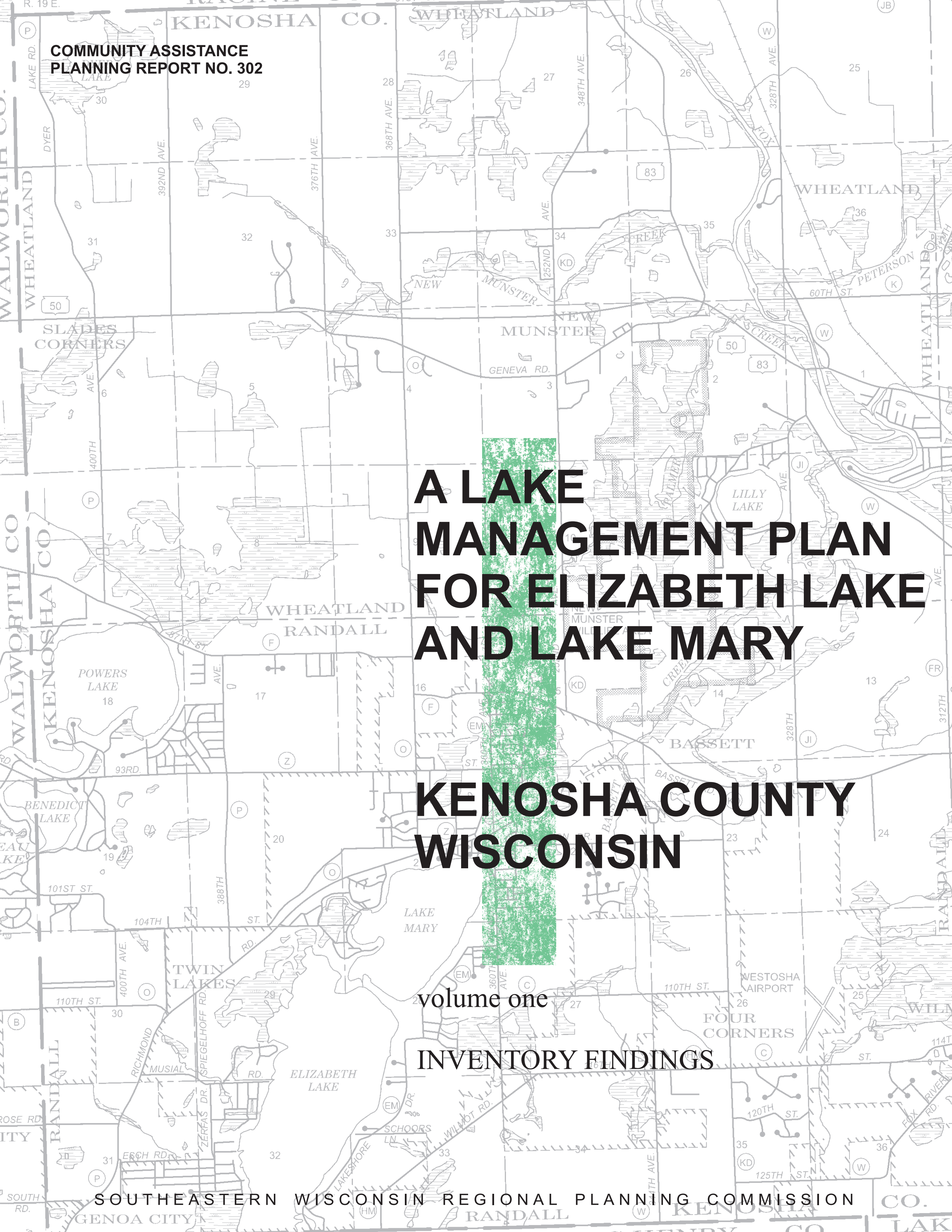
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 302

A LAKE MANAGEMENT PLAN FOR ELIZABETH LAKE AND LAKE MARY

KENOSHA COUNTY WISCONSIN

volume one

INVENTORY FINDINGS



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due to Dr. Jeffrey A. Thornton, CLM, PH, and Dr. Thomas M. Slawski, SEWRPC Principal Planners; Ms. Sara W. Teske, SEWRPC Planner; Mr. Edward J. Schmidt, SEWRPC GIS Planning Specialist; and Mr. Michael A. Borst, SEWRPC Research Aide, for their contributions to the conduct of this study and the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 302

A LAKE MANAGEMENT PLAN FOR ELIZABETH LAKE AND LAKE MARY

KENOSHA COUNTY, WISCONSIN

Volume One

INVENTORY FINDINGS

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.

July 2009

$20.00

This Page Intentionally Left Blank

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

Map | Page

This Page Intentionally Left Blank

Chapter I

INTRODUCTION

The "Twin Lakes" are comprised of two connected waterbodies, Lake Mary[1] and Elizabeth Lake, both located within the civil division limits of the Village of Twin Lakes in Kenosha County. Lake Mary is a 297-acre drained lake, situated within U.S. Public Land Survey Sections 20, 21, and 28, Township 1 North, Range 19 East, which is connected by a narrow waterway to Elizabeth Lake, a 638-acre through-flow lake, situated within U.S. Public Land Survey Sections 28, 29, 32, and 33, Township 1 North, Range 19 East, both in Kenosha County. The southern extreme of Elizabeth Lake and a portion of the Lake's tributary area extend southward into McHenry County, Illinois. The Lakes form a short chain of lakes ultimately draining to the Nippersink Creek, and the Fox River in Illinois. The Lakes, while exhibiting distinctly contrasting hydrographical and shoreland characteristics, both offer a variety of water-based recreational opportunities and are the focus of the lake-oriented community surrounding the Lakes.

For many years, the Lakes have experienced various management problems, including excessive aquatic plant growth, recreational user conflicts, water quality-related use limitations, invasive species concerns, and public concerns over the aesthetic degradation. In response to these concerns, the Twin Lakes have been the subject of various reports issued by the Wisconsin Department of Natural Resources (WDNR)[2,3] and the private sector.[4,5] Proper management of the 7,524-acre total area tributary to the Twin Lakes will be required in order to maintain the Lakes as valuable recreational resources to the residents of the County and of the Region of which the County is an integral part.

---

[1]*Lake Mary has been known variously as Lake Mary, North Twin Lake, and Marie Lake; as of August 27, 1980, the Wisconsin Geographic Names Council formally affirmed the official name of the Lake as Lake Mary, rescinding a previous action taken in 1963 that caused the Lake name to be officially stated as Marie Lake in conformance with usage by the U.S. Geological Survey.*

[2]*Wisconsin Department of Natural Resources Lake Use Report No. FX-17,* Marie *[sic]* Lake, Kenosha County, Wisconsin, *1970. See also Wisconsin Department of Natural Resources Lake Use Report No. FX-7,* Elizabeth Lake, Kenosha County, Wisconsin, *1969.*

[3]*Wisconsin Department of Natural Resources, Office of Inland Lake Renewal,* Twin Lakes, Mary and Elizabeth, Feasibility Study Results; Management Alternatives, *1980.*

[4]*Discovery Group, Ltd., Madison, Wisconsin and Blue Water Science, St. Paul, Minnesota,* Lake Management Plan, Twin Lakes Protective and Rehabilitation District, Twin Lakes, Wisconsin, *Revised, February 18, 1993.*

[5]*Aron and Associates,* Twin Lakes Aquatic Plant Management Plan, Reassessment, *2005*.

In late-2004, the Village of Twin Lakes contracted with the Southeastern Wisconsin Regional Planning Commission (SEWRPC) to conduct planning studies leading to the preparation of a lake management plan for the Twin Lakes. This plan represents part of the ongoing commitment of the Village of Twin Lakes to sound planning with respect to the Lakes and forms a logical complement to the lake management actions that have been implemented on and around the Twin Lakes. The current plan was prepared by the Regional Planning Commission in cooperation with the Village of Twin Lakes and Twin Lake Protection and Rehabilitation District, and it incorporates the data and analyses developed in the aforementioned lake management-related studies, as well as pertinent water quality and other data gathered by the U.S. Geologic Survey (USGS), the WDNR, volunteers, and private consultants working under contract to the Village and/or Twin Lakes Management District.

This plan presents feasible alternative in-lake measures for enhancing the water quality conditions and for providing opportunities for the safe and enjoyable use of the Lakes. More specifically, this report describes the physical, chemical, and biological characteristics of the Lakes and pertinent related characteristics of the tributary area, as well as the feasibility of various tributary area and in-lake management measures which may be applied to enhance the water quality conditions, biological communities, and recreational opportunities of the Lakes. In addition, the plan addresses alternative approaches to managing water levels within the Lakes, and sets forth measures to ensure, insofar as possible, the regulation of water levels within the Lakes is undertaken in a manner consistent with a published operating protocol to be implemented by the Village of Twin Lakes.

The primary management objectives for the Twin Lakes include: 1) providing water quality suitable for the maintenance of fish and other aquatic life, 2) reducing the severity of existing nuisance problems resulting from excessive macrophyte and algae growth and invasive species which constrain or preclude intended water uses, and 3) improving opportunities for water based recreational activities. The lake management plan herein presented should constitute a practical guide for the management of the water quality of Lake Mary and Elizabeth Lake, and for the management of the land surfaces which drain directly to these important bodies of water. This plan conforms to the requirements of and standards set forth in the relevant *Wisconsin Administrative Codes.*[6]

The plan is presented in two volumes. Volume One sets forth the inventory data used as the basis for reviewing the alternative lake management measures and developing the recommended management measures set forth in Volume Two. Volume One, the inventory data, includes an overview of the Lakes and their tributary areas, a review of the governance structures currently in place surrounding the Lakes, a summary of their water quality, a summary of their biology, and a review of the water use objectives established for the Twin Lakes. Volume Two, the alternative and recommended plans, sets forth alternative lake and tributary area management measures considered for application to the management of the Twin Lakes, and identifies a subset of these measures recommended for use to address current and forecast future lake management issues relevant to Lake Mary and Elizabeth Lake.

---

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

Chapter II

PHYSICAL DESCRIPTION

INTRODUCTION

The physical characteristics of a lake and its tributary area are important factors in any evaluation of existing and likely future water quality conditions and lake uses, including recreational uses. Characteristics, such as tributary area topography, lake morphometry, and local hydrology, ultimately influence water quality conditions and the composition of plant and fish communities within a lake. Therefore, these characteristics must be considered during the lake management planning process as the basis for formulating interventions necessary to achieve the lake management planning goals.

The "Twin Lakes" are comprised of two discrete waterbodies; namely, the upstream Lake Mary, which drains through a short section of unnamed waterway into Elizabeth Lake. Elizabeth Lake, in turn, discharges to the Elizabeth Lake Drain, which flows into the North Branch of the Nippersink Creek. Outflow from Elizabeth Lake, and under most conditions from Lake Mary, is controlled by a spillway in a dam located in McHenry County, Illinois.[1] The North Branch of the Nippersink Creek is a tributary to the Illinois Fox River.

This chapter provides pertinent information on the tributary areas of each of the Twin Lakes, their physical characteristics, and the climate and hydrology of the Twin Lakes area. Subsequent chapters deal with the land use conditions, and the chemical and biological environments of the Lakes.

TRIBUTARY AREA CHARACTERISTICS

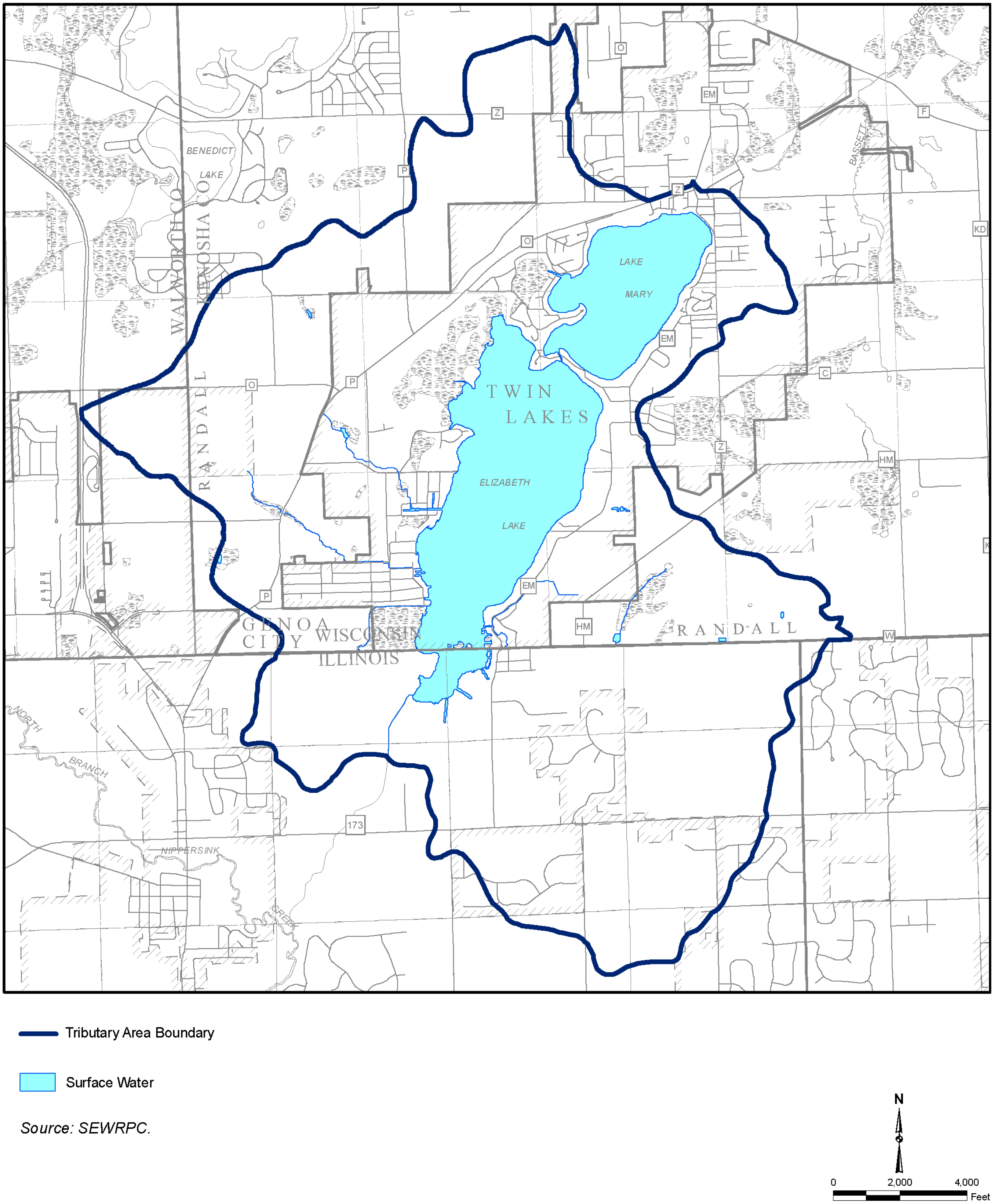
The total area tributary to the Twin Lakes—that is, the land area which drains either directly or indirectly into the Lakes—totals about 7,524 acres, or 11.75 square miles, in areal extent, as shown on Map 1 and summarized in Table 1. The area tributary to the upstream Lake Mary is about 1,450 acres, or about 2.25 square miles, in areal extent, with the balance of the drainage area being tributary to Elizabeth Lake. The size of a lake's tributary area compared to the size of the lake can have a significant impact on the flow and amount of nutrients in a lake. As the ratio of tributary area to lake surface area increases, so does the role of that tributary area in increasingly influencing the flow of nutrients into the lake. Lakes with large tributary areas and high tributary area to lake surface area ratios generally have significant surface water inflows.

---

[1]*There is a small, low weir in the channel at the outlet of Lake Mary which determines the elevation of Lake Mary during low flow conditions, and creating a slight difference, of less than one foot, in water surface elevation between Lake Mary and the downstream Elizabeth Lake.*

Map 1

LOCATION OF LAKE MARY AND ELIZABETH LAKE



Tributary Area Boundary

Surface Water

Source: SEWRPC.

Table 1

HYDROLOGY AND MORPHOMETRY CHARACTERISTICS OF THE TWIN LAKES

Parameter	Lake Mary Measurements	Elizabeth Lake Measurements
Size (total)		
Surface Area	315 acres	638 acres
Total Tributary Area	1,143 acres	7,524 acres
Volume	1,957 acre-feet	6,900 acre-feet
Residence Time[a]	1.92 years	1.85 years
Shape		
Maximum Length of Lake	1.1 miles	1.9 miles
Maximum Width	0.6 miles	0.8 miles
Length of Shoreline	3.5 miles	5.4 miles
Shoreline Development Factor[b]	1.41	1.55
Depth		
Area of Lake Less than Three Feet	17.9 percent	15.0 percent
Area of Lake Greater than 20 Feet	12.2 percent	21.0 percent
Mean Depth	9 feet	11 feet
Maximum Depth	33 feet	32 feet

[a]*Residence Time: Time required for a volume equivalent to the full volume of the lake to enter the lake from the tributary area during a year of normal precipitation.*

[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.

Lake Mary has a relatively small tributary area to lake surface area ratio, of about 4.5:1; the ratio for Elizabeth Lake is larger, but also relatively small at about 8.5:1.[2] These tributary area to lake surface area ratios are lower than those of, for example, Fowler Lake, with a ratio of 448:1,[3] or Okauchee Lake, with a ratio of 35:1,[4] that lie along the Oconomowoc River in Waukesha County. The smaller tributary area to lake surface area ratios for the Twin Lakes would suggest that these lakes are less likely to be subject to the influence of nutrient inputs from their tributary areas than either Fowler Lake or Okauchee Lake. However, in contrast, these ratios imply that the Twin Lakes are likely to be more sensitive to perturbations within their immediate vicinity that either Fowler Lake or Okauchee Lake.

Lake Mary is a drained lake with a single outlet that connects it to Elizabeth Lake. Elizabeth Lake is a through-flow lake, having both a defined inflow, from Lake Mary, and outflow, to the Elizabeth Lake Drain. Inflow to Elizabeth Lake enters at the north end of the Lake, and outflow from the Lake exits at the south end where the Lake drains to the Elizabeth Lake Drain and thence to the North Branch of Nippersink Creek, and eventually to the Fox River, in Illinois.

---

[2]*Discovery Group, Ltd., Madison, Wisconsin and Blue Water Science, St. Paul, Minnesota,* Lake Management Plan, Twin Lakes Protective and Rehabilitation District, Twin Lakes, Wisconsin, *Revised, February 18, 1993.*

[3]*SEWRPC Community Assistance Planning Report No. 187,* A Management Plan for Fowler Lake, *March 1994*

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

Soil Types and Conditions

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

Soil Type

The U.S. Natural Resources Conservation Service (NRCS), formerly the U.S. Soil Conservation Service, under contract to SEWRPC, completed a detailed soil survey of the Twin Lakes area in 1966.[5] The major soil associations within the Twin Lakes tributary area are:

- The Miami association soils, comprising the eastern portion of the tributary area, including the east shorelands of both lakes. The Miami association soils are well-drained soils comprised of a silty clay loam and clay loam subsoil. These soils are commonly found on rolling hills, drumlins, and ridges in the western part of Kenosha County; are usually sloping or gently sloping; are well-suited for farming with the more sloping areas often used for pasture or woodland; and, generally have only slight or moderate limitations that affect their use as homesites. The native vegetation of these soils was hardwood forest.

- The Casco-Rodman association soils, comprising the northwestern portion of the tributary area of the Twin Lakes, including the western shoreland areas of Lake Mary and the northwestern corner of the shoreland areas of Elizabeth Lake. The Casco-Rodman association soils are well-drained and excessively drained soils comprised of a clay loam or gravelly loam subsoil. As a good source of sand and gravel, the Casco-Rodman soils are not well-suited for cropland and are better suited to recreation, woodlands, and wildlife. These soils formed under hardwood forest and are usually found on terraces, morainic ridges, and kettleholes west of the Fox River.

- The Fox-Casco association soils, found in the remaining portions of the tributary area west of Elizabeth Lake, including the western shorelands of Elizabeth Lake. The Fox-Casco association soils are mostly well-drained soils that are comprised of a clay loam and silty clay loam subsoil. These soils underlie mostly level to rolling areas often on high terraces and hills. These soils are a good source of sand and gravel, but are also highly suitable for farming. The more steeply sloped areas can be used for pasture, woodlands, and wildlife habitat and the areas with slopes of less than 6 percent are well-suited as building sites. The native vegetation found on the Casco and Fox soils was deciduous forests mainly comprised of hardwoods, such as oaks and hickories.

Hydrologic Soil Characteristics

Using the regional soil survey, an assessment was made of the hydrologic characteristics of the soils in the tributary area of the Twin Lakes and soils were categorized generally into four principal hydrologic groups, as indicated in Table 2. Less than 1 percent of the total land area tributary to the Twin Lakes is covered by well-drained soils; moderately well drained soils cover about 76 percent of the total tributary area; poorly drained soils; and very poorly drained soils each cover about 14 percent of the total tributary area. About 15 percent of the tributary area is covered by water, and the remainder of the tributary area is covered by disturbed soils whose classification cannot be determined. The areal extent of these soils and their locations within the total tributary area are shown on Map 2.

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

Table 2

GENERAL HYDROLOGIC SOIL TYPES WITHIN THE TOTAL AREA TRIBUTARY TO THE TWIN LAKES

Group	Soil Characteristics	Total Tributary Area (acres)	Percent of Tributary Land Area[a]
A	Well drained; very rapidly to rapid permeability; low shrink-swell potential	14	<1
B	Moderately well drained; texture intermediate between coarse and fine; moderately rapid to moderate permeability; low to moderate shrink-swell potential	5,396	84
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	263	4
D	Very poorly drained; high water table for most of the year; organic or clay soils; clay soils having high shrink-swell potential	760	12
Water	- -	1,091	- -
Total		7,524	100

[a]*Excludes water.*

Source: U.S. Geological Survey and SEWRPC.

In addition to the identification and delineation of soil types, the soil survey contained interpretations for planning and engineering applications, as well as for agricultural applications. The suitability of the soils for urban residential development was assessed using different common development scenarios. The interpretations associated with the soil survey, as they related to the then existing requirements for onsite sewage disposal systems,[6] are such that they 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. Therefore, as an index of the likelihood of contaminants entering Lake Mary and Elizabeth Lake, the soil ratings for onsite sewage disposal system suitability within the total area tributary to the Twin Lakes, as determined pursuant to the then-existing requirements of Chapter Comm 83 of the *Wisconsin Administrative Code* governing onsite sewage disposal systems as of early 2000, are shown on Map 3. It is useful to note that nearly 35 percent of the lands within the total area tributary to the Twin Lakes are covered by soils that are categorized as having few limitations for onsite sewage disposal systems, while about 16 percent is covered by soils that are classified as unsuitable for onsite sewage disposal systems, suggesting a potential sensitivity to disturbance and likelihood of being permeable to pollutants. The remaining 49 percent is covered by unclassified or undetermined soils.

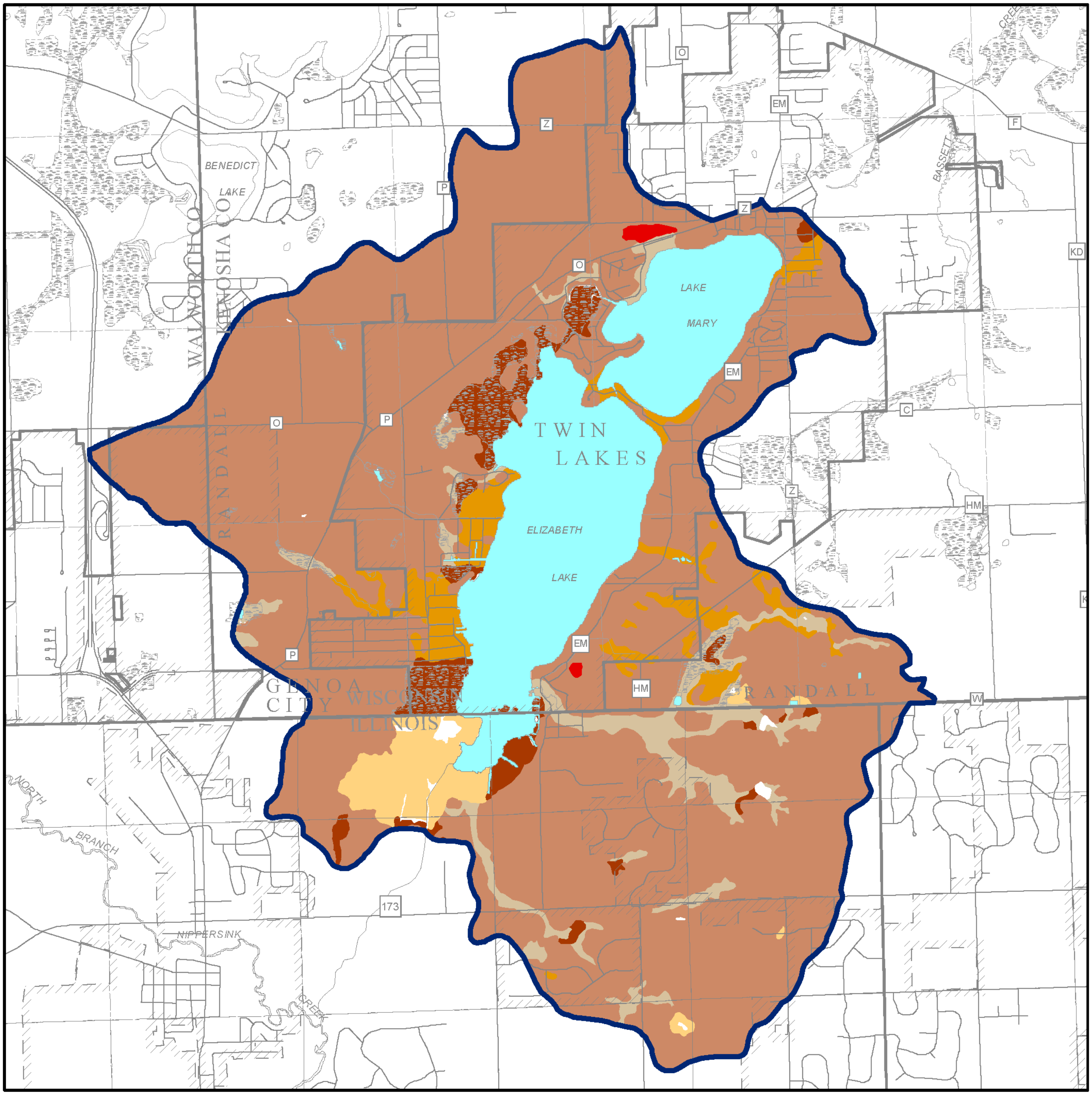
With respect to wastewater treatment, it should be noted that most of the lands in the area tributary to Lake Mary and Elizabeth Lake are currently served by a public waterborne sanitary sewerage system operated by the Village of Twin Lakes sewage treatment facility, as shown on Map 4.

---

[6]*These ratings reflected the requirements of the then existing Chapter Comm 83 of the* Wisconsin Administrative Code *governing onsite sewage disposal systems. During 2000, the Wisconsin Legislature amended Chapter Comm 83 and adopted new rules governing onsite sewage disposal systems. Effective July 1, 2000, these new rules significantly altered the existing regulatory framework, and, effectively, increased the area within which onsite sewage disposal systems could be utilized.*

Map 2

HYDROLOGIC SOIL GROUPS WITHIN THE TWIN LAKES TRIBUTARY AREA



GROUP A: WELL-DRAINED SOILS

GROUP A/D: WELL-DRAINED SOIL/VERY POORLY DRAINED SOIL (WELL-DRAINED IF WATER TABLE IS LOWERED THROUGH PROVISION OF A DRAINAGE SYSTEM. VERY POORLY DRAINED IF WATER TABLE IS NOT LOWERED.)

GROUP B: MODERATELY DRAINED SOILS

GROUP B/D: MODERATELY DRAINED SOIL/ VERY POORLY DRAINED SOIL (MODERATELY DRAINED IF WATER TABLE IS LOWERED THROUGH PROVISION OF A DRAINAGE SYSTEM. VERY POORLY DRAINED IF WATER TABLE IS NOT LOWERED.)

GROUP C: POORLY DRAINED SOILS

GROUPS C/D AND D: VERY POORLY DRAINED SOILS; POORLY DRAINED SOIL/VERY POORLY DRAINED SOIL (POORLY DRAINED IF WATER TABLE IS LOWERED THROUGH PROVISION OF A DRAINAGE SYSTEM. VERY POORLY DRAINED IF WATER TABLE IS NOT LOWERED.)

HYDROLOGIC SOIL GROUP NOT DETERMINED

SURFACE WATER

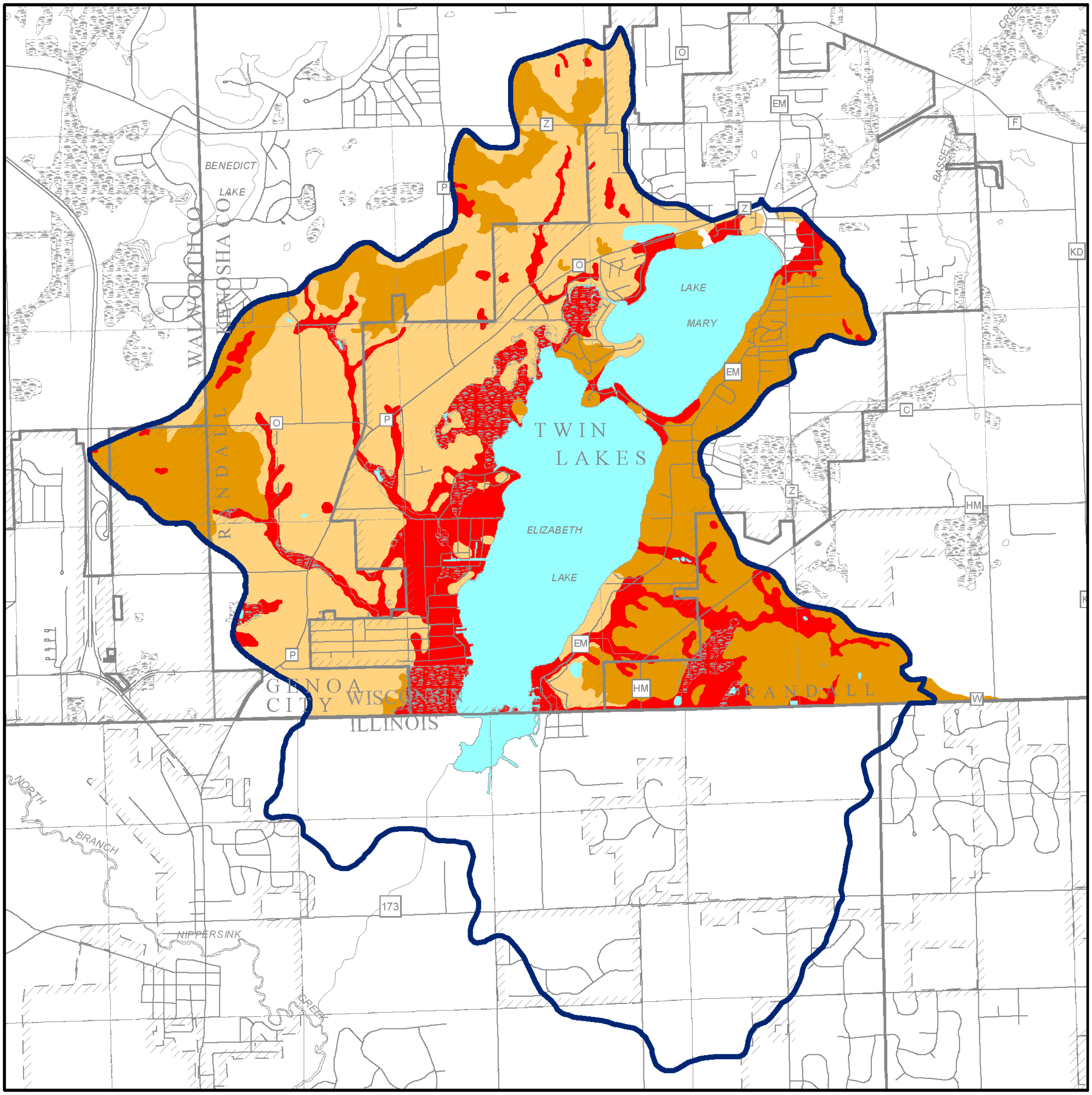
N

0 2,000 4,000 Feet

Source: McHenry County, Illinois and SEWRPC.

Map 3

GROUNDWATER CONTAMINATION POTENTIAL WITHIN THE TWIN LAKES TRIBUTARY AREA



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

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

SUITABLE: Areas covered by soils which have a high probability of meeting the June 2000 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 area available

SURFACE WATER

NOTE: This information is not available in Illinois.

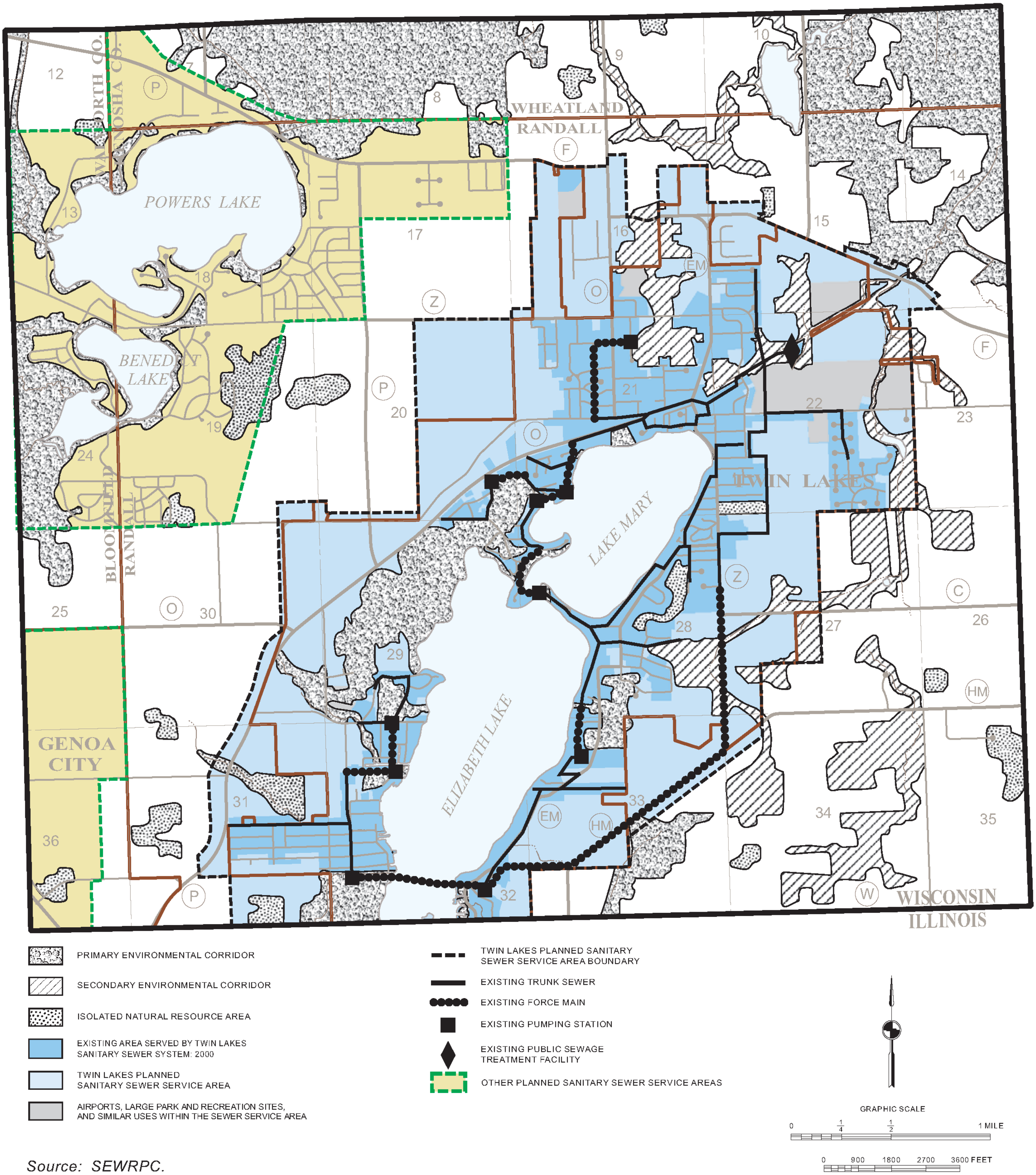
N

0 2,000 4,000 Feet

Source: SEWRPC.

Map 4

THE TWIN LAKES SANITARY SEWER SERVICE AREA



Source: SEWRPC.

Land Slope
As stated above, land slope, along with soil type and vegetative cover, is an important factor affecting the rate, amount, and quality of stormwater runoff. Land surface slopes within the total area tributary to the Twin Lakes range from less than 1 percent to greater than 20 percent. In general, slopes of over 12 percent have limitations for urban residential development and, if developed, can present potential erosion and drainage problems. Based upon soil-slope interpretations, about 587 acres, or about 8 percent of the total land area tributary to the Twin Lakes, have slopes within this range. A further 675 acres, or about 9 percent of the total area, have slopes of between 6 percent and 11 percent, while about 6,260 acres, or about 83 percent of the area, have slopes of less than 6 percent.

WATERBODY CHARACTERISTICS

Lake Mary and Elizabeth Lake are located entirely within the Village of Twin Lakes, as shown on Map 1. The lake basins originally were formed as a consequence of the retreat of continental glaciers at the end of the Wisconsin stage of glaciations, approximately 12,500 years ago. More than 90 percent of the shoreline of Lake Mary is developed for residential uses; about 60 percent of Elizabeth Lake is similarly developed. The lesser degree of urban residential development on the shores of Elizabeth Lake reflects the presence of an extensive wetland systems that fringe portions of this lake basin along the southern, southwestern, and northwestern shorelines.

Given its greater shoreline length, shoreline erosion around the lakeshore is a potential concern in Elizabeth Lake. Such concern is not limited to Elizabeth Lake, but extends to the shoreline of Lake Mary, portions of which are steeply sloping to the water's edge. Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with recreational access and lake use. Such erosion is usually caused by wind-wave erosion, ice movement, and motorized boat traffic. A survey of the lake shorelines, conducted during 2006 by Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff, identified existing shoreline protection structures around the Lakes, as shown on Maps 5 and 6. Much of the developed shorelands of the Lakes had some form of shoreline protection in 2006. Most were in a good state of repair. Improperly installed and failing shoreline protection structures and the erosion of natural shorelines on the Lakes, are limited causes for concern. This concern was reinforced during the July 2008 reconnaissance by SEWRPC staff which identified a significant number of shoreline protection structures as being "at risk" of over-topping as a result of high water conditions in the Lakes. At this time, the levels of Elizabeth Lake and Lake Mary were at an elevation of 794.6 feet above the National Geodetic Vertical Datum of 1929 (NGVD-29), or 0.1 foot above the slow-no-wake elevation as set forth in the 2004 Village ordinance. Based upon observations of 225 piers and associated shoreline protection structures observed on Elizabeth Lake, about 25 percent were classified as "underwater," which was defined as having the Lake level at or very near the pier deck level and about 45 percent were classified as "threatened," which was defined as having the Lake level within three to six inches of the pier deck. On that same date, of the 231 piers and associated shoreline protection structures observed on Lake Mary, about 20 percent were classified as "underwater" and about 30 percent were classified as "threatened."

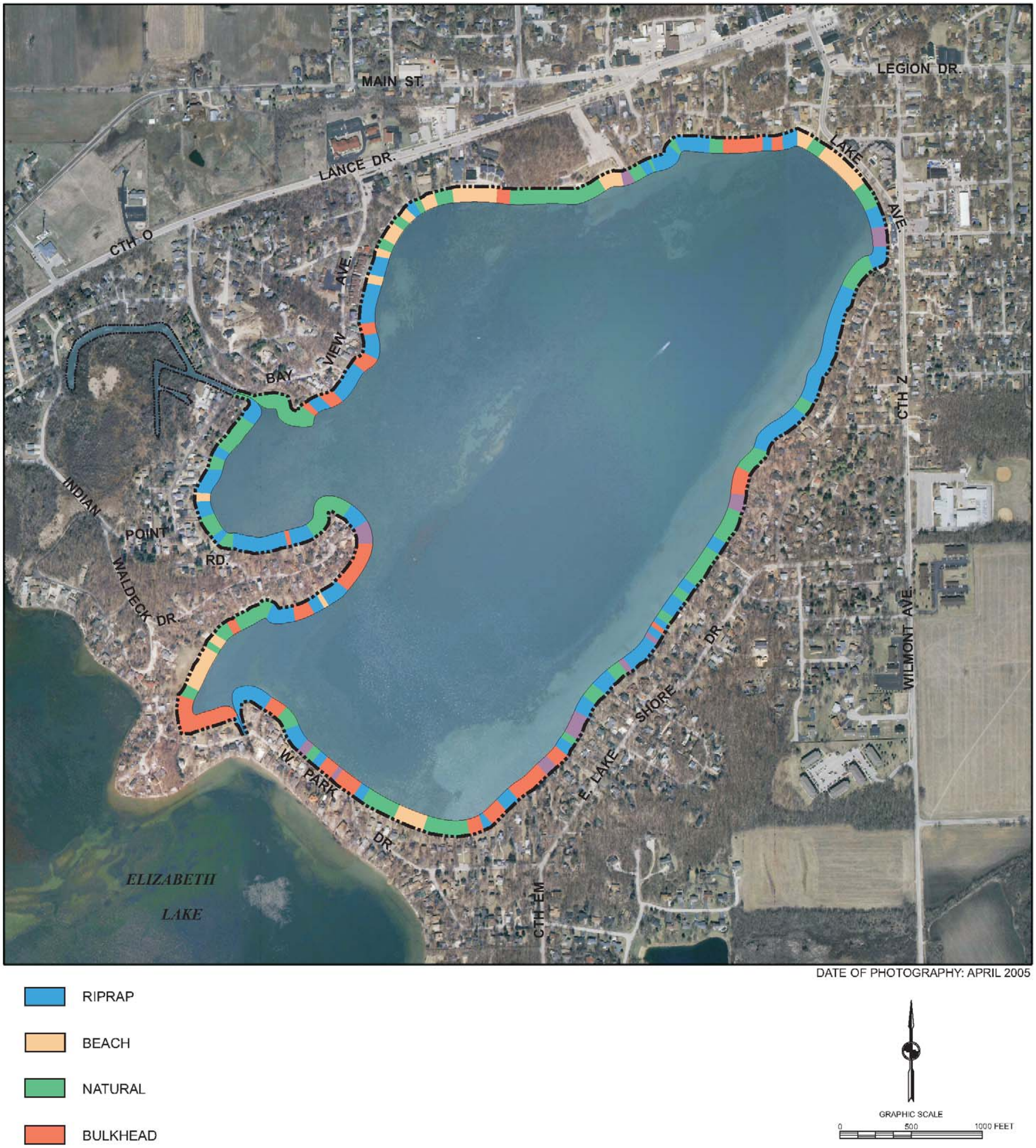
Lake Mary
Lake Mary is a drained lake, which depends principally on precipitation falling directly onto the Lake's surface, some runoff from the surrounding landscape, and groundwater flowing into the Lake from inside and outside the immediate surface tributary area for its source of water. Lake Mary flows into Elizabeth Lake through a narrow channel with a concrete spillway that maintains the water level in Lake Mary at a surface elevation of between 793.2 and 795.1 feet above NGVD-29. The nominal lake level of Lake Mary was reported by the Wisconsin Department of Natural Resources (WDNR) to be approximately 793.9 feet NGVD-29,[7] while the U.S. Geological Survey (USGS) 7.5-minute series topographic map for the Genoa City, Wisconsin, quadrangle shows the water

---

[7]*See Wisconsin Department of Natural Resources Lake Use Report No. FX-17,* Marie *[sic]* Lake, Kenosha County, Wisconsin, *1970.*

Map 5

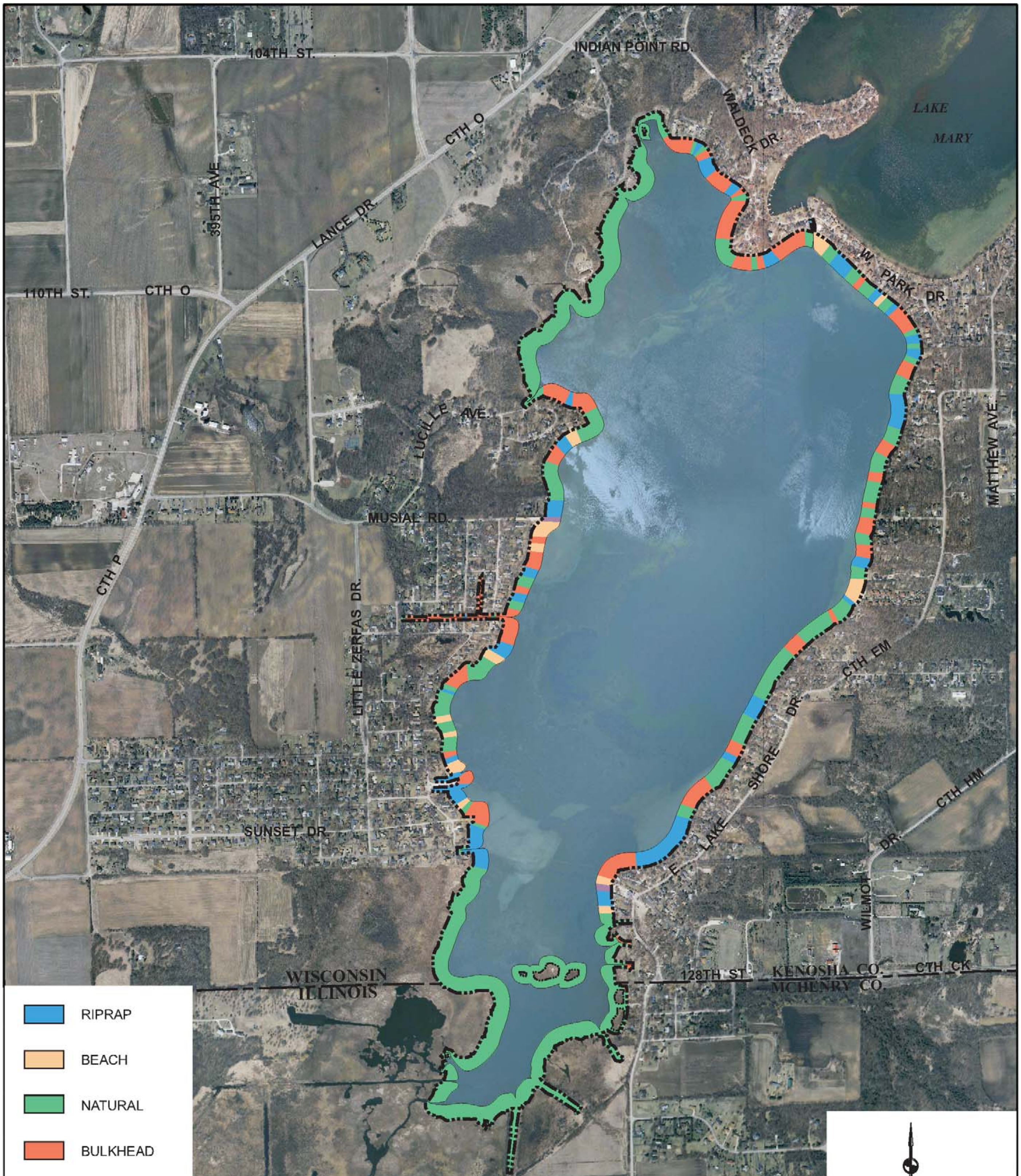
SHORELINE PROTECTION STRUCTURES ON LAKE MARY: 2006



Source: SEWRPC.

Map 6

SHORELINE PROTECTION STRUCTURES ON ELIZABETH LAKE: 2006



DATE OF PHOTOGRAPHY: APRIL 2005

surface elevation to be 794 feet NGVD-29, or about one foot above the nominal water level of Elizabeth Lake, located downstream.

Lake Mary has a surface area of 315 acres, with a maximum depth of 33 feet and a mean depth of about nine feet. Approximately 18 percent of the Lake area is less than three feet deep, and about 12 percent of the Lake has a water depth greater than 20 feet. Lake Mary is 1.1 miles long and 0.6 mile wide at its widest point. The major axis of the Lake lies in a northeastern-southwestern direction. The lake shoreline is 3.5 miles long, with a shoreline development factor of 1.41, indicating that the shoreline is about 1.4 times longer than a circular lake of the same area. The Lake has a total volume of approximately 1,957 acre-feet. The hydrographical and morphometric data is presented in Table 1 and the bathymetry of the Lake is shown on Map 7.

Lake bottom sediment types along the shoreline of Lake Mary were reported in the aforereferenced WDNR study.[8] The substrate of Lake Mary consisted of sand along about 32 percent of the shoreline, gravel and rubble along about 24 percent of the shoreline, and soft sediments in the remainder of the shoreline areas. The abundance of natural sand and gravel in these shoreline areas attests to the glacial heritage of the Lake.

Elizabeth Lake

Elizabeth Lake is a through-flow lake, having both a defined natural channel inflow—in this case from Lake Mary, and an outflow, to the Nippersink Creek in McHenry County, Illinois. The water level of Elizabeth Lake is presently maintained artificially at a surface elevation of between 793.0 and 795.1 feet NGVD-29. The nominal lake level of Elizabeth Lake was reported by the WDNR to be approximately 793.9 feet NGVD-29,[9] while the USGS 7.5-minute series topographic map for the Genoa City, Wisconsin, quadrangle shows the water surface elevation to be 793 feet NGVD-29, or about one foot below the nominal water level of Lake Mary, located downstream. This elevation is maintained by a dam, reconstructed in 1984, which is located at the south end of the Lake. The Lake flows into the Elizabeth Lake Drain.

Elizabeth Lake has a surface area of 638 acres, with about 15 percent of the Lake area less than three feet deep and about 21 percent of the Lake deeper than 20 feet. The Lake has a maximum depth of 32 feet and a mean depth of about 11 feet. Elizabeth Lake is 1.9 miles long and 0.8 mile wide with its major axis lying in a northeastern-southwestern direction. The Lake shoreline is 5.4 miles long, with a shoreline development factor of 1.55. The Lake has a total volume of approximately 6,900 acre-feet. The hydrographical and morphometric data is presented in Table 1 and the bathymetry of the Lake is shown on Map 8.

Lake bottom sediment types along the shorelines of Elizabeth Lake were reported in the aforereferenced WDNR study.[10] The substrate of Elizabeth Lake consisted of gravel along about 70 percent of shoreline, sand along about 5 percent of the shoreline, and soft sediments in the remainder of the shoreline areas. The abundance of natural sand and gravel in these shoreline areas attests to the glacial heritage of the Lake.

CLIMATE AND HYDROLOGY

Long-term average monthly air temperature and precipitation values are set forth in Table 3. These data were taken from official National Oceanic and Atmospheric Administration (NOAA) records based on data from 17 reporting stations across the Southeastern Wisconsin Region and may be considered typical of the lake area.

