acres, to almost 30 percent of the direct drainage area, as shown in Table 7. Most of this residential development is expected to occur on lands formerly devoted to agricultural uses. Rural agricultural uses are expected to decrease to about 30 percent of the direct drainage area. A similar change in land usage is anticipated to occur in the total drainage area tributary to Okauchee Lake, as shown in Table 8.

[3] *Urban development is defined, for the purposes of this report, as an area containing a closely spaced network of land access streets and attendant facing urban land uses such as residential, commercial, industrial, governmental, and institutional uses.*

Map 9

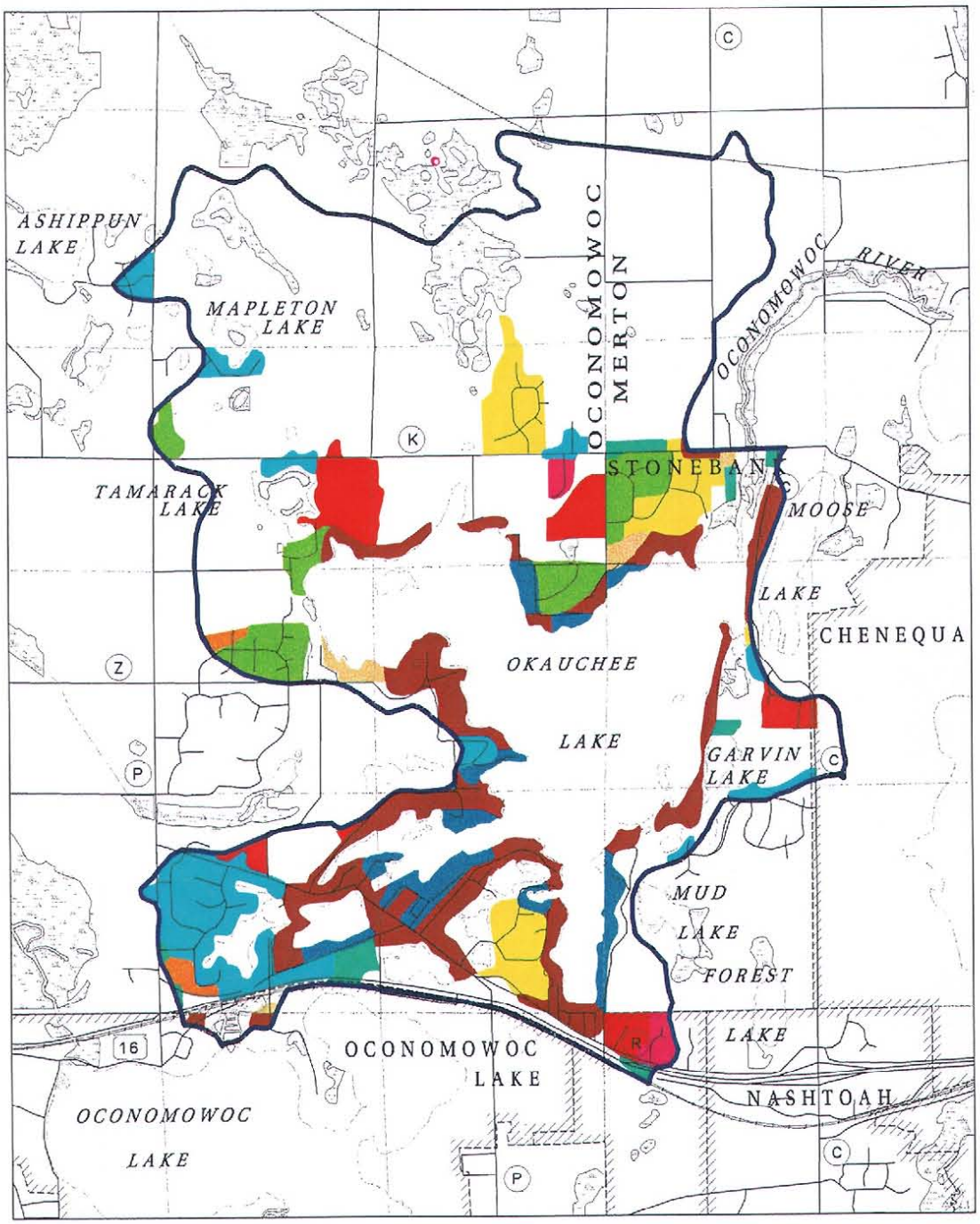
ORIGINAL UNITED STATES PUBLIC LAND SURVEY MAP OF OKAUCHEE LAKE: 1836



Source: U.S. Public Land Survey and SEWRPC.

Map 10

HISTORIC URBAN GROWTH WITHIN THE DIRECT DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE



1850
1880
1900
1920
1940
1950
1963
1970
1975
1980
1985
1990
1995

0 .5 1
Scale in miles

Source: SEWRPC.

Table 6

EXTENT OF URBAN GROWTH WITHIN THE DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE: 1850-1995

Year	Direct Drainage Area		Total Tributary Drainage Area	
	Extent of New Urban Development Occurring Since Previous Year (acres)[a]	Cumulative Extent of Urban Development (acres)[a]	Extent of New Urban Development Occurring Since Previous Year (acres)[a]	Cumulative Extent of Urban Development (acres)[a]
1880	--	--	9	9
1900	--	--	12	21
1920	140	140	162	183
1940	432	572	981	1,164
1950	31	603	203	1,367
1963	52	655	269	1,636
1970	260	915	816	2,452
1975	32	947	520	2,972
1980	175	1,122	1,665	4,637
1985	196	1,318	1,203	5,840
1990	21	1,339	407	6,247
1995	165	1,504	1,016	7,263

[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 in this analysis.*

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

The Waukesha County Development Plan recommends that most new residential development in the drainage area directly tributary to the Lake occur at relatively low densities.[4] Agricultural lands located north of Okauchee Lake, and designated as prime agricultural land, generally are recommended to remain in agricultural use. Portions of the remaining undeveloped lands, and agricultural lands other than those designated as prime agricultural lands, are recommended to be developed for urban residential uses. Certain lands lying along the Oconomowoc River are recommended to be preserved in essentially natural or open space uses, and have been designated as environmental corridor lands in the adopted regional land use plan and county development plan.

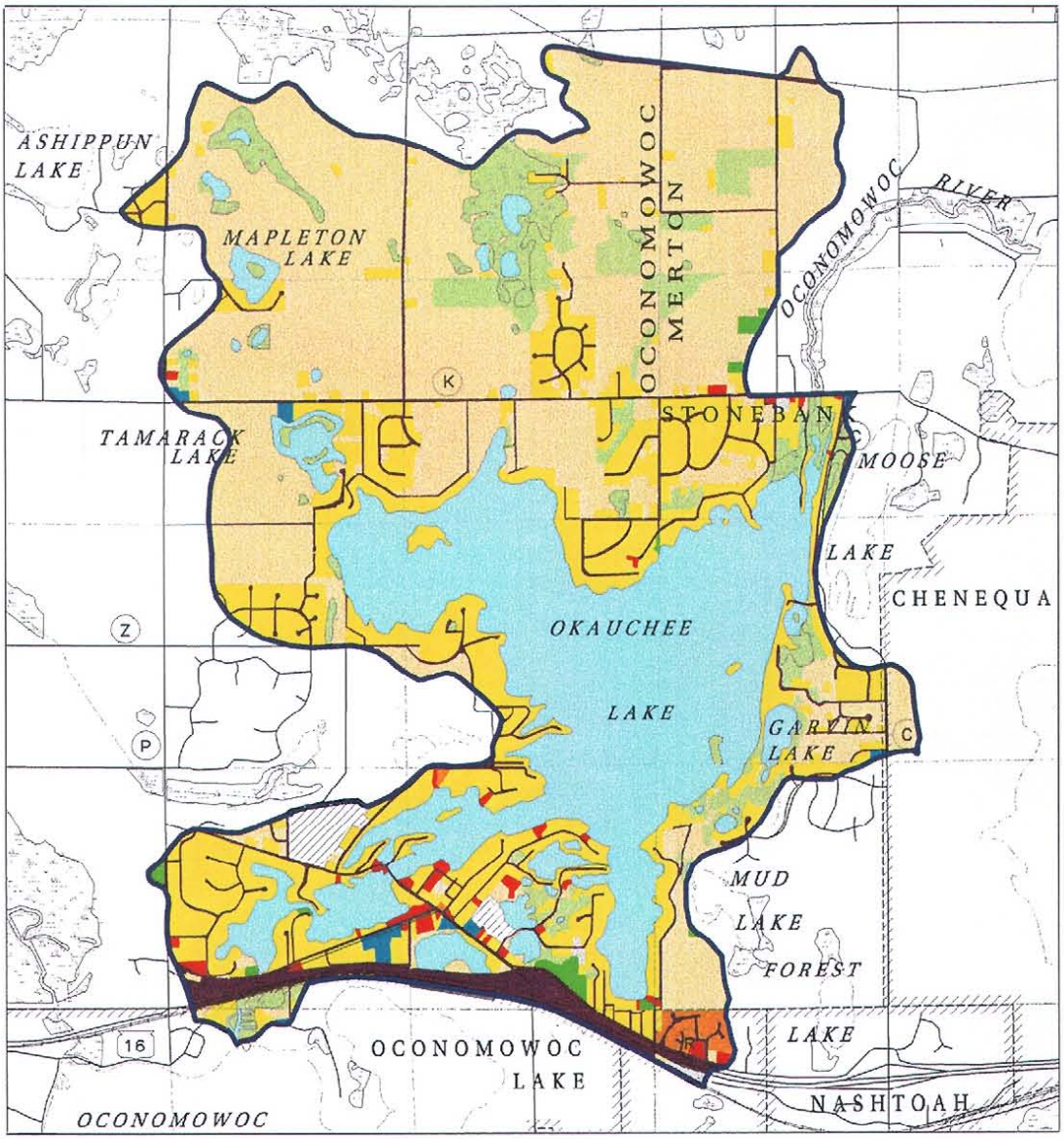
LAND USE REGULATIONS

The comprehensive zoning ordinance represents one of the most important and significant tools available to local units of government in directing the proper use of lands within their area of jurisdiction. As already noted, the drainage area tributary to Okauchee Lake includes portions of the City of Delafield; the Villages of Chenequa and Oconomowoc Lake, and the Towns of Merton, Summit, and Oconomowoc in Waukesha County, as well as the Town of Ashippun in Dodge County; the Villages of Hartland, Merton, and Nashotah and Town of Lisbon in Waukesha County; and, the Village of Slinger and Towns of Erin, Hartford, Polk, and Richfield in Washington County. The City and the Villages administer their own zoning ordinances, as shown in Table 9. The Towns, with the exception of the Town of Oconomowoc in Waukesha County and the Town of Ashippun in Dodge County, also have adopted their own zoning ordinances, as show in the table. The Towns of Oconomowoc and Ashippun are under the jurisdiction of the Waukesha County and Dodge County zoning ordinances, respectively.

[4]*SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

Map 11

EXISTING LAND USE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OKAUCHEE LAKE: 1995



Source: SEWRPC.

Table 7

EXISTING LAND USE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OKAUCHEE LAKE: 1995 AND 2020

Land Use Categories	1995		2020	
	Acres	Percent of Direct Tributary Drainage Area	Acres	Percent of Direct Tributary Drainage Area
Urban				
Residential	1,124	20	1,552	28
Commercial	36	<1	40	<1
Industrial	9	<1	91	<1
Governmental and Institutional	19	<1	36	<1
Transportation, Communication, and Utilities	309	6	458	8
Recreation	90	2	96	2
Subtotal	1,587	28	2,191	38
Rural				
Agricultural	1,920	34	1,350	25
Wetlands	377	7	377	7
Woodlands	255	5	255	5
Water	1,378	25	1,378	25
Extractive	45	1	11	<1
Subtotal	3,975	72	3,371	62
Total	5,562	100	5,562	100

Source: SEWRPC.

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*. However, a county zoning ordinance becomes effective only in those towns that ratify the county ordinance. Towns that have not adopted a county zoning ordinance may adopt village powers and subsequently utilize the city and village zoning authority conferred in Section 62.23 subject, however, to county board approval where a general-purpose county zoning ordinance exists. Alternatively, a town may adopt a zoning ordinance under Section 60.61 of the *Statutes* where a general-purpose county zoning ordinance has not been adopted, but only after the county board fails to adopt a county ordinance at the petition of the governing body of the town concerned.

General zoning is in effect in all communities in Washington County. All of the cities and villages in Waukesha and Washington Counties, within the drainage area tributary to Okauchee Lake, have adopted their own zoning ordinances. Many of the towns in Waukesha and Washington Counties, within the drainage area tributary to Okauchee Lake, have also adopted their own general zoning ordinances under village powers, although the Town of Oconomowoc has adopted the county's ordinance, as shown in Table 9.

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

Table 8

EXISTING LAND USE WITHIN THE TOTAL TRIBUTARY AREA TO OKAUCHEE LAKE: 1995 AND 2020

Land Use Categories	1995		2020	
	Acres	Percent of Total Tributary Drainage Area	Acres	Percent of Total Tributary Drainage Area
Urban				
Residential	6,009	11	8,254	16
Commercial	130	<1	177	<1
Industrial	31	<1	165	<1
Governmental	102	<1	125	<1
Transportation, Communication, and Utilities	2,014	4	2,635	5
Recreation	646	1	694	1
Subtotal	8,932	16	12,050	22
Rural				
Agricultural	25,979	50	22,796	44
Wetlands	6,156	12	6,156	12
Woodlands	6,995	14	6,995	14
Water	3,664	7	3,664	7
Extractive	170	<1	235	<1
Landfill	52	<1	52	<1
Subtotal	43,016	83	39,898	77
Not Categorized (outside Region)	423	1	423	1
Total	52,371	100	52,371	100

Source: SEWRPC.

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 must also 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 Protection Zoning Ordinance. However, all of the towns within the drainage area tributary to Okauchee Lake currently are regulated only by the county ordinance for floodplain zoning.

Floodland ordinances are in effect within all parts of the drainage area tributary to Okauchee Lake, as shown in Table 9, with the exception of the Villages of Nashotah and Chenequa, both in Waukesha County, which have no flood hazard areas identified and mapped with their boundaries.

Shoreland Zoning

Under Section 59.692 of the *Wisconsin Statutes*, counties in Wisconsin are required to adopt zoning regulations within statutorily defined shoreland areas, those lands within 1,000 feet of a navigable lake, pond, or flowage, or 300 feet of a navigable stream, or to the landward side of the floodplain, whichever distance is greater, within their unincorporated areas. 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,

Table 9

LAND USE REGULATIONS WITHIN THE DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE IN DODGE, WASHINGTON, AND WAUKESHA COUNTIES BY CIVIL DIVISION: 2001

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Erosion Control and Stormwater Management
Waukesha County	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Floodland and shoreland only	Adopted
City of Delafield	Adopted	Adopted	Adopted	Adopted	Adopted
Village of Chenequa	Adopted	None[a]	Adopted	None	Adopted[b]
Village of Hartland	Adopted	Adopted	Adopted	Adopted	Adopted
Village of Merton	Adopted	Adopted	Adopted	Adopted	None
Village of Nashotah	Adopted	None[a]	Adopted and Wisconsin Department of Natural Resources approved	Adopted	None
Village of Oconomowoc Lake	Adopted	Adopted	Adopted	Adopted	None
Town of Lisbon	Adopted	County ordinance	County ordinance	Adopted	Adopted
Town of Merton	Adopted	County ordinance	County ordinance	Adopted	None
Town of Oconomowoc	County ordinance	County ordinance	Adopted and Wisconsin Department of Natural Resources approved	Adopted	Adopted
Town of Summit	Adopted	County ordinance	Adopted and Wisconsin Department of Natural Resources approved	Adopted	None
Washington County	--[c]	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Floodland and shoreland only	Adopted
Village of Slinger	Adopted	Adopted	Adopted	Adopted	None
Town of Erin	Adopted	County ordinance	County ordinance	Adopted	County ordinance
Town of Hartford	Adopted	County ordinance	County ordinance	County ordinance	County ordinance
Town of Polk	Adopted	County ordinance	County ordinance	Adopted	County ordinance
Town of Richfield	Adopted	County ordinance	County ordinance	Adopted	County ordinance
Dodge County	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Adopted	Adopted
Town of Ashippun	County ordinance	County ordinance	County ordinance	Adopted	County ordinance

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

[b] *No erosion control ordinance.*

[c] *In 1986, Washington County rescinded its general zoning ordinance, and all nine towns which were subject to the general County zoning ordinance have since adopted a town zoning ordinance.*

Source: SEWRPC.

lagooning, dredging, ditching, and excavating that must be incorporated into county shoreland zoning regulations. In addition, Chapter NR 115 requires that counties place all wetlands five acres or larger and within the statutory shoreland zoning jurisdiction area into a wetland conservancy zoning district to ensure their preservation after completion of appropriate wetland inventories by the Wisconsin Department of Natural Resources.

In 1982, the State Legislature extended shoreland-wetland zoning requirements to cities and villages in Wisconsin. Under Sections 62.231 and 61.351, respectively, of the *Wisconsin Statutes*, cities and villages in Wisconsin are required to place wetlands 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 identification of wetlands to be protected under 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 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 discussed in Chapter V.

All of the incorporated municipalities within the total drainage area tributary to Okauchee Lake have adopted shoreland or shoreland-wetland zoning ordinances, as shown in Table 9. County shoreland zoning ordinances are in effect in all unincorporated areas of the drainage area tributary to Okauchee Lake, with the exception of the Towns of Oconomowoc and Summit which have adopted their own shoreland-wetland ordinances, approved by the Wisconsin Department of Natural Resources, as shown in Table 9.

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.[5] 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. Each of the incorporated communities within the tributary drainage area to Okauchee Lake has adopted their own subdivision ordinance, as shown in Table 9, with the exception of the Village of Chenequa. The subdivision control ordinances adopted and administered by Waukesha and Washington Counties apply only to the unincorporated statutory shoreland areas of the Counties.

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, however, to county board approval where a county ordinance exists.

Construction site erosion control and stormwater management ordinances were in effect in many of the communities within the tributary drainage area to Okauchee Lake during 2002, with the exception of the Villages of Merton, Nashotah, and Oconomowoc Lake, and the Towns of Merton and Summit in Waukesha County, and of the Village of Slinger in Washington County, as shown in Table 9. The City of Delafield and the Village of Hartland, in Waukesha County, have adopted the identical construction site erosion control and stormwater management regulations which differ from those of the County only in that they are applicable to sites of 4,000 square feet or more in areal extent, rather than sites of 3,000 square feet or more. The Towns of Lisbon and Oconomowoc in Waukesha County, likewise, have adopted construction site erosion control and stormwater

[5] *Under Section 236.02 of the* Wisconsin Statutes, *the extraterritorial plat approval jurisdiction is the area within three miles of the corporate limits of a first-, second-, or third-class city and within 1.5 miles of a fourth-class city or a village.*

management ordinances. In Dodge and Washington Counties, the Town of Ashippun and the Towns of Erin, Hartford, Polk, and Richfield, respectively, have adopted erosion control and stormwater management ordinances by reference to the County ordinances.

Waukesha, Dodge, and Washington Counties all have adopted construction erosion control and stormwater management ordinances. In the latter two counties, these ordinances apply to the unincorporated towns within each county. The Waukesha County construction site erosion control ordinance applies to all lands requiring a subdivision plat or certified survey, to sites upon which construction activities will disturb 3,000 square feet or more and/or 400 cubic yards or more of material, and to sites where pipeline placement operations disturb 300 linear feet or more of land surface. These ordinances require persons engaging in land disturbing activities to employ soil erosion control practices on affected sites that are consistent with those set forth in the *Wisconsin Construction Site Best Management Practice Handbook*[6] or equivalent practices. In general, these practices are designed to minimize soil lost from disturbed sites through prior planning and phasing of land disturbing activities and use of appropriate onsite erosion control measures.

The Waukesha County stormwater management ordinance applies to residential lands of five acres or more in areal extent, residential lands of between three and five acres in areal extent where there is at least 1.5 acres of impervious surface, nonresidential lands of 1.5 acres in areal extent where there is at least 0.5 acre of impervious surface, or other lands on which development activities may result in stormwater runoff likely to harm public property or safety. Lands within an area covered by an approved stormwater management plan are specifically exempted from the Waukesha County ordinance. One- and two-family residences, falling under the provisions of Section Comm 21.125 of the *Wisconsin Administrative Code*, are specifically exempted from the provisions of the Washington County ordinance, but are required to meet the provisions of the Wisconsin Uniform Dwelling Code. The stormwater ordinances establish performance standards to manage both rate and volume of stormwater flows from regulated sites and water quality. Performance standards adopted in these ordinances and the resultant design of appropriate management practices are based on calculation procedures and principles set forth in *Urban Hydrology for Small Watersheds.*[7]

---

[6] *Wisconsin League of Municipalities and Wisconsin Department of Natural Resources,* Wisconsin Construction Site Best Management Practices Handbook, *latest revision November 1993.*

[7] *U.S. Department of Agriculture Technical Release 55,* Urban Hydrology of Small Watersheds, *June 1986 (Washington County), or June 1992 (Waukesha County).*

(This page intentionally left blank)

Chapter IV

WATER QUALITY

HISTORICAL DATA

The earliest data on water quality conditions in Okauchee Lake date back to the early 1900s, when E.A. Birge and C. Juday, widely recognized pioneering lake researchers from the University of Wisconsin, collected basic information on the Lake. [1] However, most water quality information is relatively recent. Water chemistry data for Okauchee Lake were collected by the Wisconsin Conservation Department, now the Wisconsin Department of Natural Resources, during 1926, 1943, 1944, 1959, and in 1960. Additional data were included in the 1963 Wisconsin Department of Natural Resources Report, *Surface Water Resources of Waukesha County*, as well as in miscellaneous Wisconsin Department of Natural Resources file data and reports. While a review of these historical data, set forth in Table 10, indicates considerable variation in water quality conditions, much of this variation during the earlier years of sampling may be attributed to the differences among the analytical methods used, and not to any long-term trends in Lake water quality.

More recently, the Wisconsin Department of Natural Resources has monitored the water quality of Okauchee Lake periodically from 1973 through 1977. In recent years, since 1984, water quality conditions in Okauchee Lake have been monitored by the U.S. Geological Survey, as part of their Trophic State Index (TSI) monitoring program. These latter studies involved the determination of the physical and chemical characteristics of the Lake's water, including dissolved oxygen concentration and water temperature profiles, pH, specific conductance, water clarity, and nutrient and chlorophyll-a concentrations.

EXISTING WATER QUALITY CONDITIONS

Water quality data gathered under the auspices of the Wisconsin Department of Natural Resources monitoring programs for the period from 1973 through 1977 were used to assess water quality conditions in Okauchee Lake for purposes of the initial lake management plan. These data 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. For the purposes of this plan, the early data are supplemented with data collected by the U.S. Geological

---

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

Table 10

HISTORICAL WATER QUALITY DATA FOR OKAUCHEE LAKE: 1926-1960

Water Quality Parameter (mg/l)	Sample Date										
	November 1926	July 1943	November 1943	April 1944	July 1944	July 1959	November 1959	April 1960	July 1960	Range	Mean
Nitrate and Nitrite Nitrogen	--	0.080	0.220	0.140	0.090	0.080	0.070[a]	0.340	0.080	0.07[a]-0.34	0.140
Ammonia Nitrogen	0.070	--	--	--	--	--	--	--	--	0.07	0.070
Organic Nitrogen	--	0.380	0.320	0.390	0.530	0.690	0.790	0.550	0.240	0.24-0.79	0.400
Phosphate Phosphorus	0.003	0.003	0.003	0.003	0.003	0.095	0.020	0.010	0.059	0.003-0.095	0.022
Total Phosphorus	0.160	0.042	0.026	0.020	0.033	0.127	0.026	0.052	0.124	0.020-0.160	0.068

[a]*Nitrate Nitrogen only.*

Source: Wisconsin Deportment of Natural Resources.

Survey during the period from 1984 through 2002.[2] Water quality samples generally were taken five times per year, during winter, usually during February, and summer, between April and September, from the main basin of the Lake. The primary sampling station used for the various sampling studies was located at the deepest portion of Okauchee Lake, as shown on Map 2, with supplemental stations located in the major embayments including the bays locally known as Lower Okauchee and Upper Oconomowoc Lakes.

Thermal Stratification

Typical monthly temperature and dissolved oxygen profiles taken at the primary sampling station are shown in Figures 2 and 3. Water temperatures in Okauchee Lake ranged from a minimum of 32°F (0°C) during the winter to a maximum of 83°F (27°C) during the summer.

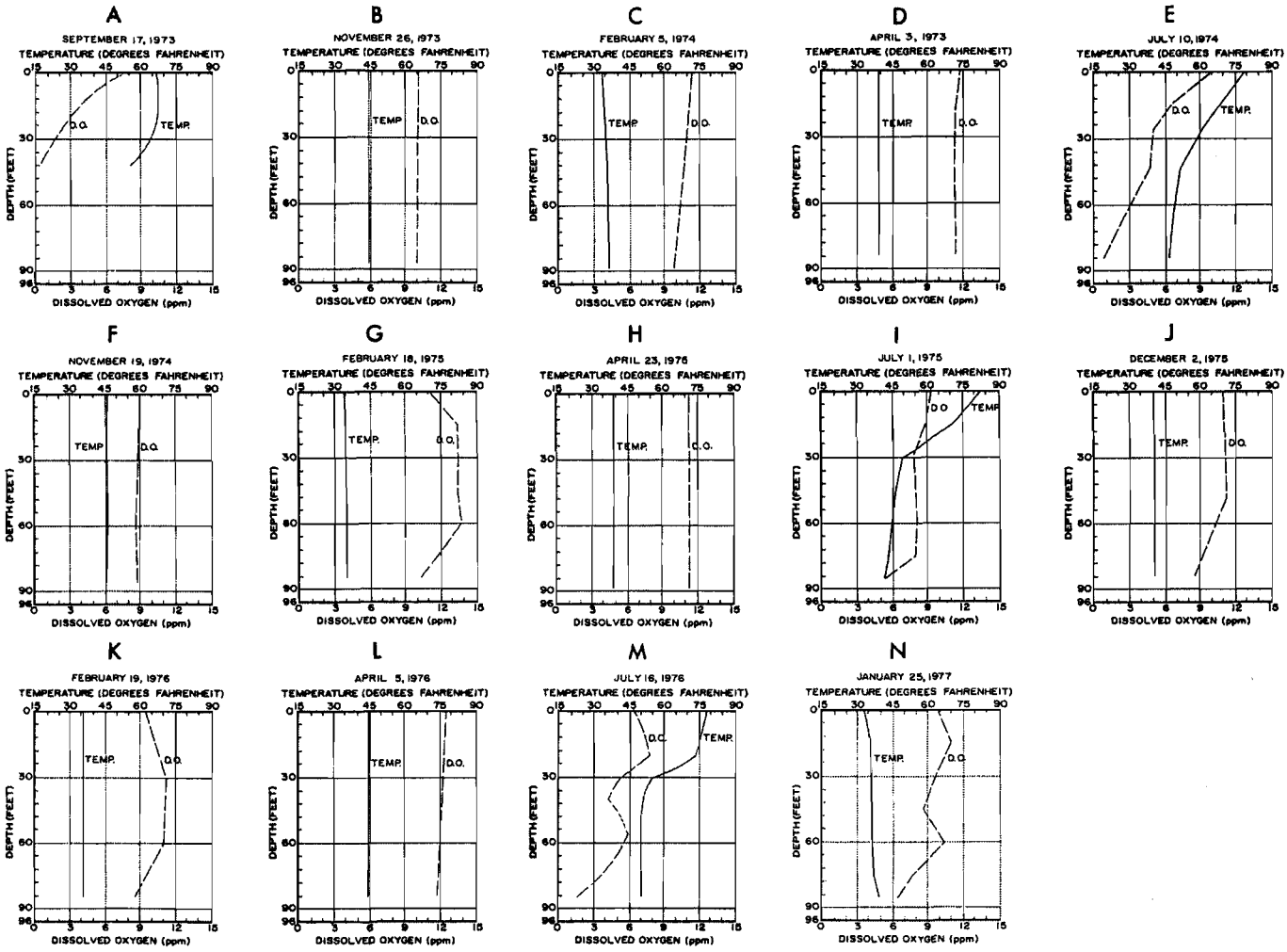
The Lake was dimictic, which means that it mixes completely two times per year, and is subject to thermal stratification during summer and winter. This process is illustrated diagrammatically in Figure 4. Thermal stratification is a result of the differential heating of the lake water, and the resulting 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°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. The annual thermal cycle within Okauchee 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 4. This "barrier" is marked by a sharp temperature gradient known as the thermocline and is characterized by a 1°C drop in temperature per one meter (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 5. 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.

[2]*These data are compiled and reported annually by the U.S. Geological Survey: during the period through 1993, the data were published in the U.S. Geological Survey Water-Data Report series,* Water Resources Data, Wisconsin, *and, subsequent to 1993, in the U.S. Geological Survey Open-File Report series,* Water-Quality and Lake-Stage Data for Wisconsin Lakes.

Figure 2

TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR OKAUCHEE LAKE: 1973-1977



Source: Wisconsin Department of Natural Resources and SEWRPC.

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 4. This action, which follows summer stratification, is known as "fall turnover."

When the water temperature drops to the point of maximum water density, 39.2°F, the waters at the lake surface become denser than the now warmer, less dense bottom waters, and "sink" to the bottom. Eventually, the water column is cooled to the point where the surface waters, cooled to about 32°F, are now lighter than the bottom waters which remain at about 39°F. The lake surface may then become ice covered, isolating the lake water from the atmosphere for a period of up to four months. On Okauchee Lake, ice cover typically exists from December until early April. As shown in Figure 4, winter stratification occurred as the colder, lighter water and ice remained at the surface, separated from the relatively warmer, heavier water near the bottom of the lake.

Figure 3

DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR OKAUCHEE LAKE: 1984-2002

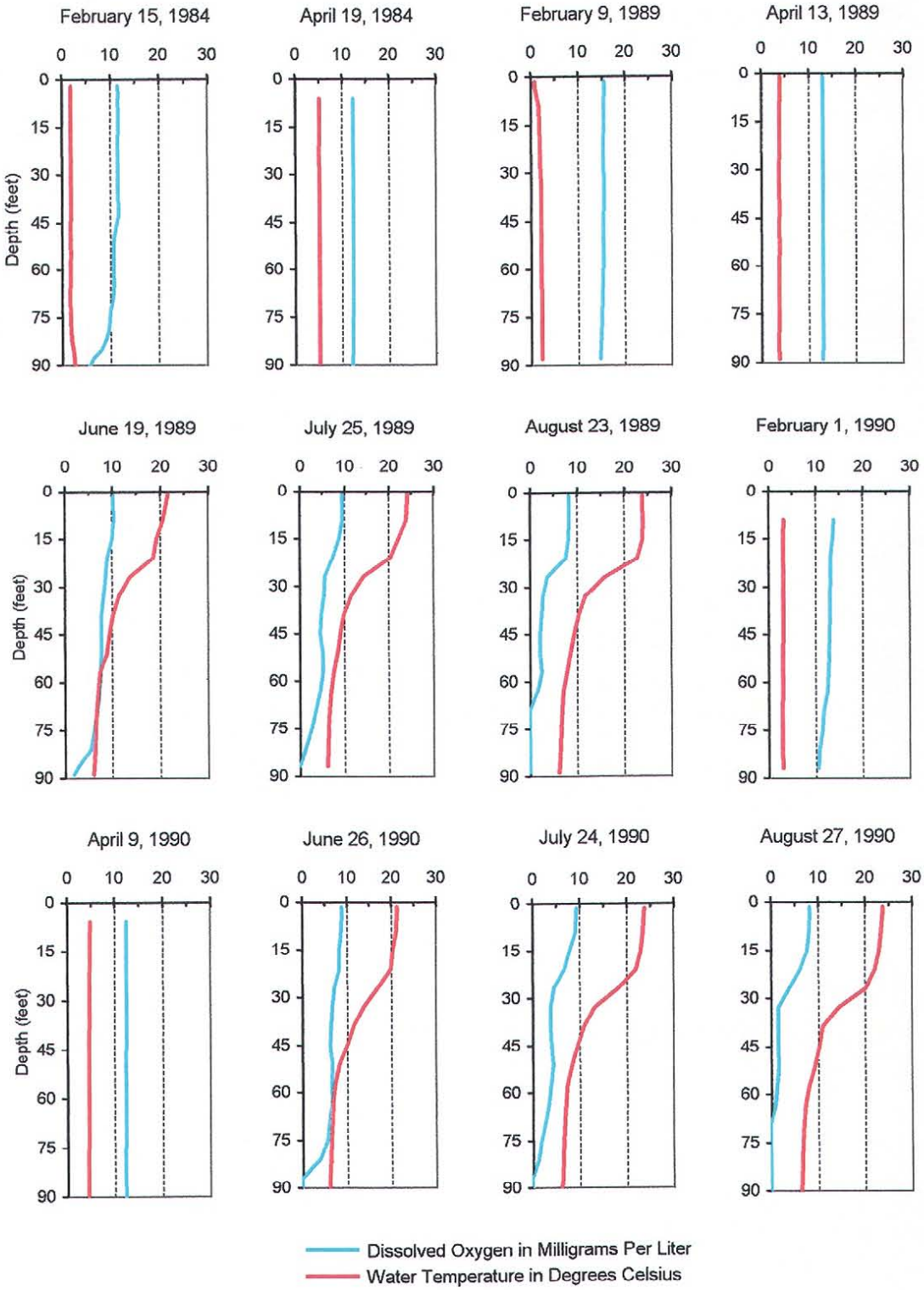


Figure 3 (continued)

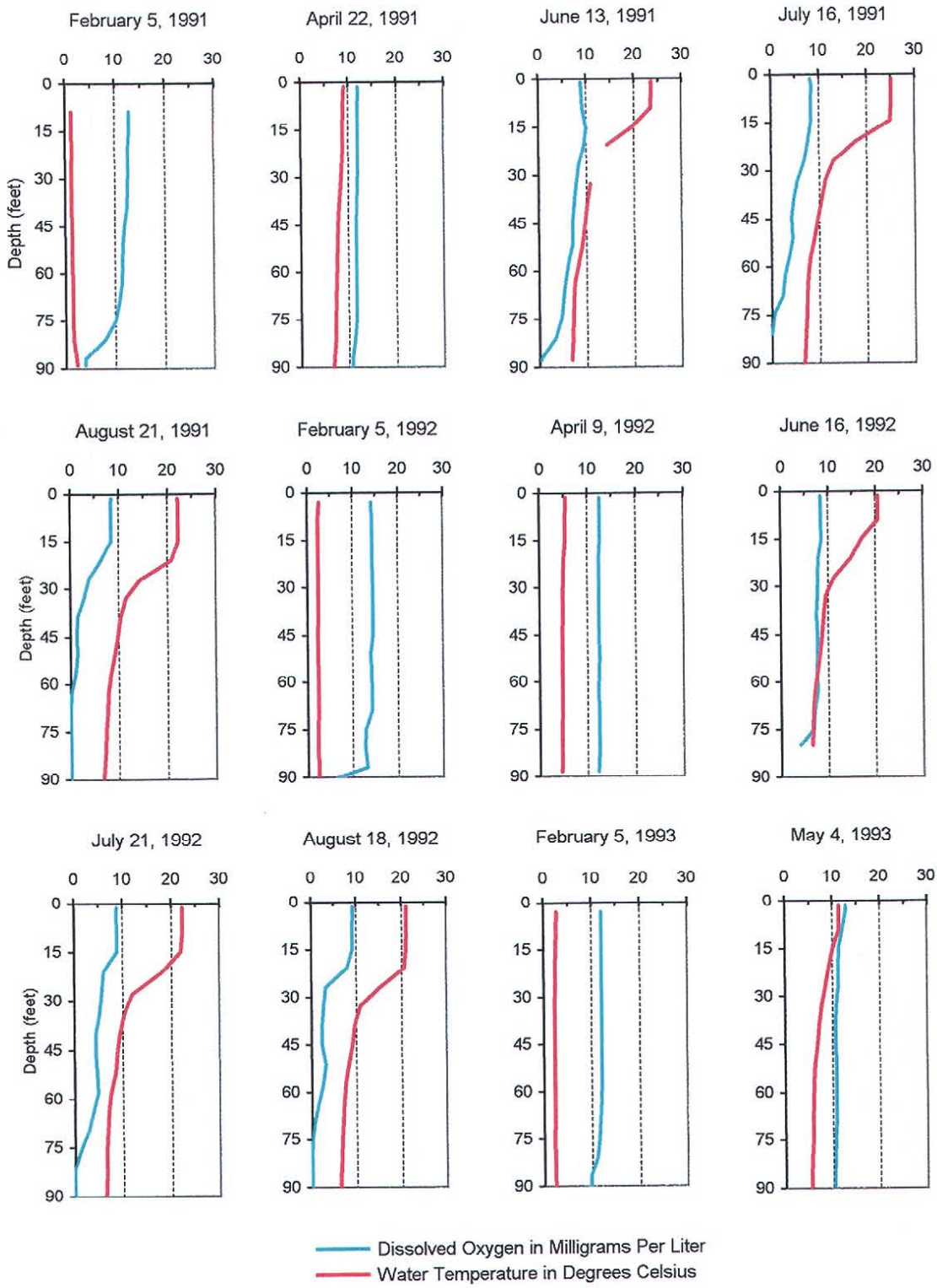


Figure 3 (continued)

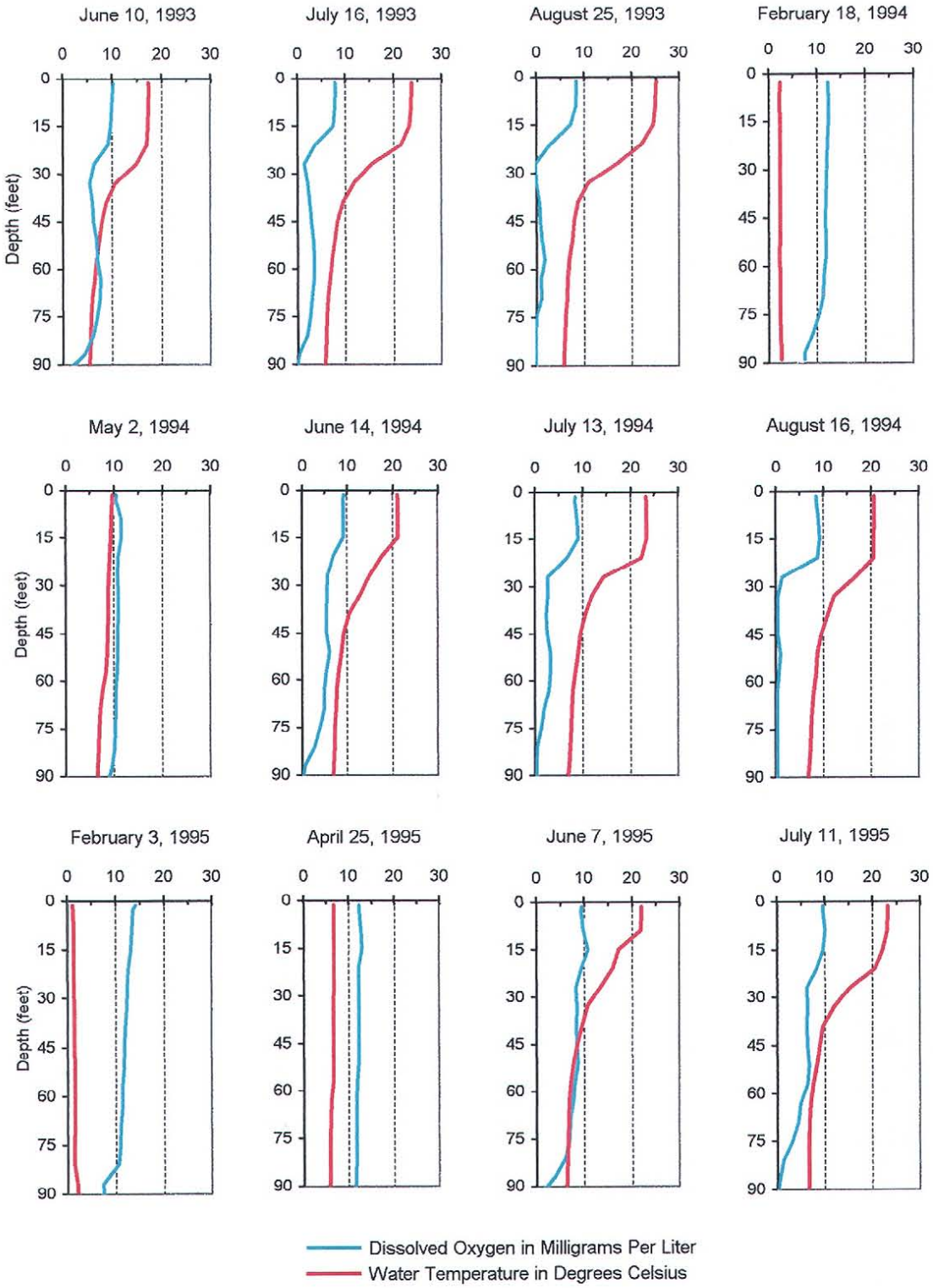


Figure 3 (continued)

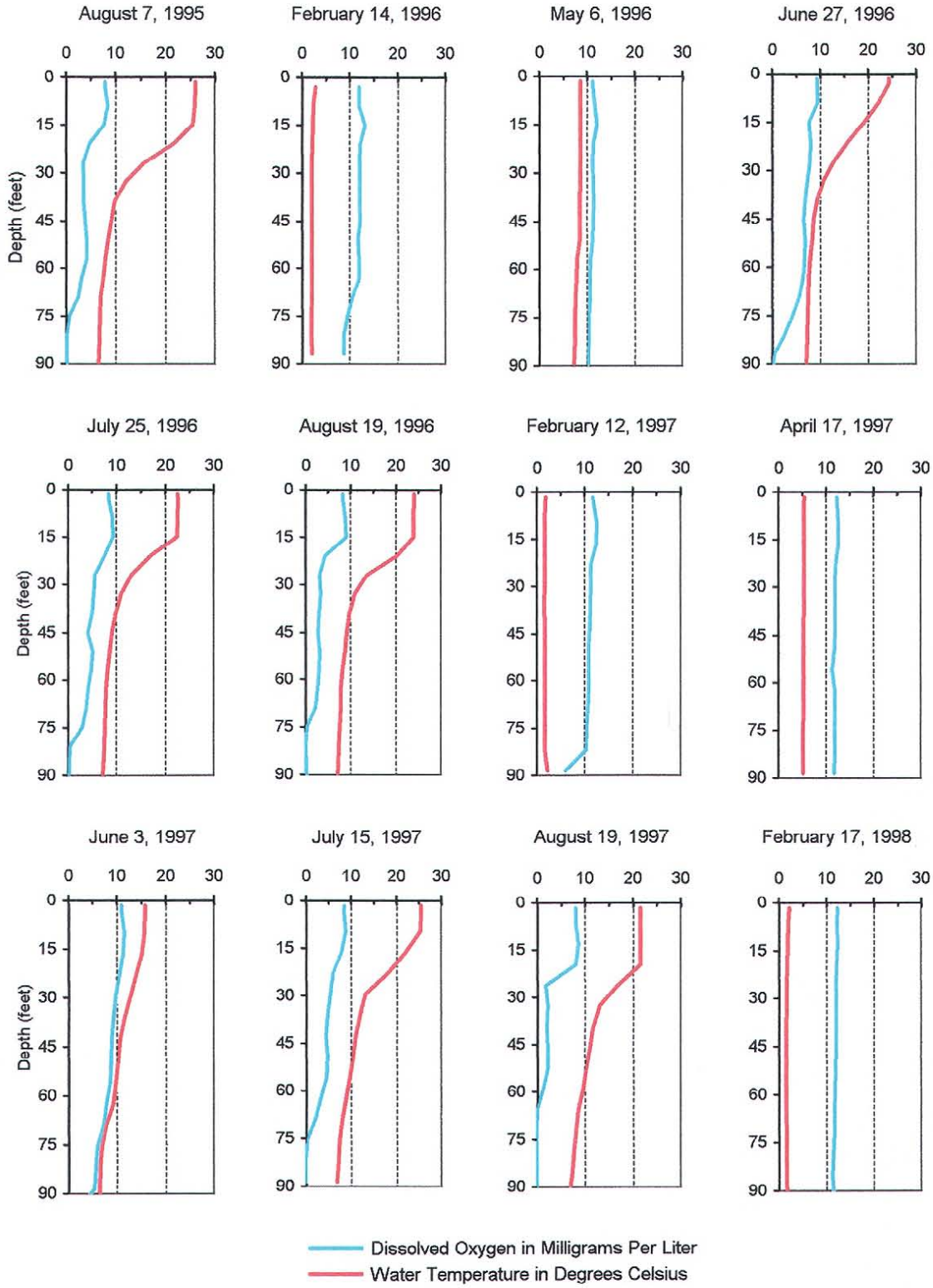


Figure 3 (continued)

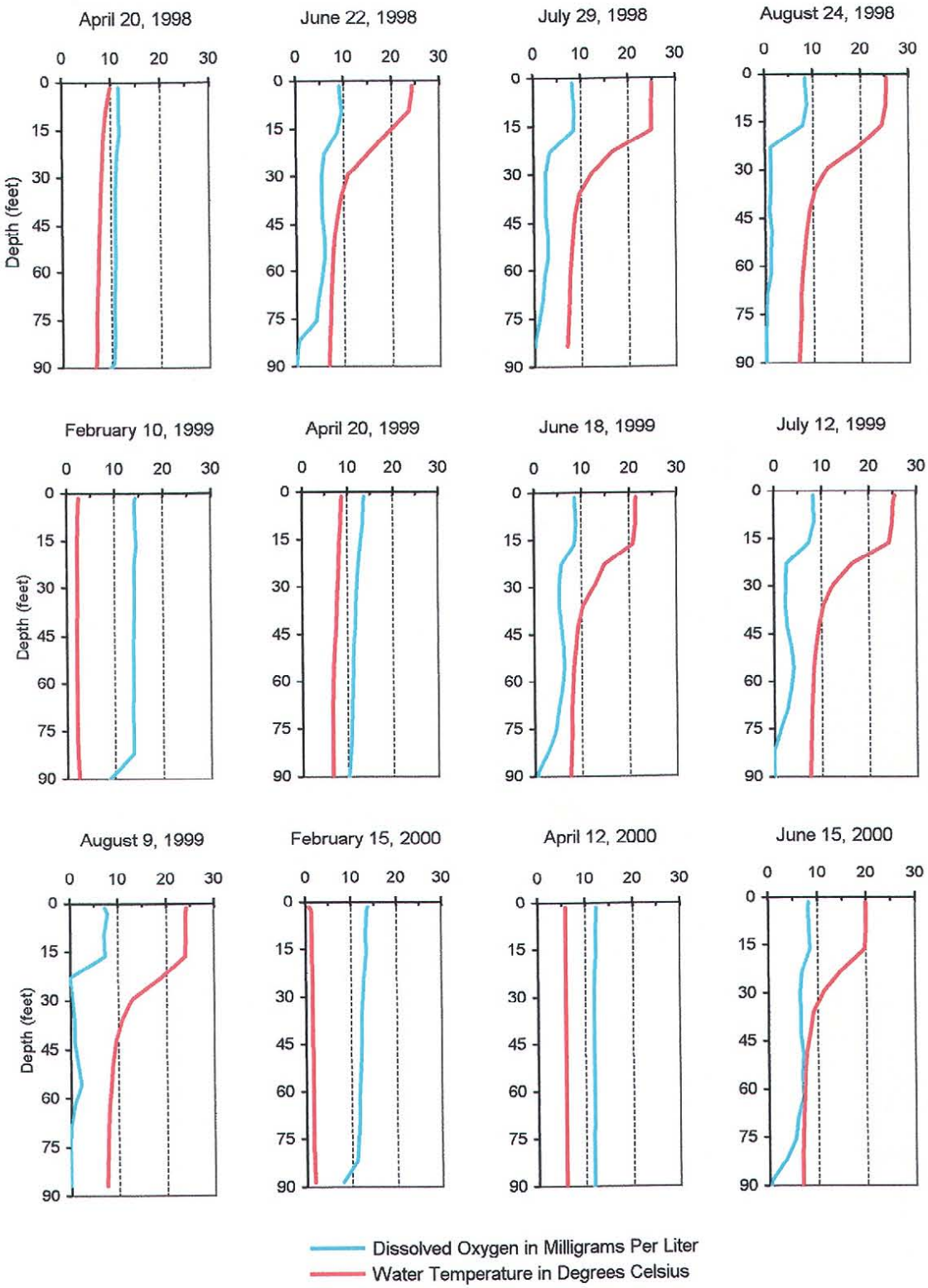
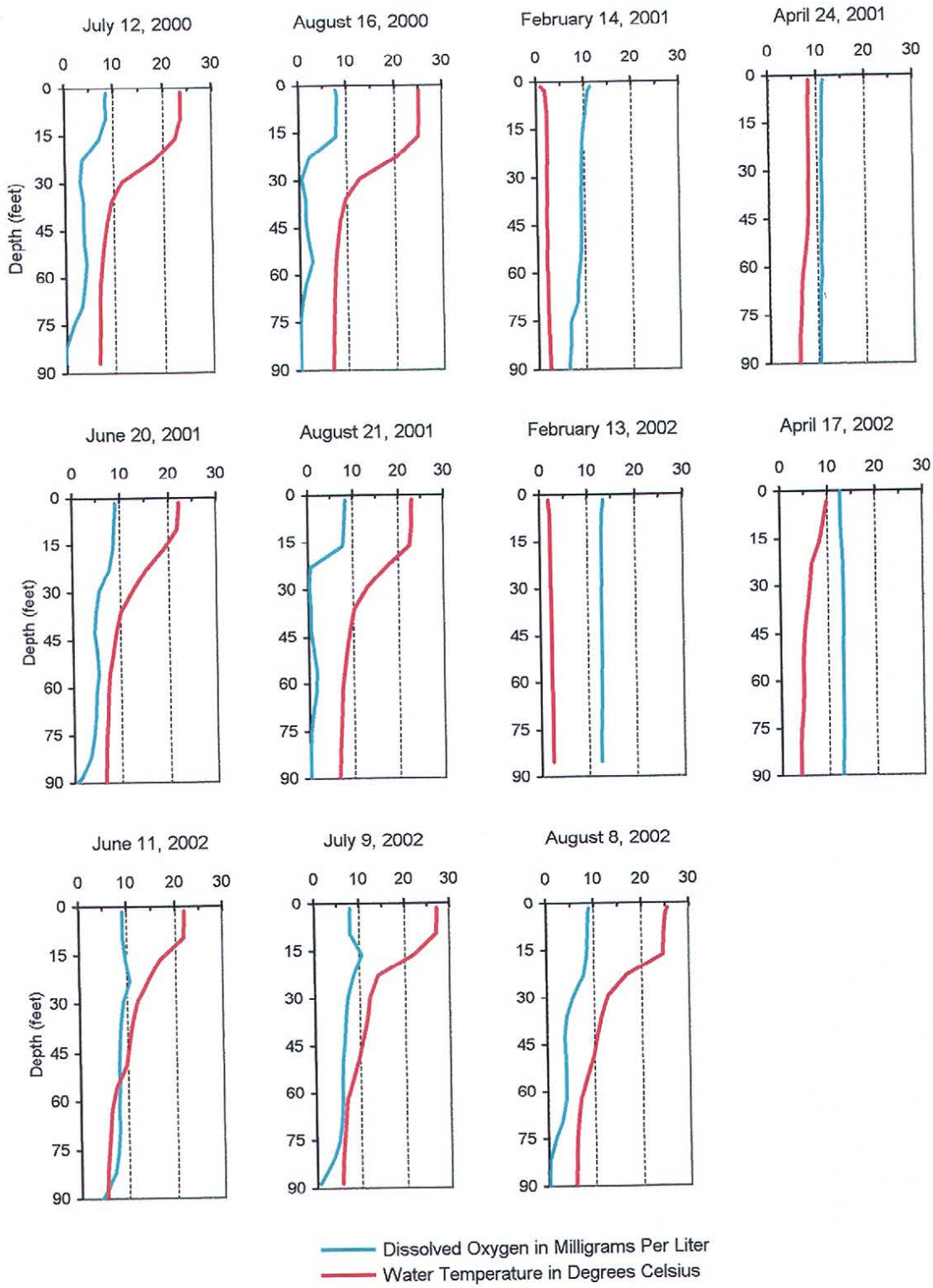


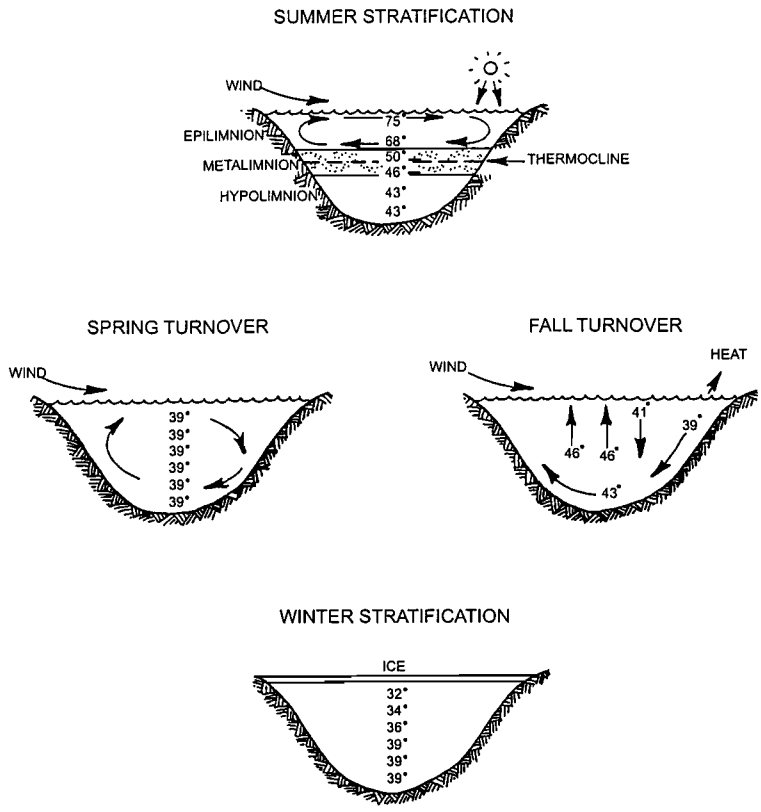
Figure 3 (continued)



Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 4

THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

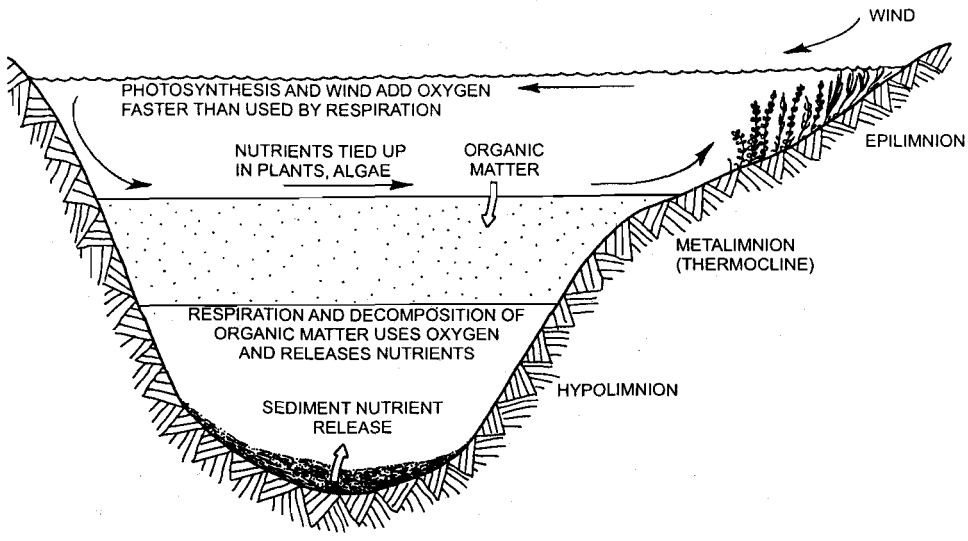
Spring brings a reversal of the process. As the ice thaws and the upper layer of water warms, it becomes denser and begins to approach the temperature of the warmer, deeper water until the entire water column reaches the same temperature from surface to bottom. This is referred to as "spring turnover" and usually occurs within weeks after the ice goes out, as shown in Figure 4. After spring turnover, the water at the surface again warms and becomes lighter, 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.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. As shown in Figures 2 and 3, dissolved oxygen levels were generally higher at the surface of Okauchee 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, thereby removing it from the water. 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 5.

Figure 5

LAKE PROCESSING DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

Dissolved oxygen concentrations in the surface waters of Okauchee Lake ranged from about 7.1 milligrams per liter (mg/l) during summer to about 15.8 mg/l during winter. Hypolimnetic dissolved oxygen concentrations dropped to zero during late summer. This pattern continues to be observed, with the hypolimnion of Okauchee Lake becoming anoxic during summer stratification. Dissolved oxygen concentrations at the bottom of the Lake fall to zero by mid- to late-June, as shown in Figure 4. During many of the years for which data are available, dissolved oxygen concentrations exhibited a bimodal distribution with depth, in which dissolved oxygen concentrations dropped below the recommended concentration of five mg/l, the minimum level necessary to support many species of fish, at about 20 feet in depth, but increased somewhat below that depth, dropping to near zero at depths of between 70 and 80 feet, as shown in Figure 3. This phenomenon is most clearly shown in the dissolved oxygen concentration profiles for the month of August during 1994 and 1995.

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 some lakes in the Region, hypolimnetic anoxia can occur during winter stratification. Under these conditions, anoxia can contribute to the winter-kill of fish. Although dissolved oxygen levels in the hypolimnion of Okauchee Lake were found to be below the five mg/l level during winter, a relatively large volume of the Lake retained adequate dissolved oxygen concentrations to sustain fish populations throughout the winter. 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 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.

Dissolved oxygen profiles were first measured in Okauchee Lake by Birge and Juday during the late summers of 1905 through 1909.[3] These profiles, shown in Figure 6, indicate that dissolved oxygen depletion in the hypolimnion of the Lake during the summer months has been common since the early 1900s. In fact, during 1909, a serious fish-kill affecting cisco, a coldwater fish species, was reported during the summer. This die-off was most likely caused by high temperatures and low dissolved oxygen levels in the hypolimnion. Consequently, there appears to have been little change in the dissolved oxygen levels and characteristics of Okauchee Lake over the 70-year period of record.

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 Okauchee Lake is discussed further below.

Specific Conductance

Specific conductance is an indicator of the concentration of dissolved solids in the water; as the amount of dissolved solids increases, the specific conductance increases. 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. During the initial planning study, conductivity ranged from 365 to 519 microSiemens per centimeter (μS/cm) at 25°C, as shown in Table 11. As shown in Table 12, the specific conductance of Okauchee Lake during 1984 through 2002 ranged from 400 to 740 μS/cm. During the latter period, significant surface to bottom conductivity gradients were observed, especially during the summer period when specific conductance increased with depth from between 400 and 554 μS/cm at the surface to between 408 and 602 μS/cm at depth, as shown on Figure 7. These ranges are within the normal range for lakes in Southeastern Wisconsin.

Chloride

During the initial planning study, chloride concentrations ranged from 11 to 24 milligrams per liter (mg/l), with an average of 15 mg/l, as shown in Table 11. These concentrations have continued to increase, with chloride concentrations in Okauchee Lake during the 1984 through 2002 study ranging from 18 to 34 mg/l, as shown in Table 12. The maximum values observed in Okauchee Lake during this period increased from about 19 mg/l in 1984 to about 34 mg/l in 2002. The most important anthropogenic sources of chlorides to Okauchee Lake are believed to be the mass of salt used on streets and highways for winter snow and ice control, and the mass of salt used in residential water softeners. These values are somewhat lower than the concentrations found in many other lakes in southeastern Wisconsin, although there is an increasing trend in chloride concentrations observed throughout the Southeastern Wisconsin Region, as shown in Figure 8.

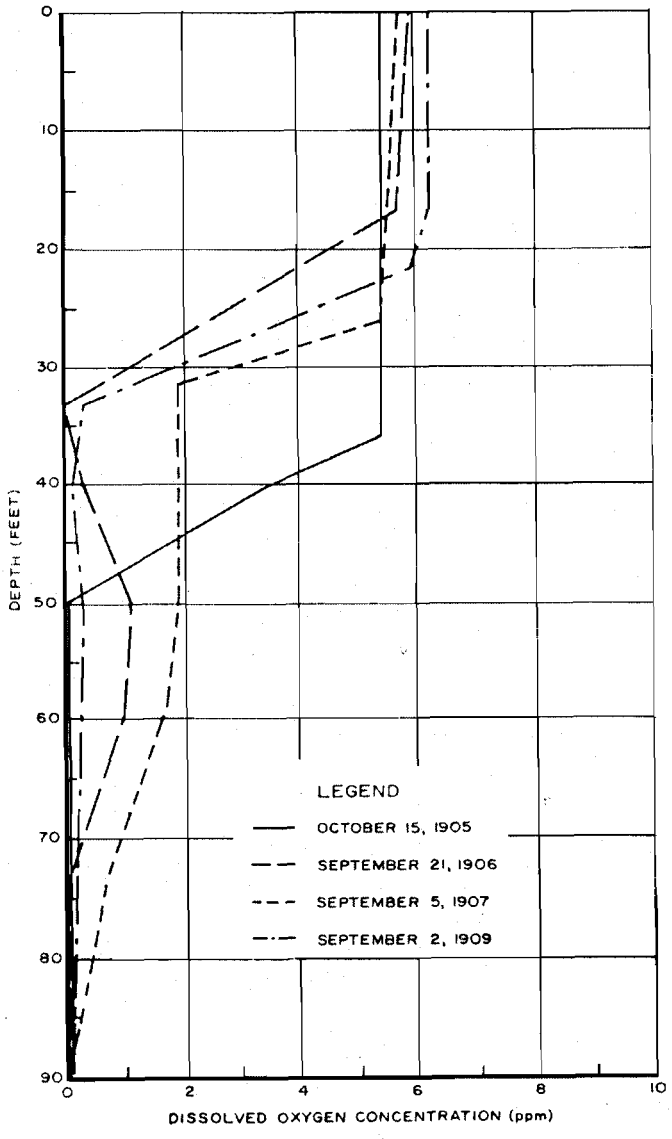
Alkalinity and Hardness

Alkalinity is an index of the buffering capacity of a lake, or the capacity of a lake to absorb and neutralize acids. The alkalinity of a lake depends on the levels of bicarbonate, carbonate, and hydroxide ions present in the water. Lakes in Southeastern Wisconsin typically have a high alkalinity because of the types of soils and underlying bedrock in the Region's watersheds. In contrast, water hardness is a measure of the multivalent metallic ion concentrations, such as those of calcium and magnesium, present in a lake. Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$). Applying these measures to the study lake, Okauchee

[3] *E.A. Birge and C. Juday,* op. cit.

Figure 6

HISTORICAL LATE SUMMER DISSOLVED OXYGEN PROFILES FOR OKAUCHEE LAKE: 1905-1909



Source: E.A. Birge and C. Juday, 1911, and SEWRPC.

Lake may be classified as a hard-water alkaline lake. During the initial study period, alkalinity averaged about 212 mg/l, as shown in Table 11. During the current study period, alkalinity ranged from 201 to 244 mg/l, with an average of about 230 mg/l, as shown in Table 12. Hardness ranged from 260 to 280 mg/l during this same period, with an average of about 270 mg/l, as shown in Table 12. These values were within the normal range of 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. In Okauchee, the pH was found to range between 7.7 and 8.4 standard units during the initial study period, and between 7.3 and about 9.0 standard units during the current study period, as shown in Figure 7. Since Okauchee 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.