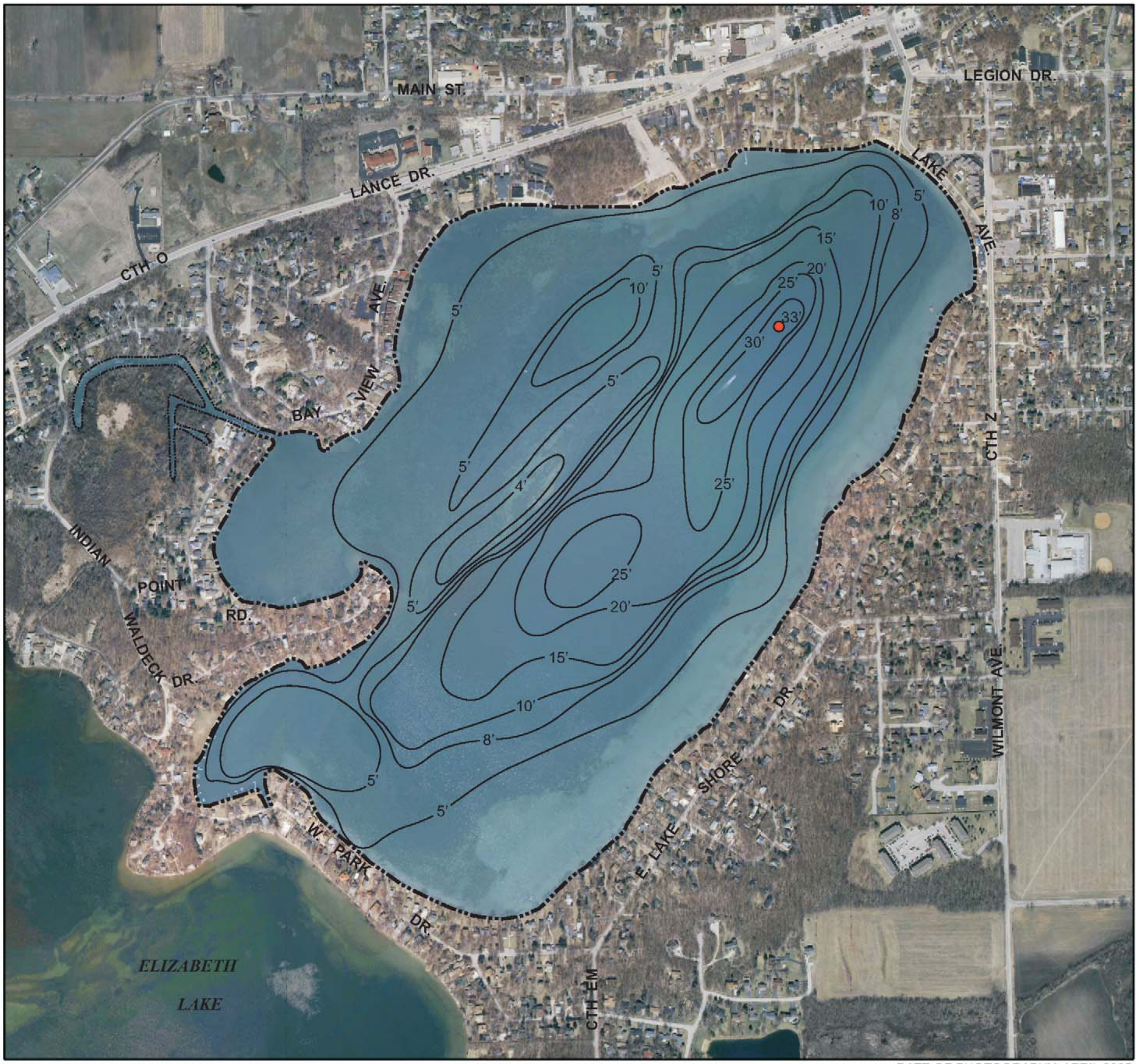
[8]Ibid.

[9]*See Wisconsin Department of Natural Resources Lake Use Report No. FX-7,* Elizabeth Lake, Kenosha County, Wisconsin, *1969.*

[10]Ibid.

Map 7

BATHYMETRIC MAP OF LAKE MARY

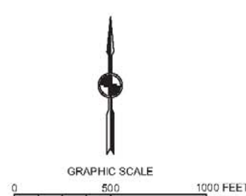


DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

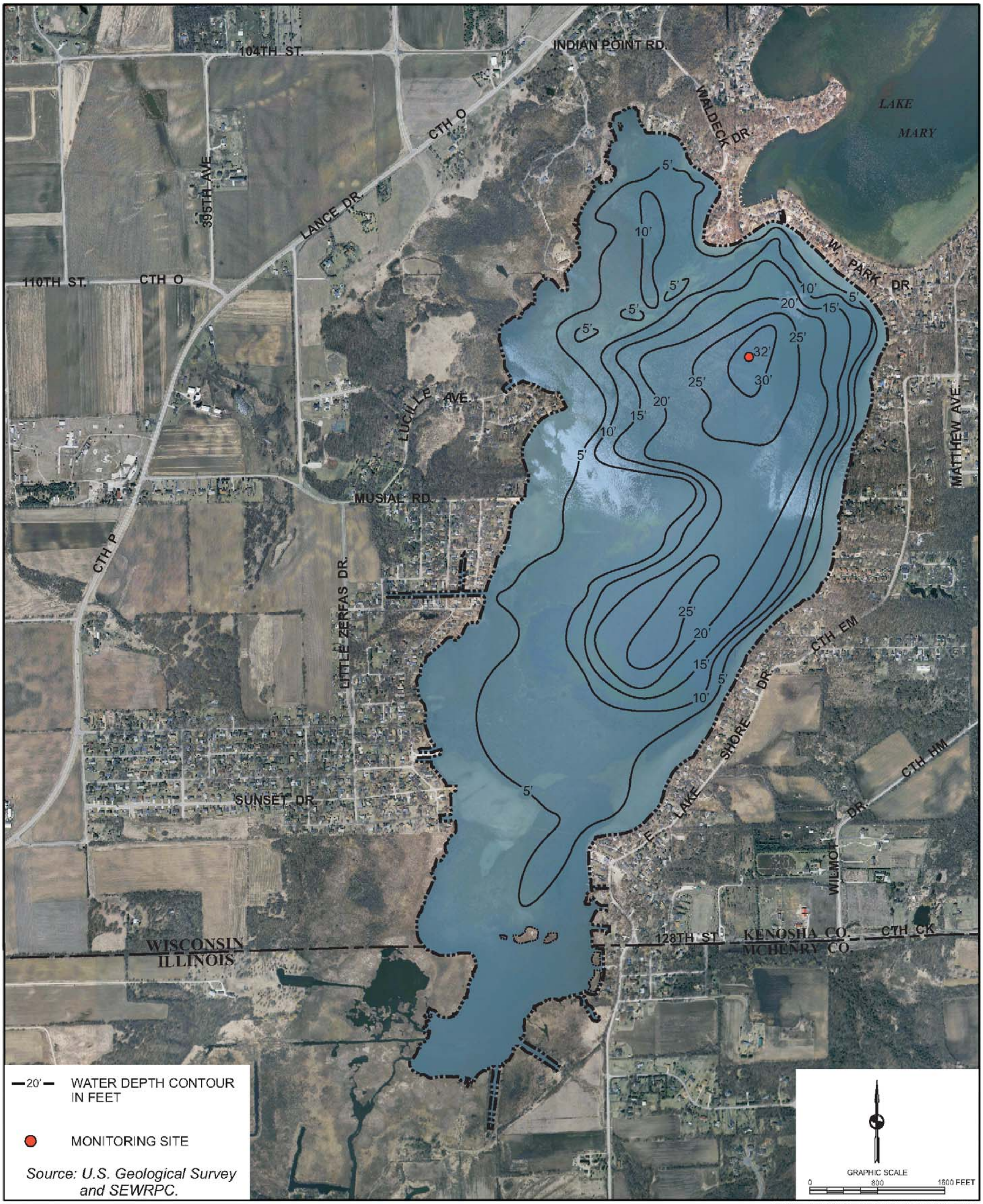
● MONITORING SITE

Source: U.S. Geological Survey and SEWRPC.



Map 8

BATHYMETRIC MAP OF ELIZABETH LAKE



Source: U.S. Geological Survey and SEWRPC.

DATE OF PHOTOGRAPHY: APRIL 2005

Table 3

LONG-TERM AND 2005 STUDY YEAR TEMPERATURE, PRECIPITATION, AND RUNOFF DATA FOR THE TWIN LAKES AREA

Temperature													
Air Temperature Data (°F)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	18.9	24.0	34.0	45.0	56.3	66.1	71.2	69.4	61.4	49.9	37.0	24.7	46.5
2005 Mean Monthly	20.6	29.1	31.1	48.3	53.5	71.0	71.8	71.9	67.2	52.4	39.1	21.2	48.1
Departure from Long-Term Mean	1.7	5.1	-2.9	3.3	-2.8	5.0	0.6	2.5	5.8	2.5	2.1	-3.5	1.6

Precipitation														
Precipitation Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean	Total
Long-Term Mean Monthly	1.56	1.55	2.19	3.48	3.13	3.76	3.82	4.22	3.48	2.51	2.55	1.91	2.83	33.93
2005 Mean Monthly	3.72	1.85	1.02	1.61	2.74	1.94	2.92	2.10	3.75	0.73	3.69	1.26	2.28	27.33
Departure from Long-Term Mean	2.16	0.53	-1.17	-1.87	-0.39	-1.82	-0.90	-2.12	0.27	-1.78	1.14	-0.65	-0.55	-6.60

Runoff[a]													
Runoff Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	0.70	0.88	1.45	1.45	1.13	1.07	0.68	0.51	0.63	1.61	0.70	0.83	0.97
2004 Mean Monthly	0.35	0.33	1.34	0.71	2.04	1.50	0.54	0.33	0.25	0.29	0.42	0.57	0.72
Departure from Mean Monthly	-0.35	-0.55	-0.11	-0.74	0.91	0.43	-0.14	-0.18	-0.38	-1.32	-0.28	-0.26	-0.25

[a]Runoff data was computed for Nippersink Creek near Spring Grove, Illinois, for calendar year 2004, which was the most recent calendar year data available at time of print.

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

The long-term mean annual temperature for the Southeastern Wisconsin Region was 46.5°F. The 12-month period for calendar year 2005, as indicated in Table 3, was a period during which temperatures were generally about normal. The greatest temperature deviation above normal was during the month of September, when temperatures were about six degrees above normal; the greatest deviation below normal occurred during December, with temperatures averaging 3.5 degrees below normal.

The calendar year 2005 was a drier year for the Southeastern Wisconsin Region in general, with eight of the 12 months experiencing below normal amounts of precipitation. The mean annual precipitation over the Southeastern Wisconsin Region is about 33.93 inches. Precipitation during the calendar year 2005 was about 27.33 inches, or about 18 percent below normal, with the greatest decrease below the average, 2.12 inches, occurring during August, and the greatest increase above average, 2.16 inches, occurring during January.

Table 3 also sets forth surface water runoff values derived from the U.S. Geological Survey (USGS) flow records for the gage station on the Nippersink Creek near Spring Grove, Illinois. Typically, more than one-half of the normal yearly precipitation falls during the growing season, from May to September. Runoff rates are generally low during this period, since evapotranspiration rates are high, vegetative cover is good, and soils are not frozen. Normally, about 20 percent of the summer precipitation is expressed as surface runoff, but intense summer storms occasionally produce higher runoff fractions. In contrast, approximately 45 percent of the annual precipitation occurs during the winter or early spring when the ground is frozen, and may result in high surface runoff during those seasons. As shown in Table 3, runoff during the study year of 2004 was somewhat below normal, a result consistent with other lakes in the Region at that time.

Lake Stage

The water levels of the Twin Lakes are influenced by local precipitation patterns, runoff conditions, and groundwater levels and rates of flow. Between 1992 and 2000, the level of Lake Mary has varied from an elevation of 793.2 feet to 795.1 feet NGVD-29. The water level of Elizabeth Lake has varied from 793.0 feet to 795.1 feet NGVD-29, as regulated by a dam and spillway located at the southern end of the Lake.

Water Budget

In the aforereferenced 1993 report, water budgets for the Twin Lakes were computed based on precipitation, tributary area surface runoff, groundwater inflow and outflow, evaporation from the lake surfaces, and outflow through the outlets at the south ends of each of the Twin Lakes. These earlier water budgets indicated that about 54 percent of the water entering Lake Mary and about 51 percent of the water entering Elizabeth Lake was contributed by precipitation directly onto the lake surfaces; groundwater contributed about 29 percent to Lake Mary and about 27 percent to Elizabeth Lake; and surface runoff from the tributary area contributed about 17 percent to Lake Mary and about 22 percent to Elizabeth Lake. Of the water flowing out of the Twin Lakes, evaporation accounted for about 48 percent of the outflow from Lake Mary and about 45 percent of the outflow from Elizabeth Lake; about 41 percent of the outflow from Lake Mary and 33 percent of that from Elizabeth Lake was the result of groundwater outflow; and the remaining 11 percent from Lake Mary and 22 percent from Elizabeth Lake were discharged via their outlets.

During the current study period, using data from USGS and NOAA, long-term and study year 2005 hydrologic budgets for the Twin Lakes were developed, as shown in Table 4. To develop these current budgets, water entering the Twin Lakes was considered to be comprised of direct precipitation onto the lake surfaces, runoff from their tributary area land surfaces, and flows of groundwater. Data for water leaving the Lakes was based on water lost through evaporation from the lake surfaces, groundwater recharge, and outflow through each lake outlet.

During the calendar year 2005, approximately 1,834 acre-feet of water entered Lake Mary. Of this total, about 781 acre-feet, or about 43 percent, were contributed from direct precipitation to the lake surfaces; about 547 acre-feet, or 30 percent, were the result of runoff from the land surfaces in the tributary area; and 506 acre-feet, or about 27 percent, were the result of groundwater inflow. Of the water lost from Lake Mary during the study year, about 829 acre-feet, or about 45 percent, evaporated from the lake surface; about 710 acre-feet, or about 39 percent, were the result of groundwater recharge; and 295 acre-feet, or 16 percent, were discharged to Elizabeth Lake.

For Elizabeth Lake during the 2005 study year, approximately 5,178 acre-feet of water entered the Lake. Of this amount, about 1,453 acre-feet, or about 28 percent, entered the Lake as precipitation directly to the lake surface; about 2,336 acre-feet, or 45 percent, entered as surface runoff from the tributary area; about 1,094 acre-feet, or 21 percent, entered as groundwater; and the remaining 295 acre-feet, or 6 percent, entered as inflow from Lake Mary. Of the water lost from Elizabeth Lake during the 2005 study year, 3,120 acre-feet, or about 60 percent, were due to evaporation; 743 acre-feet, or 14 percent, were outflow through the lake outlet at the south end; and 1,315 acre-feet, or 26 percent, was due to groundwater recharge.

Results of the long-term budget estimates are also shown in Table 4 and represented graphically in Figures 1 and 2. Over the long term, about 2,155 acre-feet of water entered Lake Mary each year, with 970 acre-feet, or 45 percent, being comprised of direct precipitation onto the lake surface; about 679 acre-feet, or 32 percent, the result of runoff from the land surfaces in the tributary area; and about 506 acre-feet, or 23 percent, the result of groundwater inflow. Over the long term, of the water lost from Lake Mary each year, about 829 acre-feet, or about 38 percent, evaporated from the lake surface; about 616 acre-feet, or 29 percent, was discharged to Elizabeth Lake; and about 710 acre-feet, or about 33 percent, was used for groundwater recharge.

Table 4

HYDROLOGIC BUDGETS FOR THE TWIN LAKES

Element	Lake Mary		Elizabeth Lake	
	2005 (acre-feet)	Long-Term (acre-feet)	2005 (acre-feet)	Long-Term (acre-feet)
Inflows				
Direct Precipitation to Surface Waters	781	970	1,453	1,804
Runoff from Tributary Land Area	547	679	2,336	2,900
Groundwater Inflow[a]	506	506	1,094	1,094
Inflow from Lake Mary	- -	- -	295	616
Total	1,834	2,155	5,178	6,414
Outflows				
Evaporation from Lake Surface	829	829	3,120	3,120
Outflow	295	616	743	1,979
Groundwater Outflow[a]	710	710	1,315	1,315
Total	1,834	2,155	5,178	6,414

[a]*Based on data presented in 1993 Discovery Group/Blue Water Science report.*

Source: National Oceanic and Atmospheric Administration and SEWRPC.

Of the water entering Elizabeth Lake over the long term, about 2,900 acre-feet, or 45 percent, entered as surface runoff; about 1,804 acre-feet or 28 percent, entered as direct precipitation; about 1,094 acre-feet, or 17 percent, entered as groundwater inflow; and about 616 acre-feet, or 10 percent, entered as inflow from Lake Mary. Over the long term, about 3,120 acre-feet, or 49 percent, left Elizabeth Lake due to evaporation; 1,315 acre-feet, or 20 percent, was lost as groundwater recharge; and 1,979 acre-feet, or 31 percent, was lost as outflow through the outlet at the south end of the Lake.

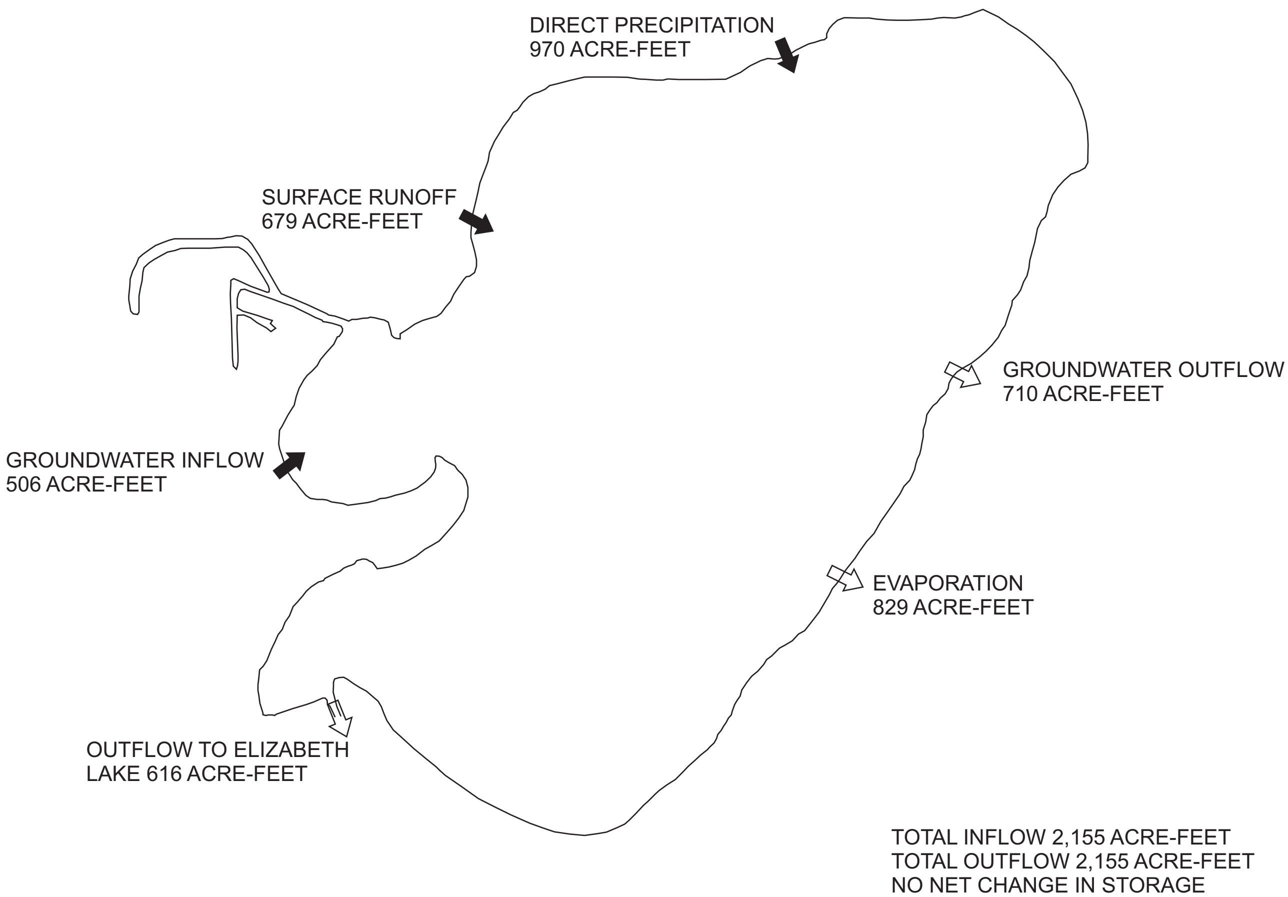
Water flows for 2005, compared to long-term amounts, were consistent with the expected results due to decreased precipitation in 2005. It should be noted that the period from winter 2007-2008 through early summer 2008 was a period of above-average precipitation, with heavy snowfalls during February 2008 and large rainfalls during June 2008. This extraordinary condition is illustrated graphically as a comparison between stream discharge in the Nippersink Creek during the period January 1 through July 31, 2008, and the long-term runoff recorded at the USGS gauging station in Figure 3. These events led to high-water conditions being experienced throughout the Upper Midwest Region, including in the Twin Lakes, and the imposition of recreational boating restrictions on numerous lakes in the Illinois-Fox River basin, including Lake Mary and Elizabeth Lake. Consequently, concerns were expressed by the Twin Lakes communities regarding the operational practices governing the water regulation structures, especially that controlling the level of Elizabeth Lake.

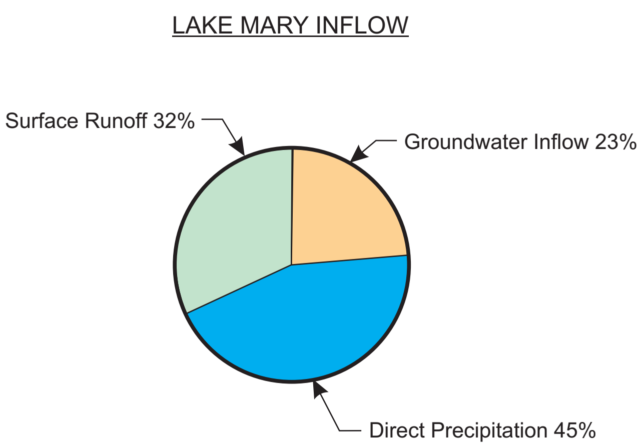
Residence Time

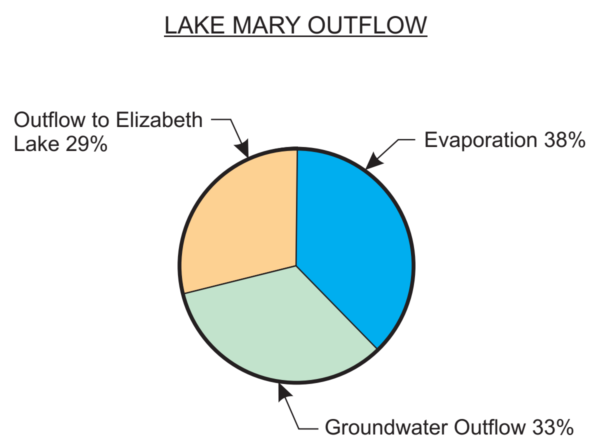
As was stated above, Lake Mary has a relatively small tributary area to lake surface area ratio of about 4.5:1; the ratio for Elizabeth Lake is only about 10:1. Lakes with large tributary area to lake surface area ratios, in the range of several hundred or more to one, typically have shorter residence times than lakes with smaller ratios. The hydraulic residence time, also referred to as retention time or flushing rate, is the time needed for a volume of water equivalent to the full volume of the lake to enter the lake. Water residence time is important in determining the expected response time of a lake to increased or reduced nutrient and other pollutant loadings. Lakes having a short residence time of less than a few years, such as lakes like Lake Mary, and through-flow lakes, such as Elizabeth Lake, including lakes with large volumes of groundwater inflow and outflow, will allow nutrients and pollutants to be flushed from the lake at a fairly rapid rate. Such lakes generally respond well when nutrient inputs

Figure 1

LONG-TERM HYDROLOGIC BUDGET FOR LAKE MARY



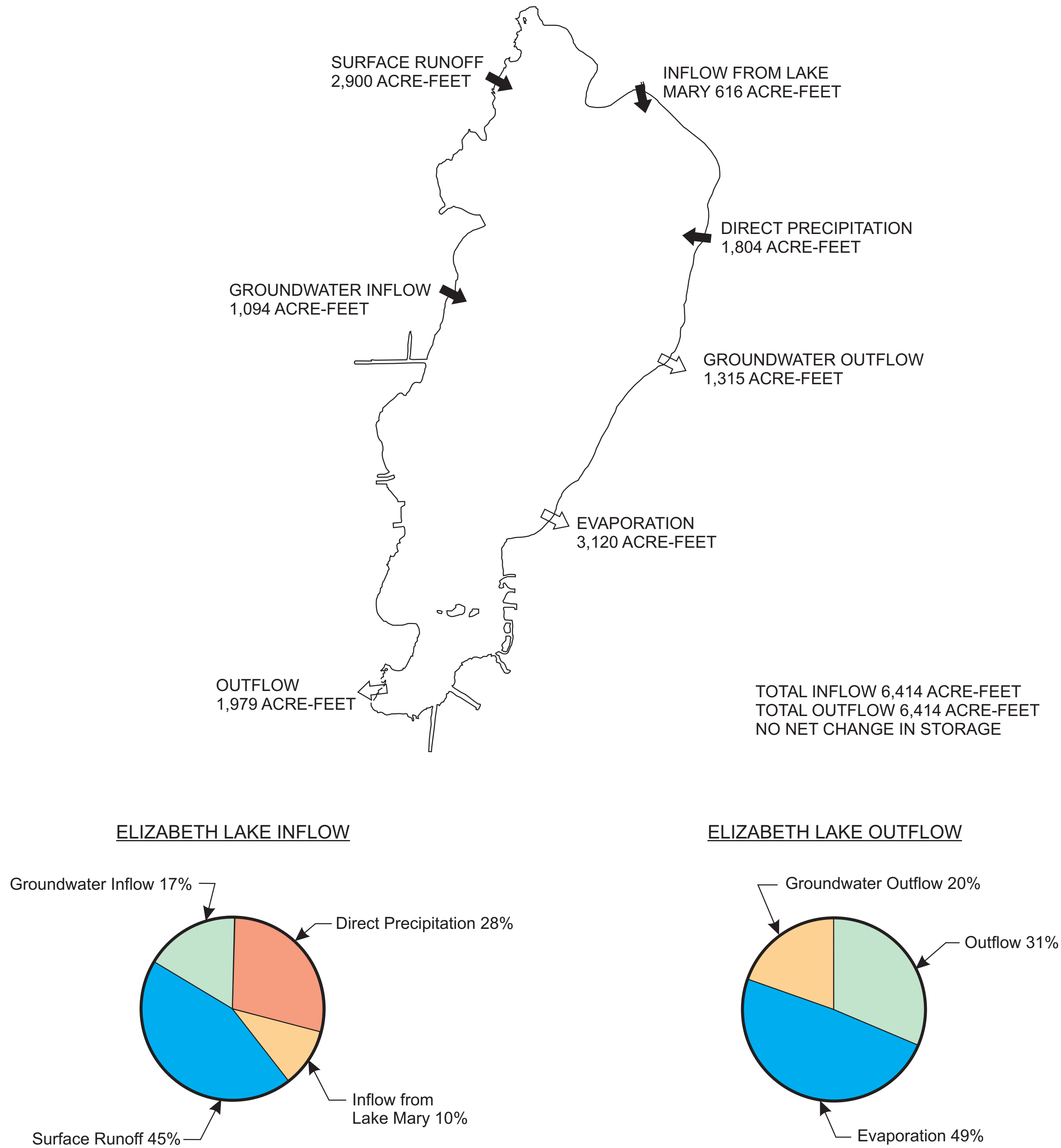




Source: U.S. Geological Survey and SEWRPC.

Figure 2

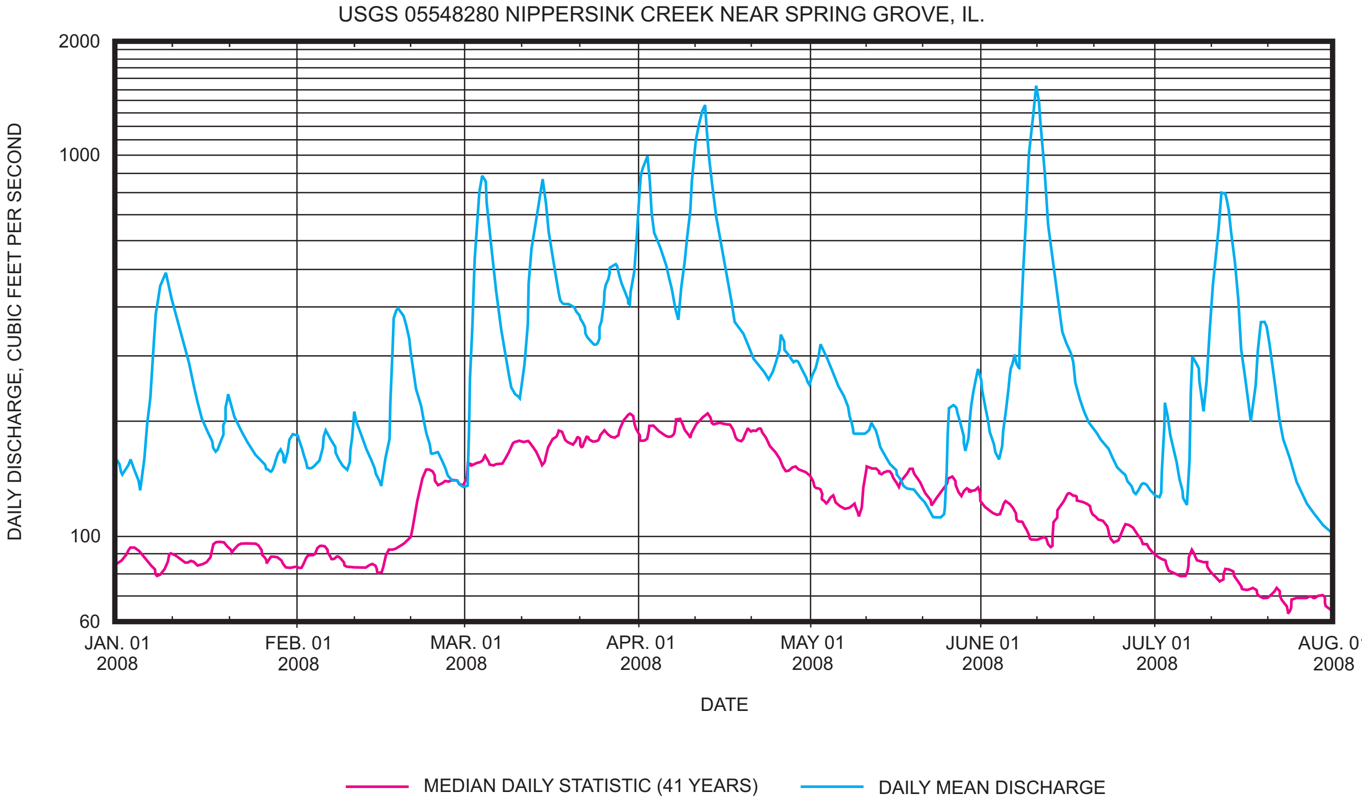
LONG-TERM HYDROLOGIC BUDGET FOR ELIZABETH LAKE



Source: U.S. Geological Survey and SEWRPC.

Figure 3

RUNOFF OBSERVED AT THE NIPPERSINK CREEK GAGING STATION, DOWNSTREAM OF THE TWIN LAKES, COMPARED WITH THE LONG TERM AVERAGE DISCHARGE: 2008



Source: U.S. Geological Survey and SEWRPC.

are decreased. Lakes with a long residence time, such as seepage lakes having no outflowing streams, typically respond more slowly to changes in their tributary area, since it takes a long time for a volume equivalent to the full volume of the lake to leave the lake. Such lakes can accumulate nutrients for many years, recycling them each year during the periods spring and fall overturn, with the result that the effects of tributary area protection may not be immediately apparent.

In the case of the Twin Lakes, the hydraulic or water residence times were about two years. The hydraulic residence time for Lake Mary was reported to be 1.92 years and, for Elizabeth Lake, 1.85 years. These values suggest that the Lakes would respond relatively rapidly to changes in their nutrient and pollutant loading rates.

Chapter III

HISTORICAL, EXISTING, AND FORECAST LAND USE AND POPULATION

INTRODUCTION

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

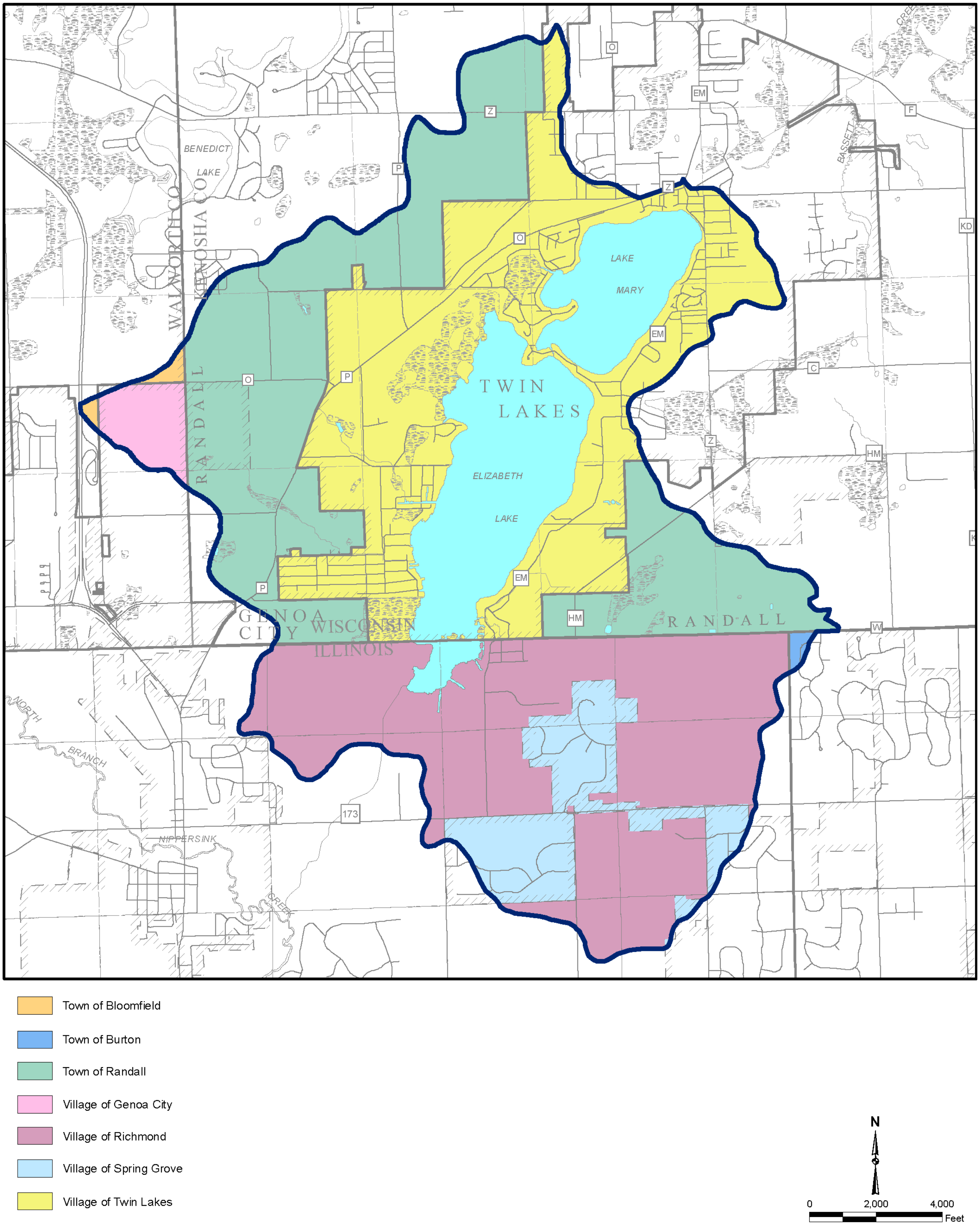
CIVIL DIVISIONS

The geographic, as well as functional jurisdictions, of general- and special-purpose units of government are important factors which must be considered in lake water quality management. Local units of government provide the basic structure for the decision-making framework within which intergovernmental environmental problems must be addressed. Superimposed on the irregular tributary areas of the Twin Lakes—Lake Mary and Elizabeth Lake—are the local civil division boundaries, shown on Map 9. Within Wisconsin, these governmental units include: the Town of Bloomfield and the Village of Genoa City, in Walworth County; and the Town of Randall and the Village of Twin Lakes, in Kenosha County. Within Illinois, these governmental units include: The Villages of Richmond and Spring Grove, and the Town of Burton, all in McHenry County. The area and proportion of the combined watersheds, lying within the jurisdiction of each civil division, as of 2000, are set forth in Table 5.

The geographic boundaries of the civil divisions are important factors which must be considered in any water quality management planning effort for a lake, since these local units of government provide the framework for, among others, defining land usage within their individual jurisdictions, creating and enforcing land use regulations, and making land management decisions affecting public lands within their jurisdictions, relevant to effectively addressing intergovernmental environmental problems. In Wisconsin, Kenosha and Walworth Counties administer a number of programs and administrative functions which relate directly to lake and tributary area management in the Twin Lakes area focused on land management in the unincorporated areas of the watershed. Additionally, the Wisconsin Department of Natural Resources (WDNR) exercises oversight of dam safety and regulation, navigability, and floodland, shoreland and wetland management. In Illinois, McHenry County and the Illinois Department of Natural Resources exercise parallel authorities.

Map 9

CIVIL DIVISION BOUNDARIES WITHIN THE TWIN LAKES TRIBUTARY AREA



Source: McHenry County, Illinois and SEWRPC.

In addition to these general-purpose units of government, the Twin Lakes Protection and Rehabilitation District, a special-purpose unit of government, created pursuant to Chapter 33 of the *Wisconsin Statutes*, is responsible for aspects of the management of the Twin Lakes.[1] Public inland lake protection and rehabilitation districts, or lake management districts, can undertake programs of lake protection or rehabilitation, including water quality, aquatic plant, and fisheries management activities. The Twin Lakes Protection and Rehabilitation District is coterminous with the Village of Twin Lakes, and encompasses the properties riparian to the Lakes, as well as other Village lands. Because the District was created by the Village pursuant to authorities granted to incorporated municipalities under Section 33.23 of the *Wisconsin Statutes*, the Village Board serves as the lake management district board of commissioners. The District has maintained an active program of public informational programming and citizen involvement in lake monitoring and management activities since its inception.

Table 5

AREAL EXTENT OF CIVIL DIVISION BOUNDARIES WITHIN THE TOTAL AREA TRIBUTARY TO TWIN LAKES

Civil Division	Civil Division Area within Total Tributary Area (acres)	Percent of Total Tributary Area within Civil Division
Town of Bloomfield	26	0.3
Town of Randall	1,963	26.1
Town of Burton	14	0.2
Village of Genoa City	139	1.9
Village of Twin Lakes	3,062	40.7
Village of Richmond	1,836	24.4
Village of Spring Grove	484	6.4
Total	7,524	100.0

Source: SEWRPC.

POPULATION

As indicated in Table 6, the resident population of the area tributary to Lake Mary and Elizabeth Lake within Wisconsin continues to increase. From 1963 to 1970, population grew by about 1,210 persons; during the decades of the 1970s and the 1990s, the population increased by more than 700 people; and, during the decade of the 1980s, the population increased by about 274 persons. The period of greatest growth in both population and numbers of households in the area tributary to the Twin Lakes was from 1963 to 1970. During this period, the population and numbers of households increased by nearly 250 percent, contributing to a near five-fold increase in the resident population and numbers of households in the approximately 40-year period since 1963.

During 2000, an estimated 3,774 people, comprising 1,430 households, were reported to reside within the Wisconsin portion of the tributary area. In the portion of the tributary area within Illinois, approximately 3,408 people were reported to reside in the area tributary to Elizabeth Lake during 2000. This population was resident in 1,169 households.

As development in the local area continues, the population growth within the area tributary to Lake Mary and Elizabeth Lake may be expected to continue, and a further increase in both populations and numbers of dwelling units is expected to continue to increase over the next two decades.[2] This population growth may be expected to place continued and increasing stress on the natural resource base of the tributary area, and both water resource demands and use conflicts may be expected to increase.

---

[1] *University of Wisconsin-Extension Publication No. G3818,* People of the Lakes: A Guide for Wisconsin Lake Organizations—Lake Associations & Lake Districts, Eleventh Edition*, 2006.*

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

Table 6

POPULATION AND HOUSEHOLDS WITHIN THE AREA TRIBUTARY TO TWIN LAKES IN WISCONSIN: 1963-2000

Year	Population	Households
1963	836	259
1970	2,046	709
1980	2,788	980
1990	3,062	1,098
2000	3,774	1,430

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

LAND USE

The type, intensity, and spatial distribution of the various land uses within the area tributary to the Twin Lakes are important determinants of lake water quality and recreational use demands. The existing land use pattern, placed in the context of the historical development of the area, therefore, is an important consideration in any lake management planning effort for Twin Lakes.

The movement of European settlers into the Southeastern Wisconsin Region began about 1830. Completion of the U.S. Public Land Survey in southeastern Wisconsin in 1836 and the subsequent sale of the public lands brought a rapid influx of settlers into the area. Map 10 shows an 1872 plat of the U.S. Public Land Survey for the Twin Lakes area of Wisconsin, and reproduces the 1872 plat for the Twin Lakes area of Illinois. Map 11 and Table 7 indicate the historical urban growth that has occurred in the vicinity of the Village of Twin Lakes since 1900. A small amount of urban-density development took place in the Village beginning about 1900. The largest increases in the amount of land in the vicinity of the Village of Twin Lakes converted to urban land uses occurred in the shoreland areas of the Lakes between 1940 and 1963, although significant amounts of land in the southwestern, northern, and eastern portions of the tributary area were developed during the 1960s and 1970s.

In the aforereferenced 1991 lake management plan for the Twin Lakes,[3] existing land uses in the tributary area were presented. At that time, rural land uses constituted about 87 percent of the direct tributary area, with agricultural uses comprising the largest portion, over 87 percent, of rural land uses, occupying 77 percent of the tributary area overall. Urban land uses at that time occupied about 13 percent of the tributary area, with residential uses comprising the major portion of urban uses, occupying about 69 percent of all urban lands and 9 percent of the tributary area overall.

During the current study, the existing land uses in the Wisconsin portion of the area of tributary to the Twin Lakes are shown in Table 8 and on Map 12. As of 2000, as shown in Table 8, about 22 percent of the area in Wisconsin tributary to the Twin Lakes was in various urban land uses as compared to about 13 percent in 1991. The dominant urban land use was residential, encompassing about 711 acres, or about 14 percent of the total tributary area. Rural land uses in 2000, such as agriculture, wetlands, woodlands, and surface waters, comprised about 4,055 acres, or about 78 percent of the total tributary area, compared to 87 percent in 1991. Conversion of rural, primarily agricultural lands, for urban-density purposes was a common theme during this last decade of the 20th Century.

Within the 7,524-acre total area tributary to the Twin Lakes, existing land uses as of 2000 are shown in Table 9. Urban residential lands comprised about 1,125 acres or 15 percent of the land uses in this area, with other urban uses making up a further 5 percent of the urban land uses. In the rural areas, agricultural land uses comprised 4,288 acres or 57 percent of the total land uses, with wetlands comprising a further 3 percent and woodlands comprising about 4 percent of the rural land uses. Surface waters made up the balance of the rural land uses, comprising about 14 percent of the total land use.

---

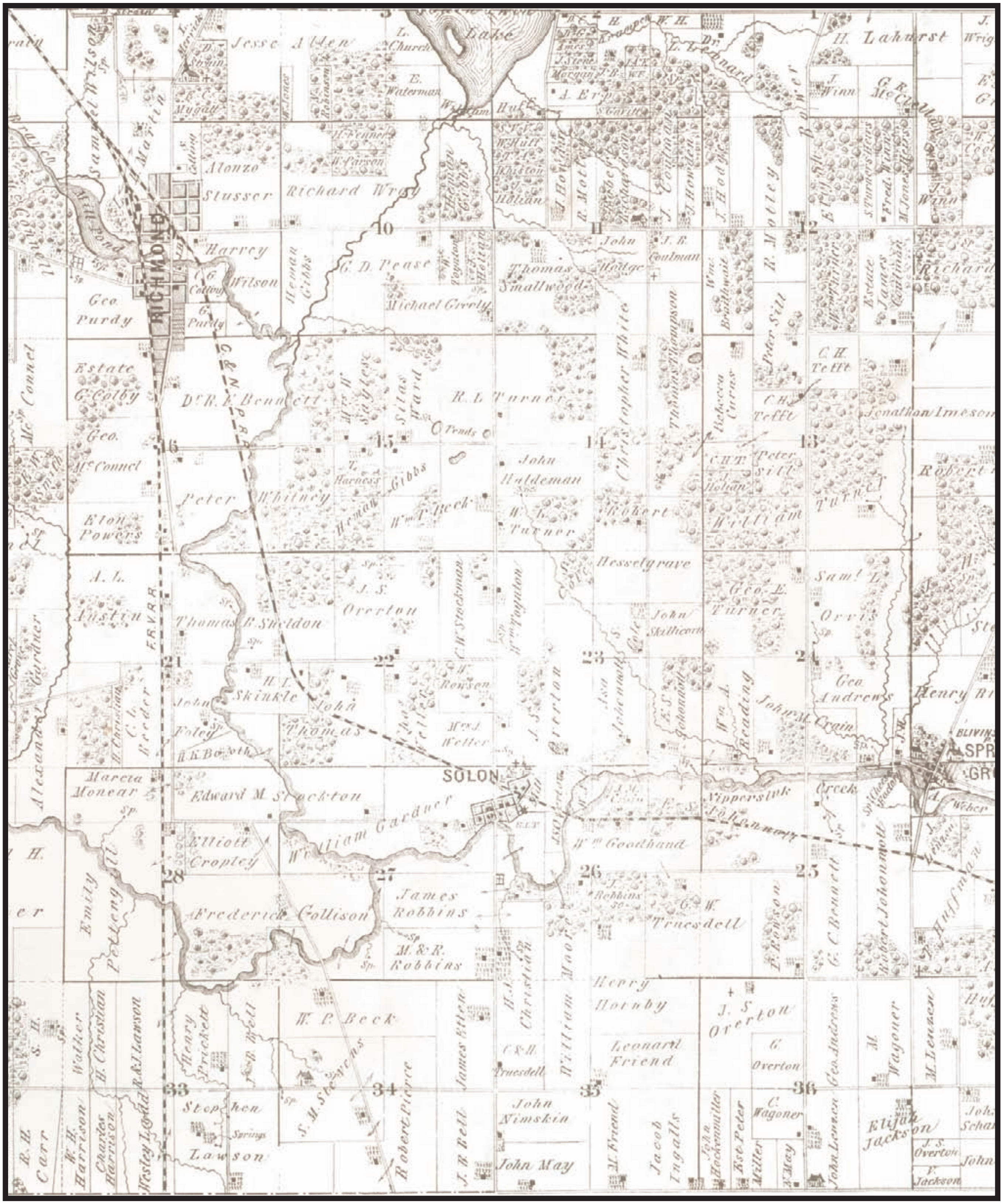
[3]*Discovery Group, Ltd., Madison, Wisconsin and Blue Water Science, St. Paul, Minnesota,* Lake Management Plan, Twin Lakes Protective and Rehabilitation District, Twin Lakes, Wisconsin, *Revised, February 18, 1993.*

Map 10

HISTORICAL PLAT MAP FOR THE TWIN LAKES AREA: 1872

Source: Edmund M. Harney, Map of Racine and Kenosha County, Wisconsin, 1872.

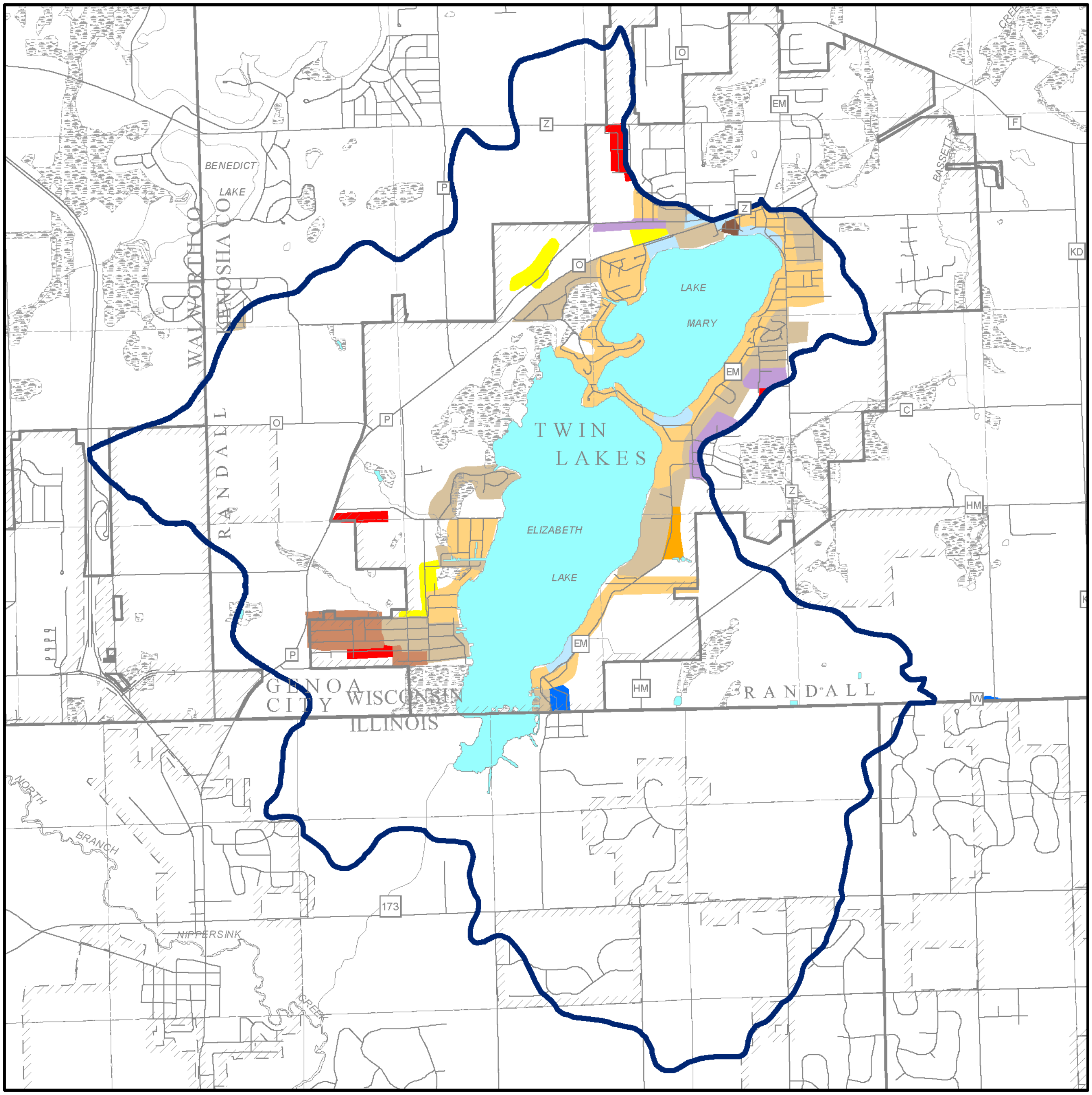
Map 10 (continued)



Source: McHenry County, Illinois, 1872.

Map 11

HISTORICAL URBAN GROWTH WITHIN THE TWIN LAKES TRIBUTARY AREA



1900		1975	
1920		1980	
1950		1990	
1963		1995	
1970		2000	
		SURFACE WATER	

N

0 2,000 4,000 Feet

NOTE: This information is not available in Illinois.

Source: SEWRPC.

Table 7

EXTENT OF HISTORICAL URBAN GROWTH IN THE TOTAL TRIBUTARY AREA OF TWIN LAKES IN WISCONSIN: 1900-2000

Year	Tributary Area: Extent of New Urban Development Occurring Since Previous Period (acres)[a]	Tributary Area: Cumulative Extent of Urban Development (acres)[a]
1900	4	4
1920	37	41
1950	357	703
1963	305	1,008
1970	57	1,065
1975	43	1,108
1980	10	1,118
1990	38	1,156
1995	11	1,167
2000	32	1,199

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

Source: SEWRPC.

Under planned year 2035 conditions, as shown on Map 13, the trend toward even more intensive urban land usage in southeastern Wisconsin is expected to be reflected also in the area tributary to the Twin Lakes.[4] Much of this development is expected to occur as agricultural lands continue to be converted to urban lands, primarily for residential use. Within the area of Wisconsin tributary to the Lakes, urban residential land uses are expected to increase by about 725 acres, to about 1,436 acres, or approximately 28 percent, of the Lakes' tributary area, as shown in Table 8. If this trend continues, some of the open space areas remaining in the tributary area are likely to be replaced with large-lot urban residential development, resulting in the potential for increased pollutant loadings to the Lakes. This continuing development could occur in the form of residential clusters on smaller lots within conservation subdivisions, thereby preserving portions of the remaining open space and, thus, reducing the impacts on the Lakes.[5]

Certain other lands immediately surrounding the Lakes, together with connected areas containing a concentration of high-value woodlands, wetlands, and wildlife habitat areas as described in Chapter V of this report, have been designated as environmental corridor lands in the adopted regional land use and regional natural areas and critical species habitat protection and management plans, and are recommended to be preserved in essentially natural, open space uses. These lands and associated open space areas are essential to maintaining the ambience of the Twin Lakes area and its lake-oriented community.

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 area tributary to the Twin Lakes includes portions of the Town of Bloomfield and the Village of Genoa City, in Walworth County; the Town of Randall and the Village of Twin Lakes, in Kenosha County; and, the Town of Burton and Villages of Richmond and Spring Grove, in McHenry County. Table 10 shows the land use regulations adopted and in use in the various civil divisions within the total area tributary to the Twin Lakes.

General Zoning

Villages in Wisconsin are granted comprehensive, or general, zoning powers under Section 61.35 of the *Wisconsin Statutes*. Counties are granted general zoning powers within their unincorporated areas under Section 59.69 of the *Wisconsin Statutes*. However, a county zoning ordinance becomes effective only in those towns that

---

[4]*SEWRPC Planning Report No. 48, op. cit.; see also Mid-America Planning Services, Inc.,* Town of Randall and Village of Twin Lakes—Smart Growth Comprehensive Plan: 2005-2024*, March 2005.*

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

Table 8

EXISTING AND PLANNED LAND USE WITHIN THE AREA TRIBUTARY TO TWIN LAKES IN WISCONSIN: 2000 AND 2035

	2000		2035	
Land Use Categories[a]	Acres	Percent of Total	Acres	Percent of Total
Urban				
Residential	711	13.7	1,436	27.6
Commercial	25	0.5	44	0.8
Industrial	7	0.1	136	2.6
Governmental and Institutional	22	0.4	126	2.4
Transportation, Communication, and Utilities	308	5.9	508	9.8
Recreational	72	1.4	92	1.8
Subtotal	1,145	22.0	2,342	45.0
Rural				
Agricultural and Other Open Lands	2,514	48.3	1,317	25.3
Wetlands	238	4.6	238	4.6
Woodlands	281	5.4	281	5.4
Water	1,022	19.7	1,022	19.7
Extractive	- -	- -	- -	- -
Landfill	- -	- -	- -	- -
Subtotal	4,055	78.0	2,858	55.0
Total	5,200	100.0	5,200	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

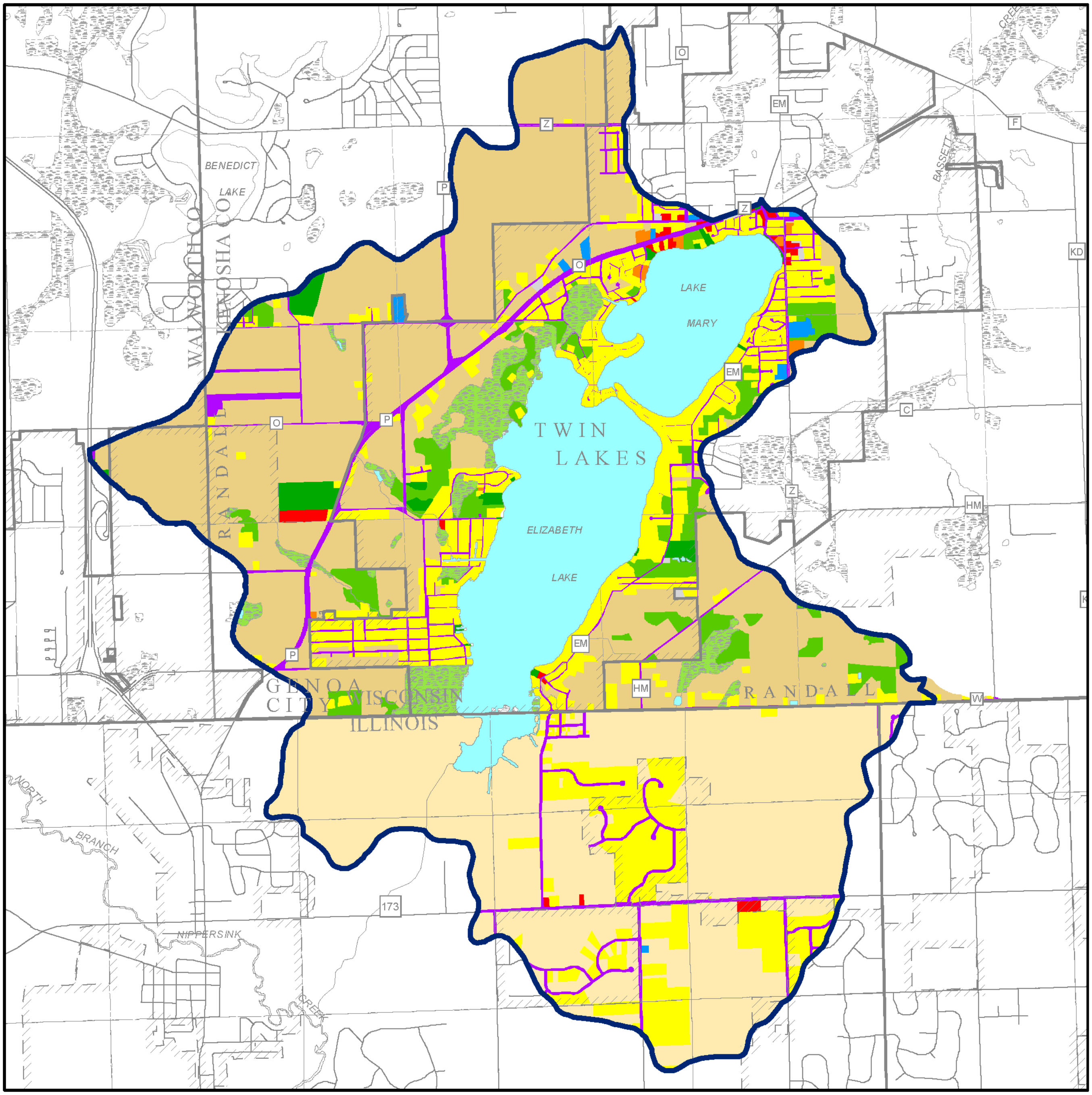
ratify the county ordinance. Towns that have not adopted a county zoning ordinance may adopt village powers, and subsequently utilize the village zoning authority conferred in Section 60.22(3), subject, however, to county board approval where a general-purpose county zoning ordinance exists. Alternatively, a town may adopt a zoning ordinance under Section 60.61 of the *Wisconsin 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.

In Illinois, villages are granted general zoning powers pursuant to the Illinois Municipal Code, Chapter 65 of the *Illinois Compiled Statutes*, Act 5, Article 11, Division 30, “General Regulatory Powers”—65 ILCS 5/Art. 11 Div. 30. Counties also are granted general zoning powers within unincorporated areas under the Counties Code, Chapter 55 of the *Illinois Compiled Statutes*, Act 5, Article 5, Division 5-12, “Zoning”—55 ILCS 5/Div. 5-12. Townships are governed pursuant to the Township Code, Chapter 60 of the *Illinois Compiled Statutes*, Act 1—60 ILCS 1/Art. 1. Zoning authority may be conveyed to Townships in which the electors of the township, at an annual or special township meeting, authorize the township board to exercise such powers, under authorities granted in Article 110, “Township Zoning”—60 ILCS 1/Art. 110. In the absence of such action by the electors of the township, county zoning is applicable to those portions of a county that lie outside the corporate limits of cities, villages, and incorporated towns that have municipal zoning ordinances in effect.

Kenosha and Walworth counties have both adopted their own general zoning ordinances, as have the Villages of Twin Lakes and Genoa City. The Town of Randall in Kenosha County and the Town of Bloomfield in Walworth County have each adopted their respective County’s general zoning ordinances. Similarly, McHenry County has adopted a general zoning ordinance, as have the Villages of Richmond and Spring Grove. The Town of Burton is governed by the McHenry County zoning code.

Map 12

EXISTING LAND USE WITHIN THE TWIN LAKES TRIBUTARY AREA: 2000



SINGLE-FAMILY RESIDENTIAL

MULTI-FAMILY RESIDENTIAL

COMMERCIAL

INDUSTRIAL

TRANSPORTATION, COMMUNICATIONS, AND UTILITIES

GOVERNMENT AND INSTITUTIONAL

RECREATION

WETLANDS AND WOODLANDS

SURFACE WATER

AGRICULTURAL, UNUSED, AND OTHER OPEN LANDS

AGRICULTURAL, UNUSED, OTHER OPEN LANDS, WETLANDS, AND WOODLANDS IN ILLINOIS

N

0 2,000 4,000 Feet

Source: McHenry County, Illinois and SEWRPC.

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 one-percent-annual-probability (100-year recurrence interval) flood event. 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 one-percent-annual-probability peak flood flow. Local regulations also must restrict filling and development within the flood fringe, which is that portion of the floodplain located outside the floodway that would be covered by floodwater during the one-percent-annual-probability flood. Permitting the filling and development of the flood fringe area, however, reduces the floodwater storage capacity of the natural floodplain, and may thereby increase downstream flood flows and stages. It should be noted that towns may enact floodland zoning regulations which may be more restrictive than those in the county shoreland and floodland zoning ordinances.

Table 9

EXISTING LAND USE WITHIN THE TOTAL AREA TRIBUTARY TO TWIN LAKES: 2000

Land Use Categories[a]	2000 Acres	2000 Percent of Total
Urban		
Residential	1,125	15.0
Commercial	27	0.3
Industrial	7	0.1
Governmental and Institutional	36	0.5
Transportation, Communication, and Utilities	380	5.1
Recreational	71	0.9
Subtotal	1,646	21.9
Rural		
Agricultural and Other Open Lands	4,288	57.0
Wetlands	238	3.2
Woodlands	281	3.7
Water	1,071	14.2
Extractive	- -	- -
Landfill	- -	- -
Subtotal	5,878	78.1
Total	7,524	100.0

[a] *Parking included in associated use.*

Source: SEWRPC

In Illinois, Section 55 ILCS 1/5-12003 of the Counties Code allows designation of “special flood hazard areas” within the territory of a county with a population in excess of 500,000 and fewer than 3 million inhabitants, and outside any city, village or incorporated town. Ordinances adopted under this section can limit the placement of fill and authorize the removal of any fill previously placed in areas affected by stormwater, in order to lessen or avoid any threat to the public health, safety or welfare and damage to property. Likewise, the Municipal Code authorizes incorporated municipalities, such as villages, to adopt ordinances to reduce or avoid hazards to persons and damage to property resulting from flooding pursuant to Section 65 ILCS 5/11-30-2. Paragraph 60 ILCS 1/110-10(a)(3) of the Township Zoning Code allows township boards to establish building and setback lines on or along, among others, storm or floodwater runoff channels and basins outside of the area that is subject to a municipal zoning ordinance.

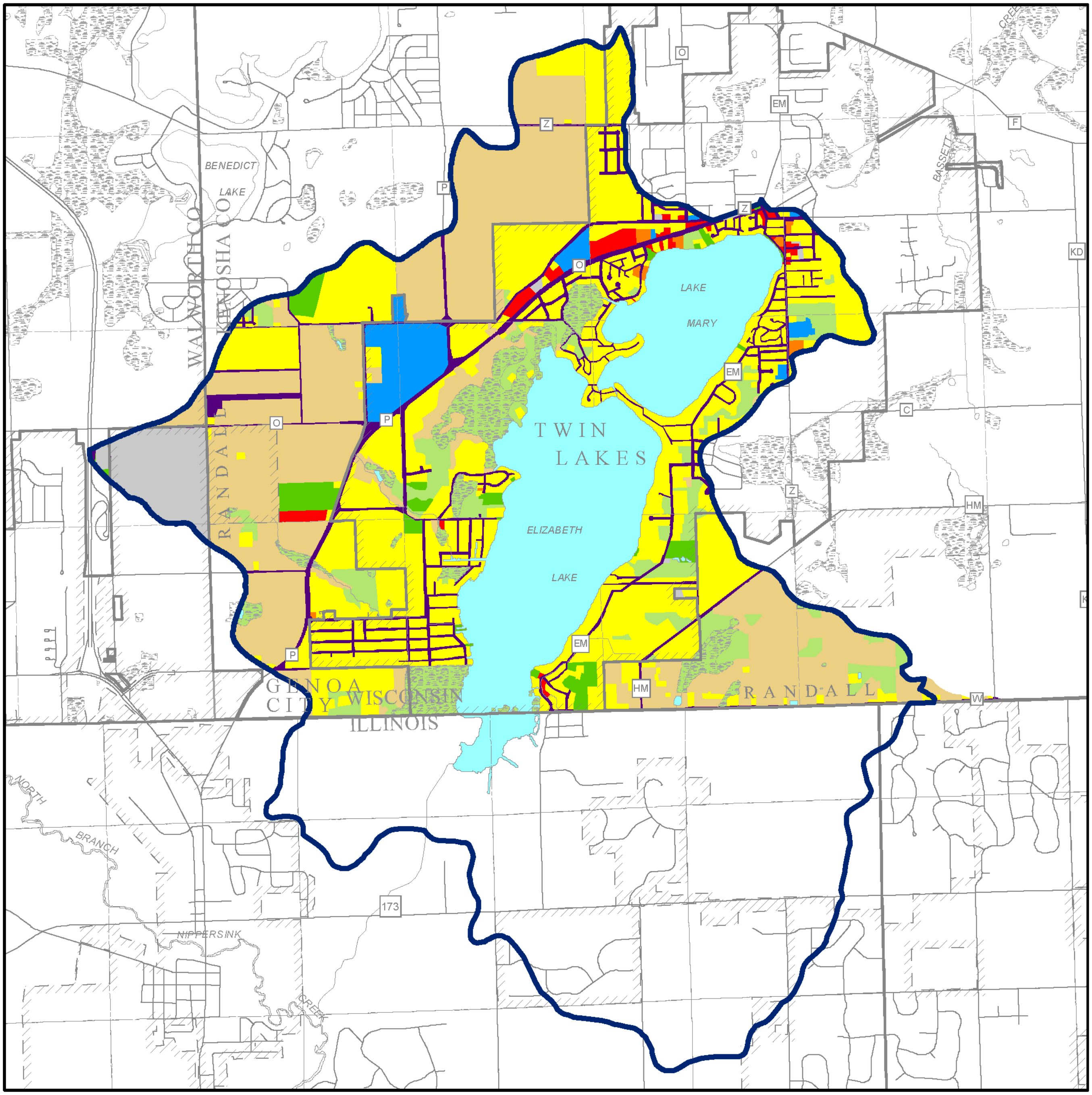
Within the area tributary to the Twin Lakes, Kenosha and Walworth counties have each adopted a countywide floodland zoning ordinance, the Towns of Randall and Bloomfield have adopted their County’s floodland zoning ordinance, and the Villages of Twin Lakes and Genoa City have adopted their own floodland zoning ordinances, as shown in Table 10. McHenry County and the Villages of Richmond and Spring Grove have incorporated floodland zoning provisions within their general zoning codes. The Town of Burton is subject to the County zoning code.

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

Map 13

PLANNED LAND USE WITHIN THE TWIN LAKES TRIBUTARY AREA: 2035



SINGLE-FAMILY RESIDENTIAL

MULTI-FAMILY RESIDENTIAL

COMMERCIAL

INDUSTRIAL

TRANSPORTATION, COMMUNICATIONS, AND UTILITIES

GOVERNMENT AND INSTITUTIONAL

RECREATION

WETLANDS AND WOODLANDS

SURFACE WATER

AGRICULTURAL, UNUSED, AND OTHER OPEN LANDS

N

0 2,000 4,000 Feet

NOTE: This information is not available in Illinois.

Source: SEWRPC.

Table 10

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO THE TWIN LAKES BY CIVIL DIVISION: 2000

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
McHenry County (IL)	Adopted	Adopted	Adopted	Adopted	Adopted
Town of Burton	County ordinance	County ordinance	County ordinance	County ordinance	County ordinance
Village of Richmond	Adopted	Adopted	Adopted	Adopted	Adopted
Village of Spring Grove	Adopted	Adopted	Adopted	Adopted	Adopted
Kenosha County (WI)	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Adopted	None
Town of Randall	County ordinance	County ordinance	County ordinance	Adopted	None
Village of Twin Lakes	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Adopted	Adopted
Walworth County (WI)	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Adopted	Adopted
Town of Bloomfield	County ordinance	County ordinance	County ordinance	County ordinance	County ordinance
Village of Genoa City	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Adopted	Adopted

Source: SEWRPC.

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, lagooning, dredging, ditching, and excavating that must be incorporated into county shoreland zoning regulations. In addition, Chapter NR 115, as recodified in 1980, requires that counties place all wetlands 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 WDNR.

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 of this report.

In Illinois, Section 55 ILCS 5/5-12001 of the Counties Code allows regulation of the placement of structures on or along, among others, storm or floodwater runoff channels and basins. Likewise, the Municipal Code authorizes incorporated municipalities to adopt ordinances to reduce or avoid hazards to persons and damage to property resulting from flooding pursuant to Section 65 ILCS 5/11-30-2. Paragraph 60 ILCS 1/110-10(a)(3) of the

Township Zoning Code allows township boards to establish building and setback lines on or along, among others, storm or floodwater runoff channels and basins outside of the area that is subject to a municipal zoning ordinance.

Within the area tributary to the Twin Lakes, Kenosha and Walworth Counties have each adopted a countywide shoreland zoning ordinance, the Towns of Randall and Bloomfield have adopted their County's shoreland zoning ordinance, and the Villages of Twin Lakes and Genoa City have adopted their own shoreland zoning ordinances, as shown in Table 10. McHenry County and the Villages of Richmond and Spring Grove have incorporated shoreland zoning provisions within their general zoning codes. The Town of Burton is subject to the County zoning code.

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 *Wisconsin 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 *Wisconsin 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, pursuant to Section 62.23(7a) of the *Wisconsin Statutes*. 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.

In Illinois, subdivisions are treated as any other land development activity and are regulated under the general zoning powers of municipalities and counties, pursuant to Section 65 ILCS 5/11-13-1 of the Municipal Code and Section 55 ILCS 5/5-12001 of the Counties Code.

Within the area tributary to the Twin Lakes, Kenosha and Walworth Counties have each adopted a countywide subdivision zoning ordinance, the Town of Bloomfield has adopted the Walworth County ordinance, and the Town of Randall and the Villages of Twin Lakes and Genoa City have each adopted their own subdivision ordinances. McHenry County has adopted a subdivision ordinance, and the Villages of Richmond and Spring Grove have incorporated subdivision regulations within their general zoning codes. The Town of Burton is subject to the County subdivision ordinance.

Construction Site Erosion Control and Stormwater Management Regulations

Section 62.234 of the *Wisconsin Statutes* grants authority to cities and Section 61.354 of the *Wisconsin Statutes* grants authority to villages in Wisconsin to adopt ordinances for the prevention of erosion from construction sites and the management of stormwater runoff from lands within their jurisdiction. Towns may adopt village powers and subsequently utilize the authority conferred under Section 60.627 of the *Wisconsin Statutes* to adopt their own erosion control and stormwater management ordinances, subject to county board approval where a county ordinance exists.

The administrative rules for the State stormwater discharge permit program are set forth in Chapter NR 216 of the *Wisconsin Administrative Code*, which initially took effect on November 1, 1994, and was most recently recreated effective from August 1, 2004. Within the area tributary to the Twin Lakes, Kenosha County, the Town of Randall, and the Village of Twin Lakes have been identified by the WDNR as being in urbanized areas that have been, or will be, required to obtain stormwater discharge permits unless they receive exemptions.

Through 1997 Wisconsin Act 27, the State Legislature required the WDNR and the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) to develop performance standards for controlling nonpoint source pollution from agricultural and nonagricultural land and from transportation facilities.[6] Chapter NR 216 of the *Wisconsin Administrative Code* identifies several categories of municipalities, industries, and construction sites that must obtain permits. The permit requirements are based on the performance standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code*, which became effective on October 1, 2002, and were revised in July 2004.

Agricultural Performance Standards
Agricultural performance standards cover the following areas:

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

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

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

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

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

Chapter NR 151 requires municipalities with Wisconsin Pollutant Discharge Elimination System (WPDES) stormwater discharge permits to reduce the amount of total suspended solids in stormwater runoff from areas of existing development that were in place as of October 2004 to the maximum extent practicable, with a 20 percent reduction to have been achieved by March 10, 2008, and a 40 percent reduction to be achieved by October 1, 2013.

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

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

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

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

Within the Wisconsin portion of the area tributary to the Twin Lakes, Walworth County has adopted its own countywide erosion control and stormwater management ordinances and the Villages of Twin Lakes and Genoa City have each adopted their own construction site erosion control and stormwater management ordinances. The Town of Bloomfield has adopted construction site erosion control and stormwater management ordinances by reference to the Walworth County ordinances. Kenosha County and the Town of Randall, as of this printing, have not yet adopted erosion control or stormwater management ordinances. Notwithstanding, Kenosha County undertakes stormwater and erosion control review as an element of the subdivision or condominium development process, or, more generally, as part of any project that requires a site plan review.

The Walworth 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 4,000 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*[7] or equivalent practices. In general, these practices are designed to minimize soil loss from disturbed sites through prior planning and phasing of land disturbing activities and use of appropriate onsite erosion control measures.

The Walworth County stormwater management ordinance applies to residential lands of five acres or more in areal extent, residential lands where there is at least 1.5 acres of impervious surface, nonresidential lands of 2.0 acres in areal extent where there is at least 1.0 acre of impervious surface, or other lands on which development activities may result in stormwater runoff likely to harm public property or safety. The stormwater management ordinance establishes performance standards to manage both rate and volume of stormwater flows from regulated sites and water quality. Performance standards adopted in this ordinance and the resultant design of appropriate management practices are based on calculation procedures and principles set forth in *Urban Hydrology for Small Watersheds*.[8]

In Illinois, authority to regulate stormwater runoff and construction site erosion within villages is granted pursuant to the general zoning powers set forth in 65 ILCS 5/Art. 11 Div. 30. The Villages of Richmond and Spring Grove have incorporated construction site erosion control and stormwater management regulations within their general zoning codes. Chapter 30, Stormwater Management, of the *Richmond Village Code*, Ordinance 2005-10 sets forth requirements for stormwater management within the Village. In the Village of Spring Grove, stormwater management is required within subdivisions and requires a permit to be issued pursuant to Chapter 16, Subdivision Control Ordinance, of the *Municipal Code of the Village of Spring Grove*. Counties also are granted authority to regulate stormwater runoff and construction site erosion pursuant to their general zoning powers in unincorporated areas set forth in 55 ILCS 5/Div. 5-12. McHenry County has adopted a stormwater management ordinance, inclusive of construction site erosion controls and requirements for established areas within its jurisdiction. The Town of Burton is subject to the County zoning code.

The McHenry County stormwater management ordinance gives administrative effect to the adopted McHenry County *Comprehensive Stormwater Management Plan*. It sets forth the minimum requirements for watershed development within McHenry County, and is implemented by the McHenry County Stormwater Committee, a corporate enforcement authority. The ordinance requires the issuance of a County stormwater management permit prior to the finalization of a plat, replat, planned development, planned unit development, or manufactured home park site plan within the County. These requirements are applicable to any development which, among other actions: results in an additional 5,000 square feet of impervious area from the original effective date of the ordinance (January 20, 2004); hydrologically disturbs 5,000 square feet or more; affects an area in excess of 500 square feet if the activity is within 25 feet of a lake, pond, stream, or wetland; or, any excavation, fill, or combination of excavation and placement of fill that exceeds 100 cubic yards. The ordinance establishes performance standards for water quality protection, requiring the implementation of appropriate stormwater management measures and buffer areas adjacent to the waters of the United States and wetlands within the County. The ordinance also requires construction site erosion controls to be placed and sets minimum standards for the design of stormwater management structures and facilities.

---

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

[8]*U.S. Department of Agriculture Technical Release 55,* Urban Hydrology of Small Watersheds*, June 1992.*

This Page Intentionally Left Blank

Chapter IV

WATER QUALITY

INTRODUCTION

Prior to 1969, there were only limited data on the water quality of Lake Mary and Elizabeth Lake. In 1969, the Wisconsin Department of Natural Resources (WDNR) published a lake use report on Elizabeth Lake that contained water quality data from the mid-1960s.[1] A similar report on Lake Mary [Marie Lake] was published in 1970 by the WDNR.[2] These reports described Lake Mary as a dimictic—mixing top-to-bottom two times per year in spring and autumn, moderately alkaline waterbody with low levels of nutrient enrichment and good water clarity. Elizabeth Lake was described in a similar manner, although Elizabeth Lake was noted as having a moderate level of enrichment based upon measured in-lake phosphorus concentrations.

During 1976 and 1977, the Twin Lakes Protection and Rehabilitation District (TLPRD) undertook a one-year feasibility study of the Twin Lakes that included groundwater flow monitoring, in-lake sampling, and acquisition of data on the tributary area to the Lakes.[3] These data were utilized in the 1980 report on lake management alternatives published by the WDNR Office of Inland Lake Renewal.[4] Due to lack of funding for the implementation of the recommended management actions, few of the recommended measures set forth in this plan were carried out, although limited dredging projects, funded privately, were implemented in accordance with the management plan during the late 1980s. These projects were documented in the initial lake management plan for the Twin Lakes.[5] This plan was developed for the TLPRD during 1993 by a private contractor, based upon water quality and other data collected during 1991, as well as data from previous reports dating back to 1951.[6]

---

[1]*Wisconsin Department of Natural Resources Lake Use Report No. FX-7,* Elizabeth Lake, Kenosha County, Wisconsin, *1969.*

[2]*Wisconsin Department of Natural Resources Lake Use Report No. FX-17,* Marie *[sic]* Lake, Kenosha County, Wisconsin, *1970.*

[3]*Aqua-Tech, Inc., and Twin Lakes Protection and Rehabilitation District,* Fourth Quarterly Report, *1978.*

[4]*Wisconsin Department of Natural Resources, Office of Inland Lake Renewal,* Twin Lakes, Mary and Elizabeth, Feasibility Study Results; Management Alternatives, *1980.*

[5]*Discovery Group, Ltd., Madison, Wisconsin, and Blue Water Science, St. Paul, Minnesota,* Lake Management Plan, Twin Lakes Protective *[sic]* and Rehabilitation District, Twin Lakes, Wisconsin, *Revised, February 18, 1993.*

[6]Ibid.

More recently, water chemistry data on the Twin Lakes have been collected under the auspices of various WDNR programs: the WDNR Self-Help Monitoring Program (now the University of Wisconsin-Extension Citizen Lake Monitoring Network) in 1987 and again from 1991 through 2006, and the WDNR Base Line Monitoring Program between 1999 and 2006. The U.S. Geological Survey (USGS) undertook water quality sampling of the Twin Lakes between 1995 and 1997. The USGS Trophic State Index (TSI) monitoring program included the determination of the physical and chemical characteristics of the Lakes' waters, including measurements of dissolved oxygen concentrations, water temperature, pH, specific conductance, water clarity, nutrient concentrations, and chlorophyll-*a* concentrations. This data set represents the most current and comprehensive water quality analysis of Lake Mary and Elizabeth Lake performed to date. These data are discussed further below.

EXISTING WATER QUALITY CONDITIONS

Water quality data gathered by USGS during the period from 1995 through 1997, along with various data gathered under the auspices of the abovementioned WDNR programs, were used to assess lake water quality in the Twin Lakes during the current study. Water quality samples generally were taken seasonally from the main basins of the Lakes at locations shown on Map 14. These locations coincided with the deepest portions of the lake basins, the so-called "deep holes."

Thermal Stratification

Thermal stratification, illustrated diagrammatically in Figure 4, is the result of differential heating of the lake water, and the resulting water temperature-density relationships at various depths within the lake water column. Water is unique among liquids because it reaches its maximum density, or mass per unit of volume, at about 39 degrees Fahrenheit (°F) or 4 degrees Celsius (°C). 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 the Twin Lakes is described below.

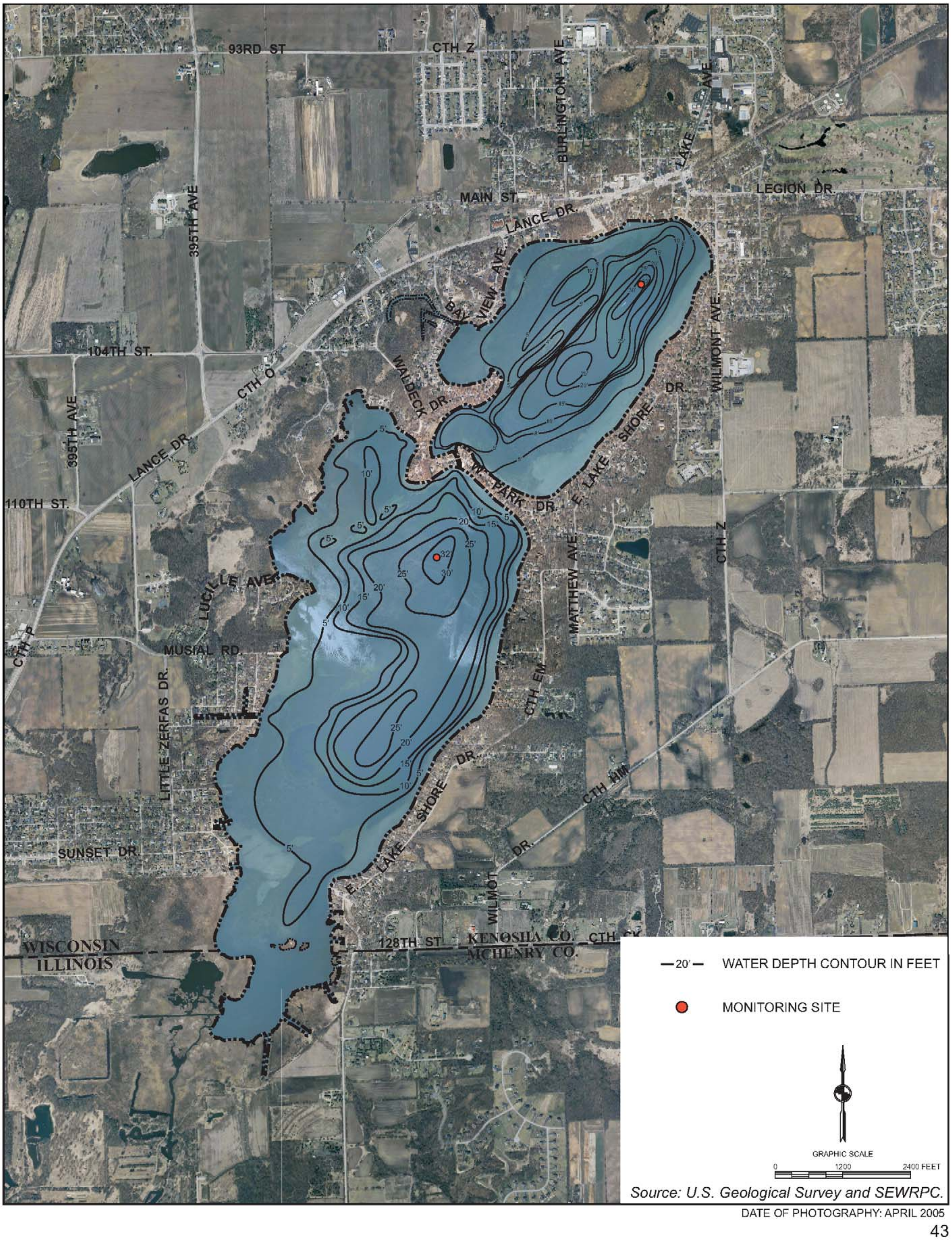
As summer begins, the Lakes absorb solar energy at the surface. Wind action and, to some extent, internal heat transfer mechanisms transmit this energy to the underlying portions of the waterbody. As the upper layer of water is heated by solar energy, a physical barrier, created by differing water densities between warmer and cooler water, begins to form between the warmer surface water and the colder, heavier bottom water, as shown in Figure 5. This "barrier" is marked by a sharp temperature gradient known as the thermocline (also called the metalimnion) and is characterized by a 1 degrees Celsius (°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.

Data from the aforereferenced lake reports, together with USGS data for the current study period of 1995 to 1997, indicate that both Lake Mary and Elizabeth Lake appear to thermally stratify during summer at a depth of about 20 feet to 25 feet. The epilimnion—or surface water layer—extends from the surface to a depth of about 15 feet, the thermocline—or metalimnion or zone of transition—extends from a depth of about 15 feet to about 25 feet, and the hypolimnion—or bottom water layer—extends from about the 25 foot depth to the bottom, as indicated in the thermal profiles shown in Figures 6 and 7. During the current study period, summer water temperatures in both of the Twin Lakes reached a maximum of 82.4°F at the surface, while bottom-water temperatures remained low, 58.1°F in Lake Mary and 57.2°F in Elizabeth Lake. The surface water temperatures of the Lakes during this period are consistent with the maxima recorded during the earlier lake studies.

The autumnal mixing period occurs when air temperatures cool the surface waters and wind action results in the erosion of the thermoclines: 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

Map 14

LOCATION OF WATER QUALITY SAMPLING SITES ON LAKE MARY AND ELIZABETH LAKE: 1995-1997

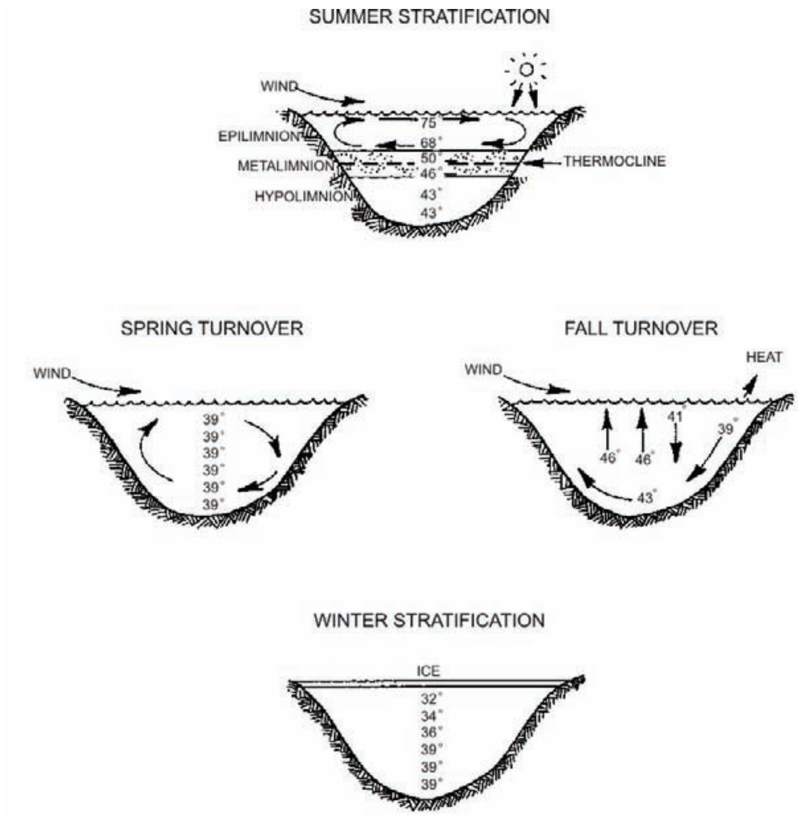


Source: U.S. Geological Survey and SEWRPC.

DATE OF PHOTOGRAPHY: APRIL 2005

Figure 4

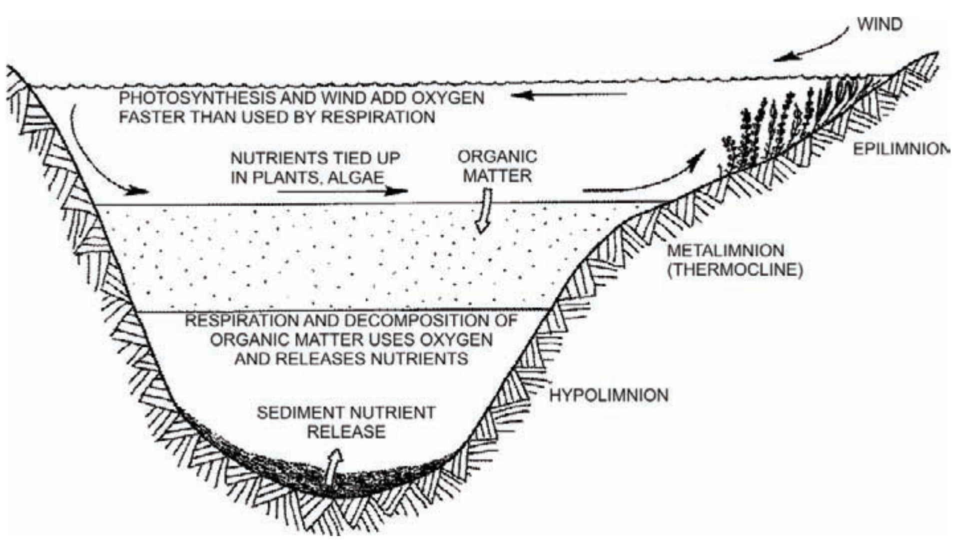
THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

Figure 5

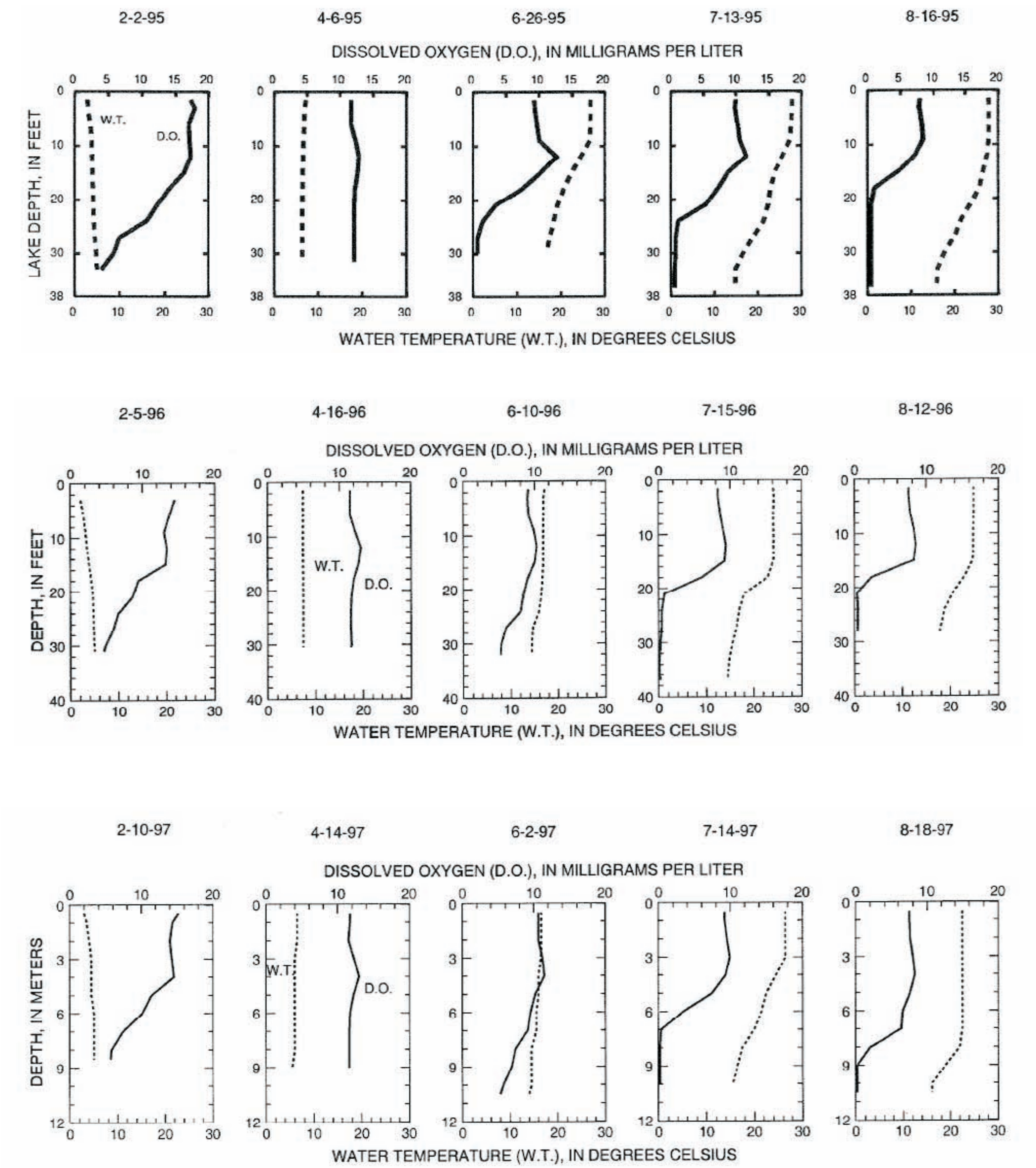
LAKE PROCESSING DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

Figure 6

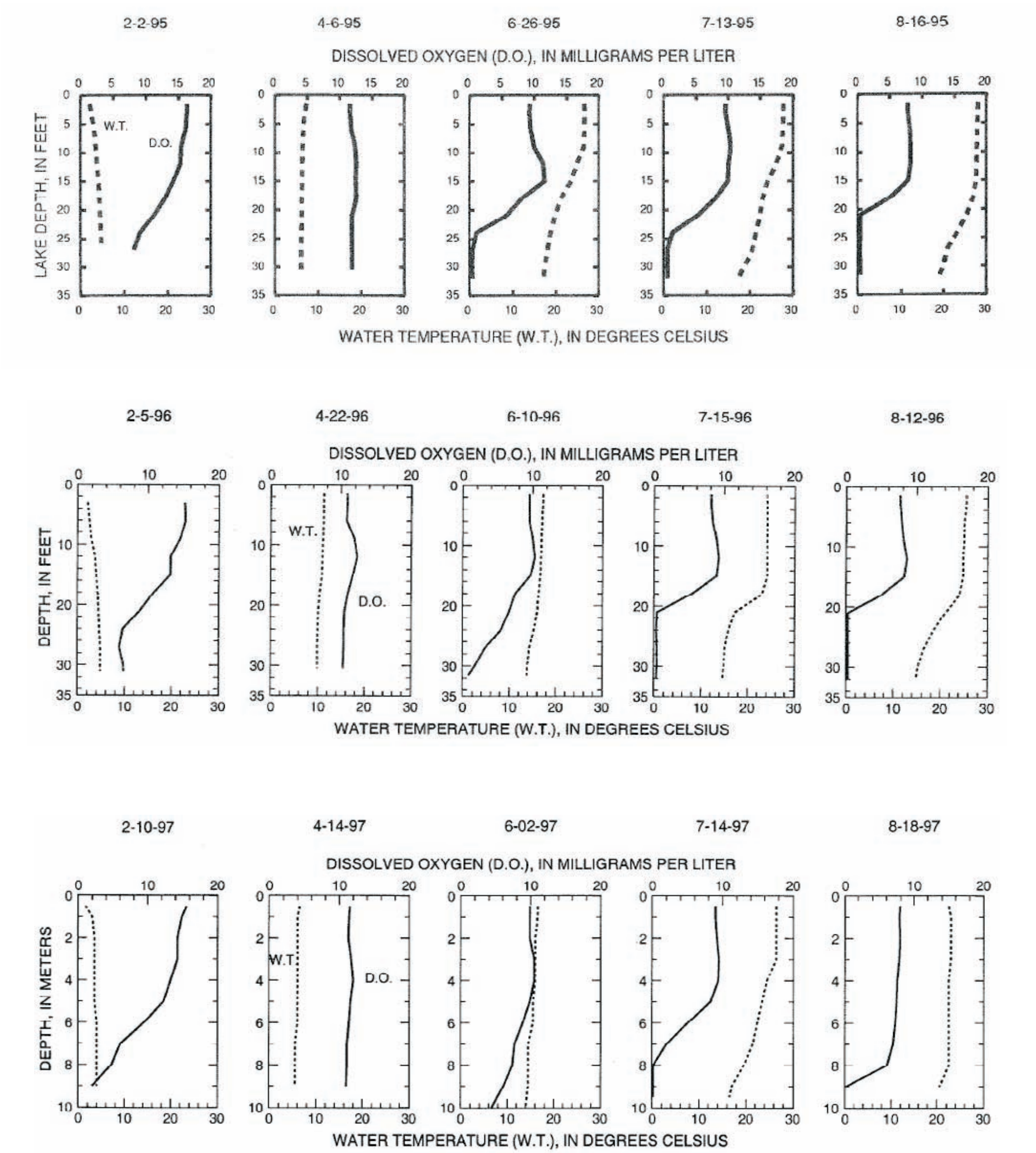
DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR LAKE MARY: 1995-1997



Source: U.S. Geological Survey and SEWRPC.

Figure 7

DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR ELIZABETH LAKE: 1995-1997



Source: U.S. Geological Survey and SEWRPC.

as "fall turnover." Thermal profiles for both the Twin Lakes indicate that this event occurs generally by about mid-September.

From fall turnover until freeze-up, surface waters continue to cool in response to the declining ambient air temperatures. Once the temperature of the water at the surface drops to this point of maximum water density, these waters will now have become denser than the warmer waters below them. As a consequence of this density difference, the surface waters begin to "sink" to the bottom. Eventually, the entire water column is cooled to the point of maximum density. The surface waters continue to cool until they reach about 32°F, and are, once again, less dense than the waters below which remain at about 39°F. At 32°F, the lake surface may become ice covered, isolating the lake water from the atmosphere for a period of up to four months. As shown in Figure 4, winter stratification occurs as the colder, lighter water and ice remains at the surface, separated from the relatively warmer, heavier water near the bottom of the lake. The ice shuts the water column off from the atmospheric source of oxygen.

Spring brings a reversal of the process of lake stratification. Once the surface ice has melted, the upper layer of water continues to warm until it reaches 39°F, the maximum density point of water and, coincidentally, the temperature of the deeper waters below it. At this point, the entire water column is, once again, the same temperature (and density) from surface to bottom and wind action results in a mixing of the entire lake. This is referred to as "spring turnover" and usually occurs within weeks after the ice goes out, as shown in Figure 4. After spring turnover, the water at the surface continues to warm and become less dense, causing it to float above the colder, deeper water. Wind and resulting waves carry some of the energy of the warmer, lighter water to lower depths, but only to a limited extent. Thus, begins the formation of the thermocline and another period of summer thermal stratification.

Thermal profiles for the Twin Lakes are shown in Figures 6 and 7. These data, together with information from the aforereferenced lake studies, indicate that the Twin Lakes are dimictic, which means that they mix completely two times per year. This mixing regime is typical of most of the larger lakes in the Southeastern Wisconsin Region.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem, since most organisms require oxygen to survive. As shown in Figures 6 and 7, during the current study period, dissolved oxygen levels were generally higher at the surface of the Twin Lakes, 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 at the bottoms of the Lakes, where decomposer organisms and chemical oxidation processes utilized oxygen in the decay process. When any lake becomes thermally stratified, as described above, the surface supply of dissolved oxygen to the hypolimnion is cut off. Gradually, if there is not enough dissolved oxygen to meet the total demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced, even to zero, a condition known as anoxia or anaerobiasis, as shown in Figure 5.

Dissolved oxygen profiles during summer stratification in the Twin Lakes showed a pattern of oxygen depletion, leading to anoxia in the hypolimnion during the summer months. Such anoxia was observed during July and August of 1951 and 1977. The anoxic condition was not observed, however, during the studies of 1991 or during the current study period between 1995 and 1997. The reasons for these different observations maybe related to inter-annual variability of wind speeds and directions, the diversion of oxygen demanding substances previously entering the Lakes from wastewater disposal system sources or related sources; and/or other physical-chemical conditions existing in the Lakes during the years prior to the 1980s. In this regard, it should be noted that a public sanitary sewerage system was installed within the Village of Twin Lakes in 1958 and upgraded in 1970;[7] the

---

[7]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000. *Volume One*, Inventory Findings, *September 1978; see also SEWRPC Community Assistance Planning Report No. 149,* Sanitary Sewer Service Area for the Village of Twin Lakes, Kenosha County, Wisconsin*, May 1987, as amended.*

diversion of wastewater from the Lakes—to Bassett Creek—would have reduced the nutrient loads to the Lakes, conveyed organic materials that result in environmental oxygen demand away from the Lakes, and resulted in improved water quality conditions in the Lakes that would limit the production of algae and aquatic plants whose senescence and decay would consume available dissolved oxygen in the bottom waters of the Lakes. Tables 11 and 12 document in-lake total phosphorus concentrations in the Twin Lakes of about 0.015 milligrams per liter (mg/l), which represent a significant reduction in the level of enrichment in the Lakes during the current study period when compared with the concentrations of 0.04 mg/l and greater reported in the 1960s WDNR studies.

Hypolimnetic anoxia is common in many of the deeper lakes in southeastern Wisconsin during summer stratification. The depleted oxygen levels in the hypolimnion cause fish to move upward, nearer to the surface of the lakes, where higher dissolved oxygen concentrations exist. This migration, when combined with temperature, can select against some fish species that prefer the cooler water temperatures that generally prevail in the lower portions of the lakes. When there is insufficient oxygen at these depths, these fish are susceptible to summer-kills, or, alternatively, are driven into the warmer water portions of the lake where their condition and competitive success may be severely impaired. 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 the Twin Lakes is discussed further below.

Fall turnover, between September and October in most years, naturally restores the supply of oxygen to the bottom waters, 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. Under these conditions, anoxia can contribute to the winter-kill of fish. At the end of winter, dissolved oxygen concentrations in the bottom waters of the Lakes were restored during the period of spring turnover, which generally occurs between March and May.

The dissolved oxygen profiles for Lake Mary and Elizabeth Lake for the current study period are shown in Figures 6 and 7. Dissolved oxygen concentrations in the Twin Lakes during winter have only been recorded for the current study period; however, during this period, winter dissolved oxygen concentrations appeared adequate for the support of fish and other aquatic life. Winter dissolved oxygen concentrations in the Lakes were near or above the recommended concentration of 5.0 milligrams per liter (mg/l), the minimum level considered necessary to support many species of fish. Winterkill has not been considered a severe problem in the Twin Lakes.

Specific Conductance

Specific conductance, or the ability of water to conduct an electric current (conductivity), is an indicator of the concentration of dissolved solids in the water; as the amount of dissolved solids increases, the specific conductance increases. As such, specific conductance is often useful as an indication of possible pollution of a lake’s waters. Freshwater lakes commonly have a specific conductance in the range of 10 to 1,000 microSiemens per centimeter (µS/cm), although measurements in polluted waters or in lakes receiving large amounts of land runoff can sometimes exceed 1,000 µS/cm.[8] Additionally, during periods of thermal stratification, specific conductance can increase at the lake bottom due to an accumulation of dissolved materials in the hypolimnion. This is a consequence of the “internal loading” phenomenon noted above.

---

[8]*Deborah Chapman,* Water Quality Assessments, 2nd Edition, *E&FN Spon, 1996.*

Table 11

SEASONAL WATER QUALITY DATA FOR LAKE MARY: 1995-1997

Parameter[a]	Winter (February)		Spring Overturn (April)		Early Summer (June)		Mid- to Late Summer (July and August)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Depth of Sample (feet)	2.0	31	1.5	31	1.5	31	1.5	31
Water Temperature (°F)	36.9	41.0	45.0	43.7	68.4	59.0	78.6	60.4
Secchi Depth (feet)	- -	- -	13.1	- -	11.5	- -	8.2	- -
Dissolved Oxygen	15.7	4.8	11.6	11.8	9.7	3.7	8.4	0.4
Specific Conductance (µS/cm)	657	759	639	645	630	652	620	695
Chloride	- -	- -	74	74	- -	- -	- -	- -
Alkalinity, as CaCO3	- -	- -	187	190	- -	- -	- -	- -
Hardness, as CaCO3	- -	- -	250	250	- -	- -	- -	- -
pH (units)	8.5	7.8	8.5	8.5	8.4	7.9	8.4	7.3
Color (Pt-Co scale)	- -	- -	8.3	8.3	- -	- -	- -	- -
Turbidity (NTU)	- -	- -	0.90	0.90	- -	- -	- -	- -
Chlorophyll-*a* (µg/l)	- -	- -	3.7	- -	5.3	- -	4.0	- -
Nitrogen, total (as N)	- -	- -	0.77	0.74	- -	- -	- -	- -
Nitrogen, NO2+NO3, diss.	- -	- -	0.07	0.07	- -	- -	- -	- -
Nitrogen, ammonia	- -	- -	0.02	0.02	- -	- -	- -	- -
Nitrogen, amm. + org., total	- -	- -	0.70	0.68	- -	- -	- -	- -
Phosphorus, total (as P)	0.009	0.009	0.011	0.010	0.014	0.031	0.012	0.064
Phosphorus, ortho	- -	- -	0.002	0.002	- -	- -	- -	- -
Calcium, diss. (Ca)	- -	- -	38	38	- -	- -	- -	- -
Magnesium, diss. (Mg)	- -	- -	38	38	- -	- -	- -	- -
Sodium, diss. (Na)	- -	- -	35	34	- -	- -	- -	- -
Potassium, diss. (K)	- -	- -	2	2	- -	- -	- -	- -
Sulfate, diss (SO4)	- -	- -	41	41	- -	- -	- -	- -
Fluoride, diss. (F)	- -	- -	0.1	0.1	- -	- -	- -	- -
Silica, diss. (SiO2)	- -	- -	1.4	1.4	- -	- -	- -	- -
Solids, diss. At 180°	- -	- -	358	357	- -	- -	- -	- -
Iron, diss (Fe) (µg/l)	- -	- -	<10	<10	- -	- -	- -	- -
Manganese, diss (Mn) (µg/l)	- -	- -	<0.4	<0.4	- -	- -	- -	- -

[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 quality data for the Twin Lakes showed gradients in conductivity that occurred concurrent with periods of summer thermal stratification during the 1977 study period and again during the current study period. In the 1977 study period, specific conductance in Lake Mary during summer stratification ranged from 580 µS/cm at the surface to 625 µS/cm at the bottom; in Elizabeth Lake, the range was from 500 µS/cm at the surface to 550 µS/cm at the bottom. These values were consistent with measurements collected from the groundwater monitoring sites around the Twin Lakes during that time, which averaged about 603 µS/cm.