Table 11

WATER QUALITY CONDITIONS OF OKAUCHEE LAKE: 1973-1978

Water Quality[a]	September 17, 1973	November 26, 1973	November 6, 1973[b]	February 5, 1974	April 3, 1974	April 5, 1974[b]	July 10, 1974	November 19, 1974	February 18, 1974	April 23, 1975	July 1, 1975
Nitrite and Nitrate Nitrogen	0.15	0.23	0.53	0.53	0.56	1.05	0.53	0.31	0.40	0.60	0.45
Ammonia Nitrogen	0.22	0.14	0.27	<0.01	0.08	0.03	0.15	0.17	0.06	0.03	<0.03
Organic Nitrogen	0.53	0.46	0.53	0.18	1.02	0.68	0.86	0.87	0.50	0.57	0.40
Total Nitrogen	0.89	0.82	1.33	0.70	1.65	1.76	1.54	1.34	0.95	1.20	0.83
Phosphate Phosphorus	0.030	0.040	0.020	0.060	0.030	0.005	0.040	0.070	0.020	0.040	0.010
Total Phosphorus	0.06	0.06	0.03	0.06	0.05	0.01	0.06	0.07	0.04	0.05	0.02
Chlorophyll-*a* (µg/l)	--	--	--	--	--	--	--	--	--	--	--
Calcium	--	48.5	53.0	41.1	86.3	--	46.7	95.5	49.3	47.0	41.0
Magnesium	41.6	30.3	31.0	26.0	41.3	--	22.7	44.0	38.0	33.5	44.0
Sodium	11.6	6.3	7.6	7.7	9.0	12.0	6.7	8.5	3.7	6.0	6.7
Potassium	2.1	2.0	2.1	0.8	1.9	3.8	1.3	0.95	1.7	3.4	5.0
Iron	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--
Specific Conductance (micromhos/cm)	445	479	494	487	493	500	468	497	518	482	448
Sulfate	33.0	35.0	34.0	39.3	37.0	44.0	37.7	36.5	40.7	41.0	36.7
Chloride	12.7	12.7	14.0	12.7	13.0	12.0	15.3	12.5	14.0	12.0	13.7
pH (standard units)	8.0	8.2	8.1	8.1	8.1	8.1	8.4	8.3	8.2	8.3	8.3
Alkalinity	200.3	218.0	254.0	218.7	221.3	212.0	210.7	215.0	221.8	212.5	203.3
Turbidity (Formazin Units)	2.2	1.2	1.7	1.5	0.7	3.2	1.3	1.4	1.4	2.2	1.6

Table 11 (continued)

Water Quality[a]	December 2, 1975	February 19, 1976	April 5, 1976	July 16, 1976	November 9, 1976	January 25, 1977	April 15, 1977[b]	August 1, 1977[b]	November 2, 1977[b]	April 14, 1978[b]	Mean
Nitrite and Nitrate Nitrogen	0.27	0.72	0.51	0.16	0.23	0.16	0.20	0.17	0.11	0.35	0.39
Ammonia Nitrogen	0.11	<0.03	0.09	0.10	0.08	0.15	0.17	0.01	0.05	<0.03	0.10
Organic Nitrogen	0.64	0.42	0.44	0.91	1.35	0.86	0.53	0.23	1.25	0.50	0.65
Total Nitrogen	1.01	1.13	1.04	1.17	1.64	1.17	0.90	0.40	1.41	0.88	1.13
Phosphate Phosphorus	0.010	--	0.010	0.020	0.030	0.030	--	0.010	0.008	0.007	0.026
Total Phosphorus	0.03	--	0.03	0.03	0.04	0.10	0.01	0.02	0.04	0.02	0.04
Chlorophyll-*a* (µg/l)	--	--	--	--	3.4	--	--	--	--	--	3.9
Calcium	41.5	45.3	56.0	44.3	47.5	40.7	48.0	--	48.0	50.0	49.5
Magnesium	40.0	33.7	33.5	34.3	42.5	39.7	35.0	--	41.0	37.0	36.3
Sodium	5.0	9.0	10.0	4.7	6.0	6.0	5.0	--	5.0	31.0	8.4
Potassium	1.2	5.1	1.8	2.4	1.4	1.2	1.9	--	2.4	2.0	2.2
Iron	0.09	<0.09	0.10	0.11	0.50	0.34	--	--	--	0.80	0.29
Manganese	<0.03	0.03	<0.03	0.09	0.16	0.15	--	--	--	<0.30	0.11
Specific Conductance (micromhos/cm)	448	480	481	478	461	479	519	365	433	418	470
Sulfate	35.5	35.3	28.0	13.7	--	--	--	--	--	--	35.1
Chloride	11.5	23.7	12.0	11.3	13.5	16.0	15.0	24.0	16.0	19.0	14.6
pH (standard units)	8.2	8.2	8.2	8.1	7.9	8.2	7.7	7.8	8.3	8.0	--
Alkalinity	208.0	204.0	210.0	200.0	200.0	229.3	206.0	204.0	192.0	208.0	211.7
Turbidity (Formazin Units)	0.95	1.9	1.4	1.3	2.4	7.4	1.0	--	1.3	1.3	2.4

[a] *All values reported in milligrams per liter unless otherwise specified.*

[b] *Values for these dates are from samples taken at the water surface. All other values are the average from samples taken at two or more depths.*

Source: Wisconsin Department of Natural Resources.

Table 12

SEASONAL WATER QUALITY CONDITIONS IN OKAUCHEE LAKE: 1984-2001

Parameter[a]	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]
Physical Properties						
Alkalinity, as $CaCO_3$						
Range	--	--	201-244	218-244	--	--
Mean	--	--	229	229	--	--
Standard Deviation	--	--	9	7	--	--
Number of Samples	--	--	18	14	--	--
Color						
Range	--	--	10-25	10-30	--	--
Mean	--	--	17	18	--	--
Standard Deviation	--	--	4	5	--	--
Number of Samples	--	--	18	13	--	--
Dissolved Oxygen						
Range	11.6-15.8	0.3-14.8	10.4-14.5	1.4-14.3	7.1-10.3	0.0-4.5
Mean	13.1	7.2	12.3	10.4	8.7	0.3
Standard Deviation	1.3	3.4	1.0	3.0	0.6	0.7
Number of Samples	18	18	20	20	52	50
Hardness, as $CaCO_3$						
Range	--	--	260-280	260-280	--	--
Mean	--	--	270	269	--	--
Standard Deviation	--	--	7	7	--	--
Number of Samples	--	--	18	14	--	--
pH (units)						
Range	7.6-9.0	7.6-8.4	7.8-8.8	7.6-8.5	8.0-8.8	7.3-8.0
Mean	8.2	7.9	8.3	8.2	8.3	7.5
Standard Deviation	0.4	0.3	0.2	0.2	0.2	0.2
Number of Samples	18	18	20	20	52	50
Secchi Depth (feet)						
Range	14.1-17.0	--	5.5-15.4	--	2.6-12.8	--
Mean	15.5	--	10.1	--	6.7	--
Standard Deviation	2.0	--	2.7	--	2.0	--
Number of Samples	2	--	20	--	49	--
Specific Conductance (µS/cm)						
Range	482-740	510-615	464-568	505-584	400-544	408-602
Mean	540	564	530	536	501	547
Standard Deviation	53	27	27	27	28	30
Number of Samples	18	18	20	20	52	50
Temperature (°C)						
Range	1.0-3.5	1.9-3.1	4.0-17.5	4.0-8.0	20.0-27.0	4.8-8.0
Mean	2.1	2.5	8.4	5.9	23.6	6.7
Standard Deviation	0.7	0.3	3.5	1.1	1.8	0.7
Number of Samples	18	18	20	20	52	50
Total Dissolved Solids, at 180°C						
Range	--	--	286-352	286-348	--	--
Mean	--	--	316	313	--	--
Standard Deviation	--	--	16	15	--	--
Number of Samples	--	--	18	14	--	--
Turbidity (NTU)						
Range	--	--	0.6-2.7	0.5-1.8	--	--
Mean	--	--	1.0	0.9	--	--
Standard Deviation	--	--	0.5	0.3	--	--
Number of Samples	--	--	18	13	--	--
Metals/Salts						
Dissolved Arsenic						
Range	--	--	--	--	--	7
Mean	--	--	--	--	--	7
Standard Deviation	--	--	--	--	--	--
Number of Samples	--	--	--	--	--	1

Table 12 (continued)

Parameter[a]	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]
Metals/Salts (continued)						
Dissolved Calcium						
Range	--	--	48-59	49-58	--	--
Mean	--	--	53	53	--	--
Standard Deviation	--	--	3	3	--	--
Number of Samples	--	--	18	14	--	--
Dissolved Chloride						
Range	--	--	18.0-33.7	19-29	--	--
Mean	--	--	25.2	23	--	--
Standard Deviation	--	--	5.0	3	--	--
Number of Samples	--	--	18	14	--	--
Dissolved Fluoride						
Range	--	--	0.06-0.10	0.05-0.10	--	--
Mean	--	--	0.09	0.09	--	--
Standard Deviation	--	--	0.01	0.02	--	--
Number of Samples	--	--	9	9	--	--
Dissolved Iron (µg/l)						
Range	--	--	5-100	7-100	--	--
Mean	--	--	28	32	--	--
Standard Deviation	--	--	26	28	--	--
Number of Samples	--	--	18	14	--	--
Dissolved Magnesium						
Range	--	--	31-35	32-35	--	--
Mean	--	--	33	33	--	--
Standard Deviation	--	--	1	1	--	--
Number of Samples	--	--	18	14	--	--
Dissolved Manganese (µg/l)						
Range	--	--	0.4-40.0	0.4-40.0	--	--
Mean	--	--	15.9	21.9	--	--
Standard Deviation	--	--	19.7	20.3	--	--
Number of Samples	--	--	18	13	--	--
Dissolved Potassium						
Range	--	--	1.8-2.4	1.7-2.3	--	--
Mean	--	--	2.0	2.0	--	--
Standard Deviation	--	--	0.2	0.2	--	--
Number of Samples	--	--	17	13	--	--
Dissolved Silica						
Range	--	--	0.4-6.1	0.9-6.1	--	--
Mean	--	--	3.0	3.5	--	--
Standard Deviation	--	--	1.4	1.6	--	--
Number of Samples	--	--	18	14	--	--
Dissolved Sodium						
Range	--	--	7.8-14.0	7.7-12.0	--	--
Mean	--	--	10,6	9.9	--	--
Standard Deviation	--	--	1.9	1.4	--	--
Number of Samples	--	--	18	14	--	--
Dissolved Sulfate SO_4						
Range	--	--	--	23-36	--	--
Mean	--	--	--	28	--	--
Standard Deviation	--	--	--	4	--	--
Number of Samples	--	--	--	14	--	--
Nutrients						
Dissolved Nitrogen, Ammonia						
Range	0.550	--	--	0.010-0.700	0.023	--
Mean	0.550	--	--	0.123	0.023	--
Standard Deviation	--	--	--	0.208	--	--
Number of Samples	1	--	--	14	1	--
Dissolved Nitrogen, NO_2+NO_3						
Range	0.550	--	--	0.010-0.600	0.051	--
Mean	0.550	--	--	0.370	0.051	--
Standard Deviation	--	--	--	0.162	--	--
Number of Samples	1	--	--	14	1	--

Table 12 (continued)

Parameter[a]	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]
Nutrients (continued)						
Total Nitrogen, Organic						
Range	--	--	--	0.050-0.670	--	--
Mean	--	--	--	0.502	--	--
Standard Deviation	--	--	--	0.152	--	--
Number of Samples	--	--	--	13	--	--
Dissolved Orthophosphorus						
Range	0.010	0.094	0.002-0.126	0.001-0.010	0.003	0.002-0.126
Mean	0.010	0.094	0.036	0.003	0.003	0.036
Standard Deviation	--	--	0.041	0.003	--	0.041
Number of Samples	1	1	14	14	1	14
Total Phosphorus						
Range	0.007-0.020	0.010-0.101	0.006-0.167	0.008-0.145	0.005-0.234	0.006-0.167
Mean	0.012	0.035	0.060	0.025	0.016	0.060
Standard Deviation	0.005	0.036	0.042	0.030	0.031	0.042
Number of Samples	9	10	52	20	51	52
Biological						
Chlorophyll-*a* (µg/l)						
Range	4.0-11.4	--	2.3-27.0	--	0.1-9.3	--
Mean	7.5	--	8.3	--	4.3	--
Standard Deviation	3.7	--	6.0	--	2.1	--
Number of Samples	3	--	19	--	45	--

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

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

[c] *Depth of sample greater than 30 feet.*

Source: U.S. Geological Survey and SEWRPC.

Water Clarity

Water clarity, or transparency, provides an indication of overall water quality; clarity may decrease because of turbidity caused by high concentrations of organic and inorganic suspended materials, such as algae and zooplankton, and suspended sediment, and/or because of color caused by high concentrations of dissolved organic substances. Water clarity is measured with a Secchi-disc, a black-and-white, eight-inch-diameter disk, which is lowered into the water until a depth is reached at which the disk is no longer visible. This depth is known as the "Secchi-disc reading." Such measurements comprise an important part of the Wisconsin Department of Natural Resources Self-Help Monitoring Program in which citizen volunteers assist in lake water quality monitoring efforts.

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in weather conditions and nutrient loadings. Secchi-disc depth measurements for the period of 1973 to 1978 for Okauchee Lake ranged from a low of about 4.8 feet during July 1974 to a high of about 22.6 feet in February 1976, with an average of 9.5 feet. The lower readings were usually recorded during July and August, primarily because of excessive growth of free-floating algae. Also, because the embayments known as Lower Okauchee and Upper Oconomowoc Lakes are shallower and potentially subject to greater mixing, and generally have more easily disturbed, mucky bottom sediments than Okauchee Lake, the Secchi-disc measurements for these bays are considerably less than those for the main lake basin, ranging from about 4.0 feet in spring to about 8.0 feet in autumn. During the current study period, Secchi-disc readings for the main basin of Okauchee Lake ranged between 2.6 and 17.0 feet, with an average of about 7.8 feet. As shown in Figure 9, during recent years,

Figure 7

SPECIFIC CONDUCTANCE AND pH PROFILES FOR OKAUCHEE LAKE: 1984-2002

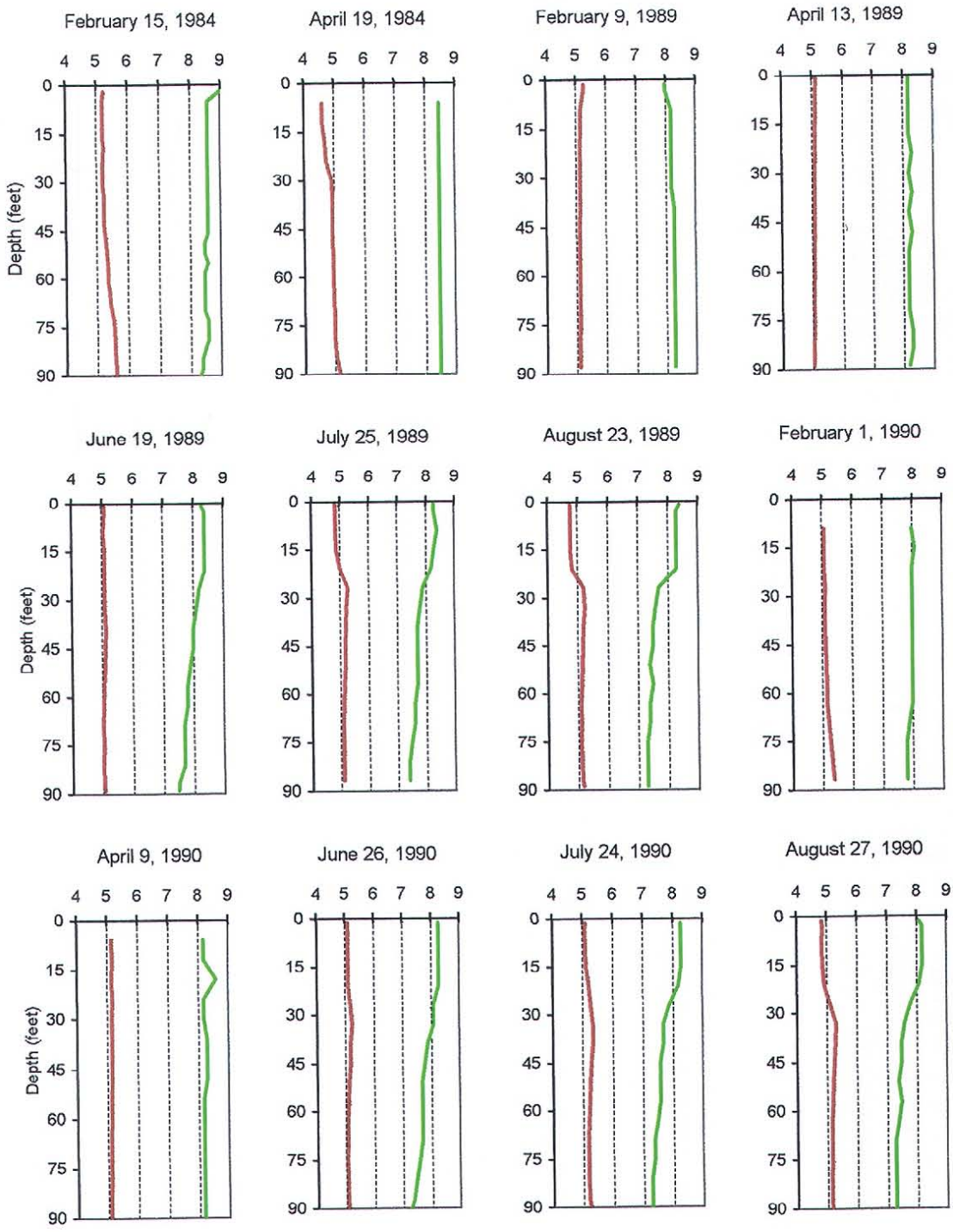


Figure 7 (continued)

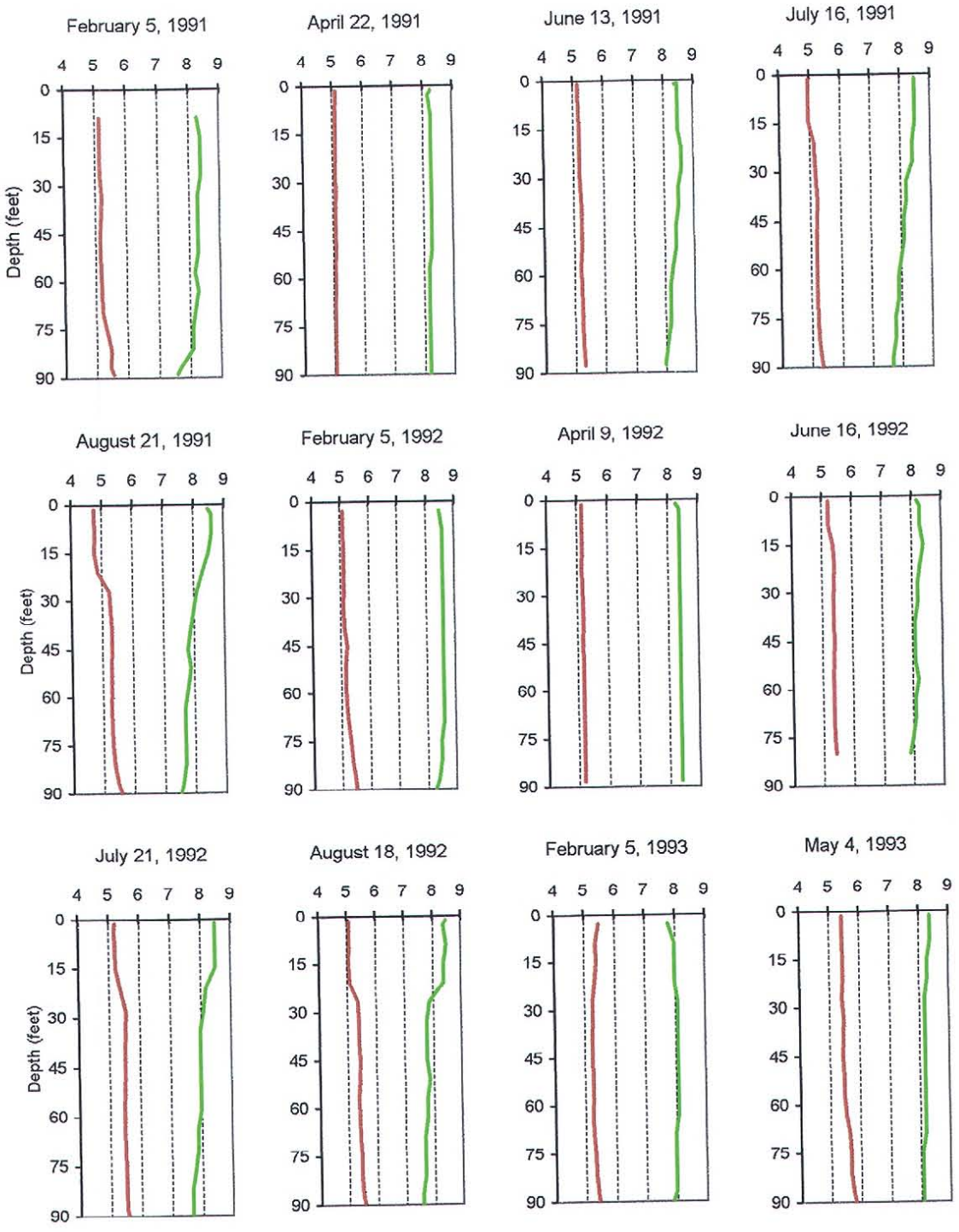


Figure 7 (continued)

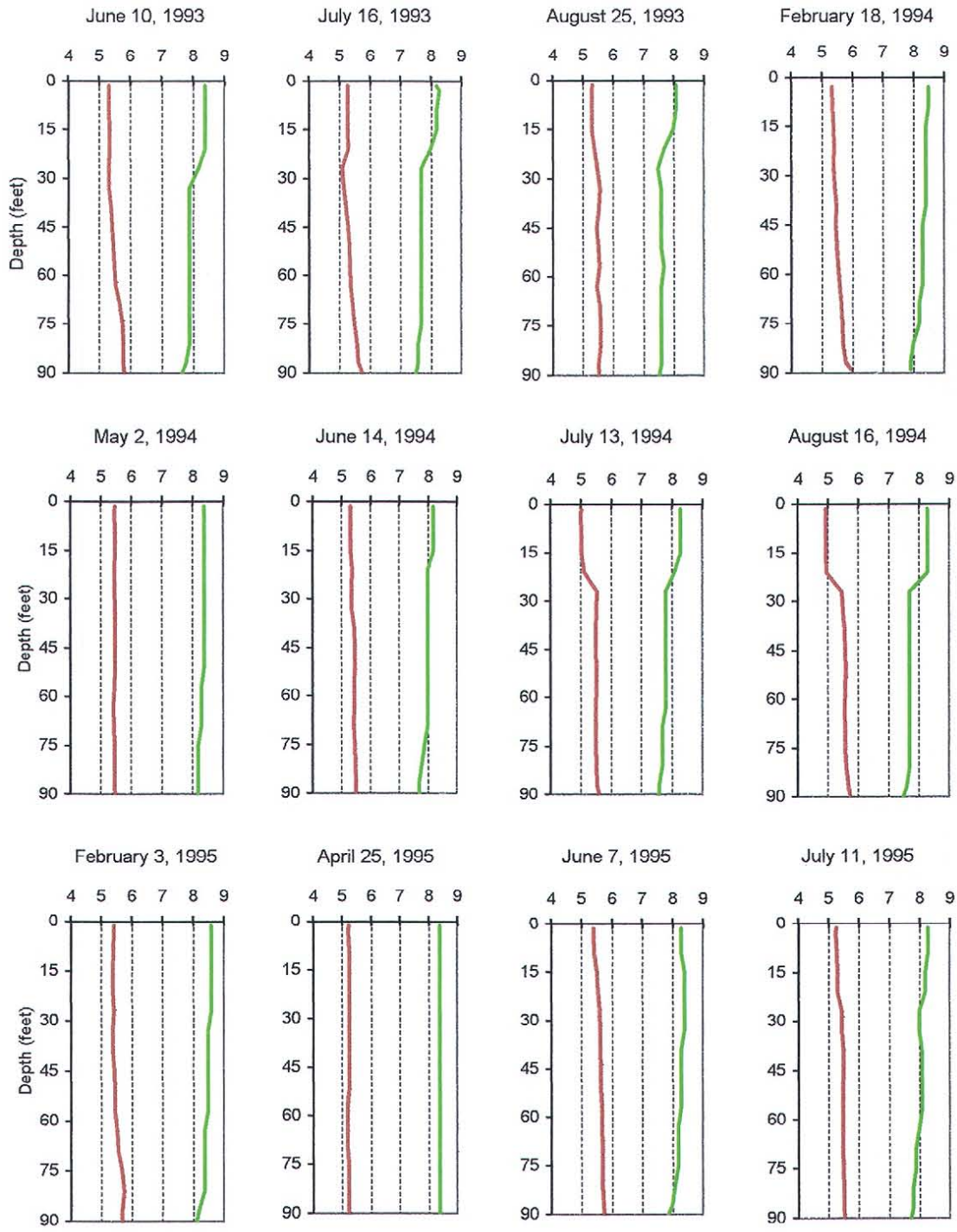


Figure 7 (continued)

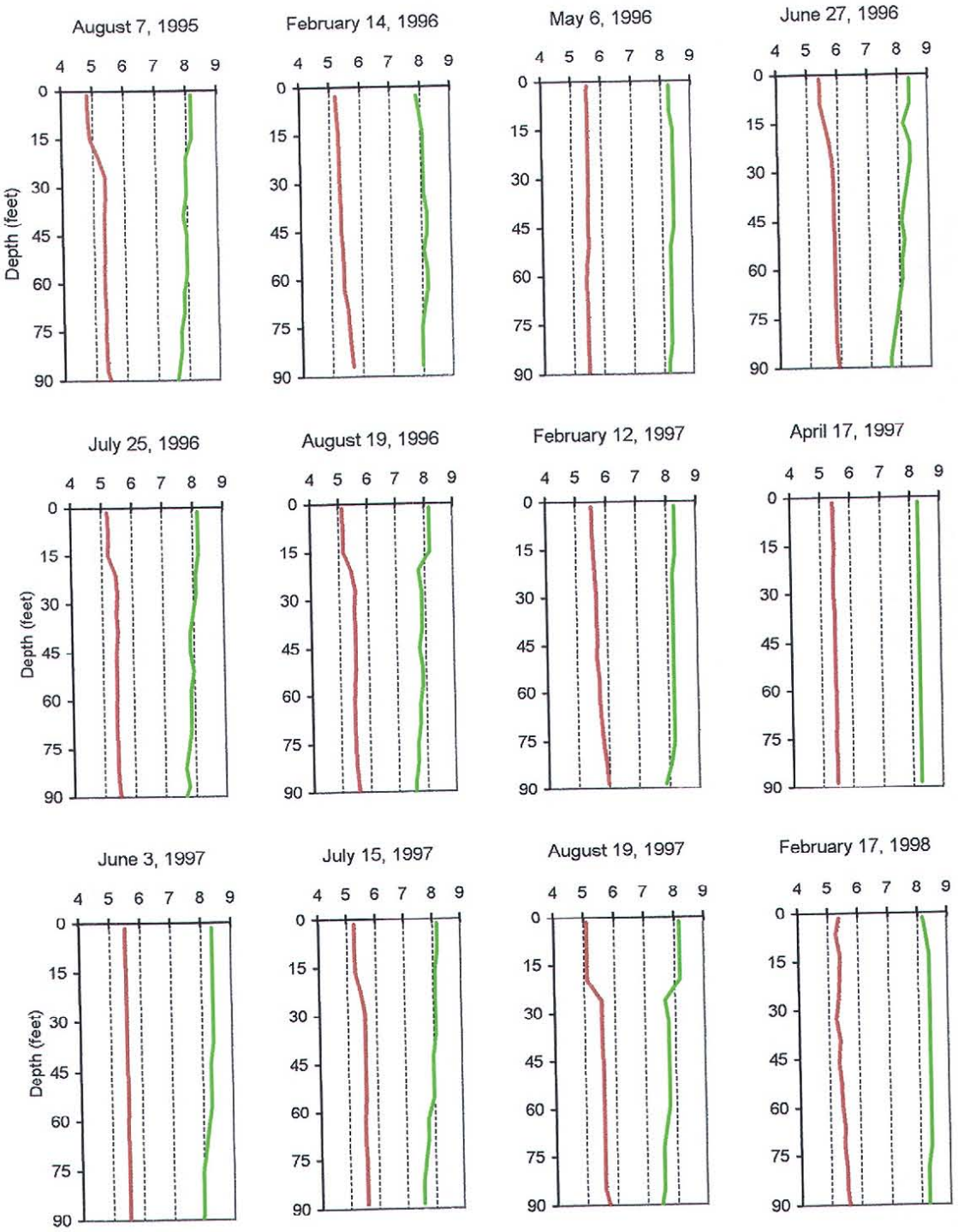


Figure 7 (continued)

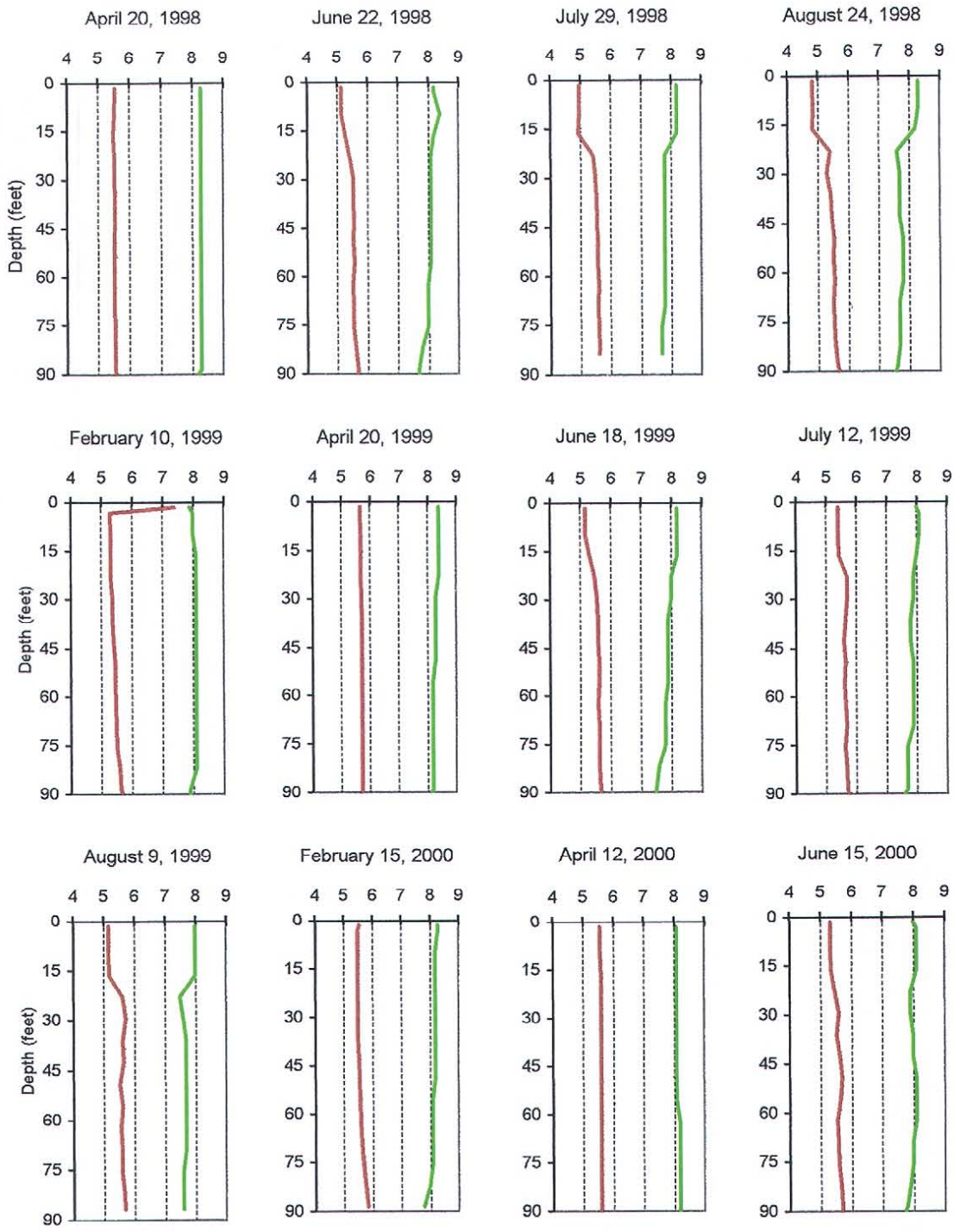
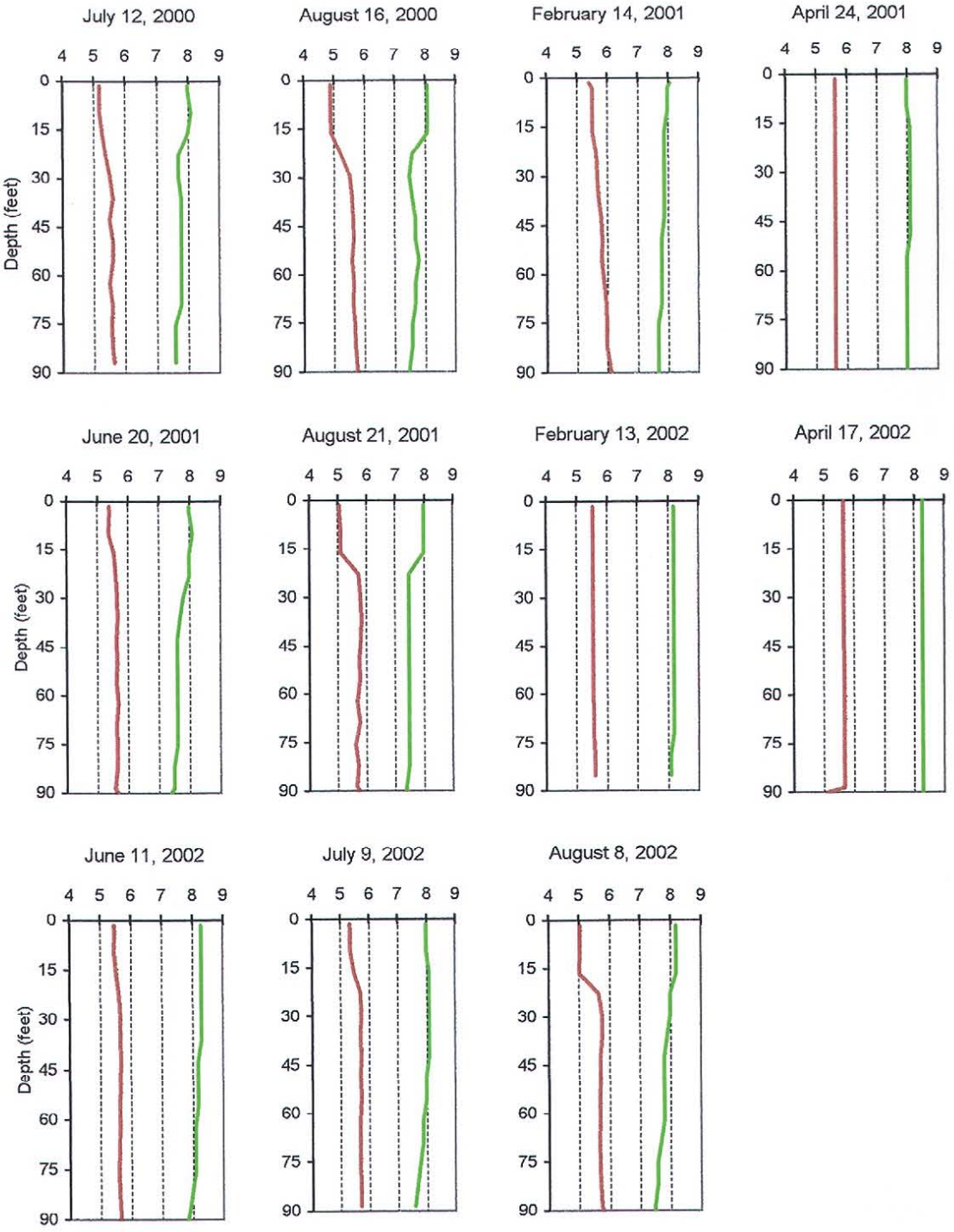


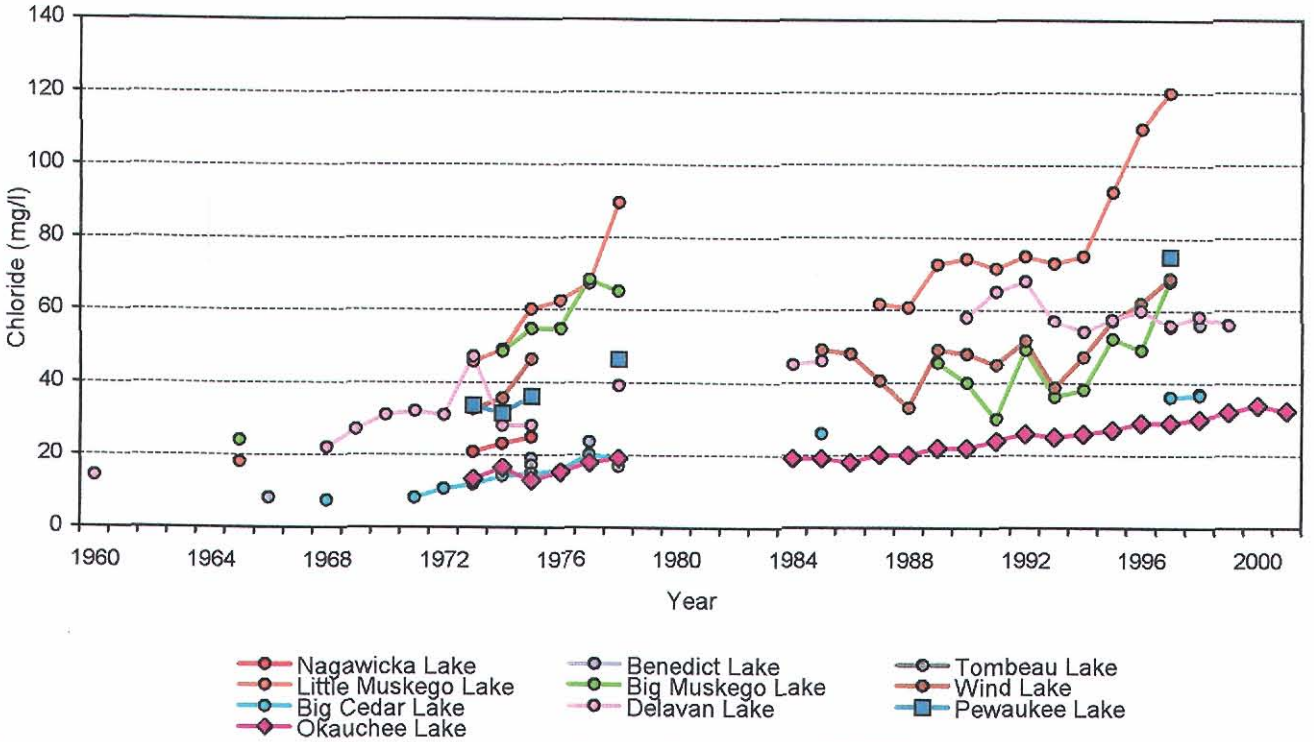
Figure 7 (continued)



Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 8

CHLORIDE CONCENTRATION TRENDS FOR ASSORTED LAKES IN SOUTHEASTERN WISCONSIN: 1960-2001



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

these values generally indicate fair to very good water quality compared to other lakes in Southeastern Wisconsin. In part, however, this improved water clarity may be related to the presence of zebra mussel, *Dreissena polymorpha*, in the Lake, which mollusk is an invasive, nonnative filter feeding shellfish known to impact water clarity in inland lakes.

Chlorophyll-*a*

Chlorophyll-*a* is the major photosynthetic ("green") pigment in algae. The amount of chlorophyll-*a* present in the water is an indication of the biomass or amount of algae in the water. Chlorophyll-*a* concentrations observed in Okauchee Lake by the U.S. Environmental Protection Agency and reported during the initial study ranged from a low of 3.4 micrograms per liter (µg/l) in November 1976, to a high of 14.9 µg/l in June 1972.[4] During the current study period, chlorophyll-*a* concentrations in Okauchee Lake ranged from 0.1 to 27.0 µg/l. During these latter years, the mean chlorophyll-*a* concentration was 5.5 µg/l. All of these values are within the range of chlorophyll-*a* concentrations recorded in other lakes in the Region and indicate fair to very good water quality, as illustrated in Figure 9. Chlorophyll-*a* levels above about were observed on less than ten occasions in Okauchee Lake, and then generally during spring or early summer when algal blooms may be expected to occur following spring turnover

[4]*U.S. Environmental Protection Agency, National Eutrophication Survey Working Paper Series,* Report on Okauchee Lake, Waukesha County, Wisconsin, EPA Region V, Working Paper No. 64, *June 1975.*

Figure 9

PRIMARY WATER QUALITY INDICATORS FOR OKAUCHEE LAKE: 1984-2002

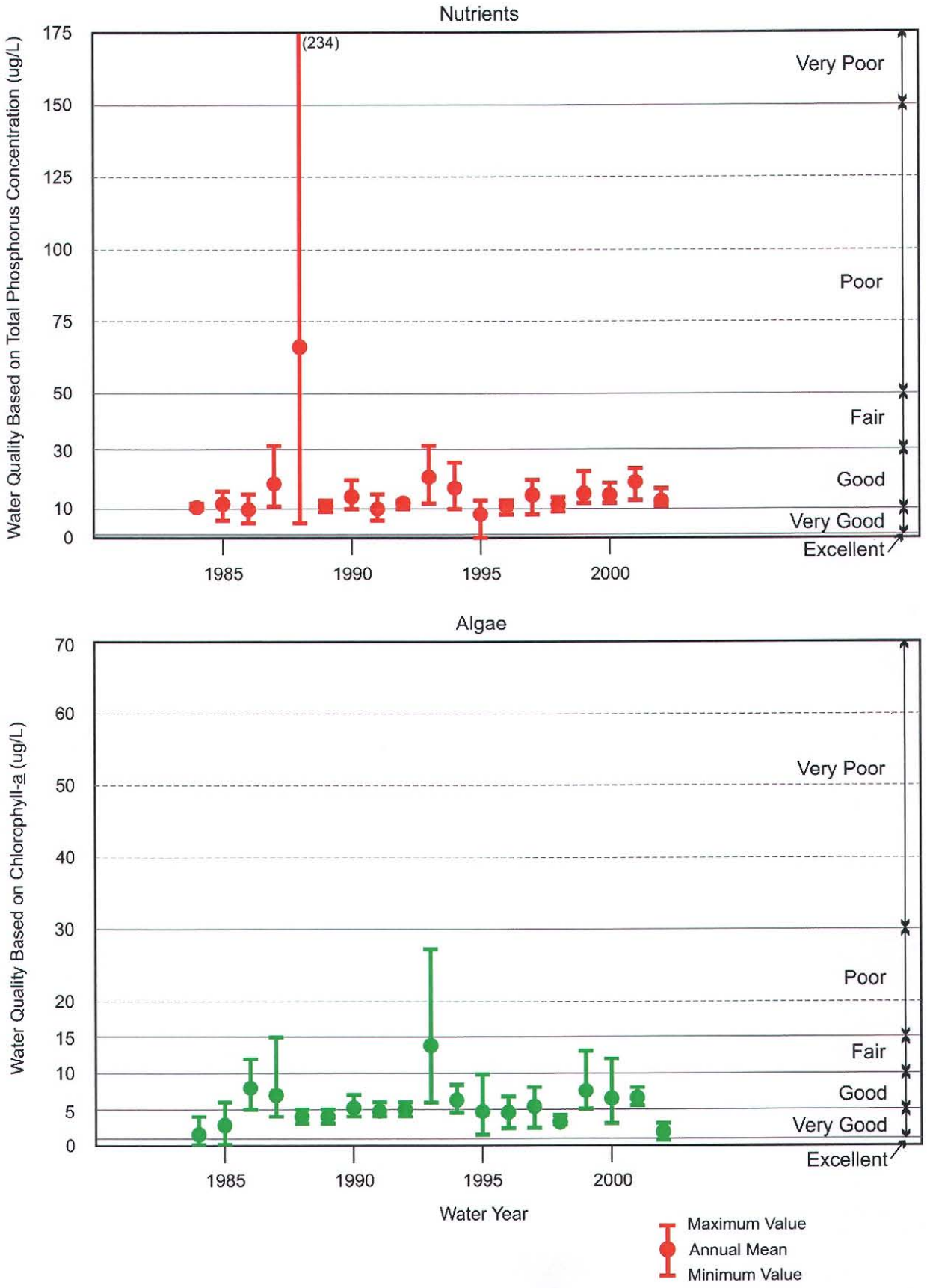
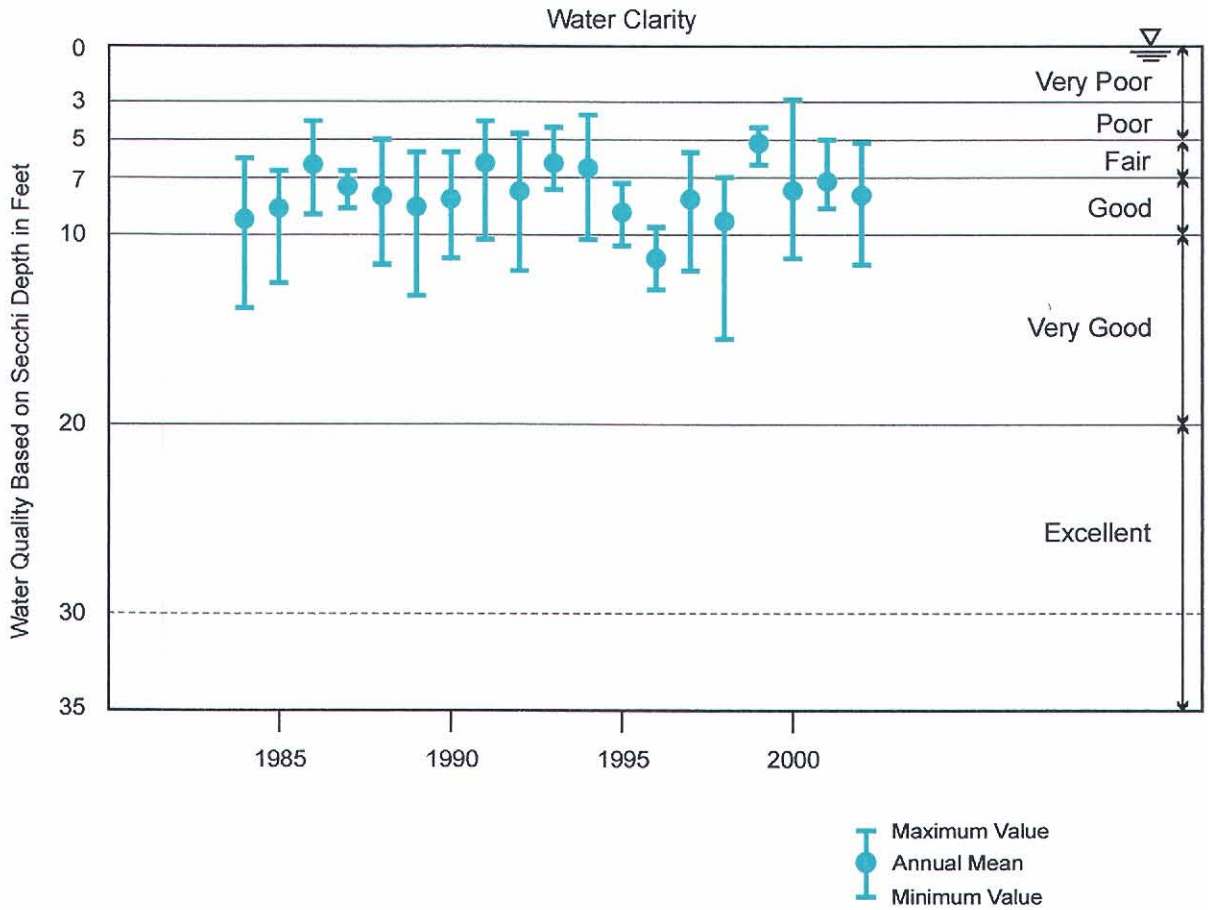


Figure 9 (continued)



Source: U.S. Geological Survey and SEWRPC.

and the introduction of hypolimnetic nutrients into the euphotic zone or zone of light penetration. Chlorophyll-*a* concentrations about 10 µg/l result in a green coloration of the water that may be severe enough to impair recreational activities such as swimming and skiing.

Nutrient Characteristics

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. 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 limiting aquatic plant growth in a lake. 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. As shown in Table 13, the N:P ratio in Okauchee Lake during the initial planning period was always equal to or greater than 14:1, except during February 1974 and January 1977 when the ratio was about 12:1, and during November 1973 when the ratio was about 13:1. This indicates that summer aquatic plant growth in Okauchee Lake was limited by phosphorus. The nitrogen-to-phosphorus ratios in samples collected from Okauchee Lake in recent years also were always greater than 10, as shown in Table 13. This indicates that plant production continues to be limited by phosphorus. In fact, the summer N:P ratio was frequently equal to or greater than 14.1.

Table 13

NITROGEN-PHOSPHORUS RATIOS FOR OKAUCHEE LAKE: 1973-1978

Sample Date	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Nitrogen to Phosphorus Ratio
September 17, 1973	0.89	0.06	14.8
November 26, 1973	0.82	0.06	13.7
November 1973	1.33	0.03	44.3
February 5, 1974	0.70	0.06	11.7
April 3, 1974	1.65	0.05	33.0
April 1974	1.76	0.01	176.0
July 10. 1974	1.54	0.06	25.7
November 19, 1974	1.34	0.07	19.1
February 18, 1975	0.95	0.04	23.8
April 23, 1975	1.20	0.05	24.0
July 1, 1975	0.83	0.02	41.5
December 2, 1975	1.01	0.03	33.7
April 5, 1976	1.04	0.03	34.7
July 16, 1976	1.17	0.03	39.0
November 9, 1976	1.64	0.04	41.0
January 25, 1977	1.17	0.10	11.7
April 1977	0.90	0.01	90.0
July 1977	0.40	0.02	20.0
November 1977	1.41	0.04	35.3
April 1978	0.88	0.02	44.0

Source: Wisconsin Department of Natural Resources and SEWRPC.

Both total phosphorus and soluble phosphorus concentrations were measured for Okauchee Lake. 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.

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

In Okauchee Lake, during the period 1973 through 1978, the mean concentration of total phosphorus was 0.03 mg/l during the spring turnover, and 0.04 mg/l on an average annual basis. Surface water total phosphorus concentrations ranged from about 0.01 to 0.10 mg/l, as shown in Table 12. During the current study period, total phosphorus concentrations in the surface waters of Okauchee Lake generally averaged 0.017 mg/l, indicating good water quality, as illustrated in Figure 9. The surface water total phosphorus concentrations ranged from less than 0.005 mg/l to 0.032 mg/l during this period, with one "spike" observed on August 22, 1988, peaking at 0.234 mg/l. The bottom water total phosphorus concentrations in Okauchee Lake during the study period ranged from less than 0.010 mg/l to 0.167 mg/l, with an average concentration of 0.051 mg/l. Dissolved phosphorus concentrations ranged from less than 0.002 mg/l to 0.004 mg/l in the surface waters, and from less than 0.001 mg/l to 0.126 mg/l in the hypolimnion during periods of summer stratification.

These seasonal gradients of phosphorus concentration between the epilimnion and hypolimnion reflect the biogeochemistry of this growth element. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed. Phosphorus from these organisms is then either stored in the bottom sediments or rereleased into the water column. 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 the change 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 phosphorus becomes soluble and is more readily released from the sediments. This 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.

The data indicated that there was internal loading of phosphorus from the bottom sediments of Okauchee Lake. As shown in Table 12 and noted above, the dissolved phosphorus concentrations in the bottom waters were relatively high during the summer, ranging up to 0.126 mg/l for samples collected when such releases of phosphorus are most likely to occur. The magnitude of the this release, however, and its concomitant effects in contributing to algal growth in the surface waters of the Lake, are generally moderated by a number of circumstance, including the rate of mixing during the spring and fall overturn events which limit the mass of phosphorus reaching the euphotic zone.

POLLUTION LOADINGS AND SOURCES

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the drainage area tributary to a lake. Currently, there are no significant point source discharges of pollutants to Okauchee Lake or to the surface waters tributary to Okauchee Lake. Nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities; and rural sources, such a runoff from agricultural lands and onsite sewage disposal systems. The pollutant loads from these sources 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 drainage lakes, like Okauchee Lake, pollutant loadings from the upstream watershed, together with those transported across the land surface directly tributary to a lake, in the absence of identifiable or point source discharges from industries or wastewater treatment facilities, comprise the principal route by which contaminants enter a waterbody. The tributary drainage area of Okauchee Lake is about 52,371 acres in areal extent, including about 5,562 acres that drain to the Lake without passing through any upstream waterbodies. As already noted, inflow to Okauchee Lake is primarily through the Oconomowoc River system. For this reason, the discussion that follows is based upon nonpoint source pollutant loadings to Okauchee Lake.

Nonpoint-sourced phosphorus, suspended solids, and urban-derived metals input to and output from Okauchee 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 adopted lake management plan, which were based upon drainage basin runoff, atmospheric fallout and washout, groundwater inflow and outflow, and flow through the lake outlet.

Phosphorus Loadings

As noted above, phosphorus has been identified as the factor generally limiting aquatic plant growth in Okauchee Lake. Excessive levels of phosphorus in the Lake, therefore, are likely to result in conditions which interfere with the desired water quality and uses of the Lake. During the previous planning program, the then-existing 1975 and forecast year 2000 phosphorus sources to the Lake were identified and quantified using Commission 1975 land use inventory data, Commission planned year 2000 land use data derived from the adopted regional land use plan,

and the Commission's water quality simulation model. At that time, the major sources of phosphorus from within the drainage area directly tributary the Lake were indicated to be livestock operations, onsite sewage disposal systems, and direct atmospheric deposition onto the water surface. Of these, it was considered that onsite sewage disposal systems would become a relatively minor source of phosphorus under the then-anticipated year 2000 conditions, as sanitary sewer service was anticipated to be provided within the drainage area directly tributary to the Lake as recommended in the adopted regional water quality management plan.

Subsequent to this study, changes in land usage have occurred throughout the drainage area to Okauchee Lake, as noted in Chapter 3, and remedial actions such as the provision of a public sanitary sewerage system have not been fully implemented. Thus, changes in the estimated nutrient, sediment, and metal loadings to Okauchee Lake were anticipated. The WILMS and unit area loading models were used to evaluate the potential impacts of these changes. Forecast nutrient, sediment, and metals loads to Okauchee Lake based upon current 1995 land use and planned 2020 land use are set forth in Tables 14 and 15, respectively. The forecast 1995 data were within the expected range of observed phosphorus levels within the Lake.

The resulting estimated phosphorus budget for Okauchee Lake under existing 1995 land use conditions is shown in Table 14. A total annual phosphorus loading of between about 22,200 and 43,400 pounds was estimated to be contributed to Okauchee Lake, with a most likely total phosphorus loading of about 28,500 pounds. Of the most likely annual total phosphorus load, it was estimated that 24,500 pounds per year, or about 86 percent of the total loading, was contributed by runoff from rural land; 3,500 pounds per year, or 13 percent, was contributed by runoff from urban land; and about 300 pounds, or about 1 percent, by direct precipitation onto the Lake surface.

Phosphorus release from the lake bottom sediments—internal loading—may also contribute phosphorus to the Lake. However, this loading was assumed to be negligible given the good agreement between predicted and observed phosphorus concentrations. It is likely that overturn events generally occur at rates such that little of the hypolimnetic phosphorus is mixed into the epilimnion of the Lake—i.e., at rates on the order of days versus hours.

Approximately 60 percent, or 17,000 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 11,500 pounds of phosphorus downstream.

Under 2020 conditions, as set forth in the Waukesha County development plan and adopted regional land use plan, the annual total phosphorus load to the Lake is anticipated to continue to diminish slightly as agricultural activities within the drainage area tributary to Okauchee Lake are replaced by urban residential land uses. The most likely annual total phosphorus load to the Lake under 2020 conditions is estimated to be 26,000 pounds. However, this trend may be offset by the increasing utilization of agro-chemicals in urban landscaping. 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. Notwithstanding, rural sources are estimated to continue to dominate the annual total phosphorus load, comprising about 21,700 pounds per year, or 83 percent of the total loading. About 4,000 pounds per year, or 16 percent, were estimated to be contributed by runoff from urban lands; and about 300 pounds, or about 1 percent, by direct precipitation onto the lake surface.

Sediment Loadings

The estimated sediment budget for Okauchee Lake under existing 1995 land use conditions is shown in Table 15. A total annual sediment load of about 6,700 tons of sediment was estimated to be contributed to Okauchee Lake. Of the likely annual sediment load, it was estimated that 5,950 tons per year, or 90 percent of the total loading, was contributed by runoff from rural lands, with about 400 tons being contributed from urban lands and about 350 by direct precipitation onto the Lake surface. Of the sediment load generated from rural land uses, almost all of the load, about 99 percent, was indicated as being of agricultural origin.

Table 14

ESTIMATED EXTERNAL SOURCES OF PHOSPHORUS TO OKAUCHEE LAKE

Source	1995		2020	
	Pounds[a]	Percentage[a]	Pounds[a]	Percentage[a]
Urban[b]				
High-Density (Commercial and Industrial Uses and Multi-family Residential Uses)	3,137	11	3,393	13
Low-Density (Single Family and Suburban Density Residential Uses)	547	2	749	3
Subtotal	3,684	13	4,142	16
Rural				
Mixed Agricultural	23,179	81	20,340	78
Pasture/Grass	172	1	185	1
Wetlands	549	2	549	2
Woodlands	635	2	635	2
Water	286	1	286	1
Subtotal	24,821	87	21,995	84
Total	28,505	100	26,137	100

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

[b]*Includes the contribution from onsite sewage disposal systems that remain in use outside of the portion of the tributary drainage area to Okauchee Lake served by public sanitary sewerage systems, estimated within the WILMS model as ranging from approximately 50 pounds per year to as much as 1,400 pounds per year, depending upon soil type, system condition, and system location. For purposes of this analysis, 440 pounds per year were used as the contribution from onsite sewage disposal systems under year 1995 conditions, as this value provided the loading that was best correlated to the measured in-lake phosphorus concentration, and 50 pounds per year were used as the contribution from onsite sewage disposal systems under year 2020 conditions, assuming that public sanitary sewerage services are provided as recommended in the regional water quality management plan.*

Source: SEWRPC.

Under 2020 conditions, as set forth in the Waukesha County development plan and adopted regional land use plan, the annual sediment load to the Lake is anticipated to remain about the same. The forecast annual sediment load to the Lake under 2020 conditions is estimated to be 6,200 tons. About 5,200 tons of this sediment are estimated to be contributed from rural, primarily, agricultural sources. A further 650 tons of sediment per year are estimated to be contributed from urban sources, with the balance, about 350 tons of sediment per year, being contributed by direct precipitation onto the Lake surface.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems. Table 15 sets forth the estimated loadings of copper, zinc, and cadmium likely to be contributed to Okauchee Lake from urban development surrounding the Lake. The majority of these metals becomes associated with sediment particles and is likely to be encapsulated within the bottom sediments of the Lake.

The estimated heavy metal budget for Okauchee Lake under existing 1995 land use conditions is shown in Table 15. About 160 pounds of copper, 1,200 pounds of zinc, and 1.5 pounds of cadmium are estimated to be contributed annually to Okauchee Lake from urban lands.

Under 2020 conditions, as set forth in the Waukesha County development plan and adopted regional land use plan, the annual heavy metal loads to the Lake are anticipated to increase significantly. The most likely annual

Table 15

ESTIMATED CONTAMINANT LOADS TO OKAUCHEE LAKE: 1995 AND 2020

Land Use	1995						2020					
	Area (acres)	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)	Area (acres)	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	6,009	300.5	1,622	120	841	0.0	8,254	412.7	2,229	165	1,156	0.0
Commercial	130	51.0	156	29	194	1.3	177	69.4	212	39	264	1.8
Industrial	31	11.7	36	7	46	0.3	165	62.0	193	36	246	1.7
Communications and Utilities	2,014	9.5	222	--	--	--	2,635	12.5	290	--	--	--
Governmental	102	26.0	138	7	82	0.0	125	31.9	169	9	100	0.0
Recreational	646	7.8	174	--	--	--	694	8.3	187	--	--	--
Water	3,664	344.4	476	--	--	--	3,664	344.4	476	--	--	--
Wetlands	6,156	11.4	246	--	--	--	6,156	11.4	246	--	--	--
Woodlands	6,995	12.9	280	--	--	--	6,995	12.9	280	--	--	--
Agricultural	26,624	5,941.5	22,730	--	--	--	23,506	5,225.6	20,000	--	--	--
Total	52,371	6,716.7	26,080	163	1,163	1.6	52,371	6,191.1	24,282	249	1,766	3.5

Source: SEWRPC.

loads to the Lake under 2020 conditions are estimated to be about 250 pounds of copper, 1,800 pounds of zinc, and 3.5 pounds of cadmium.

Stormwater Management

The Okauchee Lake community expressed specific concerns regarding stormwater management systems serving the continuing development along STH 16 at Jaeckles Boulevard, and along Lake Drive, as shown on Map 12. Four areas of concern were identified by the Okauchee Lake Management District Board of Commissioners. [5] As a result, specific analyses of the respective subbasins draining these areas to Okauchee Lake were conducted by Commission staff, and are set forth below.

The STH 16 and Jaeckles Boulevard Corridor

During the initial planning period, consideration was given to the potential impacts of highway construction associated with STH 16 on the estimated annual loads of sediment and phosphorus to Okauchee Lake. The problems and a series of alternative measures to alleviate the potential problems were analyzed jointly by the staffs of the Wisconsin Department of Transportation (WisDOT), the Wisconsin Department of Natural Resources (WDNR), the Waukesha County Soil and Water Conservation District, and the Regional Planning Commission, and documented in Appendix B of the initial plan. This analysis included an identification of the existing problems, an evaluation of the depth and volume of sediment deposited in the portion of Okauchee Lake locally known as Ice House Bay—reproduced herein as Figure 10, a quantification of the estimated peak rates of stormwater runoff from the tributary area, and an analysis of alternative measures to resolve the problems—summarized herein in Chapter VII. These alternatives were intended to significantly reduce the nonpoint source pollutant loadings to the Lake as well as to reduce the threat of stormwater damage. To date, however, these recommendations have not been fully implemented, and the problems associated with this storm water conveyance system persist.

Lake Drive

During the current planning period, residents at the intersection of W. Lake Drive and N. Lake Drive noted ongoing concerns regarding stormwater runoff from the street system, within the subbasin designated as OR-35, to the embayment locally known as Bay Five. This runoff conveyed not only stormwater and its associated pollutants from the road surface, as suggested in Table 16, but also caused soil loss from the road embankment and lawns of the properties across which the runoff was conveyed into the Bay. Attempts to resolve this problem by installing curb and gutter and placing a downpipe from the roadway elevation to the shoreland elevation, but not continuing to the lakeshore, were considered to be unsuccessful by the residents in mitigating their concerns.

Wisconsin Avenue and Lake Drive

Also during the current planning period, the Okauchee Lake Management District Commissioners identified two further areas of concern with respect to stormwater runoff from local street systems within urbanized areas of the Town of Oconomowoc. These sites, similarly located within subbasin OR-35, were located along Lake Drive between Point Comfort Drive and Road B, and Wisconsin Avenue in the vicinity of its intersection with Shady Lane. Both of these sites included areas of steeply sloping land draining to the embayment known as Lower Okauchee Lake, and both were subject to sediment and contaminant loadings from urban density residential and commercial development and the local street system. These areas are currently served by a stormwater

---

[5] *A fifth area, locally known as the "town center" development within the area bounded by Wisconsin Avenue on the south, Lakeshore Drive on the north, CTH P on the west and Harbor Court and the embayment known as Upper Oconomowoc Lake on the east, was also identified by the Okauchee Lake Management District Board of Commissioners. This area, which is proposed for urban density development, is required to be provided with appropriate stormwater quantity and quality management measures pursuant to existing Town and County stormwater and construction site management ordinances. As these measures are to be implemented during the development process, further interventions to manage stormwater in this area are moot.*

Map 12

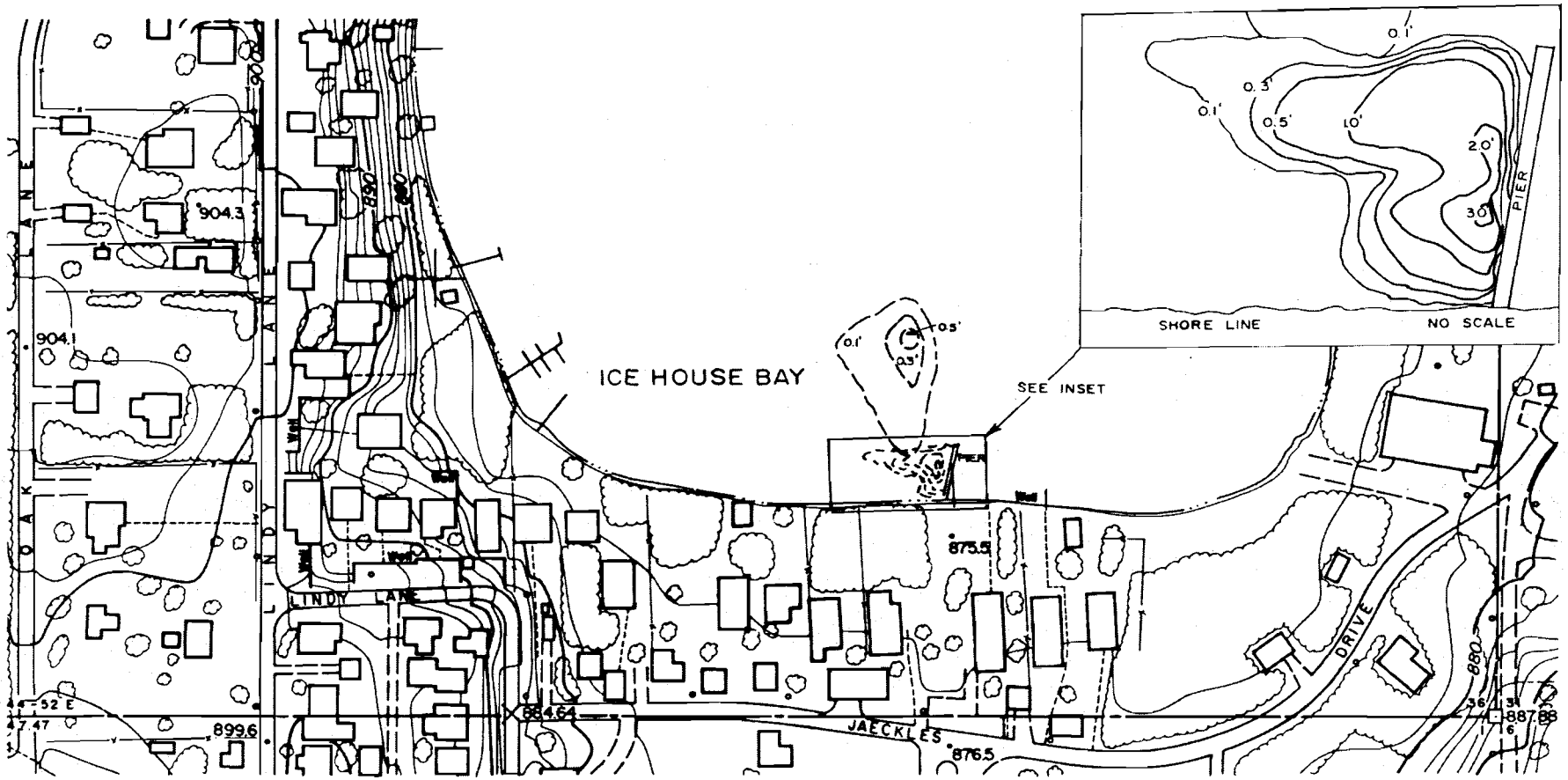
STORMWATER MANAGEMENT AREAS OF CONCERN WITHIN THE DIRECT DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE

Source: Okauchee Lake Management District and SEWRPC.

DATE OF PHOTOGRAPHY: MARCH 2000

Figure 10

SURVEYED SEDIMENTATION IN ICE HOUSE BAY AT FOOT OF JAECKLES BOULEVARD



Source: Wisconsin Department of Transportation.

Table 16

ESTIMATED POLLUTANT LOADS TO OKAUCHEE LAKE FROM URBAN DEVELOPMENT WITHIN SUBBASIN OR-35

Land Use	1995					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Multi-Family Residential	2.4	579	2	0.3	2.0	0.02
Single-Family Residential	133.3	13,259	36	2.7	18.5	0.00
Commercial	12.6	9,847	15	2.7	18.7	0.13
Industrial	34.3	25,809	40	7.6	51.1	0.34
Government and Institutional	8.7	4,425	12	O.6	6.9	0.00
Recreational	< 0.1	< 1	< 1	0.0	0.0	0.00
Agricultural	1.0	441	< 1	0.0	0.0	0.00
Water	74.1	13,929	10	0.0	0.0	0.00
Roadways	62.7	6,901	7	1.0	54.0	0.63
Other Open Lands	7.3	69	1	0.0	0.0	0.00
Total	336.4	75,259	123	14.9	151.2	1.12

Source: SEWRPC.

conveyance system that does not provide any water quality treatment during the process of conveyance to the Lake. Consequently, the Commissioners expressed concerns voiced by the residents riparian to Lower Okauchee Lake that the deposition of sediments at the outlets of the conveyance systems were resulting in loss of Lake depth and other water quality impacts within Lower Okauchee Lake.

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 that 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 that 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. Lakes that are subject to extreme levels of enrichment may be referred to as hypertrophic.

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 applies. In this case, two indices, appropriate for Wisconsin lakes, have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[6] and the Carlson Trophic State Index (TSI).[7] In addition, the Wisconsin Trophic State Index value (WTSI) is presented.[8] The WTSI is a refinement of the Carlson TSI designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes, and has been adopted by the Wisconsin Department of Natural Resources for use in lake management investigations.

Vollenweider Trophic State Classification

Using the Vollenweider trophic system and applying the phosphorus concentration data in Table 12, Okauchee Lake would be classified as having about a 50 percent probability of being oligotrophic and about a 45 percent probability of being mesotrophic, as shown in Figure 11. The Lake would have about a 5 percent probability of being eutrophic based upon mean annual phosphorus concentrations. Based upon chlorophyll-*a* levels, the Lake would be classified as having a 60 percent probability of being mesotrophic, with about a 30 percent probability of being eutrophic and about a 10 percent probability of being oligotrophic, as shown in Figure 11. Based upon Secchi-disc readings, the Lake would be classified as having a 55 percent probability of being eutrophic, with a 25 percent probability of being hypertrophic, a 20 percent probability of being mesotrophic, and a 5 percent probability of being oligotrophic, as shown in Figure 11. While these indicators result in slightly differing lake trophic state classifications, it may be concluded that Okauchee Lake should be classified as a mesotrophic lake, or a lake with acceptable water quality for most uses.

Trophic State Index

The Trophic State Index (TSI) assigns a numerical trophic condition rating based on Secchi-disc transparency, and total phosphorus and chlorophyll-*a* concentrations. The original Trophic State Index developed by Carlson has been modified for Wisconsin lakes by the Wisconsin Department of Natural Resources using data on 184 lakes throughout the State. The Wisconsin Trophic State Index (WTSI) ratings for Okauchee Lake are shown in Figure 12 as a function of sampling date. Based on the Wisconsin Trophic State Index rating that ranged generally between 40 and 55, Okauchee Lake may be classified as meso-eutrophic. Figure 12 suggests an improvement in lake trophic status, as assessed based upon total phosphorus concentrations between the 1980s and 2000s, with the WTSI decreasing from about 50 to about 40. This improvement in water quality is likely to be, in part, the result of the construction of the sewerage system around portions of Okauchee Lake. Nonetheless, slightly increased total phosphorus-based WTSI values which appear to be increasing from about 45 to about 50 in recent years, may indicate some cause for concern.

Figure 13 presents the data shown in Figure 12 as a time series by sampling site. TSI values calculated from total phosphorus concentrations and chlorophyll-*a* concentrations are shown for each of the five sampling sites monitored during the period from 1985 through 2002. These graphs demonstrate the relationship between the inlet—close to Crane's Nest Bay in the northeastern portion of Okauchee Lake, the main basin or deep hole sampling site, and the Lower Okauchee Lake embayment—close to the outlet of Okauchee Lake. Over the current study period, the degree of enrichment generally appears to decline as the relatively phosphorus-rich inflowing waters of the Oconomowoc River are diluted by the lake waters and as particulate phosphorus is deposited in the vicinity of the debouchment of the River as it enters the Lake. Data from the sampling sites located in the northwestern and southeastern embayments, shown in Figure 13 as data from Crazy Man's Island and Ice House

---

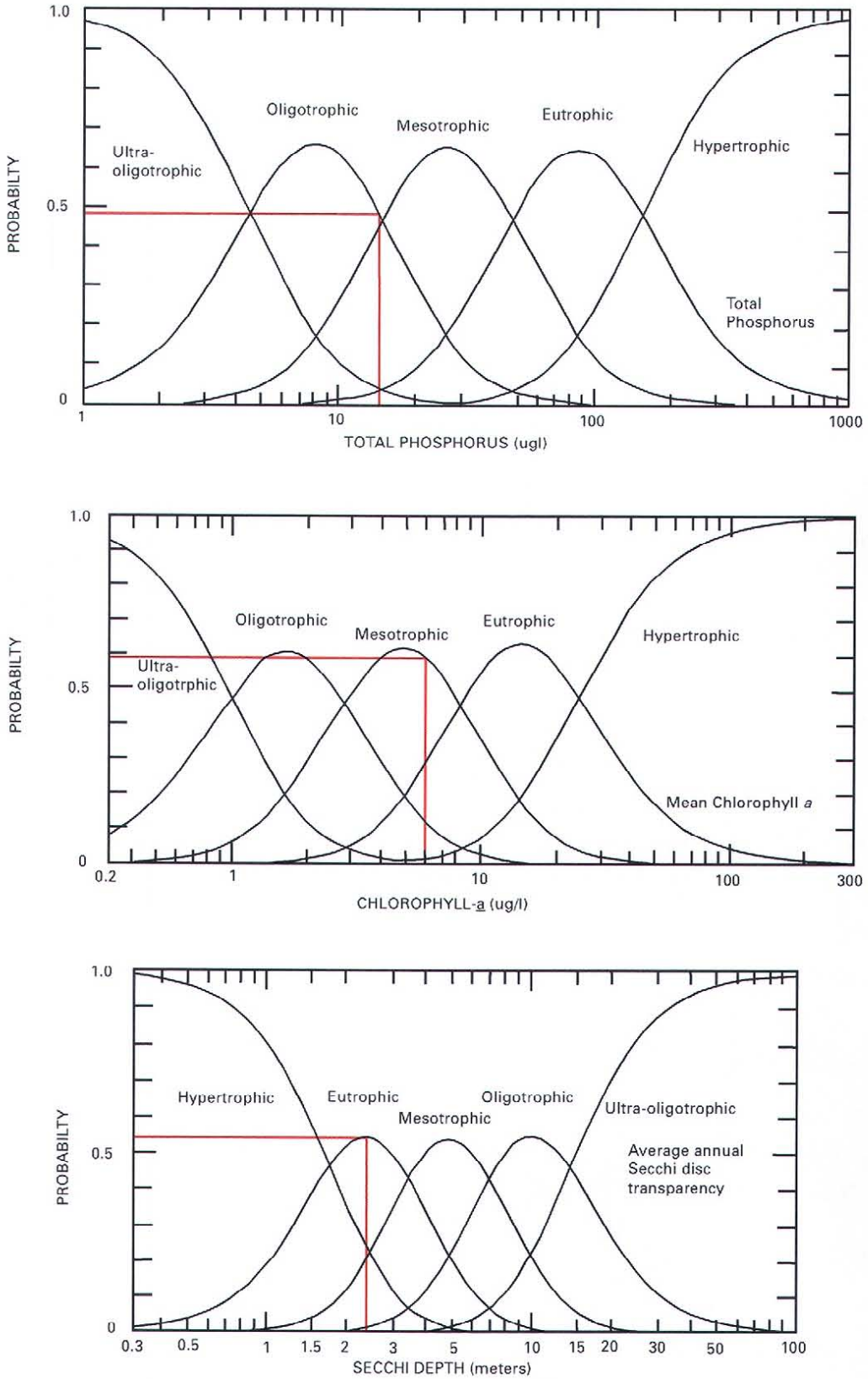
[6] *H. Olem and G. Flock, U.S. Environmental Protection Agency Report EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition, *Washington, D.C., August 1990.*

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

[8] *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.*

Figure 11

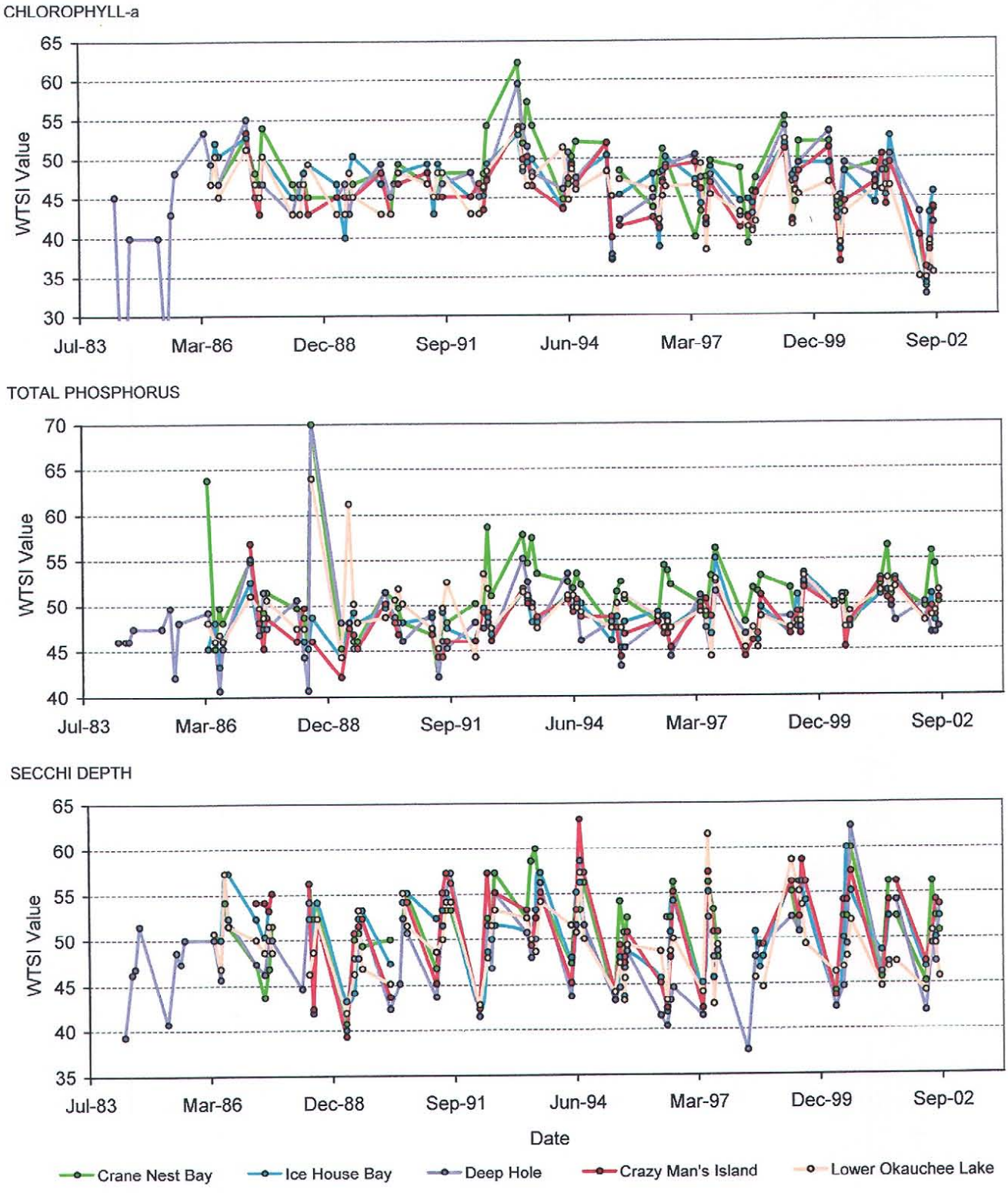
TROPHIC STATE CLASSIFICATION OF OKAUCHEE LAKE BASED UPON THE VOLLENWEIDER MODEL: 2001



Source: U.S. Geological Survey and SEWRPC.

Figure 12

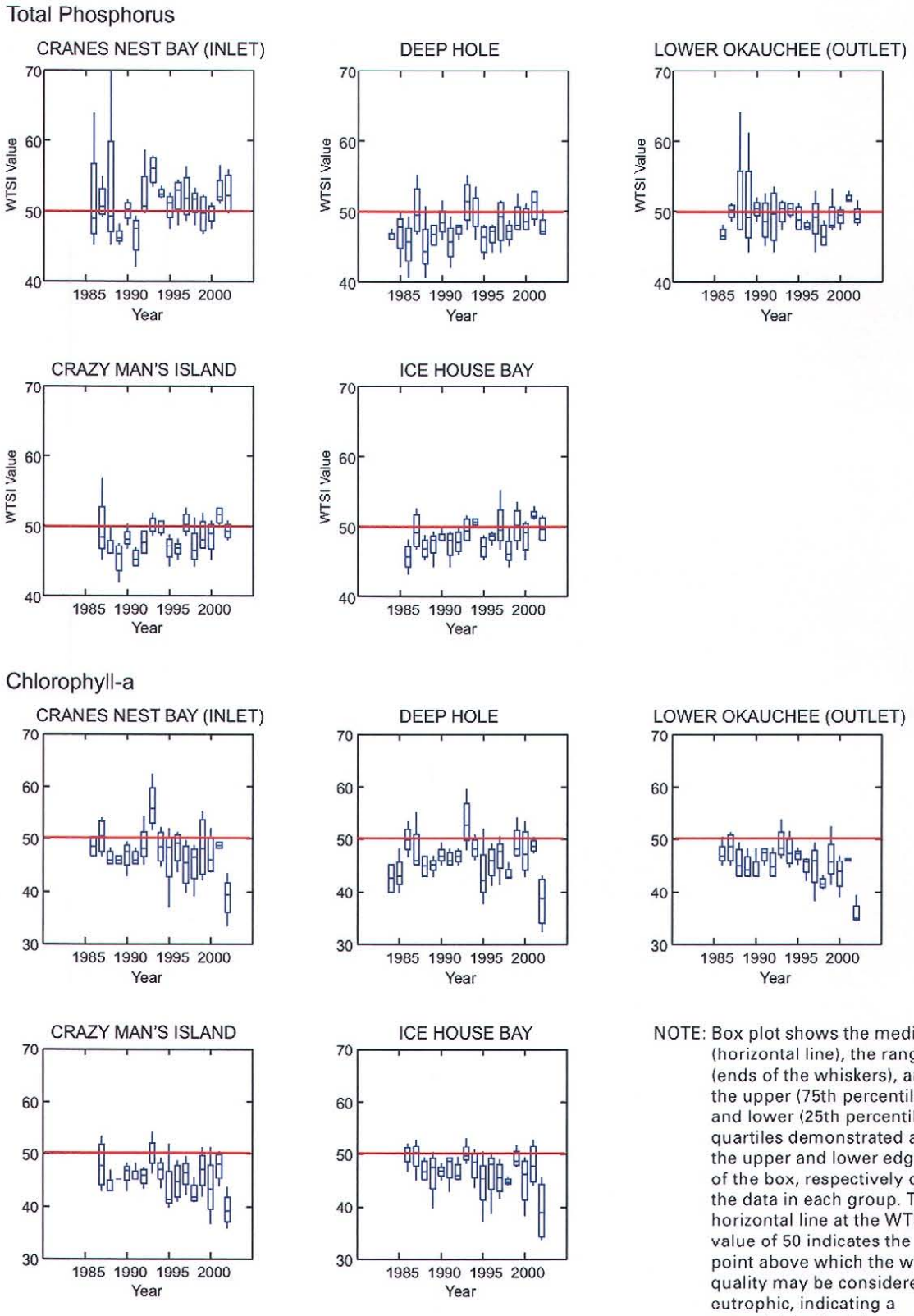
WISCONSIN TROPHIC STATE INDEX FOR OKAUCHEE LAKE: 1984-2002



Source: U.S. Geological Survey and SEWRPC.

Figure 13

WISCONSIN TROPHIC STATE INDEX AMONG FIVE SITES WITHIN OKAUCHEE LAKE: 1984-2002



NOTE: Box plot shows the median (horizontal line), the range (ends of the whiskers), and the upper (75th percentile) and lower (25th percentile) quartiles demonstrated at the upper and lower edges of the box, respectively of the data in each group. The horizontal line at the WTSI value of 50 indicates the point above which the water quality may be considered eutrophic, indicating a potential for the lake to be considered impaired.

Source: U.S. Geological Survey and SEWRPC.

Bay, generally follow the same distribution pattern as the main lake basin, and are independent of the conditions at either the inlet or outlet. The data from these latter stations, the main lake basin, and the outlet demonstrate a more consistent pattern of distribution, following an approximate decadal cycle, than the inflow, which appears more variable. While the chlorophyll-*a* data generally track the phosphorus concentration-based TSI values, with higher chlorophyll-*a*-based TSI values coinciding with higher total phosphorus-based TSI values, the cyclical distribution pattern is typically less clear. Nevertheless, these data suggest a close connection between in-lake phosphorus concentrations and the biological response of the algal community as measured by chlorophyll-*a* concentrations. As with the phosphorus-based TSI values, the deep hole, Crazy Man's Island, and Ice House Bay sites, as well as the Lower Okauchee Lake embayment, appear to have more consistent biological responses than the inlet site, which has greater inter-annual variability and general greater level of biological production.

SUMMARY

Okauchee Lake represents a typical hard-water, alkaline lake that is considered to have relatively good water quality. Physical and chemical parameters measured during the study period indicated that the water quality was within the "poor" to "good" range, depending upon the parameters considered. 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 Okauchee Lake. Nevertheless, the surface waters of the Lake remained well oxygenated and supported a healthy fish population. Winterkill was not a problem in Okauchee 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 not considered to be a problem in Okauchee Lake.

There were no significant point sources of pollutants in the Okauchee Lake watershed. Nonpoint sources of pollution included stormwater runoff from urban and agricultural areas. In 1995, the total annual phosphorus load to Okauchee Lake was estimated to be 28,500 pounds. Runoff from the rural lands contributed the largest amount of phosphorus, about 86 percent of the total phosphorus load, with the runoff from urban lands contributing about 13 percent of the total phosphorus load. In addition, direct precipitation onto the Lake surface contributed about 1 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 drainage area tributary to the Lake. Under forecast 2020 conditions, a slight decrease in the mass of phosphorus to Okauchee Lake is anticipated.

Approximately 60 percent, or 17,000 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 11,500 pounds of phosphorus downstream.

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

(This page intentionally left blank)

Chapter V

AQUATIC BIOTA AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

Okauchee Lake, and its component embayments known locally as Lower Okauchee and Upper Oconomowoc Lakes, is an important element of the natural resource base of the Towns of Merton, Summit, and Oconomowoc. The Lake, its biota, and the adjacent park and urban lands combine to contribute to the quality of life in the area. When located in such urban settings, resource features such as lakes and wetlands are typically subject to extensive recreational use and high levels of pollutant discharges, common forms of stress to aquatic systems, and this may result in the deterioration of these 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 of the urban development in the area concerned. Accordingly, this chapter provides information concerning the natural resource features of the Okauchee Lake watershed, including data on primary environmental corridors, wetlands, aquatic macrophytes, fish, and wildlife. Recreational activities relating to the use of these natural resource features are described in Chapter VI.

AQUATIC PLANTS

Aquatic plants include larger plants, or macrophytes, and microscopic algae, or phytoplankton. These plant communities 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 for other aquatic organisms. In this process, known as photosynthesis, plants utilize energy from sunlight and release oxygen required by other aquatic life forms.

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, in single cells and colonies, and can be either attached or free-floating. 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. Algal blooms have been occasionally perceived as a problem in Okauchee Lake.

Green algae (chlorophytes) are the most important source of food for zooplankton, or microscopic animals, in the lakes of Southeastern Wisconsin. Blue-green algae (cyanophytes) 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 can occur when excessive nutrient supplies are available, optimal sunlight and temperature conditions exist, and there is a lack of competition from other aquatic plant species and grazing by zooplankton.

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 decay process consumes 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.

In Okauchee Lake, analyses of the types and abundances of algae present indicated relatively low concentrations of algae during June and July, 1977. However, localized, nuisance growths of algae were reported to have occurred in some bays and along shorelines. The algal populations were greatest from late-April to early-May, 1977, due to a spring bloom of the yellow-green alga *Dinobryon*. Subsequently, the presence of blue-green algae, such as *Anabaena*, *Microcystis*, *Aphanothece*, and *Chroococcus*, indicated a potential for "bloom" conditions during mid-summer. *Chroococcus* and *Aphanothece* were the dominant algae from August to early-September, 1977.

Largely because of the dominance of the rooted aquatic plants in the Lake, further surveys of the phytoplankton community have not been undertaken. Nevertheless, based upon the chlorophyll *a* concentrations reported in Chapter IV, algal populations are likely to remain at relatively low levels in Okauchee Lake.

Aquatic Macrophytes

Aquatic macrophytes, such as pondweeds, rushes, cattails, coontail, and water milfoil, play an important role in the ecology of southeastern Wisconsin lakes. Depending on the distribution and abundance, they can be either beneficial or a nuisance. Macrophytes growing in reasonable densities in lakes are beneficial because they provide habitat for other forms of aquatic life and may remove nutrients from the water that otherwise could contribute to excessive algal growth. Notwithstanding, aquatic plants can become a nuisance when heavy densities interfere with swimming and boating activities. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate type, wave action, and type and size of the fish populations present, determine the distribution and abundance of aquatic macrophytes in a lake. Illustrations of representative macrophyte species identified in Okauchee Lake are set forth in Appendix A.

The initial aquatic plant survey on Okauchee Lake was conducted during June and August of 1977 by Environmental Resource Assessments, Inc. Subsequently, Aron & Associates conducted aquatic plant surveys during 1992 and 1996, and an aquatic plant survey was conducted by the Commission staff during July 2000. Follow-up reconnaissance surveys were done by Commission staff during July 2001 and August 2002.

The macrophyte species observed during these surveys are presented in Table 17. These aquatic plant survey data suggest that the dominant macrophyte species in the Lake were muskgrass (*Chara* sp.), coontail (*Ceratophyllum demersum*), spiked or northern water milfoil (*Myriophyllum exalbescens*, also known as *M. sibiricum*), Eurasian water milfoil (*Myriophyllum spicatum*), and Sago pondweed (*Potamogeton pectinatus*). Heavy growths of coontail, and the dominance of the water milfoils, are often indicative of fertile lakes. Other macrophytes identified in the Lake, which may produce nuisance conditions, included pondweeds (*Potamogeton* spp.), bushy pondweed (*Najas* spp.), and wild celery or eel grass (*Vallisneria americana*).

The numbers of aquatic plant species survey ranged from 23 in 1996 and 2000, to 25 in 1977, to 30 in 1992. The 1992 survey identified the greatest number of aquatic plant species observed during the years aquatic plants have been monitored. Notwithstanding, this range in numbers of species between surveys is likely to be insignificant, perhaps reflecting differences in sampling protocols or seasonal difference within the aquatic plant community in the Lake. These numbers of species, and the composition of the aquatic plant community, reflect a diverse aquatic plant community offering a variety of habitat types and conditions within the Lake. However, should there be a persistent decline in the numbers of native aquatic plants present over time, actions may be required to reverse this loss. The distribution and relative abundance of the macrophyte species present in the Lake as of the July 2000 survey are indicated in Table 18, and graphically depicted on Map 13.

Table 17

OKAUCHEE LAKE AQUATIC PLANT SURVEY RESULTS: 1977-2000[a]

Aquatic Plant Species	1977 Survey[b]	1992 Survey[b]	1996 Survey[c]	2000 Survey[d]
Bidens beckii (water marigold)	X	--	--	--
Ceratophyllum demersum (coontail)	X	X	X	X
Chara vulgaris (muskgrass)	X	X	X	X
Eleocharis acicularis (spike rush)	X	X	--	--
Elodea canadensis (waterweed)	X	X	X	X
Lemna minor (small duckweed)	--	X	X	X
Lemna trisulca (forked duckweed)	--	--	--	X
Myriophyllum exalbescens (spiked water milfoil)	X	X	--	--
Myriophyllum spp. (native water milfoil)	--	--	--	X
Myriophyllum spicatum (Eurasian water milfoil)	X	X	X	X
Myriophyllum verticullatum (northern water milfoil)	X	X	--	--
Najas flexilis (bushy pondweed)	X	X	X	X
Najas marina (spiny naiad)	X	X	X	X
Nitella sp. (nitella)	--	--	--	X
Nuphar sp. (yellow water lily)	X	X	X	X
Nymphaea sp. (white water lily)	X	X	X	X
Polygonatum natans (water smartweed)	X	X	--	--
Potamogeton amplifolius (large-leaf pondweed)[e]	X	X	X	X
Potamogeton berchtoldii (small pondweed)	X	X	--	--
Potamogeton crispus (curly-leaf pondweed)	X	X	X	X
Potamogeton filiformis (thread-leaf pondweed)	--	X	X	--
Potamogeton friesii (Fries pondweed)	--	X	X	--
Potamogeton gramineus (variable pondweed)	X	X	X	X
Potamogeton illinoensis (Illinois pondweed)[e]	X	X	X	X
Potamogeton natans (floating-leaf pondweed)	--	X	X	--
Potamogeton pectinatus (Sago pondweed)[e]	X	X	X	X
Potamogeton praelongus (white-stem pondweed)[e]	X	X	--	--
Potamogeton richardsonii (clasping-leaf pondweed)[e]	--	X	X	X
Potamogeton zosteriformis (flat-stemmed pondweed)	X	X	X	X
Ranunculus longirostris (stiff water crowfoot)	X	X	--	--
Spirodela polyrhiza (great duckweed)	--	--	--	X
Utricularia sp. (bladderwort)	X	X	X	X
Vallisneria americana (water celery)[e]	X	X	X	X
Zannichellia palustris (horned pondweed)[e]	--	X	X	--
Zosterella dubia (water stargrass)	X	X	X	X

[a]*Survey results reported for Okauchee Lake including the embayments locally known as Lower Okauchee and Upper Oconomowoc Lakes, unless otherwise specified.*

[b]*Survey conducted by Environmental Resource Assessments.*

[c]*Survey conducted by Aron and Associates for Okauchee Lake only.*

[d]*Survey conducted by SEWRPC.*

[e]*Considered a high-value aquatic plant species known to offer important values in specific aquatic ecosystems under Section NR 107.08 (4) of the* Wisconsin Administrative Code.

Source: Environmental Resource Assessments, Aron and Associates, and SEWRPC.

During the 1977 survey, macrophyte growth in Okauchee Lake was found to be moderate to high, with the maximum water depth at which macrophyte growth occurred being about 15 feet. Macrophyte growth occurred over about 45 percent to 80 percent of the lake bottom. The dominant macrophytes were muskgrass (*Chara* sp.), coontail (*Ceratophyllum demersum*), northern water milfoil (*Myriophyllum exalbescens*), Eurasian water milfoil,

Table 18

AQUATIC PLANT SPECIES PRESENT IN OKAUCHEE LAKE AND THEIR POSITIVE ECOLOGICAL SIGNIFICANCE: JULY 2000

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence (percent)[a]	Density at Sites Found[b]	Density in Whole Lake[b]	Ecological Significance[c]
Ceratophyllum demersum (coontail)	103	38.87	2.28	0.89	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	120	45.28	2.62	1.18	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)	22	8.30	1.82	0.15	Provides shelter and support for insects which are valuable as fish food
Lemna minor (lesser duckweed)	--[d]	--[d]	--[d]	--[d]	A nutritious food source for ducks and geese, also provides food for muskrat, beaver and fish, while rafts of duckweed provide shade and cover for insects, in addition extensive mats of duckweed can inhibit mosquito breeding
Lemna trisulca (forked duckweed)	--[d]	--[d]	--[d]	--[d]	Good food for ducks and geese, provides cover for fish and insects
Myriophyllum sp. (native water milfoil)	15	5.66	1.47	0.08	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	223	84.15	3.30	2.78	Exotic invasive plant species that can lead to a decrease in native aquatic plant community abundance and diversity, but it can provide cover for invertebrates and forage fish species
Najas flexilis (bushy pondweed)	126	47.55	2.02	0.96	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	17	6.41	1.82	0.12	Provides good food and shelter for fish and food for ducks
Nitella sp. (nitella)	3	1.13	2.00	0.02	Provides important food for wildfowl and attracts small aquatic animals
Nuphar sp. (yellow water lily)	--[d]	--[d]	--[d]	--[d]	Leaves, stems, and flowers are eaten by deer; roots eaten by beaver and porcupine; seeds eaten by wildfowl; leaves provide harbor to insects, in addition to shade and shelter for fish
Nymphaea tuberosa (white water lily)	--[d]	--[d]	--[d]	--[d]	Provides shade and shelter for fish; seeds eaten by wildfowl; rootstocks and stalks eaten by muskrat; roots eaten by beaver, deer, moose, and porcupine
Potamogeton amplifolius (large-leaf pondweed)[e]	8	3.02	1.38	0.04	Provides food, shelter and shade for some fish and food for some wildfowl. Provides shelter and support for insects, which are valuable as fish food
Potamogeton crispus (curly-leaf pondweed)	10	3.77	1.10	0.04	Exotic invasive plant species that can lead to a decrease in native aquatic plant community abundance and diversity, but it can provide food, shelter and shade for some fish and food for wildfowl

Table 18 (continued)

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence (percent)[a]	Density at Sites Found[b]	Density in Whole Lake[b]	Ecological Significance[c]
Potamogeton gramineus (variable pondweed)	26	9.81	1.50	0.15	Provides habitat for fish and food for waterfowl, in addition to muskrat, beaver, deer, and moose
Potamogeton illinoensis (Illinois pondweed)[e]	3	1.13	1.00	0.01	Provides shade and shelter for fish' harbor for insects; seeds are eaten by wildfowl
Potamogeton pectinatus (Sago pondweed)[e]	16	6.04	1.31	0.08	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton richardsonii (clasping leaf pondweed)	12	4.53	1.42	0.06	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-stemmed pondweed)	9	3.40	1.11	0.04	Provides some food for ducks
Spirodela polyrhiza (great duckweed)	--[d]	--[d]	--[d]	--[d]	Good food for ducks and geese; also eaten by muskrats and some fish; provides cover for fish and insects
Utricularia sp. (bladderwort)	9	3.40	1.22	0.04	Provides good food and cover for fish
Vallisneria americana (wild celery)[e]	130	49.06	2.77	1.36	Provides good shade and shelter, supports insects, and is valuable fish food
Zosterella dubia (water stargrass)	49	18.49	1.88	0.35	Provides food and shelter for fish, locally important food for waterfowl

NOTE: There were 265 sample during the July 2000 survey.

[a]*Maximum equals 100 percent.*

[b]*Maximum density equals 4.0.*

[c]*Information obtained from* A Manual of Aquatic Plants *by Norman C. Fassett,* Guide to Wisconsin Aquatic Plants, *Wisconsin Department of Natural Resources and* Through the Looking Glass...A Field Guide to Aquatic Plants, *Wisconsin Lakes Partnership.*

[d]*Emergent and floating-leaved aquatic plants are not included in the analysis of density and frequency of occurrence calculations for submerged macrophytes.*

[e]*Considered a high-value aquatic plant species known to offer important values in specific aquatic ecosystems under Section NR 107.08(4) of the* Wisconsin Administrative Code.

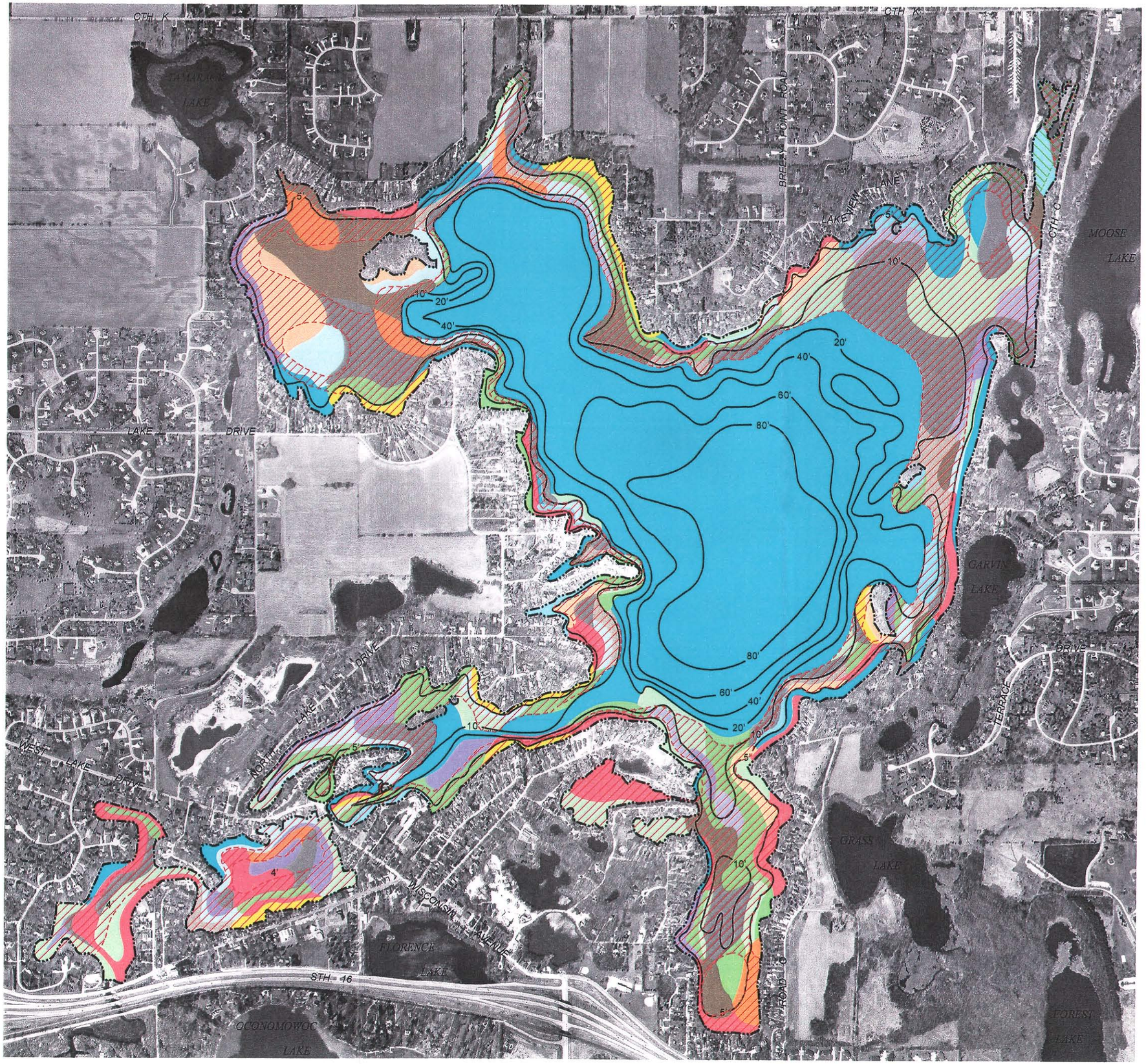
Source: SEWRPC.

(*Myriophyllum spicatum*), and Sago pondweed (*Potamogeton pectinatus*). The abundance of macrophytes was reported to have greatly decreased between June and August, 1977, although much of this decrease could be accounted for as a result of the aquatic plant management measures conducted on the Lake during this period.

During the July 2000 Commission survey, plant growth occurred throughout most of the Lake where the depth was less than 15 feet. Eurasian water milfoil (*Myriophyllum spicatum*) was the dominant species in many areas of the Lake. Eurasian water milfoil was found throughout the Lake, but largely confined to areas of the Lake with depths of between five and 15 feet. This nonnative plant was the most frequent and most widely distributed species in the Lake during the study period. It should be noted that 2000 appeared to have been a year with abundant Eurasian water milfoil growth throughout Southeastern Wisconsin, as significant stands of the plant had been reported from other area lakes during that year. Notwithstanding, the abundant growth of Eurasian water

Map 13

AQUATIC PLANT COMMUNITY DISTRIBUTION IN OKAUCHEE LAKE: 2000



—20'— WATER DEPTH CONTOUR IN FEET

- OPEN WATER
- WATER LILIES
- EURASIAN WATER MILFOIL
- MUSKGRASS AND WILD CELERY
- WILD CELERY AND FLAT-STEM PONDWEED
- WILD CELERY, COONTAIL, WATER STAR GRASS, AND BUSHY AND CLASPING-LEAF PONDWEEDS
- MUSKGRASS, SPINY NAIAD, NATIVE WATER MILFOIL AND VARIABLE, SAGO, AND CURLY-LEAF PONDWEEDS
- MUSKGRASS, COONTAIL, WATERWEED, SPINY NAIAD, NITELLA, AND BUSHY, VARIABLE, FLAT-STEM, AND LARGE LEAF PONDWEEDS
- COONTAIL, WATER STAR GRASS, WATERWEED, NATIVE WATER MILFOIL, AND VARIABLE, CURLY-LEAF, FLAT-STEM, AND LARGE LEAF PONDWEEDS
- WILD CELERY, MUSKGRASS, COONTAIL, SPINY NAIAD, BLADDERWORT, AND BUSHY, VARIABLE, FLAT-STEM PONDWEEDS
- WILD CELERY, MUSKGRASS, COONTAIL, WATERWEED, BLADDERWORT, AND BUSHY, VARIABLE, SAGO, AND CLASPING-LEAF PONDWEEDS
- COONTAIL, WATER STAR GRASS, WATERWEED, SPINY NAIAD, NATIVE WATER MILFOIL, AND BUSHY, SAGO, VARIABLE, AND CURLY-LEAF PONDWEEDS
- WILD CELERY, MUSKGRASS, COONTAIL, WATERWEED, WATER STAR GRASS, SPINY NAIAD, NATIVE WATER MILFOIL, BLADDERWORT, AND VARIABLE, SAGO, AND FLAT-STEM PONDWEEDS
- WILD CELERY, MUSKGRASS, WATER STAR GRASS, WATERWEED, SPINY NAIAD, NATIVE WATER MILFOIL, BLADDERWORT, AND BUSHY, VARIABLE, CLASPING-LEAF, LARGE LEAF, AND ILLINOIS PONDWEEDS
- WILD CELERY, COONTAIL, WATER STAR GRASS, WATERWEED, NATIVE WATER MILFOIL, BLADDERWORT, NITELLA, AND BUSHY, VARIABLE, AND CURLY-LEAF PONDWEEDS
- WILD CELERY, COONTAIL, WATER STAR GRASS, WATERWEED, SPINY NAIAD, NATIVE WATER MILFOIL, BLADDERWORT, AND CLASPING-LEAF AND FLAT-STEM PONDWEEDS

GRAPHIC SCALE
0 650 1300 FEET

Source: SEWRPC.

DATE OF PHOTOGRAPHY: MARCH 2000

milfoil in the Lake is likely to be attributable to the highly organic lake bottom sediments, which are predominantly comprised of silt, as shown on Map 3. Such bottom sediments favor the growth of Eurasian water milfoil. Both Eurasian water milfoil and curly-leaf pondweed (*Potamogeton crispus*) are designated as invasive, nonnative plants in Chapter NR 109 of the *Wisconsin Administrative Code*.[1] Both of these species can outcompete native aquatic plant communities, leading to loss of plant diversity, degraded water quality, and reduced habitat for fish, invertebrates and wildlife.

Other common macrophytes observed in the Lake during the July 2000 survey included coontail (*Ceratophyllum demersum*), bushy pondweed (*Najas flexilis*), wild celery (*Vallisneria americana*), and muskgrass (*Chara* spp.). Muskgrass was co-dominant in most of the Lake. Healthy populations of pondweeds (*Potamogeton* spp.) were most commonly found at depths of between five and 10 feet. These plants are generally viewed as beneficial in that they provide habitat for fish and wildlife, minimize shoreline erosion, and remove nutrients from the water column that might otherwise result in excessive growth of algae. In general, Okauchee Lake supported an healthy and diverse aquatic macrophyte community that may be considered typical of meso-eutrophic lakes in Southeastern Wisconsin.

Aquatic Plant Management

Excessive macrophyte growth on Okauchee Lake has historically resulted in a control program that has used both chemical treatments and harvesting. However, records of aquatic plant management efforts on Wisconsin lakes were not maintained by the Wisconsin Department of Natural Resources (WDNR) prior to 1950. Thus, while previous interventions were likely to have occurred, the first recorded efforts to manage the aquatic plants in Okauchee Lake took place during 1950. These efforts were based upon the use of chemical herbicides. The first known, organized macrophyte harvesting program on Okauchee Lake was conducted by the Town of Oconomowoc, which harvested aquatic plants in the Lake between 1963 and 1977. Since 1977, the Okauchee Lake Management District has been conducting the aquatic plant management program on the Lake. These aquatic plant management activities can be categorized as macrophyte harvesting, chemical macrophyte control, and chemical algal control.

Chemical Controls

Perceived excessive macrophyte growths on Okauchee Lake have historically resulted in application of a chemical control program. Since 1941, the use of chemicals to control aquatic plants has been regulated in Wisconsin. Chemical herbicides are known to have been applied to Okauchee Lake from at least 1950 through 2000, as set forth in Table 19.

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 Okauchee Lake and it major lake basins during the period 1950 through 1967 are listed on Table 19. The total amount of sodium arsenite applied to the Lake over this 17-year period was about 181,580 pounds. When it became apparent that arsenic was accumulating in the sediments of treated lakes, the use of sodium arsenite was discontinued in the State during 1969. The applications and accumulations of arsenic were found to present potential health hazards to both humans and aquatic life. Notwithstanding, the concentrations of arsenic within the lake sediments of Okauchee Lake are generally within draft sediment quality criteria limits set forth by the Wisconsin Department of Natural Resources, although locally higher concentrations may occur, as noted in Chapter IV. These concentrations are not generally considered to pose an health hazard.

---

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

Table 19

CHEMICAL CONTROLS ON OKAUCHEE LAKE: 1950-2001

Year	Macrophyte Control							Algal Control		
	Sodium Arsenite (pounds)	Diquat (gallons)	Endothall (gallons)	Endothall (pounds)	Fluridone (gallons)	2,4-D (gallons)	2,4-D (pounds)	Copper Sulfate (gallons)	Copper Sulfate (pounds)	Blue Vitriol (pounds)
1950-1969	181,580	22.50	82.00	--	--	5.0	--	--	4,420.0	3,195
1970	--	11.50	16.00	--	--	270.0	--	--	330.0	--
1971	--	--	--	735.00	--	10.0	--	--	291.0	--
1972	--	--	150.00	--	--	20.0	--	--	--	--
1973	--	1.00	12.00	--	--	--	--	--	--	--
1974	--	--	11.00	379.00	--	22.0	47	--	--	--
1975	--	--	79.00	78.00	--	--	--	--	105.9	--
1976	--	--	14.80	--	--	269.0	70	--	--	--
1977	--	--	34.00	--	--	242.0	242	--	--	--
1978	--	--	48.20	70.00	--	129.5	5	--	--	--
1979	--	--	71.50	400.00	--	174.0	--	--	--	--
1980	--	--	31.00	37.25	--	207.0	--	--	--	--
1981	--	--	18.00	58.00	--	145.0	--	--	--	--
1982	--	--	53.50	32.50	--	291.0	--	--	--	--
1983[a]	--	--	--	--	--	--	--	--	--	--
1984[a]	--	--	--	--	--	--	--	--	--	--
1985	--	0.67	28.50	485.00	--	118.5	--	--	--	--
1986	--	--	8.50	--	--	237.5	--	39.75	--	--
1987	--	--	14.00	--	--	47.0	--	57.50	--	--
1988	--	2.00	5.50	10.00	--	226.0	--	10.50	--	--
1989[a]	--	--	--	--	--	--	--	--	--	--
1990[a]	--	--	--	--	--	--	--	--	--	--
1991	--	--	--	3.00	--	--	--	--	--	--
1992	--	--	1.50	--	--	--	--	--	--	--
1993[a]	--	--	--	--	--	--	--	--	--	--
1994	--	--	--	--	--	9.0	--	--	--	--
1995	--	--	--	--	--	39.9	--	--	--	--
1996	--	--	--	--	--	7.5	--	1.00	--	--
1997	--	1.75	--	--	--	--	--	1.75	--	--
1998[a]	--	--	--	--	--	--	--	--	--	--
1999	--	--	--	--	--	--	602	--	--	--
2000	--	--	--	--	--	25.0	200	--	--	--
2001	--	--	--	--	0.56	107.9	107	--	--	--
Total	181,580	39.42	806.75	2,160.00	0.56	2,601.0	924	1,005.90	5,146.9	3,195

NOTE: Values include chemicals applied to Okauchee Lake and the embayments locally known as Lower Okauchee and Upper Oconomowoc Lakes.

[a]*No chemical controls were reported during these years.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Subsequent to the discontinuation of the use of sodium arsenite, other chemical herbicides have been applied to Okauchee Lake. As shown in Table 19, the aquatic herbicides diquat, endothall, fluridone, and 2,4-D have been applied to Okauchee Lake to control aquatic macrophyte growth. The present restrictions on water use after application of these herbicides are given in Table 20, while the attributes of these common aquatic herbicides are further discussed below.

Diquat and endothall are contact herbicides and kill plant parts exposed to the active ingredient. Diquat use is restricted to the control of duckweed (*Lemna* sp.), milfoil (*Myriophyllum* spp.), and waterweed (*Elodea* sp.) in lakes in Wisconsin. However, diquat 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, but does not control such nuisance species as Eurasian water milfoil (*Myriophyllum spicatum*). To address growths of Eurasian water milfoil, 2,4-D, a systemic herbicide that is absorbed by the leaves and translocated to other parts of the plant, has been used. This herbicide is more selective than the other herbicides noted above;

Table 20

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] [c]*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.

however, 2,4-D will also kill some desirable species such as water lilies (*Nymphaea* sp. and *Nuphar* sp.). More recently, the experimental herbicide, fluridone, has been used to control Eurasian water milfoil growths in Martinique Bay, Pickerel Bay, Tierney Bay, and Bay Five. Fluridone applications were made during 2001 as part of a chemical treatment demonstration project, and are currently being monitored by the Okauchee Lake Management District to determine its effectiveness. Results obtained during 2001 and 2002 suggest that the herbicide has at least a two-year period of effectivity, with a resurgence in growth of the native aquatic plant community occurring following the control of the Eurasian water milfoil growths. In Tierney Bay, the growths of pondweed species (*Potamogeton* spp.) and water celery (*Vallisneria americana*) have recurred in such abundance as to impede navigation and cause concerns among swimmers. Consequently, the Okauchee Lake Management District has proposed limited harvesting in this Bay.

In addition to the chemical herbicides used to control large aquatic plants, algicides have also been applied to Okauchee Lake. As shown in Table 19, copper sulfate and Cutrine Plus have been applied to Okauchee Lake to control algae and swimmer's itch from time-to-time. 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 found to be harmful to humans.[2] Restrictions on water uses after application of Cutrine Plus are also given in Table 20.

[2]*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.*

Permits are required pursuant to Chapter NR 107 of the *Wisconsin Administrative Code* to apply chemical herbicides to control vegetation in lakes in Wisconsin. Herbicides must be applied by a licensed applicator, pursuant to label directions and guidelines.

Macrophyte Harvesting

The existing macrophyte control program on Okauchee Lake is based upon an aquatic management plan developed for Okauchee Lake during 1996.[3] The harvesting program emphasizes the removal of nuisance growths of aquatic plants to the extent necessary to facilitate recreational uses, rather than 100 percent plant removal. In conducting this program, the Okauchee Lake Management District currently uses four harvesters, three transport barges, and two cranes. Typically, harvesting prior to June 15 is limited to cutting access channels to facilitate navigation to piers and channels. After mid-June, the harvesting operation is expanded to include all areas of the Lake that experience nuisance plant conditions. The volume of aquatic plant biomass harvested on Okauchee Lake is averages about 62 truck loads, or approximately 682 tons, of aquatic plants removed from the Lake annually. As noted above, maintenance of navigational access channels in areas included in the chemical treatment demonstration project area has been proposed by the Okauchee Lake Management District.

Permits are required pursuant to Chapter NR 109 of the *Wisconsin Administrative Code* to cut vegetation in lakes. The harvested plant materials must be removed from the water.

AQUATIC ANIMALS

Aquatic animals include microscopic zooplankton; benthic, or bottom-dwelling, invertebrates; fish and reptiles; amphibians; mammals; and waterfowl that inhabit the Lakes and their shorelines. These make up the primary and secondary consumers of the food web.

Zooplankton

Zooplankton are microscopic animals which inhabit the same environments as phytoplankton, microscopic plants. An important link in the aquatic food chain, zooplankton feed mostly on algae and, in turn, are a good food source for fish. The seasonal succession of zooplankton species within Okauchee Lake during the 1977 study year was dominated by a spring pulse of daphniid and cyclopoid species, rotifers, and ostracods. Population cycles during the summer were variable, being affected by changes in the food supply and predation by fish and other zooplankton. The density of zooplankters remained low during the summer and into early autumn of 1977, when the study was concluded.

Fishes of Okauchee Lake

Okauchee Lake supports a relatively large and diverse fish community. The earliest recorded fisheries survey of the Lake was conducted by the Wisconsin Department of Natural Resources during 1909. Cisco and whitefish were reported to be present in the Lake at that time. Subsequently, surveys conducted by the Wisconsin Department of Natural Resources between 1946 and 1999 have reported the occurrence of 32 species of fishes in the Lake. These species are shown in Table 21.

Fishes reported to occur in the Lake during the 1975 survey included banded killifish; black crappie; blackstripe topminnow; northern pike; largemouth and rock bass; blackchin, golden and pugnose shiner; Iowa and rainbow darter; logperch; yellow perch; green sunfish; lake chubsucker; bluegill; pumpkinseed; and yellow bullhead.[4] During 1979, the Wisconsin Department of Natural Resources reported black, brown and yellow bullhead; black

[3] *Aron and Associates*, Okauchee Lake Plant Management Plan, *November 1996.*

[4] *D. Fago, Wisconsin Department of Natural Resources Report No. 148,* Retrieval and Analysis System Used in Wisconsin's Statewide Fish Distribution Survey, Second Edition, *December 1988.*

Table 21

FISH SPECIES CAPTURED IN OKAUCHEE LAKE: 1946-2002

Common Name[a]	Scientific Name	Date of Survey[b]										
		1946	1950	1960	1969	1975	1985	1992	1993	1994	1998	1999
Banded Killfish	*Fundulus diaphanus*	--	--	--	--	X	--	--	--	--	--	--
Black Crappie	*Pomoxis nigromaculatus*	X	X	X	X	X	--	X	X	X	--	X
Blackchin shiner	*Notropis heterodon*	--	--	--	--	X	--	--	--	--	--	--
Blackstriped Topminnow	*Fundulus notatus*	--	--	--	--	X	--	--	--	--	--	--
Bluegill	*Lepomis macrochirus*	X	X	X	X	X	--	X	X	X	X	X
Bluntnose Minnow	*Pimephales notatus*	X	--	--	--	--	--	--		--	--	--
Brown Bullhead	*Ictalurus nebulosus*	--	--	--	--	--	--	X	X	X	--	--
Bowfin	*Amia calva*	X	X	--	--	X	--	X	X	--	X	--
Bullheads[c]	*Ictalurus* spp.	X	X	X	X	X	--	--		--		--
Carp	*Cyprinus carpio*	X	X	--	--	X	--	X	X	X	X	X
Central Quillback Carpsucker	*Carpiodes cyprinus*	--	--	--	--	X	--	X	X	--	--	--
Golden shiner	*Notemigonus crysoleucas*	--	--	--	--	X	--	--	X	--	--	--
Grass Pickerel	*Esox americanus vermiculatus*	--	--	--	--	X	--	--	--	--	--	--
Green Sunfish	*Lopomis cyanellus*	X	--	--	X	X	--	X	--	X	--	--
Horneyhead Chub	*Nocomis biguttatus*	X	--	--	--	--	--	--	--	--	--	--
Iowa Darter	*Etheostoma exile*	--	--	--	--	X	--	--	--	--	--	--
Lake Chubsucker	*Erimyzon sucetta*	X	--	--	--	X	--	--	X	--	--	--
Largemouth Bass	*Micropterus salmoides*	X	X	X	X	X	--	X	X	X	X	X
Logperch	*Percina caprodes*	X	--	--	--	X	--	--	X	--	--	--
Longnose Gar	*Lepisosteus osseus*	--	X	--	--	--	--	--	X	--	--	--
Muskellunge	*Esox masquinongy*	--	--	--	--	--	X[e]	X	X	X	--	--[f]
Northern Blacknose Shiner	*Notropis heterolepis*	X	--	--	--	X	--	--	--	--	--	--
Northern Pike	*Esox lucius*	X	X	X	X	X	X	X	X	X	X	X
Pugnose Shiner[d]	*Notropis anogenus*	--	--	--	--	X	--	--	--	--	--	--
Pumpkinseed	*Lepomis gibbosus*	--	--	X	--	X	--	--	X	X	X	X
Rainbow Darter	*Etheostoma caeruleum*	X	--	--	--	--	--	--	--	--	--	--
Rock Bass	*Ambloplites rupestris*	X	X	X	X	X	--	X	X	X		X
Smallmouth Bass	*Micropterus dolomieui*	--	--	--	--	X		--	X	X	X	--
Walleyed Pike	*Stizostedion vitreum vitreum*	X	X	X	X	X	X	X	X	X	X	X
White sucker	*Catostomus commersoni*	--	X	--	--	X	--	--	X	--	--	--
Yellow Bullhead	*Ictalurus natalis*	--	--	--	--	--	--	X	X	--	--	--
Yellow Perch	*Perca flavescens*	X	--	--	--	--	--	X	X	X	X	X

[a] *Two additional species were noted by the Lake District Commissioners and the Wisconsin Department of Natural Resources to have been observed in the Lake. These were the White bass (*Morone chrysops*) and Lake cisco (*Coregonus artedi*).*

[b] *The intensity of sampling effort was not the same for all of the surveys.*

[c] *Yellow, brown, and black bullheads were captured.*

[d] *State-designated threatened species.*

[e] *Both true and hybrid muskullunge were captured.*

[f] *Although not captured, muskellunge are known to be present.*

Source: Wisconsin Department of Natural Resources, and SEWRPC.

crappie; bluegill; bowfin; cisco or lake herring; common carp; common, emerald and golden shiner; grass pickerel; green sunfish; largemouth and rock bass; longnose gar; northern and walleyed pike; white sucker; and yellow perch.[5] Of these, the pugnose shiner (*Notropis anogenus*) is listed by the Wisconsin Department of Natural Resources as a State threatened species. As of 2001, the Wisconsin Department of Natural Resources reported muskie or muskellunge, northern pike, and largemouth bass to be common in the Lake, and walleyed pike, smallmouth bass, and panfish to be present.[6]

These data do not indicate any major, long-term changes in the fishery of Okauchee Lake. Variations in the species sampled are likely to be the result of different sampling techniques, season, and level of effort. The data suggest that Okauchee Lake remains predominantly a bluegill, largemouth bass, and northern pike fishery.

[5] Ibid.

[6] *Wisconsin Department of Natural Resources Publication No. PUBL-FH-800 2001,* Wisconsin Lakes, *2001.*

Fisheries Management

Historically, numerous species of fish were reported to have been stocked in Okauchee Lake by the Wisconsin Department of Natural Resources as well as by private fish hatcheries. The fish stocking records for the periods between 1933 and 1978, and between 1979 and 2001, are shown in Tables 22 and 23, respectively. Prior to 1957, at least eight species were stocked in the Lake, including: bluegill, largemouth bass, walleyed pike, bullhead, perch, northern pike, smallmouth bass, and crappie. All life stages were stocked, including eggs, fry, fingerlings, and adults. Between 1933 and 1957, fish were stocked annually in all but four years. Stocking was discontinued in 1957 because of the lack of an adequate public access site.

When public access to the Lake was determined to be adequate, in 1978, the Wisconsin Department of Natural Resources introduced about 27,000 walleyed pike fingerlings into the Lake during that year, and continued to stock the Lake with walleyed pike until 1992, at which time walleye pike stocking was halted due to unfavorable recruitment. This lack of recruitment was determined by the Wisconsin Department of Natural Resources based upon the analysis of the results of annual and alternate year stocking strategies.

During 1998, the Wisconsin Department of Natural Resources again conducted a fall survey to determine the success of the walleyed pike population existing in the Lake under conditions of natural reproduction, and in the absence of stocking. This survey indicated that there were few older fish, and that those fishes were likely to be survivors from an earlier stocking. Consequently, the Wisconsin Department of Natural Resources has continued to periodically stock walleyed pike into Okauchee Lake. The Wisconsin Department of Natural Resources conducted another fall survey during 1999 to assess the survival rate of the approximately 122,000 walleyed pike fingerlings stocked earlier in that year. This survey yielded one young-of-the-year walleyed pike, suggesting an extremely poor rate of survival. However, because of some natural reproduction of walleyed pike in Okauchee Lake, the Wisconsin Department of Natural Resources fish managers suggest that future management efforts should include habitat preservation for walleyed and northern pike, and bass.

A muskellunge management program, consisting of the stocking of muskellunge and hybrid, or tiger, muskellunge, was initiated in Okauchee Lake by the Wisconsin Department of Natural Resources during 1981. Since then, with the exception of 1990, the Lake has been stocked annually with fingerlings and/or yearlings of either one or both of these species. This program is reported to have generated much enthusiasm among anglers in the Okauchee Lake area and within southeastern Wisconsin. Okauchee Lake is one of the two lakes in Waukesha County to be actively stocked with muskellunge, the other being Pewaukee Lake.[7] Based upon subsequent surveys by the Wisconsin Department of Natural Resources, both Lakes are reported to have productive muskellunge fisheries. As of 1992, the Wisconsin Department of Natural Resources had reported no detrimental impacts of this stocking program on other species of fish.

Important predator fishes in Okauchee Lake include largemouth bass, northern pike, and muskellunge. These fish species are considered to be common. Walleyed pike and smallmouth bass are considered to be present. These species are carnivorous, feeding primarily on other fish, crayfish and frogs. These species are among the largest and most prized game fish sought by Okauchee Lake anglers.

The Oconomowoc River, between North Lake and Okauchee Lake, is reported by the Wisconsin Department of Natural Resources to be heavily used by both northern pike and walleyed pike for spawning. The gravel and rubble riffle areas and shallow pools within the Oconomowoc River are suitable for reproduction by these species. The shallow marsh areas bordering the Oconomowoc River are also used by northern pike for spawning. The Oconomowoc River is considered vital to the continued natural reproductive success of these game fishes in Okauchee Lake.

---

[7]*See SEWRPC Community Assistance Planning Report No. 58, 2nd Edition,* A Lake Management Plan for Pewaukee Lake, Waukesha County, Wisconsin, *in preparation, 2002.*

Table 22

OKAUCHEE LAKE FISH STOCKING RECORD: 1933-1978

Year	Bass[a]	Bass, Perch and Bluegill (combined)	Black Bass	Bluegill	Bullhead	Black Crappie	Black Crappie and Bluegill (combined)	Largemouth Bass	Northern Pike	Pickerel[b]	Perch	Smallmouth Bass	Pumpkinseed	Walleyed Pike
1933	--	--	154[c]	--	--	--	--	--	--	--	--	--	--	748,150[c]
1934	--	--	784 fingerlings	--	--	--	--	--	--	--	--	--	--	112,860 fry
1935	800[c]	2,000[c]	5,750 fingerlings	7,500 fingerlings	--	--	3,500[c]	--	--	1,500 fingerlings	700,000 fry	--	--	4,614,920 fry
1936	680[c]	--	2,000[c]	1,316[c]	116[c]	800[c]	--	--	--	500[c]	926[c]	--	--	2,400,600 fry
1937	--	--	--	11,000 adults	--	2,000 adults	--	13,750 fingerlings	1,500 fingerlings	--	11,000 adults, 28,000 fingerlings, 12,250,000 fry	80 adults	--	6,140,000 fry
1938	--	--	--	--	--	--	--	9,000 fingerlings	5,000 fingerlings	--	--	--	--	4,312,000 fry
1939	--	--	--	--	300 adults, 600 fingerlings, 4,000 yearlings	--	--	9,700 fingerlings	143,865 fry	--	2,000 adults, 6,000 fingerlings, 11,827,000 eggs	--	900 adults, 2,500 fingerlings	3,524,800 fry
1940	--	--	--	--	--	--	--	10,200 fingerlings	--	--	11,827,000 eggs	--	--	3,524,800 fry
1941	--	--	--	2,000 fingerlings	--	--	--	16,000 fingerlings	--	--	11,612,160 eggs	--	--	5,500,000 fry
1942	--	--	--	10,000 fingerlings	--	--	--	8,000 fingerlings	--	--	1,720,320 eggs	--	--	2,500,000 fry
1943	--	--	--	--	--	--	--	6,000 fingerlings	--	--	--	--	--	3,000,000 fry
1944	--	--	--	4,000 fingerlings	--	--	--	5,000 fingerlings	--	--	--	--	--	1,000,000 fry
1945	--	--	--	--	5,000 adults	--	--	4,000 fingerlings	--	--	--	--	--	2,000 fingerlings
1946	--	--	--	--	--	--	--	4,000 fingerlings	--	--	--	--	--	1,200,000 fry
1947	--	--	--	--	--	--	--	4,000 fingerlings	--	--	--	--	--	2,100,000 fry

Table 22 (continued)

Year	Bass[a]	Bass, Perch and Bluegill (combined)	Black Bass	Bluegill	Bullhead	Black Crappie	Black Crappie and Bluegill (combined)	Largemouth Bass	Northern Pike	Pickerel[b]	Perch	Smallmouth Bass	Pumpkinseed	Walleyed Pike
1948	--	--	--	--	--	--	--	4,000 fingerlings	--	--	--	--	--	--
1949	--	--	--	--	--	--	--	10,625 fingerlings	--	--	--	--	--	--
1952	--	--	--	--	--	--	--	6,250 fingerlings	--	--	--	--	--	--
1953	--	--	--	--	--	--	--	--	--	--	--	--	--	31,000 fingerlings
1956	--	--	--	550 adults	--	--	--	181 adults	--	--	--	--	--	7,900 fingerlings
1978	--	--	--	--	--	--	--	--	--	--	--	--	--	27,000 fingerlings

NOTE: No stocking occurred during 1950; 1951; 1954; 1955; and 1957 through 1977.