During the current study period, conductivity in Lake Mary during summer stratification ranged from an average of about 621 µS/cm at the surface to an average of about 688 µS/cm at the bottom, as shown in Table 11 and illustrated in Figure 8. In Elizabeth Lake, the range was from an average of about 528 µS/cm at the surface to an average of about 594 µS/cm at the bottom, as shown in Table 12 and illustrated in Figure 9. Specific conductance levels in the Twin Lakes during the current study period were considered to be within the normal range for lakes in southeastern Wisconsin.

It is worthy to note that specific conductance measurements in the Twin Lakes, albeit relatively constant over the time period of 1977 to 1991, have since shown a steady increase. Measurements near the surface of Lake Mary were about 570 µS/cm in 1991, about 630 µS/cm in 1997, and about 800 µS/cm in 2004. Although measurements for Elizabeth Lake have not been recorded since 1997, a similar increase between 1991 and 1997 was observed. It is likely that the Elizabeth Lake would have subsequently reflected a pattern similar to that observed in Lake Mary. Increases in specific conductance are consistent with the increasing chloride concentrations observed in the Lakes, as discussed below.

Table 12

SEASONAL WATER QUALITY DATA FOR ELIZABETH LAKE: 1995-1997

Parameter[a]	Winter (February)		Spring Overturn (April)		Early Summer (June)		Mid- to Late Summer (July and August)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Depth of Sample (feet)	2.0	29.2	1.5	30.2	1.5	32.3	1.5	31.0
Water Temperature (°F)	1.8	4.7	8.5	7.2	20.0	15.0	25.9	17.3
Secchi Depth (feet)	- -	- -	8.2	- -	9.5	- -	8.2	- -
Dissolved Oxygen	15.7	5.6	11.3	11.1	9.6	1.9	8.3	0.3
Specific Conductance (µS/cm)	561	607	536	543	543	567	527	598
Chloride (mg/l)	- -	- -	46	46	- -	- -	- -	- -
Alkalinity, as CaCO3	- -	- -	180	177	- -	- -	- -	- -
Hardness, as CaCO3	- -	- -	240	243	- -	- -	- -	- -
pH (units)	8.5	7.8	8.3	8.3	8.4	7.7	8.3	7.3
Color (Pt-Co scale)	- -	- -	10	10	- -	- -	- -	- -
Turbidity (NTU)	- -	- -	1.5	2.0	- -	- -	- -	- -
Chlorophyll-*a* (µg/l)	- -	- -	5.8	- -	5.7	- -	4.6	- -
Nitrogen, total (as N)	- -	- -	0.80	0.86	- -	- -	- -	- -
Nitrogen, NO2+NO3, diss.	- -	- -	0.13	0.13	- -	- -	- -	- -
Nitrogen, ammonia	- -	- -	0.06	0.06	- -	- -	- -	- -
Nitrogen, amm. + org., total	- -	- -	0.67	0.73	- -	- -	- -	- -
Phosphorus, total (as P)	- -	- -	0.013	0.015	0.014	0.043	0.011	0.066
Phosphorus, ortho	- -	- -	0.001	0.001	- -	- -	- -	- -
Calcium, diss. (Ca)	- -	- -	38	39	- -	- -	- -	- -
Magnesium, diss. (Mg)	- -	- -	35	35	- -	- -	- -	- -
Sodium, diss. (Na)	- -	- -	20	20	- -	- -	- -	- -
Potassium, diss. (K)	- -	- -	2	2	- -	- -	- -	- -
Sulfate, diss (SO4)	- -	- -	36	36	- -	- -	- -	- -
Fluoride, diss. (F)	- -	- -	0.1	0.1	- -	- -	- -	- -
Silica, diss. (SiO2)	- -	- -	1.5	1.7	- -	- -	- -	- -
Solids, diss. At 180°	- -	- -	309	308	- -	- -	- -	- -
Iron, diss (Fe) (µg/l)	- -	- -	<10	<10	- -	- -	- -	- -
Manganese, diss (Mn) (µg/l)	- -	- -	<0.4	<0.4	- -	- -	- -	

[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.

Chloride

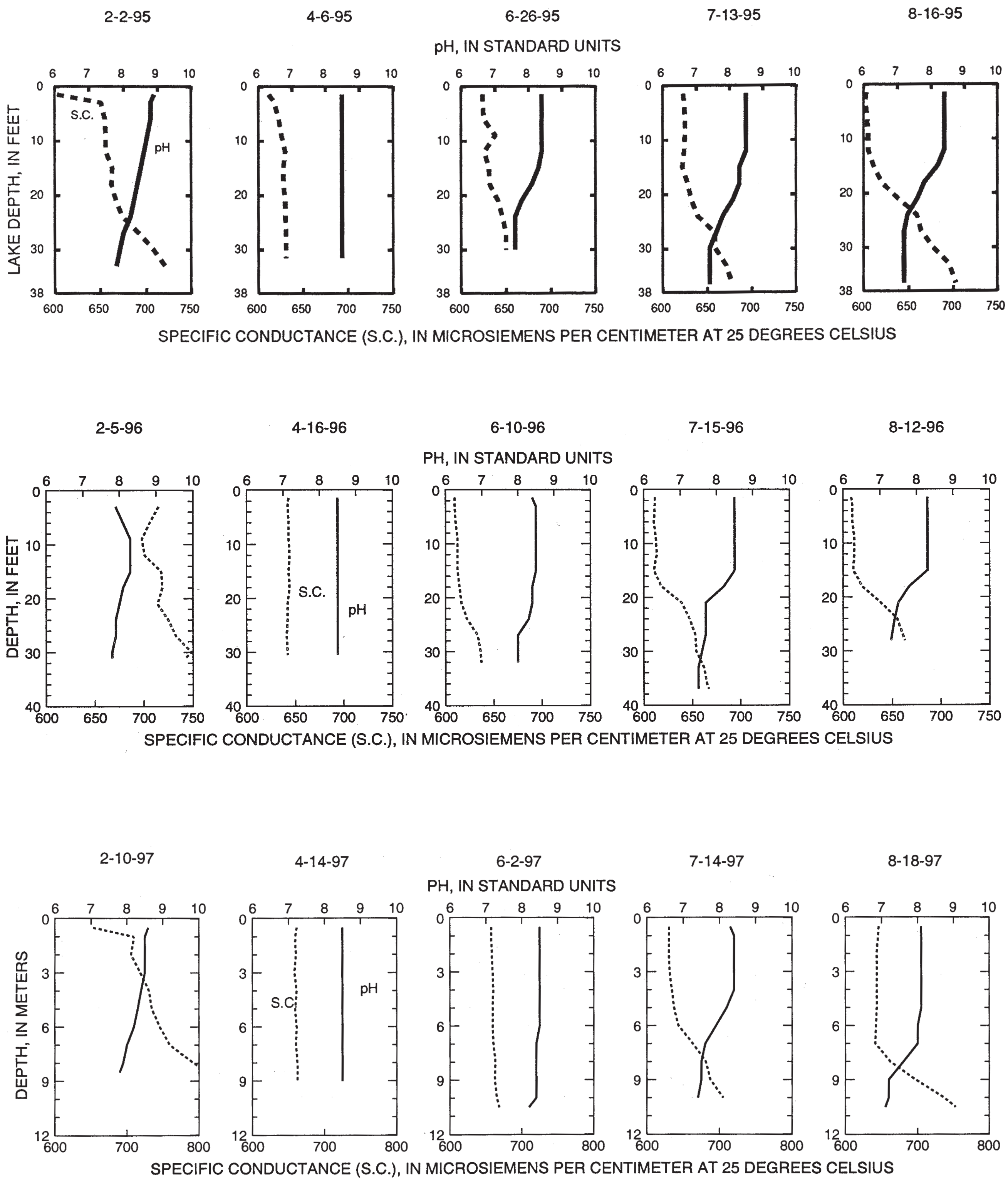
Areawide increases in specific conductance over the years appear to be associated with similar increases in the chloride component of sodium chloride (salt). Long-term continued increases of specific conductance can serve as an indicator of increased chloride concentrations and concentrations of other pollutants in the Region's lakes, with concomitant deleterious effects on the plants and animals inhabiting those environments.

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

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

Figure 8

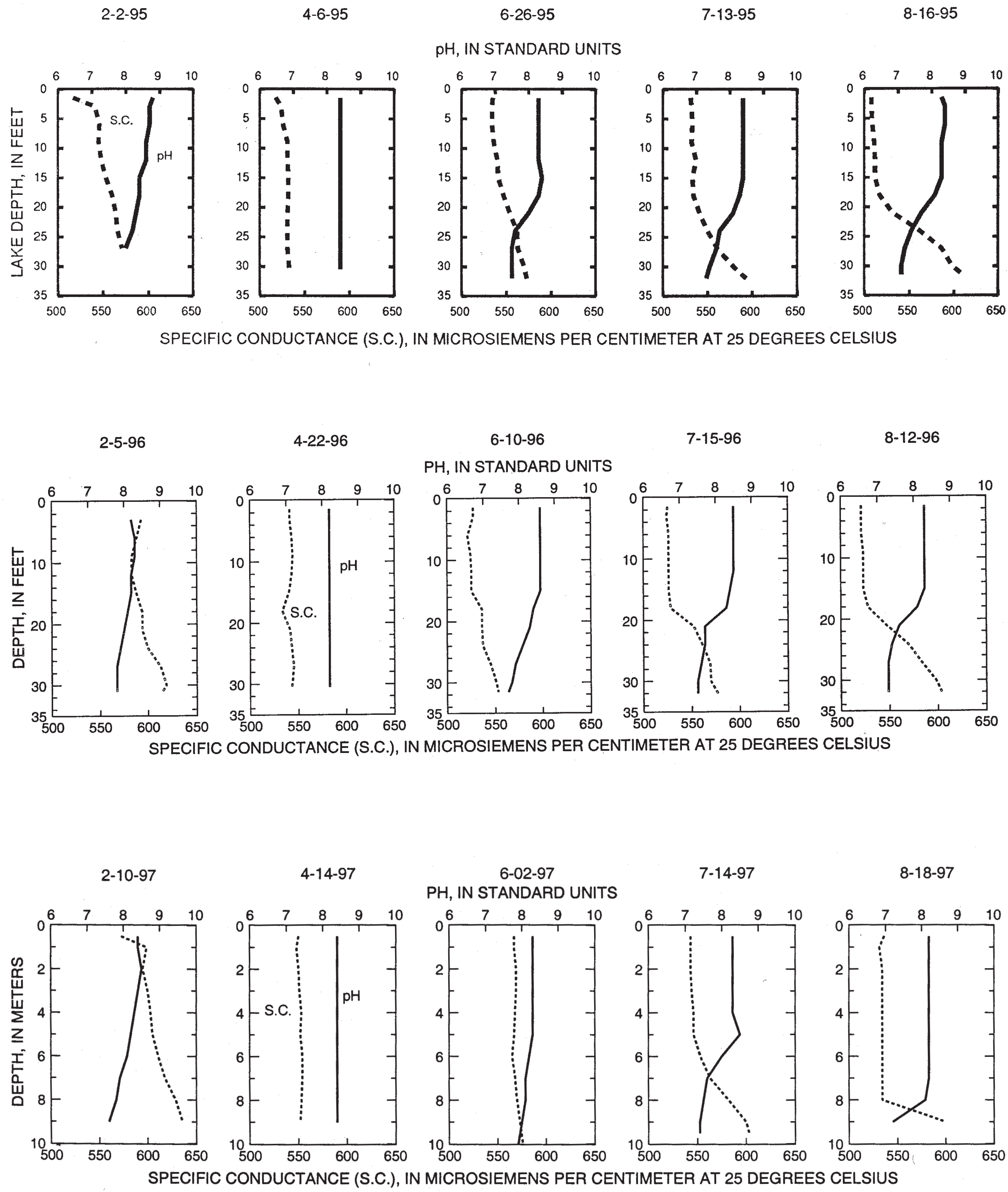
SPECIFIC CONDUCTANCE AND pH PROFILES FOR LAKE MARY: 1995-1997



Source: U.S. Geological Survey and SEWRPC.

Figure 9

SPECIFIC CONDUCTANCE AND pH PROFILES FOR ELIZABETH LAKE: 1995-1997



Source: U.S. Geological Survey and SEWRPC.

different regions of Wisconsin, where geological sources of the element are rare. Chloride concentrations in the more populated and urban southeastern region average about 19 mg/l as contrasted with about 2.0 mg/l in the northeastern and northwestern regions of the State, about 4.0 mg/l in the central region, and about 7.0 mg/l in the southwestern region.[10]

In the 1966 WDNR studies, chloride concentration was about 8.7 mg/l in the main basin of Lake Mary and about 9.3 mg/l in Elizabeth Lake. Although chloride measurements in 1977 and 1991 were not available for Lake Mary, chloride concentrations in Elizabeth Lake during 1977 averaged about 32 mg/l at the inlet and about 19 mg/l at the outlet. Groundwater samples taken from sites around the Twin Lakes at this time ranged from 12 mg/l to 112 mg/l, with an average of about 46 mg/l of chloride.

During the current study period, spring overturn chloride concentrations had increased to an average of about 74 mg/l in Lake Mary, and about 46 mg/l in Elizabeth Lake, as shown in Tables 11 and 12. The most important anthropogenic sources of chlorides to the Twin Lakes are believed to be the salts used on streets and highways for winter snow and ice control.[11] These most recent values, especially in Lake Mary, are somewhat higher than the concentrations found in many other lakes in southeastern Wisconsin,[12] although an increasing trend in chloride concentrations has been observed within many of the major lakes in the Southeastern Wisconsin Region, as shown in Figure 10.

The WDNR, as part of the National Atmospheric Deposition Program (NADP)/National Trends Network, has operated a precipitation monitoring station for the Southeastern Wisconsin Region near the City of Lake Geneva, Wisconsin, since 1984. The purpose of the precipitation monitoring is to collect precipitation chemistry data in order to develop geographical and temporal long-term trends. The samples collected at the City of Lake Geneva monitoring station indicate a gradually decreasing trend in chloride concentrations in precipitation during the period between 1984 and 2005.[13] This trend supports the hypothesis that the increasing trend in chloride concentrations in lakes in southeastern Wisconsin is not likely to be of atmospheric origin, but, rather, associated with terrestrial, anthropogenic-sourced runoff, such as deicing salts and water softener salts which reach the natural waterways through runoff or wastewater discharges.

Alkalinity and Hardness

Alkalinity is an index of the buffering capacity of a lake, or the ability of a lake to absorb and neutralize acids. Lakes having a low alkalinity and, therefore, a low buffering capacity, may be more susceptible to the effects of acidic atmospheric deposition. The alkalinity of a lake depends on the levels of bicarbonate, carbonate, and hydroxide ions present in the water. Due, in large part, to the deposits of limestone and dolomite that make up much of the bedrock underlying many of the lakes and their associated tributary areas, lakes in southeastern Wisconsin typically have a high alkalinity, with an average concentration of about 173 mg/l expressed as calcium carbonate.[14]

---

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

[11]*The major sources of chlorides to lakes in the Southeastern Wisconsin Region include both road salt applications during winter months and salts discharged from water softeners.*

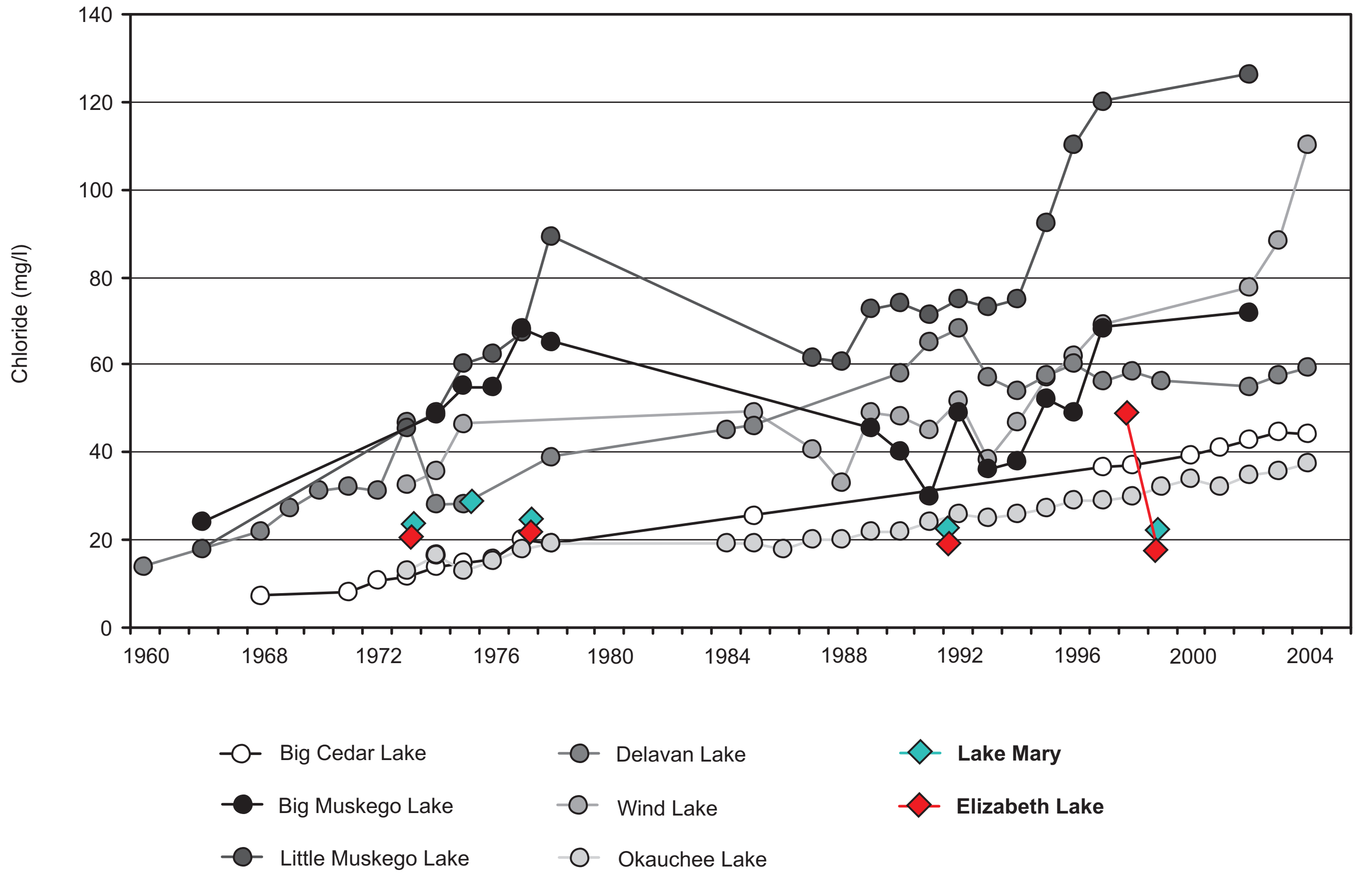
[12]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

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

[14]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

Figure 10

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



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

Alkalinity measurements in the Twin Lakes, since the earliest studies, have been consistent with those recorded during the current study period. As shown in Table 11, alkalinity in Lake Mary during the current study period was in the range of 180 mg/l to 190 mg/l; typically, drained lakes in the Region have an average alkalinity of about 187 mg/l.[15] Alkalinity in Elizabeth Lake, a through flow lake, has generally ranged from about 160 mg/l to about 190 mg/l; typically, through flow lakes in the Region have an alkalinity of about 216 mg/l.[16]

In contrast to alkalinity, water hardness is a measure of the multivalent metallic ion concentrations, such as those of calcium and magnesium, present in a lake. Generally, lakes with high levels of hardness produce more fish and aquatic plants than lakes whose water is soft.[17] Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$).

---

[15]Ibid.

[16]Ibid.

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

Hardness was not measured in the early studies. During the current study period, as shown in Tables 11 and 12, hardness in Lake Mary averaged 250 mg/l in both the surface and bottom waters, while hardness in Elizabeth Lake averaged 240 mg/l near the surface and about 243 mg/l at the bottom.

Based upon these observations, the Twin Lakes may be classified as hard-water alkaline lakes. This classification is typical of most lakes in southeastern Wisconsin.

Hydrogen Ion Concentration (pH)
The pH is a logarithmic measure of hydrogen ion concentration on a scale of 0 to 14 standard units, with 7 indicating neutrality. A pH above 7 indicates basic (or alkaline) water, and a pH below 7 indicates acidic water. The pH of lake water influences many of the chemical and biological processes that occur there. Even though moderately low or moderately high pH may not directly harm fish or other organisms, pH near the ends of the scale can have adverse effects on the organisms living in a lake. Additionally, under conditions of very low (acidic) pH, certain metals, such as aluminum, zinc, and mercury, can become soluble if present in a lake's bedrock or tributary area soils, leading to an increase in concentrations of such metals in a lake's waters with subsequent potentially harmful effects not only to the fish but also to those organisms, including humans, who eat them.[18]

As in the case of alkalinity, the chemical makeup of the underlying bedrock has a great influence on the pH of lake waters. In the case of lakes in the Southeastern Wisconsin Region, where the bedrock is comprised largely of limestone and dolomite, the pH typically is in the alkaline range above a pH of 7. In general, the pH for most natural waterbodies is within the range of about 6.0 to about 8.5.[19] Measurements of pH from lakes in the Southeastern Wisconsin Region averaged about 8.1, which, due to the underlying geology of the Region, was the highest value recorded from any region in the State. By contrast, lakes in the northeast are slightly acidic with an average pH of about 6.9.[20] Other factors influencing pH include precipitation, as well as biological (algal) activity within the Lakes.

Natural buffering of rainfall by carbon dioxide in the atmosphere and the carbonate system in the Lakes, their tributary streams and tributary area, all tend to moderate the pH level in the Twin Lakes and other lakes in the Region. The pH of rain in the Southeastern Wisconsin Region is typically in the 4.4 range.[21] Data collected as part of the aforementioned NADP indicate that there has been a gradual upward trend in precipitation pH at the City of Lake Geneva monitoring station, from about 4.4 in 1984 to about 5.0 in 2005.[22]

According to data presented in the earlier lake studies, surface water pH values in Lake Mary have ranged from 7.9 to 9.0, but have generally averaged 8.4, as shown in Figure 8. In the surface waters of Elizabeth Lake, pH has ranged from 7.3 to 8.8, but has generally averaged also 8.4, as shown in Figure 9. Tables 11 and 12 show the pH values of the Twin Lakes during the current study period to be consistent with those reported in the earlier studies.

Since the Twin Lakes have high alkalinity values or buffering capacities, and because the pH does not fluctuate below 7, the Lakes are not considered to be susceptible to the harmful effects of acidic deposition.

---

[18]Ibid.

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

[20]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[21]Ibid.

[22]*National Atmospheric Deposition Program,* http://nadp.sws.uiuc.edu, op. cit.

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-disk, 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-disk reading." Such measurements comprise an important part of the WDNR Self-Help Monitoring Program (now the University of Wisconsin-Extension Citizen Lake Monitoring Network) in which citizen volunteers assist in lake water quality monitoring efforts.[23]

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in weather conditions and nutrient loadings. Water clarity can also vary from region-to-region in the State as a reflection of regional differences in lake biogeochemistry. Lakes in the northeast region generally have low levels of turbidity, as indicated by the Region's average Secchi-disk reading of 8.9 feet compared to the average in the Southeastern Wisconsin Region of 4.9 feet.[24]

During the earlier studies of 1951 and 1966, Secchi-disk measurements averaged 8.5 feet in the Twin Lakes. During the 1977 study period, Secchi-disk readings in Lake Mary ranged from 4.8 feet to 9.5 feet, with an average of 6.6 feet, while Secchi-disk readings in Elizabeth Lake ranged from 4.8 feet to 7.3 feet, with an average of 5.8 feet. Secchi-disk readings during the 1991 study averaged 8.2 feet in Lake Mary and 7.1 feet in Elizabeth Lake.

As shown in Tables 11 and 12, Secchi-disk readings for the current study period averaged 13.1 feet in spring, 11.5 feet in early summer, and 8.2 feet in late summer in Lake Mary. In Elizabeth Lake, Secchi-disk readings during the current study period averaged 8.2 feet in spring, 9.5 feet in early summer, and 8.2 feet in late summer. Secchi-disk measurements taken by the USGS and by the WDNR Self-Help volunteers during the period between 1995 and 2004, presented in Table 12, were found to be generally in agreement. As shown in Table 12, Secchi-disk readings have been fairly consistent in Lake Mary since spring 1995, but there has been a general decline in the late summer readings. Nevertheless, these values indicate good water quality compared to other lakes in southeastern Wisconsin.[25]

Seasonal variations in Secchi-disk measurements, as shown in Tables 11 through 13, generally indicate a trend of gradually diminishing Secchi-disk depths as the seasons progress from winter, when Secchi-disk readings are typically highest, through spring and summer. This is not unusual for lakes in the Region, and reflects the growths of algae and zooplankton during the warmer months, as well as the effects of surface runoff from the tributary area and inflows into the Lakes.

As described above, two important characteristics affecting water transparency are color and turbidity. The perceived color of lake waters is often described as "green" or "brown," or some combination of these colors, and is influenced by dissolved and suspended materials in the water, phytoplankton population levels, as well as various physical factors. The actual, or true, color of lake waters is the result of substances that are dissolved in

---

[23]*Proper protocol is essential to accurate measurements. The aforereferenced publication, "Understanding Lake Data," describes the proper procedure for measuring water clarity with a Secchi-disk: "The disc (Secchi disc) is lowered over the downwind, shaded side of the boat until it just disappears from sight, then raised until it is just visible. The average of the two depths is recorded. Secchi disc readings should be taken on calm, sunny days between 10 a.m. and 2 p.m. since cloud cover, waves, and the sun's angle can affect the reading."*

[24]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[25]Ibid.

Table 13

SECCHI-DISK TRANSPARENCY MEASUREMENTS FOR LAKE MARY: 1995-2006[a]

Agency	Season	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
USGS	Spring	13.1	9.5	17.1	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Early Summer	11.5	15.1	6.6	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Late Summer	8.2	8.4	7.5	- -	- -	- -	- -	- -	- -	- -	- -	- -
WDNR	Spring	8.3	16.5	11.0	8.0	10.5	8.0	7.8	6.0	15.0	8.3	21.0	9.4
	Early Summer	10.0	15.0	9.0	6.0	8.0	- -	7.0	- -	9.5	9.4	16.3	7.5
	Late Summer	8.4	7.3	6.5	7.3	6.6	6.2	6.3	6.8	5.7	7.6	5.3	5.8

NOTE: For consistency with Tables 11 and 12, Spring represents the months of April and May; Early Summer represents June; and Late Summer represents July and August.

[a]*All measurements in feet.*

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

the water. For example, the brown-stained color of lakes in the northern part of the State is the result of organic acids from certain dissolved humic materials present in those waters. The Twin Lakes, during the current study period, consistently had low water color measurements in the main lake basins with values generally at or below 10, as shown in Tables 11 and 12. These values are far below the average of 46 for lakes in the Region, indicating that the Twin Lakes have clearer water than most lakes in the Southeastern Wisconsin Region.[26] Color was not measured in the earliest studies of the Twin Lakes; however, current WDNR baseline data for Lake Mary are consistent with those presented in Table 11.

Turbidity is another way to measure the clarity of a lake's waters. Turbidity is caused by particles of material in the water that scatter light, affecting plant growth and aesthetics of the lake. Lakes which receive large amounts of runoff from soils containing clay and silt often have high turbidities. Measured values of turbidity in the main basins of the Twin Lakes during spring overturn for the current study period averaged 0.90 in Lake Mary and 2.75 in Elizabeth Lake, as shown in Tables 11 and 12. Both measurements were significantly lower than the average of 6.7 for lakes in the Southeastern Wisconsin Region,[27] indicating clearer water than most of the lakes in the Region. These data are consistent with the data on lake color, discussed above.

In recent years, some lakes in southeastern Wisconsin have experienced improved water clarity that may be related to the presence of the zebra mussel, *Dreissena polymorpha,* an invasive, nonnative filter feeding mollusk known to impact water clarity in inland lakes. The WDNR lists both of the Twin Lakes as having established populations of this species. Zebra mussels have been reported in Lake Mary since 2002 and in Elizabeth Lake since 2001. Secchi-disk readings in Lake Mary since 2002 seem to indicate an increase in water clarity during spring overturn, but less of an increase during early summer and little or no change during late summer. Additionally, as reported in the 2005 Aron and Associates report, the maximum aquatic plant rooting depth, or Maximum Depth of Colonization (MDC), in Lake Mary increased from 16 feet in 2001 to 18 feet in 2005 as a consequence of improved water clarity, while the MDC in Elizabeth Lake decreased slightly from 16 feet in 2001 to 15 feet in 2005.[28]

[26]Ibid.

[27]Ibid.

[28]*Aron and Associates,* Twin Lakes Aquatic Plant Management Plan Reassessment, *2005.*

The Environmental Remote Sensing Center (ERSC), established in 1970 at the University of Wisconsin-Madison campus, was one of the first remote sensing facilities in the United States. Using data gathered by satellite remote sensing over a three-year period, the ERSC generated a map based on a mosaic of satellite images showing the estimated water clarity of the largest 8,000 lakes in Wisconsin. The WDNR, through its volunteer Self-Help Monitoring Program, was able to gather water clarity measurements based on Secchi-disk transparency readings for about 800 of these lakes, or about 10 percent of Wisconsin's largest lakes, which suggested that the satellite remote sensing technology utilized by ERSC was able to accurately estimate clarity for the remaining 90 percent of lakes. ERSC remote sensing estimated the average water clarity in Lake Mary to be 5.9 feet and, in Elizabeth Lake, 5.4 feet.

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 amount of algae in the water, and its level of concentration is useful in determining the trophic status of lakes and hence the suitability of a lake for certain uses. The median chlorophyll-*a* concentration for lakes in the Southeastern Wisconsin Region is about 9.9 micrograms per liter (μg/l).[29] Chlorophyll-*a* levels above 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.[30] During the 1977 study, chlorophyll-*a* concentrations in the main basin of Lake Mary ranged from a low of 3.0 μg/l to a high of 6.1 μg/l, with an average of 4.7 μg/l, indicating that, at that time, algal concentrations in Lake Mary were unlikely to interfere with recreational activities. Concentrations of chlorophyll-*a* in Elizabeth Lake ranged from 4.0 μg/l to 14.7 μg/l, with an average of 8.6 μg/l.[31] While the average value of the chlorophyll-*a* concentration in Elizabeth Lake is closer to the threshold level of 10 μg/l, it is still such that few algae-related concerns would be expected in that Lake.

The 1991 study data show an average chlorophyll-*a* concentration of 5.0 μg/l in Lake Mary and an average of 6.0 μg/l in Elizabeth Lake. During the current study period, chlorophyll-*a* concentrations in Lake Mary ranged from 3.7 μg/l to 5.3 μg/l, with an average of 4.3 μg/l, as shown in Table 11. During this same period, in Elizabeth Lake, concentrations ranged from 4.6 μg/l to 5.8 μg/l, with an average of 5.4 μg/l, as shown in Table 12. Since that time, summer chlorophyll-*a* measurements of the surface waters of Elizabeth Lake have continued as part of the WDNR Baseline monitoring program. Concentrations have ranged from 4.9 μg/l to 7.5 μg/l, with an average of 6.6 μg/l, as shown in Table 14. Chlorophyll-*a* concentrations remained consistently below 10 μg/l in Elizabeth Lake; a similar condition would be expected to have occurred in Lake Mary.

Although numeric differences in Table 14 are apparent between the chlorophyll-*a* measurements reported by the USGS and those reported by the WDNR Baseline monitoring program, such variation can be attributed to a variety of factors including, but not limited to, differences in dates of sampling with concomitant phenomena, such as algal blooms and storm events, and differences in analytical methodology. Notwithstanding these differences, there is agreement between the two data sets with regard to the overall trends in the data. This agreement would tend to underscore the importance of continuing a program of water quality monitoring on the Lakes. All of the values in Table 14 are within the ranges of chlorophyll-*a* concentrations recorded in other lakes in the Region,[32] and indicate good water quality, as illustrated in Figures 11 and 12, for Lake Mary and Elizabeth Lake, respectively.

---

[29]Ibid.

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

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

[32]Ibid.

Table 14

SUMMER SURFACE TOTAL PHOSPHORUS AND CHLOROPHYLL-*a* FOR ELIZABETH LAKE: 1995-2004

Water Quality Parameter[a]	1995	1996	1997	1998	1999	2000	2001	2002	2003[b]	2004[b]
Total Phosphorus (USGS)	0.010	0.010	0.013	- -	- -	- -	- -	- -	- -	- -
Total Phosphorus (WDNR)	0.010	0.012	0.028	0.021	0.017	0.022	0.017	0.018	0.026	0.018
Chlorophyll-*a* (USGS)	2.8	4.2	6.8	- -	- -	- -	- -	- -	- -	- -
Chlorophyll-*a* (WDNR)	5.0	5.5	7.5	6.5	5.5	7.5	7.5	5.0	9.1	4.9

[a]*Total phosphorus and chlorophyll-a concentrations are reported in milligrams per cubic meter (mg/m*^{3}*).*

[b]*Measurements taken at a depth of six feet; all other samples taken at depths of 1.5 to 3.0 feet.*

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

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 to be limiting aquatic plant growth in a lake.[33] 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. Water quality studies prior to 1991 did not report N:P ratios for the Twin Lakes; studies conducted since 1991 have reported N:P ratios to be always greater than 14:1. This indicates that plant production is most likely limited by phosphorus.

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

The recommended water quality standard for phosphorus, which is set forth in the Commission's adopted regional water quality management plan for lakes, is 0.020 mg/l of total phosphorus or less during spring turnover. This is the level considered in the regional plan as necessary to limit algal and aquatic plant growth to levels consistent with the recreational and warmwater fishery and other aquatic life water use objectives.

During the 1966 studies, summer total phosphorus concentrations averaged 0.025 mg/l in Lake Mary and 0.018 mg/l in Elizabeth Lake. During the period from 1973 to 1991, total phosphorus concentrations in Lake Mary averaged 0.021 mg/l while total phosphorus concentrations in Elizabeth Lake averaged 0.030 mg/l.[34] During the current study period, spring overturn total phosphorus measurements averaged 0.011 mg/l in Lake Mary and 0.014 mg/l in Elizabeth Lake; annual total phosphorus concentrations averaged 0.012 mg/l in Lake Mary and 0.013 mg/l in Elizabeth Lake, as shown in Tables 11 and 12.

---

[33]*M.0. Allum, R.E. Gessner, and T.H. Gakstatter, U.S. Environmental Protection Agency Working Paper No. 900,* An Evaluation of the National Eutrophication Data*, 1976.*

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

Figure 11

PRIMARY WATER QUALITY INDICATORS FOR LAKE MARY: 1995-2004

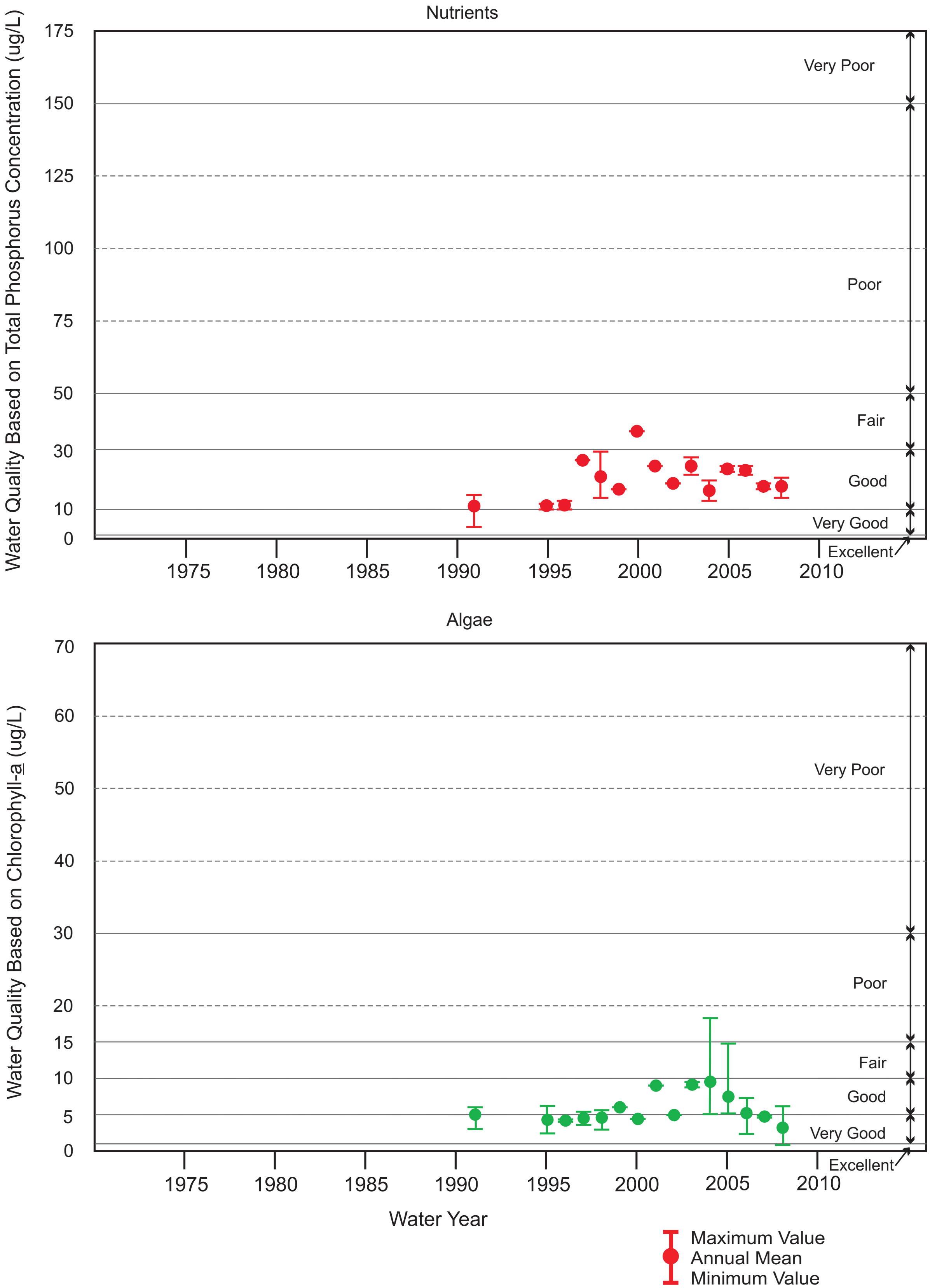
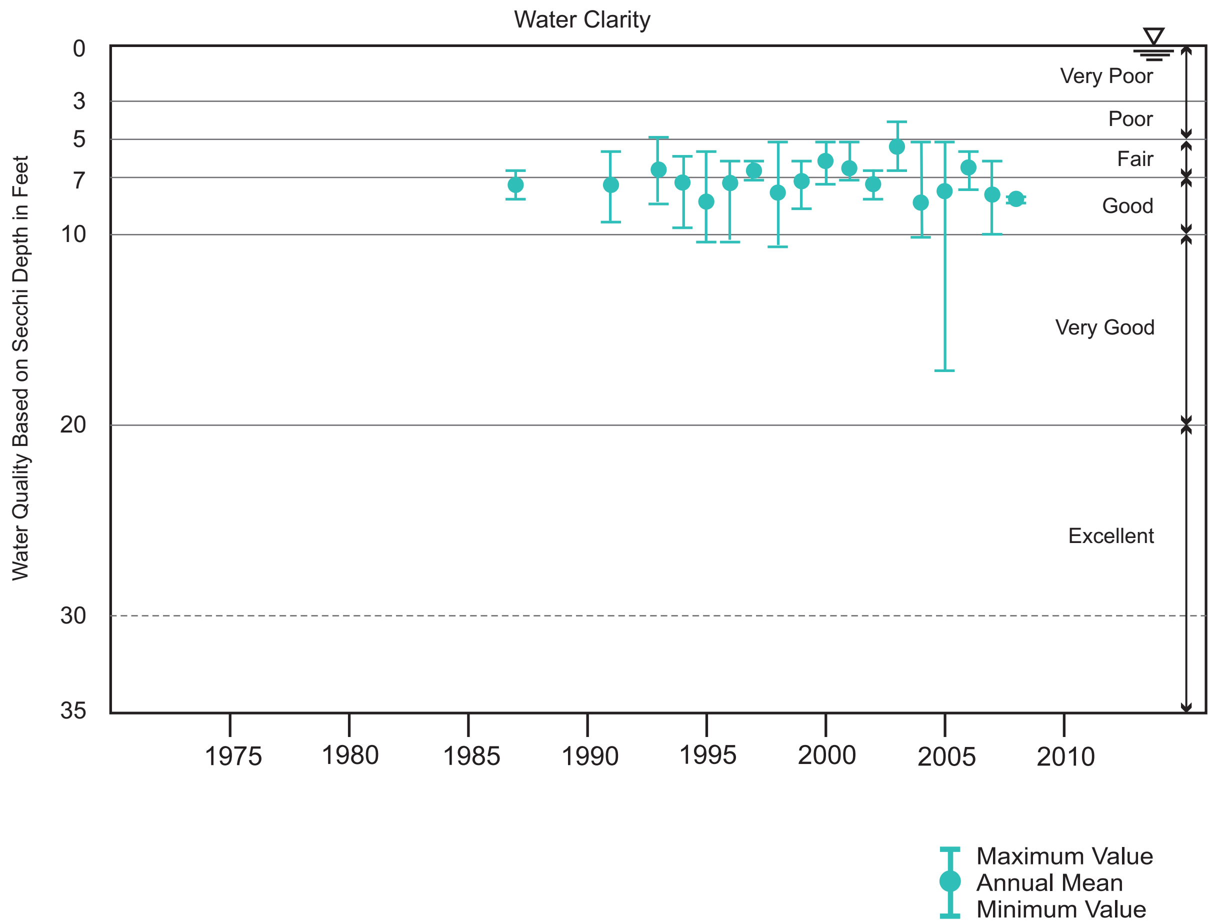


Figure 11 (continued)



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

Table 14 shows summer surface concentrations of total phosphorus in Elizabeth Lake for the period from 1995 to 2004; these levels averaged about 0.019 mg/l, indicating that total phosphorus concentrations in Elizabeth Lake approach the levels necessary to support periodic nuisance algae blooms. These most recent data are not dissimilar to those reported during the 1966 studies, suggesting that in-lake total phosphorus concentrations may have returned to levels not measured since the implementation of the public sanitary sewerage system. This would suggest that, perhaps, changes in land use in the surrounding drainage area and changes in urban landscaping practices may have resulted in a greater availability of phosphorus on the land surface, which availability results in more phosphorus reaching lakes through stormwater runoff. In this regard, it is noted that the Village of Twin Lakes has implemented an ordinance to restrict the use of phosphorus fertilizers on residential properties in the Village, which will limit the future availability of phosphorus from residential lands, benefiting the Lakes. Since there tends to be general agreement between other water quality parameters in the Twin Lakes, those trends and patterns observed in Elizabeth Lake may be considered to be indicative of those likely to occur in Lake Mary.

Total phosphorus concentrations were found to be significantly higher in the bottom water of the Lakes during summer stratification, as shown in Tables 11 and 12. This is likely to be the result of the release of phosphorus from anoxic or near-anoxic bottom sediments. During the current study period, the total phosphorus levels in Lake Mary during summer stratification averaged 0.012 mg/l at the surface and 0.064 mg/l in the hypolimnion; in Elizabeth Lake, the surface concentration averaged 0.011 mg/l, while the bottom water concentration averaged 0.066 mg/l. The seasonal gradients of phosphorus concentration between the epilimnion and hypolimnion reflect the biogeochemistry of this growth element.

Figure 12

PRIMARY WATER QUALITY INDICATORS FOR ELIZABETH LAKE: 1995-2004

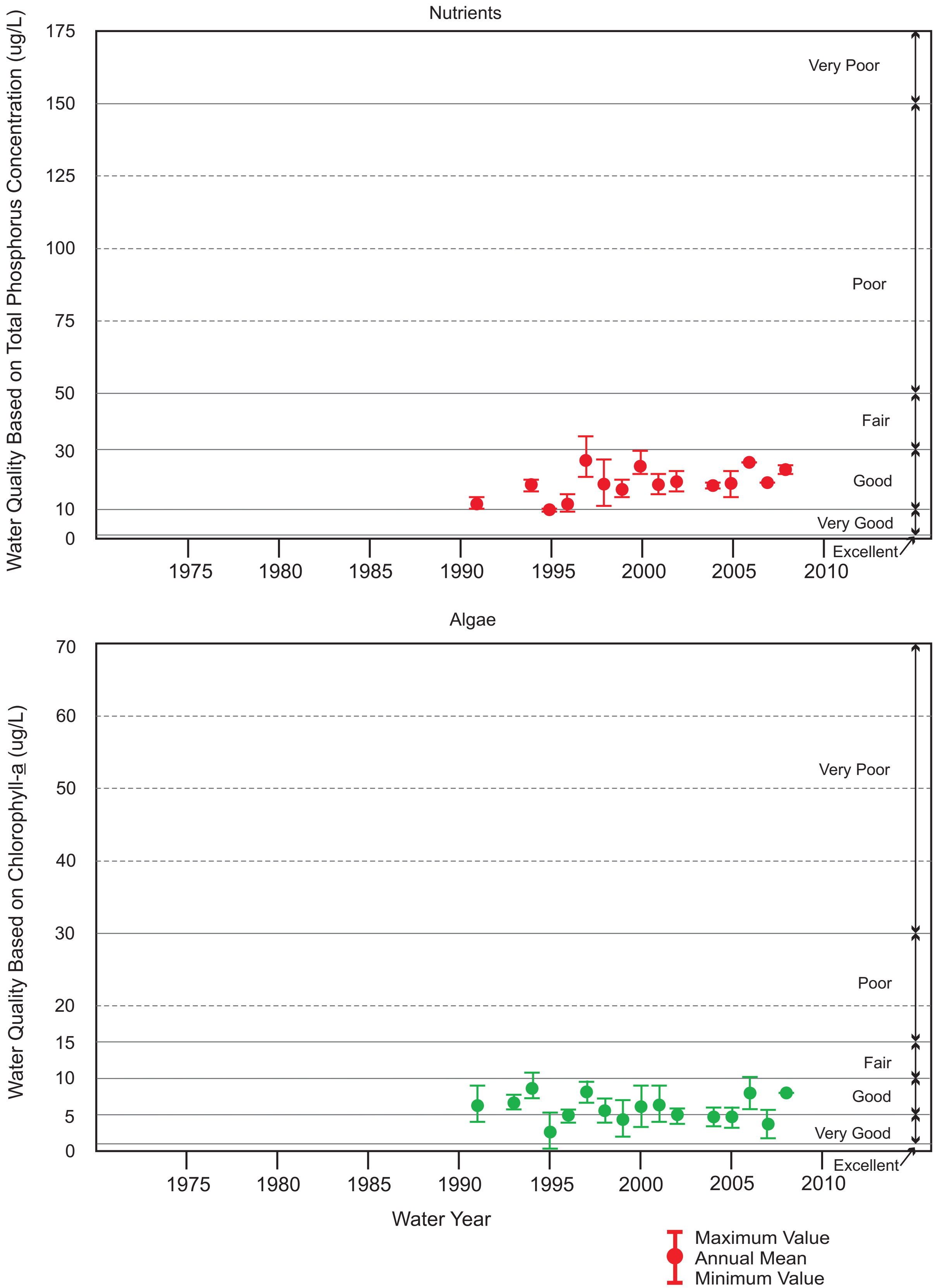
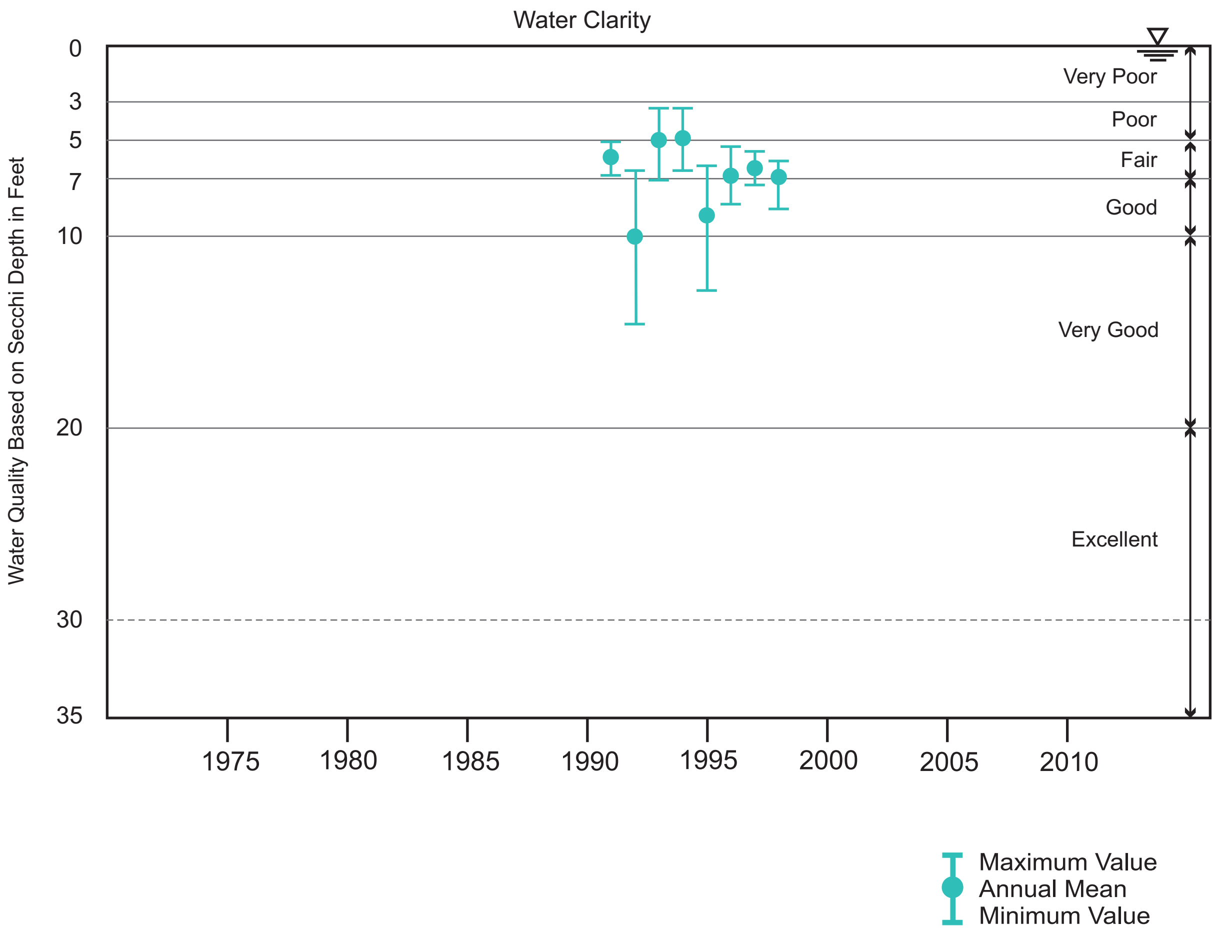


Figure 12 (continued)



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

During the growing season, nutrients become depleted in the upper waters of lakes as plants utilize the nutrients for growth. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed resulting in an accumulation of nutrients in the bottom waters and sediments. 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. The phosphorus is then either stored in the bottom sediments or rereleased from the sediments into the water column, particularly under conditions of oxygen depletion, a phenomenon mentioned above as "internal loading."