[a] *It is not known whether these stock bass were smallmouth or largemouth.*

[b] *These fish are possible northern pike rather than pickerel.*

[c] *Size and age class unknown; a fry is a newly hatch fish; a fingerling is a fish in its first year; and a yearling is an immature fish.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 23

OKAUCHEE LAKE FISH STOCKING RECORD: 1979-2001

Year	Largemouth Bass (number and size)	Muskellunge (number and size)	Muskellunge Hybrid (number and size)	Northern Pike (number and size)	Walleyed Pike (number and size)
1979	--	--	--	--	60,000 fingerlings
1980	--	--	--	--	2,200,000 fry
1981	--	--	1,230 fingerlings	--	60,000 fingerlings
1982	--	500 fingerlings	500 fingerlings	--	71,400 fingerlings
1983	--	305 fingerlings	1,000 fingerlings	--	--
1984	--	500 fingerlings	1,900 fingerlings	--	1,200,000 fry
1985	--	500 fingerlings	500 fingerlings	--	124,000 fingerlings
1986	--	500 fingerlings	1,200 fingerlings	--	60,000 fingerlings
1987	--	637 fingerlings	500 fingerlings	--	--
1988	--	1,000 fingerlings	500 fingerlings	--	--
1989	--	500 fingerlings	500 fingerlings	--	60,000 fingerlings
1990	--	--	--	--	105,000 fingerlings
1991	--	1,700 fingerlings	--	--	--
1992	2,900 yearlings	3,250 fingerlings	--	--	115,000 fingerlings
1993	--	2,018 fingerlings	--	--	--
1994	--	111 yearlings	--	--	--
1995	--	--	--	--	--
1996	--	5,003 fingerlings	--	--	--
1997	--	110,000 yearlings, 5,000 fingerlings	--	--	--
1998	--	276 fingerlings	--	--	--
1999	--	166 yearlings,[a] 4,386 fingerlings	--	--	122,149 fingerlings
2000	--	108 yearlings, 250 fingerlings	--	--	--
2001	--	2,374 fingerlings	--	--	--

[a]*Private stocking.*

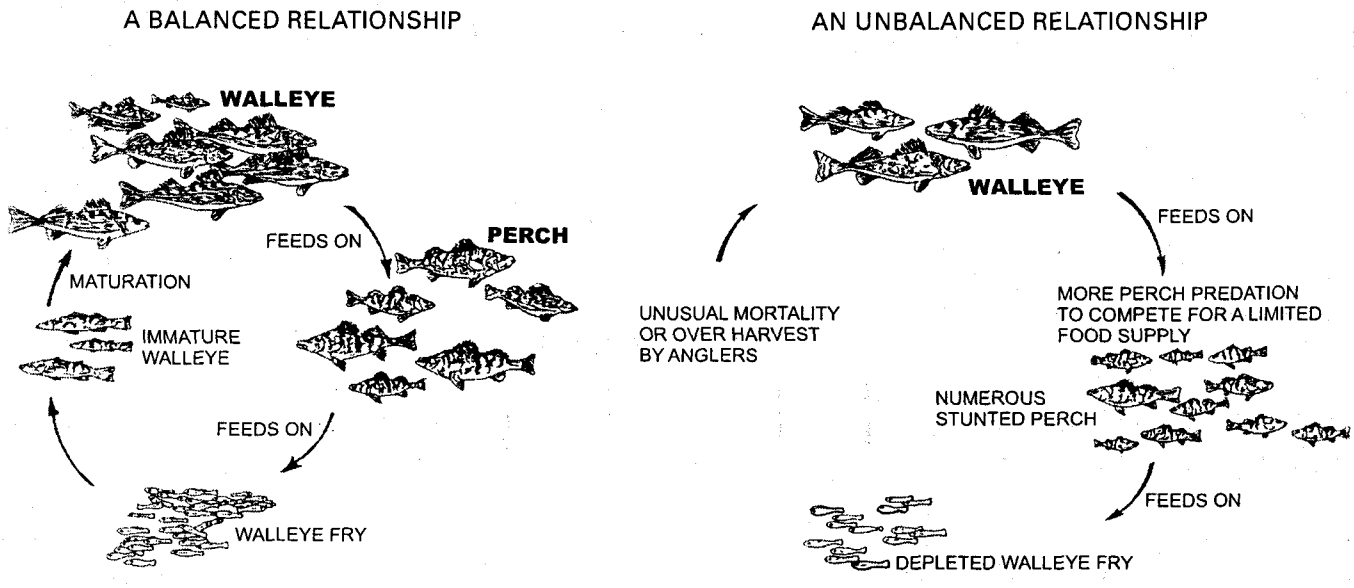
Source: Wisconsin Department of Natural Resources and SEWRPC.

A wide range of panfish is also present in the Lake, as shown in Table 21. "Panfish" is a common term applied to a broad group of smaller fish with a relatively short and usually, but not always, broad shape. Panfish species known to exist in Okauchee Lake include bluegill, pumpkinseed, rock bass, yellow perch, green sunfish, and black crappies. 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, typically leads to large populations with rapid turnover. Panfish frequently feed on the fry of predator fish and, if the panfish population is overabundant, they may quickly deplete the predator fry population. As a consequence, some lakes within Southeastern Wisconsin have stunted, or slow-growing, panfish populations because their numbers are not controlled by predator fishes. Figure 14 illustrates the importance of a balanced predator-prey relationship, using walleyed pike and perch as an example.

Bluegill are reported by the Wisconsin Department of Natural Resources to dominate the species composition of the panfish assemblage in Okauchee Lake, with black crappie, rock bass, green sunfish, pumpkinseed, and yellow perch also reported as being present in recent surveys. The proportion of bluegill recorded in the Wisconsin Department of Natural Resources fisheries surveys was reported to have remained fairly stable between 1992 and 1994. However, the fall fisheries surveys conducted by the Wisconsin Department of Natural Resources during 1998 and 1999 suggest a potential overharvest of larger bluegills, which, ultimately, may cause an imbalance in the slow-growing panfish population in the Lake. This situation will be monitored by the Wisconsin Department of Natural Resources.

Figure 14

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources.

"Rough fish" is a broad term applied to species, such as carp, that do not readily bite on hook and line, but feed on game fish and destroy habitat needed by more desirable species. Rough fish are commonly considered to be undesirable for human consumption in Southeastern Wisconsin. Rough fish species that were historically found in Okauchee Lake include bowfin, carp, and white sucker. According to the Wisconsin Department of Natural Resources, carp have been detected in recent fishery surveys in Okauchee Lake, but do not represent a significant problem.[8]

Fish kills have been reported on seven different occasions in Okauchee Lake. A partial winter kill occurred in a few shallow localized bays during the winter of 1976-1977. Fish kills also occurred during the summers of 1966, 1974, and 1976. These kills, which all occurred during June, also occurred in shallow bays and were probably caused by spawning stress as well as dissolved oxygen depletion. Kills of cisco were reported in the late summers of 1909, 1955, 1966, and 1990. Cisco require cool water temperatures to exist, and death may occur when the cooler, deeper waters beneath the thermocline becomes depleted of dissolved oxygen. Thus, these fish kills may be related to either thermal stress or lack of dissolved oxygen, or a combination of these factors. In general, the fish kills in Okauchee Lake have been infrequent and limited in extent and severity. The fish populations have not been seriously affected by these occasional kills.

Okauchee Lake is currently passively managed for the production of bluegills and yellow perch, and actively managed for the production largemouth bass, and walleyed and northern pike. As shown in Table 22, the Lake is actively stocked by the Wisconsin Department of Natural Resources, which also stocks the Lake with muskellunge to enhance and maintain sport fishing opportunities for anglers. The Wisconsin Department of

[8]*According to the Wisconsin Department of Natural Resources, carp are typically considered a significant problem if they are the most populous fish species in the lake, or if they appear stressed or cause stress among other fish populations in the lake.*

Natural Resources plans to continue to stock Okauchee Lake, depending on the availability of fishes from the Department's fish hatcheries. Passive fisheries management is accomplished through regulation of the harvest of fishes from the Lake, as implemented under current state fishing regulations. The 2001-2002 regulations governing the harvest of fishes from the waters of the State are summarized in Table 24.

OTHER WILDLIFE

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the Okauchee Lake study, it is possible, by polling naturalists and wildlife managers familiar with the area, to compile lists 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 Okauchee Lake area, associating these lists with the historic and remaining habitat areas in the Okauchee Lake area as inventoried, and projecting the appropriate amphibian, reptile, bird, and mammal species into the Okauchee Lake area. The net result of the application of this technique is a listing of those species which were probably once present in the drainage 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.

A variety of mammals, ranging is size from large animals like the white-tailed deer, to small animals like the meadow vole, are found in the drainage area tributary to Okauchee Lake. Mink, muskrat, beaver, white-tailed deer, coyote, red fox, gray squirrel, and cottontail rabbit are mammals reported to frequent the area. Table 25 lists 38 mammals whose ranges are known to extend into the Okauchee Lake drainage area.

A large number of birds, ranging in size from large game birds to small songbirds, are found in the drainage area tributary to Okauchee Lake. Table 26 lists those birds that normally occur in the drainage area tributary to Okauchee Lake. 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 Okauchee Lake drainage area also supports a significant population of waterfowl, including mallards and Canada geese. Mallards, wood duck, and blue-winged teal are the most numerous waterfowl and are known to nest in the area. Larger numbers move through the drainage area during the annual migrations when most of the regional species may also be present. Many game birds, songbirds, waders, and raptors also reside or visit the Lake or its environs. Osprey and loons are notable migratory visitors.

Because of the mixture of lowlands 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, woodpeckers, nuthatches, flycatchers, and several other species serve as major insect predators. In addition to their ecological roles, such 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 Okauchee Lake include the great egret, Osprey, cerulean warbler, and Arcadian flycatcher. Endangered species in the vicinity of Okauchee Lake include the loggerhead shrike, the Caspian tern, Forster's tern, and the common tern.

Amphibians and reptiles are vital components of the ecosystem within an environmental unit like that of the Okauchee Lake drainage area. Examples of amphibians native to the area include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the Okauchee Lake area. Table 27 lists the 14 amphibian and 15 reptile species normally expected to be present in the drainage area tributary to Okauchee Lake under present conditions, and identifies those species most sensitive to urbanization. Most amphibians and reptiles have specific 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 in migration routes, and changes in food sources brought about by urbanization.

Table 24

FISHING REGULATIONS APPLICABLE TO OKAUCHEE LAKE: 2003-2004

Species	Open Season	Daily Limit	Minimum Size
Northern Pike	May 3 to March 1	2	26 inches
Walleyed Pike	May 3 to March 1	5	15 inches
Largemouth and Smallmouth Bass	May 3 to March 1	5 in total	14 inches
Muskellunge	May 3 to November 30 (Southern Zone)	1	34 inches
Cisco	Open all year	25 pounds, plus one fish	None
Bluegill, Pumpkinseed (sunfish), Crappie, and Yellow Perch	Open all year	25 in total	None
Rock and White Bass	Open all year	None	None
Bullhead and Rough Fish	Open all year	None	None

Source: Wisconsin Department of Natural Resources Publication No. PUBL-FH-301 2003, Guide to Wisconsin Hook and Line Fishing Regulations 2003-2004, *January 2003; and SEWRPC.*

The complete spectrum of wildlife species originally native to Waukesha County, along with their habitat, has 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; road salting for snow and ice control; heavy motor vehicle traffic that produces disruptive noise levels and air pollution and nonpoint source water pollution; and the introduction of domestic pets.

Wildlife habitat areas remaining in the Region were inventoried by the Regional Planning Commission in 1985 in cooperation with the Wisconsin Department of Natural Resources. 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 such a way that the proper predatory-prey (consumer-food) relationships can occur. In addition, a reproductive interdependence must exist.

2. Territorial Requirements: The maintenance of proper spatial relationships among species, allowing 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.

5. Disturbance: Minimum levels of disturbance from human activities are necessary, other than those activities of a wildlife management nature.

Table 25

MAMMALS OF THE OKAUCHEE 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.*

On the basis of these five criteria, the wildlife habitat areas in the drainage area tributary to Okauchee Lake 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, but may, nevertheless, 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 range in an area.

As shown on Map 14, about 275 acres, or about 5 percent of the drainage area tributary to Okauchee Lake, were classified in the 1985 inventory as Class I habitat; 303 acres, or about 5 percent, were classified as Class II habitat; and 204 acres, or about 4 percent, were classified as Class III habitat.

WETLANDS

Wetlands are defined by the Regional Planning Commission 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 and the U.S. Environmental Protection Agency, is essentially the same as the definition used by the U.S. Natural Resource Conservation Service.[9]

[9]*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 the land reverts back to wetland, the land would then be subject to Federal wetland regulations.*

Table 26

BIRDS KNOWN OR LIKELY TO OCCUR IN THE OKAUCHEE 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
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 Wigeon[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[b]	--	--	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

Table 26 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Accipitridae (continued)			
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
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
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	--

Table 26 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Strigidae (continued)			
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
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

Table 26 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
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
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

Table 26 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Parulidae (continued)			
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
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]	R	--	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
Northern Oriole	X	--	X

Table 26 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
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: 219
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

[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; Wisconsin Department of Natural Resources; and SEWRPC.*

Another definition, which is applied by the State of Wisconsin Department of Natural Resources, and which is set forth in Chapter 23 of the *Wisconsin Statutes*, 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 Wisconsin Department of Natural Resources definition differs from the Regional Planning Commission definition in that the Wisconsin Department of Natural Resources considers very poorly drained, poorly drained, and some of the somewhat poorly drained soils as wetland soils meeting the State "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.[10]

[10]*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.*

Table 27

AMPHIBIANS AND REPTILES OF THE OKAUCHEE 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,d,e]	*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[f]	*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	--
Queen Snake[b,e]	*Regina septemvittata*	--	X
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	X	--
Chicago Garter Snake	*Thamnophis sirtalis semifasciata*	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] *Identified as endangered in Wisconsin.*

[c] *Identified as a special concern species in Wisconsin.*

[d] *Historically documented from Okauchee Lake.*

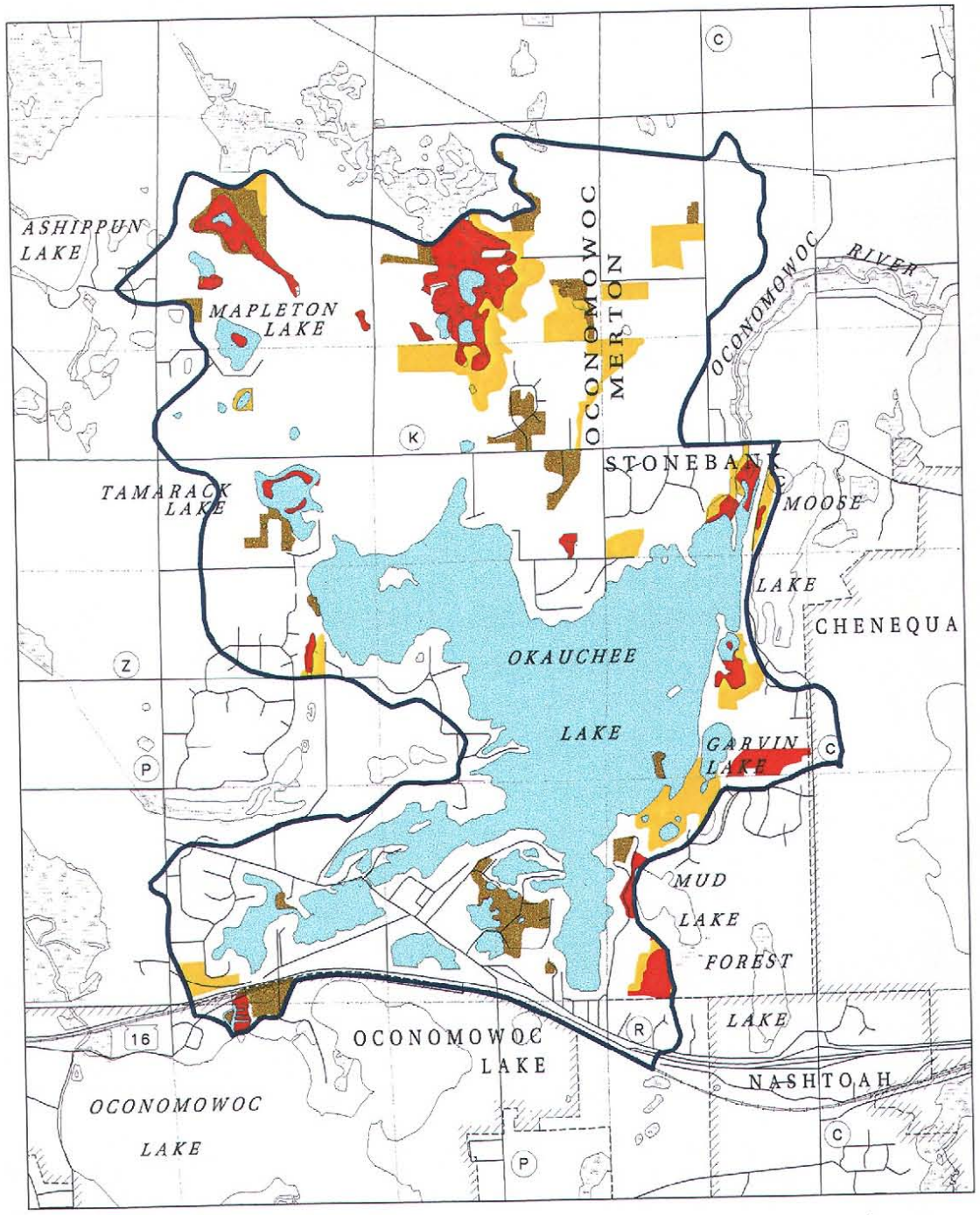
[e] *Identified in the upstream watershed.*

[f] *Identified as threatened in Wisconsin.*

Source: *Gary S. Casper,* Geographical Distribution of the Amphibians and Reptiles of Wisconsin, *1996, Wisconsin Department of Natural Resources, and SEWRPC.*

Map 14

WILDLIFE HABITAT AREAS WITHIN THE DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE: 1985



Source: SEWRPC.

As a practical matter, experience has shown that application of the Wisconsin Department of Natural Resources, the U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, and the Regional Planning Commission 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, southern sedge meadow, fresh (wet) meadow, shrub carr, alder thickets, low prairie, fens, bogs, southern wet- and wet-mesic hardwood forest, and conifer swamp. Wetlands form an important part of the landscape in and adjacent to Okauchee Lake in that they perform an important set of natural functions that make them ecologically and environmentally invaluable resources. Wetlands affect the quality of water by acting as a filter or a buffer zone allowing silt and sediments to settle out. They also influence the quantity of water by providing water during periods of drought and holding it back during periods of flood. When located along shorelines of lakes and streams, wetlands help protect those shorelines from erosion. Wetlands also may serve as groundwater discharge and recharge areas, in addition to being important resources for overall ecological health and diversity by providing essential breeding and feeding grounds, shelter, and escape cover for many forms of fish and wildlife.

Wetlands are poorly suited to urban use. This is due to the high soil compressibility and instability, high water table, low load-bearing capacity, and high shrink-swell potential of wetland soils, and, in some cases, to the potential for flooding. In addition, metal conduits placed in some types of wetland soils may be subject to rapid corrosion. These constraints, if ignored, may result in flooding, wet basements and excessive operation of sump pumps, unstable foundations, failing pavements, broken sewer and water lines, and excessive infiltration of clear water into sanitary sewerage systems. In addition, there are significant onsite preparation and maintenance costs associated with the development of wetlands, particularly as they relate to roads, foundations, and public utilities.

The Regional Planning Commission maintains an inventory of wetlands within the Region, which is updated every five years. As shown on Map 15, as of 1995, wetlands covered about 189 acres, or about 3 percent of the direct drainage area tributary to Okauchee Lake, and about 6,008 acres, or about 12 percent of the total drainage area tributary to the Lake. The amount and distribution of wetlands in the area should remain relatively constant if the recommendations contained in the adopted regional land use plan are followed.

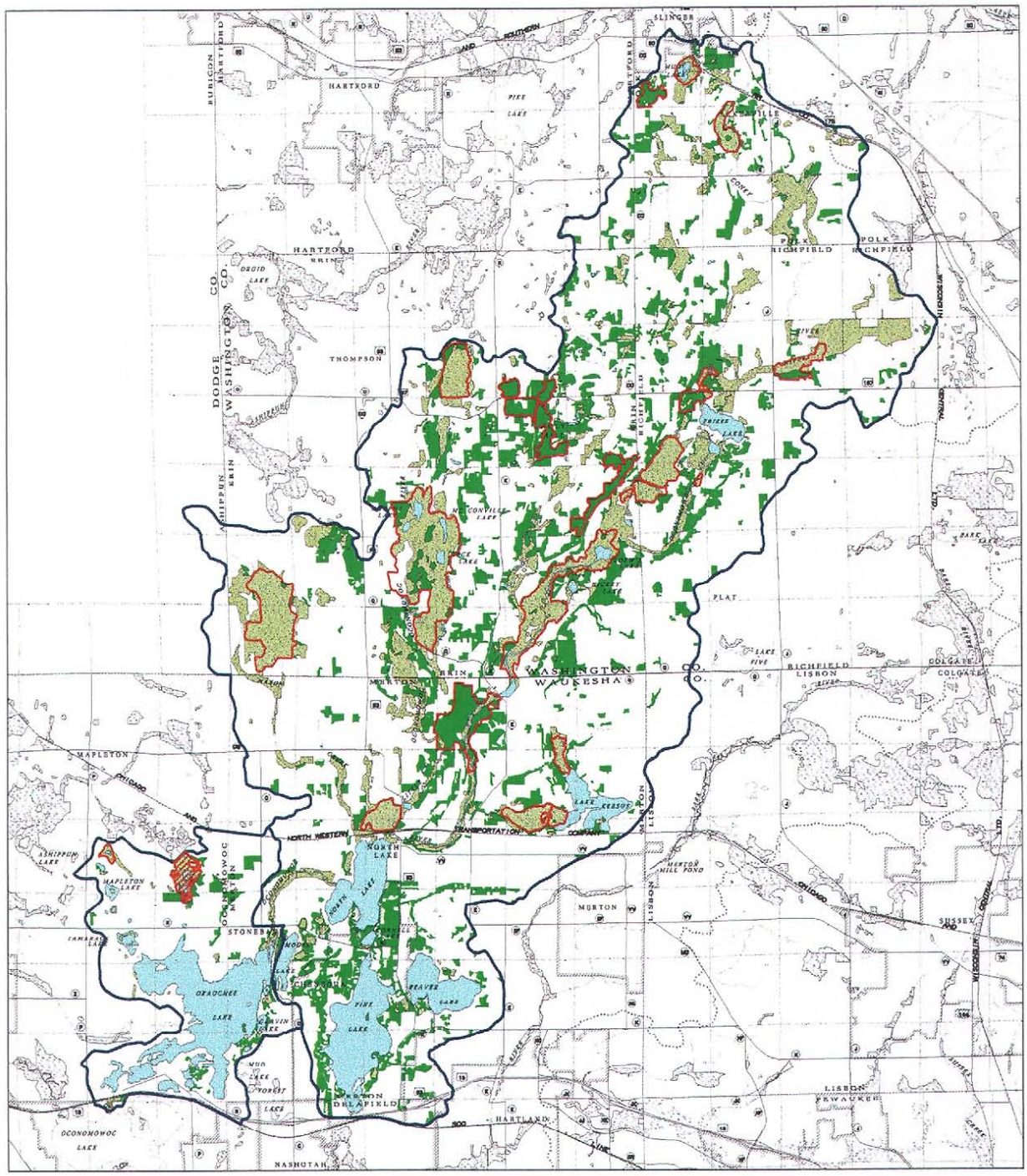
The major wetland communities located in the drainage area directly tributary to Okauchee Lake, shown on Map 15, include deep and shallow marsh, sedge meadow, fresh (wet) meadow, and shrub carr. Table 28 characterizes the wetland plant species typically found in the drainage basin.

Lowland forests in the Okauchee Lake drainage basin include southern wet to southern wet-mesic hardwood forests which are characterized by the prevalence of black willow (*Salix nigra*), cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), silver maple (*Acer saccharinum*), and American elm (*Ulmus americans*).

Sedge meadows are considered to be 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 dogwoods, and sedges are replaced by such exotic plants as honeysuckle (*Lonicera* sp.), buckthorn (*Rhamnus* sp.), and the very aggressive reed canary grass (*Phalaris arundinacea*). The highest quality sedge meadows in the basin are located in the wetland complex adjacent to the Oconomowoc River and Oconomowoc sedge meadow in Section 14, Township 8 North, Range 17 East.

Map 15

WETLANDS AND WOODLANDS WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE: 1995



Source: SEWRPC.

Table 28

EMERGENT WETLAND PLANT SPECIES IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OKAUCHEE LAKE

Typhaceae	
Typha latifolia	Broad-leaf cattail
Typha angustifolia	Narrow-leaf cattail
Sparganiaceae	
Sparganium eurycarpum	Common bur-reed
Gramineae	
Glyceria striata	Fowl manna grass
Phragmites communis	Tall reed grass
Calamogrostis canadensis	Canada blue-joint grass
Spartina pectinata	Prairie cord grass
Phalaris arundinacea[a]	Reed canary grass
Cyperaceae	
Scirpus validus	Soft-stem bulrush
Scripus acutus	Hard-stem bulrush
Scirpus atrovirens	Green bulrush
Carex stricta	Tussock sedge
Carex lacustris	Lake sedge
Carex spp.	Sedges
Iridaceae	
Iris versicolor	Blue flag iris
Salicaceae	
Salix nigra	Black willow
Salix exigua	Sandbar willow
Salix discolor	Pussy willow
Ulmaceae	
Ulmus americana	American elm
Polygonaceae	
Rumex orbiculatus	Water dock
Polygonum natans	Smartweed
Aceraceae	
Acer negundo	Boxelder
Rhamnaceae	
Rhamnus cathartica[a]	Common buckthorn
Lythraceae	
Decodon verticillatus	Water willow
Lythrum salicaria[a]	Purple loosestrife
Umbelliferae	
Angelica atropurpurea	Angelica
Oxypolis rigidior	Cowbane
Cornaceae	
Cornus amomum	Silky dogwood
Cornus stolonifera	Red-osier dogwood
Oleaceae	
Fraxinus pennsylvanica	Green ash
Asclepiadaceae	
Asclepias incarnata	Marsh milkweed
Verbenaceae	
Verbena hastata	Blue vervain
Labiatea	
Pycnanthemum virginianum	Mountain mint
Lycopus uniflorus	Northern bugleweed
Lycopus americanus	Cutleaf bugleweed
Mentha arvensis	Wild mint
Caprifoliaceae	
Sambucus canadensis	Elderberry
Cucurbitaceae	
Echinocystis lobata	Wild cucumber
Compositae	
Bidens coronata	Bur marigold
Ambrosia trifida	Giant ragweed
Solidago gigantea	Giant goldenrod
Aster Novae-angliae	New England aster
Aster puniceus	Red-stemmed aster
Aster luciduous	Swamp aster
Eupatorium maculatum	Joe-pye weed
Eupatorium perfoliatum	Boneset

NOTE: This table is presented in taxonomic order.

[a]*Alien or nonnative plant species.*

Source: SEWRPC.

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 Okauchee Lake drainage basin and are largely associated with southern sedge meadows, shallow marshes, and shrub carrs. Many of the fresh (wet) meadows have been subject to alterations such as plowing, grazing, and water level changes and are subsequently dominated by the European strain of reed canary grass, rather than Canada blue-joint grass.

Several small, shallow, and deep marshes are scattered throughout the western portion of the direct tributary drainage area and along the Oconomowoc River. These areas are dominated by broad leaf and narrow leaf cattail (*Typha* spp.) and their hybrids, bur-reed (*Sparganium eurycarpum*), lake sedge (*Carex lacustris*), bulrush (*Scirpus* sp.), common reed (*Phragmites communis*), and water willow (*Decodon verticillatus*).

WOODLANDS

Woodlands are defined by the Regional Planning Commission as those areas containing a minimum of 17 trees per acre with a diameter of at least four inches at breast height (4.5 feet above the ground).[11] The woodlands are classified as dry, dry-mesic, mesic, wet-mesic, wet hardwood, and conifer swamp forests; the last three are also considered wetlands. The Regional Planning Commission also maintains an inventory of woodlands within the Region that is updated every five years. As of 1995, approximately 260 acres of woodland were inventoried in the drainage area directly tributary to Okauchee Lake, as shown on Map 15. These woodlands covered about 4 percent of the drainage area. About 7,124 acres, or about 14 percent of the total drainage area tributary to Okauchee Lake, was considered to be woodland.

The major tree species include species characteristic of a range of woodland types, including southern dry hardwood forests, southern dry-mesic hardwood

[11] *"Refining the Delineation of the Environmental Corridors in Southeastern Wisconsin," SEWRPC* Technical Record, *Vol. 4, No. 2, March 1981.*

forests, and southern mesic hardwood forests. These woodlands are characterized by white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), black cherry (*Prunus serotina*), red cedar (*Juniperus virginiana*), northern red oak (*Quercus borealis*), white ash (*Fraxinus americana*), basswood (*Tilia americana*), and sugar maple (*Acer saccharum*).

Woodlands within the Okauchee Lake drainage area occur as scattered woodlots, primarily along the southeastern, southwestern, and northern shores of the Lake, with some relatively large, contiguous tracts in the northern portion of the drainage area directly tributary to Okauchee Lake. Most of these wooded tracts contain southern dry to dry-mesic hardwoods, although a single stand of southern mesic hardwoods, dominated by large mature sugar maple trees, is located in the southwest one-quarter of Section 18 in the Town of Merton. The amount and distribution of woodlands in the area should also remain relatively stable if the recommendations contained in the regional land use plan are followed. However, if urban development is allowed to continue within the watershed, much of the remaining woodland cover may be expected to be lost.

ENVIRONMENTAL CORRIDORS

One of the most important tasks undertaken by the Regional Planning Commission in its work program has been the identification and delineation of those areas of the Region having concentrations of natural, recreational, historic, aesthetic, and scenic resources and which, as such, 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 maps results in an essentially linear pattern of relatively narrow, elongated areas which have been termed "environmental corridors" by the Commission. Primary environmental corridors include a wide variety of the aforementioned 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 within the drainage area tributary to Okauchee Lake are contiguous with environmental corridors and isolated natural areas lying within the Oconomowoc River watershed, and, consequently, meet these size and natural resource element criteria.

It is important to note 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 in interconnected lake and stream ecosystems. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater that serves as a source of domestic, municipal, and industrial water supplies 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 in more rapid runoff and increased flooding, as well as in the destruction of wildlife habitat. Although the effects of any one of these environmental changes may not in and of itself be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the remaining environmental corridors within the drainage area tributary to Okauchee Lake thus becomes apparent and critical.

Primary Environmental Corridors

Primary environmental corridors were first identified within the Region in 1963 as part of the original regional land use planning effort of the Commission, and were subsequently refined under the Commission watershed studies and regional park and open space planning programs. 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 the major bodies of surface water and related undeveloped floodlands and shorelands.

Primary environmental corridors in the Okauchee Lake drainage area are shown on Map 16. About 604 acres, or 11 percent of the drainage area directly tributary to Okauchee Lake, were identified as primary environmental corridor.

Primary environmental corridors are subject to urban encroachment because of their desirable natural resource amenities. Unplanned or poorly planned intrusion of urban development into these corridors not only tends to destroy the very resources and related amenities sought by the development, but also tends to create severe environmental and developmental problems as well. These problems include, among others, water pollution, flooding, wet basements, failing foundations for roads and other structures, and excessive infiltration of clear water into sanitary sewerage systems. The preservation of as yet undeveloped corridors is one of the major ways in which the water quality can be protected and perhaps improved at relatively little additional cost to the taxpayers of the area.

Within the drainage area tributary to Okauchee Lake, the riverbanks 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.[12]

Within the drainage area directly tributary to Okauchee Lake, the Oconomowoc Sedge Meadow, a 19-acre natural area of local significance, designated as an NA-3 natural area in the adopted regional natural areas and critical species habitat protection and management plan, is recommended for acquisition by a private conservancy organization. The Stonebank Tamarack Relict, a 166-acre critical species habitat area, has been identified in the plan as a habitat area for rare or special concern and uncommon bird species, partially under protective ownership. The remaining portions of this wetland are recommended for acquisition by a private conservancy organization.

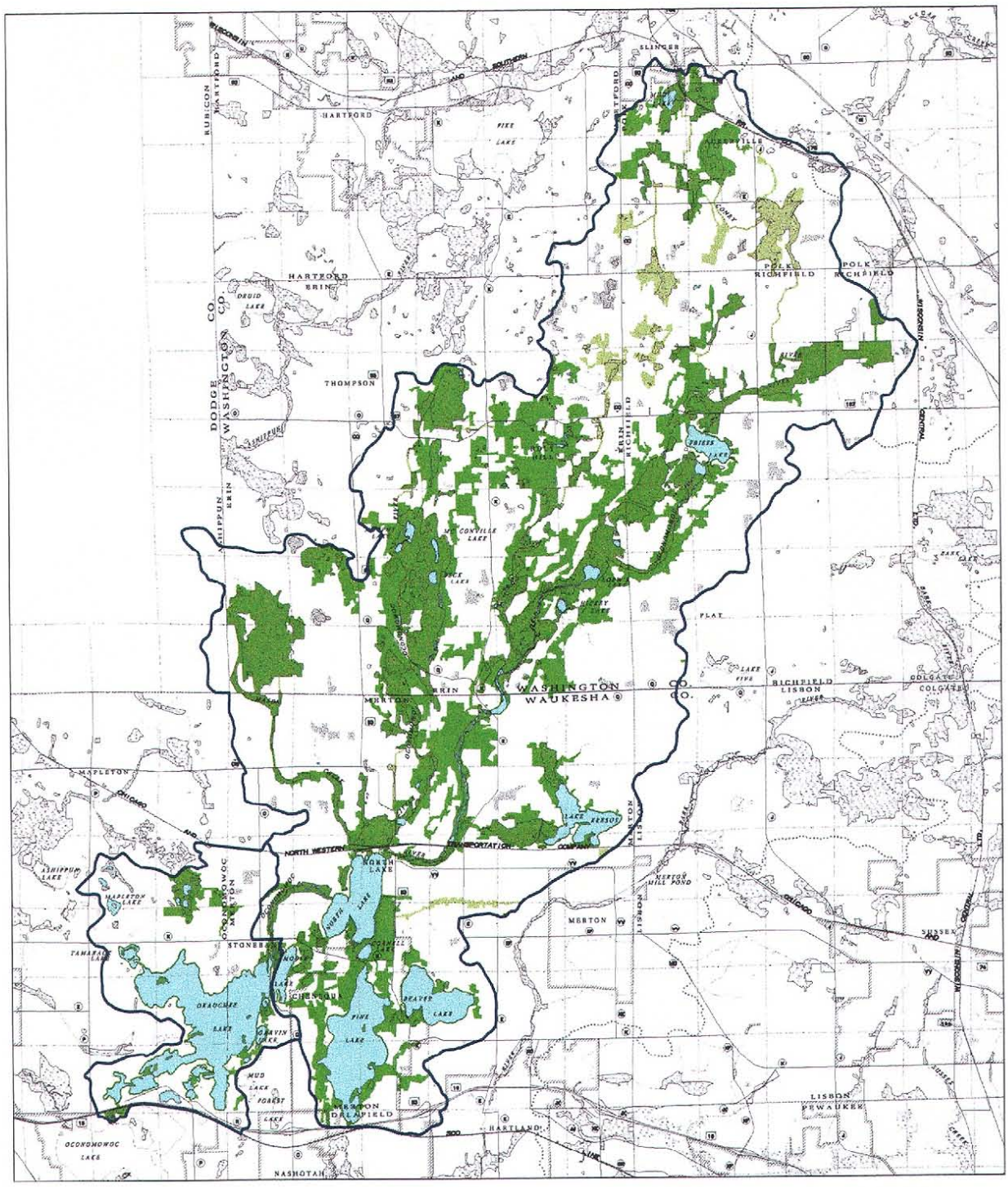
Within the portion of the total tributary drainage area to Okauchee Lake within Waukesha County, the Monches Woods, a 322-acre natural area of statewide significance, designated as an NA-1 natural area in the adopted regional natural areas and critical species habitat protection and management plan, is recommended for expansion of the current County ownership. The Lake Keesus Fen-Meadow, 141-acre natural area of countywide or regional significance, designated as an NA-2 natural area in the adopted regional natural areas and critical species habitat protection and management plan, is recommended for expansion of the current Department of Natural Resources ownership. The Camp Whitcomb Lowland, a 48-acre NA-3 designated site, is recommended for expansion of the existing ownership by the Camp, while the Chenequa Wetland Complex, a 111-acre NA-3 designated site, is recommended for County acquisition.

Within the portion of the total tributary drainage area to Okauchee Lake within Washington County, the NA-2 designated, 228-acre Friess Lake Tamarack Swamp is recommended for state acquisition. In addition, the NA-2 designated, 256-acre Holy Hill Woods, the 21-acre Daniel Boone Bogs, the 60-acre Glacier Hills Park Bogs and

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

Map 16

ENVIRONMENTAL CORRIDORS AND NATURAL AREAS WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO OKAUCHEE LAKE: 1995



Source: SEWRPC.

Upland Woods, the 54-acre Mud Lake Upland Woods, and the 59-acre Mud Lake Meadow, are recommended for acquisition by Washington County, as is the 94-acres, NA-3 designated Heritage Trails Bog. The Murphy Lake-McConville Lake Wetland Complex, a 890-acre NA-1 designated site, is recommended for expansion of The Nature Conservancy ownership. The NA-3 designated, 137-acre Donegal Road Woods, and the 11-acre St. Augustine Road Sedge Meadow, both within the Loew Lake Unit of the Kettle Moraine State Forest, are recommended for acquisition by the Wisconsin Department of Natural Resources. The NA-3 designated Mason Creek Swamp, a 432-acre wetland site, is recommended for expansion of the existing ownership by the University of Wisconsin. In addition, the 182-acre Thompson Swamp, the 100-acre CTH J Swamp, and the 11-acre Hubertus Road Sedge Meadow, are NA-3 designated sites recommended for acquisition by private conservancy organizations.

Secondary Environmental Corridors

Secondary environmental corridors in the drainage area tributary to Okauchee Lake are generally located along intermittent streams or serve as links between segments of primary environmental corridors. These secondary environmental corridors contain a variety of resource elements, and often contain remnants from primary environmental corridors that have been developed for agricultural purposes or urban land uses. As shown on Map 16, secondary environmental corridors encompass about 1,116 acres, or about 2 percent, of the total drainage area tributary to Okauchee Lake.

Secondary environmental corridors 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. Such corridors, while not as important as the primary environmental corridors, should be preserved in essentially open, natural uses as urban development proceeds within the direct drainage area, particularly when opportunity is presented to incorporate the corridors into urban stormwater detention areas, associated drainageways, and neighborhood parks.

Isolated Natural Area

In addition to the primary environmental corridors, other, small concentrations of natural resource base elements exist within the drainage area directly tributary to Okauchee Lake. As of 1995, about 106 acres, or 2 percent of the drainage area, was identified as isolated natural features, as shown on Map 16.

These resource base elements are isolated from the environmental corridors by urban development or agricultural uses and, although separated from the environmental corridor network, have important natural values. Isolated natural areas may provide the only available wildlife habitat in an area, provide good locations for local parks and nature study areas, and lend an aesthetic character or natural diversity to an area. Important isolated natural features within southeastern Wisconsin include a geographically well-distributed variety of isolated wetlands, woodlands, and wildlife habitat. These isolated natural features should also be protected and preserved in a natural state whenever possible.

Chapter VI

CURRENT WATER USES AND WATER USE OBJECTIVES

INTRODUCTION

Nearly all major lakes in Southeastern Wisconsin Region serve multiple purposes, ranging from recreation to receiving waters for stormwater management. Recreational uses range from noncontact, passive recreational uses such as picnicking and walking along the shoreline, to full-contact, active recreational uses such as swimming and water skiing. Water use objectives and supporting water quality standards have been adopted by the Southeastern Wisconsin Regional Planning Commission as set forth in the adopted regional water quality management plan[1] for all major lakes and streams in the Region. These objectives are wholly consistent with those statutorily established by the Wisconsin Legislature pursuant to Chapters NR 1, NR 102, and NR 104 of the *Wisconsin Administrative Code*. The current water uses for Okauchee Lake, as well as the water use objectives and their supporting water quality standards, are discussed in this chapter.

RECREATIONAL USES AND FACILITIES

Okauchee Lake is within about a one-half hour drive from much of the metropolitan Milwaukee area. Although Okauchee Lake is one of the larger lakes in southeastern Wisconsin, its location, access sites, and degree of shoreline development contribute to a more intensive recreation usage than is found on many other lakes in the Region, and the Lake supports a full range of lake uses. These uses include angling—during both the summer and winter fishing seasons, recreational boating, swimming, and aesthetic viewing.

Angling

The Okauchee Lake fishery has been augmented by the Wisconsin Department of Natural Resources stocking programs. Consequently, the Lake recently has become a popular "muskie lake" as a result of the muskellunge stocking program. As discussed in Chapter V, fisheries surveys indicate that the Lake also supports panfish, as well as largemouth bass, walleyed pike, and northern pike populations. Evidence of the good fishing is provided by the numbers of ice fishing shelters that appear on the ice during the winter months, and by the relatively large number of fishing boats present on the Lake during the summer. Winter recreational use of Okauchee Lake also includes cross-country skiing, ice boating, ice skating, and snowmobiling.

---

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

Recreational Boating

During July 2000, recreational use surveys were conducted on Okauchee Lake by the Commission staff, during both week and weekend days. These surveys resulted in observations of between 66 and 79 watercraft of various descriptions that were in operation during a typical weekday, as summarized in Table 29, and of between 48 and 138 watercraft that were in operation during a typical weekend day. The watercraft in operation included fishing boats, pleasure boats including pontoons, ski-boats, sailing vessels and personal watercraft (or "jetskis"®). The density of high-speed watercraft—assumed to be comprised of pleasure boats, ski-boats, and personal watercraft—on the weekend day was approximately one boat per 8 acres of Lake surface, based upon the total daily number of such watercraft reported.

In addition, at the time of the July 2000 survey, almost 2,000 watercraft were observed to be moored, docked or stored on the Lake and lakeshore, as shown in Table 30. Most of these watercraft, or about 590 boats, were considered to be power boats. Of the balance, about 470 craft were pontoon boats, about 300 were fishing boats, and about 210 were personal watercraft. In addition, about 150 paddle boats, about 100 were sailboats, about 100 canoes and about 30 kayaks were observed. Six watercraft were unclassified, and three were sailboards ("windsurfers"), as set forth in Table 30.

Boating activities on the Lake are regulated by the state boating and water safety laws, and by a uniform local ordinance, adopted by the riparian municipalities, providing specific regulations for Okauchee Lake. These ordinances are appended hereto as Appendix B.

As of 1980, a survey conducted by the Wisconsin Department of Natural Resources indicated that 10 recreational access sites were present in the vicinity of Okauchee Lake. Two publicly owned recreational boating access sites, one owned and operated by the Wisconsin Department of Natural Resources and the other by the Town of Oconomowoc, and eight privately owned and operated boat access sites. These sites were considered to provide an adequate level of public recreational boating access to Okauchee Lake. The Wisconsin Department of Natural Resources recreational boating boat access site provided 19 parking spaces for cars and/or car/trailer combinations.

By 2000, the number of recreational boating access sites had dropped to a total of four. Two remained in public ownership, and two were privately owned and operated. The State-owned public recreational boating access site is located at the western extreme of the embayment known as Lower Okauchee Lake, and the Town of Oconomowoc-owned access site is located south of the embayment locally known as Stumpy Bay on Okauchee Lake. Two privately-owned recreational boating access sites also existed around the lakeshore, through the Okauchee Lake Yacht Club, located on the northern shore of Okauchee Lake, which provided launching opportunities available to Club members, and at the Golden Mast Inn, located in the western bay of Okauchee Lake leading to Lower Okauchee Lake. These sites are shown on Map 17.

Notwithstanding, the State-owned boating access site at the western extreme of the Lake is considered to provide adequate public access pursuant to the public recreational boating access standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. Access to lakes with 1,000 to 4,999 open water acres is considered to be adequate if there are one or more access sites which, in total, provide one car-trailer unit per 50 open water acres, but not less than 29 units for lakes with between 1,000 to 1,450 open water acres. At least one handicapped-accessible parking space must also be provided.

Park and Open Space Sites

In addition to recreational boating opportunities, the Lake provides a venue for a range of seasonal community and private events and activities that take advantage of the aesthetic qualities of the Lake. Ice fishing, cross-country skiing, and snowmobiling are popular winter pastimes on Okauchee Lake.

Table 29

RECREATIONAL USE SURVEY ON OKAUCHEE LAKE: 2000

Date and Time	Weekday Participants[a]								
	Fishing from Shore	Fishing from Boats	Pleasure Boating	Water Skiing	Sailing	Jetskiing	Swimming	Other	Total
July 21, 2000									
9:45 a.m. to 10:45 a.m.	3	13	15	0	50[b]	1	3	0	85
2:00 p.m. to 3:00 p.m.	2	7	52	0	0	0	10	7[c]	78
Total	5	20	67	0	50	1	13	7	163
Percent	3	12	41	--	31	<1	8	4	100

Date and Time	Weekend Participants[a]								
	Fishing from Shore	Fishing from Boats	Pleasure Boating	Water Skiing	Sailing	Jetskiing	Swimming	Other	Total
July 29, 2000									
10:00 a.m. to 11:00 a.m.	7	18	21	2	1	4	8	2[d]	63
1:00 p.m. to 2:00 p.m.	2	12	98[e]	5	3	13	38	7[f]	178
Total	9	30	119	7	4	17	46	9	241
Percent	4	12	49	3	2	7	19	4	100

NOTE: Additional watercraft counted on the afternoon of July 29, 2000, included one Waukesha County water patrol boat, one Town of Merton water patrol boat, and three Wisconsin Department of Natural Resources warden patrol boats.

[a]*Participants are defined as numbers of watercraft in operation or numbers of individuals engaged in fishing from shore or swimming.*

[b]*Includes sailboats participating in a regatta.*

[c]*Includes one canoe, two kayaks, and four boats pulling tubes.*

[d]*Includes one paddleboat and one kayak.*

[e]*Includes 56 boats anchored and gathered together.*

[f]*Includes one paddleboat, one wind surfboard, four boats pulling tubes, and one kayak.*

Source: SEWRPC.

Table 30

WATERCRAFT OBSERVED ON AND AROUND OKAUCHEE LAKE: JULY 2000[a]

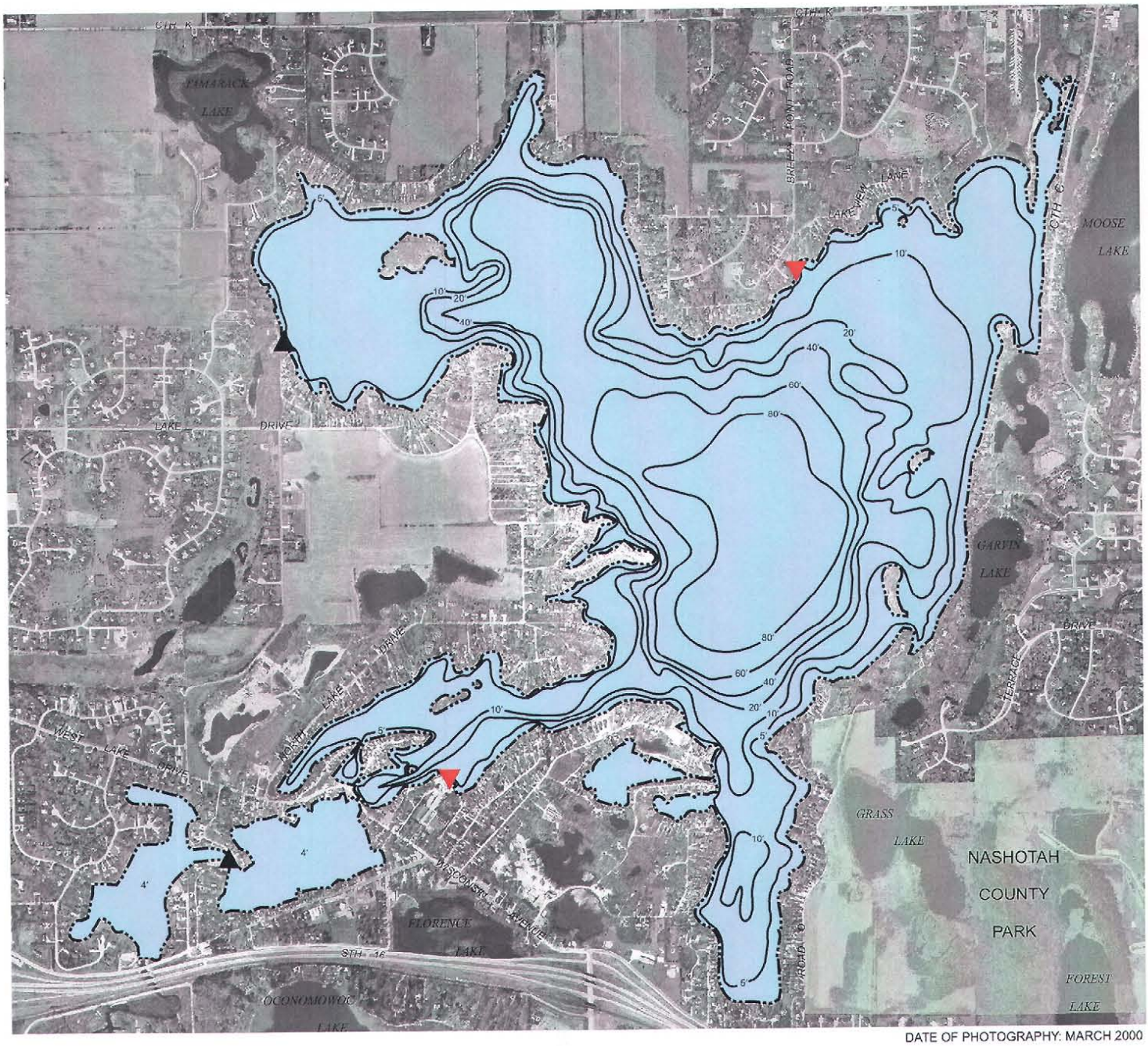
Type of Watercraft										
Power Boats	Fishing Boats	Pontoon Boats	Canoes	Paddle Boats	Sailboats	Kayaks	Sail Boards	Personal Watercraft	Other	Total
586	303	469	105	154	106	28	3	213	6	1,973

[a]*The watercraft count includes vessels moored, docked, beached, and trailered on and around Okauchee Lake, including both vessels in use and not in use.*

Source: SEWRPC.

Map 17

PARK AND LAKE ACCESS SITES IN THE VICINITY OF OKAUCHEE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

▲ PUBLIC ACCESS SITE

▼ PRIVATE ACCESS SITE

GRAPHIC SCALE

0 1000 2000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

In the larger context, it is important to note that the provision of park and open space sites within the drainage area tributary to Okauchee Lake should be guided, to the extent practicable, by the recommendations contained in the Waukesha County development plan.[2] The purpose of that plan, in part, is to guide the preservation, acquisition, and development of lands for park and outdoor recreation, and related open space purposes, and to protect and enhance the underlying and sustaining natural resource base of the area. With respect to recreational opportunities within the Okauchee Lake area, the plan recommends the acquisition of lands to support the development of a parkway along the Oconomowoc River linking Okauchee Lake with North Lake, situated northeast of the Okauchee Lake basin. Such parkways are comprised of lands within the Commission-designated primary environmental corridor system, shown on Map 16, and can serve as ideal locations for trail systems. In addition, the development of a county park to the southeast of Okauchee Lake is recommended. Within the drainage area directly tributary to Okauchee Lake, the Oconomowoc Sedge Meadow, a 19-acre natural area of local significance, is recommended for acquisition by a private conservancy organization.[3] The Stonebank Tamarack Relict, a 166-acre wetland providing habitat for rare or uncommon bird species of special concern, also has been identified for acquisition, being partially under protective ownership. The remaining land that comprises this wetland is recommended for acquisition by a private conservancy organization. Both of these latter sites are shown on Map 15.

Wisconsin Department of Natural Resources Recreational Rating

In general, Okauchee Lake provides a variety of outdoor recreational opportunities. Based upon the outdoor recreation rating developed by the Wisconsin Department of Natural Resources, Okauchee Lake received a total of 52 points out of a possible total of 72 points, as shown in Table 31. This rating indicates that the Lake provides a wide range of recreational opportunities, including unique "muskie" angling, swimming, boat launching, boating, and wildlife observation opportunities. Features that were considered to detract from the recreational rating include a minor rough fish problem, occasional algal blooms, and excessive macrophyte growths in portions of the Lake.

WATER USE OBJECTIVES

The regional water quality management plan recommended the adoption of full recreational and warmwater sport fisheries objectives for Okauchee Lake. The range and scope of uses engaged in/on Okauchee Lake are sufficiently broad to be consistent with the recommended use objective of full recreational use, as set forth in the adopted regional water quality management plan. Further, the inventories of the natural resource base, set forth in Chapters III through V, indicate that the Lake and the resources of the area are generally supportive of the warmwater sportfish objective. The recommended warmwater sport fishery objective is supported in Okauchee Lake by a sport fishery based largely on largemouth bass, muskellunge, and northern pike. These fishes have been traditionally sought after in Okauchee Lake. Nevertheless, it is likely that remedial measures will be required to be implemented if the Lake is to continue to fully meet these objectives.

WATER QUALITY STANDARDS

The water quality standards supporting the warmwater fishery and full recreation use objectives are set forth in Table 32. These standards incorporate those set forth in Chapters NR 102 and 104 of the *Wisconsin Administrative Code*, as well as the guidelines established in the adopted regional water quality management plan.

---

[2]*SEWRPC Community Assistance Planning Report No. 209*, A Development Plan for Waukesha County, Wisconsin, *August 1996; see also SEWRPC Community Assistance Planning Report No. 13*, A Park and Open Space Plan for Waukesha County, *December 1989.*

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

Table 31

WISCONSIN DEPARTMENT OF NATURAL RESOURCES RECREATIONAL RATING OF OKAUCHEE LAKE

Surface Area = 1,187 acres			Total Shore Length = 15.2 miles		
Ratio of Surface Area to Total Shore Length = 0.122:1					
Quality Rating (18 maximum points for each item):					
Fish:					
__ 9	High production	X 6	Medium production	__ 3	Low production
__ 9	No problems	X 6	Modest problems, such as infrequent winterkill, small rough fish problems	__ 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	X 4	Moderately clean water	__ 2	Turbid or darkly stained water
__ 6	No algae or weed problems	X 4	Moderate algae or weed problems	__ 2	Frequent or severe algae or weed problems
Boating:					
X 6	Adequate water depths (75 percent of basin more than five feet deep)	__ 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)
X 6	Adequate size for extended boating (more than 1,000 acres)	__ 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, algae blooms, etc.	__ 2	Overwhelming inhibiting factors, such as weedbeds throughout
Aesthetics:					
__ 6	Existence of 25 percent or more wild shore	X 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: 52 out of a possible 72					

Source: Wisconsin Department of Natural Resources and SEWRPC.

Standards are recommended for temperature, dissolved oxygen, pH, fecal coliform, total phosphorus, and chloride. These standards apply to the epilimnion of lakes and to streams. The total phosphorus standard is applied to spring turnover phosphorus concentrations measured in the surface waters of lakes. Other contaminants, such as oil and debris; odor-, taste-, and color-producing substances; and toxins are not permitted in concentrations harmful to aquatic life, as set forth in Chapters 102 of the *Wisconsin Administrative Code.*

Table 32

APPLICABLE WATER USE OBJECTIVES AND WATER QUALITY STANDARDS AND GUIDELINES FOR LAKES AND STREAMS WITHIN THE SOUTHEASTERN WISCONSIN REGION

Water Quality Parameters	Combinations of Water Use Objectives Adopted for Southeastern Wisconsin Inland Lakes and Streams[a,b]				
	Coldwater Community and Full Recreation Use	Warmwater Sportfish Community and Full Recreation Use	Warmwater Forage Fish Community and Limited Recreational Use	Limited Aquatic Life and Limited Recreational Use	Source
Temperature (°F)[c]	Background	89.0 maximum	89.0 maximum	- -	NR 102.04 (4)[d]
Dissolved Oxygen (mg/l)[c]	6.0 minimum 7.0 minimum during spawning	5.0 minimum	3.0 minimum	1.0 minimum	NR 102.04 (4) NR 104.02 (3)
pH Range (S.U.)	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	NR 102.04 (4)[e] NR 104.02 (3)
Fecal Coliform (MFFCC)	200 mean 400 maximum	200 mean 400 maximum	1,000 mean 2,000 maximum	1,000 mean 2,000 maximum	NR 102.04 (5) NR 104.06 (2)
Ammonia Nitrogen (mg/l)	- -	- -	3.0-6.0	- -	NR 104.02 (3)
Total Phosphorus (mg/l)	0.1 maximum for streams 0.02 maximum during spring turnover for lakes	0.1 maximum for streams 0.02 maximum during spring turnover for lakes	- -	- -	Regional water quality management plan[f]
Chloride (mg/l)	1,000 maximum	1,000 maximum	1,000 maximum	- -	Regional water quality management plan[g]

[a] *NR102.04(1) 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 a body of water, floating or submerged debris, oil, scum, or other material, and material producing color, odor, taste or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life.*

[b] *It is recognized that under both extremely high and extremely low flow conditions, instream water quality levels can be expected to violate the established water quality standards for short periods of time without significantly damaging the overall health of the stream. It is important to note the critical differences in the application of standards for regulatory versus planning purposes. For this purpose, the standards are often applied using a probabilistic approach, whereby the percent of time a given standard is violated is considered to allow assessment and resolution of water quality problems during high flow, as well as low flow conditions. This approach is considered appropriate for planning purposes, as opposed to regulation. The U.S. Environmental Protection Agency and the Wisconsin Department of Natural Resources, being regulatory agencies, utilize water quality standards as a basis for enforcement actions and compliance monitoring. This requires that the standards have a rigid basis in research findings and in field experience. The Southeastern Wisconsin Regional Planning Commission and others use water quality standards as criteria to measure the relative merits of alternative plans.*

[c] *Dissolved oxygen and temperature standards apply to continuous streams and the upper layers of stratified lakes and to the unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. However, trends in the period of anaerobic conditions in the hypolimnion of deep inland lakes should be considered important to the maintenance of their natural water quality.*

[d] *NR 102.04(4) 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 natural temperature shall not exceed 5°F for streams. There shall be no significant artificial increases in temperature where natural trout reproduction is to be maintained.*

[e] *The pH shall be within the stated range with no change greater than 0.5 unit outside the estimated natural seasonal maximum and minimum.*

[f] *U.S. Environmental Protection Agency, Quality Criteria for Water, EPA-440/9-76-023, 1976.*

[g] *J.E. McKee and M.W. Wolf, Water Quality Criteria 2nd edition, California State Water Quality Control Board, Sacramento, California, 1963.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

These standards are intended to specify conditions in the waterways concerned that mitigate against excessive macrophyte and algal growths, and promote all forms of recreational use, including swimming and angling. Of particular concern in Okauchee Lake is the likelihood of the Lake meeting the total phosphorus concentration guideline of 0.02 milligrams per liter (mg/l). Based upon review of the past and current conditions in the Lake, and of the controllable phosphorus inputs into Okauchee Lake, there are potential difficulties associated with the ability of the lake waters to support this quality criterion without further remedial actions being implemented. Thus, the range of alternative lake management measures considered in Chapter VII include not only measures to reduce the external pollutant loading to the Lake, but also in-lake measures, such as aquatic plant management, to treat the symptoms of higher-than-desirable nutrient concentrations.

Chapter VII

ALTERNATIVE LAKE MANAGEMENT MEASURES

INTRODUCTION

Based upon review of the inventories and analyses set forth in Chapters II through VI, six issues were identified requiring consideration in the formulation of alternative and recommended lake management measures. These issues are related to: 1) sanitary sewerage services and point source pollution control; 2) nonpoint source pollution abatement; 3) stormwater management; 4) protection of ecological valuable areas and management of aquatic plants; 5) maintenance of water quality; and, 6) enhancement of recreational water uses. The management measures considered herein are focused primarily on those measures which are applicable to the Okauchee Lake Management District, and to the Towns of Merton and Oconomowoc, with lesser emphasis given to those measures which are applicable to others with jurisdiction within the broader, total drainage area tributary to Okauchee Lake.

WATERSHED MANAGEMENT ALTERNATIVES

Point Source Pollution Control

Public Sanitary Sewerage Systems

As recommended in the regional sanitary sewerage system plan adopted by the Regional Planning Commission in 1974, the Oconomowoc sewage treatment plant is proposed to serve as a regional facility providing wastewater treatment service to the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake sewer service areas.[1] That recommendation was affirmed in the regional water quality management plan adopted by the Commission during 1979.[2] Pursuant to these recommendations, the Oconomowoc wastewater treatment facility was upgraded during 1978 to provide secondary waste treatment, tertiary waste treatment, and auxiliary waste treatment for effluent disinfection, and expanded to provide an average hydraulic design treatment capacity of 4.0 million gallons per day (mgd), with future expansion on the plant site provided for. At that time, extension of sewerage services to existing and proposed urban development around Lac La Belle, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, Silver Lake, and Oconomowoc Lake was envisioned.

---

[1]*SEWRPC Planning Report No. 16,* A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, *February 1974.*

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

As of the year 2000, the Okauchee Lake community remained within the planned sewer service area. The refined regional water quality management plan recommended the conduct of a facilities study to determine the nature and extent of any such expansion.[3] Following such facility planning, portions of the southwestern lakeshore were recommended to be served by the Oconomowoc sewage treatment plant, with a system of pump stations and trunk sewers being used to convey wastewater from the urban density development along the southern and western shores of the Lake to the treatment plant. The proposed sewer service area and trunk sewer system is shown on Map 18.[4] The local sewer system was constructed in 2002 and connected to the Oconomowoc sewerage system. Additional urban density development within the drainage area tributary to Okauchee Lake, located to the southeast of the main lake basin and adjoining the boundary of the City of Oconomowoc sewer service area, is proposed to be served by the Delafield-Hartland Water Pollution Control Commission sewage treatment facility, as shown on Map 19.[5] Notwithstanding, these recommendations were further refined as part of an overall review of sewerage services in northwestern Waukesha County.[6] This review reaffirmed the provision of sanitary sewer services to the urban density development within lakeshore areas of Okauchee Lake, with a design year of 2010, as shown on Map 20.

Onsite Sewage Disposal Systems

While a portion of the immediate lakeshore is sewered, much of the shoreline and drainage area tributary to Okauchee Lake continues to be served by onsite sewage disposal systems. As reported in Chapter IV, onsite sewage disposal systems are estimated to potentially contribute up to about 5 percent of the total phosphorus loading to Okauchee Lake. In addition to lake water quality considerations, sewage disposal options in the area have implications for groundwater quality and property values. Thus, onsite sewage disposal is an important consideration in the entire drainage 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.

As noted above, the concentrations of urban development located along the shoreline of Okauchee Lake are included within a public sanitary sewer service area, as recommended in the adopted regional water quality management plan. However, the provision of public sewer service to these areas is some time off, and lands lying outside this area, but identified as having a density of development equivalent to an urban concentration, would continue to be provided with sewage disposal through the use of onsite sewage disposal systems.

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. Generally, it is recommended that these efforts be undertaken by, or with the assistance of, the County sanitarians in Waukesha and Washington Counties. These counties currently have such programs in place.