When the bottom waters of a lake become depleted of oxygen during stratification, certain chemical changes occur, especially in the oxidation state of iron from the insoluble Fe^{3+} state to the more soluble Fe^{2+} state. The effect of these chemical changes is that the phosphorus bound to the iron can become soluble again and may be released from the sediments. This internal loading process also occurs under aerobic conditions, but generally at a slower rate than under anaerobic conditions. As the waters mix, this phosphorus may be widely dispersed throughout the lake waterbody and become available for algal growth. When the mixing process is relatively slow, on the order of days to weeks, minerals and nutrients released from the sediments into the hypolimnion of the lake tend to recombine with the multivalent cations in the lake sediments and precipitate out of the water column; if the mixing process is relatively rapid, on the order of hours to days, as may occur due to the passage of an intense storm, the minerals and nutrients may be mixed upward into the epilimnion or surface waters where they are available for plant growth.[35]

During the current study period, the data indicated that there probably was internal loading of phosphorus from the bottom sediments of the Twin Lakes, since external phosphorus inputs to the Lakes were insufficient to account for the high phosphorus concentrations measured in the Lakes (see the discussion of phosphorus loads to the Lakes, below). As shown in Tables 11 and 12, and as described above, during the current study period the dissolved phosphorus concentrations in the bottom waters were relatively high, averaging 0.064 mg/l for Lake Mary and 0.066 mg/l for Elizabeth Lake in samples collected during the summer when such releases of phosphorus are most likely to occur. While the magnitude of the these releases and their concomitant effects in contributing to algal growth in the surface waters of the Lake may be moderated by a number of circumstance, including the rate of mixing during the spring and fall overturn events, the contribution of phosphorus from the bottom waters of the Twin Lakes should be considered in terms of the total phosphorus load. This may affect the rate at which the Lakes will respond to changes in the external phosphorus loads.

CHARACTERISTICS OF BOTTOM SEDIMENT

Sediment contributions from the drainage area tributary to a lake also have important effects on water quality. As the lake bottom is covered by material washed into the lake or by dead aquatic plant and animal remains settling onto the lake bottom from the water column, valuable benthic habitats and fish spawning sites may be covered and aesthetic nuisances may develop. Observations from throughout the Southeastern Wisconsin Region would suggest, for example, that some less-desirable aquatic plant species, such as Eurasian water milfoil, prefer softer, organic-rich substrates for rooting and growth. Additionally, sediment composition has an important effect on the biogeochemistry of a lake. Sediment particles serve as transport mechanisms for nutrients, especially phosphorus, as well as for a variety of pollutants, and play a key role in establishing benthic habitat and macrophyte rooting substrate. In the Twin Lakes, there is a predominance of sand, gravel, and cobble substrates which limit the growths of aquatic macrophytes and the opportunity for nuisance conditions to occur.

POLLUTION LOADINGS AND SOURCES

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the area tributary to a lake. These loads are transported to the lake through the atmosphere, across the land surface, and by way of inflowing streams. Pollutants transported by the atmosphere are deposited onto the surface of the lake as dry fallout and direct precipitation. Pollutants transported across the land surface enter the lake as direct runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams enter a lake as surface water inflows. In drained lakes, like Lake Mary, pollutant loadings transported across land surfaces in the absence of identifiable or point source discharges from industries or wastewater treatment facilities, comprise the principal routes by which contaminants enter a waterbody; in through-flow lakes, like Elizabeth Lake, pollutant loadings transported across land surfaces and inflowing streams comprise the principal routes by which contaminants enter a waterbody.[36] Currently, there are no significant point source discharges of pollutants to the Twin Lakes or to the surface waters tributary to the Twin Lakes. The Village of Twin Lakes, as noted in Chapter III, is served by a public sanitary sewerage system. For this reason,

---

[35]*See, for example, R.D. Robarts, P.J. Ashton, J.A. Thornton, H.J. Taussig, and L.M. Sephton, "Overturn in a hypertrophic, warm, monomictic impoundment (Hartbeespoort Dam, South Africa),"* Hyperbiologia, *Volume 97, 1982, pp. 209-224.*

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

the discussion that follows is based upon nonpoint source pollutant loadings to the Twin Lakes. Nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities; and rural sources, such as runoff from agricultural lands, direct deposition onto the lake surfaces from the atmosphere, and runoff from woodlands and wetlands.

In the 1977 feasibility study, nutrient budgets for Lake Mary and Elizabeth Lake were developed to account for sources of nutrient inflow and outflow to the Twin Lakes. To aid in the development of the nutrient budgets, surface water monitoring stations were installed around the Lakes to monitor surface water runoff during storm events, and wells were drilled to monitor quantity, quality, and direction of flow of groundwater around the Lakes. Based on extrapolation of runoff data from a subbasin located within the tributary area to the Twin Lakes, together with data from the groundwater wells around the Lakes and atmospheric studies for the Lake Michigan area, it was estimated that 17 percent of the phosphorus entering Lake Mary in 1977 came from groundwater; 19 percent came from tributary area runoff; and, 64 percent came from precipitation and dry fallout onto the lake surface. A nutrient budget developed for Elizabeth Lake utilizing 1977 data indicated that 21 percent of the phosphorus entering the Lake came from groundwater; 45 percent came from tributary area runoff and intermittent stream flows entering the Lake from the marshy area along the western shores of the Lake; and 34 percent came from precipitation and dry fallout onto the lake surface.

Estimates of the total phosphorus loads to Lake Mary and Elizabeth Lake were made during the 1993 studies executed by the Discovery Group, Ltd., and Blue Water Science.[37] These estimates utilized unit area load values set forth in the lake management plan for Powers Lake,[38] and suggested that approximately 614 pounds of phosphorus per year entered Lake Mary and about 1,395 pounds of phosphorus per year entered Elizabeth Lake. Approximately 40 percent of the phosphorus load to Lake Mary was generated from urban lands, about 45 percent from rural lands, and the balance from atmospheric deposition and/or internal loading from the Lake sediments. Of the estimated annual phosphorus load to Elizabeth Lake, 20 percent was generated from urban lands, 70 percent from rural lands, and the balance from atmospheric deposition and/or internal loading from the Lake sediments. The study noted the likelihood of a significant decline in the annual phosphorus load, from that estimated in the regional water quality management plan,[39] which could be attributed in large measure to the installation of the public sanitary sewerage system and diversion of animal waste from livestock operations in the watershed. These findings are consistent with the total phosphorus concentration trends observed in the Lakes.

For the current study, nonpoint source phosphorus, suspended solids, and urban-derived metals inputs to the Twin Lakes 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 discussed in greater detail below.

Phosphorus Loadings

Phosphorus has been identified as the factor generally limiting aquatic plant growth in the Twin Lakes. Consequently, excessive levels of phosphorus in the Lakes are likely to result in conditions that interfere with the desired uses of the Lakes, indicating that management of controllable phosphorus sources is an important management measure to be considered.

---

[37]*Discovery Group, Ltd., and Blue Water Science,* op. cit.

[38]*SEWRPC Community Assistance Planning Report No. 196,* A Management Plan for Powers Lake, Kenosha and Walworth Counties, Wisconsin, *November 1991.*

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

Lake Mary

During the aforementioned 1977 study, it was estimated that the total phosphorus load to Lake Mary was 248 pounds. Of this total, the major contributions of phosphorus to the Lake were: direct atmospheric contributions to water surfaces, about 158 pounds, or 64 percent; tributary area surface runoff, about 48 pounds, or 19 percent; and groundwater inflow, about 42 pounds, or 17 percent.

For the 1991 study, it was estimated that the total phosphorus load to Lake Mary was 614 pounds. Of this total, the major contributions of phosphorus to the Lake were: direct atmospheric contributions to water surfaces, about 44 pounds, or 6 percent; tributary area surface runoff, about 513 pounds, or 85 percent; and groundwater inflow, inclusive of internal loading, about 57 pounds, or 9 percent.

During the current study, as shown in Table 15, existing year 2000 phosphorus loads to Lake Mary were quantified using Commission land use inventory data. It was estimated that, under year 2000 conditions, the total phosphorus load to Lake Mary was 315 pounds. Of the annual total phosphorus load, it was estimated that 117 pounds per year, or about 37 percent of the total loading, was contributed by runoff from urban land; 172 pounds per year, or 55 percent, was contributed by runoff from rural land; and 26 pounds, or about 8 percent, by direct precipitation onto the lake surface.

Under 2035 conditions, as set forth in the adopted regional land use plan,[40] the annual total phosphorus load to Lake Mary is anticipated to continue to diminish slightly as agricultural activities within the area tributary to the Twin Lakes are replaced by urban residential land uses. Table 15 shows the estimated phosphorus loads to Lake Mary under 2035 conditions. Of the total annual forecast phosphorus load of about 283 pounds of phosphorus to Lake Mary, 53 pounds per year, or 19 percent of the total loading, are estimated to be contributed by runoff from rural land; 225 pounds per year, or 79 percent, contributed by runoff from urban land; and five pounds, or 2 percent, by direct precipitation onto the lake surface.

Elizabeth Lake

During the 1991 study, it was estimated that the total phosphorus load to Elizabeth Lake was 1,395 pounds. Of this total, the major contributions of phosphorus to the Lake were: direct atmospheric contributions to water surfaces, about 95 pounds, or 8 percent; tributary area surface runoff, about 1,206 pounds, or 85 percent; and groundwater inflow, inclusive of internal loading, about 93 pounds, or 7 percent.

Table 16 sets forth estimated phosphorus loading for Elizabeth Lake under existing 2000 conditions. Of the total annual load of 1,215 pounds of phosphorus to Elizabeth Lake, about 136 pounds per year, or 11 percent of the total loading, was contributed by runoff from urban land; 1,023 pounds per year, or 84 percent, was contributed by runoff from rural land; and about 56 pounds, or about 5 percent, by direct precipitation onto the lake surface.

Under 2035 conditions, as set forth in the adopted regional land use plan,[41] the annual total phosphorus load to Elizabeth Lake is anticipated to decrease slightly as urban land uses within the area tributary to the Twin Lakes replace some rural agricultural land uses. Table 16 shows the estimated phosphorus loads to Elizabeth Lake under 2035 conditions. Of the total annual forecast phosphorus load of about 1,203 pounds of phosphorus to Elizabeth Lake, 324 pounds per year, or 27 percent of the total loading, are estimated to be contributed by runoff from urban land; 823 pounds per year, or 68 percent, contributed by runoff from urban land; and 56 pounds, or about 5 percent, by direct precipitation onto the lake surface.

---

[40]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006; also, assuming no change in land use within the Illinois portion of the Basin.*

[41]Ibid.

Table 15

ESTIMATED TOTAL PHOSPHORUS LOADS TO LAKE MARY: 2000 AND 2035

Source	2000			2035		
	Area (acres)	Total Loading (pounds per year)	Percent Distribution	Area (acres)	Total Loading (pounds per year)	Percent Distribution
Urban						
Residential Land	287	13.2	4.2	617	26.5	9.4
Commercial Land	31	8.8	2.8	62	17.6	6.2
Industrial Land	105	92.4	29.4	188	167.5	59.3
Recreational Land	6	2.2	0.7	6	13.2	4.7
Subtotal	429	116.6	37.1	873	224.8	79.6
Rural						
Agricultural Land	614	165.0	52.4	170	46.3	16.4
Water	330	26.4	8.4	330	4.8	1.7
Woodlands	55	2.2	0.7	55	2.2	0.7
Wetlands	24	4.4	1.4	24	4.4	1.6
Subtotal	1,023	198.0	62.9	579	57.7	20.4
Total	1,452	314.6	100.0	1,452	282.5	100.0

Source: SEWRPC.

Table 16

ESTIMATED TOTAL PHOSPHORUS LOADS TO ELIZABETH LAKE: 2000 AND 2035

Source	2000			2035[a]		
	Area (acres)	Total Loading (pounds per year)	Percent Distribution	Area (acres)	Total Loading (pounds per year)	Percent Distribution
Urban						
Residential Land	839	37.5	3.1	1,234	55.1	4.6
Commercial Land	300	78.4	6.4	512	136.7	11.4
Industrial Land	14	13.2	1.2	140	125.7	10.5
Recreational Land	65	6.6	0.5	85	6.6	0.5
Subtotal	1,218	135.7	11.2	1,971	324.1	27.0
Rural						
Agricultural Land	3,675	983.4	80.9	2,922	782.8	65.0
Water	638	56.3	4.6	638	56.3	4.7
Woodlands	226	11.0	1.0	226	11.0	0.9
Wetlands	317	28.6	2.3	317	28.6	2.4
Subtotal	4,856	1,079.3	88.8	4,103	878.6	73.0
Total	6,074	1,215.0	100.0	6,074	1,202.7	100.0

[a]Based upon SEWRPC forecast 2035 land use within the Wisconsin portion of the Basin and McHenry County 2000 land use within the Illinois portion of the Basin: assumes that the Illinois portion of the Basin is built out under year 2000 land use conditions.

Source: SEWRPC.

Internal Phosphorus Loading

Phosphorus release from the lake bottom sediments—internal loading—may also contribute phosphorus to the Lakes. In the initial lake management plan, it was estimated that during water year 1991 the portion of the total load contributed to the Lakes from internal recycling was 2.5 percent of the total load, or about 16 pounds per year for Lake Mary, and about 34 pounds per year for Elizabeth Lake.

During the current study, as noted above, hypolimnetic phosphorus concentrations measured in the Twin Lakes suggest the potential for internal loading to occur. Total phosphorus levels in the hypolimnion of Lake Mary during summer stratification were approximately five times higher than those measured in the surface waters. In Elizabeth Lake, the hypolimnetic total phosphorus concentrations were approximately six times higher than those measured in the surface waters. Notwithstanding, it is likely that overturn events generally occurred at rates such that little of this hypolimnetic phosphorus was mixed into the epilimnia of the Lakes, i.e., at rates on the order of days.[42] When mixing occurs at rates on the order of hours,[43] such as during high-intensity storm events, portions of this internal load, at times, can be mixed into the surface waters of the Lakes, but these events are not likely to be of such frequency as to contribute significant amounts of phosphorus to the epilimnia of the Lakes.

Sediment Loadings

The estimated sediment loadings to the Twin Lakes for existing year 2000 and forecast year 2035 are shown in Tables 17 and 18.

Under existing year 2000 conditions, it is estimated that a total annual sediment loading of 186 tons was contributed to Lake Mary, as shown in Table 17. Of the likely annual sediment load, it was estimated that 138 tons per year, or about 74 percent of the total loading, was contributed by runoff from rural agricultural lands, with 17 tons, or about 9 percent, being contributed by urban lands. Approximately 31 tons, or 17 percent, was contributed by atmospheric deposition to the lake surface.

As shown in Table 18, a total annual sediment loading of 918 tons was estimated to be contributed to Elizabeth Lake under existing year 2000 conditions, with about 827 tons per year, or 90 percent of the total loading, contributed by runoff from rural agricultural land. About 21 tons, or 2 percent, were contributed by urban lands, and approximately 70 tons, or 8 percent, contributed by atmospheric deposition to the lake surface.

The most likely annual sediment load to the Lake Mary under year 2035 conditions[44] is estimated to be 101 tons. In addition, the distribution of the sources of the sediment load to the Lake may be expected to change, with an increased mass of sediment being contributed from urban sources, estimated to be 31 tons of sediment per year; and rural sources, estimated to be 39 tons of sediment per year. Approximately 31 tons of sediment per year are estimated to be contributed by direct precipitation onto the lake surface.

The most likely annual sediment load to the Elizabeth Lake under year 2035 conditions is estimated to be 825 tons. As in the case of Lake Mary, the distribution of the sources of the sediment load to Elizabeth Lake also may be expected to change, with an increased mass of sediment being contributed from urban sources, estimated to be 97 tons of sediment per year; and a decreased mass of sediment being contributed from rural sources, estimated to be 658 tons of sediment per year. Approximately 70 tons of sediment per year are estimated to be contributed by direct precipitation onto the lake surface.

---

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

[43]*See, for example, R.D. Robarts, et al.*, op.cit.

[44]*SEWRPC Planning Report No. 48,* op. cit.; *also, assuming no change in land use within the Illinois portion of the Basin.*

Table 17

ESTIMATED TOTAL SEDIMENT AND HEAVY METAL LOADS TO LAKE MARY: 2000 AND 2035

Source	2000				2035			
	Area (acres)	Sediment Loading (tons per year)	Copper Loading (pounds per year)	Zinc Loading (pounds per year)	Area (acres)	Sediment Loading (tons per year)	Copper Loading (pounds per year)	Zinc Loading (pounds per year)
Urban								
Residential Land	286	4.3	1.6	1.5	617	7.4	1.6	1.6
Commercial Lands	15	5.7	3.1	3.0	36	14.1	7.9	3.0
Industrial Lands	5	2.0	1.2	1.5	6	2.2	1.3	1.5
Transportation and utilities	99	0.5	0.0	0.0	182	0.9	0.0	0.0
Governmental	17	4.3	1.2	24.8	26	6.6	1.8	24.8
Recreational	6	0.1	0.0	0.0	6	0.1	0.0	0.0
Subtotal	428	16.8	7.1	30.8	873	31.3	12.6	30.9
Rural								
Agricultural Land	613	138.2	- -	- -	170	38.3	- -	- -
Water	330	31.0	- -	- -	330	31.0	- -	- -
Woodlands	55	0.1	- -	- -	55	0.1	- -	- -
Wetlands	24	<0.1	- -	- -	24	0.1	- -	- -
Subtotal	1,023	169.2	- -	- -	579	69.4	- -	- -
Total	1,451	186.0	7.1	30.8	1,452	100.7	12.6	30.9

Source: SEWRPC.

Table 18

ESTIMATED TOTAL SEDIMENT AND HEAVY METAL LOADS TO ELIZABETH LAKE: 2000 AND 2035

Source	2000				2035[a]			
	Area (acres)	Sediment Loading (tons per year)	Copper Loading (pounds per year)	Zinc Loading (pounds per year)	Area (acres)	Sediment Loading (tons per year)	Copper Loading (pounds per year)	Zinc Loading (pounds per year)
Urban								
Residential Land	839	8.2	0.0	1.6	1,234	12.0	0.0	1.6
Commercial Lands	12	4.7	2.6	2.9	10	3.9	2.2	3.0
Industrial Lands	2	0.8	0.5	1.5	130	48.9	28.6	1.5
Transportation and utilities	281	1.3	0.0	0.0	398	1.9	0.0	0.0
Governmental	19	4.8	1.3	24.8	114	29.1	7.9	24.8
Recreational Land	65	0.8	0.0	0.0	85	1.0	0.0	0.0
Subtotal	1,218	20.6	4.4	30.8	1,971	96.8	38.7	30.9
Rural								
Agricultural Land	3,675	826.9	- -	- -	2,922	657.5	- -	- -
Water	741	69.6	- -	- -	741	69.6	- -	- -
Woodlands	226	0.4	- -	- -	226	0.4	- -	- -
Wetlands	214	0.4	- -	- -	214	0.4	- -	- -
Subtotal	4,856	897.3	- -	- -	4,103	727.9	- -	- -
Total	6,074	917.9	4.4	30.8	6,074	824.7	38.7	30.9

[a]*Based upon SEWRPC forecast 2035 land use within the Wisconsin portion of the Basin and McHenry County 2000 land use within the Illinois portion of the Basin: assumes that the Illinois portion of the Basin is built out under year 2000 land use conditions.*

Source: SEWRPC.

Urban Heavy Metals Loadings
Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[45] The majority of these metals become associated with sediment particles, and are likely to be encapsulated into the bottom sediments of the Lakes.[46]

For the current study, the estimated loadings of copper, zinc, and cadmium likely to be contributed to the Twin Lakes for existing year 2000 and forecast year 2035 are show in Tables 17 and 18. Under year 2000, about seven pounds of copper and 31 pounds of zinc were estimated to be contributed annually to Lake Mary from urban lands; about four pounds of copper and 31 pounds of zinc were estimated to be contributed annually to Elizabeth Lake from urban lands.

Under 2035 conditions, as set forth in the adopted regional land use plan,[47] the annual heavy metal loads to the Lakes are anticipated to increase as urban land uses increase in areal extent. The most likely annual loads to Lake Mary under buildout conditions are estimated to be 13 pounds of copper and 31 pounds of zinc. The most likely annual loads to Elizabeth Lake under buildout conditions are estimated to be 39 pounds of copper and 31 pounds of zinc.

Groundwater Quality
During the 1977 study period, groundwater monitoring wells were installed around the Twin Lakes; their purpose was to measure groundwater flow into or out of the Lakes and to provide data on groundwater quality. Groundwater quality samples were obtained on three sampling dates during the summer of 1977. Groundwater measurements at that time indicated that nitrate concentrations ranged from less than 0.010 mg/l to 0.185 mg/l, with an average of 0.062 mg/l; ammonia concentrations ranged from less than 0.05 mg/l to 0.30 mg/l, with an average of 0.29 mg/l; and, total phosphorus concentrations ranged from less than 0.010 mg/l to 0.134 mg/l, with a mean value of 0.027 mg/l. Groundwater quality was not measured during the current study period.

In-Lake Sinks
Of the annual total phosphorus load entering the Twin Lakes, it is estimated that 12.5 percent of the total phosphorus load, or about 40 pounds of phosphorus, was retained within Lake Mary. Likewise, it is estimated that 20 percent of the total phosphorus load, or about 245 pounds of phosphorus, was retained within Elizabeth Lake. This mass of phosphorus is either used by the biomass within the Lakes or deposited in the lake sediments.[48] The balance of the phosphorus entering the Lakes is transported downstream. In the case of Lake Mary, this phosphorus is discharged to the downstream Elizabeth Lake; from Elizabeth Lake, the mass of phosphorus is discharged to the Elizabeth Lake Drain.

RATING OF TROPHIC CONDITION

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

---

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

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

[47]*SEWRPC Planning Report No. 48,* op. cit.

[48]*D.P. Larsen and H.T. Mercier, "Phosphorus retention capacity of lakes,"* Journal of the Fisheries Research Board of Canada*, Volume 33, 1976, pp. 1742-1750.*

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

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

Eutrophic lakes are nutrient-rich lakes. These lakes often exhibit excessive aquatic macrophyte growths and/or experience frequent algae blooms. If the lakes are shallow, fish winterkills may be common. While portions of such lakes are not ideal for swimming and boating, eutrophic lakes may support very productive fisheries.

Several numeric "scales," based on one or more water quality indicators, have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale used is appropriate for the lake to which it is applies. In this case, two indices appropriate for Wisconsin lakes have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[49] and the Carlson TSI.[50] In addition, the Wisconsin Trophic State Index value (WTSI) is presented.[51] The WTSI is a refinement of the Carlson TSI designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes, and has been adopted by the WDNR for use in lake management investigations.

Vollenweider Trophic State Classification

Vollenweider's trophic state classification system assigns a trophic condition rating based on observed concentrations of total phosphorus and/or chlorophyll-*a*, and/or Secchi-disk transparency. The open-ended classification system assigns a probability rating to each observed measurement, allowing the observer to determine the most likely trophic state, given that individual observers may assign slightly different trophic conditions to individual waterbodies based upon local norms or other factors which influence the trophic classification of a specific lake.

Using the Vollenweider trophic system and applying the data in Tables 11 and 12, Lake Mary, with a mean annual total phosphorus concentration of 0.012 mg/l, would be classified as having about a 50 percent probability of being oligotrophic based upon observed phosphorus levels, as shown in Figure 13. The Lake would have about a 40 percent probability of being mesotrophic, and less than a 5 percent probability of being either ultra-oligotrophic or eutrophic, based upon mean annual phosphorus concentrations. Based upon Secchi-disk readings of about 11.5 feet (3.5 meters), the Lake would be classified as having an 45 percent probability of being either mesotrophic or eutrophic, with about a 5 percent probability of being either oliotrophic or hypertrophic, as shown in Figure 13. While these indicators result in slightly differing lake trophic state classifications, it may be concluded that Lake Mary could be classified as a meso-oligotrophic lake, or a lake with acceptable water quality for most desired uses.

---

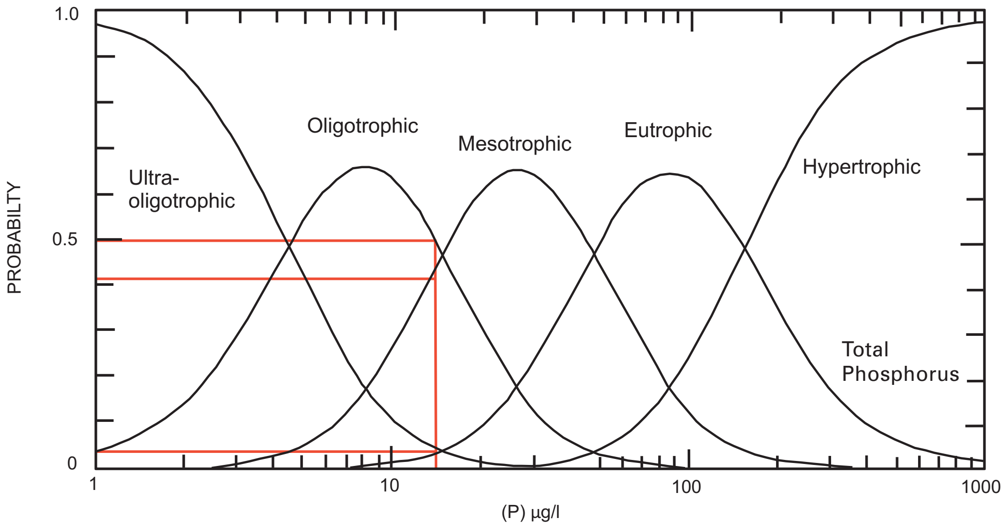
[49]*H. Olem and G. Flock, U.S. Environmental Protection Agency Report EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition*, Washington, D.C., August 1990.*

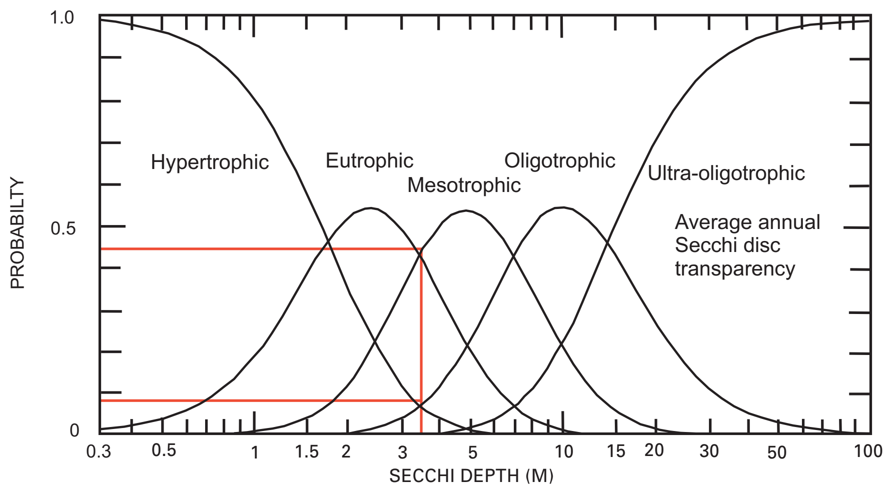
[50]*R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography*, Vol. 22, No. 2, 1977.*

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

Figure 13

TROPHIC STATE CLASSIFICATION OF LAKE MARY BASED UPON THE VOLLENWEIDER MODEL



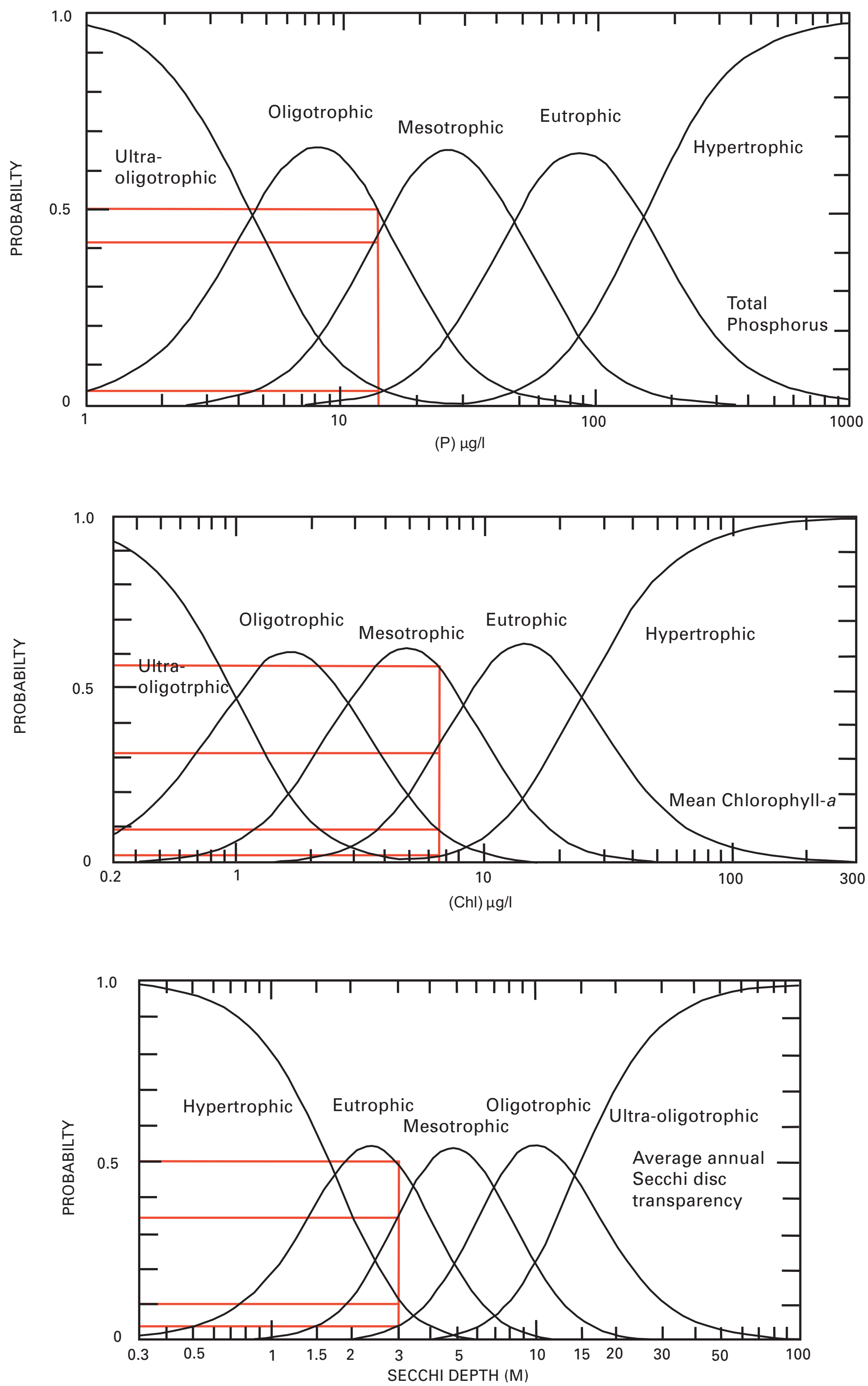


Source: Organization for Economic Cooperation and Development and SEWRPC.

Using the Vollenweider trophic system and applying the data in Tables 11 and 12, Elizabeth Lake, with a mean annual total phosphorus concentration of 0.013 mg/l, also would be classified as having about a 50 percent probability of being oligotrophic based upon observed phosphorus levels, as shown in Figure 14. The Lake would have about a 40 percent probability of being mesotrophic, and less than a 5 percent probability of being either ultra-oligotrophic or eutrophic, based upon mean annual phosphorus concentrations. Based upon chlorophyll-*a* levels of about 6.6 µg/l, the Lake would be classified as having a 55 percent probability of being mesotrophic, with about a 30 percent probability of being eutrophic, about a 10 percent probability of being oligotrophic, and about a 5 percent probability of being hypertrophic, as shown in Figure 14. Based upon Secchi-disk readings of about 9.5 feet (3.0 meters), the Lake would be classified as having an 50 percent probability of being oligotrophic, with a 35 percent probability of being ultra-oligotrophic, a 10 percent probability of being hypertrophic, and a 5 percent probability of being mesotrophic, as shown in Figure 14. While these indicators result in slightly differing lake trophic state classifications, it may be concluded that Elizabeth Lake could be classified as an oligo-mesotrophic lake, or a lake with acceptable water quality for the majority of desired uses.

Figure 14

TROPHIC STATE CLASSIFICATION OF ELIZABETH LAKE BASED UPON THE VOLLENWEIDER MODEL



Source: Organization for Economic Cooperation and Development and SEWRPC.

Trophic State Index
The TSI assigns a numerical trophic condition rating based on Secchi-disk transparency, total phosphorus, and chlorophyll-*a* concentrations. The original Trophic State Index developed by Carlson has been modified for Wisconsin lakes by the WDNR using data on 184 lakes throughout the State.[52]

Utilizing the WTSI rating system, Lake Mary could be classified as mesotrophic. Remote sensing data gathered as part of the aforementioned ERSC program, estimated the TSI rating of Lake Mary at 52, which places Lake Mary in the upper mesotrophic category with fair to good water quality. The WTSI rating for Lake Mary, based upon an average total phosphorus concentration of 0.012 mg/l, is 47; based upon an average Secchi-disk transparency of 11.5 feet (3.5 meters), the WTSI value is 42. Wisconsin Trophic State Index ratings of between 42 and 47 would suggest that the Lake is mesotrophic,

Utilizing the same WTSI rating system, Elizabeth Lake could be classified as mesotrophic. Remote sensing data gathered as part of the aforementioned ERSC program, estimated the TSI rating of Elizabeth Lake at 53, which places Elizabeth Lake in the upper mesotrophic category with fair to good water quality. The WTSI rating for Elizabeth Lake, based on an average total phosphorus concentration of 0.013 mg/l, is 48; based upon an average chlorophyll-*a* concentration of 6.6 μg/l, 49; and, based upon an average Secchi-disk transparency of 3.0 meters, is 44. Based upon the WTSI ratings of between 44 and 49, Elizabeth Lake can be classified as mesotrophic.

SUMMARY

The Twin Lakes represent typical hard-water, alkaline lakes that are considered to have relatively good water quality. Total phosphorus levels were found to be generally just below the level considered to cause nuisance algal and macrophytic growths. Summer stratification was observed in the Twin Lakes, although deoxygenation did not occur every year, based upon the available data sets. The surface waters of the Lakes remained well oxygenated and supported healthy fish populations; winterkill was not considered to be a problem in the Twin Lakes. Similarly, internal releases of phosphorus from the bottom sediments were not considered to be a problem in the Twin Lakes.

There were no significant point sources of pollutants in the Twin Lakes tributary area. Nonpoint sources of pollution to both lakes included stormwater runoff from urban and agricultural areas. The total annual phosphorus load to Lake Mary was estimated to be 315 pounds; 1,215 pounds of phosphorus were estimated to be delivered to Elizabeth Lake. Runoff from the agricultural lands contributed the largest amounts of phosphorus, which were estimated to be 52 percent of the total phosphorus load to Lake Mary and 81 percent of the total phosphorus load to Elizabeth Lake. Urban lands contributing about 37 percent of the total phosphorus load to Lake Mary and about 11 percent of the total phosphorus load to Elizabeth Lake. In addition, direct precipitation onto the lake surface contributed about 5 percent to 8 percent of the total phosphorus load, or relatively minor amounts of phosphorus, to the Lakes. Under forecast buildout conditions, the annual total phosphorus loads to the Lakes are anticipated to decrease slightly, to approximately 283 pounds to Lake Mary and to about 1,203 pounds to Elizabeth Lake, as land uses shift from rural uses toward urban uses. Under forecast year 2035 land use conditions, urban lands will contribute more than one-quarter of the annual total phosphorus loads to the Lakes. Direct precipitation onto the lake surfaces will remain a minor contributor to the annual total phosphorus loads.

Approximately 12.5 percent of the total phosphorus load to Lake Mary and about 20 percent of the total phosphorus load to Elizabeth Lake were retained within the Lakes. About 245 pounds of phosphorus are estimated to remain in Elizabeth Lake by conversion to biomass or through sedimentation, resulting in a net transfer of about

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

970 pounds of phosphorus downstream to the Elizabeth Lake Drain. About 40 pounds of phosphorus were retained within Lake Mary upstream of Elizabeth Lake.

Based on the Vollenweider open-ended trophic state classification model and the WTSI ratings calculated from the Twin Lakes data, the Twin Lakes may be classified as borderline mesotrophic lakes, with Lake Mary tending more toward oligotrophy than the downstream Elizabeth Lake.

This Page Intentionally Left Blank

Chapter V

AQUATIC BIOTA AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

Lake Mary and Elizabeth Lake are important elements of the natural resource base, providing a valuable ecological and recreational resource for the western portion of Kenosha County, Wisconsin, and the northern portion of McHenry County, Illinois. The Lakes, their biota, parks, and surrounding landscape, form an integral part of, and setting for, the Village of Twin Lakes, and contribute to the quality of life in the area. When located in urban settings, natural resource features, such as lakes and wetlands, are typically subject to extensive recreational use pressures and high levels of pollutant discharges, common forms of stress to aquatic systems, and these may result in the deterioration of the natural resource features. For this reason, the formulation of sound management strategies must be based on a thorough knowledge of the pertinent characteristics of the individual resource features, as well as of the urban development within the area concerned. Accordingly, this chapter provides information concerning the natural resource features of the Twin Lakes tributary area, including data on aquatic macrophytes, fish, wildlife, wetlands and woodlands, and environmental corridors. Recreational activities are described and quantified in Chapter VI of this volume; human use of the landscape was described in Chapter III of this volume.

AQUATIC PLANTS

The aquatic plant community includes both larger plants, or macrophytes, and microscopic plants, or phytoplankton and algae, phytoplankton being free-floating varieties of algae. These plants form an integral part of the aquatic food web, converting inorganic nutrients present in the water and sediments into organic compounds that are directly available as food to other aquatic organisms. In this process, known as photosynthesis, plants utilize energy from sunlight and release oxygen required by other aquatic life forms. In addition, the larger plants can provide valuable habitat for other aquatic organisms, including juvenile fishes.

To document the types, distribution, and relative abundance of aquatic plants in the Twin Lakes, data from various earlier reports were examined. Additionally, Aron and Associates conducted an aquatic plant survey of the Lakes during the summer of 2005 as part of the current planning effort.[1] Phytoplankton populations were not sampled during the current lake management planning program. Data from the various aquatic plant surveys are summarized below.

---

[1]*Aron and Associates,* Twin Lakes Aquatic Plant Management Plan Reassessment, *2005.*

Phytoplankton
Phytoplankton and other algae are small, generally microscopic, plants that are found in lakes and streams. They occur in a wide variety of forms, as single cells or colonies, and can be either attached or free floating. Free-floating algae are known as phytoplankton. Algae are primary producers that form one of the bases of aquatic food webs. As primary producers, they utilize the process of photosynthesis to convert energy and nutrients to the compounds necessary to support life in the aquatic system. Oxygen, which is vital to higher forms of life in a lake or stream, is also produced during the photosynthesis process.

Phytoplankton abundance varies seasonally with fluctuations in solar irradiance, turbulence due to prevailing winds, and nutrient availability. In temperate lakes, such as the Twin Lakes, there is a typical seasonal succession of algae. Also, in lakes with high nutrient levels, heavy growths of phytoplankton, or periodic algal blooms, may occur. Algal blooms have occasionally been perceived as a problem in the Twin Lakes.

Algae are generally classified according to their dominant photosynthetic pigment; for example, as green, blue-green, yellow-brown, or golden brown algae. Green algae (Chlorophytes) are the most important sources 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 may occur when excessive nutrient supplies are available, optimum sunlight and temperature conditions exist, and there is a lack of competition from other aquatic plant species and insufficient grazing by zooplankton. Certain species of blue-green algae may develop toxins within their cells which can be released into the water upon senescence and death of the cells. Yellow-brown algae, also referred to as diatoms, and golden-brown algae are adapted for growth under low-light conditions, cooler water temperatures, and more turbulent conditions, such as those that occur during the windy days of spring and autumn.

Algal blooms may reach nuisance proportions in fertile, or eutrophic-lakes, resulting in the accumulation of surface scums or slimes. In some cases, heavy concentrations of wind-blown algae accumulate on shorelines, where they die and decompose, causing noxious odors and unsightly conditions. The decaying algae consume oxygen, sometimes depleting available supplies and resulting in fish kills. Also, as noted above, certain blue-green algae, which typically do well under enriched conditions, can develop toxins which are released into the water.

Algae species in the Twin Lakes have not been identified or enumerated as part of any aforementioned or current reports. In many inland lakes in the Southeastern Wisconsin Region, it is normal for blue-green algae to dominate the algal population from May through October. During November, cooler water temperatures and low-light conditions generally favor diatoms and golden-brown algae, whose populations often peak during that time of year. By mid-December, blue-green algae can again gain in importance until after ice-out the following March, when the diatoms usually increase once again and become the dominant algal group. Such a spring diatom increase is typical of north temperate lakes, because diatoms thrive in cold water temperatures when adequate light and nutrients are available. As temperatures warm, golden-brown algae may became more common, reaching their maximum growth by mid-April. By the end of April, the blue-green algae often again become the dominant algal group, the result of a combination of slow growth rates and low loss rates.

Low loss rates can be attributed, in part, to special adaptations of some blue-green algal species. Some blue-green algae, for example, possess specialized organs within their cells which allow them to regulate their buoyancy, minimizing loss of cells by sedimentation and maximizing growth by allowing them to control their vertical position in the water in order to obtain optimal levels of light and nutrients. The blue-green alga, *Coelosphaerium naegelianum,* for example, forms hollow spheres of numerous coccoid algae and may, during bloom periods and the ensuing decomposition period, be deposited as wind-concentrated accumulations along shorelines with resultant odor problems, thereby, having a negative impact on recreational and esthetic qualities of a lake.

While data concerning the types and concentrations of algae found in the Twin Lakes are not available, data on the algal pigment, chlorophyll-*a* have been collected from Elizabeth Lake, and are summarized in Chapter IV of this volume. The concentrations of chlorophyll-*a* reported generally indicate good water quality. These concentrations are less than the threshold level of about 10 micrograms per liter (μg/l), above which algal populations generally are at densities that result in a green coloration of the water that may be severe enough to impair recreational activities, such as swimming and waterskiing.[2]

Aquatic Macrophytes

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

To document the types, distribution, and relative abundance of aquatic macrophytes in the Twin Lakes, periodic aquatic plant surveys have been conducted on the Lakes since 1951. For purposes of the current study, an aquatic plant survey was conducted during 2005 by Aron and Associates.[3] Vegetation was identified by species. The frequency of occurrence, relative density, and importance value for each species is calculated and presented in Tables 19 and 20. The distributions of the aquatic plant communities in the Lakes during 2005 are shown on Maps 15 and 16.

The positive ecological values of the aquatic plants reported from Lake Mary and Elizabeth Lake are set forth in Table 21. Comparisons of macrophyte surveys conducted in 2005 with those conducted as part of the earlier studies of the Twin Lakes are presented in Tables 22 and 23. Illustrations of representative macrophyte species identified in the Twin Lakes are set forth in Appendix A.

Macrophyte Flora of Lake Mary

Of the 21 submergent aquatic plants observed in Lake Mary during 2005, the dominant species was muskgrass (*Chara* spp.), with significant populations of Sago pondweed (*Potamogeton pectinatus*) and widgeon grass (*Ruppia maritime*) being observed. Other species noted in the year 2005 aquatic plant survey in Lake Mary included bladderwort *(Utricularia vulgaris)*, brittle naiad (*Najas marina*), and eel-grass (*Vallisneria americana*).

As shown in Table 22, in Lake Mary, the dominant species over time has consistently been muskgrass (*Chara* sp.), along with Sago pondweed (*Potamogeton pectinatus)* and widgeon grass (*Ruppia* sp.). Muskgrass (*Chara* spp.) is considered to be an indicator of good water quality, and is frequently present in groundwater-fed lakes in southeastern Wisconsin. Also of note in Lake Mary is the presence of white-stem pondweed (*Potamogeton praelongus*), which is viewed as a sign of good water quality due to the intolerance of this species to turbidity. Other species which have had relatively stable populations in Lake Mary over time include bladderwort (*Utricularia* sp.), bushy pondweed (*Najas* flexilis), coontail (*Ceratophyllum demersum*), eel-grass (*Vallisneria*

---

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

[3]*Aron and Associates,* op. cit.

Table 19

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

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence[a] (percent)	Relative Density[b]	Importance Value[c]
Bladderwort *(Utricularia vulgaris)*	16	26.2	1.9	49.8
Brittle Naiad (*Najas marina*)	12	19.7	2.4	47.6
Clasping-Leaf Pondweed *(Potamogeton richardsonii)*	N/D	- -	- -	- -
Coontail (*Ceratophyllum demersum*)	1	1.6	2.0	3.2
Curly-Leaf Pondweed *(Potamogeton crispus)*	G/S	- -	- -	- -
Eel-Grass/Wild celery *(Vallisneria americana)*	10	16.4	1.9	31.2
Elodea *(Elodea canadensis)*	2	3.3	1.5	5.0
Eurasian Water Milfoil *(Myriophyllum spicatum)*	6	9.8	1.8	18.0
Flat-Stem Pondweed *(Potamogeton zosteriformis)*	1	1.6	1.0	1.6
Floating-Leaf Pondweed (*Potamogeton natans*)	N/D	- -	- -	- -
Fries Pondweed (*Potamogeton fresii*)	1	1.6	2.0	3.2
Leafy Pondweed *(Potamogeton foliosis)*	N/D	- -	- -	- -
Muskgrass *(Chara vulgaris)*	44	72.1	3.4	244.2
Nitella (*Nitella* sp.)	3	4.9	3.0	14.7
Northern Water Milfoil *(Myriophyllum sibiricum)*	N/D	- -	- -	- -
Sago Pondweed *(Potamogeton pectinatus)*	26	42.6	3.0	127.8
Slender Naiad (*Najas flexilis*)	1	1.6	2.0	3.2
Variable Pondweed *(Potamogeton gramineus)*	4	6.6	2.3	14.9
Water Stargrass (*Zosterella dubia*)	G/S	- -	- -	- -
White-Stem Pondweed (*Potamogeton praelongus)*	2	3.3	2.5	8.3
Widgeon Grass (*Ruppia maritime*)	20	32.8	3.8	124.6

NOTES: There were 77 sites sampled during the 2005 survey; 16 sites contained no plants.

N/D = This species was listed in the 2005 Aron and Associates aquatic plant management plan report as being identified, but numerical data regarding sampling sites was not available.

G/S = This species was observed as part of a general survey of the Lake's littoral zone, but was not collected at any of the sampling sites and not, therefore, recorded statistically.

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

[b]*The average or relative density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 5.0 is assigned to plants that occur at all points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

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

Source: Aron and Associates and SEWRPC.

americana), and brittle naiad (*Najas marina*). Species showing an apparent decrease in abundance include clasping-leaf pondweed (*Potamogeton richardsonii*), curly-leaf pondweed (*Potamogeton crispus*), flat-stem pondweed (*Potamogeton zosteriformis*), floating-leaf pondweed (*Potamogeton natans*), narrow-leaf pondweed (*Potamogeton filiformis*), quillwort (*Isoetes* sp.), waterweed (*Anacharis accidintalis*), and water stargrass (*Zosterella dubia*).[4] Species showing an apparent increase in populations include elodea (*Elodea canadensis*), Eurasian water milfoil (*Myriophyllum spicatum*), and stonewort (*Nitella*).

[4]*Seasonality among the pondweeds is significant, with one species replacing another throughout the year. Consequently, the particular species of pondweeds sampled at any given time vary significantly. In evaluating the likely consequences of the presence or absence of specific species of pondweed, the observer should take note of the relative abundance and frequency of occurrence of the pondweed species as a whole in making assessments of major changes in the aquatic plant community.*

Table 20

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

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence[a] (percent)	Relative Density[b]	Importance Value[c]
Bladderwort *(Utricularia vulgaris)*	3	4.5	1.3	5.9
Brittle Naiad (*Najas marina*)	9	13.4	2.3	30.8
Clasping-Leaf Pondweed *(Potamogeton richardsonii)*	N/D	- -	- -	- -
Coontail (*Ceratophyllum demersum*)	4	6.0	2.3	8.3
Curly-Leaf Pondweed *(Potamogeton crispus)*	1	1.5	2.0	3.0
Eel-Grass/Wild celery *(Vallisneria americana)*	26	38.8	2.6	100.9
Elodea *(Elodea canadensis)*	5	7.5	2.2	16.5
Eurasian Water Milfoil *(Myriophyllum spicatum)*	24	35.8	2.3	82.3
Flat-Stem Pondweed *(Potamogeton zosteriformis)*	6	9.0	2.5	22.5
Fries Pondweed (*Potamogeton friesii*)	2	3.0	2.0	6.0
Floating-Leaf Pondweed (*Potamogeton natans*)	3	4.5	1.7	7.7
Large-Leaf Pondweed (*Potamogeton amplifolius*)	N/D	- -	- -	- -
Leafy Pondweed *(Potamogeton foliosis)*	9	13.4	2.7	36.2
Muskgrass *(Chara vulgaris)*	38	56.7	3.4	192.8
Nitella (*Nitella* sp.)	G/S	- -	- -	- -
Sago Pondweed *(Potamogeton pectinatus)*	28	41.8	2.0	83.6
Slender Naiad (*Najas flexilis*)	13	19.4	2.2	42.7
Variable Pondweed *(Potamogeton gramineus)*	18	26.9	1.7	45.7
Water Marigold (*Megalodonta beckii*)	N/D	- -	- -	- -
Water Stargrass (*Zosterella dubia*)	7	10.4	2.1	21.8
White-Stem Pondweed (*Potamogeton praelongus*)	8	11.9	2.1	25.0
Widgeon Grass (*Ruppia maritime*)	16	23.9	2.9	69.3

NOTES: There were 78 sites sampled during the 2005 survey; 11 sites contained no plants.

N/D = This species was listed in the 2005 Aron and Associates aquatic plant management plan report as being identified, but numerical data regarding sampling sites was not available.

G/S = This species was observed as part of a general survey of the Lake's littoral zone, but was not collected at any of the sampling sites and not, therefore, recorded statistically.

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

[b] *The average or relative density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 5.0 is assigned to plants that occur at all points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

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

Source: Aron and Associates and SEWRPC.

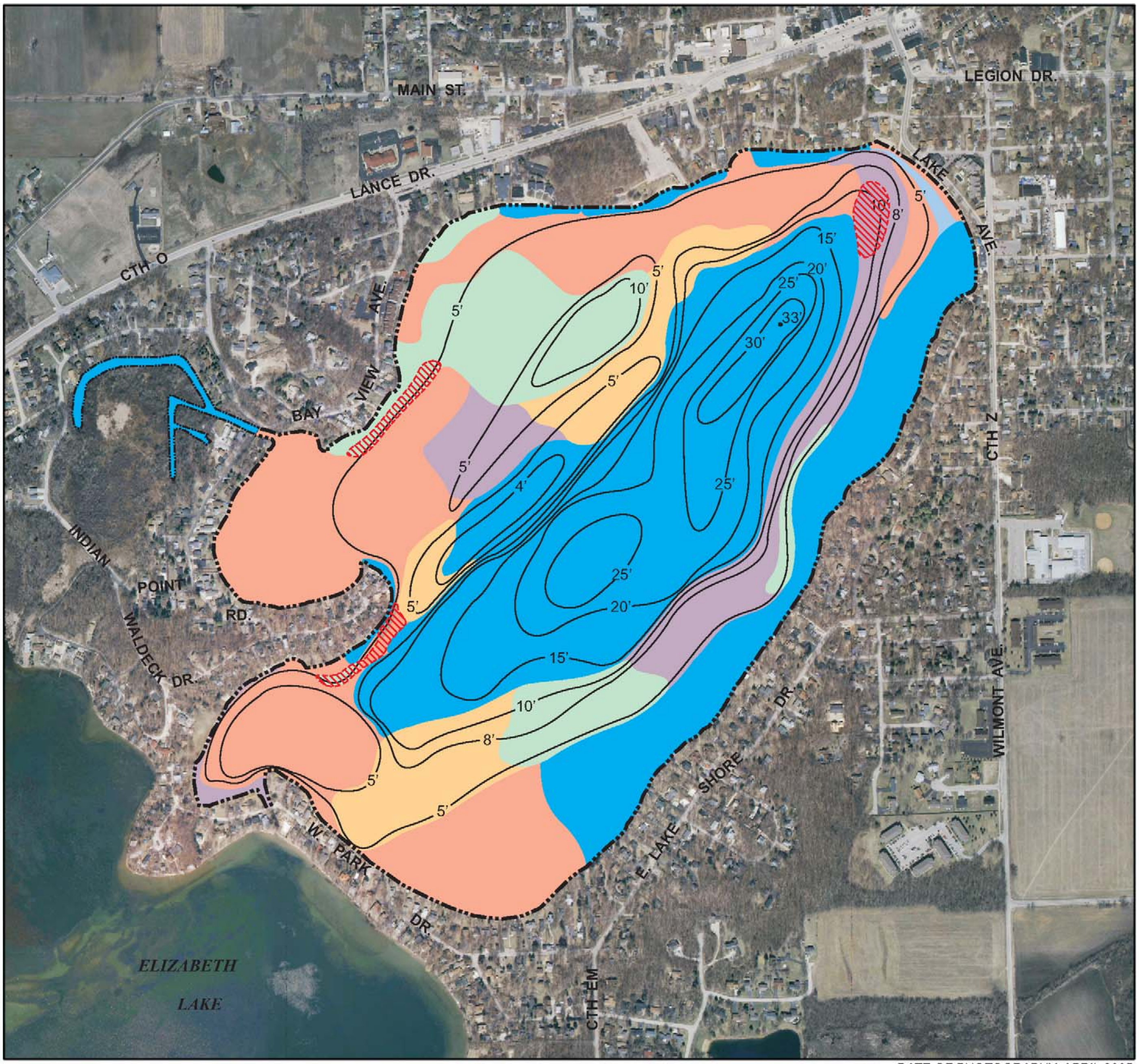
Macrophyte Flora of Elizabeth Lake

In Elizabeth Lake, the 23 species of submerged aquatic plants recorded were dominated by muskgrass (*Chara* spp.), with water celery or eel-grass (*Vallisneria americana*), Sago pondweed *(Potamogeton pectinatus)*, Eurasian water milfoil (*Myriophyllum spicatum*), and widgeon grass (*Ruppia* sp.) also being present in significant numbers. Other species noted in the year 2005 aquatic plant survey in Elizabeth Lake included variable pondweed (*Potamogeton gramineus*), slender naiad (*Najas flexilis*), and leafy pondweed (*Potamogeton foliosis*).

As shown in Table 23, patterns in the aquatic plant community in Elizabeth Lake over time have included: a dominant population of muskgrass (*Chara* spp.); stable populations of eel-grass (*Vallisneria americana*), and Sago pondweed *(Potamogeton pectinatus)*; decreasing populations of native water milfoil, clasping-leaf pondweed (*Potamogeton richardsonii*), and large-leaf pondweed (*Potamogeton amplifolius*); and increasing populations of bladderwort (*Utricularia* sp.), coontail (*Ceratophyllum demersum*), curly-leaf pondweed (*Potamogeton crispus*),

Map 15

AQUATIC PLANT COMMUNITY DISTRIBUTION IN LAKE MARY: 2005



20' WATER DEPTH CONTOUR IN FEET

OPEN WATER

EURASIAN WATER MILFOIL

BLADDERWORT, BUSHY PONDWEED, MUSKGRASS, FRIES PONDWEED, COONTAIL, WATERWEED, FLOATING-LEAF PONDWEED, LEAFY PONDWEED, NITELLA, SPINY NAIAD, SAGO PONDWEED, WILD CELERY, VARIABLE PONDWEED, WATER STAR GRASS, WHITE-STEM PONDWEED, AND DITCH GRASS

BLADDERWORT, BUSHY PONDWEED, MUSKGRASS, SAGO PONDWEED, WATERWEED, WILD CELERY, DITCH GRASS, VARIABLE PONDWEED, AND WHITE-STEM PONDWEED

MUSKGRASS, WATERWEED, SAGO PONDWEED, WILD CELERY, WHITE-STEM PONDWEED, AND DITCH GRASS

BLADDERWORT, MUSKGRASS, WATERWEED, SAGO PONDWEED, FLAT-STEM PONDWEED, SPINY NAIAD, AND DITCH GRASS

BLADDERWORT, MUSKGRASS, WATERWEED, SAGO PONDWEED, FLAT-STEM PONDWEED, SPINY NAIAD, FRIES PONDWEED, LEAFY PONDWEED, NITELLA, SAGO PONDWEED, WILD CELERY, VARIABLE PONDWEED, WHITE-STEM PONDWEED, AND DITCH GRASS

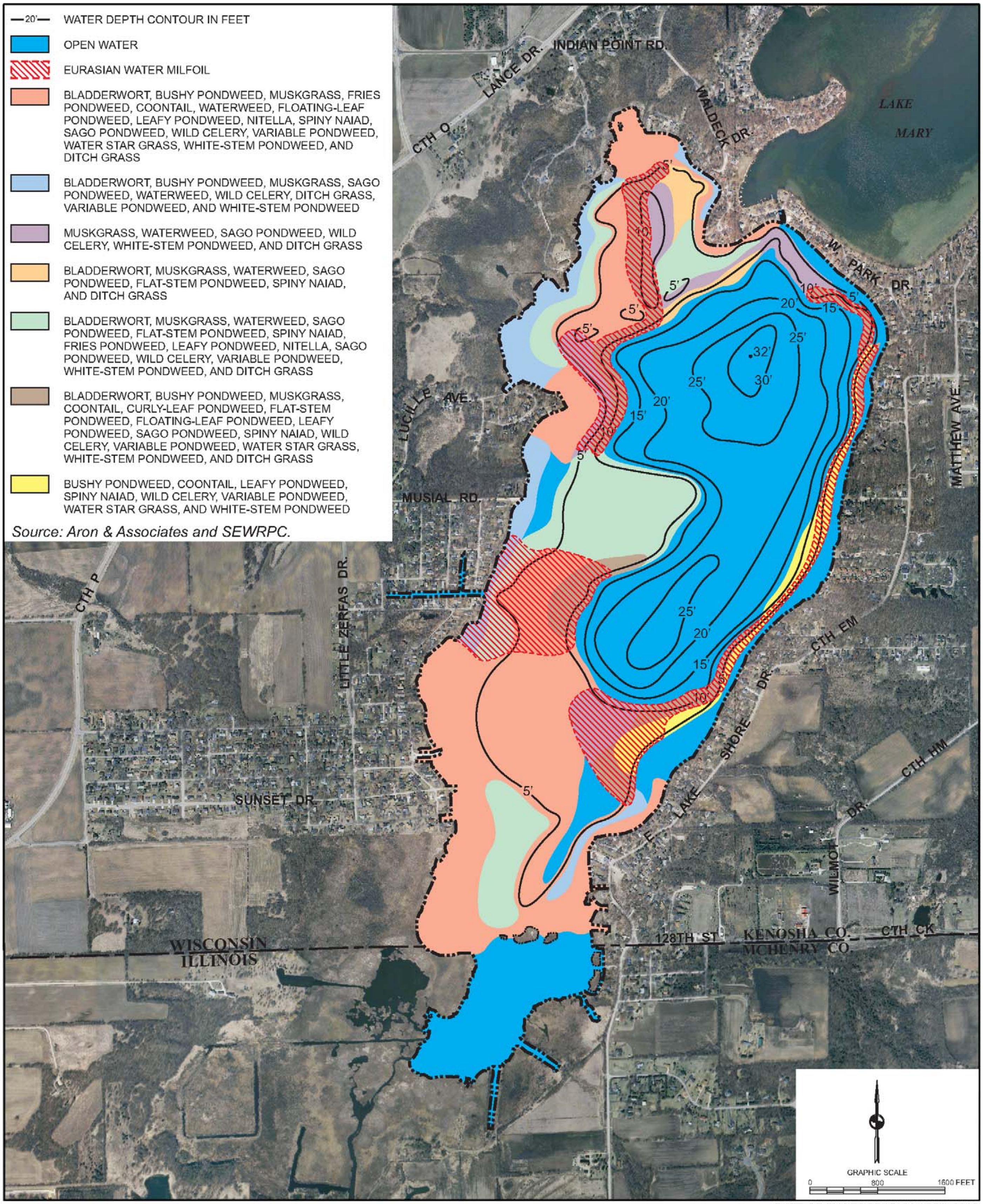
BLADDERWORT, BUSHY PONDWEED, MUSKGRASS, COONTAIL, CURLY-LEAF PONDWEED, FLAT-STEM PONDWEED, FLOATING-LEAF PONDWEED, LEAFY PONDWEED, SAGO PONDWEED, SPINY NAIAD, WILD CELERY, VARIABLE PONDWEED, WATER STAR GRASS, WHITE-STEM PONDWEED, AND DITCH GRASS

GRAPHIC SCALE
0 500 1000 FEET

Source: Aron & Associates and SEWRPC.

Map 16

AQUATIC PLANT COMMUNITY DISTRIBUTION IN ELIZABETH LAKE: 2005



DATE OF PHOTOGRAPHY: APRIL 2005

Table 21

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN THE TWIN LAKES

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass, stabilizes bottom sediments, and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed)	Provides shelter and support for insects which are valuable as fish food
Megalodontia beckii (water marigold)	Above-water flowers attract insects; submersed foliage provides shelter and foraging for fish; fruit is food for waterfowl
Myriophyllum sibiricum (northern water milfoil)	Provides food for waterfowl, insect habitat and foraging opportunities for fish
Myriophyllum spicatum (Eurasian water milfoil)	None known
Najas flexilis (bushy pondweed/slender naiad)	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (brittle naiad)	Important food source for ducks
Nitella sp. (nitella)	Provides forage for fish and food for waterfowl
Potamogeton amplifolius (large-leaf pondweed)	Food for waterfowl and foraging opportunities for fish
Potamogeton crispus (curly-leaf pondweed)	Provides food, shelter and shade for some fish and food for wildfowl
Potamogeton foliosis (leafy pondweed)	Provides food for geese and ducks; food for muskrat, beaver and deer; good surface area for insects and cover for juvenile fish
Potamogeton friesii (Fries pondweed)	Food for numerous kinds of waterfowl, muskrat, deer, beaver and a source of food and shelter for fish
Potamogeton gramineus (variable pondweed)	Provides habitat for fish and food for waterfowl, muskrat, beaver and deer
Potamogeton natans (floating-leaf pondweed)	Fruit is food for waterfowl, muskrat, beaver and deer; provides shade and foraging for fish
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton praelongus (white-stem pondweed)	Good food provider for waterfowl, muskrat, and some fish species; valuable habitat for musky. Considered an indicator species for water quality due to its intolerance of turbid water conditions
Potamogeton richardsonii (clasping-leaf pondweed)	Provides food, shelter and shade for some fish, food for some wildfowl, and food for muskrat. Provides shelter and support for insects, which are valuable as fish food
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks
Ruppia maritime (widgeon grass)	Fruit and foliage are food for waterfowl and fish
Utricularia spp. (bladderwort)	Provides cover and foraging for fish
Vallisneria americana (water celery/eel-grass)	Provides good shade and shelter, supports insects, and is valuable fish food
Zosterella dubia (water stargrass)	Important food source for waterfowl; cover for fish

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

Source: SEWRPC.

Table 22

FREQUENCY OF OCCURRENCE OF MAJOR PLANT SPECIES PRESENT IN LAKE MARY: 1951-2005

Common Name	Scientific Name	Frequency of Occurrence				
		1951	1967	1970	1991	2005
Bladderwort	*Utricularia* spp.	- -	Present	- -	Present	Present
Bushy Pondweed	*Najas flexilis*	Common	Present	- -	Common	Present
Clasping-Leaf Pondweed	*Potamogeton richardsonii*	- -	- -	Common	Present	- -
Coontail	*Ceratophyllum demersum*	- -	Present	Common	Common	Present
Curly-Leaf Pondweed	*Potamogeton crispus*	Scarce	Present	Common	Scarce	- -
Eel-Grass	*Vallisneria americana*	Common	Present	Common	Common	Present
Elodea	*Elodea canadensis*	- -	- -	- -	- -	Present
Eurasian Water Milfoil	*Myriophyllum spicatum*	- -	- -	- -	Common	Present
Flat-Stem Pondweed	*Potamogeton zosteriformis*	Common	Present	Present	Common	Scarce
Floating-Leaf Pondweed	*Potamogeton natans*	- -	Present	Present	- -	- -
Fries Pondweed	*Potamogeton friesii*	Common	- -	- -	- -	Present
Large-Leaf Pondweed	*Potamogeton amplifolius*	- -	Present	- -	Present	- -
Leafy Pondweed	*Potamogeton foliosis*	- -	- -	- -	- -	N/D
Muskgrass	*Chara* spp.	Abundant	Abundant	Abundant	Abundant	Abundant
Narrow-Leaf Pondweed	*Potamogeton filiformis*	Abundant	- -	- -	- -	- -
Northern Water Milfoil	*Myriophyllum sibiricum*	Very abundant	Present	Abundant	Common	N/D
Quillwort	*Isoetes* sp.	- -	- -	Present	- -	- -
Sago Pondweed	*Potamogeton pectinatus*	Very abundant	Abundant	Abundant	Abundant	Common
Spiny Naiad	*Najas marina*	- -	Abundant	Abundant	Abundant	Common
Stonewort	*Nitella* spp.	- -	- -	- -	- -	Common
Variable Pondweed	*Potamogeton gramineus*	- -	Present	Present	- -	Common
Water Weed	*Anacharis accidintalis*	Common	Present	Common	- -	- -
Water Stargrass	*Zosterella dubia*	- -	- -	Present	Present	- -
White-Stem Pondweed	*Potamogeton praelongus*	Abundant	Present	- -	- -	Common
Widgeon Grass	*Ruppia* sp.	- -	Abundant	- -	Abundant	Abundant

NOTES: For the 2005 survey, the descriptor "Scarce" is used to indicate the species had a relative density value of 1.0 or less; "Present" represents a value of 1.1 to 2.0; "Common" represents a value of 2.1 to 3.0; "Abundant" represents a value of 3.1 to 4.0; and, "Very abundant" represents a value of 4.1 to 5.0. It is not certain how precisely these descriptors match those used for the earlier surveys, but are used to indicate general relative abundances and not exact measurements.

N/D= Species was listed in the 2005 Aron and Associates survey as being identified, but numerical data was not available.

Source: Wisconsin Department of Natural Resources, Aron and Associates, Discovery Group, Ltd. and Blue Water Science, and SEWRPC.

elodea (*Elodea canadensis*), Eurasian water milfoil (*Myriophyllum spicatum*), leafy or variable pondweed (*Potamogeton foliosus*), spiny or brittle naiad (*Najas marina*), water stargrass (*Zosterella dubia*), and widgeon grass (*Ruppia* sp.).

Eurasian Water Milfoil in the Twin Lakes

Eurasian water milfoil has been documented in aquatic plant surveys of the Twin Lakes since 1991. In the 1991 survey, Eurasian water milfoil was observed in both the Lakes. In Lake Mary, the species was present in three areas near stormwater discharge points, totaling about two acres in areal extent. In Elizabeth Lake, the plant was found to be growing in a band around the entire lake.[5] In the 2005 survey, Eurasian water milfoil was present in both Lakes, but in greater overall densities. The plant was present in much greater numbers in Elizabeth Lake than in Lake Mary. In Lake Mary, the three areas in which the species was found in 2005 totaled about 11 acres, compared to about two acres in 1991. In Elizabeth Lake, the total area where the species was found to total about 30 acres in 2005, forming a nearly complete ring around the Lake at the five- to 12-foot depth.

---

[5]*Discovery Group, Ltd., Madison, Wisconsin, and Blue Water Science, St. Paul, Minnesota,* Lake Management Plan, Twin Lakes Protective and Rehabilitation District, Twin Lakes, Wisconsin, *Revised, February 18, 1993*.

Table 23

FREQUENCY OF OCCURRENCE OF MAJOR PLANT SPECIES PRESENT IN ELIZABETH LAKE: 1951-2005

Common Name	Scientific Name	Frequency of Occurrence			
		1951	1967	1991	2005
Bladderwort	*Utricularia* spp.	- -	- -	Present	Present
Bushy Pondweed	*Najas flexilis*	Common	- -	Common	Common
Clasping-Leaf Pondweed	*Potamogeton richardsonii*	- -	- -	Present	- -
Coontail	*Ceratophyllum demersum*	- -	- -	Common	Common
Curly-Leaf Pondweed	*Potamogeton crispus*	- -	- -	Scarce	Common
Eel-Grass	*Vallisneria americana*	Scarce	Abundant	Common	Common
Elodea	*Elodea canadensis*	- -	- -	- -	Common
Eurasian Water Milfoil	*Myriophyllum spicatum*	- -	- -	Abundant	Common
Flat-Stem Pondweed	*Potamogeton zosteriformis*	Common	- -	Present	Common
Floating-Leaf Pondweed	*Potamogeton natans*	Common	- -	Present	Present
Fries Pondweed	*Potamogeton friesii*	Common	- -	- -	Present
Large-Leaf Pondweed	*Potamogeton amplifolius*	Abundant	- -	Present	- -
Leafy Pondweed	*Potamogeton foliosus*	- -	- -	- -	Common
Muskgrass	*Chara* sp.	Very abundant	Abundant	Abundant	Abundant
Stonewort	*Nitella* sp.	- -	- -	- -	G/S
Quillwort	*Isoetes* sp.	- -	- -	- -	- -
Sago Pondweed	*Potamogeton pectinatus*	Very abundant	- -	Abundant	Present
Spiny Naiad	*Najas marina*	- -	Abundant	Abundant	Common
Variable Pondweed	*Potamogeton gramineus*	- -	- -	- -	Present
Water Marigold	*Megalodonta beckii*	- -	- -	- -	N/D
Water Milfoil	*Myriophyllum* sp.	Common	- -	Common	- -
Water Stargrass	*Zosterella dubia*	- -	- -	Present	Common
Water Weed	*Anacharis accidintalis*	Common	- -	- -	- -
White-Stem Pondweed	*Potamogeton praelongus*	Abundant	- -	- -	Common
Widgeon Grass	*Ruppia* sp.	- -	- -	Common	Common

NOTES: For the 2005 survey, the descriptor "Scarce" is used to indicate the species had a relative density value of 1.0 or less; "Present" represents a value of 1.1 to 2.0; "Common" represents a value of 2.1 to 3.0; "Abundant" represents a value of 3.1 to 4.0; and, "Very abundant" represents a value of 4.1 to 5.0. It is not certain how precisely these descriptors match those used for the earlier surveys, but are used to indicate general relative abundances and not exact measurements.

G/S = This species was observed as part of a general survey of the Lake's littoral zone conducted in 2005 by Aron and Associates, but was not collected at any of the sampling sites and not, therefore, recorded statistically.

N/D = This species was listed in the 2005 Aron and Associates Aquatic Plant Management Plan report as being identified, but numerical data regarding sampling sites was not available.

Source: Wisconsin Department of Natural Resources, Aron and Associates, Discovery Group, Ltd. and Blue Water Science, and SEWRPC.

Eurasian water milfoil (*Myriophyllum spicatum*) is one of eight milfoil species found in Wisconsin and the only one known to be an exotic or nonnative plant. The plant has been designated as an aquatic invasive species pursuant to Chapter NR 109 of the *Wisconsin Administrative Code* and is, as such, a plant species of concern to be considered in this plan. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can control its potentially explosive growth, which the plant typically exhibits in lakes with organic-rich sediments or where the lake bottom has been disturbed. In such cases, the Eurasian water milfoil populations can displace native plant species which, in turn, can lead to the loss of plant diversity, degradation of water quality, and reduction in habitat value for fish, invertebrates and wildlife. In addition, the plant has been known to cause severe aesthetic and recreational use problems in lakes in southeastern Wisconsin.

Eurasian water milfoil reproduces primarily by the rooting of plant fragments, although there is evidence that seeds may play a role, as well. Consequently, some recreational uses of lakes can result in the expansion of Eurasian water milfoil communities, especially when boat propellers fragment Eurasian water milfoil plants. These fragments, as well as fragments that occur for other reasons, such as wind-induced turbulence or fragmentation of the plant by fishes, are able to generate new root systems, allowing the plant to colonize new sites.

The fragments also can cling to boats, trailers, motors, and/or bait buckets, and can stay alive for weeks contributing to the transfer of milfoil to other lakes. For this reason, it is very important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies. Removal of such plant fragments is required pursuant to Chapter NR 109.

Shoreland Plants

Emergent shoreline species in the Twin Lakes during the earlier surveys included abundant populations of bulrush (*Scirpus* sp.), cattail (*Typhia latifolia*), and spadderdock (*Nuphar advena*) and floating plants, such as white and yellow water lilies (*Nuphar* sp. and *Nymphaea* sp.).

In general, the Twin Lakes support healthy and diverse aquatic macrophyte communities. The beneficial nature of the aquatic plant communities in the Twin Lakes, as well as the importance of these communities in maintaining the ecological balance in the Lakes, is generally recognized by the lakeshore residents, although some residents report difficulties with navigation in portions of the Lakes. Generally, the diversity of the plant communities in and adjacent to the Lakes contribute to the wildlife habitat value of the area, as set forth below. Fish, waterfowl, pheasants, muskrats, and other wetland wildlife species dependent on aquatic vegetation for feeding and nesting, brooding, or resting areas, are known to make use of the Lakes.

Aquatic Plant Management

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, the first recorded efforts to manage the aquatic plants in the Twin Lakes have taken place since 1950. Aquatic plant management activities in the Twin Lakes can be categorized as primarily chemical control. Currently, all forms of aquatic plant management are subject to permitting by the WDNR, pursuant to authorities granted under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*. Limited manual removal of aquatic plants under specific conditions may be permitted under a general statewide permit granted pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*; other forms of aquatic plant management require individual permits under the current *Wisconsin Administrative Code* provisions.

Chemical Controls

Perceived excessive macrophytes growths on Lake Mary and Elizabeth Lake have generally resulted in the implementation of a chemical control program. Recorded chemical herbicide treatments that have been applied to the Lakes are set forth in Tables 24 and 25. In Wisconsin, the use of chemicals to control aquatic plants and algae has been regulated since 1941, even though records of aquatic herbicide applications have only been maintained by the WDNR since 1950.

In 1926, sodium arsenite, an agricultural herbicide, was first applied to lakes in the Madison area, and, by the 1930s, sodium arsenite was widely used throughout the State for aquatic plant control. No other chemicals were applied in significant amounts to control macrophytes until recent years, when a number of organic chemical herbicides came into general use. The amounts of sodium arsenite applied to Lake Mary and Elizabeth Lake, and years of application during the period 1950 through 1967, are listed in Tables 24 and 25. The total amount of sodium arsenite applied to the Twin Lakes over this 17-year period was about 360 pounds, all of which was applied to Elizabeth Lake. This amount is low compared to most other lakes in the Region.

Sodium arsenite was typically sprayed onto the surface of Elizabeth 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) sodium arsenite (about five mg/l arsenic) in the treated lake water. The sodium arsenite typically remained in the water column for less than 120 days. Although the arsenic residue was naturally converted from a highly toxic form to a less toxic and less biologically active form, much of the arsenic residue was deposited in the lake sediments.

Table 24

CHEMICAL CONTROL OF AQUATIC PLANTS IN LAKE MARY: 1950-2005

Year	Total Acres Treated	Algae Control			Macrophyte Control				
		Copper Granular (pounds)	Copper Liquid (gallons)	Other	Sodium Arsenite (pounds)	2, 4-D	Diquat (gallons)	Endothall (gallons)	Other
1950-1973	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1974	0.03	- -	- -	- -	- -	2 lbs.	- -	- -	- -
1975	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1976	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1977-1979	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1980[a]	2.75	- -	- -	- -	- -	- -	- -	29.5	- -
1981	2.75	- -	- -	- -	- -	15 gal.	- -	- -	- -
1982-1983	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1984[a]	14.00	- -	- -	- -	- -	- -	- -	- -	- -
1985-1997	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1998	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1999	0.00	- -	- -	- -	- -	- -	- -	- -	- -
2000	0.00	- -	- -	- -	- -	- -	- -	- -	- -
2001	3.50	- -	- -	- -	- -	- -		- -	- -
2002	0.25	- -	0.2	- -	- -	- -	0.2	0.2	- -
2003	0.96	- -	1.0	- -	- -	- -	1.0	1.0	- -
2004	4.32	- -	2.5	- -	- -	- -	2.5	2.5	- -
2005	8.00	- -	4.2	- -	- -	- -	4.2	4.2	- -
Total	36.56	- -	7.9	- -	- -	- -	7.9	37.4	- -

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

[a]*WDNR permit assigned to "Twin Lakes" without specifying Lake Mary or Elizabeth Lake.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

When it became apparent that arsenic was accumulating in the sediments of treated lakes and that the accumulations of arsenic were found to present potential health hazards to humans and aquatic life, the use of sodium arsenite was discontinued in the State in 1969. Draft sediment quality criteria limits set forth by the WDNR are shown in Table 26.

As shown in Tables 24 and 25, the aquatic herbicides diquat, endothall, and 2,4-D have also been applied to the Twin Lakes to control aquatic macrophyte growth. Diquat and endothall (Aquathol) are contact herbicides and kill plant parts exposed to the active ingredient. Diquat use is restricted to the control of duckweed (*Lemna* sp.), milfoil (*Myriophyllum* spp.), and waterweed (*Elodea* sp.). However, this herbicide is nonselective and will kill many other aquatic plants, such as pondweeds (*Potamogeton* spp.), bladderwort (*Utricularia* sp.), and naiads (*Najas* spp.). Endothall primarily kills pondweeds, 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 listed above and is generally used to control Eurasian water milfoil. However, it will also kill species, such as water lilies (*Nymphaea* sp. and *Nuphar* sp.). The present restrictions on water use after application of these herbicides are given in Table 27.

In addition to the chemical herbicides used to control large aquatic plants, algicides have also been applied to the Twin Lakes. As shown in Tables 24 and 25, copper in liquid form (Cutrine) has been applied to Lake Mary and Elizabeth Lake, on occasion, since 2002. 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

Table 25

CHEMICAL CONTROL OF AQUATIC PLANTS IN ELIZABETH LAKE: 1950-2005

Year	Total Acres Treated	Algae Control			Macrophyte Control				
		Copper Granular (pounds)	Copper Liquid (gallons)	Other	Sodium Arsenite (pounds)	2, 4-D	Diquat (gallons)	Endothall (gallons)	Other
1950-1965	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1966	N/A	- -	- -	- -	- -	- -	- -	43.20	- -
1967	N/A	- -	- -	- -	360	- -	- -	19.80	- -
1968-1971	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1972	1.00	- -	- -	- -	- -	- -	4.50	- -	- -
1973-1975	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1976	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1977-1979	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1980[a]	2.75	- -	- -	- -	- -	- -	- -	29.50	- -
1981	3.21	- -	- -	- -	- -	15 gal.	- -	- -	- -
1982-1983	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1984	0.23	- -	- -	- -	- -	5 gal	- -	- -	- -
1984[a]	14.00	- -	- -	- -	- -	30 gal	- -	- -	- -
1985-1997	0.00	- -	- -	- -	- -	- -	- -	- -	- -
1998	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1999-2002	0.00	- -	- -	- -	- -	- -	- -	- -	- -
2003	1.24	- -	1.00	- -	- -	- -	1.00	1.00	- -
2004	9.37	- -	0.50	- -	- -	860 lbs	0.50	0.50	- -
2005	9.47	- -	1.09	- -	- -	800 lbs	1.09	1.09	- -
Total	41.27	- -	2.59	- -	360	1,600 lbs. + 50 gal.	7.09	95.09	- -

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

[a]*WDNR permit assigned to "Twin Lakes" without specifying Lake Mary or Elizabeth Lake.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

benthic organisms, but, generally, have not been found to be harmful to humans.[6] Restrictions on water uses after application of Cutrine Plus and other copper-containing compounds are also given in Table 27.

Macrophyte Harvesting

As noted above, excessive macrophyte growths on the Twin Lakes have been controlled primarily using chemical herbicides. However, manual harvesting of aquatic plants around piers and docks is undertaken by individual riparian residents. As of 2003, manual removal of aquatic plants from lakes is governed by Chapter NR 109 of the *Wisconsin Administrative Code*. Under a general statewide permit authority, subject to certain conditions, individuals may remove aquatic plants from along a 30-foot-wide linear shoreland corridor; any removal beyond this linear length of shoreland, or within a designated sensitive area established under Chapter NR 107 of the *Wisconsin Administrative Code*, requires an individual permit under Chapter NR 109. Currently, the magnitude of such removals is not quantified as permits governing the conduct of shoreland aquatic plant management programs have only recently been required by the WDNR. No data on permits issued to Village of Twin Lakes residents are available, although riparian property owners and residents report periodic application of manual harvesting techniques along portions of the shoreline of the Lakes. Mechanical harvesting of aquatic plants on the Twin Lakes has not been undertaken. Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, the harvested material must be removed from the water.

[6]*Jeffrey A. Thornton and Walter Rast, "The Use of Copper and Copper Compounds as Algicides," in H. Wayne Richardson,* Handbook of Copper Compounds and Applications*, Marcel Dekker, New York, 1997, pp. 123-142.*

Table 26

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

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

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

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 27

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

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

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

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

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

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

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

Source: Wisconsin Department of Natural Resources and SEWRPC.

Physical and Biological Controls

The use of physical control measures, such as placement of bottom barriers, pea gravel blankets, or surface water colorants, is not reported from the Twin Lakes. Likewise, with the exception of the use of the purple loosestrife weevils, *Galerucella* spp. and *Hylobius* sp., the use of biological control agents to manage aquatic plant populations in the Twin Lakes has not been reported. The use of grass carp, *Ctenopharyngodon idella*, to control aquatic plant growths is expressly prohibited in Wisconsin.

AQUATIC ANIMALS

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

Zooplankton

Zooplankton are microscopic animals which inhabit the same environment as phytoplankton, the microscopic plants. An important link in the food chain, crustacean zooplankton feed mostly on algae, and, in turn, are a good food source for fish. Zooplankton populations have not been surveyed in the Twin Lakes.

Benthic Invertebrates

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

A survey of mussels was conducted in Elizabeth Lake and in the Elizabeth Lake Drain during 1999 by the McHenry County Conservation District. Eight species of mussels were reported, two of which are listed by the State of Illinois as species of special concern. These are the Plain Pocketbook (*Lampsilis cardium*) and Round Pigtoe (*Pleurobema sintoxia*), both of which are native species.

Zebra mussels, *Dreissenia polymorpha*, a nonnative species of shellfish with known negative impacts on native benthic populations, is currently spreading into inland lakes from the Laurentian Great Lakes system, where it is considered an invasive species, originally introduced into the Great Lakes by means of ballast water discharged from ships arriving from Europe. Zebra mussels are having a varied impact on inland lakes in the Upper Midwest. While they disrupt the food chain by removing significant amounts of phytoplankton which serve as food, not only for themselves, but also for larval and juvenile fish and many forms of zooplankton, many lakes experience improved water clarity as a result of the filter feeding proclivities of these animals. This improved clarity has led to increased growths of rooted aquatic plants, including Eurasian water milfoil. Curiously, within the Southeastern Wisconsin Region, zebra mussels have been observed attaching themselves to the stalks of the Eurasian water milfoil plants, dragging these stems out of the zone of light penetration due to the weight of the zebra mussel shells, and interfering with the competitive strategy of the Eurasian water milfoil plants. This, in turn, has contributed to improved growths of native aquatic plants, in some cases, and to the growths of filamentous algae too large to be ingested by the zebra mussels in others. Regardless of the seemingly beneficial impacts of these animals, the overall effect is that, as zebra mussels and other invasive species spread to inland lakes and rivers, so do the environmental, aesthetic, and economic costs to water users. Some of these costs include injuries to feet suffered as a result of coming into contact with the sharp edges of the mussel shells and clogged water intakes.

According to WDNR records, the Twin Lakes are listed as inland lakes having communities of zebra mussels since 2001. In the 2005 aquatic plant survey report by Aron and Associates, it was noted that, in Lake Mary, zebra mussels were found mainly at the northern end of the Lake, while, in Elizabeth Lake, the mussels were wide-spread throughout, and showed a preference for colonizing the stems of Eurasian water milfoil.[7]

Fishes of the Twin Lakes

The Twin Lakes support a relatively large and diverse fish community and are considered to have generally well-balanced populations of gamefish and panfish. Previous WDNR surveys have indicated the presence of at least 19 fish species whose populations were reflective of the good water quality of the Lakes.

The latest fish survey on Lake Mary was conducted in 2004. Seventeen species of fishes were recorded, including bluegill, pumpkinseed, warmouth, rock bass, green sunfish, longnose gar, grass pickerel, largemouth bass, smallmouth bass, and northern pike. Additionally, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) reports the presence in the Twin Lakes of the lake chubsucker (*Erimyzon sucetta*), a State of Wisconsin-designated species of special concern, and of the pugnose shiner (*Notropis anogeus*), a State-designated threatened species.[8]

No recent surveys have been conducted on the Wisconsin-portion of Elizabeth Lake due to the historic lack of adequate public recreational boating access. The Village of Twin Lakes has acquired a recreational boating access site on Elizabeth Lake, which was opened to the public during the spring of 2007. Both Lakes now have adequate public recreational boating access, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*, as noted in Chapter VI of this volume. In the Illinois portion of Elizabeth Lake, and in the Elizabeth Lake Drain, the McHenry County Conservation District conducted six fish surveys between 1990 and 2000. Thirty-four species of fishes were recorded, including bowfin, bluegill, pumpkinseed, warmouth, rock bass, yellow bass, redear sunfish, longnose gar, grass pickerel, largemouth bass, smallmouth bass, yellow perch, northern pike, and walleye. Lake chubsucker and bowfin were also recorded, together with black, yellow, and brown bullhead, six species of shiner, and three species of minnow, among others. Of these species, blacknose shiner (*Notropis heterolepis*), pugnose shiner (*Notropis anogenus*), and Iowa darter (*Etheostoma exile*) are State of Illinois-listed endangered species, and blackchin shiner (*Notropis heterodon*) is a State of Illinois-listed threatened species.[9]

“Panfish” is a common term applied to a broad group of smaller fish with a relatively short and usually broad shape that makes them a perfect size for the frying pan. A wide range of panfish is present in the Twin Lakes. Panfish species known to exist in the Twin Lakes include yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), rock bass (*Ambloplites rupestris*), and black crappie (*Pomoxis nigromaculatus*). During the 2004 WDNR survey of Lake Mary, bluegill dominated the panfish sample.

The habitats of panfish vary widely among the different species, but their cropping of the plentiful supply of insects and plants, coupled with prolific breeding rates, leads to large populations with a rapid turnover. Some lakes within southeastern Wisconsin have stunted, or slow-growing, panfish populations. This condition arises when the numbers of panfish are not controlled by predator fishes. Panfish frequently feed on the fry of predatory fishes and, if the panfish population is overabundant, they may quickly deplete the predator fry population. Figure 15 illustrates the importance of a balanced predator-prey relationship, using walleyed pike and perch as an example.

“Roughfish” is a broad term applied to species, such as carp, that do not readily bite on hook and line, but feed on gamefish, destroy habitat needed by more desirable species, and are commonly considered in southeastern

---

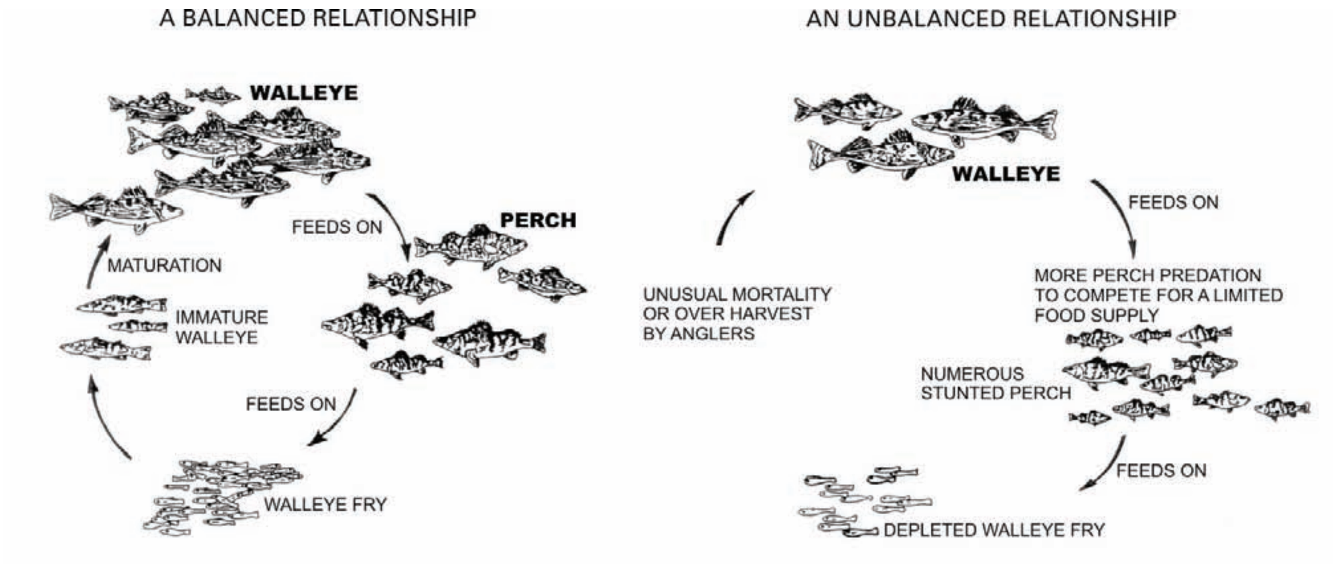
[7] *Aron and Associates,* op. cit.

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

[9] *McHenry County Conservation District,* Fish Sitings: Lake Elizabeth*, January 2009.*

Figure 15

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources and SEWRPC.

Wisconsin as undesirable for human consumption. Roughfish species which have been found in the Twin Lakes include the common carp (*Cyprinus carpio*).

"Gamefish" is the term applied to those fishes that are typically sought by anglers, and which are generally considered to be desirable species. Gamefish that have been found in the Twin Lakes include northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), and walleye (*Stizostedion vitreum vitreum*). All gamefish species found in the Twin Lakes, except walleye, are known to reproduce naturally in the Lakes.

Fisheries Management

The Lakes are judged to have a good fishery. Currently, the WDNR manages the Twin Lakes for self-sustaining populations of largemouth bass, northern pike, and panfish. Fish management efforts have included passive maintenance through compliance with the State fishing regulations, with one modification allowing motor trolling on Elizabeth Lake. The 2006-2007 regulations governing the harvest of fishes from the waters of the Twin Lakes are summarized in Table 28.

The Lakes are judged to provide adequate spawning, nursery, and feeding habitat for largemouth bass, bluegill, and other native panfish, and, as such, are not considered to need to have these populations supplemented by stocking. However, due largely to the popularity of northern pike and walleye among anglers, supplemental stocking of these two species has been conducted. Stocking data for the Twin Lakes are shown in Tables 29 and 30. All stocking of lakes with fishes in Wisconsin is regulated by the WDNR through the granting of stocking permits. While stocking was suspended during 2006 and 2007 due to the presence of viral hemorrhagic septicemia (VHS), the implementation of strict control measures, including testing of fish eggs and fry for VHS, pursuant to Chapters NR 19 and NR 20 of the *Wisconsin Administrative Code*, have limited the impact of this disease and have allowed the reinstitution of stocking in waters of the State. The importation of live bait fishes from outside of the State is prohibited under Section ATCP 10.62 of the *Wisconsin Administrative Code*.

Management measures are recommended to include protection of existing, remnant populations of the lake chubsucker (*Erimyzon sucetta*), a State of Wisconsin-designated special concern species; the pugnose shiner

Table 28

FISHING REGULATIONS APPLICABLE TO THE TWIN LAKES: 2006-2007

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

NOTE: Motor trolling is permitted on Elizabeth Lake.

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

(*Notropis anogeus*), a State of Wisconsin-designated threatened species and State of Illinois-designated endangered species; the blacknose shiner (*Notropis heterolepis*) and Iowa darter (*Etheostoma exile*), State of Illinois-designated endangered species; and, the blackchin shiner (*Notropis heterodon*), a State of Illinois-designated threatened species.[10]

OTHER WILDLIFE

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted in the Wisconsin portion of the tributary area as a part of the current Twin Lakes study, it was possible, by polling naturalists and wildlife managers familiar with the area, to complete a list of amphibians, reptiles, birds, and mammals which may be expected to be found in the area under existing conditions. The technique used in compiling the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to exist, or known to have existed, in the Twin Lakes area; associating these lists with the historic and remaining habitat areas in the Twin Lakes area as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the Twin Lakes area. The net result of the application of this technique is a listing, summarized in Tables 31 through 33, of those species which were probably once present in the tributary area; those species which may be expected to still be present under currently prevailing conditions; and those species which may be expected to be lost or gained as a result of urbanization within the area. These lists are consistent with the observed species reported by the McHenry County Conservation District, who conducted annual surveys of birds between 1993 and 2006 and additional surveys in 1988 and 2008; surveys of butterflies in 1988, 1994, 1998, 2001, and 2008; and annual surveys of herptiles between 1987 and 2006 and an additional survey in 2008; and a mammal survey in 2008. These data also are summarized in Tables 31 through 33.

A variety of mammals, ranging in size from large animals, like the northern white-tailed deer, to small animals, like the least shrew, are expected to be found in the Twin Lakes area. Mink, muskrat, beaver, white-tailed deer, red and grey fox, grey and fox squirrel, and cottontail rabbits are mammals reported to frequent the area. Table 31 lists 38 mammals whose ranges are known to extend into the area.

A large number of birds, ranging in size from large gamebirds to small songbirds, also are expected to be found in the Twin Lakes area. Table 32 lists those birds that normally occur in the tributary area. Each bird is classified as to whether it breeds within the area, visits the area only during the annual migration periods, or visits the area only on rare occasions. The Twin Lakes tributary area supports a significant population of waterfowl, including

[10]*SEWRPC Planning Report No. 42,* op. cit.*; McHenry County Conservation District,* ibid.

Table 29

FISH STOCKED INTO LAKE MARY: 1974-2009

Year	Species Stocked	Number Stocked	Average Length (inches)
1974	Northern pike	300	15.0
1975	Walleye	10,000	5.0
1980	Northern pike	500,000	Fry
1981	Walleye	17,500	3.0
1982	Northern pike	630	7.0
1982	Northern pike	500	8.0
1983	Walleye	12,865	3.0
1985	Northern pike	760	8.0
1985	Walleye	15,000	3.0
1987	Walleye	37,800	2.0
1990	Walleye	550	7.0
1991	Northern pike	1,500	8.0
1992	Northern pike	600	8.0
1994	Northern pike	594	7.5
1994	Northern pike	118	12.0
1996	Smallmouth bass	237	5.0
1998	Smallmouth bass	220	4.0
1998	Walleye	630	10.0
1999	Northern pike	628	7.4
2001	Northern pike	745	7.6
2003	Walleye	598	- -
2006	Smallmouth bass	7,400	- -
2007	Walleye	833	- -
2008	Northern pike	740	- -
2009	Walleye	11,458	- -

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 30

FISH STOCKED INTO ELIZABETH LAKE: 1974-2009

Year	Species Stocked	Number Stocked	Average Length (inches)
1974	Walleye	7,225	5.0
1984	Walleye	600	5.0
1985	Walleye	30,000	3.0
1986	Northern pike	1,300	9.0
1989	Walleye	34,880	3.0
1990	Walleye	950	7.0
1991	Walleye	14,975	3.0
1991	Northern pike	2,500	8.0
1994	Walleye	1,367	8.0
1996	Smallmouth bass	165	7.0
1996	Walleye	330	9.0
1998	Smallmouth bass	440	4.0
1998	Walleye	1,300	10.0
2000	Northern pike	206	13.0
2001	Walleye	1,305	6.0
2002	Smallmouth bass	816	5.0
2003	Walleye	1,198	4.0
2009	Walleye	25,360	- -

Source: Wisconsin Department of Natural Resources and SEWRPC.

mallard and teal. Larger numbers of birds move through the tributary area during migrations when most of the regional species may also be present.

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

Because of the mixture of lowland and upland woodlots, wetlands, and agricultural lands still present in the area, along with the favorable summer climate, the area supports many other species of birds. Hawks and owls function as major rodent predators within the ecosystem. Swallows, whippoorwills, woodpeckers, nuthatches, and flycatchers, as well as several other species, serve as the major insect predators. In addition to their ecological roles, birds, such as robins, red-winged blackbirds, orioles, cardinals, kingfishers, and mourning doves, serve as subjects for bird watchers and photographers. Threatened species migrating in the vicinity of the Twin Lakes include the Cerulean warblers, the Acadian flycatcher, great egret, and the osprey. Endangered species migrating in the vicinity of the Twin Lakes include the common tern, Caspian tern, Forster's tern, and the loggerhead shrike. Additionally, Elizabeth Lake is identified as containing habitat for a State of Wisconsin-designated species of special concern and State of Illinois-designated endangered species, the black tern (*Chlidonias niger*); as well as the State of Illinois-designated endangered species, the American bittern (*Botaurus lentiginosus*), black-crowned night-heron (*Nycticorax nycticorax*), Forster's tern (*Sterna forsteri*), and yellow-headed blackbird (*Xanthocephalus xanthocephalus*), and State of Illinois-designated threatened species, the least bittern (*Ixobrychus exilis*) and sandhill crane (*Grus canadensis*).

Amphibians and reptiles are vital components of the ecosystem in an environmental unit like the Twin Lakes tributary area. Examples of amphibians native to the area include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the Twin Lakes area. Table 33 lists the 15 amphibian and 15 reptile species normally expected to be present in the Twin Lakes area under present conditions, and identifies those species most sensitive to urbanization. Also of note, the Twin Lakes fall within the range of the Western Ribbon Snake (*Thamnophis proximus*), a State of Wisconsin-designated endangered species, and Blanding's turtle (*Emydoidea blandingii*), a State of Illinois- and State of Wisconsin-designated threatened species. The Twin Lakes area contains assemblages of suitable habitat and nesting area to support this species.

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

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

Table 31

MAMMALS OF THE TWIN LAKES 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.*

Table 32

BIRDS KNOWN OR LIKELY TO OCCUR IN THE TWIN LAKES 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 Widgeon[a]	- -	- -	X
Canvasback[a]	- -	- -	X
Redhead[a]	- -	- -	X
Ring-Necked Duck	- -	- -	X
Lesser Scaup[a]	- -	- -	X
Greater Scaup	- -	- -	R
Common Goldeneye[a]	- -	X	X
Bufflehead	- -	- -	X
Red-Breasted Merganser	- -	- -	X
Hooded Merganser[a]	R	- -	X
Common Merganser[a]	- -	- -	X
Ruddy Duck	- -	- -	X
Cathartidae			
Turkey Vulture	X	- -	X
Accipitridae			
Osprey[a]	- -	- -	X
Bald Eagle[a,d]	- -	- -	R
Northern Harrier[a]	X	R	X
Sharp-Shinned Hawk	X	X	X
Cooper's Hawk[a]	X	X	X
Northern Goshawk[a]	- -	R	X
Red-Shouldered Hawk[b]	R	- -	X
Broad-Winged Hawk	R	- -	X
Red-Tailed Hawk	X	X	X
Rough-Legged Hawk	- -	X	X
American Kestrel	X	X	X
Merlin[a]	- -	- -	X

Table 32 (continued)

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

Table 32 (continued)

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

Table 32 (continued)

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

Table 32 (continued)

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

NOTE: Total number of bird species: 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

Table 32 Footnotes

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

[b]*State-designated threatened species.*

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

[d]*Federally designated threatened species.*

[e]*State-designated endangered species.*

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

Wildlife Habitat and Resources

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

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

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

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

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

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

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

As shown on Map 17, approximately 927 acres, or about 18 percent of the total area tributary to the Twin Lakes, were classified in the 1985 inventory as wildlife habitat, with about 269 acres, or about 5 percent of the total tributary area, classified as Class I habitat; about 233 acres, or about 4 percent, classified as Class II habitat; and

Table 33

AMPHIBIANS AND REPTILES OF THE TWIN LAKES AREA

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

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

[b]*State-designated endangered species.*

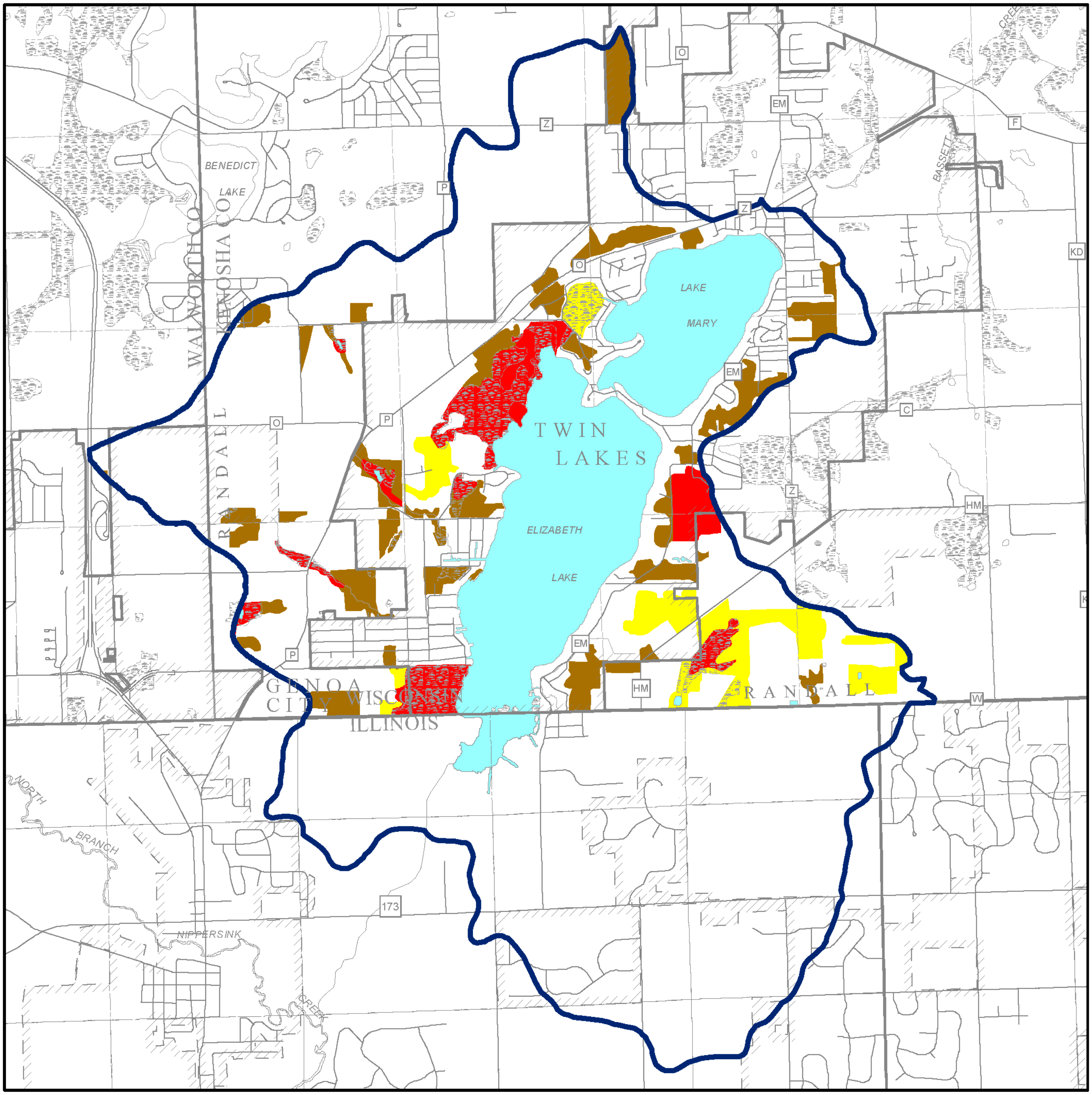
[c]*State-designated special concern species.*

[d]*State-designated threatened species.*

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

Map 17

WILDLIFE HABITAT AREAS WITHIN THE TWIN LAKES TRIBUTARY AREA: 1985



Class I, High-Value Habitat

Class II, Medium-Value Habitat

Class III, Good-Value Habitat

Surface Water

NOTE: This information is not available in Illinois.

Source: SEWRPC.

about 425 acres, or about 8 percent, classified as Class III habitat. Of the 927 acres of wildlife habitat in the total tributary area of the Twin Lakes, about 29 percent is considered Class I habitat, 25 percent is Class II habitat, and 46 percent is Class III habitat.