---

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

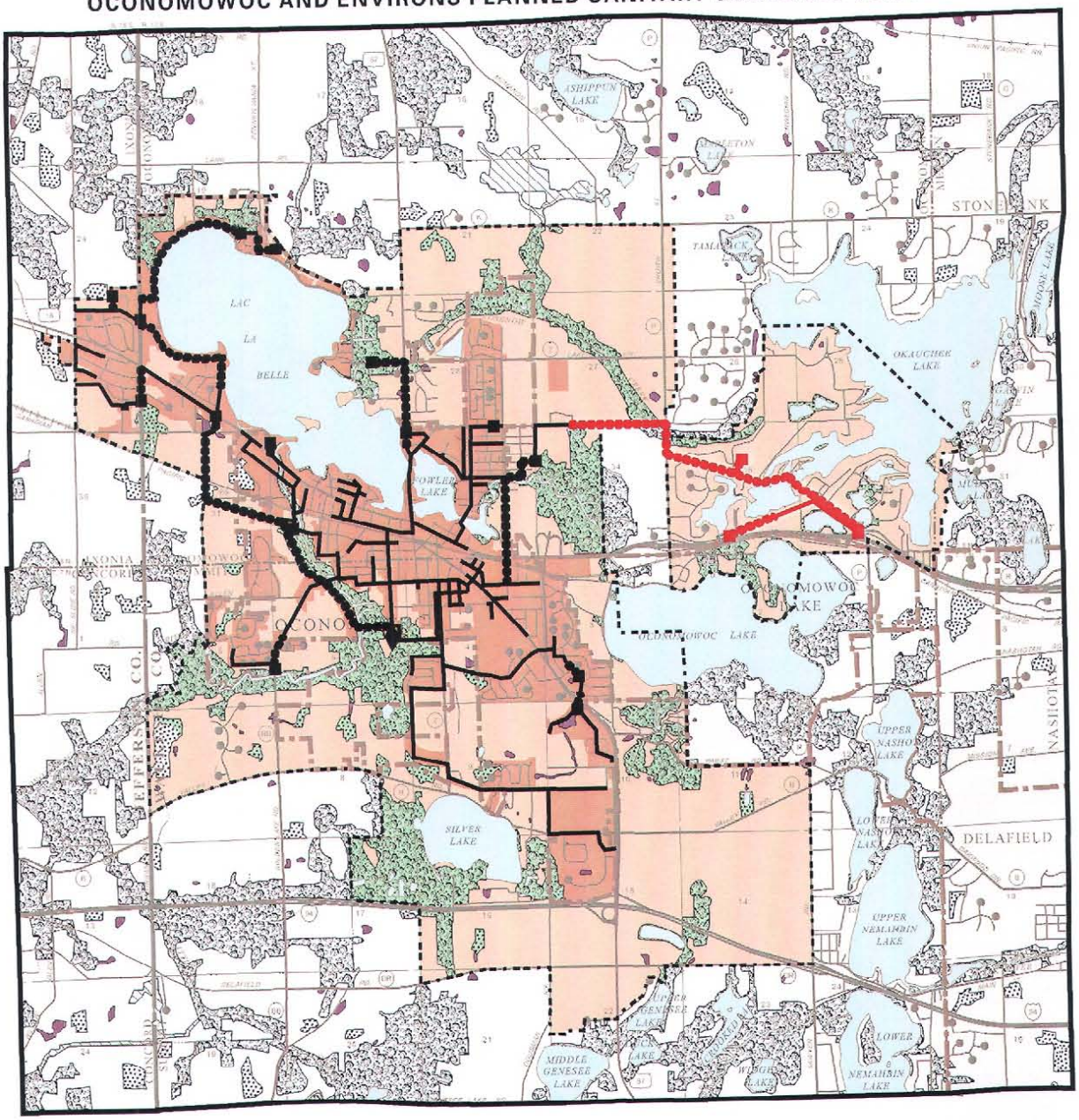
[4]*SEWRPC,* Amendment to the Regional Water Quality Management Plan: City of Oconomowoc, *December 2001; see also SEWRPC Community Assistance Planning Report No. 172, 2nd Edition,* Sanitary Sewer Service Area for the City of Oconomowoc and Environs, Waukesha County, Wisconsin, *September 1999.*

[5]*SEWRPC Community Assistance Planning Report No. 127,* Sanitary Sewer Service Area for the City of Delafield and the Village of Nashotah and Environs, Waukesha County, Wisconsin, *November 1992.*

[6]*Black & Veatch Corporation,* Sanitary Sewerage System Plan for the Northwestern Waukesha County Area, *April 2000.*

Map 18

OCONOMOWOC AND ENVIRONS PLANNED SANITARY SEWER SERVICE AREA



- PRIMARY ENVIRONMENTAL CORRIDOR
- SECONDARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL RESOURCE AREA
- WETLAND AND SURFACE WATER AREAS LESS THAN FIVE ACRES IN SIZE
- EXISTING AREA SERVED BY CITY OF OCONOMOWOC SANITARY SEWERS: 1999
- PLANNED CITY OF OCONOMOWOC SANITARY SEWER SERVICE AREA: 2020
- ENVIRONMENTALLY SIGNIFICANT LANDS WITHIN THE PLANNED SANITARY SEWER SERVICE AREA WHERE THE EXTENSION OF SEWERS TO SERVE NEW INTENSIVE URBAN DEVELOPMENT IS NOT PERMITTED. NEW SEWERED DEVELOPMENT IS CONFINED TO LIMITED RECREATIONAL AND INSTITUTIONAL USES AND RURAL-DENSITY RESIDENTAL DEVELOPMENT IN UPLAND AREAS.

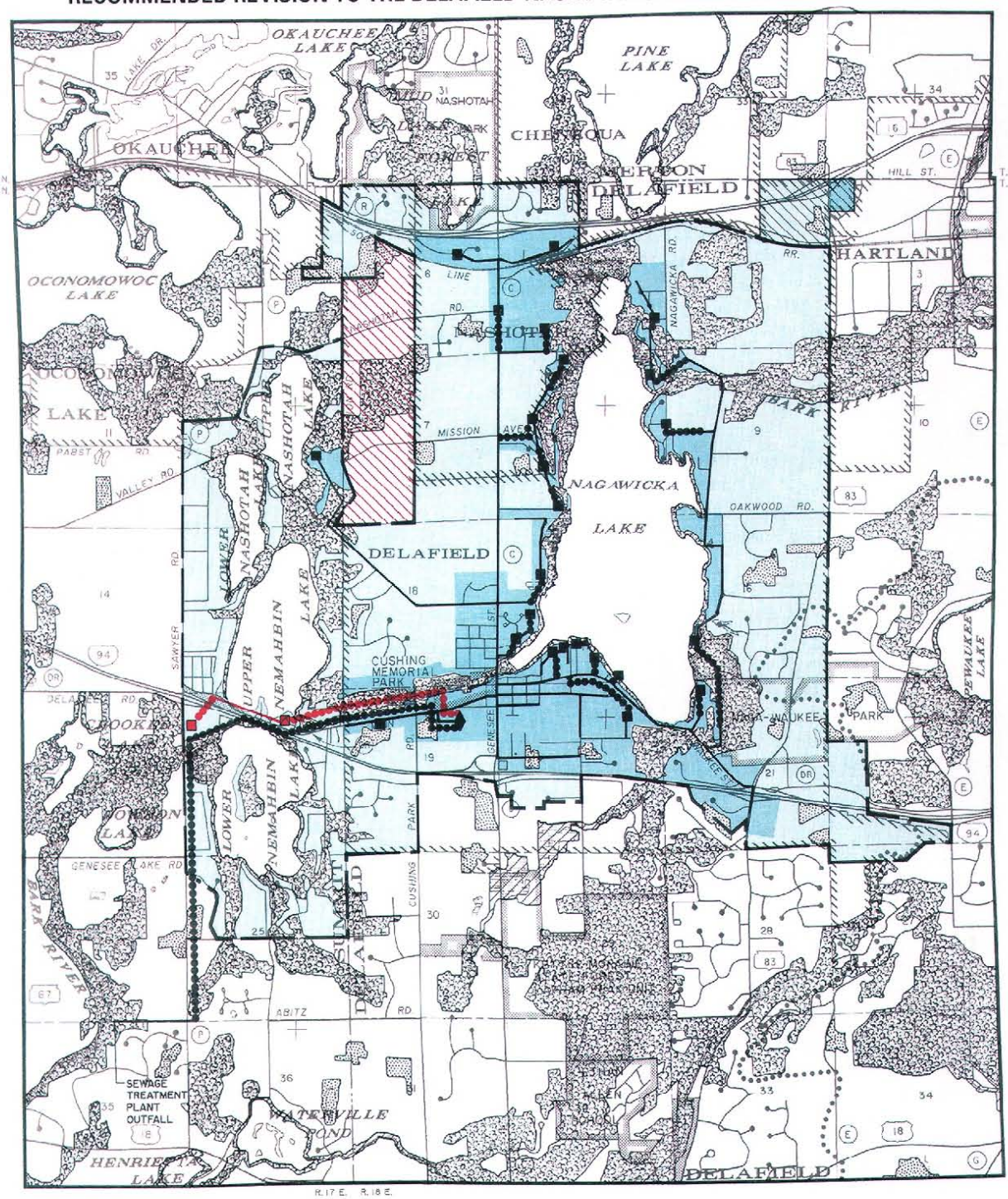
- PLANNED SANITARY SEWER SERVICE AREA BOUNDARY
- EXISTING PUBLIC SEWAGE TREATMENT FACILITY
- EXISTING TRUNK SEWER
- EXISTING FORCE MAIN
- EXISTING PUMPING STATION
- PROPOSED TRUNK SEWER
- PROPOSED FORCE MAIN
- PROPOSED PUMPING STATION
- CITY AND VILLAGE BOUNDARIES

March 2003

Source: SEWRPC.

Map 19

RECOMMENDED REVISION TO THE DELAFIELD-NASHOTAH SANITARY SEWER SERVICE AREA



LEGEND

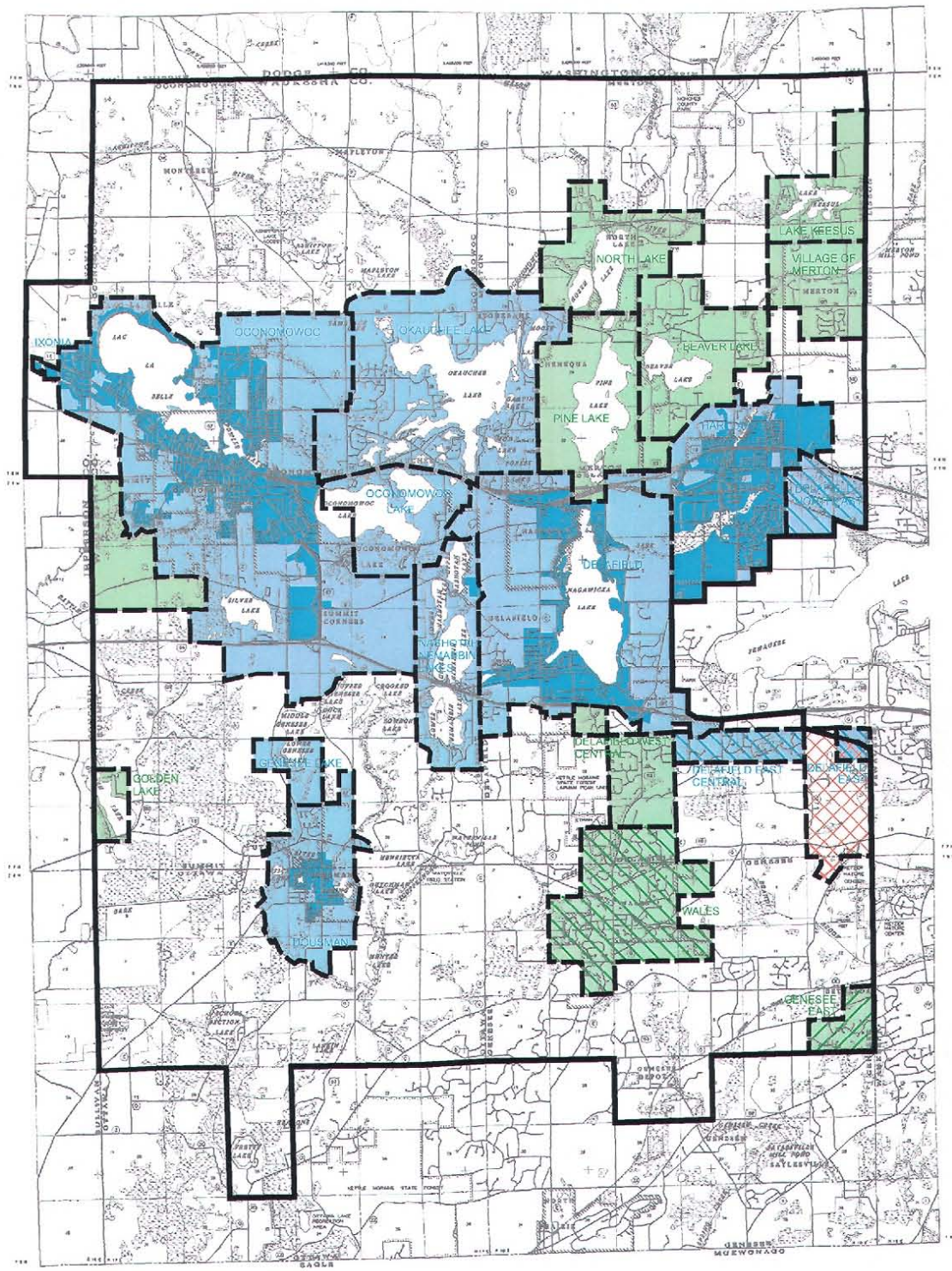
- PRIMARY ENVIRONMENTAL CORRIDOR
- SECONDARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL RESOURCE AREA
- NET SANITARY SEWER SERVICE AREA (EXISTING)
- NET SANITARY SEWER SERVICE AREA (2010)
- GROSS SANITARY SEWER SERVICE AREA BOUNDARY
- EXISTING PUBLIC SEWAGE TREATMENT FACILITY
- EXISTING PUMPING STATION
- EXISTING TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED PUMPING STATION
- PROPOSED TRUNK SEWER
- PROPOSED FORCE MAIN
- LANDS IN THE CITY OF DELAFIELD WHICH ARE CURRENTLY, OR ARE PROPOSED TO BE, SERVED BY CITY OF DELAFIELD SEWERS WHICH CONNECT TO THE VILLAGE OF HARTLAND SEWER SYSTEM FOR CONVEYANCE TO THE DELAFIELD - HARTLAND SEWAGE TREATMENT FACILITY
- LANDS PROPOSED TO BE ADDED TO THE DELAFIELD-NASHOTAH SANITARY SEWER SERVICE AREA

GRAPHIC SCALE
0 1/4 1/2 MILE
0 2000 4000 FEET

Source: SEWRPC.

Map 20

NORTHWESTERN WAUKESHA COUNTY SEWERAGE SYSTEM PLAN
EXISTING AND PLANNED SEWER SERVICE AREAS: REVISED DECEMBER 1999



- STUDY AREA BOUNDARY
- SEWER SERVICE AREA BOUNDARY
- EXISTING
- PLANNED (2010)
- PLANNED (BEYOND 2010)
- PLANNED (2010 - ASSUMED TO BE SERVED TO FOX RIVER WATERSHED SYSTEM)
- PLANNED (BEYOND 2010 - ASSUMED TO BE SERVED TO FOX RIVER WATERSHED SYSTEM)
- AREA INCLUDED IN THE CITY OF WAUKESHA SEWER SERVICE AREA

GRAPHIC SCALE
0 1/2 1 MILE
0 5000 10000 FEET

Source: SEWRPC.

Nonpoint Source 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 watershed, 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 drainage area tributary to individual lakes and streams.

Land Use Management and Zoning

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 watershed. The type and location of future urban and rural land uses in the tributary drainage area to Okauchee 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 1995 and planned 2020 land use patterns and existing zoning regulations in the tributary area to Okauchee Lake have been described in Chapter III. Infilling of existing platted lots and some backlot development, as well as the redevelopment and reconstruction of existing single-family homes and commercial structures on lakefront properties, 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 Okauchee Lake and within the drainage area directly tributary to the Lake should be evaluated for potential impacts on the Lake, as such proposals are advanced.

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.[7] 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 this concern, a number of communities are debating the enactment of fertilizer control ordinances in addition to the public informational programming discussed below; 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 Okauchee Lake, and within its drainage area, consideration of a comprehensive program to regulate urban agricultural practices appears to be warranted.

Development in the Tributary Drainage Area

If the recommendations set forth in the adopted Waukesha County development plan and regional land use plan are followed, under buildout conditions, the extent of residential development within the urban areas of the drainage basin is expected to increase.[8] Most of this residential development is expected to occur on lands

---

[7]*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.*

[8]*SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

formerly devoted to agricultural uses, which uses are expected to decrease within the drainage area. Notwithstanding, the Waukesha County development plan recommends that most new residential development within the drainage area of the Lake occur at relatively low densities. Careful review of applicable zoning ordinances to incorporate levels and patterns of development consistent with the plan within the drainage area tributary to Okauchee Lake is recommended. Changes in the zoning ordinances could be considered to better reflect the land use patterns recommended in the County development plan. Consideration should be given to minimizing the areal extent of development by providing specific provisions and incentives to conservation subdivision 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.[9]

Protection of Environmentally Sensitive Lands
Environmentally sensitive lands within the drainage area tributary to Okauchee Lake include wetlands, woodlands, and wild life habitat areas. Nearly all of these areas within the Okauchee Lake drainage area are included in the environmental corridors and isolated natural features delineated by the Regional Planning Commission. 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, Wisconsin Department of Natural Resources (WDNR), and County and municipal authorities under one or more of the Federal, State, County, and local regulations.

Some of the wetland, woodland, and wildlife habitat areas within the drainage area tributary to Okauchee Lake, however, have been recommended for public acquisition in the adopted regional natural areas and critical species habitat management and protection plan.[10] These lands include the Oconomowoc Sedge Meadow, a 19-acre natural area of local significance recommended for acquisition by a private conservancy organization, and the Stonebank Tamarack Relict, a 166-acre wetland that provides habitat for rare or uncommon bird species of special concern.

Nonpoint Source Pollution Control
Watershed management measures may be used to minimize nonpoint sources pollutant loadings from the watershed by locating development within a drainage basin based upon the principles of sound land use planning. Beyond such actions, specific interventions may be required to control the mass of contaminants generated by various types of land use activity, and 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, watershed-based nonpoint sources pollution control measures considered in this report are based upon the recommendations set forth in the regional water quality management plan,[11] in the Oconomowoc River priority watershed plan,[12] and in the Waukesha County land and water resource management plan.[13]

---

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

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

[11]*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.*

[12]*Wisconsin Department of Natural Resources Publication No. WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

[13]*Waukesha County,* Land and Water Resource Management Plan: 1999-2002, *January 1999.*

The water quality analyses presented in Chapter IV indicate that a reduction in nutrient loads from nonpoint sources within the tributary area will be needed to meet the recommended water use objectives and supporting water quality standards as set forth in Chapter VI. The regional water quality management plan recommended that the nonpoint source pollutant loadings from the areas tributary to Okauchee Lake be reduced by about 25 percent in both urban and rural areas, in addition to implementation of urban construction erosion controls, stream bank erosion controls, and onsite sewage disposal system management practices. The Oconomowoc River Priority Watershed plan refined these recommendations, and proposed an overall reduction of phosphorus loadings of between 28 and 76 percent, and of sediment loadings of between 30 and 50 percent. Generally, the higher phosphorus load reductions were proposed for the more urbanized, lower portions of the watershed, downstream of Okauchee Lake, while the higher sediment load reductions were proposed for the more rural areas upstream of Oconomowoc Lake.

As described in Chapter IV, the most readily controllable loadings are associated primarily with runoff from urban lands within the direct drainage area tributary to the Lake and from urbanizing lands throughout the total drainage area tributary to the Lake that are linked to the Lake by way of streams and stormwater drainage systems. These loadings were estimated to constitute about 10 percent of the total phosphorus and sediment loadings to Okauchee Lake, and 100 percent of the heavy metals loadings, based upon 1995 land uses. In addition, onsite sewage disposal systems were estimated to contribute up to about 5 percent of the phosphorus load to the Lake. 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. Thus, the control of these 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 C presents a list of alternative nonpoint source pollution management measures that could be considered for use within the drainage area tributary to Okauchee Lake to reduce loadings from nonpoint sources of pollution. Information on the cost and effectivity of the measures is also presented in Appendix C. 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. The measures considered to be most viable for application to Okauchee Lake are discussed further 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 drainage area tributary to Okauchee 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 drainage area tributary to Okauchee Lake.

Based upon the pollutant loading analysis set forth in Chapter IV, a total annual phosphorus load of about 28,500 pounds is estimated to be contributed to Okauchee Lake. Of that mass, it is estimated that about 25,000 pounds per year, or 87 percent of the total loading, were contributed by runoff from rural land. In addition, it is estimated that about 6,700 tons of sediment, or about 90 percent of the total sediment load to Okauchee Lake, were contributed annually from agricultural lands in the drainage area tributary to the Lake. As of 1995, such lands comprised about 43,000 acres, or about 83 percent of the total drainage area tributary to Okauchee Lake, which area is anticipated to diminish to about 39,900 acres, or about 77 percent, of the tributary drainage area by the year 2020.

While agricultural land uses are anticipated to be a declining form of land usage within the drainage area tributary to Okauchee Lake, the agricultural operations that remain within the drainage area will continue to contribute a significant proportion of the sediment load to the waterbody. Table 16 suggests that, based upon estimated contaminant loadings, agricultural land uses will continue to contribute more than 90 percent of the total sediment

load, or about 5,000 tons of sediment annually, to Okauchee 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 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.

Urban Nonpoint Source Controls

As of 1995, established urban land uses comprised about 9,000 acres, or about 16 percent, of the total drainage area tributary to Okauchee Lake. The annual phosphorus loading from these urban lands was estimated to be about 3,700 pounds, or about 13 percent of the total load of phosphorus to the Lake. This is anticipated to increase to about 4,100 pounds, or to about 16 percent of the total load of phosphorus, under planned year 2020 conditions. Those urban nonpoint pollutant sources that are most controllable include runoff from the residential lands adjacent to the Lake, urban runoff from areas with an high proportion of impervious surface, and discharges from onsite sewage disposal systems. The potential also exists within the Okauchee Lake watershed for significant construction site erosion impacts if development continues in the tributary drainage 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, 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-sourced pollutants from urban and urbanizing area, and reduce urban nonpoint source pollution loads by up to about 50 percent.

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 and county development plans envision only limited new urban development within the drainage area. However, as previously noted, some large-lot suburban-density development is currently taking place in the drainage area tributary to Okauchee 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 Wisconsin Department of Natural

Resources in cooperation with the Wisconsin League of Municipalities.[14] 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 drainage 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.

As was noted in Chapter III, construction site erosion control and stormwater management ordinances were in effect in many of the communities within the tributary drainage area to Okauchee Lake during 2002, with the exception of the Villages of Merton, Nashotah, Oconomowoc Lake and Slinger, and the Towns of Merton and Summit in Waukesha County, and of the Village of Slinger in Washington County. Waukesha, Dodge, and Washington Counties all have adopted construction erosion control and stormwater management ordinances. In the latter two counties, these ordinances also apply to the unincorporated towns within each county. 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. Because of this potential for development, some of it albeit unplanned, in the drainage area tributary to Okauchee Lake, it is important that adequate construction erosion control programs, including enforcement, be in place. Therefore, additional measures to reduce nonpoint source pollution from existing development would appear to be warranted. One such measure would include the periodic review of these ordinances and their provisions for consistency with best management practices, and to ensure their currency.

Stormwater Management Measures

As noted in Chapter IV, the Okauchee Lake Management District Board of Commissioners identified four sites at which electors of the District reported concerns relating to nonpoint source pollution, specifically associated with stormwater discharges to Okauchee Lake and its embayments. Of these sites, the area draining to Icehouse Bay from streets and infrastructure along STH 16 and Jaeckles Boulevard had been identified in the previous plan, and specific recommendations were made in the plan to address this issue. The additional sites all drain roadways to other portions of the Lake, including Bay Five and Lower Okauchee Lake. Each of these sites is severely constrained by topography and existing development, which provide limitations for the application of structural stormwater management practices, although, in each case, the adoption of good housekeeping practices should be considered as a minimal level of intervention. Other interventions should be developed as part of a detailed, local level stormwater management planning process. The alternatives noted below form a conceptual starting point for such detailed planning.

Stormwater Management in the Vicinity of STH 16 and Jaeckles Boulevard

Specific practices applicable to that portion of the drainage area tributary to Okauchee Lake, adjacent to STH 16 and south of the embayment locally known as Ice House Bay were set forth in the initial plan, and are summarized below. Four basic stormwater management alternatives were developed in the initial plan to resolve this localized sediment loading problem, and reflected varying degrees of nonpoint source pollution control for the area draining to Ice House Bay in the vicinity of STH 16. The principal features of these alternatives are summarized in Table 33. Each of these alternatives was considered to have impacts on the hydraulics of the drainage systems serving this area, and each alternative was designed to have two phases: a first phase during the interim period until the next phase of reconstruction of STH 16, and a second phase that would address long term measures. The second phase would be implemented during the next phase of reconstruction of the portion of

[14] *Wisconsin Department of Natural Resources,* Wisconsin Construction Site Best Management Practices Handbook, *April 1994.*

Table 33

PRINCIPAL FEATURES OF STORMWATER MANAGEMENT ALTERNATIVES FOR THE STH 16 DRAINAGE AREA AT ICE HOUSE BAY, OKAUCHEE LAKE

Alternative Number	Hydraulic Discharge									
	Estimated Tributary Area (acres)			Estimated Maximum Stormwater Discharge Rate (cfs)				Estimated Annual Average Total Discharge Volume (million gallons)		
				West[b]		East[c]				
	West[b]	East[c]	Total	5-year	25-Year	5-year	25-Year	West[b]	East[c]	Total
1—"No Action"										
Pre-Construction STH 16 to CTH PP[d]	22.2	23.8	46.0	24.8	33.6	20.3	28.0	4.2	4.1	8.3
Post-Construction STH 16 to CTH PP[e]	7.4	25.9	33.3	10.0	13.6	24.9	34.3	1.1	3.3	4.4
Total	--	--	--	--	--	--	--	--	--	--
2—Interim Erosion Control and Stormwater Management Measures										
Pre-Construction STH 16 to CTH PP[d]	22.2	23.8	46.0	23.1	31.8	19.8	27.3	2.9	2.7	5.6
Post-Construction STH 16 to CTH PP[e]	7.4	25.9	33.3	10.0	13.6	24.9	34.3	1.1	3.3	4.4
Total	--	--	--	--	--	--	--	--	--	--
3—Maximum In-Basin Storage										
Pre-Construction STH 16 to CTH PP[d]	22.2	23.8	46.0	23.1	31.8	19.8	27.3	2.9	2.7	5.6
Post-Construction STH 16 to CTH PP[e]	7.4	25.9	33.3	9.6	13.1	21.4	28.2	1.1	3.0	4.1
Total	--	--	--	--	--	--	--	--	--	--
3A—Limited In-Basin Stormwater Storage										
Pre-Construction STH 16 to CTH PP[d]	22.2	23.8	46.0	23.1	31.8	19.8	27.3	2.9	2.7	5.6
Post-Construction STH 16 to CTH PP[e]	7.4	25.9	33.3	9.6	13.1	21.4	28.2	1.1	3.0	4.1
Total	--	--	--	--	--	--	--	--	--	--
4—Diversion with Limited In-Basin Stormwater Storage										
Pre-Construction STH 16 to CTH PP[d]	22.2	23.8	46.0	23.1	31.8	19.8	27.3	2.9	2.7	5.6
Post-Construction STH 16 to CTH PP[e]	7.4	5.4	12.8	9.6	13.1	8.2	11.4	1.1	0.7	1.8
Total	--	--	--	--	--	--	--	--	--	--

[a] *Cost data are based upon January 1980 dollars.*

[b] *Designates area tributary to the west 24-inch-diameter CMCP storm sewer at Jaeckles Boulevard and Frontage Road.*

[c] *Designates area tributary to the east 24-inch-diameter RCCP storm sewer at Jaeckles Boulevard and Frontage Road.*

[d] *Designates the existing drainage conditions prior to construction of the remaining segment of STH 16 to CTH PP, but after the alternative measures are in place. For cost analysis purposes, it was assumed the project would be completed by 1986.*

[e] *Designates the proposed drainage condition after completion of STH 16 to CTH PP (estimated to be in 1986).*

[f] *These costs are common to all alternatives and for comparison purposes, are not shown.*

[g] *Computed against loading resulting from alternative No. 1.*

Source: SEWRPC.

STH 16 within the drainage area. Of the alternatives set forth in the initial plan, Alternative 2 was recommended as an interim measure, and Alternative 4 was recommended as a longer term measure, to potentially control pollutant loads in this subbasin.

In the immediate term, Alternative 2 was recommended because of its relatively low cost and the likelihood that this alternative would result in significant reductions in pollutant loads. In this regard, it was recommended that erosion control procedures—such as covering with topsoil and seeding exposed soil areas; critical area protection; and provision of temporary check-dams as sediment traps and storage areas in drainageways—be implemented in the short term. The beneficial impacts of these interim components on the hydraulics of the existing system, however, were considered to be minimal.

In the longer term, implementation of Alternative 4 was recommended in order to achieve significant reductions in nonpoint source loads from the STH 16 corridor. Nevertheless, full implementation of these alternatives was considered to be capable of removing less than 2 percent of the anticipated phosphorus load to Okauchee Lake, and it was ultimately suggested that WisDOT implement the contaminant and runoff diversion components during a future reconstruction of STH 16, with little or no increase in the drainage system construction costs. Specifically, it was recommended that the capacity of the 29-inch by 18-inch CMPA storm sewer at the lower end of the western pipeline along Jaeckles Boulevard be increased to handle a 25-year recurrence interval storm.[15] It was estimated that the existing capacity of that storm sewer segment was approximately 7.5 cfs, or slightly more than one-half of the estimated 25-year peak flow from the area tributary to the 24-inch CMCP storm sewer along the western side of Jaeckles Boulevard of 13.6 cfs. While this flow rate could potentially be reduced if runoff from additional areas draining to Ice House Bay was diverted, it was recommended that a parallel CMPA storm sewer segment be installed at the foot of Jaeckles Boulevard in order to resolve this problem. That pipe would consist of approximately 200 feet of 29-inch by 18-inch CMPA storm sewer segment, with an estimated hydraulic capacity of 7.5 cfs. These parallel storm sewer segments were considered to more closely match the capacity of the upstream 24-inch CMCP storm sewer.

To the extent that these alternatives have been implemented, the residents of the Ice House Bay area continue to perceive that pollutants are transported into the Bay from the surrounding residential area and roadway system. To address these concerns, compilation of a local level stormwater management plan could consider placement of a stormwater basin within lands adjacent to Jaeckles Drive. To implement such an alternative, the Okauchee Lake Management District or other appropriate governmental unit would have to acquire the lands upon which to develop a basin, and carefully engineer the basin to ensure that gravity flows can be maintained. Nongravity systems are not likely to be feasible due to issues related to pump noise, operational costs, and other intrusive aspects of the design. Alternatively, placement of a treatment device, such as a vortex separator or so-called "stormceptor" system, within the stormwater conveyance system could potentially remove much of the contaminant load. However, it would require ongoing maintenance and periodic cleaning. Such operations would be conducted by the operator of the system, which would most likely be the Town of Oconomowoc or the Okauchee Lake Management District.

Wisconsin Avenue at Shady Lane and Lake Drive at Road B near Point Comfort Drive

Two other potential areas of concern with respect to stormwater runoff were identified by the Okauchee Lake Management District Commissioners during the planning project; namely, areas within the urbanized portion of the Town of Oconomowoc that drain to the embayment known as Lower Okauchee Lake. These areas are both subject to stormwater runoff from local street systems, as shown on Map 12, and both have limited land area within which to locate appropriate stormwater management measures.

The portion of Wisconsin Avenue in the vicinity of Shady Lane is served by a piped stormwater conveyance system which discharges in a northerly direction to Lower Okauchee Lake. Runoff from this street system is currently not treated for water quality improvement purposes. Severe site constraints imposed by existing urban density development limits alternatives to maintaining the status quo or installing a technical water quality system such as the vortex separator system noted above. As the current conveyance system is placed within an existing utility easement, installation of the vortex separator system would appear to be a feasible option for use in this location.

---

[15] *The initial plan contained an additional recommendation that would divert runoff from STH 16 to the south, to an internally drained pond south of the Chicago, Milwaukee, St. Paul & Pacific Railroad line and east of CTH PP. This recommendation, however, is unlikely to meet current state permitting requirements for the discharge of stormwater to wetland ecosystems, and is not considered further in this analysis, which focuses instead on moderating the delivery of sediments to Ice Bay through the Jaeckles Boulevard stormwater conveyance system.*

Immediately north of the aforementioned site, and west of the intersection between Lake Drive and Wisconsin Avenue, Lake Drive descends to the point where Okauchee Lake joins with the embayment known as Lower Okauchee Lake. Drainage from this portion of the street system, and from the surrounding lands including those located on the western side of this junction between Okauchee Lake and Lower Okauchee Lake, flows along the road right-of-way and ultimately drains through a system of culverts in a southerly direction into Lower Okauchee Lake, both east and west of the narrows. The existing stormwater conveyance system is largely comprised of the swales and culverts within the road right-of-way. While some site constraints exist, especially on the eastern side of the narrows, installation of the vortex separator system also would appear to be a feasible option for use in this location. On the western side of the narrows, Town-owned lands would obviate the need for the acquisition of additional easements wherein to situate the stormwater management measures.

Both of these stormwater management measures, serving Wisconsin Avenue in the vicinity of Shady Lane and Lake Drive at Road B near Point Comfort Drive, would contribute to the control of urban runoff and contaminant loading to the Lake, and, while subject to considerable limitations imposed by the density of urban development in these areas, would appear to be feasible approaches for addressing nonpoint source pollution loads from this portion of the Town of Oconomowoc. These measures also should be considered during the preparation of local level stormwater management plan that include consideration of the use of good housekeeping practices and the "do nothing" alternative.

Stormwater Management in the Vicinity of West Lake Drive and North Lake Drive
Runoff from the local street system also contributes to the delivery of contaminants and stormwater to Okauchee Lake. As noted in Chapter IV, electors of the Okauchee Lake Management District identified runoff from the street system in the vicinity of the intersection of W. Lake Drive and N. Lake Drive as a factor in the transport of sediments and contaminants into Bay Five. Three alternatives may be considered to mitigate the impacts of drainage from this local street system to the Lake, in addition to the "do nothing" alternative.

Alternative one would require regrading on the local roadway to alter the camber of the street such that drainage from the street system is directed to the internally drained ponds located in the northwestern quadrant of the intersection. These ponds are currently situated on privately owned lands, so implementation of this alternative would require negotiation of appropriate easements for the conveyance and storage of stormwater on private lands or fee simple purchase. Based upon field reconnaissance by Commission staff and review of the Waukesha County large-scale topographic maps, the ponds in question, created as the result of sand and gravel extraction, are within the drainage area directly tributary to Okauchee Lake and would, during periods of exceptionally high rainfall, potentially overflow into the embayment known as Upper Oconomowoc Lake.

Alternative two would require the placement of a stormwater detention basin at the outfall of the current storm sewer. As with alternative one above, this basin would be located on privately owned lands. Thus, implementation of this alternative would require negotiation of appropriate easements for the conveyance and storage of stormwater on private lands or fee simple purchase. This basin would need to be sized so as to provide not only water quantity storage but also water quality benefit, especially in terms of the retention of solids carried in the runoff. Limited modification to the current outfall would also be required to provide for piped drainage into the basin.

Alternative three would require extension of the current piped stormwater drainage to the Lake. Property owners adjacent to this site have indicated that stormwater discharges commonly erode portions of their yards, while the historic placement of rock ballast adjacent to the street system would indicate a longer history of bank erosion in this area. While implementation of this alternative would obviate the concerns of the property owners located within the northeastern quadrant of the intersection, this option would not result in any significant beneficial impact on the Lake; a reduction in soil loss from the riparian lands may result, but the major portion of the stormwaterborne contaminant load would be conveyed directly into Bay Five. A variation of this alternative would involve the placement of a treatment device, such as a vortex separator system, within the stormwater conveyance system. While such a device could potentially remove much of the contaminant load, it would require ongoing maintenance and periodic cleaning. Such operations would be conducted by the operator of the system,

which would most likely be the Town of Oconomowoc or the Okauchee Lake Management District. Nevertheless, given the geometry of the site, this option may provide a feasible alternative for mitigating runoff from this intersection.

IN-LAKE MANAGEMENT ALTERNATIVES

The reduction of external nutrient loadings to Okauchee 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 continue to result in abundant macrophyte growth, that can result in restricted water use potentials, even after the implementation of watershed-based management measures. Given that Okauchee Lake falls within this trophic range, the application of in-lake rehabilitation techniques should be considered.

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 some 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, aquatic plant and fisheries management, and recreational use management measures. Each of these groups of management measures is described further below.

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 separately considered 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, 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 rate of continued sedimentation. Impacts can include the release of toxic quantities of free aluminum into the water. The resulting improved water clarity can also encourage the spread of rooted aquatic plants.

Nutrient inactivation is not recommended for Okauchee Lake due to the generally soft sediments and shallow depth of management areas, the susceptibility to wind- and boat motor-induced mixing, and the overall pollutant loading which mediate against the effective use of nutrient inactivation.

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 watershed is generally preferable to attempting such control within a lake. Many of the techniques presented in the watershed 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. 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 Okauchee Lake, especially given that internal loading from the lake sediments does not appear to be an important nutrient course to the water column. As noted in Chapter IV, the good agreement between predicted and observed phosphorus concentrations in the Lake strongly suggests that the external nutrient load to the Lake accounts for the largest portion of the phosphorus concentration in the Lake water column.

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 is to enhance a particular class of recreational uses, to control the types and densities of organisms within a waterbody, or to minimize high water or flooding problems. Consideration can be given to outlet control modifications, drawdown, and dredging. Because of the relatively high costs of these practices, and the (temporary) disruption to the lake community which occurs when these practices not recommended for widespread application in Okauchee Lake. However, dredging was considered in the initial plan to be appropriate for consideration within highly localized areas of the Lake, including the embayments known as Ice House Bay and Tierney Lake, the Tierney Lake channel, and Upper Oconomowoc and Lower Okauchee Lakes. The initial plan proposed dredging to a mean depth of between 10 feet and 15 feet, which depths could potentially reduce macrophyte growths over large portions of the Lake.

Outlet Control Operations

The outflow from Okauchee Lake is controlled by a dam located at the Oconomowoc River outlet located on the southern side of the Lake. The outlet structure has a fixed discharge elevation that maintains an operating level governed by the dam operating permit issued by the Wisconsin Department of Natural Resources.

Drawdown

Drawdown refers to a the 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 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 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 game fishing, an opportunity to collect fish more effectively in fish removal programs, an opportunity to improve docks and dams, and an opportunity to clean and repair shorelines and deepen areas using conventional earth-moving equipment. Limited, over-winter drawdowns, conducted pursuant to the dam operating permit, 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 algae 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.

As noted above, the water level of Okauchee Lake is controlled by an hydraulic control structure located on the eastern shore of the Lake. A limited drawdown could be obtained by opening the gate on the weir, while a total breaching of the dam would allow a drawdown of approximately six feet, exposing about 15 percent of the lake bottom. However, 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 recommended for Okauchee Lake.

Water Level Stabilization
Riparian residents have reported significant seasonal changes in the water levels in Okauchee Lake. 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 owners 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 the 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 recommended, it is desirable form the point of view of aquatic habitat that water level fluctuations be maintained within these natural limits.

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 cutter-head 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 and $5 per cubic yard. Effectiveness of dredging varies with the effectiveness of watershed controls in reducing or minimizing the sediment sources. Federal and State permits are required for use of this option.

Dredging in Okauchee 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 both the summer and winter recreational seasons, use of these methods is not recommended.

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 Okauchee Lake should be to increase water depth to maintain recreational boating access and increased public safety.

Notwithstanding, 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, and destruction of benthic 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 Okauchee 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 drainage area tributary to the lake. The sediment load reaching Okauchee Lake comes from both urban and agricultural lands within the drainage area tributary to Okauchee 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 watershed. Such practices should be implemented in the drainage 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 Wisconsin Department of Natural Resources Chapter 30 permit and a U.S. Army Corps of Engineers 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 Department of Natural Resources for review and potential solid waste licensing of the disposal site. Because sodium arsenite was applied to Okauchee 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.

Because of the considerations noted above, extensive dredging of Okauchee Lake is not considered a viable alternative at this time.

Aquatic Plant and Fisheries Management

Fisheries Management Measures

Okauchee Lake provides a quality habitat for a healthy, warmwater fishery. Currently adequate water quality, dissolved oxygen levels, sand and gravel shorelines, and diverse plant community exist for the maintenance of a sportfish population in the Lake. While winterkills have occurred in the past, winterkill is currently not a problem. The Lake supports a good largemouth bass and muskellunge fishery, along with a wide range of sport and panfish.

Habitat Protection

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat, including measures such as restricting recreational and other intrusions into gravel-bottomed shoreline areas during the spawning season. For bass this is mid-April to mid-June. 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 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.

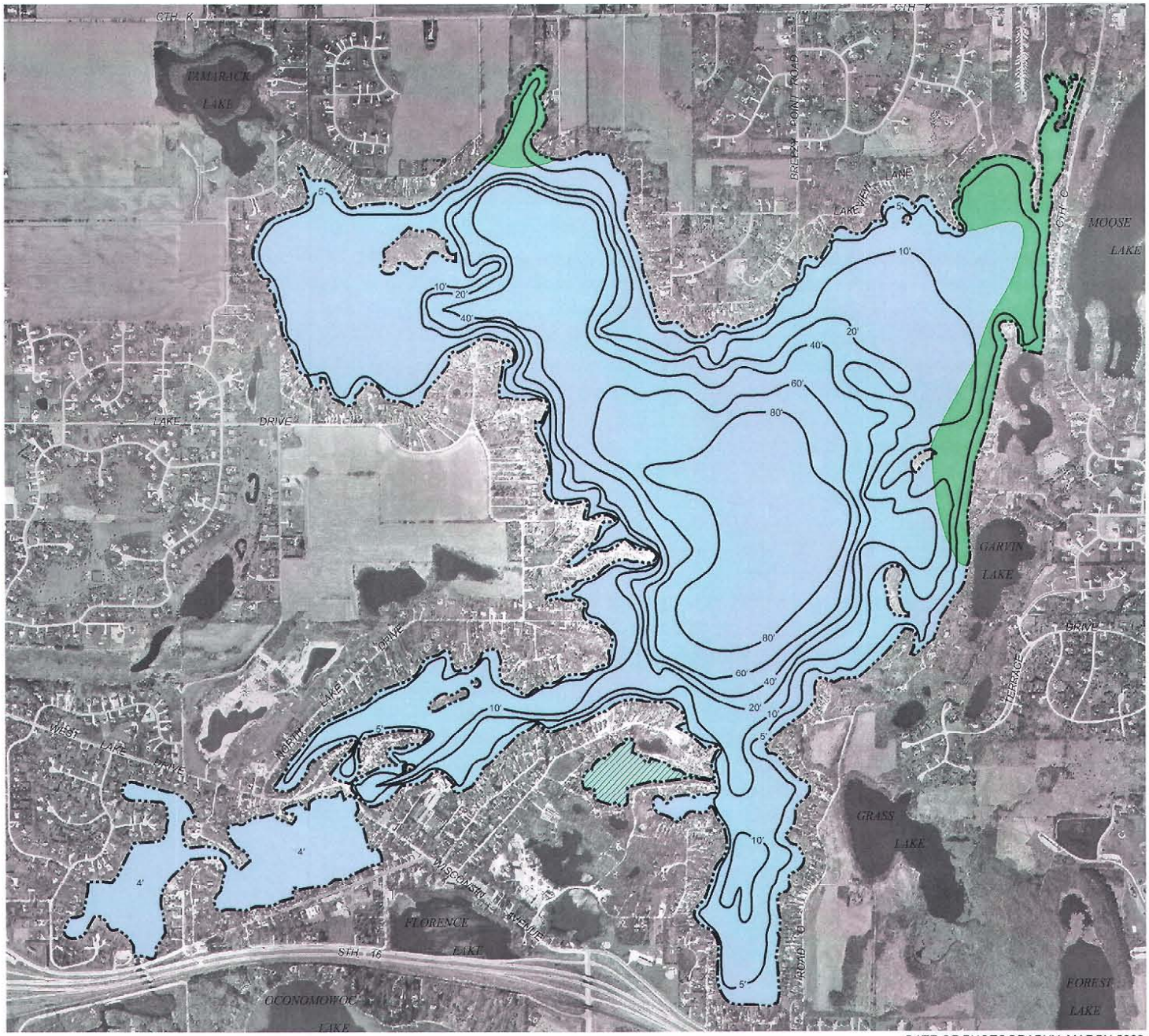
Loss of habitat should be a primary concern of any fisheries management program. The environmentally valuable areas identified within the Lake and its watershed are the most important areas to be protected. In addition, limiting or restricting certain activities in sensitive areas of the Lake will prevent significant disturbance of fish nests and aquatic plant beds. The areas currently proposed to be designated by the WDNR as sensitive areas within Okauchee Lake, pursuant to authorities granted under Chapter NR 107 of the *Wisconsin Administrative Code*, are shown on Map 21. Within these areas, aquatic plant management measures may be restricted, and dredging, filling, and the construction of piers and docks may be discouraged.[16] 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.

---

[16]*Section NR 107.05(3)(2) of the* Wisconsin Administrative Code *provides that the Wisconsin Department of Natural Resources, in issuing permits for the utilization of aquatic herbicides in lakes, may designate specific areas as "sensitive" for reasons of being critical fish habitat or wildlife habitat, offering water quality benefit, or providing erosion control benefit. Designation of such areas requires two actions; namely, 1) delineation or mapping of sensitive areas, as are shown on Map 21; and 2) notification of affected property owners, lake associations, and lake districts, which requirement has yet to be undertaken at Okauchee Lake. In the process of delineating and designating these areas, Wisconsin Department of Natural Resources staff frequently invoke parallel authorities pursuant to Chapter 30 of the* Wisconsin Statutes, *that affect other lake management alternatives, such as dredging, placement of piers, and related activities not specifically addressed in Chapter NR 107 of the* Wisconsin Administrative Code. *Pursuant to Section 227.42 of the* Wisconsin Statutes, *persons concerned have a right to request a public hearing on issues involving the application of the provisions of the* Wisconsin Statutes *and* Wisconsin Administrative Code, *should there be actual or threatened injury to their interests, the protection of their interests, or specific injury likely to arise from either action or inaction and a dispute of fact. This right is embodied in Section NR 107.05(1) with respect to the issuance of permits by the Wisconsin Department of Natural Resources for aquatic plant management in the waters of the State, and is applicable to determinations of sensitive areas under this* Wisconsin Administrative Code. *As of 2003, the Wisconsin Department of Natural Resources indicated, in a memorandum dated December 8, 2003, their intention of pursuing the designation of sensitive areas in Okauchee Lake during 2004.*

Map 21

WISCONSIN DEPARTMENT OF NATURAL RESOURCES-PROPOSED OKAUCHEE LAKE ENVIRONMENTALLY SENSITIVE AREAS



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

ENVIRONMENTALLY SENSITIVE AREA PROPOSED BY WISCONSIN DEPARTMENT OF NATURAL RESOURCES PURSUANT TO S. NR 107.05(3)(i)

ADDITIONAL ENVIRONMENTALLY SENSITIVE AREA UNDER CONSIDERATION BY WISCONSIN DEPARTMENT OF NATURAL RESOURCES AS OF 2003

GRAPHIC SCALE

0 1000 2000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

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. Currently, about 99 percent of the shoreline of Okauchee Lake is protected by some type of structural measure, as shown on Map 3. Four shoreline erosion control techniques were in use in 2000: vegetative buffer strips, rock revetments, wooden and concrete bulkheads, and beaches. Of these measures, 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. Along more active shorelines, such as those exposed to wind wave action or heavy boat wake action, use of riprap is generally the option recommended by the WDNR. Notwithstanding, placement of riprap as well as other shoreline protection measures is an action that requires a WDNR permit pursuant to Chapter 30 of the *Wisconsin Statutes*.

Desirable plant species that may be expected and encouraged to create a vegetated buffer strip, or which could be planted along a shoreline, 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 an 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 Okauchee Lake. The technique involves the shaping of the shoreline slope, the placement of a porous filter material, such as sand, gravel, or pebbles, on the slope and the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of rock revetments are that they are highly flexible and not readily weakened by movements caused by settling or ice expansion, they can be constructed in stages, and they require little or no maintenance. The disadvantages of rock revetments are that they limit some uses of the immediate shoreline. The rough, irregular rock surfaces are unsuitable for walking; require a relatively large amount of filter material and rocks to be transported to the lakeshore; and can cause temporary disruptions and contribute sediment to the lake. If improperly constructed, revetments may fail because of washout of the filter material. A rock revetment is estimated to cost $25 to $40 per linear foot.

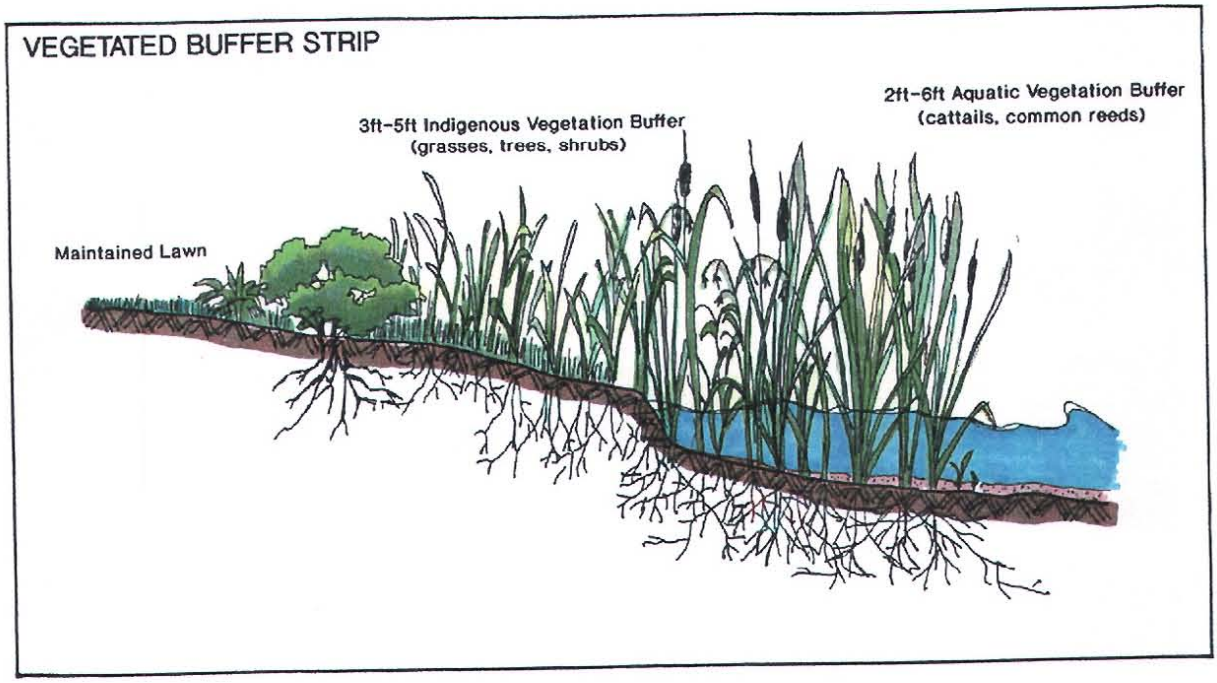
The use of vegetated buffer strips and riprap, as shown in Figure 15, is recommended, especially in those areas of Okauchee Lake subject to significant wind-wave, boat wake, and ice scour erosion. In those portions of the Lake subject to direct action of wind waves and ice scour, the use of riprap would 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 proposed to be subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*, which Chapter, as of 2002, is currently in draft and under administrative review by the Wisconsin Natural Resources Board.

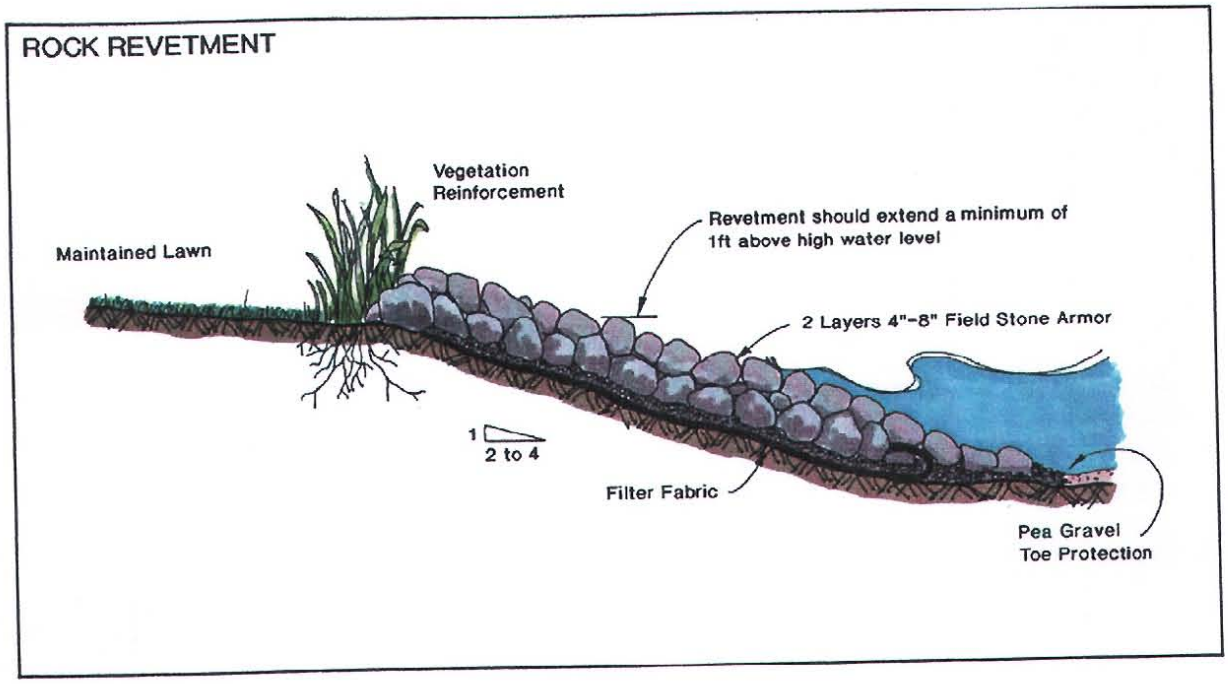
Modification of Species Composition

Species composition management refers to a group of conservation and restoration measures that includes 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 forage fish and increase

Figure 15

PLAN 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.

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/or other rough fish, 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 recommended for Okauchee Lake.

As noted in Chapter V, Okauchee Lake is currently managed for warmwater sportfish, and selective stocking is undertaken by the WDNR and private sport fish organizations. Continued fish stocking by the WDNR and the private organizations is recommended for Okauchee Lake, subject to monitoring and creel survey data collected from the Lake by the WDNR. Additional fish population control measures do not appear to be warranted at this time, although rough fish populations should continue to be monitored

Regulations and Public Information

To reduce the risk of overharvest, the Wisconsin Department of Natural Resources 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 Okauchee Lake are given in Table 24. Enforcement of these regulations is critical to the success of any sound fish management program.

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 classed into three groups: physical measures, which include lake bottom coverings and water level management; mechanical removal measures, which include harvesting and manual removal; and chemical measures, which include using aquatic herbicides. In addition, biological control measures, which include the use of various organisms, including insects, form a fourth group of aquatic plant management measures. All of these 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 for the purchase of a mechanical plant harvester and ancillary equipment, the operational costs for which can approach $10,000 to $20,000 per harvester 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 the Lake, 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.

Aquatic Herbicides

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 relatively low cost and the ease, speed, and convenience of application. 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.[17]

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 are nonselective, often affecting nontarget, desirable species as well as the "weeds."

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.[18]

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 Okauchee 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 recommended.

Aquatic Plant Harvesting

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:

---

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

[18]*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.*

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.[19]

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.

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.[20]

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 Wisconsin Department of Natural Resources study found that four pounds of fish were removed per ton of plants harvested.[21]

---

[19] *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.*

[20] *James E. Breck, and J.F. Kitchell, "Effects of Macrophyte Harvesting on Simulated Predator-Prey Interactions," edited by Breck et al., 1979, pp. 211-228.*

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

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.[22] 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.

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 Okauchee Lake could be continued by the Okauchee Lake Management District staff or be contracted to a private company. These costs are largely staff costs and operating costs such as fuel, oil, and maintenance. The cost of new harvesting equipment, when needed, would be about $282,500.

Various types of harvesters and harvesting practices are available to address the many issues encountered on Okauchee Lake. The Village of Okauchee currently operates an aquatic plant harvester, primarily in the easternmost portion near the outlet of the Lake, and the Okauchee Lake Management District operates along the nearshore areas of the western basin and the portion of the eastern basin not harvested by the Village.

A harvesting program 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 no utilize these dense beds.[23] 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 plans such as Eurasian water milfoil, as shown in Figure 16, is suggested. The harvest of water lilies and other emergent native plants, however, 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.[24] Stress can be brought on by watershed 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

---

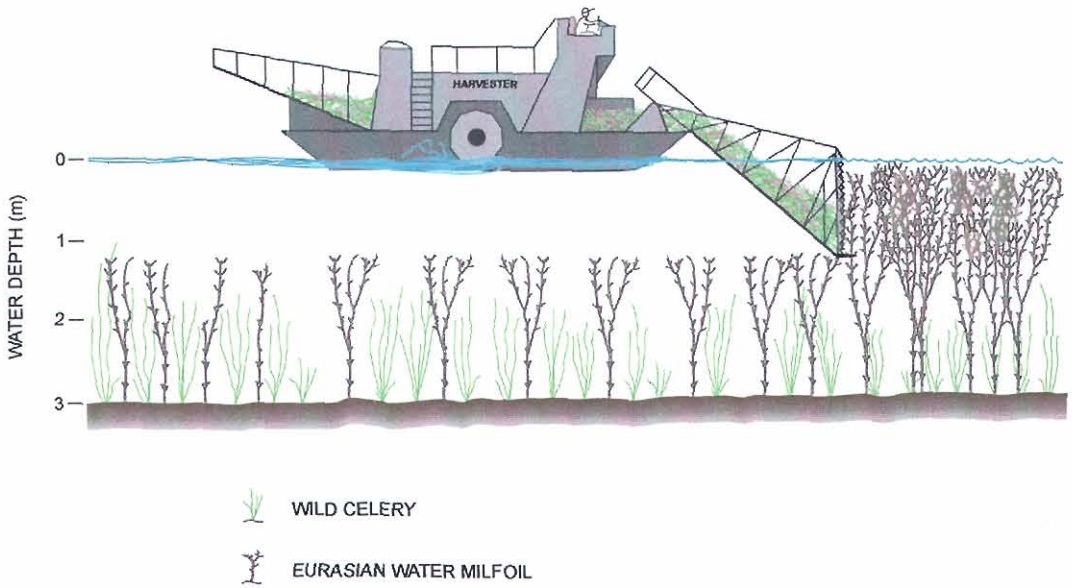
[22] *James E. Breck, et. al.,* op. cit.

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

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

Figure 16

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.

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.[25]

Because of the demonstrated need for control of aquatic plants in Okauchee Lake, harvesting is considered a viable continued management option. Mechanical harvesting of aquatic plants must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code.*

Manual Harvesting

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 assist lakefront homeowners in manually removing aquatic plants from the shoreline area. The advantage 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 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

[25]*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.*

30-feet-wide recreational corridor 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-feet-wide recreational corridor.

Biological Controls

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.[26] 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.[27] 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.

To date, relatively few studies have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control.[28] Nevertheless, *Eurhychiopsis lecontei* appears to be effective control agents in certain situations. However, they are extremely sensitive to disturbances, especially those created by recreational boating traffic, and are not generally compatible with large-scale harvesting operations which remove the weevils with the plant materials being harvested. The weevil prefers the upper portion of the Eurasian water milfoil plant, suggesting that harvesting would have to be extremely limited or not used at all in conjunction with this type of aquatic plant management control. These factors have contributed to variable levels of control. Consequently, the use of this biological control agent, while priced competitively with aquatic herbicides, is not recommended as being practical for Okauchee 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, 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. Notwithstanding, use of the purple loosestrife beetles as a control agent for purple loosestrife infestations within the watershed and in the wetland areas adjacent to the Lake is recommended.

---

[26] *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.*

[27] *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.*

[28] *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.*

Lake Bottom Covering

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 Wisconsin Department of Natural Resources 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 recommended for Okauchee 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 recommended 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 18, 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 Okauchee 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 Wisconsin Department of Natural Resources and the University of Wisconsin-Extension Service. The aquatic plant species lists provided in Chapter V, and the illustrations of common aquatic plants present in Okauchee 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 Okauchee Lake, Eurasian water milfoil is one of the few species likely to cause lake-use problems. 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. While the Okauchee Lake Management District harvester crews conduct an extensive shoreline clean-up effort as part of the current aquatic plant management program, 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 and into new areas of the Lake.

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).[29] Providing the opportunity for the removal of plant fragments at the boat landing on Okauchee 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 Wisconsin Department of Natural Resources and University of Wisconsin-Extension Service 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. 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 approximately 200 feet of shore or 150 feet of pierheads. These areas typically coincide with water depths of less than five feet in depth. Demarcation of WDNR-delineated sensitive areas, Eurasian water milfoil control areas, and similar environmentally valuable or

---

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

sensitive areas of the Lake is recommended. It is also recommended that the governmental bodies surrounding Okauchee Lake continue to enforce recreational boating ordinance and winter lake use 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 University of Wisconsin-Extension Service, the Wisconsin Department of Natural Resources, and the Waukesha County Department of Parks and Land Use. 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. Other Waukesha County lake organizations, in cooperation with the Waukesha County Department of Parks and Land Use, have compiled and distributed information packets to landowners on water quality protection measures and residential "good housekeeping" practices. 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.

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. These educational opportunities include programs and curricula such as Project WET, Adopt-A-Lake, and the Waukesha Water Walk program are available from and supported by the University of Wisconsin-Extension and Waukesha County, respectively. Through these programs, youth have an opportunity to experience "hands on" the aquatic environment and become better informed about current and future lake issues and concerns.

Finally, the participation of the Okauchee Lake community in the Wisconsin Department of Natural Resources Self-Help Monitoring Program should be continued. Volunteer monitoring under the auspices of the WDNR "Self-Help Monitoring Program" involves citizens in taking Secchi-disc transparency readings in the Lake at regular intervals. The Lake Coordinator of the Wisconsin Department of Natural Resources-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 Okauchee 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 watershed inventory. Selected characteristics of these measures are summarized in Table 34.

An evaluation of the potential management measures for improving the Okauchee 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, drawdown by water level control modifications, dredging, biological control of aquatic plants, lake bottom covering, and development of alternative institutions. The remaining measures are recommended to be considered further for incorporation in the recommended plan described in Chapter VIII.

Table 34

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR OKAUCHEE LAKE

Alternative Measure	Description	Estimated Costs: 2000		Considered Viable for Potential Inclusion in Recommended Lake Management Plan
		Capital	Operation and Maintenance	
Land Use Management and Zoning	Implement regional land use and county development plans within watershed	--	--	Yes
	Maintain existing urban density development in lakeshore areas	--	--	Yes
Protection of Environmentally Sensitive Lands	Implement regional natural areas and critical species habitat protection and management plan recommendations within watershed	--	--	Yes
Point Source Pollution Abatement	Implement refined regional water quality management plan recommendations to provide sanitary sewerage services to urban areas of the lake shore	--	--	Yes
	Implement onsite sewage disposal system management, including inspection and maintenance	--	$100[b]	Yes
Nonpoint Source Pollution Abatement	Implement regional water quality management plan, Oconomowoc River priority watershed plan, and county land and water resource management plan recommendations within watershed	--	--	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 watershed	--[a]	--[a]	Yes
Urban Nonpoint Source Controls	Promote urban housekeeping practices, public educational programming, and grassed swales	--[a]	--[a]	Yes
	Implement additional urban nonpoint source controls, including street sweeping, catch basin cleaning, leaf litter and garden refuse collection, materials storage facility protection, and stormwater management measures in urban areas of the watershed	--[a]	--[a]	Yes

Table 34 (continued)

Alternative Measure	Description	Estimated Costs: 2000		Considered Viable for Potential Inclusion in Recommended Lake Management Plan
		Capital	Operation and Maintenance	
Developing Area Nonpoint Source Controls	Enforce construction site erosion control ordinances requiring soil stabilization, surface roughening, barriers, diversion swales, sediment traps and basins	$250 per acre	$25 per acre	Yes
Stormwater Management Measures	Implement stormwater management measures for water quality protection at four sites in the vicinity of STH 16/Jaeckles Boulevard, Lake Drive, and Wisconsin Avenue	--	--	Yes
	Develop and implement consistent stormwater management ordinances in all riparian communities	--	--	Yes
In-Lake Water Quality Improvement Measures	Conduct alum treatment to achieve phosphorus inactivation in lake sediments	--	$15,000/40 acres	No
	Promote nutrient load reduction within the Lake basin through sediment management	--	Variable	No[c]
Hydraulic and Hydrologic Management	Modify outlet control operations	--	--	No
	Drawdown	--	--	No
	Water level stabilization	--	--	No
	Dredging	--	--	No
Fisheries Management	Protect fish habitat	--	--	Yes
	Maintain shoreline and littoral zone fish habitat	--	--	Yes
	Continue stocking of selected game fish species and monitor rough fish populations	--	--	Yes
	Enforce size and catch limit regulations	--	$1,200	Yes
Aquatic Plant Management	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife	--	Variable	Yes[d]
	Harvest aquatic plants to provide boating access lanes and fish lanes; remove Eurasian water milfoil canopy to promote growth of native plants	$100,000	$22,000	Yes[e]
	Manually harvest aquatic plants from around docks and piers	$200	--	Yes
	Employ biological controls using inocula of Eurasian water milfoil weevils	--	Variable	No
	Employ biological controls using inocula of purple loosestrife beetles	--	Variable	Yes

Table 34 (continued)

Alternative Measure	Description	Estimated Costs: 2000		Considered Viable for Potential Inclusion in Recommended Lake Management Plan
		Capital	Operation and Maintenance	
Aquatic Plant Management (continued)	Use sediment covers to shade out aquatic plant growth around piers and docks	--	$40 to $220 per 700 square feet	No
	Conduct public informational and educational programming on aquatic plants and options for their management	--	$100 to $300	Yes
Recreational Use Management	Enforce boating regulations to maximize public safety; improve signage	--	$1,000[f]	Yes
Public Informational and Educational Programming	Conduct public informational programming	--	$3,000	Yes
	Support participation of schools in Project WET, Adopt-A-Lake, etc.	--	--	Yes
	Continue participation in Self-Help Monitoring Program	--	$1,000	Yes

[a]*Cost of nonpoint source management practices to be determined by detailed farm plans and stormwater management plans.*

[b]*Onsite sanitary sewage disposal systems installed after 1983 are subject to regular inspection and maintenance requirements under Waukesha County Code; the cost shown represents an average pumping cost per property.*

[c]*While no in-lake nutrient management measures are recommended, control of nutrient runoff from the drainage area tributary to Okauchee Lake is recommended to be conducted as part of the nonpoint source pollution abatement program.*

[d]*In limited areas when necessary to control exotic, invasive species.*

[e]*Estimated capital cost is for new harvesting equipment to replace existing equipment, when needed.*

[f]*Cost for improved signage.*

Source: SEWRPC.