NATURAL AREAS AND CRITICAL SPECIES HABITAT

The Twin Lakes total tributary area contains natural areas of local, countywide, and regional importance, due to its richness of natural habitat and biota. As shown on Map 18, of the total tributary area of the Twin Lakes, approximately 48 acres, or about 1 percent, are identified as natural areas, and about 18 acres, or 0.3 percent, as critical species habitat.

Within the immediate vicinity of the Lakes, there are two natural areas and one area of critical species habitat that have been delineated as defined in the adopted regional natural areas and critical species habitat plan.[11] These areas are:

1. Elizabeth Lake Lowlands—This area, located at the southwest end of Elizabeth Lake, is a 48-acre, good-quality wetland complex consisting of sedge meadow, shallow marsh, and shrub-carr. It has received an NA-2 designation identifying it as a natural area of countywide or regional significance.

2. The Twin Lakes—The Twin Lakes are designated as Critical Lakes of Southeastern Wisconsin and have received a rating of AQ-2, identifying them as aquatic areas of countywide or regional significance. The Lakes, in addition to providing good water quality, contain critical fish, herptile, and bird species, as well as providing a good overall fishery.

3. Hamilton Woods—This 18-acre, privately owned upland woods is identified as a critical plant species habitat site containing the State-designated species of concern Purple trillium (*Trillium recurvatum*).

Table 34 represents a summary of the endangered, threatened, rare, or special concern species found within the area tributary to the Twin Lakes and in the vicinity of the Lakes.

WETLANDS

Wetlands are defined by SEWRPC as “areas that have a predominance of hydric soils and that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and, under normal circumstances, do support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions.” This definition, which is also used by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency, is essentially the same as the definition used by the U.S. Natural Resource Conservation Service.[12]

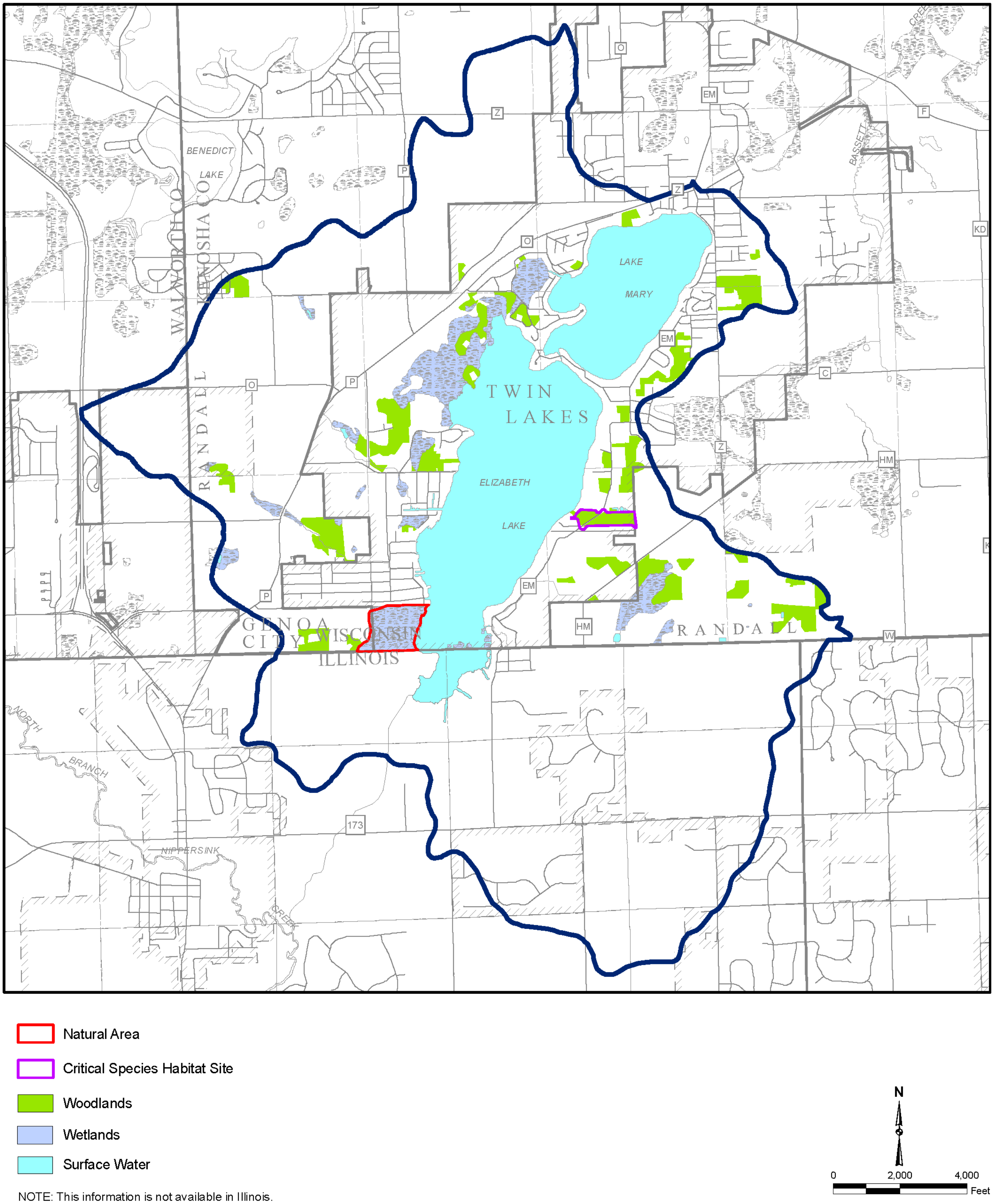
Another definition, which is applied by the WDNR and which is set forth in Chapter 23 of the *Wisconsin Statutes*, defines a wetland as “an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative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

[11]Ibid.

[12]*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.*

Map 18

WETLANDS, WOODLANDS, NATURAL AREAS, AND CRITICAL SPECIES HABITAT WITHIN THE TWIN LAKES TRIBUTARY AREA: 2000



NOTE: This information is not available in Illinois.

Source: SEWRPC.

Table 34

ENDANGERED, THREATENED, RARE, SPECIAL CONCERN, AND UNCOMMON SPECIES IN THE TWIN LAKES AREA: 1994, 2009

Species of Concern	Location	Species Status
Plants		
Purple Trillium	Hamilton Woods	WI Special concern
Small Yellow Lady's Slipper	Elizabeth Lake	IL Endangered
Round-leaved Sundew	Elizabeth Lake	IL Endangered
Downy Willow Herb	Elizabeth Lake	IL Threatened
Bog Bedstraw	Elizabeth Lake	IL Threatened
Buckbean	Elizabeth Lake	IL Threatened
Autumn Willow	Elizabeth Lake	IL Endangered
Pitcher Plant	Elizabeth Lake	IL Endangered
Horned Bladderwort	Elizabeth Lake	IL Endangered
Flat-leaved Bladderwort	Elizabeth Lake	IL Threatened
Cuckoo Flower	Elizabeth Lake	IL Endangered
Fish		
Lake Chubsucker	Lake Mary, Elizabeth Lake	WI Special concern
Blackchin Shiner	Elizabeth Lake	IL Threatened
Blacknose Shiner	Elizabeth Lake	IL Endangered
Pugnose Shiner	Lake Mary, Elizabeth Lake	WI Threatened; IL Endangered
Iowa Darter	Elizabeth Lake	IL Endangered
Mussels		
Plain Pocketbook	Elizabeth Lake, Elizabeth Lake Drain	IL Special Concern
Round Pigtoe	Elizabeth Lake, Elizabeth Lake Drain	IL Special Concern
Reptiles and Amphibians		
Western Ribbon Snake	Elizabeth Lake Lowlands	WI Endangered
Butler's Garter Snake	Lake Mary, Elizabeth Lake	WI Threatened
Blanchard's Cricket Frog	Lake Mary, Elizabeth Lake	WI Endangered
Bull Frog	Lake Mary, Elizabeth Lake	WI Special Concern
Pickerel Frog	Lake Mary, Elizabeth Lake	WI Special Concern
Blanding's Turtle	Elizabeth Lake	WI Threatened; IL Threatened
Butterflies		
Aphrodite Fritillary	Elizabeth Lake	IL Rare
Appalachian Brown	Elizabeth Lake	IL Rare
Baltimore Checkerspot	Elizabeth Lake	IL Rare
Common Wood Nymph	Elizabeth Lake	IL Rare
Eyed Brown	Elizabeth Lake	IL Rare
Great Spangled Fritillary	Elizabeth Lake	IL Rare
Meadow Fritillary	Elizabeth Lake	IL Rare
Silver-bordered Fritillary	Elizabeth Lake	IL Rare
Acadian Hairstreak	Elizabeth Lake	IL Rare
Bronze Copper	Elizabeth Lake	IL Rare
Purplish Copper	Elizabeth Lake	IL Rare
Black Dash	Elizabeth Lake	IL Rare
Broad-winged Skipper	Elizabeth Lake	IL Rare
Dion Skipper	Elizabeth Lake	IL Rare
Long Dash	Elizabeth Lake	IL Rare
Mulberry Wing	Elizabeth Lake	IL Rare
Birds		
American Bittern	Elizabeth Lake	WI Special Concern; IL Endangered
Common Loon	Lake Mary, Elizabeth Lake	WI Special Concern
Least Bittern	Elizabeth Lake	WI Special Concern; IL Threatened
Black-Crowned Night-Heron	Elizabeth Lake	IL Endangered
Great Blue Heron	Lake Mary, Elizabeth Lake	WI Special Concern
Sandhill Crane	Elizabeth Lake	IL Threatened
Great Egret	Lake Mary, Elizabeth Lake	WI Special Concern
Cattle Egret	Lake Mary, Elizabeth Lake	WI Special Concern
American Black Duck	Lake Mary, Elizabeth Lake	WI Special Concern
Northern Pintail	Lake Mary, Elizabeth Lake	WI Special Concern
American Widgeon	Lake Mary, Elizabeth Lake	WI Special Concern
Canvasback	Lake Mary, Elizabeth Lake	WI Special Concern

Table 34 (continued)

Species of Concern	Location	Species Status
Birds (continued)		
Redhead	Lake Mary, Elizabeth Lake	WI Special Concern
Lesser Scaup	Lake Mary, Elizabeth Lake	WI Special Concern
Common Goldeneye	Lake Mary, Elizabeth Lake	WI Special Concern
Hooded Merganser	Lake Mary, Elizabeth Lake	WI Special Concern
Common Merganser	Lake Mary, Elizabeth Lake	WI Special Concern
Osprey	Lake Mary, Elizabeth Lake	WI Special Concern
Bald Eagle	Lake Mary, Elizabeth Lake	WI Special Concern
Northern Harrier	Lake Mary, Elizabeth Lake	WI Special Concern
Cooper's Hawk	Lake Mary, Elizabeth Lake	WI Special Concern
Northern Goshawk	Lake Mary, Elizabeth Lake	WI Special Concern
Red-Shouldered Hawk	Lake Mary, Elizabeth Lake	WI Threatened
Merlin	Lake Mary, Elizabeth Lake	WI Special Concern
Upland Sandpiper	Lake Mary, Elizabeth Lake	WI Special Concern
Foster's Tern	Elizabeth Lake	WI Endangered; IL Endangered
Common Tern	Lake Mary, Elizabeth Lake	WI Endangered
Caspian Tern	Lake Mary, Elizabeth Lake	WI Endangered
Black Tern	Elizabeth Lake	WI Special Concern; IL Endangered
Yellow-Billed Cuckoo	Lake Mary, Elizabeth Lake	WI Special Concern
Long-Eared Owl	Lake Mary, Elizabeth Lake	WI Special Concern
Short-Eared Owl	Lake Mary, Elizabeth Lake	WI Special Concern
Red-Headed Woodpecker	Lake Mary, Elizabeth Lake	WI Special Concern
Yellow-Bellied Flycatcher	Lake Mary, Elizabeth Lake	WI Special Concern
Acadian Flycatcher	Lake Mary, Elizabeth Lake	WI Threatened
Purple Martin	Lake Mary, Elizabeth Lake	WI Special Concern
Sedge Wren	Lake Mary, Elizabeth Lake	WI Special Concern
Ruby-Crowned Kinglet	Lake Mary, Elizabeth Lake	WI Special Concern
Veery	Lake Mary, Elizabeth Lake	WI Special Concern
Wood Thrush	Lake Mary, Elizabeth Lake	WI Special Concern
Loggerhead Shrike	Lake Mary, Elizabeth Lake	WI Endangered
Golden-Winged Warbler	Lake Mary, Elizabeth Lake	WI Special Concern
Tennessee Warbler	Lake Mary, Elizabeth Lake	WI Special Concern
Nashville Warbler	Lake Mary, Elizabeth Lake	WI Special Concern
Cape May Warbler	Lake Mary, Elizabeth Lake	WI Special Concern
Cerulean Warbler	Lake Mary, Elizabeth Lake	WI Threatened
Prothonotary Warbler	Lake Mary, Elizabeth Lake	WI Special Concern
Connecticut Warbler	Lake Mary, Elizabeth Lake	WI Special Concern
Kentucky Warbler	Lake Mary, Elizabeth Lake	WI Threatened
Hooded Warbler	Lake Mary, Elizabeth Lake	WI Threatened
Dickcissel	Lake Mary, Elizabeth Lake	WI Special Concern
Vesper Sparrow	Lake Mary, Elizabeth Lake	WI Special Concern
Grasshopper Sparrow	Lake Mary, Elizabeth Lake	WI Special Concern
Henslow's Sparrow	Lake Mary, Elizabeth Lake	WI Threatened
Bobolink	Lake Mary, Elizabeth Lake	WI Special Concern
Eastern Meadowlark	Lake Mary, Elizabeth Lake	WI Special Concern
Western Meadowlark	Lake Mary, Elizabeth Lake	WI Special Concern
Yellow-Headed Blackbird	Elizabeth Lake	IL Endangered
Orchard Oriole	Lake Mary, Elizabeth Lake	WI Special Concern
Pine Siskin	Lake Mary, Elizabeth Lake	WI Special Concern

Source: McHenry County Conservation District, and SEWRPC.

WDNR definition differs from the SEWRPC definition in that the WDNR considers very poorly drained, poorly drained, and some of the somewhat poorly drained soils as wetland soils meeting the Department's "wet condition" criterion. The Commission definition only considers the very poorly drained and poorly drained soils as meeting the "hydric soil" criterion. Thus, the State definition as actually applied is more inclusive than the Federal and Commission definitions in that the Department may include some soils that do not show hydric field characteristics as wet soils capable of supporting wetland vegetation, a condition that may occur in some floodlands.[13]

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

Wetlands perform a variety of valuable functions in natural communities: serving as stormwater and flood water storage and retention and aid in the moderation of water level fluctuations; participating in various important groundwater-wetland water exchanges; providing filtration or storage of sediments, nutrients or toxic substances that would otherwise adversely impact the quality of other waters; protecting shoreline areas against erosion through dissipation of wave energy and water velocity and anchoring of sediments; providing habitat for aquatic organisms in the food web including, but not limited to, fish, crustaceans, mollusks, insects, annelids, planktonic organisms, and the plants and animals upon which these aquatic organisms feed and depend on for their needs in all life stages; providing habitat for both resident and transient wildlife species, including mammals, birds, reptiles, and amphibians for breeding, resting, nesting, escape cover, travel corridors, and feeding; and, enhancing human recreational, cultural, educational, scientific, and natural aesthetic values and uses.[14]

Wetlands in southeastern Wisconsin are classified predominantly as deep marsh, shallow marsh, bog, fen, low prairie, southern sedge meadow, fresh (wet) meadow, shrub carr, southern wet and wet-mesic hardwood forest, and conifer swamp. As of 2000, the major wetland communities located in the total area tributary to the Twin Lakes, as shown on Map 18, encompassed approximately 235 acres, or approximately 3 percent of the total tributary area to the Lakes. Wetland types included sedge meadow, shrub carr, fresh (wet) meadow, deep and shallow marsh, and southern wet and wet-mesic hardwood forest.

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

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

---

[13]*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.*

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

Southern wet and wet-mesic hardwood forest occur in scattered areas of the tributary area. These lowland forests 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 americana*).

As shown on Map 18, large areas of wetlands within the total area tributary to the Twin Lakes are located along the northwestern and southwestern shorelands of Elizabeth Lake, as well as in scattered areas to the east and west of Elizabeth Lake and to the west of Lake Mary throughout the total tributary area.

WOODLANDS

Woodlands in southeastern Wisconsin are defined as those areas containing 17 or more trees per acre which have at least a four-inch-diameter at breast height, that is, at a height of 4.5 feet above ground. In addition, the native woodlands are classified as dry, dry-mesic, mesic, wet-mesic, and wet hardwoods, and conifer swamp forests. The latter three woodland classifications are also considered to be wetlands. As of 2000, the total area tributary to the Twin Lakes contained about 281 acres of woodlands, covering approximately 4 percent of the total tributary area to the Lakes, as shown on Map 18. These woodlands consisted of all of the native upland woodland classifications. Specifically, upland woodlands in the area tributary to the Twin Lakes included southern dry hardwoods, consisting primarily of white oak (*Quercus alba*), burr oak (*Quercus macrocarpa*), shagbark hickory (*Carya ovata*), and black cherry (*Prunus serotina*); southern dry-mesic hardwoods, consisting primarily of northern red oak (*Quercus borealis*), paper birch (*Betula papyrifera*), and white ash (*Fraxinus americana*); and mesic hardwoods, consisting primarily of sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and basswood (*Tilia americana*).

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

ENVIRONMENTAL CORRIDORS

The Environmental Corridor Concept

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

The delineation of these 12 natural resource and natural resource-related elements on a map results in an essentially linear pattern of relatively narrow, elongated areas which have been termed “environmental corridors” by SEWRPC. Primary environmental corridors include a wide variety of the abovementioned important resource and resource-related elements and are, by definition, at least 400 acres in size, two miles in length, and 200 feet in width. The primary environmental corridors delineated by the Regional Planning Commission within the Wisconsin portion of the tributary area to the Twin Lakes are, in some cases, contiguous with environmental corridors and isolated natural resource areas lying outside the lake tributary area boundary and, consequently, do meet these size and natural resource element criteria.

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

In the area of southeastern Wisconsin tributary to the Twin Lakes, the streambanks and lakeshores located within the environmental corridors should be candidates for immediate protection through proper zoning or through public ownership. Of the areas not already publicly owned, the remaining areas of natural shoreline, and riparian wetland areas, are perhaps the most sensitive areas in need of greatest protection. In this regard, the regional natural areas and critical species habitat protection and management plan recommends public acquisition of specific lands.[15] With respect to those lands located in proximity to the Twin Lakes, the plan recommends acquisition of the 48-acre Elizabeth Lake Lowlands by the WDNR, and acquisition of the 18-acre Hamilton Woods area, located just east of Elizabeth Lake and currently under private ownership, by the Village of Twin Lakes.[16]

Primary Environmental Corridors

The primary environmental corridors in southeastern Wisconsin generally lay along major stream valleys and around major lakes, and contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all of the major bodies of surface water and related undeveloped floodlands and shorelands. As shown on Map 19, primary environmental corridors, as of 2000, encompassed about 443 acres, or about 6 percent of the Twin Lakes total tributary area.

Primary environmental corridors may be subject to urban encroachment because of their desirable natural resource amenities. Unplanned or poorly planned intrusion of urban development into these corridors, however, not only tends to destroy the very resources and related amenities sought by the development, but tends to create severe environmental and development problems, as well. These problems include, among others, water pollution, flooding, wet basements, failing foundations for roads and other structures, and excessive infiltration of clearwater into sanitary sewerage systems. The preservation of such corridors, thus, is one of the major ways in which the water quality of the Twin Lakes can be maintained and, perhaps, improved.

Secondary Environmental Corridors

Secondary environmental corridors are located generally along intermittent streams or serve as links between segments of primary environmental corridors. Secondary environmental corridors contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive agricultural purposes or urban land uses, and facilitate surface water drainage, maintain “pockets” of natural resource features, and provide for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species. As shown on Map 19, secondary environmental corridors, as of 2000, encompassed about 34 acres, or about one-half of 1 percent of the total tributary area.

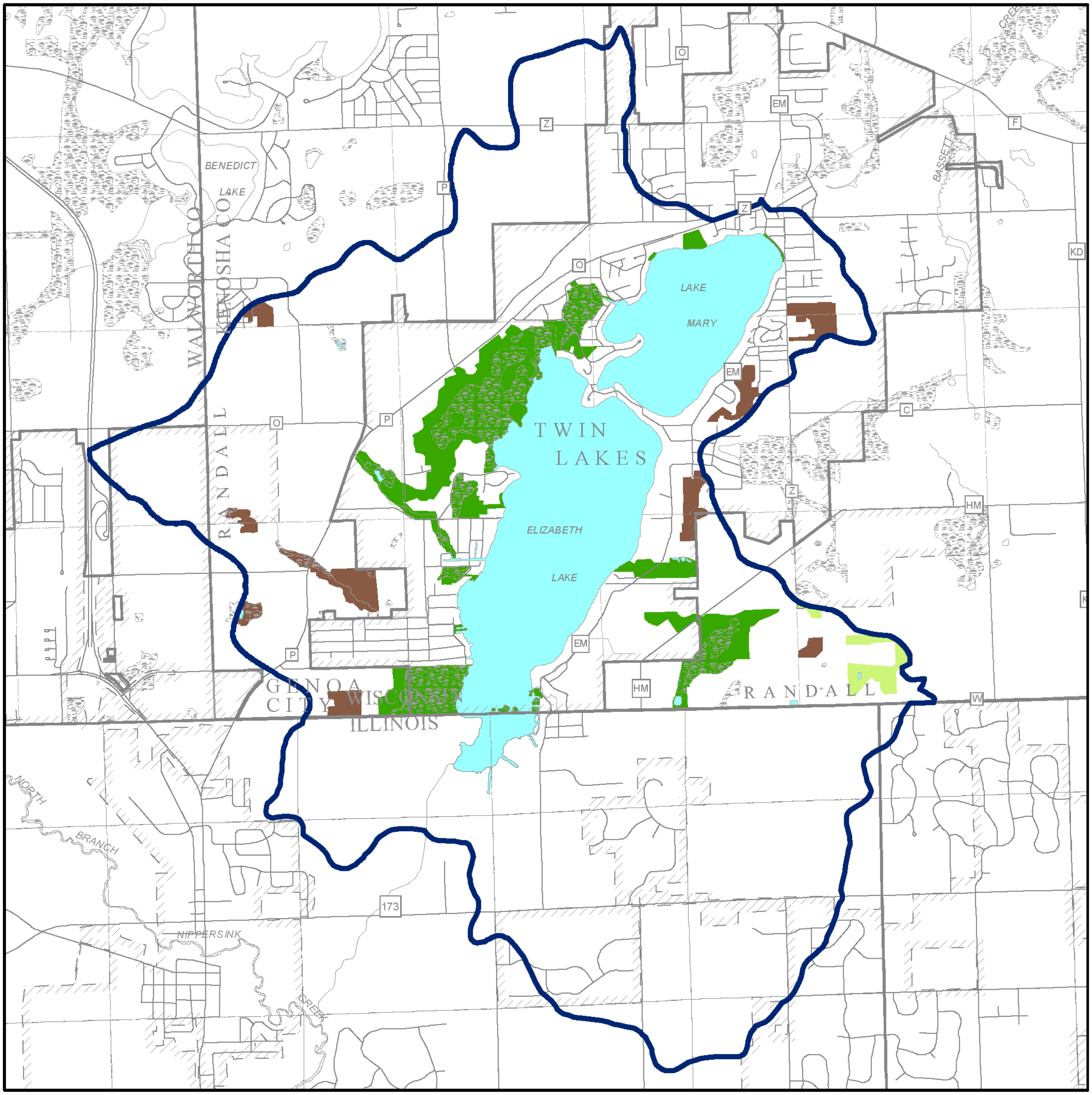
---

[15]Ibid.

[16]Ibid.

Map 19

ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS WITHIN THE TWIN LAKES TRIBUTARY AREA: 2000



Primary Environmental Corridor

Secondary Environmental Corridor

Isolated Natural Resource Area

Surface Water

NOTE: This information is not available in Illinois.

Source: SEWRPC.

N

0 2,000 4,000 Feet

Isolated Natural Resource Areas
In addition to the primary environmental corridors, other small concentrations of natural resource base elements exist within the Twin Lakes tributary area. These concentrations are isolated from the environmental corridors by urban development or agricultural lands and, although separated from the environmental corridor network, have important natural values. These isolated natural resource areas may provide the only available wildlife habitat in a localized area, provide good locations for local parks and nature study areas, and lend a desirable aesthetic character and diversity to the area. Important isolated natural resource features include a variety of isolated wetlands, woodlands, and wildlife habitat. These isolated natural resource features should also be protected and preserved in a natural state whenever possible. Such isolated areas five or more acres in size within the area tributary to the Twin Lakes also are shown on Map 19 and total about 136 acres, or about 2 percent of the total tributary area.

WDNR Sensitive Areas
Within or around lakes, the WDNR, pursuant to authorities granted to the Department under Chapter NR 107 of the *Wisconsin Administrative Code*, can identify sites that have special importance biologically, historically, geologically, ecologically, or even archaeologically. Areas may be identified as sensitive areas after a comprehensive examination and study is completed by WDNR staff from many different disciplines and fields of study. WDNR-delineated sensitive areas, delineated pursuant to Chapter NR 107 of the *Wisconsin Administrative Code*, are areas of aquatic vegetation identified by the WDNR as offering critical or unique fish and wildlife habitat to the body of water. While such delineations focus on aquatic plant management practices within lakes, recommendations relating to the wider range of WDNR permitting authorities, such as shoreland management, placement of piers and docks, and navigation, are often included in order to expedite decision-making by the WDNR in this broader area of water regulation and zoning.

There are five WDNR-designated sensitive areas currently delineated within the Twin Lakes: two sensitive areas are located in Elizabeth Lake and three sensitive areas are located in Lake Mary. In Lake Mary, there is a small area at the northern end of the Lake and two areas in the large bay on the western side of the Lake; and, in Elizabeth Lake, there is one area along the northwestern shoreline adjacent to a large wetland complex and another at the southern end of the Lake. These areas are shown on Map 20.

In the case of Elizabeth Lake, aquatic plant management activities in the sensitive areas are limited to the control of Eurasian water milfoil and purple loosestrife, and the maintenance of navigation. Dredging, placement of fill, and use of physical control measures such as bottom screens and pea gravel blankets are not allowed within the two areas. Gasoline-fueled motors are recommended not to be used in Area 1, at the southern extreme of Elizabeth Lake, and motorized watercraft are recommended to be operated at slow-no-wake speeds within 150 feet of the shores adjacent to Area 2 on the northwestern shore of Elizabeth Lake. Shoreland vegetation is recommended to be protected along the shorelines of both areas, with limited removal of shoreland vegetation along no more than 30 percent of the shoreline being allowed within Area 1.

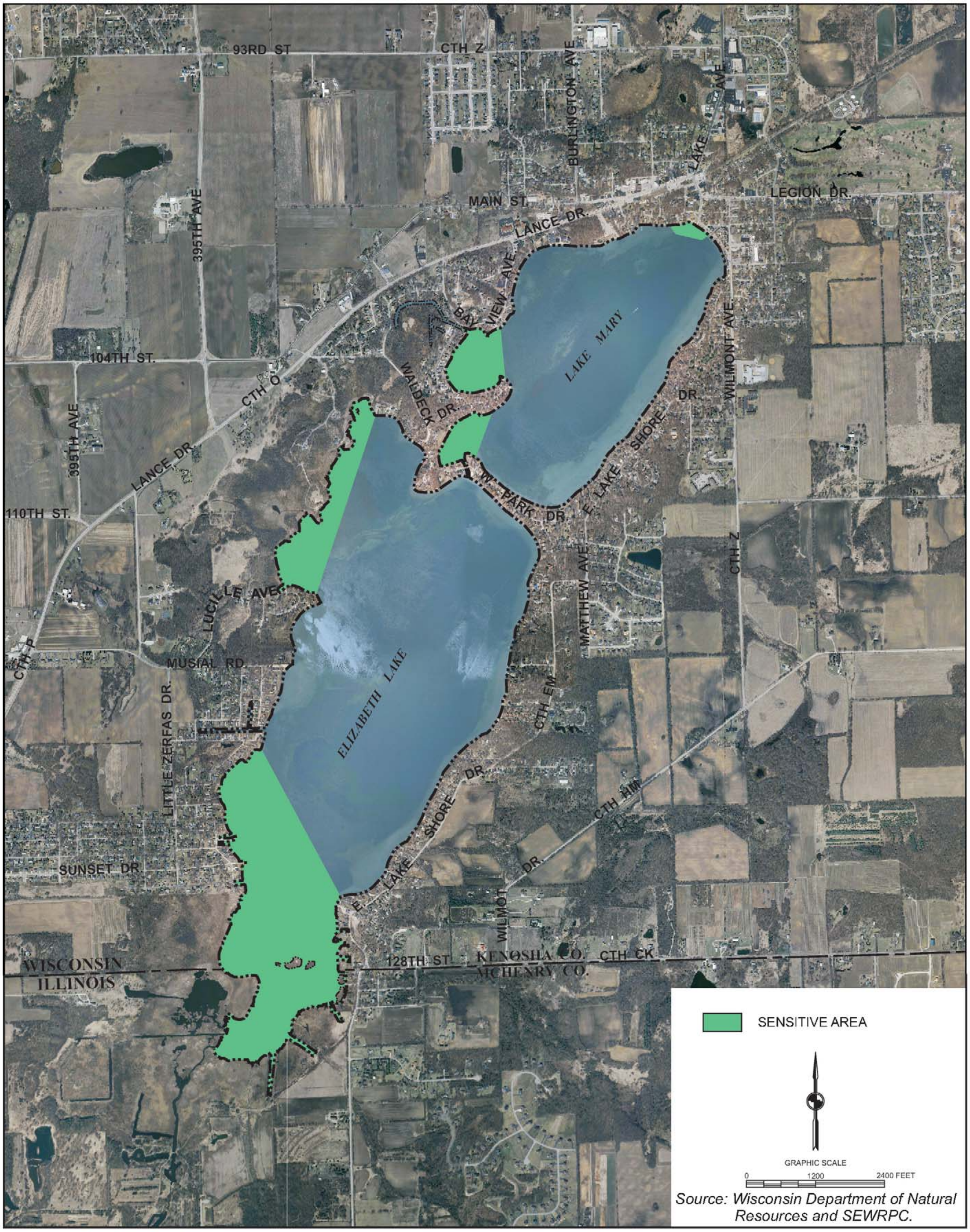
In the case of Lake Mary, aquatic plant management measures are limited to the control of Eurasian water milfoil, with targeted use of aquatic herbicides or manual harvesting methods being recommended in all three areas. Dredging, filling and placement of pea gravel blankets are not recommended, with use of these management measures being disallowed in Area 1. Placement of physical control measures, such as bottom screens, also is not allowed in the three designated sensitive areas. Continuation of slow-no-wake regulations in these areas also is recommended. Appendix B reproduces the WDNR findings.

SUMMARY

The Twin Lakes environment is a reflection of its tributary area. As noted in Chapter IV, Lake Mary and Elizabeth Lake are typical hard-water, alkaline lakes that are considered to have relatively good water quality. While total phosphorus levels were found to be generally at, or below, the levels considered to cause nuisance algal and macrophytic growths, chlorophyll-*a* concentrations were such in recent years as to suggest that algal

Map 20

CHAPTER NR 107 SENSITIVE AREAS ON LAKE MARY AND ELIZABETH LAKE
AS DELINEATED BY THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES



DATE OF PHOTOGRAPHY: 2005

growth was not an issue in the Lakes. In contrast, the increasing abundance of rooted aquatic plants, especially Eurasian water milfoil, was remarked as an issue of concern. Nevertheless, the Lakes provide suitable habitat for a self-sustaining gamefish population, and support a healthy fishery.

The Twin Lakes total tributary area provides a range of habitats for birds, large and small mammals, and reptiles and amphibians, with about 12 percent of the total tributary area being considered to be valuable wildlife habitat and nearly one-third of the area delineated as wildlife habitat within southeastern Wisconsin being considered to be of very high value.

The primary environmental corridors contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas within the area tributary to the Twin Lakes, as well as the major surface water resources and related undeveloped floodlands and shorelands. The preservation of such corridors, therefore, is one of the major ways in which the water quality of the Twin Lakes can be maintained and, perhaps, improved. The environmental corridor network, including the isolated natural resource areas, contributes to the ambience of the Twin Lakes community, and provides the framework for environmental management efforts. Consequently, maintenance of this network, including acquisition and protection of the natural areas and critical species habitat areas identified in the regional natural areas and critical species habitat protection and management plan, is an important element in managing the Twin Lakes.

This Page Intentionally Left Blank

Chapter VI

CURRENT WATER USES AND WATER USE OBJECTIVES

INTRODUCTION

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

RECREATIONAL USES AND FACILITIES

The Twin Lakes are located within about a one-hour drive from much of the metropolitan areas of Milwaukee and Chicago. Their location, accessibility, and degree and type of shoreline development, contribute to a moderate degree of recreational use by residents and nonresidents alike. The Lakes support a full range of lake uses, providing opportunities for a variety of water-based outdoor recreational activities, including fishing, boating, swimming, and nature studies. Winter recreational uses include cross-country skiing, ice skating, and snowmobiling. The scope of these recreational uses engaged in/on the Twin Lakes is sufficiently broad to be consistent with the recommended use objectives for full recreational use and the support of a healthy warmwater sport fishery, as set forth in the adopted regional water quality management plan.

Park and Open Space Sites

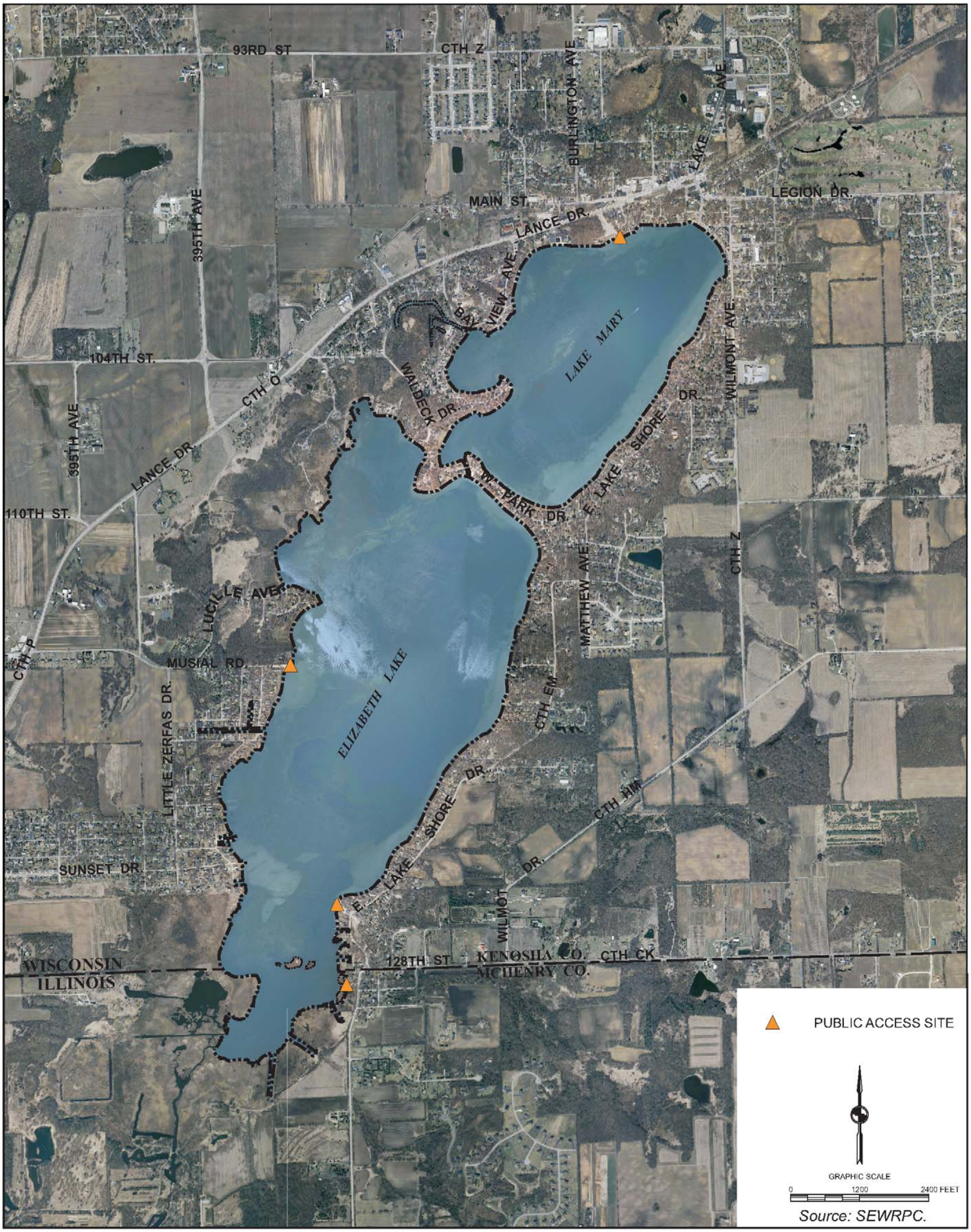
The Twin Lakes provide ideal settings for the provision of park and open space sites and facilities. As shown on Map 21, there are four public access sites on the Twin Lakes.

---

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

Map 21

LOCATIONS OF PUBLIC ACCESS SITES ON LAKE MARY AND ELIZABETH LAKE: 2006



DATE OF PHOTOGRAPHY: APRIL 2005

Lance Park, which is owned and operated by the Village of Twin Lakes, is located in the northwestern corner of Lake Mary and provides a paved double boat launch ramp, pier, and paved car-trailer unit parking lot with regular and handicapped car/trailer parking spaces. There also is a swimming beach. The park serves as the viewing area for the local waterski shows and there are bleachers and a concession stand located at the south end of the park for this purpose. The boat launch ramp and parking lot facilities at Lance Park were found to be well maintained and in good condition. Public recreational boating access to Lake Mary is considered to be adequate as defined in Chapter NR 1 of the *Wisconsin Administrative Code*.

Musial Park, located at the end of Musial Road on the western side of Elizabeth Lake, is one of two public parks located around that Lake. Musial Park contains a single, gravel boat launch ramp with no available parking and a small swim beach. A second site, located in the southeastern corner of the Lake and locally known as "Mad Dan's," is in the process of development, having opened to the public during the 2007 season. This second facility, located on the site of the former Mad Dan's restaurant, is owned by the Wisconsin Department of Natural Resources (WDNR) and operated by the Village of Twin Lakes under a joint agreement. Paved recreational boat launching facilities and a paved parking area is provided at this site. Upon completion of the site improvements proposed for the public recreational boating access sites on Elizabeth Lake,[2] Elizabeth Lake also should be deemed to have adequate public access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*.

Elizabeth Lake Nature Area Preserve, located in McHenry County (Illinois) at the southeastern extreme of Elizabeth Lake, encompasses 341 acres that include a number of natural resource features, including a graminoid bog. The Preserve features an interpretive hiking trail, scenic overlook areas, and parking facilities designed to inform visitors of the various resource features of the area. Lake access, however, is not provided.

Recreational Boating

A recreational needs assessment survey of Twin Lakes residents was conducted during the 1993 lake management planning program.[3] Responses to this survey indicated that the number, speed, and size of boats on the Twin Lakes ranked as the greatest concern among residents. During the current study period, observations were made by Commission staff in order to determine the extent and types of recreational activities, including boating, in which people participate on the Twin Lakes as the basis for a further evaluation of the concern voiced by electors and property owners of the Twin Lakes Protection and Rehabilitation District.

In recent years, lakes in the Southeastern Wisconsin Region have generally experienced an increase in growth of recreational boating. This, at times, has resulted in periods of heavy boating pressures on some of the Region's lakes. There is a range of opinion on the issue of what constitutes optimal boating density on a lake. In the mid-1980s, an average area of about 16 acres per powerboat or sailboat was considered suitable for the safe and enjoyable use of a boat on a lake. For safe waterskiing and fast boating, an area of 40 acres per boat was suggested in the regional park and open space plan guidelines as the minimum area necessary for safe operations.[4] Subsequently, the State of Wisconsin, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*, has established an area of between 15 acres and 30 acres as the minimum area necessary for recreational boating. Provision of public car or car-trailer unit parking spaces to support a number of watercraft consistent with these

[2]*As of 2008, the State of Wisconsin has made cost-share funding available to the Village of Twin Lakes for the improvements to the public recreational boating access sites on Elizabeth Lake through the Chapter NR 7 Recreational Boating Facilities grant program, managed by the WDNR on behalf of the Wisconsin Waterways Commission.*

[3]*Discovery Group, Ltd., Madison, Wisconsin, and Blue Water Science, St. Paul, Minnesota,* Lake Management Plan, Twin Lakes Protective and Rehabilitation District, Twin Lakes, Wisconsin, *Revised, February 18, 1993.*

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

standards forms a “gateway” for local communities to access State enhancement services for public lakes. Enhancement services include eligibility for many State grant programs, fish stocking, and related lake management services.

The types of motorized watercraft on a lake, as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the lake, the riparian residents. On Mary Lake, about 80 percent of all boats are motorized, with the two largest categories, pontoon boats and powerboats, being about equally represented, as shown in Table 35. On Elizabeth Lake, about 75 percent of all watercraft are motorized, with powerboats accounting for about 30 percent of all boats and pontoon boats comprising about 20 percent, as shown in Table 36. Fishing boats accounted for only about 3 percent of the boats on Lake Mary and about 9 percent of those on Elizabeth Lake. Of nonmotorized watercraft, paddleboats made up the largest percentage on Lake Mary, while sailboats were the most common nonmotorized watercraft on Elizabeth Lake. These data tend to support the notion that power boating and related activities, such as waterskiing, may be somewhat more popular on Lake Mary than on Elizabeth Lake, whereas the opposite pattern seems to be true in regards to fishing.

Watercraft Census

One method for assessing the degree of recreational boat use on a lake indirectly is through counts of docked and moored boats on and around a lake. It has been estimated that, in southeastern Wisconsin, the number of watercraft in operation at any given time is approximately 2 to 5 percent of the total number of watercraft docked and moored, although a greater percentage of watercraft is likely to be in operation during holiday periods.

During a survey conducted in 2006 by Commission staff, 713 watercraft of various descriptions were observed docked or moored on Lake Mary, or observed to be trailered or on land in proximity to the Lake, as shown in Table 35. Of the motorized watercraft, powerboats comprised the largest proportion, with a total of 234 watercraft being recorded, representing about one-third of the watercraft on the Lake. Pontoon boats made up the next largest group with 195 watercraft, or about 27 percent of all watercraft; while personal watercraft (PWCs or jetskis®) comprised the third largest proportion, totaling 123 watercraft, or about 17 percent of all the watercraft counted. Fishing boats numbered 22 watercraft, or about 3 percent of the watercraft population observed during 2006. Of the nonmotorized watercraft, paddleboats formed the largest proportion, totaling 49 watercraft, or about 7 percent of all watercraft on the Lake. Rowboats, sailboats, canoes, and kayaks made up the remaining nonmotorized watercraft with a combined total of 89 watercraft, or about 13 percent of all the watercraft counted.

Applying the 2 percent to 5 percent estimation of watercraft in operation on Lake Mary to the total number of watercraft documented in Table 35 assumed to be capable of high-speed operation would result in estimated high-speed boating densities that range from 11 acres per boat to 27 acres per boat. Such estimated densities would be largely consistent with the range considered appropriate for the conduct of safe, high-speed boating activities set forth in the State standards for lakes of comparable surface area.

In a similar survey conducted on Elizabeth Lake, summarized in Table 36, 769 watercraft either moored or on land were counted. Powerboats totaled 233 watercraft, or 30 percent of all watercraft, while pontoon boats numbered 151 vessels, or about 20 percent of all watercraft. Personal watercraft accounted for 121 watercraft, or about 16 percent of all watercraft. Fishing boats totaled 67 vessels, or about 9 percent of watercraft, while nonmotorized watercraft, comprised of canoes, paddleboats, sailboats, rowboats, and kayaks, accounted for a combined total of 195 watercraft, or about 25 percent or all watercraft.

Applying the 2 to 5 percent estimation of watercraft in operation on Elizabeth Lake to the total number of watercraft documented in Table 36 assumed to be capable of high-speed operation would result in estimated high-speed boating densities that range from 24 acres per boat to 58 acres per boat. Such estimated densities would place Elizabeth Lake generally in excess of the range considered appropriate for the conduct of safe, high-speed boating activities set forth in the State standards.

Table 35

WATERCRAFT DOCKED OR MOORED ON LAKE MARY: SEPTEMBER 2006[a]

Type of Watercraft								
Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak/ Rowboat	Wind Surf Board	Paddle Boat	Total
234	195	22	123	24	64	0	49	713

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

Source: SEWRPC.

Table 36

WATERCRAFT DOCKED OR MOORED ON ELIZABETH LAKE: SEPTEMBER 2006[a]

Type of Watercraft								
Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak/ Rowboat	Wind Surf Board	Paddle Boat	Total
233	151	67	121	65	85	0	47	769

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

Source: SEWRPC.

A survey of moored watercraft and watercraft on land around the Twin Lakes conducted in 2001 by volunteers working with the Twin Lakes Protection and Rehabilitation District produced results very similar to those of the 2006 Commission survey. These results suggest a relatively stable boating population on the Lakes.

Recreational Use Survey

Another way to assess the degree of recreational boat use on a lake is through direct observation of recreational water uses and numbers of recreational water users on and around the lake. These observations include counts of boat types and numbers in use on a lake at a given time. Such counts also can be used to calculate the boating density, or the numbers of acres of open water available in which to operate a boat, and are, therefore, an indication of the intensity of recreational boating occurring on a lake.

Table 37 shows direct counts made by Commission staff of watercraft in use on Lake Mary during a weekday and a weekend day in September of 2006. As shown in Table 37, powerboats represented the majority of watercraft in operation on the weekend day. A significant percentage of pontoon boats, fishing boats, and personal watercraft were also observed on these weekends. On the weekday, fishing boats comprised the largest percentage of watercraft in use on the Lake. Based on the data in Table 37 and the direct counts of boats in use on Lake Mary, typical densities of high-speed recreational boating traffic on the Lake would account for about one boat per 10 acres on a summer weekend afternoon, one boat per 75 acres on a weekend morning, one boat per 99 acres on a weekday afternoon, and about one boat per 149 acres on a weekday morning. These densities are well within the State standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code*.

Table 37

WATERCRAFT IN USE ON LAKE MARY: 2006

Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Saturday, September 16									
10:00 a.m. to 11:00 a.m.	2	0	2	1	0	0	0	0	5
1:30 p.m. to 2:30 p.m.	14	8	3	6	2	0	0	0	33
Wednesday, September 6									
10:00 a.m. to 11:00 a.m.	1	0	2	0	0	0	0	0	3
1:30 p.m. to 2:30 p.m.	1	0	4	0	0	0	0	0	5

Source: SEWRPC.

Table 38

WATERCRAFT IN USE ON ELIZABETH LAKE: 2006

Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Saturday, September 16									
10:00 a.m. to 11:00 a.m.	0	1	16	0	0	1	0	0	18
1:30 p.m. to 2:30 p.m.	13	7	13	1	2	0	0	0	36
Wednesday, September 6									
10:00 a.m. to 11:00 a.m.	1	0	4	0	0	0	0	0	5
1:30 p.m. to 2:30 p.m.	2	0	2	0	0	0	0	0	4

Source: SEWRPC.

Table 38 shows the direct counts of watercraft in use on Elizabeth Lake during both a weekday and a weekend day in September of 2006. Fishing boats represented the majority of watercraft in use on the weekend morning, while fishing boats and powerboats were the most numerous watercraft in use on the weekend afternoon. Fishing boats were generally the most numerous boats in use on weekday mornings and afternoons. Boating densities on Elizabeth Lake, based on the data in Table 38, ranged from one boat per 24 acres on a weekend afternoon, to one boat per 213 acres on a weekday morning or afternoon. Boating densities based on direct counts of boats on Elizabeth Lake, as described above, are generally consistent with the State standards.

The observations by Commission staff during 2006 are not dissimilar to those reported for 2004 by the Twin Lakes Boating Safety and User Conflict Committee at the 2005 annual meeting of the Twin Lakes Protection and Rehabilitation District.[5] These data are summarized in Table 39, and show a similar distribution in numbers and types of watercraft in use on the Lakes. This suggests a consistency in usage patterns on the Lakes over this period.

---

[5]*Twin Lakes Boating Safety and User Conflict Committee, "Comprehensive Recreational Plan for Twin Lakes Lake Protection and Rehabilitation District: Phase 1—Revision 4," May 2005 as amended; Twin Lakes Boating Safety and User Conflict Committee, "Comprehensive Recreational Plan for Twin Lakes Lake Protection and Rehabilitation District: Phase 1—Revision 3," May 2005 (noted as being "Approved as a Guideline, July 18, 2005 by the Village Board)."*

Table 39

WATERCRAFT IN USE ON LAKE MARY AND ELIZABETH LAKE: 2004

Lake, Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Waterski Boat	Canoe/ Kayak	Total
Lake Mary								
Sunday, August 8								
1:00 p.m. to 3:00 p.m.	0	4	10	4	0	3	- -	21
Sunday, September 5								
9:00 a.m. to 11:00 a.m.	17	1	0	4	0	0	- -	22
Elizabeth Lake								
Sunday, August 8								
9:00 a.m. to 11:00 a.m.	1	0	12	1	0	3	- -	17
1:00 p.m. to 3:00 p.m.	0	3	6	3	0	4	- -	16
3:00 p.m. to 5:00 p.m.	4	3	7	4	1	5	- -	24
Sunday, September 5								
1:00 p.m. to 3:00 p.m.	0	3	6	5	11	8	- -	33

Source: Twin Lakes Boating Safety and User Conflict Committee, and SEWRPC.

Boating Regulations

Recreational boating activities on the Twin Lakes are regulated by State boating and water safety laws, and by the specific provisions of the Village of Twin Lakes *Code of Ordinances*, Chapter 8.36. The ordinance is summarized in Appendix C.

Angling

The Twin Lakes provide a high-quality habitat for gamefish, such as walleye, northern pike, smallmouth bass, largemouth bass, and panfish. The size and the numbers of fish in the Lakes provide a range of angling opportunities to both the lake residents and other lake users alike. Evidence of good fishing is provided by the number of ice fishing shelters that occur on the ice during the winter months and by the numbers of fishing boats and shoreline anglers using the Lakes during the summer. The good water quality and bottom substrate provide habitat suitable for the natural reproduction of popular gamefish, such as largemouth bass and northern pike. Both northern pike and walleye have been periodically stocked into both Lakes. Panfish are reported present in good numbers, although somewhat stunted in size.

Recreational Use Summary

During the summer of 2006, Commission staff conducted a survey of recreational activities observed in and on the Twin Lakes. The results of this survey are shown in Tables 40 and 41. Of the various recreational activities being engaged in or on Lake Mary during the observational sessions, pleasure boaters represented a majority of recreational users on weekend days, while anglers fishing from boats represented a majority on weekdays. On Elizabeth Lake, anglers fishing from boats represented a clear majority of recreational users on both weekend days and weekdays. These data tend to support the idea, noted above, that Lake Mary is preferred slightly more by users for power boating, while Elizabeth Lake is preferred by users for fishing.

Wisconsin Department of Natural Resources Recreational Rating

In general, the Twin Lakes provide a variety of outdoor recreational opportunities. Based upon the outdoor recreation rating system developed by the WDNR, Lake Mary received at total of 62 points of a possible 72 points, as shown in Table 42. Elizabeth Lake received a total of 70 of a possible 72 points, as shown in Table 43. These ratings indicate that the Lakes provide a range of recreational opportunities, including moderately productive fisheries, water quality conducive to swimming and boating, an adequate number of recreational boat launch sites, adequate water depths and surface area conditions conducive to boating, and a varied landscape that enhances the natural aesthetics of the Lakes. Elizabeth Lake provided a slightly wider range of recreational

Table 40

RECREATIONAL USE IN AND ON LAKE MARY: 2006

Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
	Weekend Participants									
Saturday, September 16										
10:00 a.m. to 11:00 a.m.	0	1	0	0	1	1	5	0	1	9
1:30 p.m. to 2:30 p.m.	0	51	4	2	8	5	6	0	18	94
Total for the Day	0	52	4	2	9	6	11	0	19	103
Percent	0	50	4	2	9	6	11	0	18	100
	Weekday Participants									
Wednesday, September 6										
10:00 a.m. to 11:00 a.m.	1	0	2	0	0	0	5	0	0	8
1:30 p.m. to 2:30 p.m.	0	0	3	0	0	2	9	0	3	17
Total for the Day	1	0	5	0	0	2	14	0	3	25
Percent	4	0	20	0	0	8	56	0	12	100

Source: SEWRPC.