(This page intentionally left blank)

Chapter VIII

RECOMMENDED PLAN

INTRODUCTION

This chapter, building on the land use, land and water management, and biological and water quality inventory findings; pollution source analyses; land use and population forecasts; and alternative water quality management plan evaluations, presents a recommended management plan and its projected costs for Okauchee Lake. The plan sets forth the recommended means for: 1) providing water quality conditions suitable for the maintenance of fish and aquatic life; 2) reducing the severity of existing nuisance problems due to excessive aquatic plant growths which constrain or preclude intended water uses; and 3) improving opportunities for a range of water-based recreational activities. 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 34, that may be expected to best meet the foregoing lake management objectives. The recommendations address each of the lake management issues described in Chapter VII.

Analyses of water quality and biological conditions indicate that the general condition of the water of Okauchee Lake is 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 drainage area tributary to the Lake, as set forth in the adopted Waukesha County development plan, 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 in the drainage area tributary to Okauchee Lake, protection of environmentally sensitive lands, water quality improvement, aquatic plant and fisheries management, and informational programming. These measures complement and refine the watershedwide land use controls and management measures recommended in the adopted regional water quality management plan,[1] the Oconomowoc River priority watershed plan,[2] and the Waukesha County land and water resource management plan.[3]

---

[1] *SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume Three,* Recommended Plan, *June 1979.*

[2] *Wisconsin Department of Natural Resources Publication No. WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

[3] *Waukesha County,* Land and Water Resource Management Plan: 1999-2002, *December 1998.*

The recommended management measures for Okauchee Lake are graphically summarized on Map 22, and are listed in Table 35. The recommended plan measures are more fully described in the following paragraphs. It should be noted that recreational use management measures were also considered in developing this management plan, but were not included within the recommended management plan at this time. The recommended management agency responsibilities for watershed land management also are set forth in Table 35.

WATERSHED MANAGEMENT MEASURES

Land Use Control and Management

A fundamental element of a sound management plan and program for Okauchee Lake is the promotion of a sound land use pattern within the drainage area tributary to the Lake. The type and location of rural and urban land uses in the drainage 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 drainage area tributary to Okauchee 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 Waukesha County development plan.[4] The recommended land use and county development plans envision that urban land use development within the drainage area tributary to Okauchee 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 Okauchee Lake is the redevelopment of existing lakefront properties, replacing lower-density uses with higher-density, multi-family dwellings or significantly larger single-family dwellings with potential for increased roof areas, parking areas, and other areas of impervious surfaces. Replacement of a pervious land surface with an 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 drainage 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 Okauchee 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 Merton and Town of Oconomowoc Plan Commissions, with advice from the Okauchee Lake Management District as appropriate. 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 benefit are practices to be encouraged.

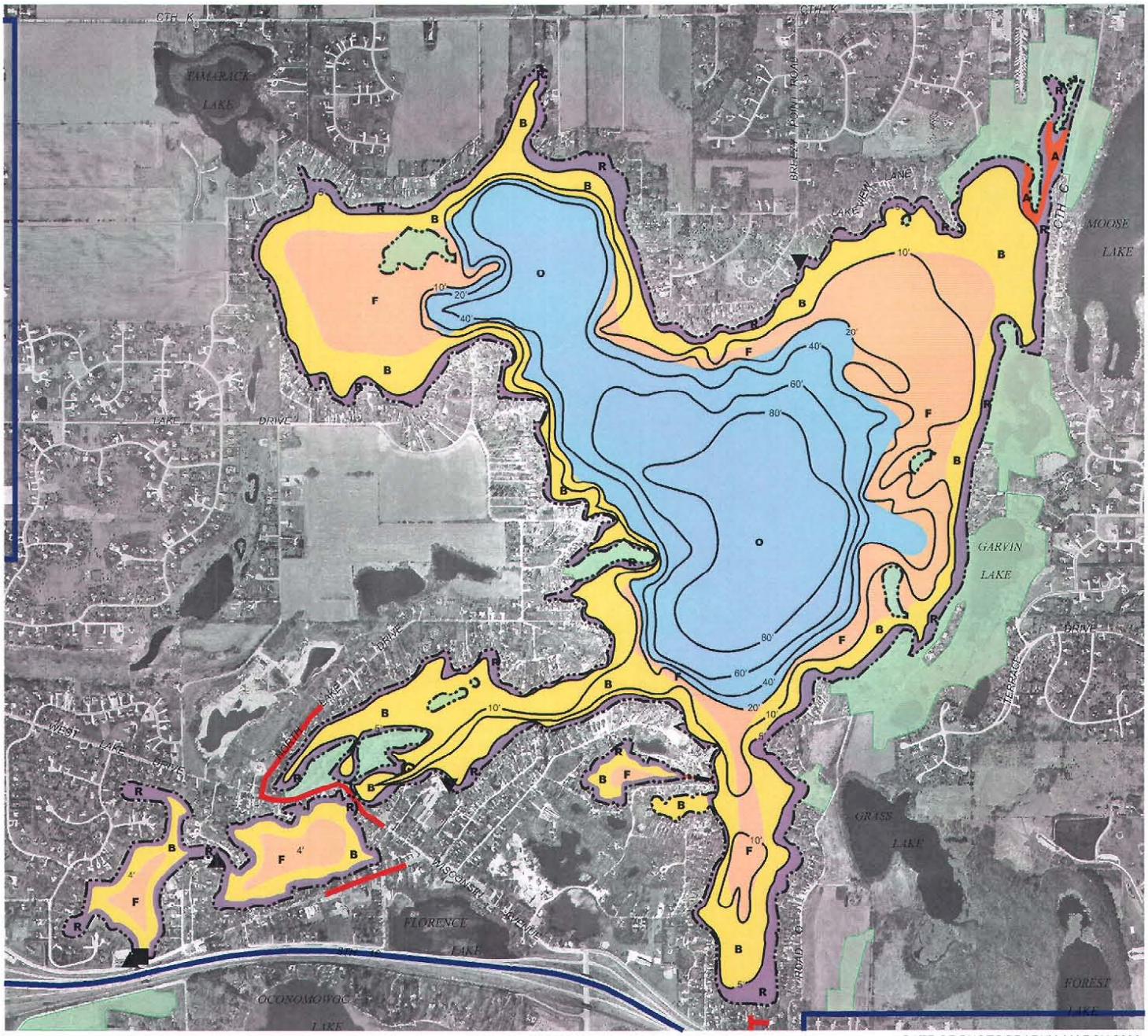
Development in the Tributary Drainage Area

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 drainage area. As previously noted, large-lot residential development is planned to occur in selected areas of the lake watershed. If this trend continues, much of the open

[4]*SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

Map 22

RECOMMENDED LAKE MANAGEMENT PLAN FOR OKAUCHEE LAKE



— 20' — WATER DEPTH CONTOUR IN FEET

■ WATER LEVEL CONTROL STRUCTURE

▲ PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA

▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

A ACCESS: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

B BOATING / RECREATION: SURFACE CUT OF EURASIAN WATER MILFOIL, HARVESTING MODERATE PRIORITY

R RIPARIAN ZONE: MAINTAIN SHORELINE PROTECTION STRUCTURES AS NECESSARY, INSTALL VEGETATIVE BUFFERS, MANUALLY HARVEST AQUATIC PLANTS AROUND PIERS AND DOCKS

F FISH BREEDING AND HABITAT/ANGLING AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON

O OPEN WATER: DEPTH GREATER THAN 20 FEET - NO AQUATIC MANAGEMENT MEASURES RECOMMENDED

LAND USE MANAGEMENT

PROTECT ENVIRONMENTAL CORRIDOR LANDS

- OBSERVE GUIDELINES SET FORTH IN THE COUNTY DEVELOPMENT PLAN, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS

BOUNDARY OF SANITARY SEWER SERVICE AREA: OKAUCHEE LAKE- PROVIDE PUBLIC SANITARY SEWERAGE SERVICES, REFINE AS NECESSARY

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM

IMPLEMENT RUNOFF MANAGEMENT PRACTICES

FISHERIES MANAGEMENT

- CONTINUE TO MONITOR FISH POPULATIONS, MODIFY STOCKING/ HARVESTING PROGRAM AND REGULATIONS, AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

GRAPHIC SCALE

0 1000 2000 FEET

Source: Okauchee Lake Management District and SEWRPC.

Table 35

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR OKAUCHEE LAKE

Plan Element	Subelement	Location	Management Measures	Management Responsibility
Land Use Control and Management	Land use development and planning	Entire watershed	Observe guidelines set forth in the regional land use plan and Waukesha County development plan	Waukesha County, Washington County, City of Delafield, Village of Chenequa, Village of Hartland, Village of Merton, Village of Nashotah, Village of Oconomowoc Lake, Village of Slinger, Town of Erin, Town of Hartford, Town of Lisbon, Town of Merton, Town of Oconomowoc, Town of Polk, Town of Richfield, and Town of Summit
		Enforce adequate setbacks and promote environmentally friendly landscaping practices in shoreland areas	Waukesha County, Town of Merton, Town of Oconomowoc, WDNR	WisDOT, Waukesha County, Town of Oconomowoc
	Density management	Lakeshore areas	Maintain historic lake front residential dwelling densities to extent practicable	Town of Merton and Town of Oconomowoc
	Stormwater Management	Minimize shoreland impacts on lake water quality and lakeshore habitat	Restrict pollutant loading from stormwater discharges to the Lake through implementation of stormwater management practices	Waukesha County Town of Merton, Town of Oconomowoc, WDNR
			Install construction site erosion control measures as required by local ordinance; enforce construction site erosion control and stormwater ordinance provisions	Private landowners, Waukesha County, Town of Merton, Town of Oconomowoc, WDNR
		Develop and implement detailed, local-level stormwater plans for selected areas of the lakeshore	Prepare and implement detailed local-level stormwater management plans to minimize contaminant loadings from STH 16 and Jaeckles Boulevard, Wisconsin Avenue at Shady Lane, Lake Drive between Road B and Point Comfort Drive, and W. Lake Drive at N. Lake Drive	Okauchee Lake Management District, Town of Oconomowoc, Waukesha County, WisDOT
	Protection of environmentally sensitive lands	Oconomowoc Sedge Meadow, and Stonebank Tamarack Relict	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	Waukesha County, Town of Merton, Town of Oconomowoc, Okauchee Lake Management District

Table 35 (continued)

Plan Element	Subelement	Location	Management Measures	Management Responsibility
Nonpoint Source Pollution Control	Rural nonpoint source controls	Entire watershed	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 plan	USDA, WDATCP, Waukesha County
	Urban nonpoint source controls	Entire watershed	Promote sound urban housekeeping and yard care practices through informational programming	Town of Merton, Town of Oconomowoc, Okauchee Lake Management District
		Entire watershed	Consider development of lawn care management and shoreland protection ordinances	Town of Merton, Town of Oconomowoc, Okauchee Lake Management District
	Construction site erosion control and stormwater management ordinance	Entire watershed	Develop and enforce construction site erosion control and stormwater management ordinances; review ordinances for concurrency with proposed NR 152	Waukesha County, Town of Merton, Town of Oconomowoc
		New residential development in conservation subdivisions	Use conservation subdivision designs and develop integrated stormwater management systems where appropriate densities exist	Waukesha County Town of Merton, Town of Oconomowoc
Point Source Pollution Control	Sewerage system management	Entire watershed	Implement refined regional water quality management plan recommendations to provide sanitary sewerage services to selected urban areas of the lake drainage area	Waukesha County, City of Oconomowoc, Delafield-Hartland Water Pollution Control Commission, Town of Merton, Town of Oconomowoc
			Implement onsite sewage disposal system management, including inspection and maintenance	Waukesha County, private landowners
Surface Water Management	Water quality monitoring	Entire Lake	Continue participation in WDNR Self-help Monitoring Program; continue participation in U.S. Geological Survey TSI monitoring program	WDNR, USGS, Okauchee Lake Management District
	Dam operations and Lake level monitoring	Entire Lake	Maintain outlet structure and monitor water levels	WDNR, Town of Oconomowoc
Fish Management	Fish survey and stocking program	Selected areas of Lake	Conduct periodic fish surveys to determine management and stocking needs; continue stocking; conduct periodic creel census; enforce size and catch limit regulations	WDNR
	Habitat Protection	WDNR-delineated sensitive areas	Limit chemical treatments and harvesting pursuant to Chapter NR 107 and NR 109 requirements	WDNR, Okauchee Lake Management District
		WDNR-delineated sensitive areas	Manage aquatic plant harvesting program pursuant to Chapter NR 109 requirements	WDNR, Okauchee Lake Management District
	Shoreland Protection	Entire Lake	Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Waukesha County, Town of Merton, Town of Oconomowoc, WDNR

Table 35 (continued)

Plan Element	Subelement	Location	Management Measures	Management Responsibility
Fish Management (continued)			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, Waukesha County, Town of Merton, Town of Oconomowoc, Okauchee Lake Management District, WDNR, UWEX
Aquatic Plant Management	Comprehensive plan refinement	Entire Lake	Update aquatic plant management plan every three to five years	WDNR, Okauchee Lake Management District
	Major and minor channel harvesting	Selected areas of Lake	Harvest aquatic plants as required to facilitate recreational boating access; restrict harvesting in spring and autumn to avoid disturbances in fish breeding areas and WDNR-delineated sensitive areas	Okauchee Lake Management District
	Manual harvesting	Littoral areas	Manually harvest around piers and docks as necessary	Okauchee Lake Management District, private landowners
	Chemical treatment	Selected areas of Lake and shoreland	Limited to control of nuisance aquatic plant growth where necessary; specifically target Eurasian water milfoil, curly-leaf pondweed, garlic mustard, and purple loosestrife infestations	WDNR, Okauchee Lake Management District
	Biological control of nonnative species	Shoreland areas	Use purple loosestrife beetles and weevils to control purple loosestrife infestations as appropriate	Okauchee Lake Management District, private landowners
	Shoreline maintenance	Lakeshore areas	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials in Lake	Okauchee Lake Management District, private landowners
Recreational Use Management	Boating Access	Public access sites	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines	Waukesha County, WDNR
	Recreational boating and vehicular use	Entire Lake	Continue to enforce and periodically review, recreational boating (summer) and vehicular use (winter) ordinances	Waukesha County, Town of Merton, Town of Oconomowoc, Okauchee Lake Management District, WDNR
Informational and Educational Program	Public informational and educational programming	Entire watershed	Continue public awareness and informational programming	Waukesha County, Town of Merton, Town of Oconomowoc, Okauchee Lake Management District, WDNR, UWEX
		Entire Lake	Encourage inclusion of lake studies in environmental curricula (e.g., Project WET, Adopt-A-Lake, Waukesha Water Walk)	Kettle Moraine School District, Arrowhead Union High School, UWEX, Waukesha County

Source: SEWRPC.

space areas remaining in the drainage area will be replaced over time with large-lot urban development. This may increase the pollutant loadings to the Lake and increase the pressures for recreational use of the Lake. Under the full buildout condition envisioned under the Waukesha County development 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 drainage 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 Okauchee 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 Towns of Merton and Oconomowoc 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 programs within specific portions of the drainage 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 Okauchee Lake. Adoption by all riparian municipalities of common stormwater management ordinance provisions is strongly recommended.

Based upon concerns identified by the Commissioners and electors of the Okauchee Lake Management District, four areas of concern were identified and are recommended to be priority areas for detailed, local-level stormwater planning. As noted in Chapters IV and VII, these areas are generally severely constrained with respect to structural stormwater management practices as a consequence of existing urban density development. However, each drains directly to the Lake and forms a conduit for the delivery of contaminants directly to the nearshore areas of the Lake and its embayments. Thus, stormwater management measures implemented in these areas are recommended to include practices resulting in water quality benefit. In each of these areas, as elsewhere in the watershed draining to Okauchee Lake, in addition to site-specific measures, implementation of informational programming to promote good urban housekeeping practices is highly recommended.

Stormwater Management in the Vicinity of STH 16 and Jaeckles Boulevard

Specific practices were recommended in the initial plan to be applied to that portion of the drainage area tributary to Okauchee Lake, adjacent to STH 16 and south of the embayment locally known as Ice House Bay. These practices included measures to prevent soil erosion along STH 16 within the Lake drainage area, and enhance the retention of stormwater within the drainage system. These measures recommended the permanent installation of facilities to redirect stormwater from Ice House Bay to an internally drained pond south of the Chicago, Milwaukee, St. Paul & Pacific Railroad and east of CTH PP, and installation of a parallel CMPA storm sewer segment be installed at the foot of Jaeckles Boulevard in order to resolve the remaining concerns noted in the initial plan with respect to the sizing of the existing structure. That pipe was proposed to consist of an approximately 200-feet length of 29-inch by 18-inch CMPA storm sewer segment, with an estimated hydraulic capacity of 7.5 cfs. These parallel storm sewer segments were designed to more closely match the capacity of the upstream 24-inch CMCP storm sewer.

While the recommended diversion of highway stormwater runoff to an internally drained wetland area is no longer likely to be considered a feasible option, the upgrading of the stormwater conveyance system remains a viable alternative to be evaluated as part of a site-specific stormwater management planning program for this

subbasin. Provision of water quality benefit is recommended to be integrated into this stormwater management system, using in-line water quality treatment systems such as the vortex separator or so-called "stormceptor" system, surface detention or retention basins, or a combination thereof, as appropriate. Provision of in-line water quality treatment could be accomplished within existing rights-of-way for utility services along Jaeckles Boulevard; development of stormwater basins would require land acquisition within this primarily residential community by either the Okauchee Lake Management District or relevant local unit of government. This latter, while likely a more expensive alternative, has the potential to provide an higher degree of water quality protection and benefit than the in-line treatment systems.

Wisconsin Avenue at Shady Lane
The portion of Wisconsin Avenue in the vicinity of Shady Lane is served by a piped stormwater conveyance system which discharges in a northerly direction to the embayment locally known as Lower Okauchee Lake. This system currently does not include treatment for water quality improvement. Due to severe site constraints imposed by existing urban density development, the installation of a technical water quality treatment system such as the vortex separator system noted above is recommended, subject to a detailed evaluation conducted as part of a site-specific stormwater management planning program. Because the current conveyance system is placed within an existing utility easement, use of this technical approach is a feasible option for use in this location.

Lake Drive at Road B near Point Comfort Drive
Immediately north of the aforementioned site, and west of the intersection between Lake Drive and Wisconsin Avenue, Lake Drive descends to the point where Okauchee Lake joins with the embayment known as Lower Okauchee Lake. Drainage from the surrounding lands and street system flows along the road right-of-way and, ultimately, through a system of culverts, into Lower Okauchee Lake. Given that some site constraints exist, especially on the eastern side of the narrows, installation of the vortex separator system is recommended for use in this location, subject to an evaluation conducted as part of a site-specific stormwater management planning program. On the western side of the narrows, Town-owned lands would obviate the need for the acquisition of additional easements wherein to situate these stormwater management measures.

Stormwater Management in the Vicinity of West Lake Drive and North Lake Drive
Runoff from the local street system also contributes to the delivery of contaminants and water to Okauchee Lake. Extension of the current piped stormwater drainage to the Lake, and placement of a water quality treatment device, such as a vortex separator, within this extended stormwater conveyance system is recommended. These options should be evaluated as part of a site-specific stormwater management planning and design program. Because the vortex separator potentially removes much of the contaminant load, it requires ongoing periodic maintenance and cleaning. Such operations would be conducted by the operator of the system, or under contract to the operator of the system. Acquisition of appropriate easements from the adjoining landowners would be required.

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 drainage area tributary to Okauchee Lake. The wetland areas within the drainage area tributary to the Lake are currently largely protected through the existing 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 Okauchee Lake drainage 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.

Notwithstanding, some wetland and woodland areas have been identified for acquisition in the adopted regional natural areas and critical species habitat protection and management plan, including the Oconomowoc Sedge Meadow, a 19-acre natural area of local significance recommended for acquisition by a private conservancy organization, and the Stonebank Tamarack Relict, a 166-acre wetland that provides habitat for rare or uncommon

bird species of special concern recommended for public acquisition. In this regard, implementation of the recommendations of the adopted park and open space plan for Waukesha County and regional natural areas and critical species habitat protection and management plan would complement the protection and preservation of these environmentally sensitive lands.

Nonpoint Source Pollution Control

The recommended watershed land management measures are specifically aimed at reducing the water quality impacts on Okauchee Lake of nonpoint sources of pollution within the tributary drainage area. These measures are set forth in the aforereferenced regional water quality management plan and the Waukesha County land and water resource management plan. As indicated in the lake and watershed inventory, the only significant sources of phosphorus loading to the Lake that are subject to potential controls are rural and urban nonpoint sources, and onsite sewage disposal systems in the drainage area. Portions of the lakeshore areas tributary to Okauchee Lake are partially served by a public sanitary sewerage system.

Nonpoint source control measures should be considered for the areas tributary to Okauchee Lake, including the upstream tributary drainage area. The regional water quality management plan recommended a reduction of about 25 percent in both urban and rural, nonpoint-sourced pollutants plus streambank erosion control, construction site erosion control, and onsite sewage disposal system management be achieved in the drainage area tributary to Okauchee Lake. The Oconomowoc River Priority Watershed plan subsequently refined these recommendations, and indicated an overall reduction of phosphorus loading of about 20 percent, excluding the management of onsite sewage disposal systems which, if included, indicated an overall reduction of phosphorus loading of about 35 percent.

Nonpoint source pollution abatement controls in the drainage 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-sourced 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 Waukesha 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 Counties and local government units within the drainage basin tributary to Okauchee Lake, as well as of the private landowners resident within the basin. Technical assistance can be provided by the U.S. Department of Agriculture Natural Resources Conservation Service; the Wisconsin Department of Agriculture, Trade and Consumer Protection; and the Waukesha County Department of Parks and Land Use. As discussed previously, it is recommended that the local units of government, in coordination with the Wisconsin Department of Natural Resources (WDNR) and the Counties, 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 U.S. Department of Agriculture Environmental Quality Incentive Program (EQIP), the Wisconsin Department of Natural Resources 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 drainage area tributary to Okauchee 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 loading to Okauchee Lake. Implementation of the recommendations and work planning activities set forth in the Waukesha 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, pending promulgation of Chapters NR 153 and NR 154 of the *Wisconsin Administrative Code*, which become effective during the autumn of 2002, cost-share funding might 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.

Urban Nonpoint Source Pollution Controls

The development of urban nonpoint source pollution abatement measures for the Okauchee Lake areas should be the primary responsibility of the Towns of Merton and Oconomowoc in Waukesha County. 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 Okauchee Lake Management District, in cooperation with the Towns, take the lead in sponsoring such programming for the Okauchee Lake community through regular public informational meetings and mailings. The District should also ensure that relevant literature, available through the University of Wisconsin-Extension Service and the WDNR, is made available at these meetings and at the local Public Library and government offices. Such low-cost measures complement the Town litter collection activities.

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 Okauchee Lake be prepared and distributed to property owners. This fact sheet could be distributed by the Towns of Merton and Oconomowoc, and the Okauchee Lake Management District, with the assistance of the University of Wisconsin-Extension Service and Waukesha County Department of Parks and Land Use 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 Waukesha County, the Towns of Merton and Oconomowoc continue efforts to control soil erosion attendant to construction activities in accordance with existing ordinances. As noted in Chapter III, Waukesha County has adopted construction erosion control ordinances. Enforcement of the ordinances by the County 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. In the Towns of Merton and Oconomowoc, this function is performed by the municipal Building Inspection staff.

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 Okauchee 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 drainage area to Okauchee Lake, it is important that adequate construction erosion control programs be in place.

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.

Point Source Pollution Control

Onsite Sewage Disposal System Management

Although portions of the lakeshore areas tributary to Okauchee Lake are served by public sanitary sewerage systems, portions of the direct and total drainage area to the Lake continue to be served by onsite sewage disposal systems. While such systems have been estimated to contribute less than one 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 Waukesha County, in cooperation with the Towns of Merton and Oconomowoc, 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.

Public Sewage Disposal System Management

For those portions of the drainage area tributary to Okauchee Lake served by public sanitary sewerage systems, it is recommended that the Okauchee Lake Management District, in cooperation with the Towns of Merton and Oconomowoc, assume the lead in providing public informational and educational programs to encourage affected property owners to use their sewerage systems appropriately and wisely. In an analogous recommendation, stenciling of storm drains and related informational programming encourages District residents to dispose of waste products safely, avoiding discharge directly to the surface waters or indirectly thorough the wastewater treatment works to the environment.

IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for Okauchee Lake are summarized in Table 35 and are graphically summarized on Map 22. The major recommendations include water quality monitoring, fisheries management and habitat protection, shoreland protection, aquatic plant management, recreational use management, and informational and educational programming.

Surface Water Management

Continued water quality monitoring of Okauchee Lake is recommended. Continuation of the Okauchee Lake Management District participation in the U.S. Geological Survey TSI monitoring program will maintain the data base that has been developed on water quality in this Lake. In addition, enrollment of one or more lake residents as WDNR Self-Help Monitoring Program volunteers may provide for more immediate feedback with respect to water quality conditions in the Lake, and also is recommended. Data acquired by the Self-Help volunteer supplement the more detailed data gathered by the U.S. Geological Survey staff. Enrollment can be accomplished through the Southeast Region Office of the Wisconsin Department of Natural Resources. A firm commitment of time is required of the volunteers. Such monitoring should be conducted five times a year at a central station in the deepest portion of the lake basin.

In addition to water quality monitoring programs, it is recommended that the Town of Oconomowoc continue to monitor lake water levels and operate the dam pursuant to the permitted authority delegated to the Town by the WDNR. Current operating protocols are recommended to be continued.

Fisheries Management

Management of Species Composition

Three specific actions are recommended with respect to fisheries management: the conduct of a fishery survey and the formulation of refined stocking and size and bag limitations; the assessment of angling pressures; and, the analysis of potential contamination of fishes in the Lake.

The fishery survey should be conducted periodically by the WDNR and should have the following objectives:

1. To identify changes in fish species composition that may have taken place in the Lake since the previous surveys, undertaken between 1975 and 2001;

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 rough fish populations; and,

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

The second recommended action relative to a fishery management program is an assessment of angling pressures on the Lake. This assessment should:

1. Provide data to determine the intensity of public use of the Okauchee Lake fishery through creel surveys, citizen reporting activities, and evaluation of the fish survey data; and

2. Provide data to assess the impact of harvesting of fishes from the Lake, relative to the bag limits established for Pewaukee Lake.

Thirdly, given the fishing pressures on the Lake, it would be desirable to also conduct a one-time analysis of fish tissues for metal and toxic contamination at the time the fisheries survey was conducted.

These three actions are recommended to provide a sound basis for the District and the WDNR to continue the ongoing 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.

The cost of the recommended comprehensive fish survey is estimated to be $16,000.

Habitat Protection

The habitat protection measures recommended for Okauchee Lake are, in part, provided by the recommended aquatic plant management program set forth below. The aquatic plant management plan is designed to provide for habitat protection by avoiding disturbances in fish breeding areas during spring and autumn; reducing the use of aquatic plant herbicides; and maintaining stands of native aquatic plants. In particular, this recommendation extends to, and includes, the proposed WDNR-delineated NR 107 environmentally sensitive areas located along the western and northern shorelines of the Lake as shown on Map 21. In addition, it is recommended that environmentally sensitive lands, including wetlands along the western and northern lakeshore be preserved.

Most of the Okauchee 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.

In addition to the foregoing measures, it is also recommended that the Towns of Merton and Oconomowoc continue to enforce existing shoreland setback requirements, and construction site erosion control and stormwater management 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 represents a refinement of the ongoing program of aquatic plant management being conducted on Okauchee Lake by the Okauchee Lake Management District. The recommended aquatic plant management program recognizes the importance of fishing as a recreational use of Okauchee 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 Okauchee Lake by an 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. These uses and activities include both passive uses the Lake as a visual amenity in this Lake-centered community, as well as active recreational uses, including both swimming and boating activities. The recommended aquatic plant management measures provide for the active recreational boating usage of the Lake, which serves a variety of watercraft ranging from individual recreational watercraft such as kayaks to motorized watercraft to sailing vessels, which are often used in competitive situations organized by the Okauchee Lake Yacht Club. Thus, the management measures set forth below are directed toward both protecting in-lake habitat as well as providing adequate navigational access on the Lake. An aquatic macrophyte control plan consistent with Chapters NR 103, NR 107, and NR 109 of the *Wisconsin Administrative Code* is included as Appendix A of this report.

The recommended aquatic plant management plan consists of a program based upon the integrated use of mechanical and manual harvesting, supplemented as necessary through the limited application of appropriate aquatic herbicides. The plan is designed to minimize the negative impacts on the ecologically valuable areas of the Lake, while providing a level of control needed to facilitate the desired recreational uses of the Lake. In addition, such management measures are recommended to be supplemented by an informational and educational program.

In order to implement the recommended aquatic plant management program, the following management actions are recommended:

1. The continued operation by the Okauchee Lake Management District of the existing harvesters and transport equipment, and replacement of that equipment as required.

2. The acquisition and operation of skimming equipment to collect aquatic plant fragments.

3. Maintenance of the shared access channels, which should be harvested in such manner as 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.

4. Use of shallow harvesting, cutting at approximately two feet to remove the surface canopy of nonnative plants such as Eurasian water milfoil, to provide a competitive advantage to the low-growing native plants in the Lake is recommended. By not disturbing these low-growing species, which generally grow within one to two feet of the lake bottom and in relatively low densities, and leaving the root stocks and stems of the cut plants in place, the resuspension of sediments in the Lake will be minimized. This type of harvesting should be focused, primarily, on boating channels around the perimeter of the principle lake embayments, and, secondarily, on other areas with extensive growths of Eurasian water milfoil.

5. Chemical herbicides, if found to be necessary, should be limited to controlling nuisance growths of exotic species in shallow water around docks and piers, or, as indicated within the demonstration project sites, in isolated embayments where plant growth is dominated by invasive nonnative species. Only herbicides that are selective in their control, such as 2,4-D and fluridone, should be used. Algicides, such as Cutrine Plus, generally are not recommended as algal blooms are rare in the Lake, and valuable macroscopic algae, such as *Chara* and *Nitella*, may be killed by this product.

6. It is recommended that chemical applications, if required, should be made in early spring to maximize their effectiveness on nonnative plant species, minimize their impacts on native plant species, and act as a preventive measure to reduce the development of nuisance conditions. Applications for herbicide permits made to the WDNR should be reviewed annually by the Okauchee Lake Management District, and the recommended management plan updated accordingly.

7. 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 the mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. As an alternative option it is recommended that the Okauchee Lake Management District obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to be made available to these residents.

8. It is recommended that ecologically valuable areas be restricted from aquatic plant management activities, especially during fish spawning seasons in early summer and autumn.

9. The incorporation by the Okauchee Lake Management District and riparian communities of educational and informational programming within the aquatic plant management program for the Lake is recommended. Such programming can provide students and householders with information on the types of aquatic plants in Okauchee Lake and 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. An organized aquatic plant identification day is one method of providing effective informational programming to lake residents. Other sources of information and technical assistance include the Department of Natural Resources Aquatic Plant Monitoring Program and the University of Wisconsin-Extension Service. The aquatic plant illustrations provided in Appendix B may assist individuals interested in identifying plants near their residences. Residents should be encouraged to observe and document changes in the abundance and types of aquatic plants in their part of the Lake on annual basis.

The recommended aquatic plant control areas are shown on Map 22. The control measures in each area are designed to optimize desired recreational opportunities and to protect the aquatic resources.

OTHER LAKE MANAGEMENT MEASURES

Recreational Use Management

With respect to boating ordinances applicable to Okauchee 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 exotic invasive species within Okauchee Lake, including zebra mussel and Eurasian water milfoil. 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 the 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 Okauchee Lake Management District assume the lead in the development of a public informational and educational program. 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, 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 University of Wisconsin-Extension Service. 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 Okauchee Lake, it is recommended that the Okauchee Lake Management District and the local municipalities 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 Okauchee Lake Management District and the municipalities are also encouraged to take an active role in encouraging the Kettle Moraine School Districts, and the Arrowhead Union High School, 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 $4,000 per year.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the Okauchee Lake Management District and the Towns of Merton and Oconomowoc, 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, such as monitoring, harvesting, and public awareness campaigns currently implemented by the Okauchee Lake Management District, are recommended to continue with refinements as proposed herein. Some aspects of these programs lend themselves to citizen involvement through participation in the Wisconsin Department of Natural Resources Self-Help Monitoring Program, and identification with environmentally sound owner-based land management activities. It is recommended that the Okauchee Lake Management District, 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 University of Wisconsin-Extension Service office, and SEWRPC.

A major cost element in the plan relates to the eventual replacement of harvesting equipment. Implementation of the recommended plan would entail a capital expenditure of about $317,000 for the District and an annual operation and maintenance expenditure of about $200,000 by the District, including existing expenditures, over the next 10 years. The current, annual operation and maintenance budget of the Okauchee Lake Management District for the harvesters and related equipment is appropriate to cover this level of future investment. When it is necessary to replace the existing harvesting equipment, some of the capital costs could be offset with grants from the Wisconsin Waterways Commission under the Chapter NR 7 Recreational Boating Facilities Grant Program, while additional cost share assistance may be available from the Wisconsin Waterways Commission for the conduct of Eurasian water milfoil control programs using chemical herbicides. Additional lake and watershed management measures may be cost-shared through the Chapter NR 191 Lake Protection Grant Program, Chapter NR 120 Nonpoint Pollution Abatement Program, or NR 153/NR 154 runoff management programs.

The suggested lead agency or agencies for initiating program-related activities, by plan element, are set forth in Table 35 and the estimated costs of these elements, linked to possible funding sources where such are available, are set forth in Table 36. In general, it is recommended that the Okauchee Lake Management District continue to provide a coordinating role for community-based lake management actions, in cooperation with the appropriate local government units.

Okauchee Lake is a valuable natural resource in the Southeastern Wisconsin Region. Increases in population, urbanization, income, leisure time, and individual mobility forecast for the Region may be expected to result in additional pressure for development in the drainage area tributary to the Lake and for water-based recreation on the Lake. Adoption and administration of an effective lake management program for Okauchee Lake, based upon the recommendations set forth herein, will provide the water quality protection needed to maintain conditions in Okauchee Lake suitable for recreational use and for fish and other aquatic life.

Table 36

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR OKAUCHEE LAKE

Plan Element	Subelement	Estimated Cost 2000-2020[a]		Potential Funding Sources[b]
		Capital	Annual Operation and Maintenance	
Land Use Control and Management	Land use development planning	--	--	County, Cities, Villages, Towns
	Density management in the shoreland zone	--	--	Towns
	Protection of environmentally sensitive lands	--	--	WDNR Lake Protection Grant and Stewardship Grant Programs, Waukesha County Land Conservancy, Okauchee Lake Management District
Point Source Pollution Control	Onsite sewerage system management	--[c]	$100-$200[c]	Okauchee Lake Management District, County, private firms, individuals
	Public sewerage services	--	--	City of Oconomowoc, Delafield-Hartland Water Pollution Control Commission
Nonpoint Source Pollution Control	Rural nonpoint source controls	--[c]	--[c]	County, USDA EQIP, WDNR/WDATCP Runoff Management Program
	Urban nonpoint source controls	--[c]	--[c]	County, WDNR/WDATCP Runoff Management Program
	Construction site erosion controls and stormwater management ordinances	--[c]	$250-$500/acre[c]	County, municipalities, private firms, individuals
Stormwater Management	Stormwater management plan development and implementation	$2,100,000	$1,000	County, Town of Oconomowoc, Wisconsin DOT, WDNR Runoff Management Program
Surface Water Management	Water quality monitoring	--	--[d]	USGS, WDNR Self-Help Lake Monitoring Program
	Water quantity monitoring and dam operations	--	--[e]	Town of Oconomowoc, Okauchee Lake Management District, USGS, WDNR
Fish Management	Fish survey and continuation of stocking program	$16,000[d]	--[d]	WDNR
	Enforcement of fishing regulations	--	--	WDNR
	WDNR-delineation of Chapter NR 107 sensitive areas	--	--	WDNR
	Shoreland protection and maintenance of structures	--	--	Private firms, individuals
	Minimization of shoreland impacts on lake water quality and habitat	--	--	County, municipalities, private firms, individuals, WDNR
Aquatic Plant Management	Comprehensive plan refinement	--	$1,500[f]	Okauchee Lake Management District, WDNR Lake Management Planning Grant Program
	Major/minor boating channel harvesting	$303,000[g]	$20,000	Okauchee Lake Management District, Wisconsin Waterways Commission

Table 36 (continued)

Plan Element	Subelement	Estimated Cost 2000-2020[a]		Potential Funding Sources[b]
		Capital	Annual Operation and Maintenance	
Aquatic Plant Management (continued)	Manual harvesting around piers and docks	$ 200	--	Okauchee Lake Management District, individuals
	Chemical treatment	--	$1,000/acre[h]	Wisconsin Waterways Commission, Okauchee Lake Management District, individuals
	Biological control of purple loosestrife	--	$1,000/acre	Okauchee Lake Management District, individuals
Recreational Use Management	Maintain recreational boating access; enforce existing boating and winter use ordinances	--	$1,000	County, municipalities, Okauchee Lake Management District, WDNR
Informational and Educational Program	Public informational and educational programming	--	$4,000	Okauchee Lake Management District, UWEX/ WDNR/WAL Lakes Partnership, County, school districts
Total	--	$2,419,200	$27,500[i]	--

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

[b] *Unless otherwise specified, USDA is the U.S. Department of Agriculture, USGS is the U.S. Geological Survey, WDNR is the Wisconsin Department of Natural Resources, WDATCP is the Wisconsin Department of Agriculture, Trade and Consumer Protection, County is Waukesha County, City is the City of Pewaukee, Village is the Village of Pewaukee, Town if the Town of Delafield, UWEX is the University of Wisconsin-Extension, and WAL is the Wisconsin Association of Lakes.*

[c] *Costs vary with the amount of land under development during any given year.*

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

[e] *Water quantity monitoring should be conducted in conjunction with an hydraulic and hydrologic analysis of the entire Pewaukee River system; USGS hydrological monitoring is proposed.*

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

[g] *Costs are based on the assumption that the existing harvester and ancillary equipment may eventually need replacement; cost-share assistance for harvester purchase may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program. Planning costs assume that plan revisions will be completed at a cost of $6,000 every four years.*

[h] *Cost-share assistance may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program.*

[i] *Costs exclude the costs to the City of Pewaukee, Village of Pewaukee, and Town of Delafield related to land use planning and zoning, and exclude costs related to herbicide treatments.*

Source: SEWRPC.

Chapter IX

SUMMARY

The preparation of the lake management plan for Okauchee Lake was a cooperative effort by the Southeastern Wisconsin Regional Planning Commission and the Okauchee Lake Management District. The plan incorporates pertinent data assembled and synthesized during the preparation of the adopted water quality management plan for Okauchee Lake, previously prepared by the Southeastern Wisconsin Regional Planning Commission.[1] These data are supplemented with new data, gathered between 1978 and 2002, collected by the U.S. Geological Survey; Wisconsin Department of Natural Resources; and Aron & Associates, consultant to the Okauchee Lake Management District. Inventories and analyses were conducted of existing and recommended future land use patterns within the watershed of the Lake, associated pollutant loadings and sources,[2] the physiography and natural resource base of the watershed,[3] the recreational uses of the Lake, the shoreland conditions, and the management practices employed both on the Lake and in the watershed. In addition, the planning effort included an aquatic plant survey conducted by Commission staff as part of this study, and an analysis of the results from previously conducted water quality sampling programs and aquatic plant surveys. Field studies associated with these activities were conducted from 1984 through 2002 by the U.S. Geological Survey, during 1992 and 1996 by Aron & Associates, and during 2000 through 2003 by the Commission staff.

The primary management objectives for Okauchee Lake include: providing a level of water quality in Okauchee Lake and its component embayments suitable for the maintenance of warmwater fish and other aquatic life, reducing the severity of existing nuisance conditions caused by excessive macrophyte and algal growth, and improving opportunities for water-based recreational activities.

Okauchee Lake is a 1,198-acre drainage lake on the Oconomowoc River, a tributary stream to the Rock River, located within U.S. Public Land Survey Township 8 North, Range 17 East, Town of Oconomowoc, and Township 8 North, Range 18 East, Town of Merton, Waukesha County. The Lake is the third lake is a chain of

---

[1]*SEWRPC Community Assistance Planning Report No. 53,* A Water Quality Management Plan for Okauchee Lake, Waukesha County, Wisconsin (Also Reporting on Lower Okauchee and Upper Oconomowoc Lakes), *August 1981.*

[2]*See also WDNR Publication No. WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

[3]*See SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996; and SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997.*

six major lakes situated along the Oconomowoc River, Friess Lake in Washington County and North Lake in Waukesha County are situated upstream of Okauchee Lake, and Oconomowoc Lake, Fowler Lake, and Lac La Belle, all in Waukesha County, are located downstream of Okauchee Lake. Okauchee Lake consists of a single large main basin surrounded by a number of embayments, some of which, Tierney Lake, Upper Oconomowoc Lake, and Lower Okauchee Lake, have been identified at times as individual waterbodies. Water levels in the Lake are controlled by a dam, located at the point where the embayment locally known as Upper Oconomowoc Lake discharges into the Oconomowoc River upstream of Oconomowoc Lake. The Lake has a maximum depth of about 95 feet, and a mean depth of about 25 feet. The Lake's tributary drainage area totals about 81 square miles.

Okauchee Lake is a typical hard-water, alkaline lake that is considered to have relatively good water quality. Physical and chemical parameters measured during the study period indicated that the water quality was within the "poor" to "good" range, depending upon the parameters considered. Total phosphorus levels were found to be generally at a level consistent with a mesotrophic state, contributing to nuisance algal and macrophytic growths, which exerts constraints on the recreational usage of the Lake.

INVENTORY AND ANALYSIS FINDINGS

Population

- The 2000 resident population of the drainage area directly tributary to Okauchee Lake was estimated to be 4,100 persons, which is about the same as the estimated 1980 population and approximately double the population estimated to reside within the drainage area directly tributary to Okauchee Lake in 1950.

- Population forecasts prepared by the Regional Planning Commission, on the basis of a normative regional land use plan and the Waukesha County development plan, indicate that the population will probably approach 6,000 persons in the drainage area directly tributary to the Lake by the year 2020.

Land Use and Zoning

- As of 1995, approximately 9,000 acres, or about 16 percent of the tributary drainage area, were in urban land usage, with the dominant urban land use being residential, encompassing about 6,000 acres or about two-thirds of the urban lands in the drainage area. Commercial, industrial, governmental and institutional, transportation, communications and utilities, and recreational lands comprised the balance of the urban lands.

- As of 1995, approximately 43,000 acres, or 84 percent of the tributary drainage area, were in rural land usage, with the dominant rural land use being agricultural, encompassing about 26,000 acres or about 60 percent of the rural lands in the drainage area. Woodlands, wetlands, surface water, and open lands comprised the largest portion of the balance of the rural lands, with some, comprising less than one percent of the total drainage area, scattered extractive and landfill activities.

- Under year 2020 conditions, continued urban growth is anticipated, primarily in residential land uses which are expected to exceed 8,000 acres in areal extent. Urban lands are anticipated to increase to about 12,000 acres. Rural land uses are expected to decrease to about 40,000 acres, primarily due to the conversion of agricultural lands to urban residential land uses. Limited redevelopment and infilling of existing platted lots may also be anticipated.

- As of 2000, the sanitary and household wastewaters from the estimated 4,100 persons residing in the drainage area directly tributary to the Lake were treated and disposed of largely through the use of onsite disposal systems, although a portion of the lakefront and adjacent development was provided with public sanitary sewerage services during 2002 as recommended in the regional water quality management plan.

Water Budget

- The long-term water budget for Okauchee Lake was computed using the U.S. Geological Survey data for the Oconomowoc River, compiled during the period from 1931 through 2001. It is estimated that, annually, 34,000 acre-feet of water enters Okauchee Lake, 90 percent of which enters from the Oconomowoc River and 10 percent through direct precipitation onto the lake surface.

- Of this total, about 3,900 acre-feet of water, or about 11 percent of the inflow, evaporates from the surface of the Lake; about 4,300 acre-feet, or about 13 percent, is discharged as groundwater; and, about 25,800 acre-feet, or about 76 percent, is discharged via the Oconomowoc River.

Water Quality

- Physical and chemical characteristics of Okauchee Lake were measured during the period from 1984 through 2002 by the U.S. Geological Survey and the Okauchee Lake Management District.

- Okauchee Lake was shown to be a typical Southeastern Wisconsin hard-water, alkaline lake having relatively good water quality, especially since the implementation of public sewerage services.

- The Lake is dimictic, mixing completely twice per year during spring and fall. Temperature and dissolved oxygen concentration profiles indicate that complete mixing of Okauchee Lake is restricted during summer and winter by thermal stratification. Winter kill is not a problem in Okauchee Lake.

- Water clarity, as measured by a Secchi disc, ranged from a minimum of about 2.6 feet in summer to a maximum of about 17.0 feet during winter, with an average Secchi-disc depth of about 10.2 feet. Chlorophyll-*a* concentrations ranged from a minimum of 0.1 µg/l to a maximum of 27.0 µg/l, indicating that visible green coloration of the water may be apparent, especially during spring when the maximum concentration was recorded. Total phosphorus concentrations ranged from 0.006 mg/l to 0.234 mg/l in the surface waters, with a mean annual concentration of 0.030 mg/l. This value exceeds the Commission-recommended water quality standard for recreational use and maintenance of warmwater fish and aquatic life of 0.020 mg/l and is consistent with the higher values of chlorophyll-*a* concentrations reported.

- These data indicate that Okauchee Lake is a meso-eutrophic lake, being moderately fertile and capable of supporting abundant aquatic plant growths and productive fisheries. Mesotrophic lakes are typical of inland lakes in the Southeastern Wisconsin Region.

Pollutant Loadings

- The total phosphorus load to Okauchee Lake was estimated to be 28,500 pounds per year, about 400 pounds of which was estimated to be contributed from onsite sewage disposal systems within the watershed. Of this total, about 24,500 pounds, or about 86 percent, were estimated to be contributed through the Oconomowoc River. The balance was contributed by direct precipitation onto the Lake surface, comprising about 300 pounds, and runoff from the land surface directly to the Lake, comprising about 3,500 pounds.

- It also was estimated that under year 2020 conditions, the total phosphorus load to the Lake would decrease slightly, to approximately 26,000 pounds per year, due to conversion of agricultural lands. However, this trend may be offset by the increasing use of lawn and garden fertilizers in urban areas that contributes to higher phosphorus concentrations being observed in urban runoff. Due to the implementation of a public sanitary sewerage system in the watershed, replacing existing onsite sewage disposal systems, the portion of this load contributed from onsite systems is expected to decrease to about 50 pounds per year. About 21,700 pounds is expected to be contributed through the Oconomowoc River, 300 pounds by direct precipitation, and 4,000 pounds from direct runoff into the Lake.

- Sediment loading to Okauchee Lake is estimated to be 6,700 tons per year. This load is not expected to change significantly under planned land use conditions. About 5,200 tons is likely to be contributed from rural lands, about 650 tons from urban lands, and about 350 tons by direct precipitation onto the lake surface.

- Heavy metal loads, of copper, zinc, and cadmium, are estimated to be contributed solely from urban lands, and are estimated to be 160 pounds per year of copper, 1,200 pounds of zinc, and 1.5 pounds of cadmium. Under planned 2020 land use conditions, these loads are expected to increase to about 250 pounds of copper, 1,800 pounds of zinc, and 3.5 pounds of cadmium annually, as urban land use increase in the drainage area.

- Four areas of concern with respect to stormwater management and contaminant loadings were identified: STH 16 at Jaeckles Boulevard, Lake Drive at the intersection of W. Lake Drive and N. Lake Drive, Lake Drive between Point Comfort Drive and Road B, and Wisconsin Avenue at Shady Lane.

Aquatic Plants

- Aquatic macrophyte growth in Okauchee Lake was found to be diverse in composition and moderate to high in abundance. However, the increasing dominance of Eurasian water milfoil in the Lake suggests that some interference with boat traffic and other water-based recreational uses may occur.

- During 1977, the aquatic plant flora was dominated by muskgrass (*Chara* spp.), coontail (*Ceratophyllum demersum*), northern milfoil (*Myriophyllum exalbescens*), Eurasian water milfoil (*Myriophyllum spicatum*), and Sago pondweed (*Potamogeton pectinatus*).

- During the July 2000 aquatic plant survey, aquatic plant growth occurred in waters of less than 15 feet in depth. Eurasian water milfoil (*Myriophyllum spicatum*) was the dominant aquatic plant in the system. Other common aquatic plants included coontail (*Ceratophyllum demersum*), bushy pondweed (*Najas flexilis*), water celery or eel grass (*Vallisneria americana*), and muskgrass (*Chara* spp.). Pondweeds (*Potamogeton* spp.) were commonly found at depths of between five and 10 feet.

Fishery

- Wisconsin Department of Natural Resources fisheries surveys conducted between 1909 and 1999 suggest a relatively stable fish population in the Lake, with 32 species of fishes being recorded. Cisco and whitefish, reported from the Lake during the 1909 survey, were not recorded during any of the surveys conducted between 1946 and 1999.

- Okauchee Lake supports a relatively large and diverse fish community. The Lake is predominantly a bluegill, largemouth bass, and northern pike fishery, with muskellunge also being an important sportfish.

Natural Resource Base

- In 1985, wildlife habitat covered about 18,400 acres, or 16 percent of the drainage area directly tributary to Okauchee Lake, about one-half of this habitat being comprised of high-value habitat capable of supporting a diverse population of wildlife, with adequate land area and appropriate vegetative cover for nesting, cover, and subsistence, and minimal levels of disturbance.

- As of 1995, wetlands covered about 6,000 acres of the total drainage area tributary to Okauchee Lake, or about 12 percent of the watershed. Woodlands covered a further approximately 7,100 acres or 14 percent of the total drainage area tributary to the Lake.

- Environmental corridors, or contiguous lands containing the majority of the high value woodlands, wetlands, and wildlife habitat and surface waters within the drainage area tributary to Okauchee Lake, comprised about 19,200 acres, of which about 85 percent, or about 16,700 acres, were considered to be primary corridor lands. About 1,100 acres were considered to be secondary environmental corridor, with the balance being comprised of isolated natural resource features.

Recreational Use

- As of 2000, there were four recreational boating access sites of Okauchee Lake, two of which were in public ownership: one of the public sites was owned by the Town of Oconomowoc, and one by the Wisconsin Department of Natural Resources. Okauchee Lake has been determined to have adequate public recreational boating access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code.*

- During July 2000, approximately 2,000 watercraft were observed on and around Okauchee Lake. Of these, about 590 were power boats, about 470 craft were pontoon boats, about 300 were fishing boats, and 210 were personal watercraft. The balance was comprised of sailboats, rowboats, canoes, and similar nonmotorized watercraft.

- In a recreational rating technique developed by the Wisconsin Department of Natural Resources to characterize the recreational value of inland lakes, Okauchee Lake received 52 out of a possible total of 72 points, indicating that the Lake provides a wide range of recreational opportunities, including "muskie" angling, swimming, boating, and aesthetic viewing opportunities.

ALTERNATIVE LAKE MANAGEMENT MEASURES

Alternative management techniques, including watershed, lake rehabilitation, and in-lake measures, were evaluated based on effectiveness, cost, and technical feasibility. Techniques assessed included land use management and zoning; protection of environmentally sensitive lands; nonpoint source pollution abatement, including nonpoint source controls in urban areas, rural areas, and developing areas; stormwater management; in-lake water quality management; hydraulic and hydrologic management; fisheries management; aquatic plant management; recreational use management; and public informational and educational programming. As a result of this analysis, in-lake water quality management measures, hydraulic and hydrologic management measures, and certain aquatic plant management measures were eliminated from further consideration at this time. The remaining alternatives were incorporated into the recommended plan described below.

RECOMMENDED PLAN

Analyses of water quality and biological conditions indicate that general water quality conditions of Okauchee Lake are considered to be comparable to other regional lakes. Water-based recreational uses may be limited in certain areas of the Lake and at certain times of the year. Therefore, in-lake management measures are recommended for the Lake to meet full recreational use and aquatic resource objectives. In addition to the in-lake management measures, additional land use and land management measures are recommended for application within the drainage area tributary to the Lake. The recommended measures are summarized graphically on Map 22 and are listed in Table 35, both in Chapter VIII of this report.

In summary, the lake management measures recommended for Okauchee Lake include:

For the protection of the natural resource base:

- Observe the guidelines set forth in the adopted regional land use and Waukesha County development plans, through the modification of local land use zoning ordinances to bring local planning and zoning into conformance with these plans, and through maintenance, to the extent practicable, of historic lakefront residential dwelling densities.

- Establish adequate protection of wetlands and shorelands, as well as other environmental corridor lands and isolated natural resource features, through public or private acquisition of features of local or greater significance, based upon recommendations set forth in the adopted regional natural areas and critical species habitat protection and management plan, and county land and water resource management plan.

For the protection and maintenance of water quality and aesthetic conditions:

- Continue to implement the recommendations set forth in the regional water quality management plan to provide sanitary sewerage services to selected urban areas of the Lake drainage area. Wastewater treatment to be provided at the City of Oconomowoc and Delafield-Hartland Water Pollution Control Commission treatment facilities as set forth in the adopted regional water quality management plan.

- Continue to implement inspection and maintenance measures with respect to onsite sewage disposal systems in those portions of the watershed not served by public sanitary sewerage services.

- Restrict pollutant loadings carried by stormwater into the Lake through the implementation of stormwater management practices. Install construction site erosion control measures as required by local ordinances and enforce the construction site erosion control and stormwater management ordinance provisions.

- For rural areas, continue to implement nonpoint source pollution controls through promotion of sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans and implementation of integrated nutrient and pest management practices in accordance with the adopted county land and water resource management plan.

- For urban areas, continue to promote sound urban "good housekeeping" and yard care practices through informational programming. Consider the development of lawn care and shoreland management ordinances in the Towns of Merton and Oconomowoc.

- For developing areas, develop and enforce construction site erosion control and stormwater management ordinances and periodically review such ordinances for concurrency with the *Wisconsin Administrative Code*. Consider the use of conservation subdivision designs with integrated stormwater management systems where appropriate densities exist.

- For the four stormwater management "hot spots" identified in this analysis, STH 16 at Jaeckles Boulevard, Lake Drive at the intersection of W. Lake Drive and N. Lake Drive, Lake Drive between Road B and Point Comfort Drive, and Wisconsin Avenue at Shady Lane, prepare and implement detailed local level stormwater management plans to minimize contaminant loadings.

- Continue water quality monitoring through participation in the Wisconsin Department of Natural Resources Self-Help Monitoring Program and U.S. Geological Survey Trophic State Index Monitoring Program.

For the protection and enhancement of fish and natural resources, including wildlife habitat, woodlands, and wetlands:

- Conduct periodic fisheries surveys to determine management and stocking needs and maintain sticking programs as appropriate. Enforce size and catch limits.

- Maintain existing shoreline protection structures and repair as necessary using vegetative means insofar as practicable and subject to any applicable Wisconsin Department of Natural Resources permit requirements. Encourage shoreline restoration projects and the creation of shoreland buffer

strips, and promote consistency in the application of landscaping practices in sensitive shoreland areas, through informational programming and demonstration sites.

- Maintain the integrity of wetlands, shorelands, and environmental corridor lands, including isolated natural resource features, through public or private acquisition, application of appropriate ordinance provisions and zoning restrictions, and restoration activities, as previously noted.

For the enhancement of recreational opportunities:

- Maintain public recreational boating access opportunities pursuant to guidelines set forth in Chapters NR 1 and NR 7 of the *Wisconsin Administrative Code*. Continue to enforce and periodically review recreational boating (summer) and vehicular use (winter) ordinances relating to the operation of petroleum-powered watercraft and vehicles on the Lake.

- Limit the application of aquatic plant management measures in Wisconsin Department of Natural Resources-delineated environmentally sensitive areas pursuant to the limitations on herbicide applications and harvesting as set forth in Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*.

- Harvest aquatic plants as required to facilitate recreational boating access to Okauchee Lake, minimizing harvesting during the spring and autumn to avoid disturbances to fish breeding areas and Wisconsin Department of Natural Resources-delineated environmentally sensitive areas. Manually harvest around piers and docks as necessary. Collect floating aquatic plant fragments in shoreland areas to minimize rooting potential of Eurasian water milfoil and accumulation of organic debris.

- Apply appropriate chemical herbicides to limited, selected areas of the Lake where necessary to specifically target Eurasian water milfoil and curly-leaf pondweed infestations in the Lake and purple loosestrife infestations in shoreland wetland areas.

- Consider application of biological control of purple loosestrife infestations, using loosestrife beetles.

For public information and education:

- Continue ongoing public informational and awareness-building programs, and encourage inclusion of lake studies in environmental curricula of local schools through the use, for example, of programs such as Adopt-A-Lake, Project WET, and the Waukesha County Water Walk programs.

The recommended plan is based largely on existing and ongoing lake management measures being carried out by the Okauchee Lake Management District, in partnership with the Towns of Merton and Oconomowoc, Waukesha County, the Wisconsin Departments of Natural Resources, Transportation, and Agriculture, Trade, and Consumer Protection, and the U.S. Geological Survey, among others. It is recommended that the Okauchee Lake Management District take primary responsibility for implementing this plan, with the ongoing assistance of the other agencies and units of government as necessary and appropriate. It is estimated that the plan would entail a capital expenditure of $2,400,000, primarily for stormwater management and aquatic plant management actions over the next 20 years, and an annual operations and maintenance expenditure of upwards of $27,500, as summarized in Table 36 in Chapter VIII of this report. Many of the recommended lake management measures set forth above involve actions by homeowners and property owners within the drainage area tributary to the Lake, and, while valuable and important, incur few direct costs to the Okauchee Lake community as they are undertaken as voluntary actions.

Okauchee Lake is a valuable natural resource in the Southeastern Wisconsin Region. The delicate, complex relationship between water quality conditions in the Lake and land uses within its tributary drainage area is likely to be subject to ongoing pressures and demands for water-based recreation in the Lake and for urban-density

development within the tributary drainage area, given the projected increases in population, urbanization, income, leisure time, and individual mobility, forecast for the Region. To provide the water quality protections needed to maintain conditions in Okauchee Lake conducive to meeting such pressures and providing for the greatest possible range of active and passive recreational water uses, it will be necessary to adopt and administer an effective program of lake management based upon comprehensive water quality management and related plans. This plan comprises an important element of such a program, and is consistent with previously adopted regional land use, water quality protection, recreational use, land and water management, and sanitary sewer service area plan for the drainage area tributary to, and inclusive of, Okauchee Lake.

APPENDICES

(This page intentionally left blank)

Appendix A

AN AQUATIC PLANT MANAGEMENT PLAN FOR OKAUCHEE LAKE, WAUKESHA COUNTY, WISCONSIN

INTRODUCTION

This aquatic plant management plan is prepared by the Southeastern Wisconsin Regional Planning Commission staff as an integral part of the lake management plan for Okauchee Lake.[1] It represents an important element of the ongoing commitment of the Okauchee Lake Management District and the Towns of Oconomowoc and Merton to sound environmental management with respect to the Lake. The plan is based upon field surveys conducted by Commission staff during the summer of 2000, and subsequent field reconnaissance surveys conducted during the 2001 and 2002 summer seasons, and follows the format adopted by the Wisconsin Department of Natural Resources (WDNR) for aquatic plant management plans pursuant to Chapters NR 103, NR 107, and NR 109 of the *Wisconsin Administrative Code.* Its scope is limited to those management measures which can be effective in the control of aquatic plant growth; those measures which can be readily undertaken by the Okauchee Lake Management District and Town of Oconomowoc in concert with the riparian residents; and those measures which will directly affect the recreational use of Okauchee Lake. The aquatic plant management plan for Okauchee Lake is comprised of seven elements.

1. A set of aquatic plant management objectives;
2. A brief description of the Lake and its watershed;
3. A statement of the current use restrictions and need for aquatic plant management in Okauchee Lake;
4. An evaluation of alternative means of aquatic plant management and a recommended plan for such management;
5. A description of the recommended plan;
6. A description of the equipment needs for the recommended plan; and
7. A recommended means of monitoring and evaluating the efficacy of the plan.

---

[1] *SEWRPC Community Assistance Planning Report No. 53, 2nd Edition,* A Lake Management Plan for Okauchee Lake, Waukesha County, Wisconsin, *December 2003.*

STATEMENT OF AQUATIC PLANT MANAGEMENT GOALS AND OBJECTIVES

The aquatic plant management program objectives for Okauchee Lake were developed in consultation with the Okauchee Lake Management District and the Okauchee Lake community. The primary goal of the aquatic plant management program is to provide a full range of recreational access opportunities for all lake users, focused on those areas of the Lake within which aquatic plants can become overly abundant, in a manner that preserves and maintains the underlying natural resource base of the Lake. Pursuant to the current aquatic plant management plan for Okauchee Lake, prepared by Aron & Associates,[2] this overarching goal is to be achieved through the accomplishment of a number of practical objectives that focus on:

1. Providing a pleasurable recreational experience to all lake users, including lake community residents and lake users.

2. Preventing the occurrence of unsightly floating aquatic plant fragments created by recreational boating activity.

3. Promoting recreational boating and navigational access throughout Okauchee Lake and the adjacent portions of the Oconomowoc River.

4. Enhancing a balanced lake fishery by encouraging the competitive success and diversity of native plant communities that is better able to support the array of recreational uses to which the Lake is subjected.

5. Minimizing the input of contaminants to the Lake and contributing to the reduction of the in-lake nutrient pool by removal of excessive aquatic plant biomass from the Lake in a sustainable and environmentally friendly manner.

OKAUCHEE LAKE AND ITS WATERSHED CHARACTERISTICS

Okauchee Lake is located within the Towns of Merton and Oconomowoc, both in Waukesha County. Surface water enters and leaves the Lake primarily through the Oconomowoc River. A low-head dam located at the outlet of Okauchee Lake within the Town of Oconomowoc controls the rate of discharge and Lake levels within Okauchee Lake. The Lake drains in a southerly direction to Oconomowoc Lake about one-half mile downstream of the dam. Okauchee Lake is a drainage or through-flow lake, or a lake having both a defined inflow and outflow. The Lake has two connected, yet distinct basins. A bathymetric map of the Lake is set forth as Map A-1.

Okauchee Lake is a natural lake that was impounded by a low-head dam initially constructed in 1838. This impoundment increased the surface water elevation of the Lake by about nine feet. This original dam has been replaced over time, and the progressive downstream location of the structures has resulted in the creation of embayments within Okauchee Lake locally known as Lower Okauchee Lake and Upper Oconomowoc Lake. The Lake has a surface area of 1,187 acres, a maximum depth of approximately 95 feet, and a mean depth of about 25 feet. As noted, Lake levels are presently controlled by the dam operated by the Town of Oconomowoc located at the Lake outlet. Surface elevations are maintained within a range between 872.60 feet National Geodetic Vertical Datum of 1929 (NGVD-29) and 873.71 feet NGVD-29.

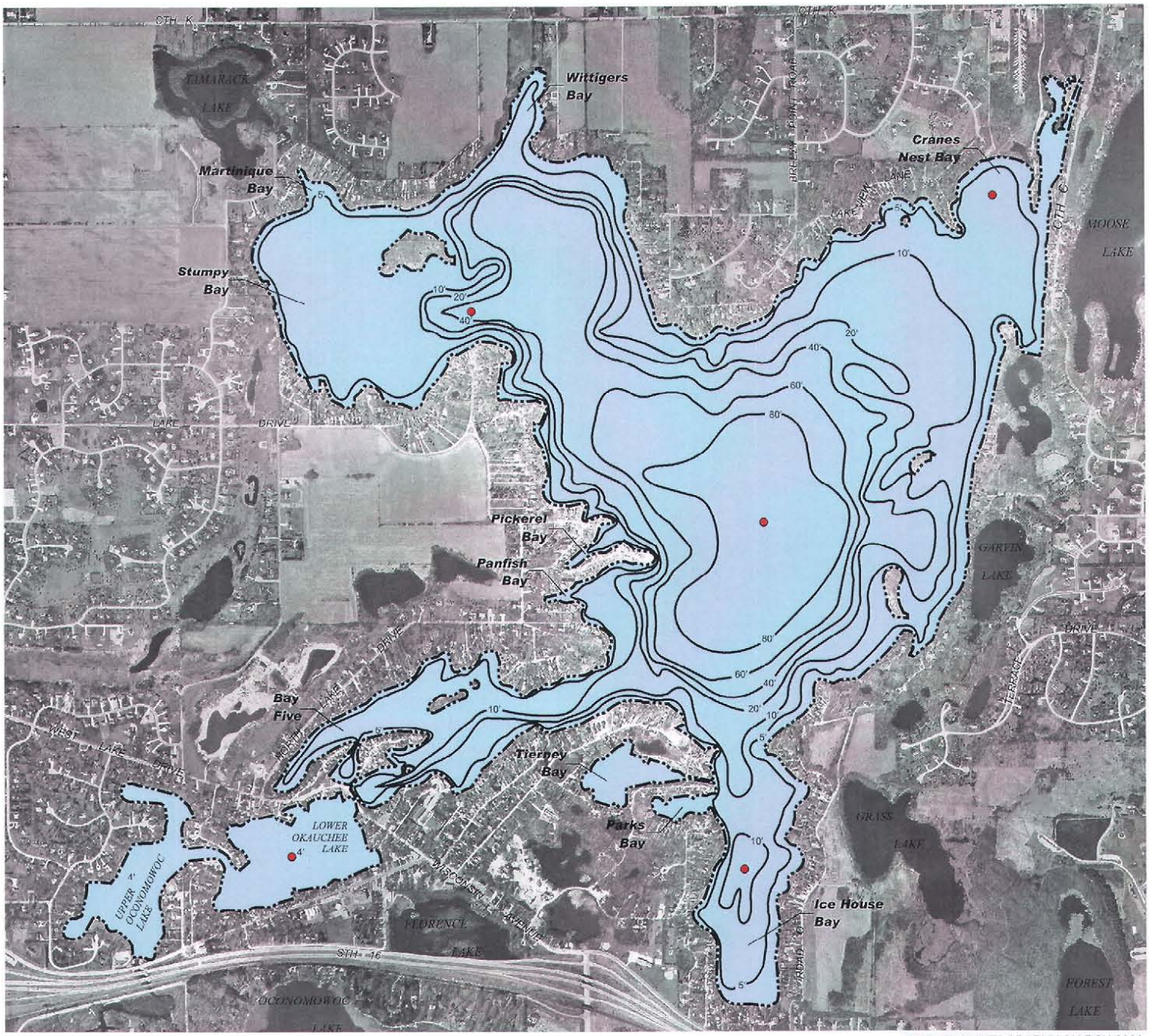
The watershed area draining to Okauchee Lake is approximately 70 square miles in areal extent, about 5.25 square miles of which drains directly to Okauchee Lake without passing through an upstream waterbody. Okauchee Lake is the central lake in a chain of six lakes, comprised of Friess, North, Okauchee, Oconomowoc,

---

[2] *Aron & Associates,* Okauchee Lake Plant Management Plan, *1993; Aron & Associates,* Okauchee Lake Plant Management Plan 1st Revision, *November 1996.*

Map A-1

BATHYMETRIC MAP OF OKAUCHEE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

MONITORING SITE

GRAPHIC SCALE

0 1000 2000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

and Fowler Lakes, and Lac La Belle, within the Southeastern Wisconsin Region. Portions of the total tributary drainage area lie in three counties: Dodge, Washington, and Waukesha Counties. Portions of the City of Delafield, the Villages of Chenequa, Hartland, Merton, Nashotah, Oconomowoc Lake, and Slinger, and the Towns of Ashippun, Delafield, Erin, Hartford, Lisbon, Merton, Oconomowoc, Polk, Richfield, and Summit, are included within this tributary drainage area.

Land Use and Shoreline Development

The importance of the Okauchee Lake area as an attractive setting for residential development within a reasonable commuting distance of major commercial and industrial centers in Southeastern Wisconsin has increased steadily since the 1920s. In addition, many summer cottages have, over the years, been converted into year-round homes. By 1995, about 8,500 acres, or about 17 percent of the total drainage area tributary to Okauchee Lake, were in urban land uses, with residential uses being the dominant urban land use. As of 1995, about 50,800 acres, or about 83 percent of the total drainage area tributary to Okauchee Lake, were still in rural land uses. Of these uses, about 50 percent of the drainage area was in agricultural use. The shorelands of the Lake are generally considered to be fully developed, although some limited infilling, backlot development, and redevelopment of platted lots may be expected to occur. Nearly all of the shoreland around Okauchee Lake has some form of shoreline protection. Map A-2 shows current shoreline conditions as of the year 2000.

Aquatic Plants, Distribution and Management Areas

Aquatic macrophytes, such as pondweeds, rushes, cattails, coontail, and water milfoil, play an important role in the ecology of Southeastern Wisconsin lakes. Depending on the distribution and abundance, they can be either beneficial or a nuisance. Macrophytes growing in reasonable densities in lakes are beneficial because they provide habitat for other forms of aquatic life and may remove nutrients from the water that otherwise could contribute to excessive algal growth. Notwithstanding, aquatic plants can become a nuisance when heavy densities interfere with swimming and boating activities. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate type, wave action, and type and size of the fish populations present, determine the distribution and abundance of aquatic macrophytes in a lake. Illustrations of representative macrophyte species identified in Okauchee Lake are appended hereto.

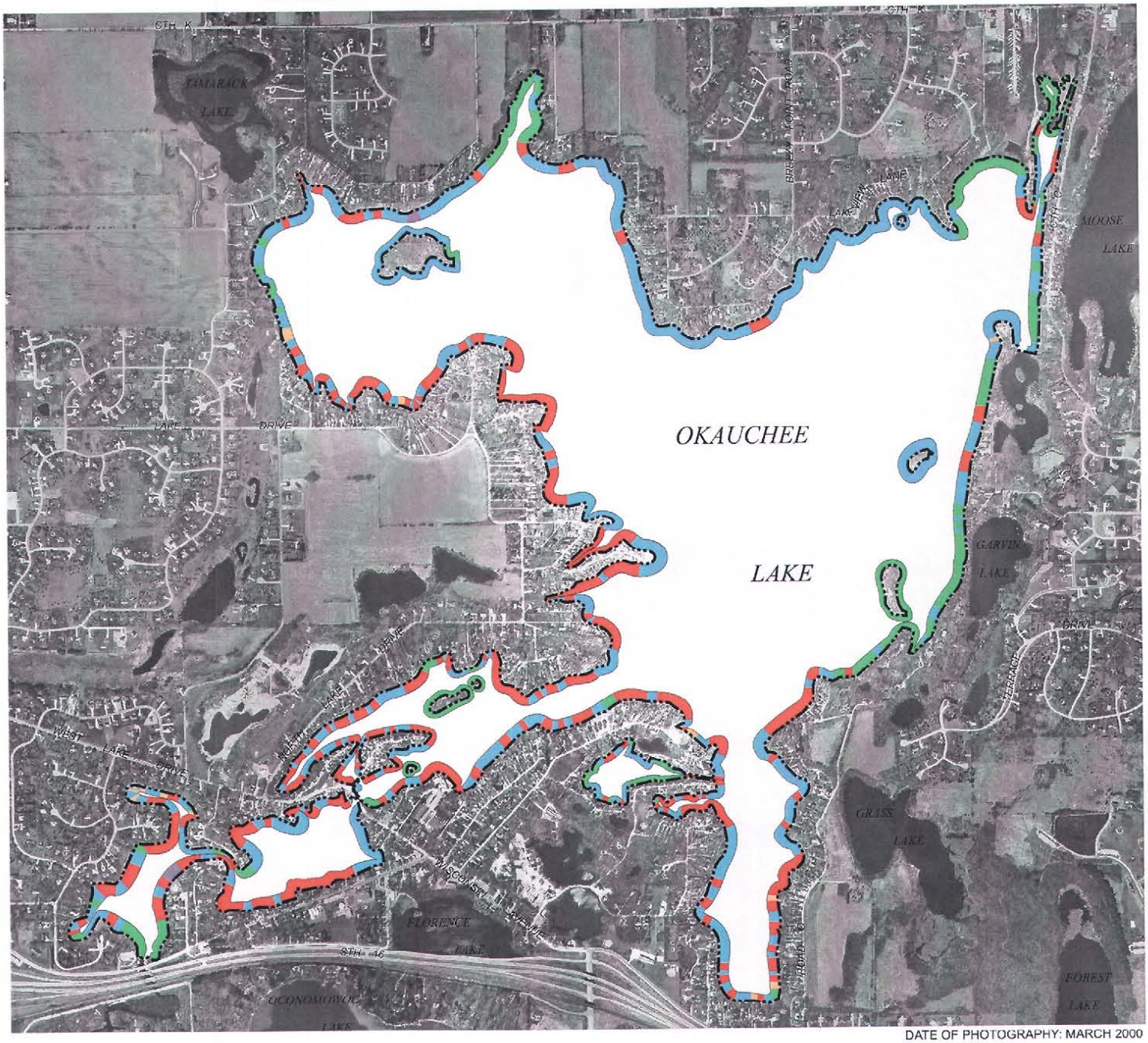
The initial aquatic plant survey on Okauchee Lake was conducted during June and August of 1977 by Environmental Resource Assessments, Inc. Subsequently, Aron & Associates conducted aquatic plant surveys during 1992 and 1996. The most recent aquatic plant survey was conducted by the Commission staff during July 2000, with follow-up reconnaissance surveys being undertaken by Commission staff during July 2001 and August 2002.

The macrophyte species observed during these surveys are presented in Table A-1. These aquatic plant survey data suggest that the dominant macrophyte species in the Lake were muskgrass (*Chara* sp.), coontail (*Ceratophyllum demersum*), spiked or northern water milfoil (*Myriophyllum exalbescens*, also known as *M. sibiricum*), Eurasian water milfoil (*Myriophyllum spicatum*), and Sago pondweed (*Potamogeton pectinatus*). Heavy growths of coontail, and the dominance of the water milfoils, are often indicative of fertile lakes. Other macrophytes identified in the Lake, which may produce nuisance conditions, included pondweeds (*Potamogeton* spp.), bushy pondweed (*Najas* spp.), and wild celery or eel grass (*Vallisneria americana*).

The numbers of aquatic plant species survey ranged from 23 in 1996 and 2000, to 25 in 1977, to 30 in 1992. The 1992 survey identified the greatest number of aquatic plant species observed during the years aquatic plants have been monitored. Notwithstanding, this range in numbers of species between surveys is likely to be insignificant, perhaps reflecting differences in sampling protocols or seasonal difference within the aquatic plant community in the Lake. These numbers of species, and the composition of the aquatic plant community, reflect a diverse aquatic plant community offering a variety of habitat types and conditions within the Lake. However, should there be a persistent decline in the numbers of native aquatic plants present over time, actions may be required to reverse this loss. The distribution and relative abundance of the macrophyte species present in the Lake as of the July 2000 survey are indicated in Table A-2, and graphically depicted on Map A-3.

Map A-2

SHORELINE PROTECTION STRUCTURES ON OKAUCHEE LAKE: 2000



DATE OF PHOTOGRAPHY: MARCH 2000

RIPRAP

BULKHEAD

BEACH

REVETMENT

NATURAL

Source: SEWRPC.

Table A-1

OKAUCHEE LAKE AQUATIC PLANT SURVEY RESULTS: 1977-2000[a]

Aquatic Plant Species	1977 Survey[b]	1992 Survey[b]	1996 Survey[c]	2000 Survey[d]
Bidens beckii (water marigold)	X	--	--	--
Ceratophyllum demersum (coontail)	X	X	X	X
Chara vulgaris (muskgrass)	X	X	X	X
Eleocharis acicularis (spike rush)	X	X	--	--
Elodea canadensis (waterweed)	X	X	X	X
Lemna minor (small duckweed)	--	X	X	X
Lemna trisulca (forked duckweed)	--	--	--	X
Myriophyllum exalbescens (spiked water milfoil)	X	X	--	--
Myriophyllum spp. (native water milfoil)	--	--	--	X
Myriophyllum spicatum (Eurasian water milfoil)	X	X	X	X
Myriophyllum verticullatum (northern water milfoil)	X	X	--	--
Najas flexilis (bushy pondweed)	X	X	X	X
Najas marina (spiny naiad)	X	X	X	X
Nitella sp. (nitella)	--	--	--	X
Nuphar sp. (yellow water lily)	X	X	X	X
Nymphaea sp. (white water lily)	X	X	X	X
Polygonatum natans (water smartweed)	X	X	--	--
Potamogeton amplifolius (large-leaf pondweed)[e]	X	X	X	X
Potamogeton berchtoldii (small pondweed)	X	X	--	--
Potamogeton crispus (curly-leaf pondweed)	X	X	X	X
Potamogeton filiformis (thread-leaf pondweed)	--	X	X	--
Potamogeton friesii (Fries pondweed)	--	X	X	--
Potamogeton gramineus (variable pondweed)	X	X	X	X
Potamogeton illinoensis (Illinois pondweed)[e]	X	X	X	X
Potamogeton natans (floating-leaf pondweed)	--	X	X	--
Potamogeton pectinatus (Sago pondweed)[e]	X	X	X	X
Potamogeton praelongus (white-stem pondweed)[e]	X	X	--	--
Potamogeton richardsonii (clasping-leaf pondweed)[e]	--	X	X	X
Potamogeton zosteriformis (flat-stemmed pondweed)	X	X	X	X
Ranunculus longirostris (stiff water crowfoot)	X	X	--	--
Spirodela polyrhiza (great duckweed)	--	--	--	X
Utricularia sp. (bladderwort)	X	X	X	X
Vallisneria americana (water celery)[e]	X	X	X	X
Zannichellia palustris (horned pondweed)[e]	--	X	X	--
Zosterella dubia (water stargrass)	X	X	X	X

[a]*Survey results reported for Okauchee Lake including the embayments locally known as Lower Okauchee and Upper Oconomowoc Lakes, unless otherwise specified.*

[b]*Survey conducted by Environmental Resource Assessments.*

[c]*Survey conducted by Aron & Associates for Okauchee Lake only.*

[d]*Survey conducted by SEWRPC.*

[e]*Considered a high-value aquatic plant species known to offer important values in specific aquatic ecosystems under Section NR 107.08 (4) of the* Wisconsin Administrative Code.

Source: Environmental Resource Assessments, Aron & Associates, and SEWRPC.

During the 1977 survey, macrophyte growth in Okauchee Lake was found to be moderate to abundant, with the maximum water depth at which macrophyte growth occurred being about 15 feet. Macrophyte growth occurred over about 45 percent to 80 percent of the lake bottom. The dominant macrophytes were muskgrass (*Chara* sp.), coontail (*Ceratophyllum demersum*), northern water milfoil (*Myriophyllum exalbescens*), Eurasian water milfoil, (*Myriophyllum spicatum*), and Sago pondweed (*Potamogeton pectinatus*). The abundance of macrophytes was reported to have greatly decreased between June and August, 1977, although much of this decrease could be accounted for as a result of the aquatic plant management measures conducted on the Lake during this period.

Table A-2

AQUATIC PLANT SPECIES PRESENT IN OKAUCHEE LAKE AND THEIR POSITIVE ECOLOGICAL SIGNIFICANCE: JULY 2000

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence (percent)[a]	Density at Sites Found[b]	Density in Whole Lake[b]	Ecological Significance[c]
Ceratophyllum demersum (coontail)	103	38.87	2.28	0.89	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	120	45.28	2.62	1.18	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)	22	8.30	1.82	0.15	Provides shelter and support for insects which are valuable as fish food
Lemna minor (lesser duckweed)	--[d]	--[d]	--[d]	--[d]	A nutritious food source for ducks and geese, also provides food for muskrat, beaver and fish, while rafts of duckweed provide shade and cover for insects, in addition extensive mats of duckweed can inhibit mosquito breeding
Lemna trisulca (forked duckweed)	--[d]	--[d]	--[d]	--[d]	Good food for ducks and geese, provides cover for fish and insects
Myriophyllum sp. (native water milfoil)	15	5.66	1.47	0.08	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	223	84.15	3.30	2.78	Exotic invasive plant species that can lead to a decrease in native aquatic plant community abundance and diversity, but it can provide cover for invertebrates and forage fish species
Najas flexilis (bushy pondweed)	126	47.55	2.02	0.96	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	17	6.41	1.82	0.12	Provides good food and shelter for fish and food for ducks
Nitella sp. (nitella)	3	1.13	2.00	0.02	Provides important food for wildfowl and attracts small aquatic animals
Nuphar sp. (yellow water lily)	--[d]	--[d]	--[d]	--[d]	Leaves, stems, and flowers are eaten by deer; roots eaten by beaver and porcupine; seeds eaten by wildfowl; leaves provide harbor to insects, in addition to shade and shelter for fish
Nymphaea tuberosa (white water lily)	--[d]	--[d]	--[d]	--[d]	Provides shade and shelter for fish; seeds eaten by wildfowl; rootstocks and stalks eaten by muskrat; roots eaten by beaver, deer, moose, and porcupine
Potamogeton amplifolius (large-leaf pondweed)[e]	8	3.02	1.38	0.04	Provides food, shelter and shade for some fish and food for some wildfowl. Provides shelter and support for insects, which are valuable as fish food
Potamogeton crispus (curly-leaf pondweed)	10	3.77	1.10	0.04	Exotic invasive plant species that can lead to a decrease in native aquatic plant community abundance and diversity, but it can provide food, shelter and shade for some fish and food for wildfowl

Table A-2 (continued)

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence (percent)[a]	Density at Sites Found[b]	Density in Whole Lake[b]	Ecological Significance[c]
Potamogeton gramineus (variable pondweed)	26	9.81	1.50	0.15	Provides habitat for fish and food for waterfowl, in addition to muskrat, beaver, deer, and moose
Potamogeton illinoensis (Illinois pondweed)[e]	3	1.13	1.00	0.01	Provides shade and shelter for fish' harbor for insects; seeds are eaten by wildfowl
Potamogeton pectinatus (Sago pondweed)[e]	16	6.04	1.31	0.08	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton richardsonii (clasping leaf pondweed)	12	4.53	1.42	0.06	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-stemmed pondweed)	9	3.40	1.11	0.04	Provides some food for ducks
Spirodela polyrhiza (great duckweed)	--[d]	--[d]	--[d]	--[d]	Good food for ducks and geese; also eaten by muskrats and some fish; provides cover for fish and insects
Utricularia sp. (bladderwort)	9	3.40	1.22	0.04	Provides good food and cover for fish
Vallisneria americana (water celery)[e]	130	49.06	2.77	1.36	Provides good shade and shelter, supports insects, and is valuable fish food
Zosterella dubia (water stargrass)	49	18.49	1.88	0.35	Provides food and shelter for fish, locally important food for waterfowl

NOTE: There were 265 sample during the July 2000 survey.

[a]*Maximum equals 100 percent.*

[b]*Maximum density equals 4.0.*

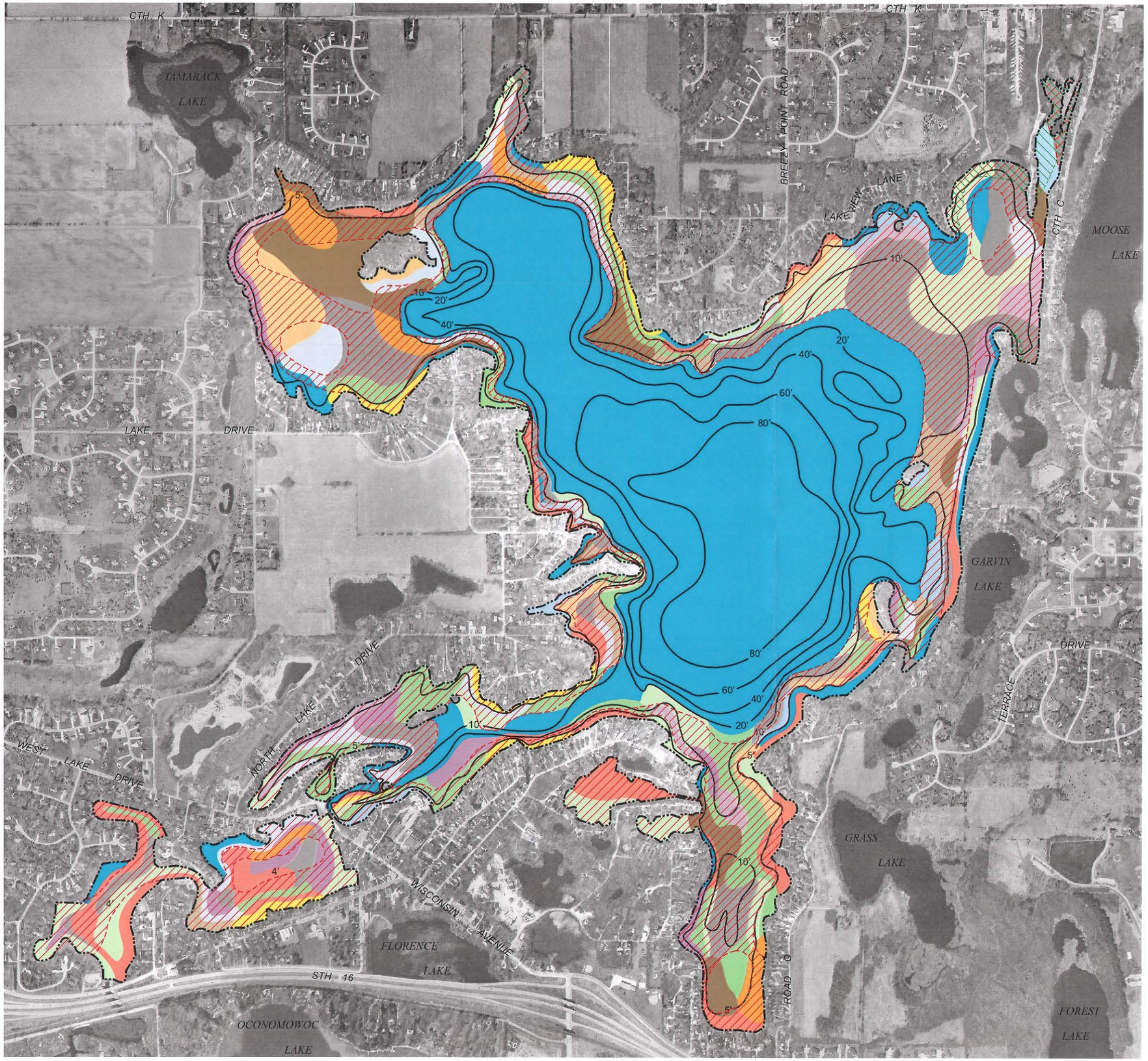
[c]*Information obtained from* A Manual of Aquatic Plants *by Norman C. Fassett,* Guide to Wisconsin Aquatic Plants, *Wisconsin Department of Natural Resources and* Through the Looking Glass...A Field Guide to Aquatic Plants, *Wisconsin Lakes Partnership.*

[d]*Emergent and floating-leaved aquatic plants are not included in the analysis of density and frequency of occurrence calculations for submerged macrophytes.*

[e]*Considered a high-value aquatic plant species known to offer important values in specific aquatic ecosystems under Section NR 107.08(4) of the* Wisconsin Administrative Code.

Source: SEWRPC.

During the July 2000 Commission survey, plant growth occurred throughout most of the Lake where the water depth was less than 15 feet. Eurasian water milfoil (*Myriophyllum spicatum*) was the dominant species in many areas of the Lake. Eurasian water milfoil was found throughout the Lake, but largely confined to areas of the Lake with depths of between five and 15 feet. This nonnative plant was the most frequent and most widely distributed species in the Lake during the study period. It should be noted that the year 2000 appears to have been a year with abundant Eurasian water milfoil growth throughout Southeastern Wisconsin, as significant stands of the plant were reported from other area lakes during that year. Notwithstanding, the abundant growth of Eurasian water milfoil in the Lake is likely to be attributable to the highly organic lake bottom sediments, which are predominantly comprised of silt, as shown on Map A-4. Such bottom sediments favor the growth of Eurasian water milfoil. Both Eurasian water milfoil and curly-leaf pondweed (*Potamogeton crispus*) are designated as



Map A-3

AQUATIC PLANT COMMUNITY DISTRIBUTION IN OKAUCHEE LAKE: 2000

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

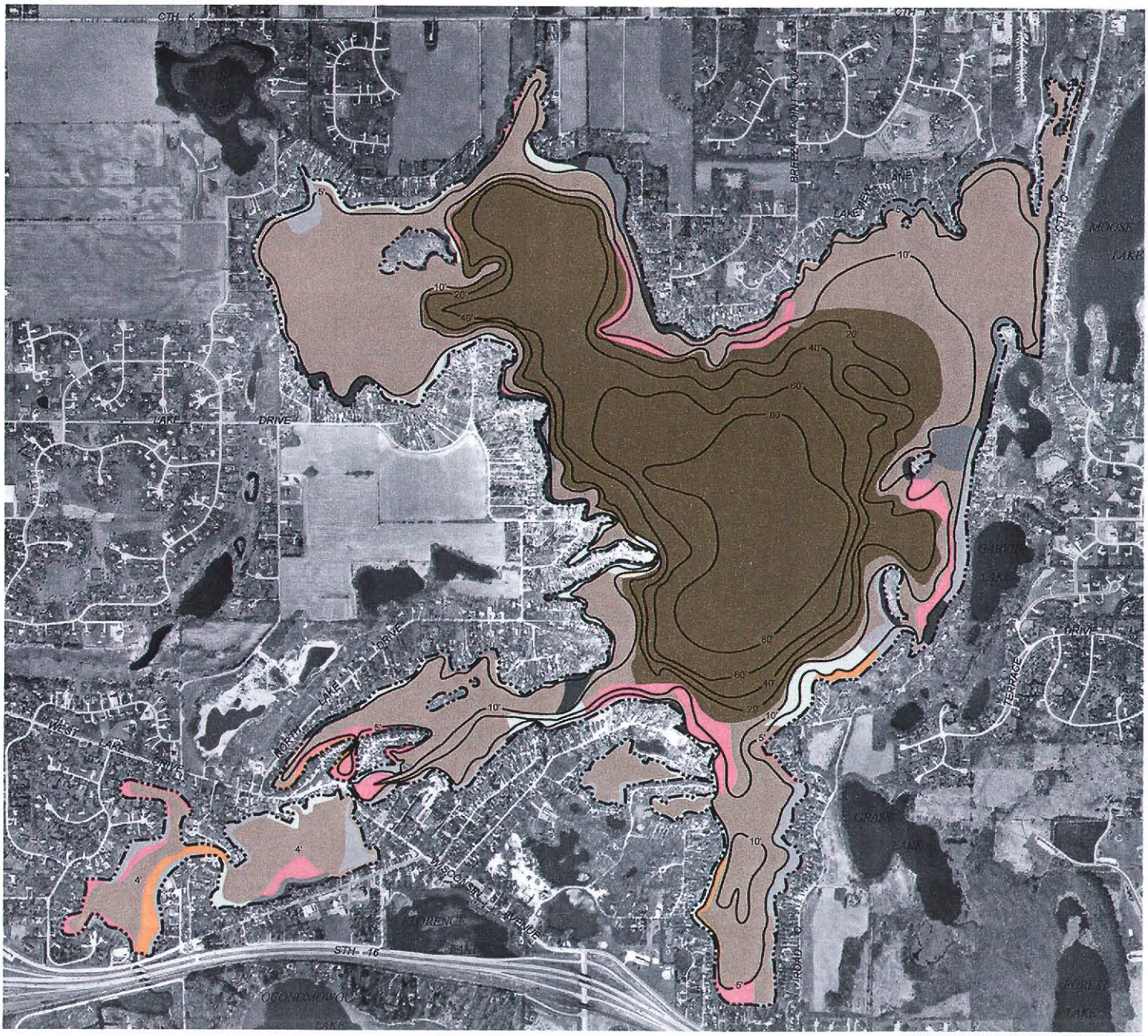
GRAPHIC SCALE
0 650 1300 FEET

Source: SEWRPC.

DATE OF PHOTOGRAPHY: MARCH 2000

Map A-4

SEDIMENT SUBSTRATES DISTRIBUTION IN OKAUCHEE LAKE: 2000



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

SAND AND ROCK

ROCK

SILT AND GRAVEL

GRAVEL

SAND AND GRAVEL

SAND

SILT AND SAND

SILT

MUCK

GRAPHIC SCALE

0 1000 2000 FEET

Source: SEWRPC.

invasive, nonnative plants in Chapter NR 109 of the *Wisconsin Administrative Code*.[3] Both of these species can outcompete native aquatic plant communities, leading to loss of plant diversity, degraded water quality, and reduced habitat for fish, invertebrates and wildlife.

Other common macrophytes observed in the Lake during the July 2000 survey included coontail (*Ceratophyllum demersum*), bushy pondweed (*Najas flexilis*), wild celery (*Vallisneria americana*), and muskgrass (*Chara* spp.). Muskgrass was co-dominant in most of the Lake. Healthy populations of pondweeds (*Potamogeton* spp.) were most commonly found at depths of between five and 10 feet. These plants are generally viewed as beneficial in that they provide habitat for fish and wildlife, minimize shoreline erosion, and remove nutrients from the water column that might otherwise result in excessive growth of algae. In general, Okauchee Lake supported an healthy and diverse aquatic macrophyte community that may be considered typical of meso-eutrophic lakes in Southeastern Wisconsin.

Eurasian Water Milfoil

At the time of the year 2000 Commission survey, the dominant aquatic plant within the Lake was Eurasian water milfoil, *Myriophyllum spicatum*. Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one that is known to be exotic or nonnative. Because of its nonnative nature, Eurasian water milfoil has few natural enemies and can exhibit "explosive" growth under suitable conditions, such as the presence of organic-rich sediments, or in areas where the lake bottom has been disturbed. It can displace native plant species and disrupt the ecosystem functioning of a lake as it lacks many of the positive ecological values of native aquatic plants. This particular species of milfoil has been known to become the dominant plant present in a lake with its ability to regenerate, to replace native vegetation, and to reduce the quality of fish and wildlife habitat.

Eurasian water milfoil is especially abundant in the eastern lake basin of Okauchee Lake where depths rarely exceed 10 feet, as well as within the littoral zone of the western basin at depths of between five and 15 feet. The abundant growths of Eurasian water milfoil are known to cause extreme problems for recreational users of Okauchee Lake due to its ability to grow to the lake surface, making certain recreational uses less enjoyable, if not dangerous, and impairing the aesthetic qualities of the waterbody. When Eurasian water milfoil is fragmented by boat propellers, or by other means, the fragments often are able to sprout new roots and potentially colonize new sites. These fragments can also cling to boats, trailers, motors, propellers, and bait buckets, among other things, and stay alive for weeks, facilitating their transfer to other lakes. [4] Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, boat owners and operators are obligated to remove any such plant materials from their boats and trailers.

Environmentally Sensitive Areas

As of early 2003, areas on Okauchee Lake were in the process of being designated as environmentally sensitive areas by the Wisconsin Department of Natural Resources pursuant to Chapter NR 107 of the *Wisconsin Administrative Code*. Such a designation is made because of the importance of these areas to the maintenance of good water quality conditions and the biological integrity of the Lake. The areas likely to be so designated, among others, are located within the embayment locally known as Whitteger's Bay situated on the north-central portion of the lake shore, and along the eastern shoreline of Okauchee Lake, including the debouchment of the Oconomowoc River and portion of the lakeshore eastward of the islands and the embayment locally known as Crane's Nest Bay. These areas are shown on Map A-5 as ecologically valuable areas.

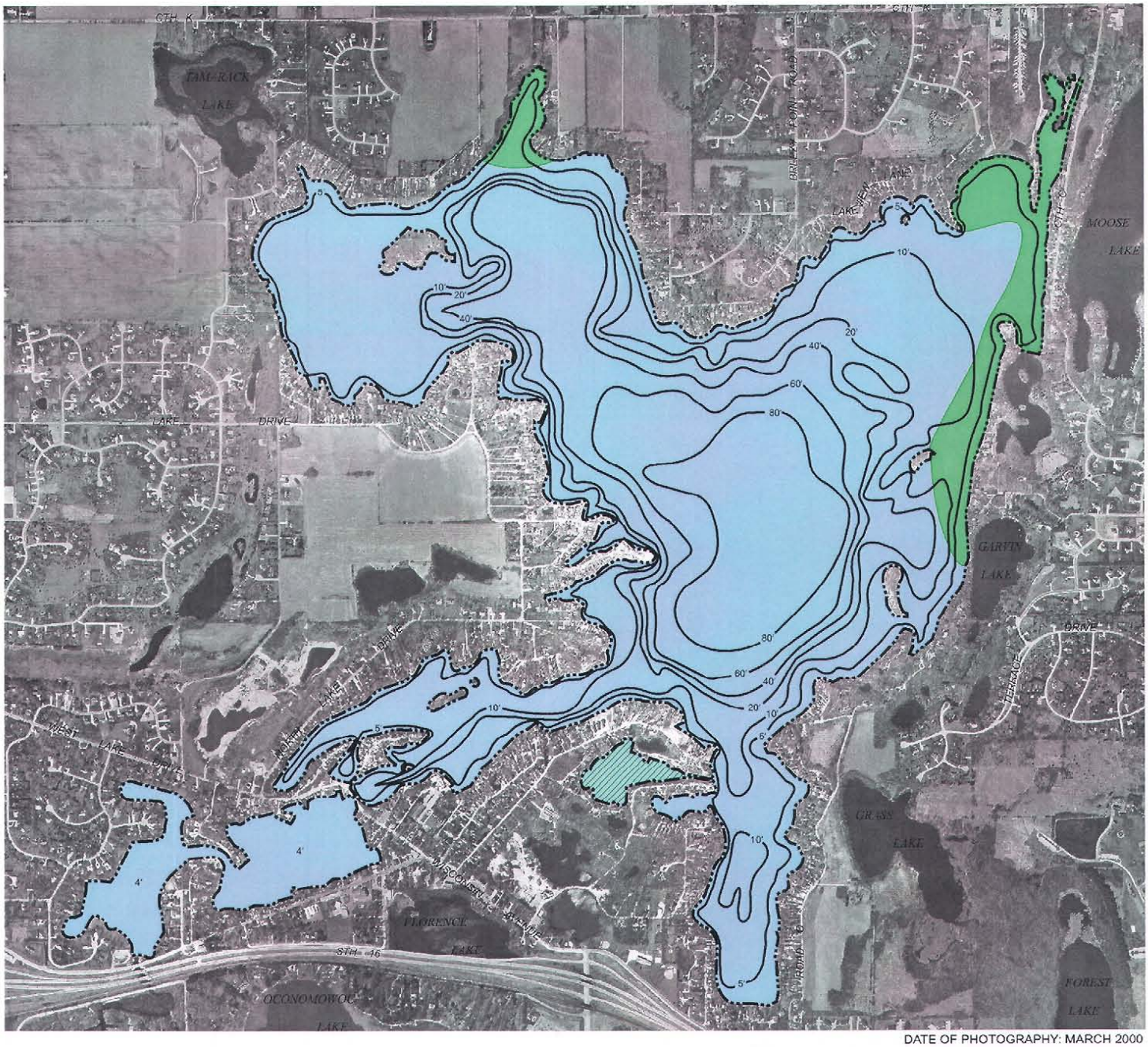
---

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

[4] Ibid.

Map A-5

WISCONSIN DEPARTMENT OF NATURAL RESOURCES-PROPOSED OKAUCHEE LAKE ENVIRONMENTALLY SENSITIVE AREAS



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

ENVIRONMENTALLY SENSITIVE AREA PROPOSED BY WISCONSIN DEPARTMENT OF NATURAL RESOURCES PURSUANT TO S. NR 107.05(3)(i)

ADDITIONAL ENVIRONMENTALLY SENSITIVE AREA UNDER CONSIDERATION BY WISCONSIN DEPARTMENT OF NATURAL RESOURCES AS OF 2003

GRAPHIC SCALE

0 1000 2000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

Fisheries, Wildlife and Waterfowl

Okauchee Lake is well known for its sport fishing. The Wisconsin Department of Natural Resources Publication PUB-FH-800 2001, *Wisconsin Lakes*, indicates that muskellunge, northern pike, and largemouth bass are common, and walleyed pike, smallmouth bass, and panfish are present in Okauchee Lake. Because of the abundant muskellunge habitat present in the Lake, muskellunge fingerlings have been stocked annually, with the exception of 1990, since 1981. Walleyed pike also have been stocked periodically since 1978.[5]

Given the urban nature of much of the shoreland of the Lake only smaller urban tolerant mammals are generally present. A somewhat more diverse animal community, and greater number of waterfowl, makes use of the extensive outlying wetland and other habitat areas located throughout the tributary drainage area of Okauchee Lake. Muskrats and cottontail rabbits are probably the most abundant and widely distributed fur-bearing mammals in the immediate riparian areas. Larger mammals, such as the whitetail deer, are generally confined to the larger wooded areas and the open meadows found in the park and open space lands within the drainage area tributary to the Lake. The Okauchee Lake drainage area supports a significant population of waterfowl, including mallards and geese. During migration seasons, a greater variety of waterfowl may be present and in greater numbers.

Recreational Uses and Facilities

Okauchee Lake is a multipurpose waterbody serving numerous forms of recreation, including both active and passive recreational uses. Boating, waterskiing, swimming, and fishing are popular activities during open water periods, and ice fishing and snowmobiling are common during closed water periods. The Lake is used year round as a visual amenity, with walking, bird watching, and picnicking being popular passive recreational uses of the waterbody and its surrounds. Several restaurants and other, water-oriented commercial establishments are situated on or close to the lakeshore.

Boating use of the Lake has been increasing, with maximum boating use of the Lake generally occurring between the hours of 10:00 a.m. and 3:00 p.m. The most recent boat survey, conducted by the Commission staff during the current planning program period, between these hours on a typical weekend day (July 29, 2000) indicated that about 185 watercraft of all descriptions were in use on the Lake. A weekday survey conducted on the Lake during this program (on July 21, 2000) indicated that about 145 watercraft of all descriptions were in use on the Lake. A total of almost 2,000 watercraft of all descriptions were observed on and around Okauchee Lake during July 2000. Powerboats comprised the largest class of vessel accounting for about one-third of the total number observed; pontoon boats comprised the next largest class, accounting for about one-quarter of the watercraft observed. Personal watercraft were the next largest class of vessel, comprising about one-tenth of the total.

There are two public boating access sites located on Okauchee Lake, on the western shores of the Lake. The current public access sites are adequate to meet the criteria set forth in Section NR 1.91(11) of the *Wisconsin Administrative Code*. In addition, as of 2000, there were two private recreational facilities offering boating access to the general public on Okauchee Lake, plus the Okauchee Lake Yacht Club. These private facilities are not private providers under Section NR 1.91(7) of the *Wisconsin Administrative Code* and do not currently contribute to the determination that Okauchee Lake has adequate public recreational boating access; however, they do provide additional access opportunities with the Okauchee Lake Yacht Club hosting numerous regattas during the summer months.

Local Ordinances

The comprehensive zoning ordinance represents one of the most important and significant tools available to local units of government in directing the proper use of lands within their area of jurisdiction. Local zoning regulations

---

[5]*E.R. Schumacher, Wisconsin Department of Natural Resources Fish Management Report No. 131,* Creel Survey on Pewaukee and Nagawicka Lakes, Waukesha County, Summer 1982, *February 1987, and Sue Beyler, Steve Gospodarek,* Okauchee Lake 1998 Comprehensive Survey (WBIC 0772000), *Wisconsin Department of Natural Resources, Internal Report File Ref: 3600, 2000.*

include general, or comprehensive, zoning regulations and special-purpose regulations governing floodland and shoreland areas. With the exception of the Town of Oconomowoc in Waukesha County and the Town of Ashippun in Dodge County, all of the municipalities within the drainage area tributary to Okauchee Lake have adopted local zoning ordinances. The towns within the drainage area tributary to Okauchee Lake, with the exception of those noted above, also have adopted their own zoning ordinances under village powers.

USE RESTRICTIONS IMPOSED BY AQUATIC PLANTS

Aquatic plant growth in Okauchee Lake is perceived to have reached densities in portions of the Lake that interfere with recreational usage of the Lake, impeding boat traffic and making some areas of the Lake impassable without aquatic plant control. At numerous sample sites, plant growth recorded by the Commission staff exceeded a density rating of three, indicating a moderate to abundant density. As noted above, Eurasian water milfoil is a major contributor to these higher densities. In particular, such abundant plant growth in the littoral zone makes access to the open water extremely difficult, and severely restricts shoreline angling and swimming. The abundance of aquatic plants in Okauchee Lake also adversely affects the aesthetic quality of the Lake, and can have a significant impact in terms of the level of enjoyment experienced by visitors to the Lake. During the summer months, these beds of vegetation can become foul smelling and unsightly, especially in areas where the aquatic plants serve as a substrate for algae and bacteria that can senesce and decompose when exposed to extreme sunlight. The result is numerous public concerns and complaints particularly expressed throughout open water periods.

PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

Excessive macrophyte growth on Okauchee Lake has historically resulted in a control program that has used both chemical treatments and harvesting. However, records of aquatic plant management efforts on Wisconsin lakes were not maintained by the Wisconsin Department of Natural Resources (WDNR) prior to 1950. Thus, while previous interventions were likely to have occurred, the first recorded efforts to manage the aquatic plants in Okauchee Lake took place during 1950. These efforts were based upon the use of chemical herbicides. The first known, organized macrophyte harvesting program on Okauchee Lake was conducted by the Town of Oconomowoc, which harvested aquatic plants in the Lake between 1963 and 1977. Since 1977, the Okauchee Lake Management District has been conducting the aquatic plant management program on the Lake, using both aquatic herbicides and aquatic plant harvesting as the control measures employed. The aquatic plant management activities can be categorized as mechanical and manual macrophyte harvesting, chemical macrophyte control, and chemical algal control.

Chemical Controls

Perceived excessive macrophyte growths on Okauchee Lake have historically resulted in application of a chemical control program. Chemical herbicides are known to have been applied to Okauchee Lake from at least 1950 through 2000, as set forth in Table A-3.

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 Okauchee Lake and it major lake basins during the period 1950 through 1967 are listed on Table A-3. The total amount of sodium arsenite applied to the Lake over this 17-year period was about 181,580 pounds.

Sodium arsenite was typically sprayed onto the surface of Okauchee Lake within an area of up to 200 feet from the shoreline. Treatment 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 an highly toxic form to a less toxic and less biologically active form, much of the arsenic residue was deposited in the lake sediments.

Table A-3

CHEMICAL CONTROLS ON OKAUCHEE LAKE: 1950-2001

Year	Macrophyte Control							Algal Control		
	Sodium Arsenite (pounds)	Diquat (gallons)	Endothall (gallons)	Endothall (pounds)	Fluridone (gallons)	2,4-D (gallons)	2,4-D (pounds)	Copper Sulfate (gallons)	Copper Sulfate (pounds)	Blue Vitriol (pounds)
1950-1969	181,580	22.50	82.00	--	--	5.0	--	--	4,420.0	3,195
1970	--	11.50	16.00	--	--	270.0	--	--	330.0	--
1971	--	--	--	735.00	--	10.0	--	--	291.0	--
1972	--	--	150.00	--	--	20.0	--	--	--	--
1973	--	1	12.00	--	--	--	--	--	--	--
1974	--	--	11.00	379.00	--	22.0	47	--	--	--
1975	--	--	79.00	78.00	--	--	--	--	105.9	--
1976	--	--	14.80	--	--	269.0	70	--	--	--
1977	--	--	34.00	--	--	242.0	242	--	--	--
1978	--	--	48.20	70.00	--	129.5	5	--	--	--
1979	--	--	71.50	400.00	--	174.0	--	--	--	--
1980	--	--	31.00	37.25	--	207.0	--	--	--	--
1981	--	--	18.00	58.00	--	145.0	--	--	--	--
1982	--	--	53.50	32.50	--	291.0	--	--	--	--
1983[a]	--	--	--	--	--	--	--	--	--	--
1984	--		--	--	--	--	--	--	--	--
1985	--	0.67	28.50	485.00	--	118.5	--	--	--	--
1986	--	--	8.50	--	--	237.5	--	39.75	--	--
1987	--		14.00	--	--	47.0	--	57.50	--	--
1988	--	2.00	5.50	10.00	--	226.0	--	10.50	--	--
1989	--	--	--	--	--	--	--	--	--	--
1990	--	--	--	--	--	--	--	--	--	--
1991	--	--	--	3.00	--	--	--	--	--	--
1992	--	--	1.50	--	--	--	--	--	--	--
1993[a]	--	--	--	--	--	--	--	--	--	--
1994	--	--	--	--	--	9.0	--	--	--	--
1995	--	--	--	--	--	39.0	--	--	--	--
1996	--	--	--	--	--	7.5	--	1.00	--	--
1997	--	1.75	--	--	--	--	--	1.75	--	--
1998[a]	--	--	--	--	--	--	--	--	--	--
1999	--	--	--	--	--	--	602	--	--	--
2000	--	--	--	--	--	25.0	200	--	--	--
2001	--	--	--	--	0.56	107.0	107	--	--	--
Total	181,580	39.42	679.00	2,287.75	0.56	2,601.0	1,273	110.50	5,146.9	3,195

NOTE: Values include chemicals applied to Okauchee Lake and the embayments locally known as Lower Okauchee and Upper Oconomowoc Lakes.

[a]*No chemical controls were reported during these years.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

When it became apparent that arsenic was accumulating in the sediments of treated lakes, the use of sodium arsenite was discontinued in the State during 1969. The applications and accumulations of arsenic were found to present potential health hazards to both humans and aquatic life. Notwithstanding, the concentrations of arsenic within the lake sediments of Okauchee Lake are generally within draft sediment quality criteria limits set forth by the Wisconsin Department of Natural Resources, although locally higher concentrations may occur, as noted in Chapter IV of the lake management plan. These concentrations are not generally considered to pose an health hazard.

Subsequent to the discontinuation of the use of sodium arsenite, other chemical herbicides have been applied to Okauchee Lake. As shown in Table A-3, the aquatic herbicides diquat, endothall, and 2,4-D have been applied to Okauchee Lake to control aquatic macrophyte growth. Diquat and endothall are contact herbicides and kill plant parts exposed to the active ingredient. Diquat use is restricted to the control of duckweed (*Lemna* sp.), milfoil (*Myriophyllum* spp.), and waterweed (*Elodea* sp.). However, this herbicide is nonselective and will kill many

other aquatic plants, such as pondweeds (*Potamogeton* spp.), bladderwort (*Utricularia* sp.), and naiads (*Najas* spp.). Endothall primarily kills pondweeds, but does not control such nuisance species as Eurasian water milfoil (*Myriophyllum spicatum*). 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 noted above and is generally used to control Eurasian water milfoil. However, it will also kill some desirable 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 A-4.

In addition to the chemical herbicides used to control large aquatic plants, algicides have also been applied to Okauchee Lake. As shown in Table A-3, copper sulfate has been applied to Okauchee Lake to control algae and swimmer's itch from time-to-time. 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 found to be harmful to humans.[6] Restrictions on water uses after application of copper sulfate are also given in Table A-4.

Permits are required pursuant to Chapter NR 107 of the *Wisconsin Administrative Code* to apply chemical herbicides to control vegetation in lakes in Wisconsin. Herbicides must be applied by a licensed applicator, pursuant to label directions and guidelines.

Macrophyte Harvesting

The existing macrophyte control program on Okauchee Lake is based upon an aquatic management plan developed for Okauchee Lake during 1996.[7] The harvesting program emphasizes the removal of nuisance growths of aquatic plants to the extent necessary to facilitate recreational uses, rather than 100 percent plant removal. In conducting this program, the Okauchee Lake Management District currently uses four harvesters, three transport barges, and two cranes.

Typically, harvesting prior to June 15th is limited to cutting access channels to facilitate navigation to piers and channels. After mid-June, the harvesting operation is expanded to include all areas of the Lake that experience nuisance plant conditions. The volume of aquatic plant biomass harvested on Okauchee Lake averages about 62 truck loads, or approximately 682 tons, of aquatic plants removed from the Lake annually.

In addition to the mechanical harvesting operations conducted by the Okauchee Lake Management District, limited manual harvesting of aquatic plants occurs around piers and docks, and is conducted by individual homeowners as necessary.

Permits are required pursuant to Chapter NR 109 of the *Wisconsin Administrative Code* to cut vegetation in lakes. Permits under this *Code* are required for mechanical harvesting operations, and for manual harvesting operations that result in the removal of aquatic plants from an area greater than 30 linear feet of shoreline. There is no depth restriction on harvesting within this 30-foot section; however, boats, piers and other access-related facilities should be located within this area. All harvested plant materials must be removed from the water.

ALTERNATIVE METHODS FOR AQUATIC PLANT CONTROL

Background

Various aquatic plant management techniques (manual, mechanical, physical, biological, and chemical) are potentially applicable on Okauchee Lake. A number of these methods have been employed with varying success

---

[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.*

[7] *Aron & Associates*, Okauchee Lake Plant Management Plan, *November 1996.*

Table A-4

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.

on Okauchee Lake in the past, although aquatic plant harvesting has been the major control measure utilized throughout the Lake in recent years.

Physical Controls

Physical methods of aquatic plant control involve water level manipulation, placement of bottom barriers, and use of shoreline protection structures.

Water level manipulations generally focus on drawdowns that reduce the surface level of a waterbody in order to change or create specific types of habitat and thereby manage species composition within the waterbody. Drawdowns were not considered practical on Okauchee Lake due to the heavy recreational demands placed on the Lake throughout the year. Drawdowns can also encourage algal blooms and the growths of some plant species. For these reasons, drawdowns are not a recommended technique for Okauchee Lake at this time.

In certain situations, increasing or frequently changing the lake level has also been considered as a water level manipulation measure for the control of certain nuisance species. Fluctuating water levels have limited practicality on Okauchee Lake due to the intensity of year-round lake usage, while the ability to raise water levels for aquatic plant management purposes is limited by the topography of the lake basin, which would create unacceptable risks of flooding of residential properties and infrastructure. For these reasons, raising or frequently changing water levels is not a recommended technique for Okauchee Lake at this time.

Other physical controls, such as the placement of bottom barriers and use of shoreline protection structures, such as vegetated buffer strips, may be more practicable for Okauchee Lake. Extensive use of shoreline protection structures has occurred adjacent to the residential areas of Okauchee Lake, primarily to control erosion of the shoreline. Depending upon the nature of the measures used, certain structures, such as vegetated buffer strips and

enhanced littoral vegetation, can serve to filter out agro-chemicals that stimulate aquatic plant growth. While there is currently only limited opportunity for installing bottom barriers, increasing the extent of shoreline buffers around the Lake, especially within planned unit developments, provides an important and ready means of moderating the nutrient loads that stimulate the growth of aquatic plants.

Physical control options, such as dredging and covering bottom sediments with sand and or plastic lining, are techniques which may be used on a limited scale to eliminate macrophyte growth in localized areas, such as in swimming or boating access areas. While some limited dredging has been done on Okauchee Lake, extensive dredging to alleviate excessive macrophyte growth is not recommended due to the potential presence of arsenic residues in the Lake sediments from the extensive sodium arsenite applications conducted on the Lake during the 1950s and 1960s.

Chemical Controls

Chemical controls, in the form of herbicides and algicides, have been used on Okauchee Lake. However, an important goal of the Okauchee Lake Management District has been to manage the aquatic plant communities of the Lake with limited use of chemicals. Currently, the use of herbicides on the Lake has been limited to individual applications around piers and docks, and some demonstration projects in specific locations, such as Tierney Bay.

As noted above, the aquatic herbicides diquat, endothall, and 2,4-D have been applied to Okauchee Lake to control aquatic macrophyte growth. In addition, the use of fluridone has been proposed and used in Tierney Bay on an experimental basis during 2001. Diquat is a nonselective herbicide that will kill many aquatic plants, 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, the use of chemical control techniques may contribute to an ongoing aquatic plant problem by augmenting the natural rates of accumulation of decayed 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 the Lake, damaging or destroying nontarget plant species that provide needed habitat for fish and other aquatic life. Hence, this option is not considered to be feasible on the scale required to control the infestations of aquatic plants in Okauchee Lake.

Chemical control may be a suitable technique for the control of relatively small-scale infestations of Eurasian water milfoil. Chemical applications in early spring 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 Department of Natural Resources administrative rules, 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. A recommended checklist is provided as Figure A-1.

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 means are considered a viable option on Okauchee Lake to control nearshore plant growths, especially around piers and docks, and are encouraged by the Okauchee Lake Management District.

Mechanical Controls

Based on previous experience of the use of mechanical harvester technologies on Okauchee Lake, mechanical harvesting of aquatic plants appears to be a practical and environmentally sensitive method of controlling plant

Figure A-1

DISTRICT CHECKLIST FOR HERBICIDE APPLICATION

- ☐ Nuisance report completed defining areas of potential treatment
- ☐ Permit filed with the Wisconsin Department of Natural Resources
- ☐ Certified applicator hired[a]
- ☐ Required public notice in the newspaper
- ☐ Public informational meeting (required if five or more parties request a meeting)
- ☐ Posting of areas to be treated in accordance with regulations (discussed previously in report)
- ☐ Weather conditions cooperating
  - Wind direction and velocity
  - Temperature

[a]*A licensed applicator will determine the amount of herbicide to be used, based upon discussions with appropriate staff from the Wisconsin Department of Natural Resources, and will keep records of the amount applied.*

Source: SEWRPC.

growth and associated filamentous algae. The most significant impact of mechanical harvesting is the removal of the organic plant biomass, decreasing nutrient inputs to the Lake. Potential negative impacts of mechanical harvesting, as outlined by the U.S. Environmental Protection Agency,[8] 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 game fish, 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.

[8]*Environmental Protection Agency,* The Lake and Reservoir Restoration Guidance Manual, *2nd Edition, August 1990, p. 146.*

Creation of shared access lanes, allowing several residents to use the same lane, can result in increased use of these lanes and will help to keep them open for longer periods than would be the case if a less directed harvesting program was followed. Because of the demonstrated need for control of aquatic plants in Okauchee Lake, and because the current lake uses continue to indicate a need for aquatic plant harvesting, harvesting is considered a viable management option that should be continued by the Okauchee Lake Management District.

It also has been the experience of the Okauchee Lake Management District that recreational boating activities within the lake basin, together with the ongoing use of mechanical aquatic plant management measures, results in the creation of floating aquatic fragments within the Lake. In addition, the natural vegetative reproduction strategy of Eurasian water milfoil results in the fragmentation of the plant, encouraging its spread to new locations within the Lake. As a consequence, decomposing, floating vegetation can build up within sheltered embayments and along the leeward shorelines, and, together with terrestrial leaf litter, can limit the use of these areas. Not only is this material unsightly and potentially foul smelling, but it also contributes to the organic and mucky substrates favored by invasive plant species, such as Eurasian water milfoil. Further, it is not always feasible for the riparian owners to clean their shoreline when needed. To alleviate this problem, the Okauchee Lake Management District have incorporated a skimming operation into their harvesting program. While this operation continues to leave the control of rooted vegetation between the piers to the riparian owners, the operation of the skimming program is considered to be a feasible part of the aquatic plant management plan for the Lake.

Biological Controls

An alternative approach to controlling nuisance aquatic plant conditions is biological control. Recent WDNR studies have shown that *Eurhychiopsis lecontei*, an aquatic weevil species, has potential as a biological control agent for the control of Eurasian water milfoil. In 1989, the weevil was "discovered" during a study of the decline of Eurasian water milfoil growth in a Vermont pond. *Eurhychiopsis* subsequently proved to have significant impacts on Eurasian water milfoil both in the field and in the laboratory, and has been found to be far more widespread than previously thought. The adult weevil feeds on the milfoil plant, causing lesions that make the plant more susceptible to pathogens such as bacteria or fungi. During its feeding process, the weevil burrows into the stem of the plant, causing tissue damage to the plant such that its will lose buoyancy and collapse.[9] However, like all predator-prey relationships, the effectiveness of this organism as a Eurasian water milfoil control agent is limited by its numbers at any given time. While these numbers can be artificially enhanced by stocking, the use of these insects is highly labor-intensive and is subject to failure if the insects are exposed to the level of disturbances by boating traffic as might be expected in Okauchee Lake. Thus, this type of control remains largely experimental in Wisconsin and, because of the sensitivity of the weevils to disturbance and heavy predation by native fishes, is not recommended for widespread application at this time.

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 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 launches 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, Adopt-A-Lake, and other school-based programs can help to build community awareness of the value of lake ecosystems, and the need for

[9]*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.*

vigilance on the part of individual citizens and households within the drainage 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.

Thus, the conduct and support of informational and educational programming is recommended.

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

The recommended aquatic plant management plan consists of the integrated use of mechanical and manual harvesting, supplemented as necessary through the limited application of appropriate aquatic herbicides, designed to minimize the negative impacts on the ecologically valuable areas of the Lake while providing a level of control needed to facilitate the desired recreational uses of the Lake. In addition, such management measures are recommended to be supplemented by an informational and educational program.

In order to implement the recommended aquatic plant management program, the following management actions are recommended:

1. The continued operation by the Okauchee Lake Management District of the existing harvesters and transport equipment, and replacement of that equipment as required.

2. The acquisition and operation of skimming equipment to collect aquatic plant fragments.

3. Maintenance of the shared access channels, which should be harvested in such manner as 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.

4. Use of shallow harvesting, cutting at approximately two feet to remove the surface canopy of nonnative plants such as Eurasian water milfoil, to provide a competitive advantage to the low-growing native plants in the Lake is recommended. By not disturbing these low-growing species, which generally grow within one to two feet of the lake bottom and in relatively low densities, and leaving the root stocks and stems of the cut plants in place, the resuspension of sediments in the Lake will be minimized. This type of harvesting should be focused, primarily, on boating channels around the perimeter of the principle lake embayments, and, secondarily, on other areas with extensive growths of Eurasian water milfoil.[10]

5. Chemical herbicides, if found to be necessary, should be limited to controlling nuisance growths of exotic species in shallow water around docks and piers, or, as indicated within the demonstration project sites, in isolated embayments where plant growth is dominated by invasive nonnative species. Only herbicides that are selective in their control, such as 2,4-D and fluridone, should be used. Algicides, such as Cutrine Plus, generally are not recommended as algal blooms are rare in the Lake, and valuable macroscopic algae, such as *Chara* and *Nitella*, may be killed by this product.

6. It is recommended that chemical applications, if required, should be made in early spring to maximize their effectiveness on nonnative plant species, minimize their impacts on native plant species, and act as a preventive measure to reduce the development of nuisance conditions. Applications for herbicide permits should be reviewed annually and plan recommendations updated accordingly.

---

[10] *Use of shallow harvesting is also recommended in areas where aquatic herbicides have been applied to control nonnative aquatic plants and native aquatic plant growths have recurred in such density and abundance as to impede navigation or cause concern with respect to public safety, especially related to swimming.*

7. 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 the mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. As an alternative option it is recommended that the Okauchee Lake Management District obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to be made available to these residents.

8. It is recommended that ecologically valuable areas be restricted from aquatic plant management activities, especially during fish spawning seasons in early summer and autumn.

9. The incorporation by the Okauchee Lake Management District and riparian communities of educational and informational programming within the aquatic plant management program for the Lake is recommended. Such programming can provide students and householders with information on the types of aquatic plants in Okauchee Lake and 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. An organized aquatic plant identification day is one method of providing effective informational programming to lake residents. Other sources of information and technical assistance include the Department of Natural Resources Aquatic Plant Monitoring Program and the University of Wisconsin-Extension Service. The aquatic plant illustrations provided in Appendix B may assist individuals interested in identifying plants near their residences. Residents should be encouraged to observe and document changes in the abundance and types of aquatic plants in their part of the Lake on annual basis.

The recommended aquatic plant management plan for Okauchee Lake is graphically summarized on Map A-6. Aquatic plant management operations are recommended to be concentrated in the areas recommended for fishing and boating. Harvesting should not take place in shallow waters, generally three feet or less, to avoid disturbance of fish spawning areas and beds of native aquatic plants. Special care should be taken to avoid disturbing major spawning areas of bass in Okauchee Lake during spring spawning season, May 1st to June 30th, annually.

The primary objective of the management program is to accommodate recreational uses of the Lake, and to enhance the public perceptions of the Lake, without inflicting irreparable damage to the structure and functioning of the lake ecosystem. To accomplish this objective, specific control measures should be applied in each of the lake zones as summarized in Table A-5 and shown on Map A-6. The recommended sequence of the harvester operations on Okauchee Lake is set forth in Figure A-2.

Depth of Harvesting and Treatment of Fragments

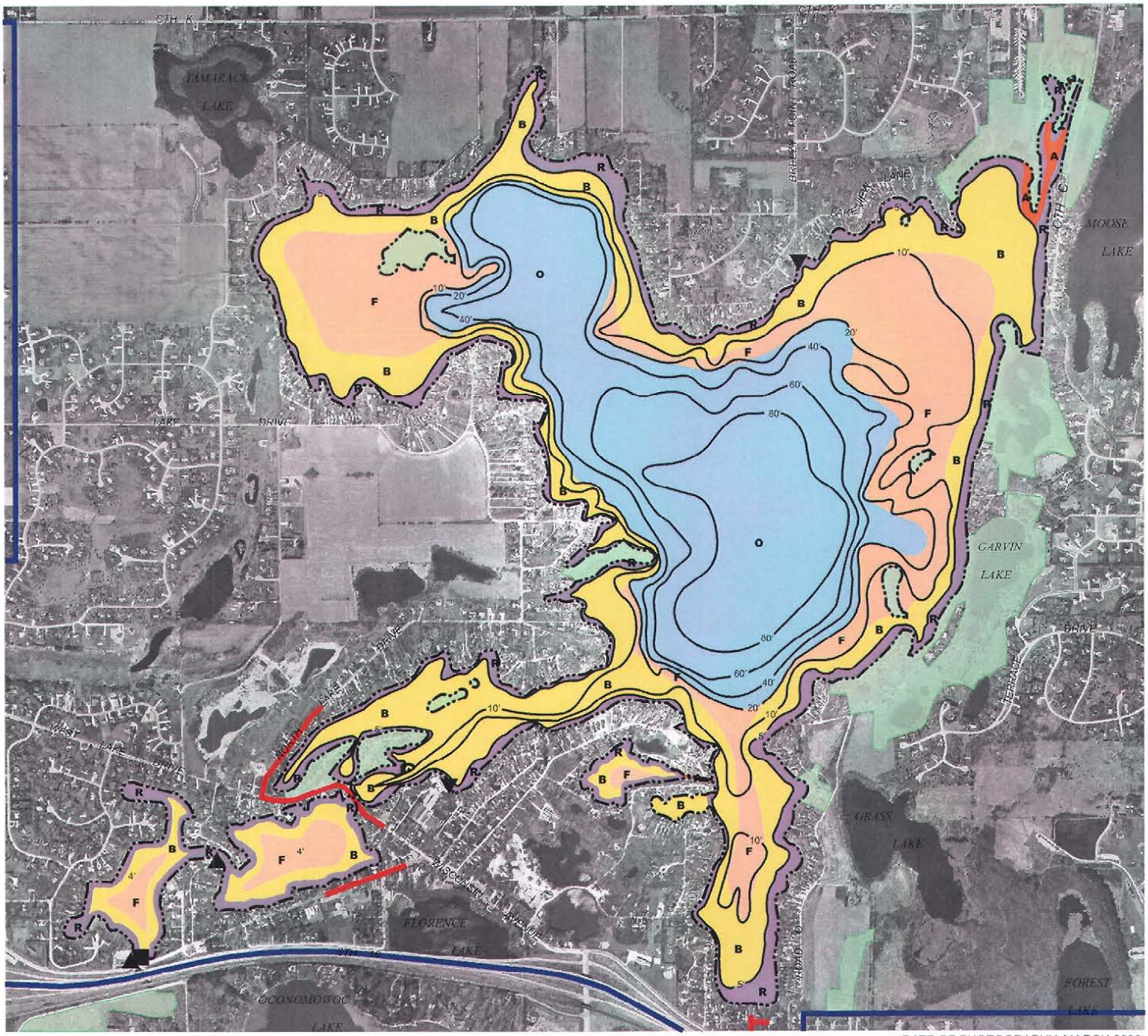
The H-620 aquatic plant harvester has a maximum cutting depth of 5.6 feet. While this exceeds the actual water depth of approximately 15 percent of the Lake, it is not the intention of the owners or operators of the equipment to denude the Lake of aquatic plants, given the intensive angling use of the waterbody; its morphology, in which portions may not be conducive to extensive motorized boat traffic; and the program goals. Sufficient plant materials will be retained in the Lake to minimize resuspension of lake bottom sediments and to maintain desirable plant communities, such as those dominated by the low-growing *Chara* spp. All plant cuttings and fragments will be collected *in situ*, to the extent practicable, by the harvesters. Those fragments accumulating within embayments and other sheltered areas of the Lake will be collected by the Okauchee Lake Management District skimming program or by the riparian homeowners. Fragments collected by the homeowners can be used as garden mulch and compost.

Buoyage

Temporary marker buoys may be used to direct harvesting operations in the lake basin by marking the areas to be cut. The size of the Lake may warrant the use of such buoys. Notwithstanding, the harvester operators will be provided with a laminated copy of the harvesting plan and made familiar with the plan and local landmarks to the degree necessary to carry out the plan without the use of buoyage. Harvesting operations will be regularly supervised by Management District staff.

Map A-6

RECOMMENDED LAKE MANAGEMENT PLAN FOR OKAUCHEE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

— 20' — WATER DEPTH CONTOUR IN FEET

■ WATER LEVEL CONTROL STRUCTURE

▲ PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA

▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

A ACCESS: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

B BOATING / RECREATION: SURFACE CUT OF EURASIAN WATER MILFOIL, HARVESTING MODERATE PRIORITY

R RIPARIAN ZONE: MAINTAIN SHORELINE PROTECTION STRUCTURES AS NECESSARY, INSTALL VEGETATIVE BUFFERS, MANUALLY HARVEST AQUATIC PLANTS AROUND PIERS AND DOCKS

F FISH BREEDING AND HABITAT/ANGLING AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON

O OPEN WATER: DEPTH GREATER THAN 20 FEET - NO AQUATIC MANAGEMENT MEASURES RECOMMENDED

LAND USE MANAGEMENT

PROTECT ENVIRONMENTAL CORRIDOR LANDS

- OBSERVE GUIDELINES SET FORTH IN THE COUNTY DEVELOPMENT PLAN, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS

BOUNDARY OF SANITARY SEWER SERVICE AREA: OKAUCHEE LAKE- PROVIDE PUBLIC SANITARY SEWERAGE SERVICES, REFINE AS NECESSARY

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM

IMPLEMENT RUNOFF MANAGEMENT PRACTICES

FISHERIES MANAGEMENT

- CONTINUE TO MONITOR FISH POPULATIONS, MODIFY STOCKING/ HARVESTING PROGRAM AND REGULATIONS, AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

GRAPHIC SCALE

0 1000 2000 FEET

Source: Okauchee Lake Management District and SEWRPC.

Table A-5

RECOMMENDED AQUATIC PLANT MANAGEMENT TREATMENTS FOR OKAUCHEE LAKE

Zone and Priority	Recommended Aquatic Plant Management Treatment
Zone B (Boating) High-Priority Harvesting	Harvesting limited to maintaining 75-foot-wide navigational channels along the perimeter of the Lake, and 30-foot-wide shared access lanes perpendicular to the shoreline extending towards the center of the Lake to allow boat access to the open water area of the Lake; chemical use should be limited to the control of nonnative invasive species
	Shallow harvesting of Eurasian water milfoil and other aquatic plants, as may be necessary, is recommended to maintain navigational access and public safety of recreational water users
	Limited late season harvesting (late August to early September) may be necessary to maintain adequate open water areas in the central portion of the Lake
Zone F (Fishing) Low-Priority Harvesting	Zone F is intended to accommodate fishing from a boat
	It is recommended that approximately 15-foot-wide channels be harvested perpendicular to the shore at about 100-foot intervals
	Chemical use, if required, should be restricted to selective control of nuisance species near the public access sites; no chemical controls during fish spawning periods in early spring and late autumn
Zone O (Open Water) Low-Priority Harvesting[a]	Harvesting should be conducted in selected areas of the deeper water to provide a larger shared space for boating and fishing
	Navigation channels approximately 30 feet in width, should be harvested
Zone R (Riparian Access) High-Priority Harvesting	Littoral zone—the entire area may not require intensive plant management
	Nuisance aquatic macrophyte growth within 150 feet of shoreline should be harvested to provide maximum opportunities for boating, fishing, and limited swimming
	Areas between piers should not be harvested due to potential liability and maneuverability problems. Residents are encouraged to manually harvest aquatic plants in these areas; however, limited chemical use for the control of nonnative invasive species may be allowed subject to permit requirements
	Additional 30-foot-wide shared access channels should be harvested to extend to the center of the Lake
Zone A (Recreational Boating Access) High-Priority Harvesting	Harvest a 50-foot-wide channel following the shorelines of the bays to connect to channels perpendicular to shore to allow access to the main body of the Lake
	Patterns of harvesting will vary yearly dependant on macrophyte abundance
	Chemical use, if required, should be restricted to pier and dock areas and should not extend more than 100 feet from shore; subject to permit requirements
Approximate Total Area to Be Harvested	570 acres

[a]*Excludes areas greater than 15 feet which require no harvesting.*

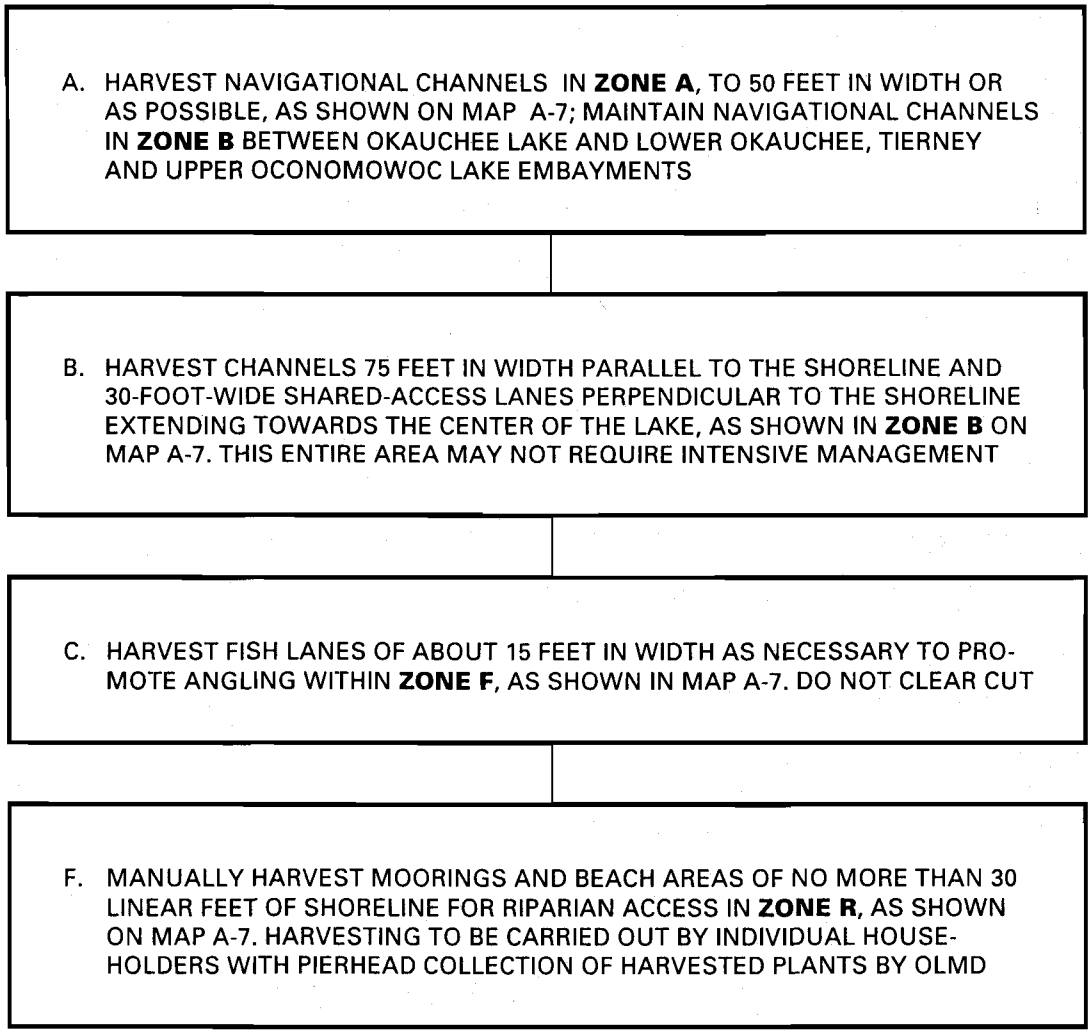
Source: SEWRPC.

Harvested Plant Material Disposal and Transfer Site(s)

Plant material will be removed from the harvesters on a transporter and conveyed to the off-loading area at the Okauchee Lake Management District property at the Oconomowoc River inlet. Plant material will be transferred at this site to a dump truck using a conveyor and transported to disposal sites identified by the Okauchee Lake Management District. Plant material will be collected and disposed of daily to avoid leaching of nutrients back into the impoundment and to minimize the visual degradation of the environment near the boat launch site. The operators will stringently monitor the off-loading site to ensure minimal disruption of boaters and of the people using the riparian areas of the Lake.

Figure A-2

HARVESTING SEQUENCE FOR OKAUCHEE LAKE



NOTE: Sequence A and B could be done concurrently in one area of the Lake as a time-saving measure.

[a]*No harvesting would be conducted within 100 feet of the island areas.*

Source: SEWRPC.

Precautions to Protect Wildlife and Ecologically Valuable Areas

As noted above, harvester operators will be provided with a laminated copy of the approved harvesting plan map and operational sequence chart, as set forth in Map A-6 and Figure A-2, showing the limits and priorities of harvesting operations. A copy of these items will be kept on the harvesters at all times. Harvesting operations in the areas identified as suitable for bass spawning will be restricted until the beginning of June to permit undisturbed spawning. Harvesting in all areas will be to a maximum depth of one foot above the lake bottom in order to provide adequate protection for the lake bottom, to minimize resuspension of the bottom sediments, and to allow low-growing native plants present within the system, such as *Chara* sp., to retain their competitive advantage over less-desirable invasive species, such as the Eurasian water milfoil.

Public Informational Programming
It is the policy of the Okauchee Lake Management District to maintain an active dialogue with the community. This dialogue is carried out through the medium of the public press and in public fora through various District Commissioner meetings, public meetings, and other scheduled hearings. Further, the Okauchee Lake Management District holds regular public informational meetings serving both community members and the schools within their jurisdiction. Staff are available during normal office hours to answer questions, respond to citizen concerns, and interact with the public as necessary.

Harvesting Schedule
The harvesting season should begin no earlier than mid-May and will end no later than mid-October of each year. Harvesting should average 40 hours per week over a five-day week, depending on weather conditions and plant growth, to minimize recreational conflicts. Further, harvesting should be confined to daylight hours to minimize public disturbances resulting from harvester and plant removal operations. As provided for above, the harvesting operations should also be modified to protect fish spawning areas.

EQUIPMENT NEEDS AND OPERATION

The Okauchee Lake Management District currently owns and operates three harvesters, with three transporters and one shore conveyor, each with 10-year anticipated life spans. The Aquarius Systems Harvester was purchased by the District during 1989, and the Inland Lake harvesters were purchased during 1993 and 1997. The Grunwald transporter was purchased during 1967, and the Inland Lake transporters were purchased by the District during 1993 and 1997. Replacement of two harvesters and one shore conveyor, when necessary, may be expected to cost about $212,500.

Harvester/Transporter:	One Aquarius Systems Model H-620 or Equivalent Two Inland Lake Harvesters or Equivalent One Grunwald Transporter or Equivalent Two Inland Lake Transporter or equivalent
Shore Conveyor:	One Aquarius Systems Model S/C-34 or equivalent
Skimmer:	One Inland Lake Harvesters Model LH-6-250 or equivalent

Costs:	Two Aquatic Plant Harvesters with 12,000 pound capacity ($101,000 each)	$202,000
	One Skimmer with 10,500 pound capacity	$ 70,000
	Two Shore Conveyors ($22,500 each)	$ 45,000
	Total Costs	$317,000

Maintenance Schedule, Storage, and Related Costs
Routine maintenance will be performed on the harvesters, transport barges, and skimmer by the Okauchee Lake Management District in accordance with the manufacturer's recommended maintenance schedule. Maintenance costs will be borne by the Okauchee Lake Management District. Winter storage of the harvesting equipment will be the responsibility of the Okauchee Lake Management District.

Insurance Coverage
Insurance coverage on the respective harvesters will be incorporated into the policy held by the Okauchee Lake Management District on all capital equipment. Liability insurance for the operation of the harvesters will also be borne by the District. The relevant certificates of insurance will be held by the Superintendent of the Okauchee Lake Management District.

Operators, Training, and Supervision
The harvesters will be owned and operated by the Okauchee Lake Management District, respectively, who will be responsible for day-to-day operations of the equipment. The District will provide operator training as required. Initial training will be provided by the manufacturer on delivery of the machinery.

Day-to-day supervision will be by the Okauchee Lake Management District staff.

EVALUATION AND MONITORING

Daily Record-Keeping Relating to the Harvesting Operation
Daily harvesting activities will be recorded by the operators of harvesting equipment in an operations log. An annual summary of the harvesting program will be submitted to the Okauchee Lake Management District Commission, and made available to the public at that time.

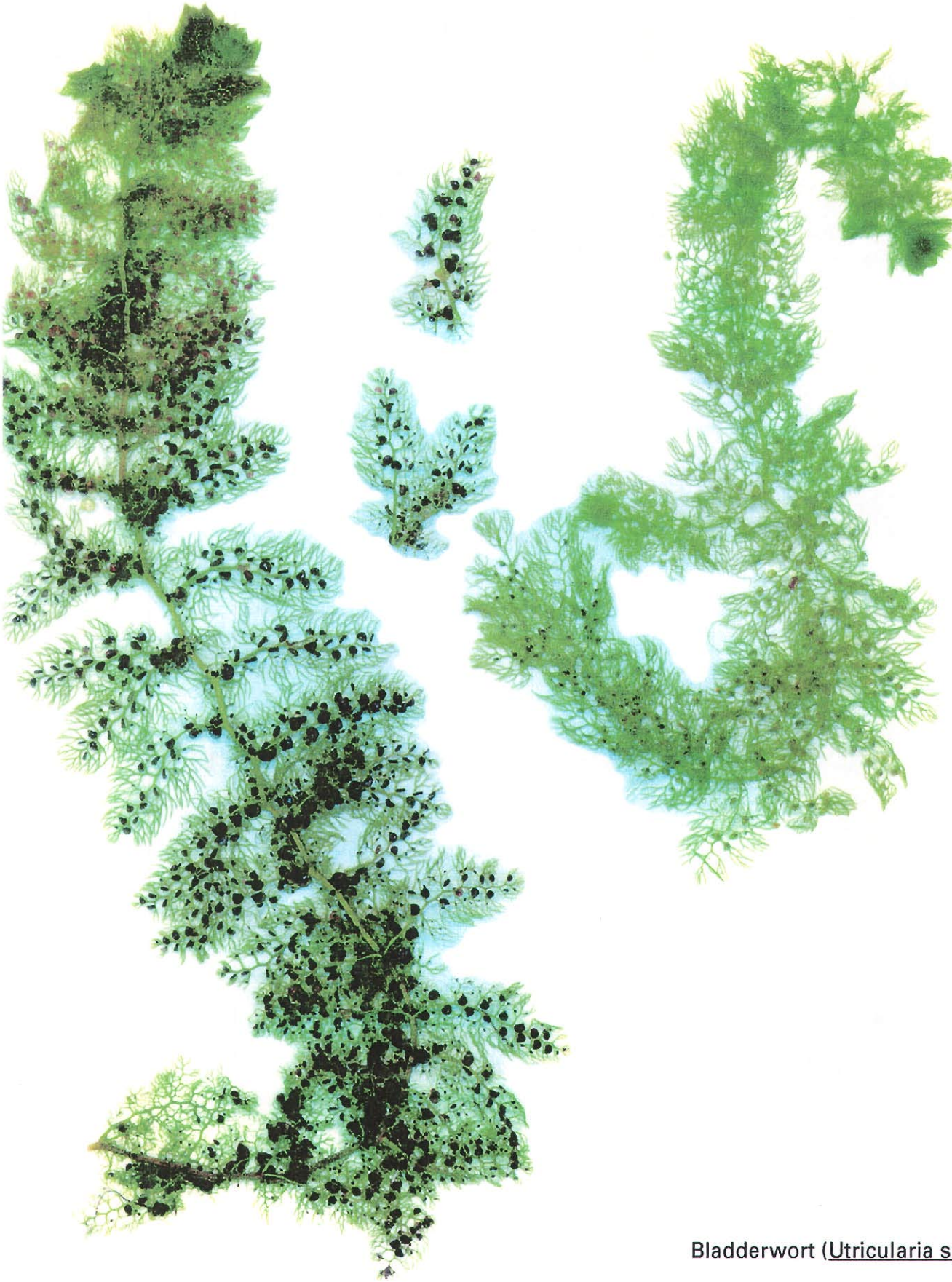
It is the intention of the Okauchee Lake Management District to undertake the lead in a periodic, formal review of the harvesting program as set forth in the Management Plan for Okauchee Lake, a copy of which has been lodged with the WDNR's Southeast Region office.

Daily Record-Keeping Relating to the Harvesters
Daily maintenance and service records showing engine hours, fuel consumed and oil used, will be recorded in a harvester operations log.

(This page intentionally left blank)

ILLUSTRATIONS OF COMMON AQUATIC PLANTS FOUND IN OKAUCHEE LAKE

(This page intentionally left blank)



Bladderwort (Utricularia sp.)

Bushy Pondweed (Najas flexilis)

Clasping-Leaf Pondweed
(Potamogeton richardsonii)

Coontail (Ceratophyllum demersum)

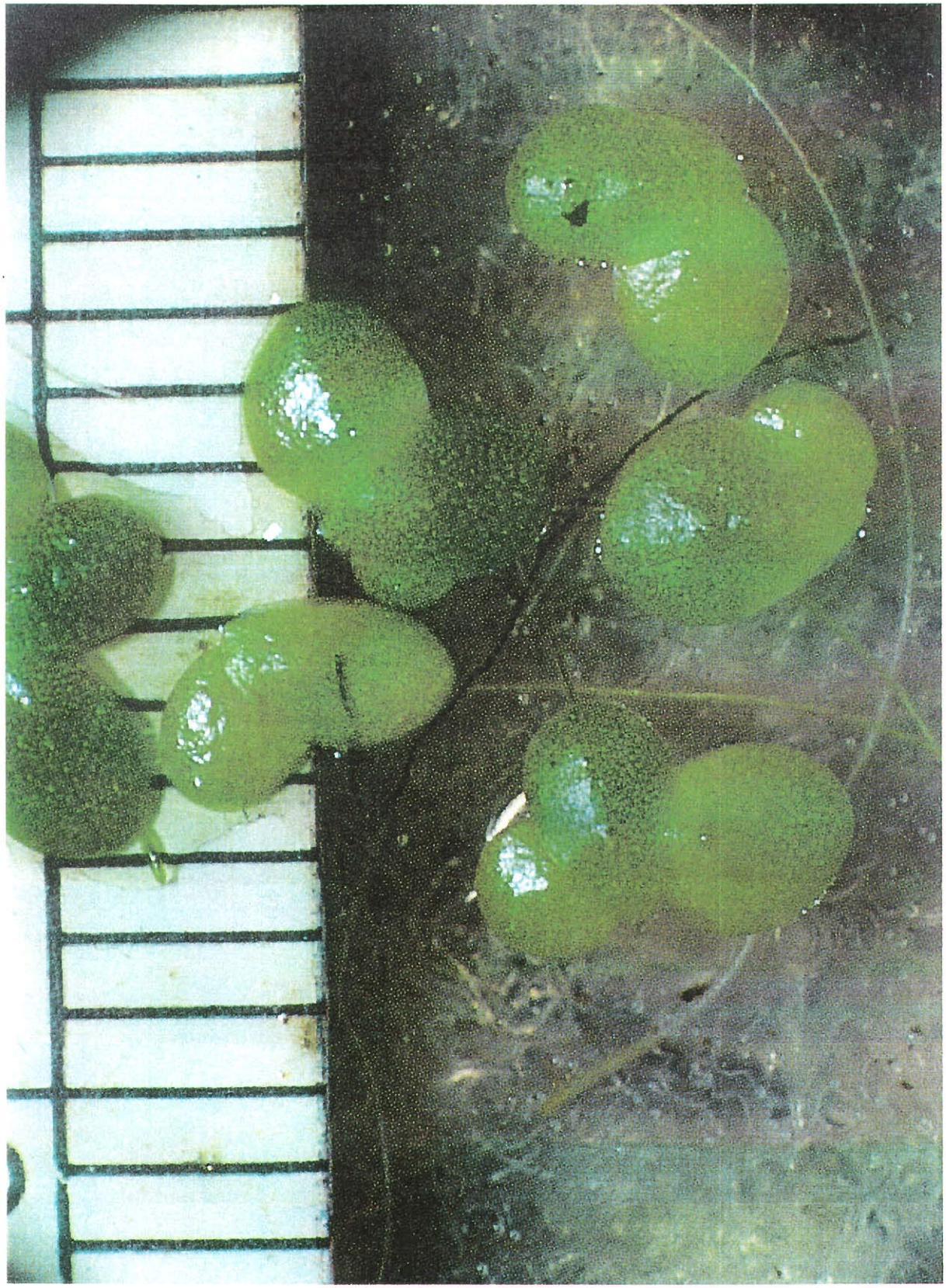
Curly-Leaf Pondweed (Potamogeton crispus)

Eurasian Water Milfoil (Myriophyllum spicatum)

Flat-stem Pondweed (Potamogeton zosteriformis)

Illinois Pondweed (Potamogeton illinoensis)

Large Leaf Pondweed (Potamogeton amplifolius)

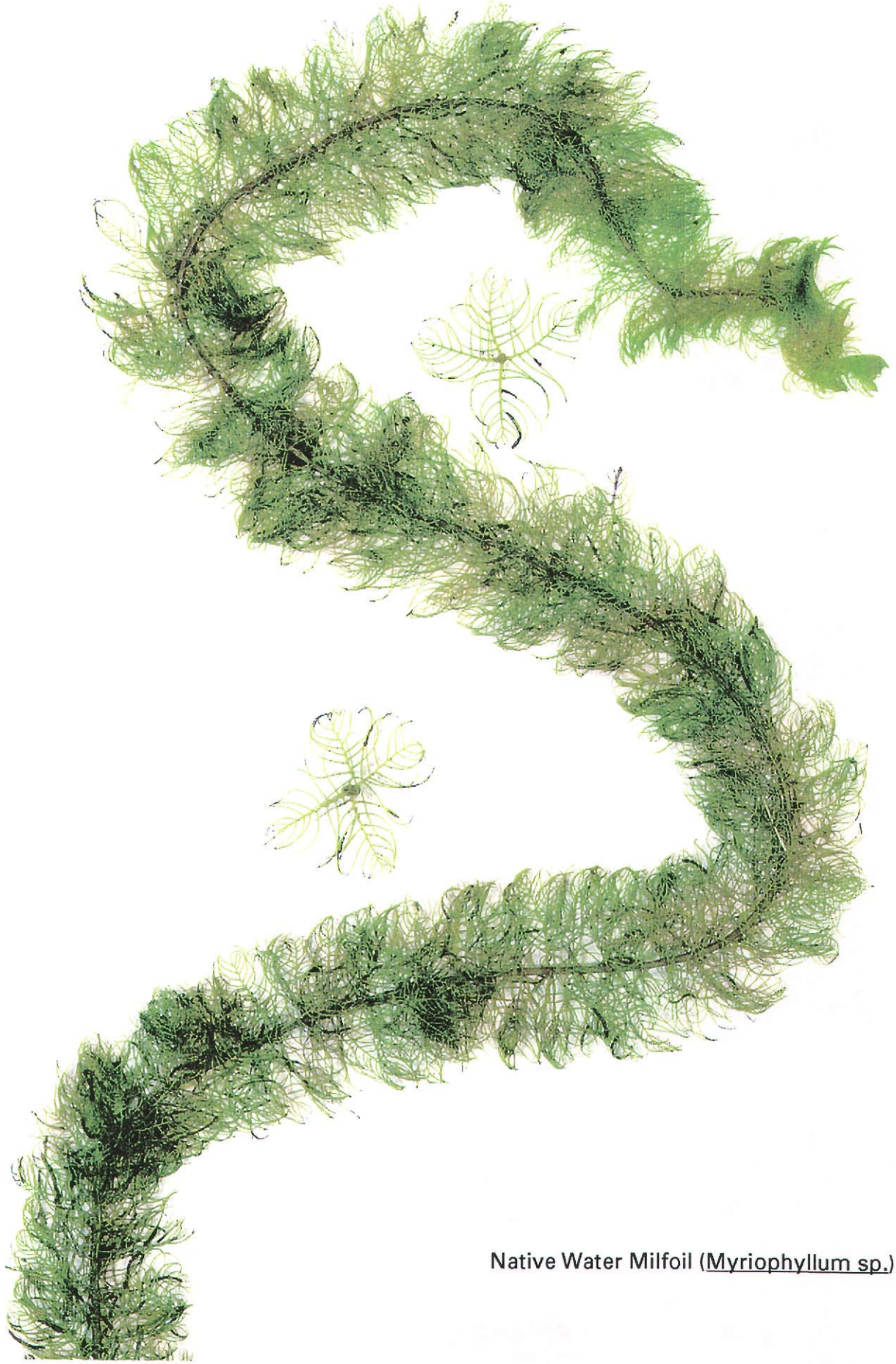


Lesser Duckweed (Lemna minor)

NOTE: Plant species in photograph are not shown proportionate to actual size

Source: Steve D. Eggers and Donald M. Reed, Wetland Plants and Plant Communities of Minnesota & Wisconsin, 2nd Edition, 1997

Muskgrass (Chara vulgaris)



Native Water Milfoil (Myriophyllum sp.)

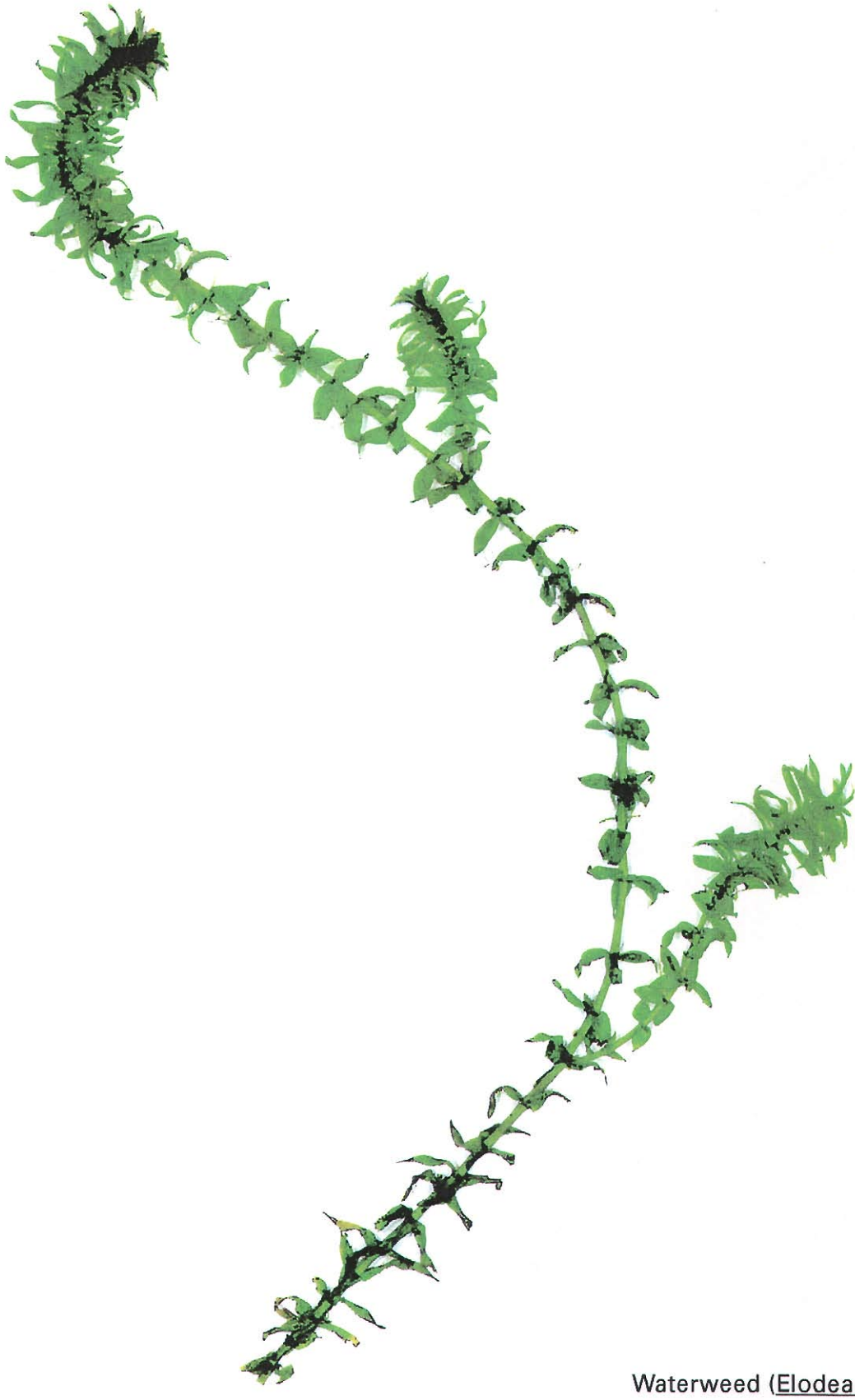
Nitella (Nitella spp.)

Sago Pondweed (Potamogeton pectinatus)

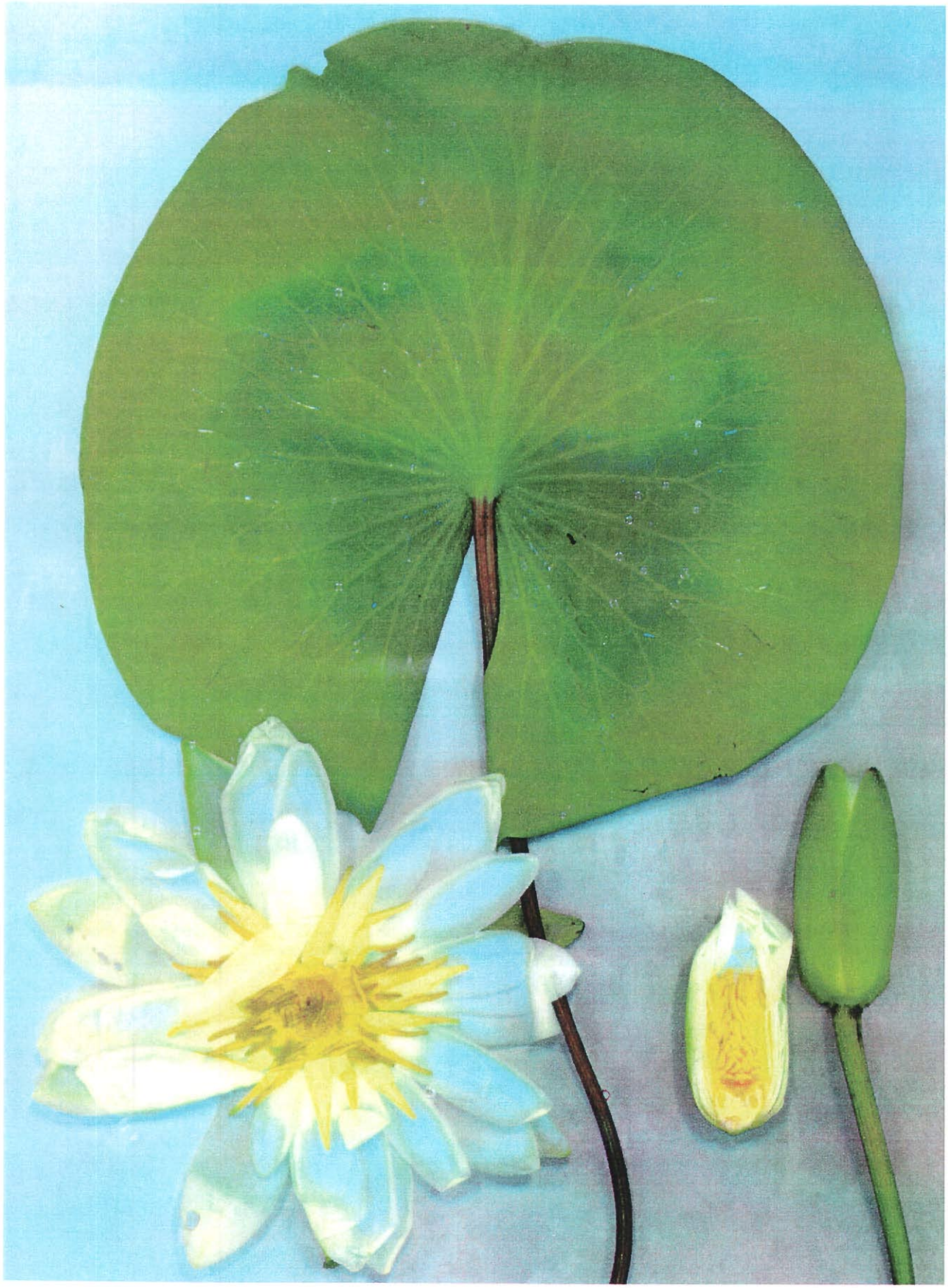
Spiny Naiad (Najas marina)

Variable Pondweed (Potamogeton gramineus)

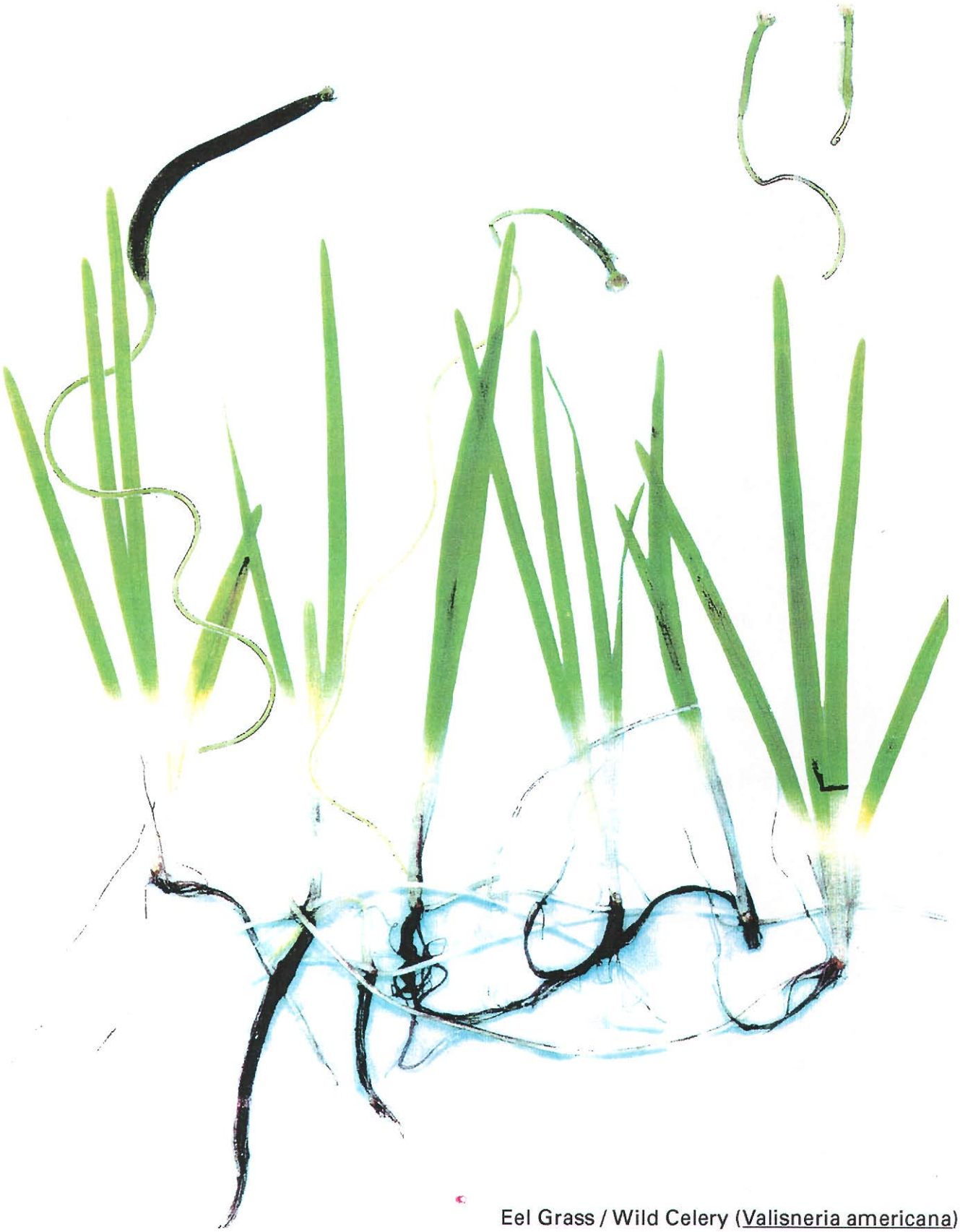
Water Stargrass (Zosterella dubia)



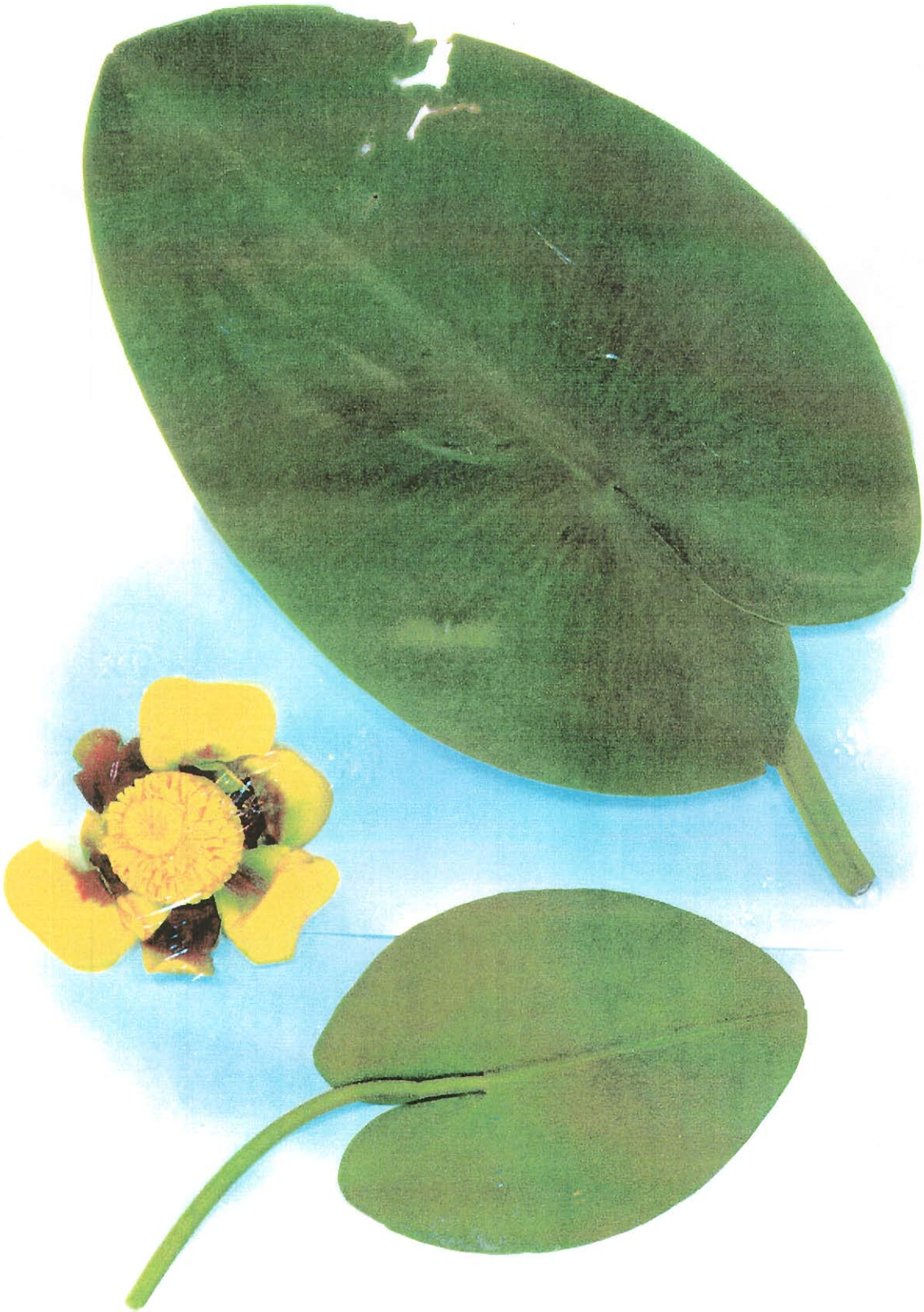
Waterweed (Elodea canadensis)



White Water Liliy (Nymphaea odorata)



Eel Grass / Wild Celery (Valisneria americana)



Yellow Water Lily (Nuphar variegatum)

(This page intentionally left blank)

Appendix B

RECREATIONAL USE ORDINANCE GOVERNING OKAUCHEE LAKE

(This page intentionally left blank)

20.01 OKAUCHEE LAKE, GARVIN LAKE, UPPER OCONOMOWOC LAKE, ASHIPPUN LAKE AND FLORENCE LAKE.

(1) INTENT. The intent of this section 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.

(2) APPLICABILITY AND ENFORCEMENT. (Am. 06/02/86) The provisions of this section are adopted in the interest of public health and safety and shall apply to persons, vehicles, boats and other objects upon, in and under the waters and ice of the Okauchee Lake and Garvin Lake within the jurisdictions of the Town of Oconomowoc and Merton, which are all such municipalities surrounding, riparian to and having jurisdiction over Okauchee Lake, and of Upper Oconomowoc Lake, Ashippun Lake and Florence Lake within the jurisdiction of the Town of Oconomowoc, which is the only municipality surrounding, riparian to and having jurisdiction over such lakes.

(3) STATE BOATING AND WATER SAFETY LAWS ADOPTED. (Rep. & recr. 01/06/98) The following statutory provisions describing and defining regulations with respect to water traffic, boats, boating and related water activities in the following enumerated sections of the statutes, exclusive of any provisions therein relating to the penalties to be imposed or the punishment for violation of such statutes, are hereby adopted and by reference made a part of this section as if fully set forth herein:

30.50	Definitions
30.501	Capacity plates on boats
30.505	Certificate of number system to conform to federal system
30.51	Certificate of number and registration; requirements; exemptions
30.52	Certificate of number and registration; application; certification and registration period; fees; issuance
30.523	Certification or registration card to be on board; display of stickers or decals and identification number
30.53	Certificate of origin; requirements; contents
30.531	Certificate of title; requirements; exemptions
30.533	Application for certificate of title; hull and engine identification numbers
30.537	Certificate of title; issuance, records, fees
30.539	Contents of certificate of title
30.54	Lost, stolen or mutilated certificates
30.541	Transfers of boat titles
30.543	Report of stolen or abandoned boats

30.544	Inspection of boats purchased out-of-state
30.547	Penalty
30.549	Transfer of ownership of boats with a certificate of title, certificate of number or registration
30.55	Notice of abandonment or destruction of boat or change of address
30.553	Sharing boat title records
30.60	Classification of motorboats
30.61	Lighting equipment
30.62	Other equipment
30.63	Sale and use of certain outboard motors restricted
30.635	Motorboat prohibition
30.64	Patrol boats
30.65	Traffic rules
30.66	Speed restrictions
30.67	Accidents and accident reports
30.675	Distress signal flag
30.68	Prohibited operation
30.681	Intoxicating boating
30.682	Preliminary breath screening test
30.683	Implied consent
30.684	Chemical tests
30.686	Report arrest to department
30.687	Officer's action after arrest for violating intoxicated boating law
30.69	Water skiing
30.70	Skin diving
30.71	Boats equipped with toilets

(4) DEFINITIONS.

DESIGNATED ANCHORAGE: An area of water established and marked as an anchorage by lawful authority.

HOUSEBOAT: A boat on which a toilet or food preparation facilities exist or on which persons are living, sleeping or camping.

PUBLIC ACCESS: Any access to the water by means of public property.

NAVIGATION LANE: An area designated by authorized aids to navigation.

SEALED OR INOPERATIVE TOILETS OR HEADS: Being plugged from the outside of the hull in such a manner that the plug cannot be removed from the inside of the boat.

SLOW-NO-WAKE: The slowest possible speed so as to maintain steerage.

SWIMMING ZONE: An authorized area marked by regulatory markers to designate a swimming area.

(5) SPEED RESTRICTIONS.

(a) General Limits.

1. No person shall operate a boat at a speed in excess of 10 mph from sunset each day until 8:00 a.m. the following morning.

2. No person shall operate a boat at a speed in excess of 40 mph on Okauchee Lake and Upper Oconomowoc Lake.

3. No person shall operate a boat a speed in excess of 30 miles per hour on Ashippun Lake. (Cr. #3-18-96)

(b) Special Limits.

1. No person shall, at any time operate a boat in excess of slow-no-wake in an area from a shore to shore line in Little Okauchee Lake, such line to be parallel to and 300' southwest of the Lake Drive bridge and extending eastward to the mouth of the channel (entrance to Big Okauchee Lake), Bay Five, Park Bay, Pickerel Bay, and in the channel between Little Okauchee and Upper Oconomowoc Lakes.

2. No person shall, at any time, operate a boat in excess of a slow-no-wake speed in the area north of an east-west line, such line being 100' south of the mouth of the Oconomowoc River in the northeast portion of Okauchee Lake.

3. No person shall, at any time, operate a boat in excess of a slow-no-wake speed in the mouth of the southwest bay of Upper Oconomowoc Lake. A slow-no-wake sign and buoy shall be placed in such location on the lake as to be observed by an ordinarily prudent person and at a specified distance north and south of the area to which this subparagraph applies. (Cr. 5/1/89)

4. No person shall, at any time, operate a boat in excess of a slow-no-wake speed in Martinique Bay on Okauchee Lake. A slow-no-wake sign and buoy shall be placed in such a location at the mouth of Martinique Bay as to be observed by an ordinarily prudent person. (Cr. #3-18-96)

5. No person may operate or use a motor boat or personal watercraft repeatedly in a circuitous course with a diameter of less than 200' at a speed in excess of slow-no-wake speed (Okauchee Lake, Upper Oconomowoc Lake, Florence Lake and Ashippun Lake). (Cr. #5-6-96)

6. No person may operate or use a motor boat or personal watercraft repeatedly in a circuitous course with a diameter of less than 200 feet at a speed in excess of slow-no-wake speed (Okauchee Lake and Upper Oconomowoc Lake). (Cr. #5-6-96)

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

(7) STATIONARY OBJECTS. (a) Reflectors Required. All piers, rafts, ski jumps or other stationary objects, extending into and/or located upon the waters covered by this section, shall have red reflector signals on each side thereof and in the case of piers, such reflectors shall be not less than 3' from the outer limits thereof and shall be at least 3" in diameter.

(b) Permits Required. No water ski jump shall be placed upon the waters covered by this section at any time unless a permit is obtained from the Water Safety Patrol. No raft or other stationary object shall be placed more than 100' from the shore unless a permit is obtained from the Water Safety Patrol.

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

(8) PROHIBITED OPERATION. (a) Intoxicated Person not to Ride in Boats. No person shall permit any person who is so intoxicated or under the influence of a controlled substance so as to be unable to provide for his own safety, to be a passenger in a boat operated by him, except in case of an emergency.

(b) Safe Operation Required. No person shall operate, direct or handle a boat in such manner as to unreasonably annoy, unnecessarily frighten or endanger the occupants of his or other boats.

(c) Noise Levels. 1. Maximum Noise Levels for Operation. a. No person may operate a motor boat powered by an engine manufactured before January 1, 1978, in such a manner as to exceed a noise level of 86 measured on an "A" weighted decibel scale measured at a distance of 50' from the motor boat.

b. No person may operate a motor boat powered by an engine manufactured on or after January 1, 1978, and before January 1, 1982, in such a manner as to exceed a noise level of 84 measured on an "A" weighted decibel scale measured at a distance of 50' from the motor boat.

c. No person may operate a motor boat powered by an engine manufactured on or after January 1, 1982, in such a manner as to exceed a noise level of 82 measured on an "A" weighted scale measured at a distance of 50' from the motor boat.

2. *Tampering*. No person may move or alter any part of a marine engine, its propellation unit or its enclosure or modify the mounting of a marine engine on a boat in such a manner as to exceed the noise levels prescribed under sub-par. 1. above.

3. *Exemption for Regattas*. This section does not apply to a motorboat while competing in a race conducted under a permit issued by the Town, nor does it apply to a boat designed and intended solely for racing, while the boat is operated incidentally to the tuning up of the boat and engine for the race.

(d) Motor Limitation on Ashippun Lake. (Cr. #3-18-96) No person may operate a motor boat powered by an internal combustion engine on Ashippun Lake in an area described as the "west end channel" which leads from Ashippun Lake to the Ashippun River. This prohibition shall extend from the mouth of the west end channel northwesterly to the Ashippun River. Electric motors only may be used in this restricted zone. A sign and buoy shall be placed in the mouth of said channel in such location and so marked as to be observed by an ordinarily prudent person.

(e) Upper Oconomowoc Lake Dam Restrictions. (Cr. #3-18-96) No person shall swim or fish from the Upper Oconomowoc Lake dam, which empties into the Oconomowoc River, nor may any person occupying a boat on Upper Oconomowoc Lake fish over the Upper Oconomowoc Lake dam into the waters of the Oconomowoc River.

(9) ADDITIONAL TRAFFIC RULES. In addition to the traffic rules in §30.65, Wis. Stats., adopted in sub. (3), the following rule shall apply to boats using the waters covered by this section:

(a) Right-of-Way at Docks, Piers and Wharves. Boats leaving or departing from pier, dock or wharf shall have the right-of-way over all other watercraft approaching such dock, pier or wharf.

(b) Right-of-Way of Sailboats. Boats propelled entirely by muscular power shall yield the right-of-way to sailboats when necessary to avoid risk of collision.

(10) SWIMMING REGULATIONS.

(a) From Boats. No person shall swim from any unmanned boat unless such boat is anchored.

(b) Distance from Shore. No person shall swim more than 150' from the shore unless in a designated swimming zone or when accompanied by a competent person in a boat.

(c) Hours Limited. No person shall swim more than 150' from the shore line between sunset and sunrise.

(11) LITTERING AND POLLUTING PROHIBITED.

(a) Refuse. No person shall deposit, place or throw any cans, paper, bottles, debris, refuse, garbage, solid or liquid waste, into the water of any lake covered by this section.

(b) Toilets and Heads. The toilet of any boat, the nautical term for which is "head", must be plugged from the outside of the hull in such manner that the plug cannot be removed from the inside of the boat.

(12) RACES, REGATTAS, SPORTING EVENTS AND EXHIBITIONS. (a) Permit Required. No person shall direct or participate in any boat race, regatta, water ski meet or other water sporting events or exhibition unless such event has been authorized and a permit issued therefor by the Water Safety Patrol.

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

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

(13) MARKERS AND NAVIGATION AIDS: POSTING ORDINANCE. (a) Navigation Aids. The Water Safety Patrol is authorized and directed to place and maintain suitable markers, navigation aids and signs in such water areas as shall be appropriate to advise the public of the provisions of this section and to post and maintain a copy of this section at all public access points on waters covered by this section.

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

(c) Interference with Markers Prohibited. No person shall without authority remove, damage or destroy or moor or attach any watercraft to any buoy, beacon or marker placed on the waters of any lake covered by this section, by the authority of the United States, State, County or Town or by any private person, pursuant to the provisions of this section.

(d) Marking Required for Restricted Areas. Any person operating a business, or any association, corporation, organization of lot owners or groups of persons who allow the public or members to swim from shore line under his or its control, shall mark the intended restricted area to be used for swimming. Marking shall be with appropriate "regulatory restricted activity area markers".

(14) NAVIGATION LANES. (Cr. 6/2/86) Pursuant to §30.74 (2), Wis. Stats., the following designated area is established as a navigation lane and mooring of boats is hereby prohibited in such area:

> An area in the channel between Steinmeyers Island and the east shore of Okauchee Lake, extending 480' north to south and 75' east to west located between lines extending from the northeast and southeast corner of such island due east to the east shore of Okauchee Lake.

(15) HOUSEBOATS. (Ren. MSC '87) No person shall use any houseboat as a place of residence on Okauchee Lake, Upper Oconomowoc Lake, Ashippun Lake or Florence Lake.

(16) DRIVING AUTOMOBILES OR OTHER MOTOR DRIVEN VEHICLES ON THE ICE; FISHERIES. (Ren. MSC '87) (a) Vehicles on Ice Prohibited. No person shall operate an automobile on the ice of Ashippun or Florence Lakes.

(b) Safe Operation. No person shall use or operate any automobile or other motor driven vehicle on ice in any manner so as to endanger persons engaged in skating or in any other winter sport or recreation activity upon the ice, or so as to endanger property belonging to others, and no person shall, while using or operating any automobile upon the ice, tow, pull or push any person on skates, sleds, skis, toboggan or device or thing of any kind designated or utilized to carry or support one or more persons.

(c) Speed. No person shall use or operate any automobile on the ice at a speed in excess of 10 mph.

(d) Hours. 1. No person shall use or operate any automobile on the ice between 9:30 p.m. and 6 a.m.

2. No person shall use or operate any other motor driven vehicle on the ice between 1:30 a.m. and 6 a.m.

(e) Races, Time Trials, Sporting Events, Exhibitions and Fisheries. 1. Permit Required. No person shall sponsor, direct or participate in any race, time trial, sporting event, exhibition or fisherie upon the ice, unless such event has been authorized and a permit issued therefor by the Town Board.

2. Permit. A permit issued under this section shall specify the course or area of ice to be used by participants in such event and the permittee shall be required to place markers or flags approved by the Town Board, designating the specified area. The Town Board shall refer all such applications to the Police Department for investigation, report and recommendation, and the permits shall be issued only if, in the opinion of the Police Department, the proposed use of the ice can be carried on safely without danger to or substantial obstruction to other persons using the ice. Permits shall be valid only for the hours and area specified thereon.

3. Right-of-Way of Participants. Participants in any such permitted events shall have the right-of-way on the marked area and no other person shall obstruct such area during the event or interfere with the participants.

4. Cleanup. The permittee shall be required to remove all debris from the designated area immediately following the termination of the event. The Town Board may require a bond so as to insure satisfactory cleanup.

5. Police. The permittee shall be required to provide adequate and proper policing during the event, including control of vehicular parking.

(f) Definitions. The word automobile, as used in this section, shall be construed to mean all motor vehicles of the type and kind permitted to be operated on the highways in the State. Motor driven vehicle, as used in this section, shall be construed to mean any kind of device or thing designed or utilized for propulsion or movement upon the ice using a motor, whether of internal combustion design or not, including snowmobiles.

(g) Risk and Liability. All traffic on the icebound waters of the lakes to which this section applies, shall be at the risk of the traveller as set forth in §30.81(3), Wis. Stats., and nothing in this section shall be construed as rendering the enacting authority liable for any accident to those engaged in permitted traffic while this section is in effect.

(h) No person shall operate a motor boat towing a person on water skis, aquaplane or similar device, including any form of "tubing," on Ashippun Lake nor shall any person engage in water skiing, aquaplaning or similar activity, including any form of "tubing," on Ashippun Lake in other than a counter-clockwise direction. (Cr. #3-18-96)

(17) WATER SKIING. (Ren. MSC '87) In addition to the rules contained in §30.69, Wis. Stats., the following rules shall control water skiing on the waters covered by this section.

(a) No person shall operate a motor boat and tow any person upon water skis or other similar device in the following designated area of Okauchee Lake: an area from a shore-to-shore line in Little Okauchee Lake, such line to be parallel to and 300' southwest of the Lake Dr. bridge extending eastward under the bridge and eastward to the mouth of the channel (entrance to Big Okauchee Lake), Bay Five, Park Bay, Pickerel Bay and Tierney Bay. (Am. 5/18/87)

(b) No person shall operate a motor boat towing a person on water skis, aquaplane or similar device, nor shall any person engage in water skiing, aquaplaning or similar activity, at any time from sunset to 8 a.m. the following morning.

(c) Garvin Lake is less than 50 acres in size and comes under the limitations of §30.635, Wis. Stats. Water skiing is prohibited on Garvin Lake. (Cr. 6/2/86)

20.02 WATER TRAFFIC, BOATS, BOATING AND RELATED WATER ACTIVITIES ON LAC LA BELLE.

(1) APPLICABILITY AND ENFORCEMENT.

(a) Applicability. The provisions of this section are adopted in the interest of public health and safety and shall apply to persons, vehicles, boats and other objects upon, in and under the waters and ice of Lac La Belle within the jurisdictions of the City, Village and Town above-named, which are all such municipalities surrounding, riparian to and having jurisdiction over such lake.

(b) Enforcement. This section shall be enforced by the officers, employees and agents of the respective law enforcement agencies of any or all of the municipalities having jurisdiction over such lake.

(2) STATE BOATING AND WATER SAFETY LAWS, ORDERS AND RULES ADOPTED.

(a) State Statutes Adopted. Section 20.01(3) of this chapter shall apply to this section.

(b) Administrative Code Provisions Adopted. All rules and orders created by the Wisconsin Department of Natural Resources designated NR, Wis. Adm. Code, modifying or supplementing the provisions adopted in par. (a) above or which may be adopted or made in the future are hereby incorporated in and made a part of this section by reference to the same as if they are or were to be set out herein verbatim.

(3) SPEED LIMITS.

(a) Generally. (Cr. 06/1/92) Speed of motorboats on Lac LaBelle shall not exceed 10 mph between sunset one day and sunrise the following day.

(b) Special Limits. (Cr. 05/7/90) No person shall at any time operate a boat in excess of slow-no-wake in an area from a shore to shore line in Lac LaBelle, such line to be parallel to and approximately 1,000' north of the City beach, extending east and west from a point on the shore of property located at 326 N. Lake Rd. to a point on the shore of property located at 259 Woodland Ln. The area in which this special speed limit shall apply lies between the aforementioned line and the south shore of Lac LaBelle and shall include the entire width of the bay as well as the channel circling the island located at the southwest corner of such bay.

(4) EMERGENCY SLOW NO WAKE SPEED AT TIMES OF HIGH WATER. (Cr. #5/7/01)

(a) Definitions.

1. *High water* means when the waters of Lac LaBelle exceed an elevation of 852.20 feet as based upon the USGS benchmark or 3.27 feet measured at the fourth bay from West Wisconsin Avenue down from the top of the existing concrete abutment of the Lac LaBelle Dam (outlet of Lac LaBelle) and/or when the Mayor of the City, Town Chairman of the Town of Oconomowoc, or Village President of the Village of Lac LaBelle determines conditions warrant declaring that an emergency exists requiring reduced boat speed. When the high water elevation has been reached, either the Mayor, Town Chairman or Village President may make the high water declaration.
2. *Slow no wake* has the meaning specified in §30.50(12), Wis. Stats.
3. *Motor boat* has the meaning specified in §30.50(6), Wis. Stats.

(b) Slow No Wake Speed Required. No person shall operate a motor boat at a speed in excess of slow no wake on Lac LaBelle for a period commencing 2 hours after a high water condition has been declared until the declaration of a high water condition is repealed.

(c) Notice. Notice of a high water condition shall be posted at the public launch site and by publication of a notice in both the Oconomowoc Enterprise and Focus and by public service announcements on radio and television. Posted notice shall state the time of the declaration of a high water condition.

20.025 MARY LANE COURT ACCESS RULES. (Cr. #8-17-98)

(1) DEFINED. The Mary Lane Court access area is defined as the Mary Lane Court road end, extending from the end of the asphalt pavement to the shore of Lac LaBelle.

(2) REGULATIONS. The following regulations are hereby imposed on the use of the Mary Lane Court/Lac LaBelle access area. No person shall make use of the Mary Lane Court access to Lac LaBelle in violation of the following rules and regulations.

(a) Hours. The Mary Lane Court access to Lac LaBelle shall be closed between the hours of 8:00 p.m. and 8:00 a.m.

(b) Launching of Watercraft. No person shall launch or cause to be launched any motorboat from the Mary Lane Court access. Nonmotorized boats may be launched from the Mary Lane Court access. "Motorboat" and "nonmotorized boat" shall have the meanings set forth in §30.50(6) and (7), Wis. Stats. The definition of motorboat includes "personal watercraft" as defined in §30.50(9d).

(c) No person shall take upon the Mary Lane Court access point any glass receptacle or any glass object.

(d) Barbecue grills are not allowed in the Mary Lane Court access area.

(e) Littering. No person shall throw upon the Mary Lane Court access area any waste or refuse, nor shall any person leave upon such area any food, food scraps, paper, container, carton, towels or any other article or object of any kind.

(f) Supervision. No person shall allow a child of an age of five years or less to use the Mary Lane Court access area unless accompanied by a parent or adult over the age of 16 years.

(g) Vehicles Prohibited. No person shall operate or park any vehicle beyond the terminus of the asphalt pavement of Mary Lane Court. "Vehicle" has the meaning given in §340.01(74), Wis. Stats. A snowmobile is not considered a vehicle. Snowmobiles and all-terrain vehicles may use the Mary Lane Court access point as an access to Lac LaBelle. All-terrain vehicles are given the meaning set forth in §340.01(2g), Wis. Stats.

(h) Pets. No person shall cause or permit any pet to run loose on the Mary Lane Court access area.

20.026 JAECKLES BOULEVARD ACCESS RULES. (Cr. #07/08/99)

(1) DEFINED. The Jaeckles Boulevard access area is defined as Jaeckles Boulevard extending from the Town of Summit boundary to the shore of Okauchee Lake, bounded on the west by Lot 1, Schimmel's Subdivision, and bounded on the east by Lot 21, Schimmel's Subdivision.

(2) REGULATIONS. The following regulations are hereby imposed on the use of the Jaeckles Boulevard access area: no person shall make use of the Jaeckles Boulevard access to Okauchee Lake in violation of the following rules and regulations.

(a) Hours. The Jaeckles Boulevard access to Okauchee Lake shall be closed between the hours of 9:00 p.m. and 8:00 a.m.

(b) Launching of Watercraft. No person shall launch or cause to be launched any motorboat from the Jaeckles Boulevard access. No person shall land and remove any motorboat from Okauchee Lake onto the Jaeckles Boulevard access. Nonmotorized boats may be launched from the Jaeckles Boulevard access. "Motorboat" and "nonmotorized boat" shall have the meanings set forth in §30.50(6) and (7), Wis. Stats. The definition of "motorboat" includes "personal watercraft" as defined in §30.50(9d).

(c) Glass Prohibited. No person shall take upon the Jaeckles Boulevard access area any glass receptacle or any glass object.

(d) Barbecue Grills Prohibited. Barbecue grills are not allowed in the Jaeckles Boulevard access area.

(e) Littering. No person shall throw upon the Jaeckles Boulevard access area any waste or refuse, nor shall any person leave upon such area any food, food scraps, paper, container, carton, towels or any other article or object of any kind.

(f) Supervision. No person shall allow a child of the age of five years or less to use the Jaeckles Boulevard access area unless accompanied by a parent or adult over the age of 16 years.

(g) Vehicles Prohibited. No person shall operate or park any vehicle on the access area north of the north line of Jaeckles Drive. "Vehicle" has the meaning given in §340.01(74), Wis. Stats. A snowmobile is not considered a vehicle. Snowmobiles and all-terrain vehicles may use the Jaeckles Boulevard access point as an access to Okauchee Lake. "All-terrain vehicles" are given the meaning in §340.01(2g), Wis. Stats.

(h) Pets. No person shall cause or permit any pet to run loose on the Jaeckles Boulevard access area.

20.03 SWIMMING AND DIVING FROM LAKE DRIVE BRIDGE AND UPPER OCONOMOWOC LAKE DAM AND DEFACING PUBLIC PROPERTY PROHIBITED.

(1) No person shall swim or dive from the Lake Drive Bridge or the Upper Oconomowoc Lake Dam or mark, deface, injure or tamper with such bridge or dam, or appurtenances thereof, or signs, notices or placards placed thereon or adjacent thereto by the Town authorities.

(2) No person, other than authorized Town personnel, shall go upon the Upper Oconomowoc Lake Dam for any purpose.

20.05 PENALTY.

Except as otherwise provided, any person found to be in violation of any provision of this chapter or any rule or order promulgated hereunder shall be subject to a penalty as provided in §25.04 of this Code.

(This page intentionally left blank)

Appendix C

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 C-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 control 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 C-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 chapter.[1] These various individual nonpoint source control practices are summarized by group in Table C-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 C-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 C-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 C-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 C-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
	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 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.

Table C-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 conversation 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.

Of the sets of practices recommended for various levels of diffuse source pollution control presented in Table C-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.