Table 41

RECREATIONAL USE IN AND ON ELIZABETH LAKE: 2006

Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
	Weekend Participants									
Saturday, September 16										
10:00 a.m. to 11:00 a.m.	0	0	0	0	0	0	31	2	0	33
1:30 p.m. to 2:30 p.m.	7	30	3	4	1	0	28	0	0	73
Total for the Day	7	30	3	4	1	0	59	2	0	106
Percent	7	28	3	4	1	0	56	1	0	100
	Weekday Participants									
Wednesday, September 6										
10:00 a.m. to 11:00 a.m.	0	3	0	0	0	0	7	0	0	10
1:30 p.m. to 2:30 p.m.	0	0	6	0	0	0	3	0	0	9
Total for the Day	0	3	6	0	0	0	10	0	0	19
Percent	0	16	31	0	0	0	53	0	0	100

Source: SEWRPC.

opportunity and had a wider range of recreational attributes than Lake Mary, as evidenced by the differing scores, but both Lakes provided a range of opportunities for recreational water users that were similar to other lakes in the Region.[6]

[6]*See, for example, Community Assistance Planning Report No. 60, 2nd Edition,* A Lake Management Plan for Geneva Lake, Walworth County, Wisconsin*, May 2008.*

Table 42

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

Space: Total Area = 315 acres			Total Shore Length = 3.5 miles		
Quality (18 maximum points for each item)					
Fish:					
X 9	High production	__ 6	Medium production	__ 3	Low production
X 9	No problems	__ 6	Modest problems, such as infrequent winterkill, small rough fish problems	__ 3	Frequent and overbearing problems, such as winterkill, carp, excessive fertility
Swimming:					
X 6	Extensive sand or gravel substrate (75 percent or more)	__ 4	Moderate sand or gravel substrate (25 to 50 percent)	__ 2	Minor sand or gravel substrate (less than 25 percent)
X 6	Clean water	__ 4	Moderately clean water	__ 2	Turbid or darkly stained water
__ 6	No algal or weed problems	__4	Moderate algal or weed problems	X 2	Frequent or severe algal or weed problems
Boating:					
X 6	Adequate water depths (50 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 (50 percent of basin)
__ 6	Adequate size for extended boating (more than 1,000 acres)	X 4	Adequate size for some boating (200 to 1,000 acres)	__ 2	Limit of boating challenge and space (less than 200 acres)
__ 6	Good water quality	X 4	Some inhibiting factors, such as weedy bays, algal blooms, etc.	__ 2	Overwhelming inhibiting factors, such as weed beds throughout
Aesthetics:					
__ 6	Existence of 25 percent or more wild shore	X 4	Less than 25 percent wild shore	__ 2	No wild shore
X 6	Varied landscape	__ 4	Moderately varied	__ 2	Unvaried landscape
X 6	Few nuisances, such as excessive algae, carp, etc.	__ 4	Moderate nuisance conditions	__ 2	High nuisance condition
Total Quality Rating: 62 out of a possible 72					

Source: Wisconsin Department of Natural Resources and SEWRPC.

WATER USE OBJECTIVES

The regional water quality management plan recommended adoption of full recreational use and warmwater fisheries objectives for the Twin Lakes. The findings of the inventories of the natural resource base, set forth in Chapters III through V of this volume, indicate that the uses of the Lakes and the resources of the area are generally supportive of such objectives, although it is expected that remedial measures will be required if the Lakes are to continue to fully meet the objectives. The recommended warmwater sport fishery objective is supported in Lake Mary and Elizabeth Lake by a sport fishery based largely on largemouth bass and panfish. These fishes have traditionally been sought after in the Twin Lakes.

Table 43

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

Space: Total Area = 637.8 acres			Total Shore Length = 6.0 miles		
Quality (18 maximum points for each item)					
Fish:					
X 9	High production	__ 6	Medium production	__ 3	Low production
X 9	No problems	__ 6	Modest problems, such as infrequent winterkill, small rough fish problems	__ 3	Frequent and overbearing problems, such as winterkill, carp, excessive fertility
Swimming:					
X 6	Extensive sand or gravel substrate (75 percent or more)	__ 4	Moderate sand or gravel substrate (25 to 50 percent)	__ 2	Minor sand or gravel substrate (less than 25 percent)
X 6	Clean water	__ 4	Moderately clean water	__ 2	Turbid or darkly stained water
X 6	No algal or weed problems	__ 4	Moderate algal or weed problems	__ 2	Frequent or severe algal 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 (50 percent of basin)
__ 6	Adequate size for extended boating (more than 1,000 acres)	X 4	Adequate size for some boating (200 to 1,000 acres)	__ 2	Limit of boating challenge and space (less than 200 acres)
X 6	Good water quality	__ 4	Some inhibiting factors, such as weedy bays, algal blooms, etc.	__ 2	Overwhelming inhibiting factors, such as weed beds throughout
Aesthetics:					
X 6	Existence of 25 percent or more wild shore	__ 4	Less than 25 percent wild shore	__ 2	No wild shore
X 6	Varied landscape	__ 4	Moderately varied	__ 2	Unvaried landscape
X 6	Few nuisances, such as excessive algae, carp, etc.	__ 4	Moderate nuisance conditions	__ 2	High nuisance condition
Total Quality Rating: 70 out of a possible 72					

Source: Wisconsin Department of Natural Resources and SEWRPC.

WATER QUALITY GUIDELINES

The water quality guidelines supporting the warmwater fishery and full recreational use objectives, as established for planning purposes in the regional water quality management plan, are set forth in Table 44. These guidelines are similar to the standards set forth in Chapters NR 102 and 104 of the *Wisconsin Administrative Code*, but were refined for planning purposes in terms of their application. Guidelines are recommended for temperature; pH; and dissolved oxygen, fecal coliform, and total phosphorus concentrations. These guidelines apply to the epilimnion of lakes and to streams. The total phosphorus guideline applies to spring turnover concentrations measured in the surface waters. Such contaminants as oil, debris, and scums; odors, tastes, and color-producing substances; and toxins are not permitted in concentrations harmful to the aquatic life, as set forth in Chapter NR 102 of the *Wisconsin Administrative Code*.

Table 44

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

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

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

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

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

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

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

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

Source: SEWRPC.

The adoption of these guidelines is intended to specify conditions in the waterways concerned that mitigate excessive macrophyte and algal growths and promote all forms of recreational use, including angling, in these waters. Implementation of these guidelines will maintain the Twin Lakes in a mesotrophic, or moderately enriched, condition that is consistent with the natural states of the Lakes. A mesotrophic condition will continue to support a full range of recreational uses, including fishing and swimming, as mandated under the Federal Clean Water Act.

This Page Intentionally Left Blank

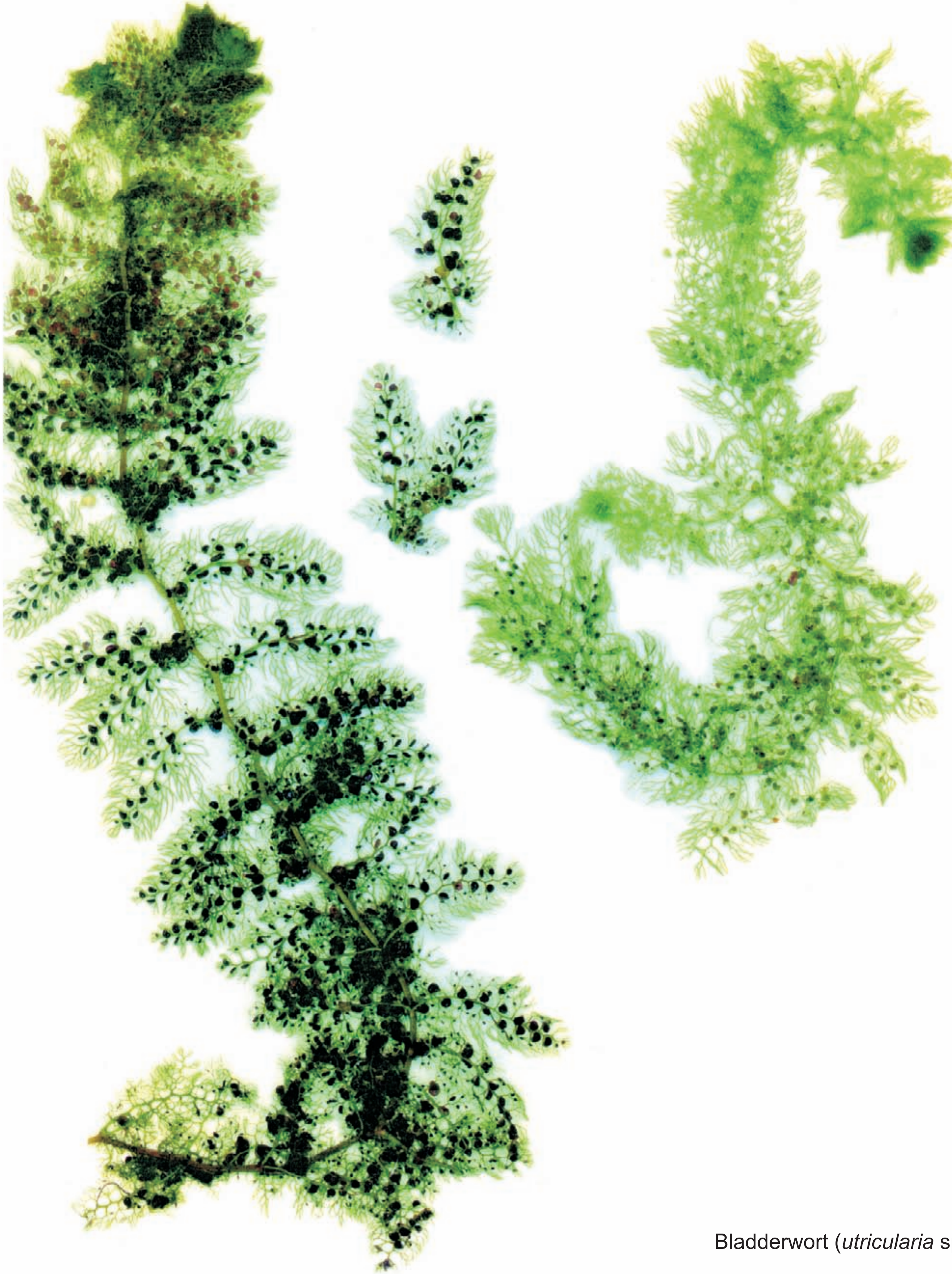
APPENDICES

This Page Intentionally Left Blank

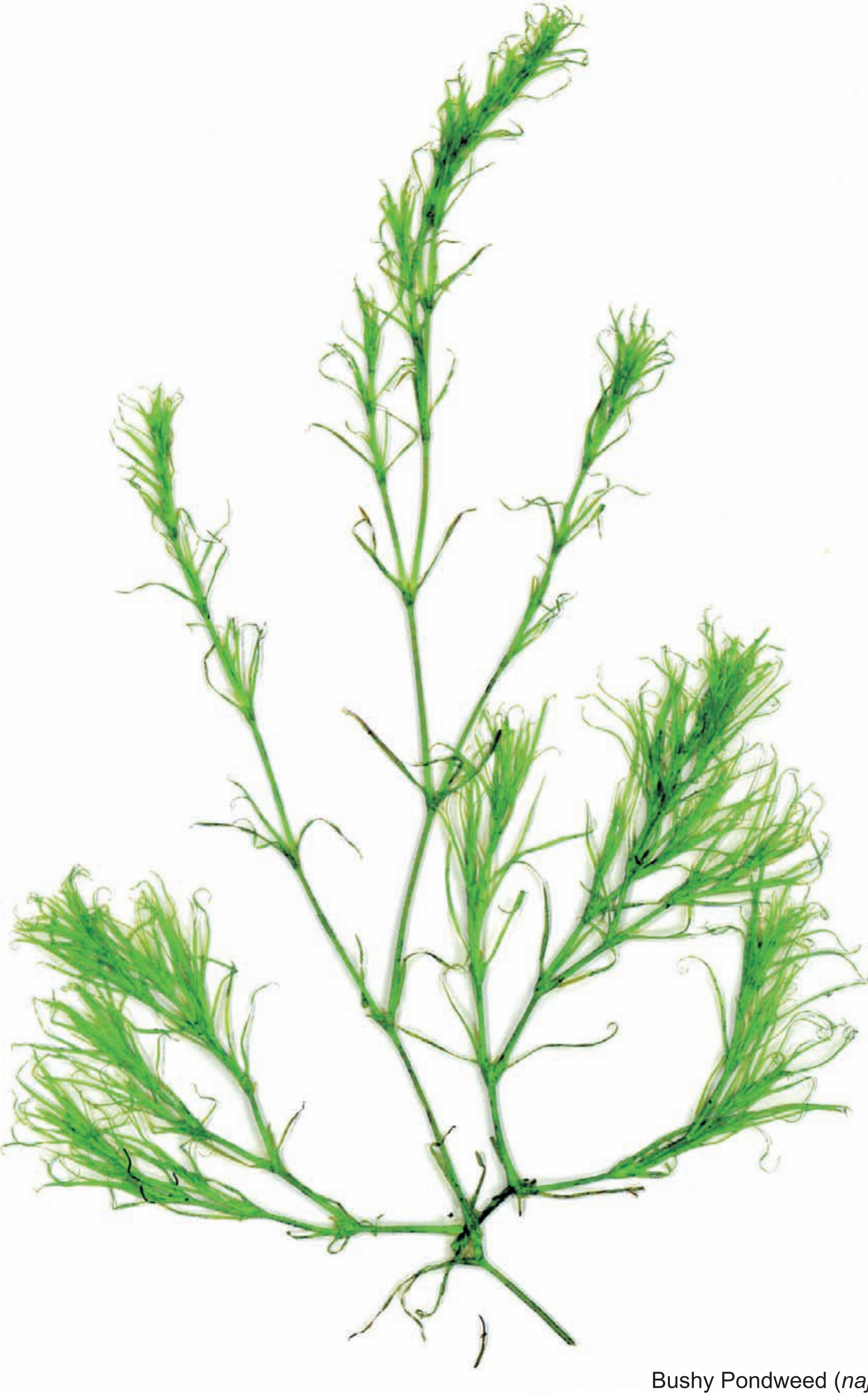
Appendix A

ILLUSTRATIONS OF COMMON AQUATIC PLANTS FOUND IN TWIN LAKES

This Page Intentionally Left Blank



Bladderwort (*utricularia* sp.)



Bushy Pondweed (*najas flexilis*)

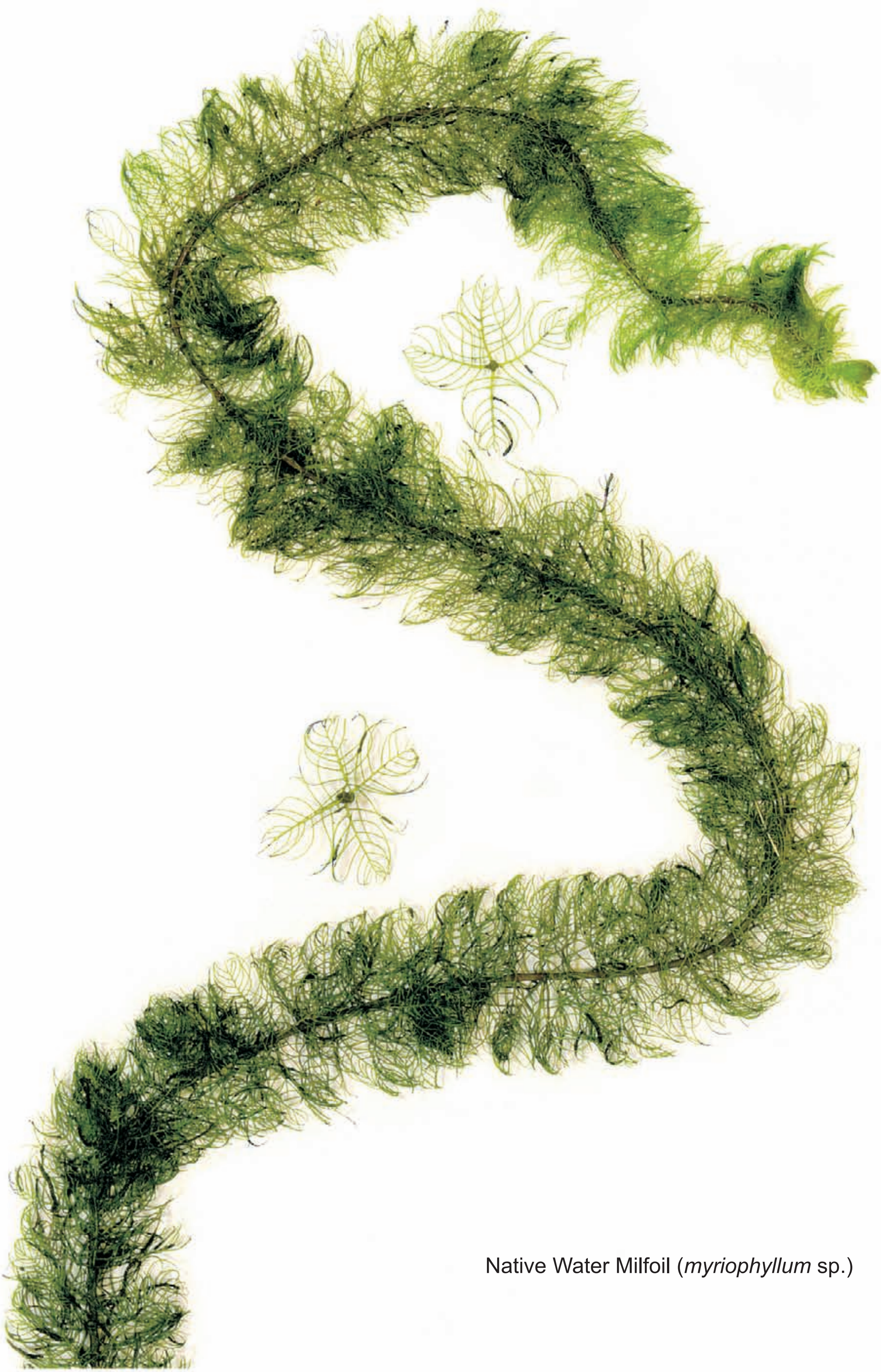
Clasping-Leaf Pondweed
(*potamogeton richardsonii*)

Coontail (*ceratophyllum demersum*)

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

Ditch-Grass (*ruppia maritima*)

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



Native Water Milfoil (*myriophyllum* sp.)

Flat-Stem Pondweed (*potamogeton zosteriformis*)

Floating-Leaf Pondweed (*potamogeton natans*)

Large-Leaf Pondweed (*potamogeton amplifolius*)

Leafy Pondweed (*potamofeton foliosus*)

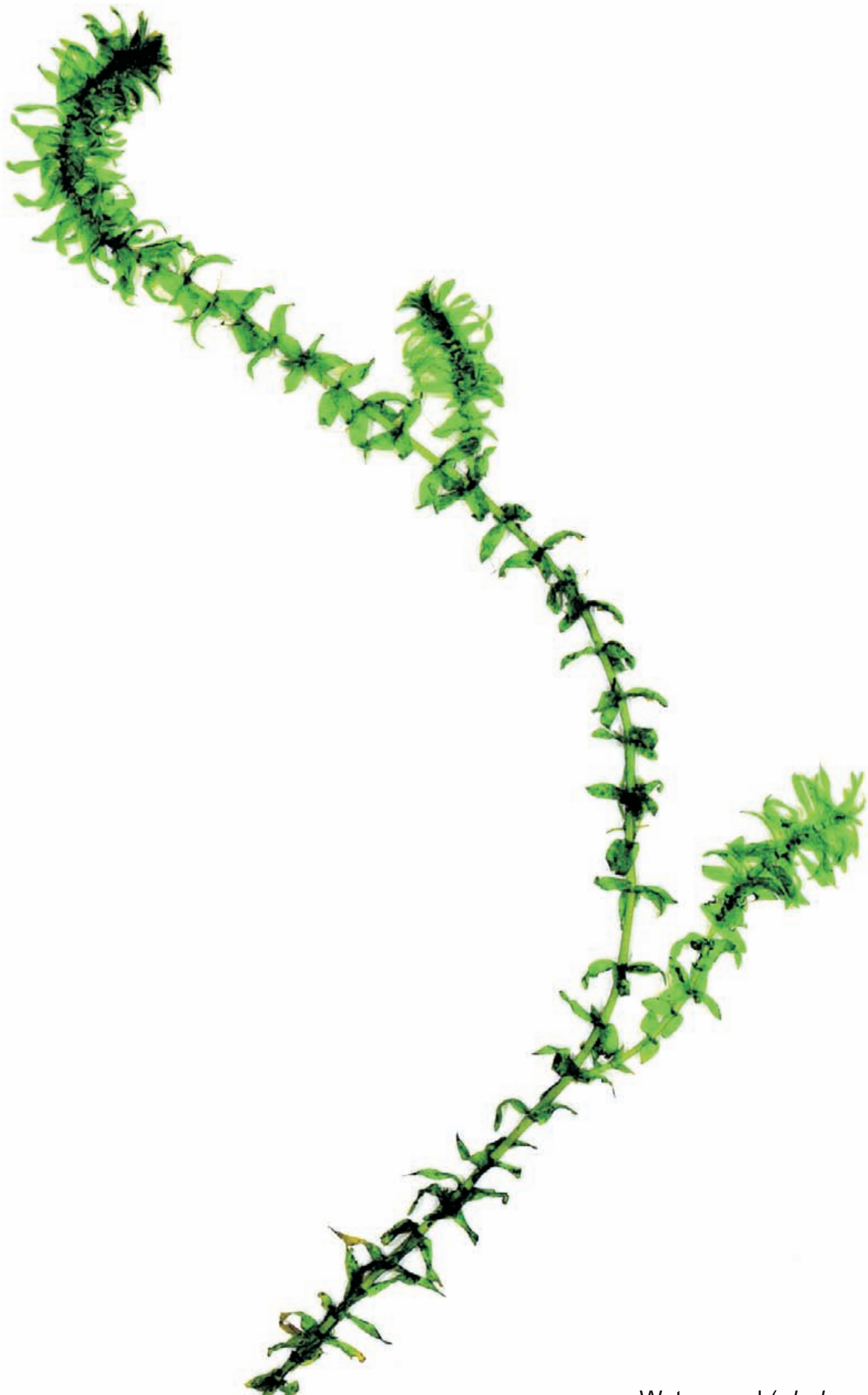
Muskgrass (*chara vulgaris*)

Nitella (*nitella* spp.)

Sago Pondweed (*potamogeton pectinatus*)

Variable Pondweed (*potamogeton gramineus*)

Water Stargrass (*zosterella dubia*)



Waterweed (*elodea canadensis*)

White-Stem Pondweed (*potamogeton praelongus*)

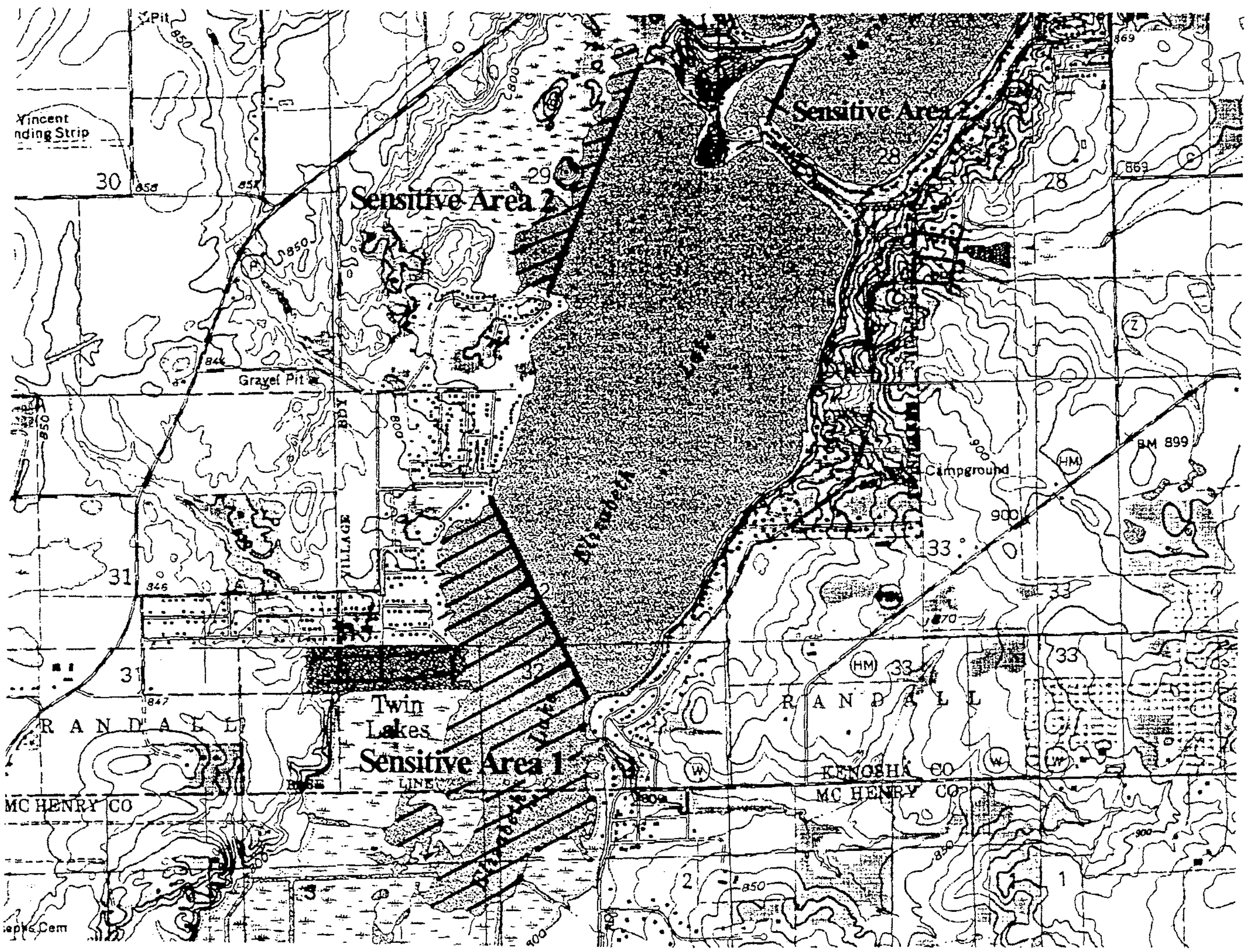
Eel-Grass / Wild Celery (*valisneria americana*)

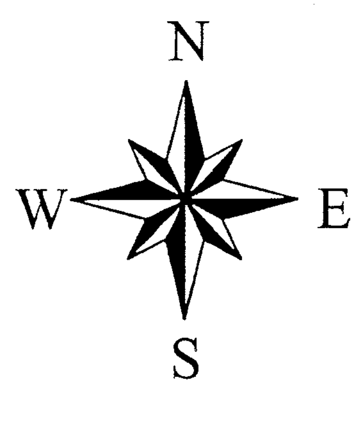
Appendix B

WISCONSIN DEPARTMENT OF NATURAL RESOURCES SENSITIVE AREA DELINEATIONS FOR ELIZABETH LAKE AND LAKE MARY

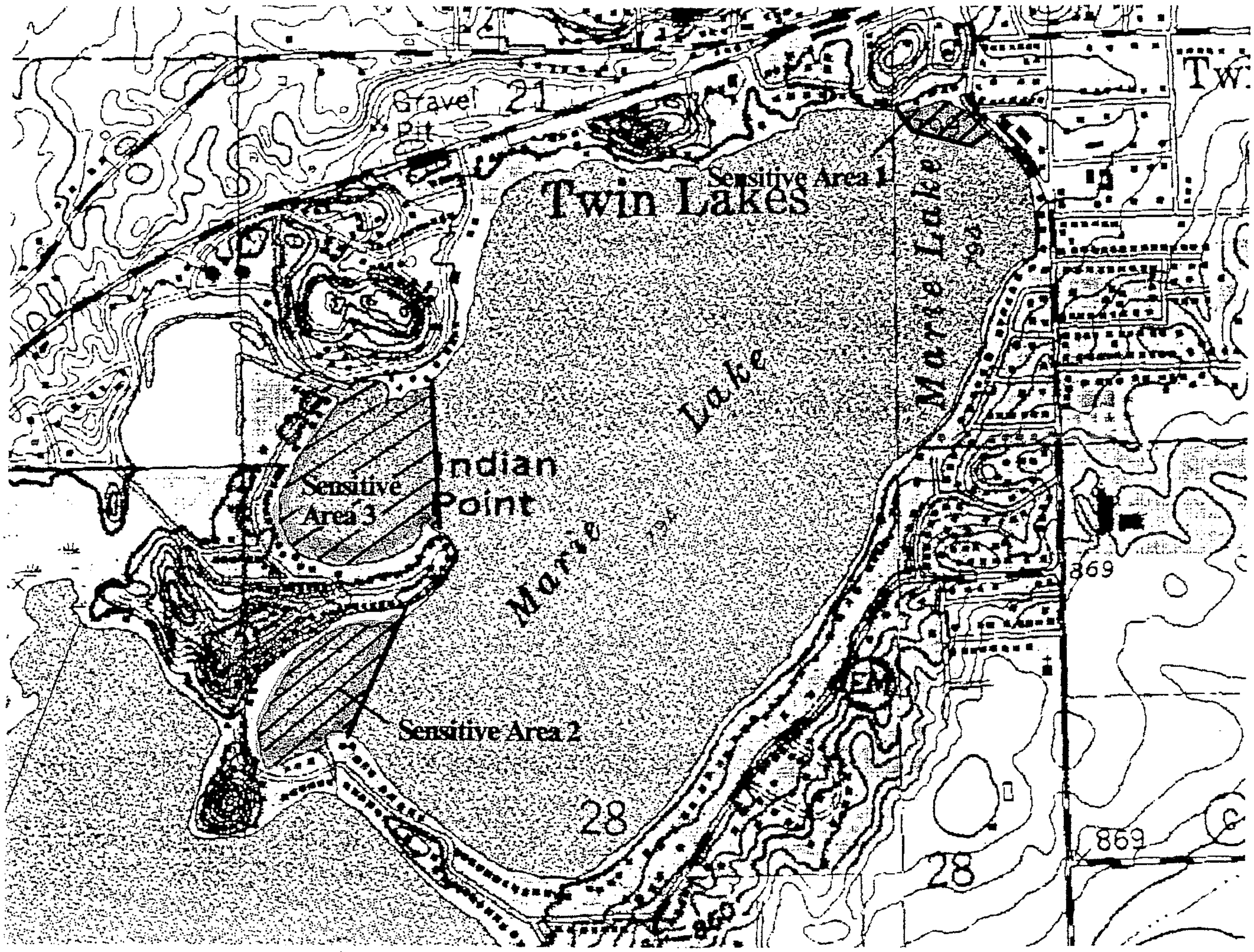
This Page Intentionally Left Blank

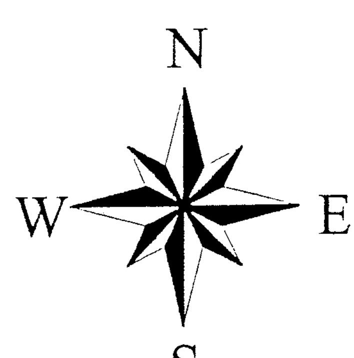
Elizabeth Lake Sensitive Areas





Marie Lake Sensitive Areas





In-Lake Activities

Aquatic Plant Control

	Liz 1	Liz 2	Mary 1	Mary 2	Mary 3
1. Chemical: chemical treatment in this area is to be restricted to the exotic species present - purple loosestrife and Eurasian water milfoil. Cutting and spot applications of herbicides are recommended to help stop the invasion of purple loosestrife. While Eurasian wate milfoil spread can be slowed by using selective herbicides and specific applications on the exotic plant beds only. Care must be taken during applications to prevent harming the native aquatic plant community.	X	X			
1. No treatment will be allowed as long as EWM is not present. If and when EWM does appear alternative control methods, such as handpulling, should be explored before chemical use is considered. In its present condition chemical treatments would unnecessarily harm the excellent native plant community.			X	X	
1. Selective chemical treatment of EWM already present in this area may be considered to stop its spread. However, the area of EWM present is small enough to attempt hand pulling. EWM reduction in this area would provide space for expansion of native aquatic plant species and reduce the threat of expansion of the exotic species.					X
2. Mechanical: *As of 1997 the DNR has no regulatory control over mechanical harvesting on public waters.* However, the DNR recommends only a narrow navigation channel which could extend to riparian owners within the sensitive area. The sensitive area would be off limits to mechanical harvesting other than navigation channels. This would prevent disturbance of the native plant communities and help reduce the fragmentation of EWM and its consequential spread to uncolonized areas. Fragmentation is the primary way in which milfoil spreads, and mechanical harvesting often causes fragmentation of the plants being harvested, thereby spreading them.	X	X			X
2. Mechanical control is recommended only for access to piers. The harvester should constrain its operation to the outside edge of the piers and no closer to shore. This will help prevent sediment disruption in shallow water areas near shore.			X		
2. Mechanical harvesting in this bay is not recommended. Mechanical harvesting would disturb bottom sediments in most of this bay due to the shallow depths found there. Restricting mechanical harvesting would reduce impacts to the native plant community which is important to stabilizing the bottom and providing water quality benefits to the lake.				X	

Water Regulation & Zoning:

1. Dredging would disturb the native plant communities and affect fish that use this area for spawning and feeding.	X	X			
1. Dredging will not be permitted in this area. Dredging would adversely impact the diverse aquatic plant community now present.			X		
1. Dredging projects in the future need to be scrutinized for the ability of the native vegetation to return and the impacts on fish with a change in water depths. Dredging will be limited to creating area for navigation only, no steep side slopes due to substrate instability and area needs for fish.				X	
1. There is no immediate need for dredging in the bay, any future proposals need to be scrutinized for depth and impacts to the surrounding habitat.					X
2. Filling will not be permitted in this area.	X	X			
2. No filling will be permitted, the exception being the installation of riprap on the shoreline.			X		
2. Filling will not be permitted with the exception of riprap placement. The muck and silt bottom present in the sensitive area are not conducive to any filling.				X	
2. Filling will not be permitted with the exception of riprap on shoreline areas.					X
3. Pea gravel/sand blankets would not be permitted in this area due to the muck/silt bottom which would allow the pea gravel or sand to pass through.	X	X			
Also, in areas with sand and gravel, no pea gravel or sand blankets would be necessary.		X			
3. Pea gravel/sand blanket will not be permitted. The near shore area is presently sand and gravel and where sediment is muck the pea gravel and sand would simply sink through.			X		
3. Pea gravel/sand blanket should not be permitted. The silt bottom is too thick and the sand or pea gravel blankets would sink beneath it.				X	
3. Pea gravel/sand blanket will not be permitted due to the depth of the silt. The sand or pea gravel would sink through and be detrimental to the aquatic plants present there.					X

4. Aquatic plant screens would not be permitted. This activity would unnecessarily harm the native plant community. (Plant screens would have an adverse effect on the diversity of the native plant community.)	X	X	X		
4. Aquatic plant screens will not be permitted. They would destroy native aquatic plant diversity, herptile and fish habitat, and waterfowl feeding areas.				X	
4. Aquatic plant screens will not be permitted. The native plant community would be adversely impacted.					X
5. Piers and boardwalks would be allowed if they stay within state standards in NR 326. They are not to exceed reasonable use and can be installed only on current residential homesites.	X	X			
5. Piers and boardwalks will be considered on a case by case basis. The existing shoreline is currently developed. Any additional development should follow the guidelines for riparian owners in NR 326.			X		
5. Piers and boardwalks will be considered on a case by case basis. Any pier installations should follow planner guidelines set forth in NR 326.				X	
5. Piers and boardwalks will only be permitted under the provisions in NR 326					X
6. Recommend restricting gasoline motors in this area to minimize damage to the native aquatic plant community and disturbance to wildlife.	X				
6. The area is currently slow no wake and it is recommended that this designation continue. (Sensitive area 2 is contained within a slow no wake area, it is recommended that this continue.)			X	X	
6. The area is already a slow no wake area and it is recommended that this continue.					X
7. Recommend a no wake zone to 150 feet from shore.		X			

Riparian Activities:

1. Wetland alterations will not be permitted with the exception of a purple loosestrife control program. Wetlands are very important to the water quality of the lake and to the fish, wildlife, and plant communities supported by the lake, and must be protected or improved.	X				
1. Developed shoreline should follow best management practices in any and all new construction.			X		
1. Wetland areas need to remain in place for protection from erosion and to maintain duck nest sites and fish habitat. Leaving these wetlands in place will also help in nutrient absorption and sediment retention which will help improve the water quality of the lake.					X
2. Boardwalks will not be permitted.	X	X			X
1. Boardwalks are non-applicable due to the steepness of the slopes and the residential characteristics of the shore.				X	
3. Shoreland zoning is within the village, although zoning should not exceed NR 115 and NR 117 standards.	X	X			
2. Shoreland zoning is controlled within the village, although zoning should not exceed NR 115 and NR 117 standards.				X	
2. Shoreland zoning is controlled by the village. Setbacks from the water edge should be required. Zoning should not exceed NR 115 and NR 117 standards.					X
4. Removal of vegetation should not be permitted beyond 30% to protect the shoreline.	X				
4. Recommend no shoreline removal of vegetation.		X			

AQUATIC PLANT MANAGEMENT
SENSITIVE AREA DESIGNATION FOR AREA # 1
ELIZABETH LAKE, KENOSHA COUNTY, WISCONSIN

DATE OF ASSESSMENT: AUGUST 13, 1997   NUMBER OF SENSITIVE AREAS: 2

SENSITIVE AREA SITE DESCRIPTION

Sensitive area 1 is located on the southeast shore of Elizabeth Lake. It encompasses a large majority of the wetland complex located in the southeast portion of the lake (please see map). The average depth in this area is 2.5 feet, with a maximum depth of 4 feet. The substrate in this area is comprised entirely of silt and muck.

RESOURCE ASSETS OF SENSITIVE AREA # 1

Sensitive area 1 supports a diverse aquatic plant community, both emergent and submergent. The emergent community includes softstem bulrush (*Scirpus* sp.), cattail (*Typha* sp.), purple loosestrife (*Lythrum salicaria*), and water willow (*Decadon* sp.). The floating leaved community consists of yellow lily pad (*Nuphar variegatum*), white lily pad (*Nymphaea tuberosa*), and floating leaf pondweed (*Potamogeton natans*). The submergent community includes northern milfoil (*Myriophyllum sibiricum*), chara (*Chara* sp.), large leaf pondweed (*P. amplifolius*)[1], curly leaf pondweed (*P. crispus*), elodea (*Elodea canadensis*), coontail (*Ceratophyllum demersum*), eurasian water milfoil (*M. spicatum*), slender naiad (*Najas flexis*), spiny naiad (*Najas marina*), widgeon grass (*Ruppia maritina*), water buttercup (*Ranunculus* sp.), leafy pondweed (*P. puscillus*), flatstem pondweed (*P. zosteriformis*), eelgrass (*Valisneria americana*)[1], illinois pondweed (*P. illinoensis*)[1] and waterstar grass (*Zosterella dubia*).

Fish utilize this community in a variety of different ways. Northern pike, largemouth bass, bluegill, pumpkinseed, yellow perch, and crappie use this area for spawning, as a nursery for their young, and as a feeding area. The floating leaved and submergent plant community provide cover for insects on which the juvenile fish may feed extensively. Larger predator fish are able to ambush their prey among the diverse plant community. Northern pike use the bulrushes as spawning habitat.

Wildlife also depends on the resources provided by sensitive area 1. Canadian geese, mallards, wood ducks, and blue winged teal nest, feed, and raise their young here. Wading birds such as the great blue heron feed here and visit during migration. The diverse marsh provides good habitat for a number of different songbirds and other birds such as redwinged blackbirds who utilize the cattails extensively. Muskrat, raccoon and mink all feed, find shelter and raise their young here. Painted turtles may be found sunning on logs along the shoreline.

The plant community in sensitive area 1 acts as a sediment and nutrient trap as well as protecting the shoreline from erosion. This benefits the entire lake as it improves water clarity and reduces nutrients available in the water to support the growth of nuisance plants such as algae.

Sensitive area 1 is ecologically important to the lake for several reasons. The mix of bulrush and water lily is unique and provides valuable habitat for fish and wildlife. The large wetland complex provides a sediment and nutrient trap as well as valuable nesting and breeding habitat for waterfowl, herptiles, and fish. The species diversity in this area is excellent (18 species found during assessment), with many native species of aquatic plants which will serve as an buffer against invasion of exotic plants which are currently present in the system. The preservation of native vegetation in this area will provide a valuable resource to the entire lake.

MANAGEMENT RECOMMENDATIONS FOR SENSITIVE AREA # 1

In-lake activities:

Aquatic plant control:

1. Chemical: chemical treatment in this area is to be restricted to the exotic species present, purple loosestrife and Eurasian water milfoil. Cutting and spot applications of herbicides are recommended to help stop the invasion of purple loosestrife. While Eurasian water milfoil spread can be slowed by using selective herbicides and specific applications on the exotic plant beds only. Care must be taken during applications to prevent harming the native aquatic plant community.

2. Mechanical: As of 1997 the Department of Natural Resources has no regulatory control over mechanical harvesting on public waters. However, the Department recommends only a narrow navigation channel which could extend to riparian owners within the sensitive area. The sensitive area would be off limits to mechanical harvesting other than navigation channels. This would prevent disturbance of the native plant communities and help reduce the fragmentation of Eurasian water milfoil and its consequential spread to uncolinized areas. Fragmentation is the primary way in which milfoil spreads, and mechanical harvesting often causes fragmentation of the plants being harvested, thereby spreading them. (Bode, et. al., 1992)

Water regulation and zoning:

1. Dredging will not be permitted in this area. Dredging would disturb the native plant communities and affect fish that use this area for spawning and feeding.

2. Filling will not be permitted in this area.

3. Pea gravel/sand blankets are no longer permitted by the Department of Natural Resources due to the covering of fish habitat and breeding areas that occurs as a result of installation and migration.

4. Aquatic plant screens would not be permitted. This activity would unnecessarily harm the native plant community.

5. Piers and boardwalks would be allowed if they stay within state standards in NR 326. Piers are not to exceed the "reasonable use threshold" and can be installed only on current residential homesites. (NR 326, 1991)

6. Recommend restricting gasoline motors in this area to minimize damage to the native aquatic plant community and disturbance to wildlife.

Riparian activities:

1. Wetland alterations will not be permitted with the exception of a purple loosestrife control program. Wetlands are very important to the water quality of the lake and to the fish, wildlife and plant communities supported by the lake, and must be protected or improved.

2. Boardwalks will not be permitted.

3. Shoreland zoning is within the village, although zoning should not exceed NR 115 and NR 117 standards. Shoreline developements should follow erosion control best management practices in any and all new construction and property improvements. (NR 115, 1985)(NR 117, 1983).

4. Removal of vegetation should not be permitted beyond 30 percent to protect the shoreline.

SENSITIVE AREA ASSESSMENT TEAM

Sensitive areas are identified and assessed by a team of personnel from the Department of Natural Resources. Each member of the team has expertise in areas relating to the ecological value of the area being assessed. The members of the team which investigated this area are:

Dan Helsel - Water Resources
Doug Welch - Fish Management
Pam Beirsach - Water Regulation and Zoning
Scott Toshner - Water Resources

Protection of areas identified as sensitive is vital to the future health of the lake, and will require cooperation and understanding of everyone who uses the lake. If you have any questions regarding the identification of this area as a sensitive area or the management implications, please feel free to contact any of the above team members.

AQUATIC PLANT MANAGEMENT
SENSITIVE AREA DESIGNATION FOR AREA # 2
ELIZABETH LAKE, KENOSHA COUNTY, WISCONSIN

DATE OF ASSESSMENT: AUGUST 13, 1997   NUMBER OF SENSITIVE AREAS: 2

SENSITIVE AREA SITE DESCRIPTION

Sensitive area 2 is located on the northwest shore of Elizabeth Lake. It includes approximately 2000 feet of shoreline and extends 50-100 feet into the lake depending on which area is the focus. The water depth in this area averages 2.5 feet, with a maximum depth of 5 feet. For simplification of explanation of substrate types this area was split into 4 areas (A,B,C,D). Area A is located at the southernmost portion of the sensitive area and area D is located at the northernmost portion of the sensitive area. Areas B and C are located in between A and D (see map). Area A had substrate composed of silt with smaller portions of sand and gravel. Area B had substrate composition of silt only. Area C had substrate composed of rubble, gravel and sand. Area D had composition similar to B with silt only. In general the northern portion of this sensitive area had higher concentrations of sand and gravel and the southern portion had higher proportions of silt which would be more conducive to resuspension.

RESOURCES ASSETS OF SENSITIVE AREA # 2

Sensitive area 2 supports a diverse aquatic plant community, both emergent, submergent, and floating leaved. The emergent community consists of cattail (*Typha* sp.), softstem bulrush (*Scirpus* sp.), purple loosestrife (*Lythrum salicaria*), and water willow (*Decadon* sp.). The floating leaved community consists of yellow water lily (*Nuphar variegatum*), white water lily (*Nymphea tuberosa*), and floating leaf pondweed (*Potamogeton natans*). The submergent aquatic plant community consists of northern water milfoil (*Myriophyllum sibiricum*), chara (*Chara* sp.), widgeon grass (*Ruppia* sp.), bladderwort (*Utricularia vulgaris*), slender naiad (*Najas flexis*), spiny naiad (*Najas marina*), illinois pondweed (*P. illinoiensis*), eurasian water milfoil (*M. spicatum*), leafy pondweed (*P. pusillus*), sago pondweed (*P. pectinatus*), and eelgrass (*Valisineria americana*).

Fish utilize this community in a variety of different ways. Northern pike, largemouth bass, bluegills, pumpkin seed, yellow perch, and crappie use this area for spawning, as a nursery for their young, and as a feeding area. The floating leaved and submergent plant community provide cover for insects on which juvenile fish may feed extensively. (Nichols and Vennie, 1991). Larger predator fish are able to ambush their prey among the diverse plant community. Northern pike use the bulrushes as spawning habitat.

Wildlife also depends on the resources provided in sensitive area 2. Canadian geese, mallards, wood ducks, and blue winged teal nest, feed and raise their young here. Wading birds such as the great blue heron feed here and visit during migration. The diverse community provides good habitat for a number of different songbirds and other birds such as the red winged black birds who utilize the cattails extensively. Muskrat, raccoon, and mink feed, find shelter and raise their young here. Painted turtles may be found sunning on logs along the shoreline.

The plant community in sensitive area 2 acts as a sediment and nutrient trap as well as protecting the shoreline from erosion. This benefits the entire lake as it improves water clarity and reduces nutrients available in the water to support the growth of nuisance plants such as algae.

Sensitive area 2 is ecologically important to the lake for several reasons. The mix of bulrush and water lily is unique and provides valuable habitat for fish and wildlife. This area represents one of two portions of the lake that is rich in species diversity and has wetland type shoreline. Seventeen different species of aquatic plants were observed during the assessment, making this a highly diverse area for plants. This large species diversity of aquatic plants will serve as a buffer against invasion of exotic plants which are currently in the system. The preservation of native vegetation in this area will provide a valuable resource to the entire lake.

MANAGEMENT RECOMMENDATIONS FOR SENSITIVE AREA # 2

In-lake activities:

Aquatic plant control:

1. Chemical: chemical treatment in this area is to be restricted to the exotic species present, purple loosestrife and Eurasian water milfoil. Cutting and spot applications of herbicides are recommended to help stop the invasion of purple loosestrife. While Eurasian water milfoil spread can be slowed by using selective herbicides and specific applications on the exotic plant beds only. Care must be taken during applications to prevent harming the native aquatic plant community.

2. Mechanical: As of 1997 the Department of Natural Resources has no regulatory control over mechanical harvesting on public waters. However, the Department recommends only a narrow navigation channel which could extend to riparian owners within the sensitive area. The sensitive area would be off limits to mechanical harvesting other than navigation channels. This would prevent disturbance of the native plant communities and help reduce the fragmentation of Eurasian water milfoil and its consequential spread to uncolinized areas. Fragmentation is the primary way in which milfoil spreads, and mechanical harvesting often causes fragmentation of the plants being harvested, thereby spreading them. (Bode, et. al., 1992)

Water regulation and zoning:

1. Dredging will not be permitted in this area. Dredging would disturb the native plant communities and affect fish that use this area for

spawning and feeding.

2. Filling will not be permitted in this area.

3. Pea gravel/sand blankets are no longer permitted by the Department of Natural Resources due to the covering of fish habitat and breeding areas that occurs as a result of installation and migration.

4. Aquatic plant screens would not be permitted. This activity would unnecessarily harm the native plant community.

5. Piers and boardwalks would be allowed if they stay within state standards in NR 326. Piers are not to exceed the "reasonable use threshold" and can be installed only on current residential homesites. (NR 326, 1991)

6. Recommend a slow no wake zone to 150 feet from shore.

Riparian activities:

1. Wetland alterations will not be permitted with the exception of a purple loosestrife control program. Wetlands are very important to the water quality of the lake and to the fish, wildlife and plant communities supported by the lake, and must be protected or improved.

2. Boardwalks will not be permitted.

3. Shoreland zoning is within the village, although zoning should not exceed NR 115 and NR 117 standards. Shoreline developements should follow erosion control best management practices in any and all new construction and property improvements. (NR 115, 1985)(NR 117, 1983).

4. Recommend no shoreline removal of vegetation.

SENSITIVE AREA ASSESSMENT TEAM

Sensitive areas are identified and assessed by a team of personnel from the Department of Natural Resources. Each member of the team has expertise in areas relating to the ecological value of the area being assessed. The members of the team which investigated this area are:

Dan Helsel - Water Resources
Doug Welch - Fish Management
Pam Beirsach - Water Regulation and Zoning
Scott Toshner - Water Resources

Protection of areas identified as sensitive is vital to the future health of the lake, and will require cooperation and understanding of everyone who uses the lake. If you have any questions regarding the identification of this area as a sensitive area or the management implications, please feel free to contact any of the above team members.

References

Bode, J., S. Borman, D. Helsel, F. Koshere, and S. Nichols. 1992. Eurasian Water Milfoil in Wisconsin, A report to the legislature. Bureau of Water Resources, Wisconsin Department of Natural Resources, Madison, WI.

DNR, Administrative Code NR 107, 1989.

DNR, Administrative Code NR 115, 1985.

DNR, Administrative Code NR 117, 1983.

DNR, Administrative Code NR 326, 1991.

Fassett, Norman C. (1957) A Manual of Aquatic Plants. University of WIsconsin Press. Madison, WI.

Nichols, Stanley A. and James G. Vennie (1991) Attributes of Wisconsin Lake Plants. Wisconsin Geological & Natural History Survey Information, Circular # 173.

Appendix C

BOATING ORDINANCE FOR THE VILLAGE OF TWIN LAKES

This Page Intentionally Left Blank

Twin Lakes Village Code
Chapter 8.36

BOATING AND WATER CODE

Sections:

8.36.010 Intent.

The intent of the Ordinance codified in this Chapter is to revise and recreate Chapter 8.36 of the Municipal Code of the Village relating to the Boating and Water Code to provide for the public health, safety and general welfare of all people for the enjoyment of aquatic recreation consistent with statutes of the State of Wisconsin and the rights of the public in interest of Lake Mary and Lake Elizabeth. (Ord. 87-4-1 (part), 1987).

8.36.020 Applicability.

The provisions of this Chapter shall apply to Lake Mary and Lake Elizabeth and shall be enforced by the Police Department of the Village. (Ord. 87-4-1 (part), 1987).

8.36.030 Definitions.

The following definitions apply for the purposes of this Chapter:

A. "Board" means the Village Board of the Village of Twin Lakes.

B. "Slow-no-wake" is the slowest possible speed whereas to maintain steerage.

C. "Shoreline" means the waters edge when Lake Elizabeth is at its datum level of ninety eight point two four (98.24) feet as defined by Public Service Commission Order dated April 15, 1959 (D-938.10).

D. "Shore zone" means all surface waters within two hundred (200) feet of the shoreline.

E. “Swimming zone” shall mean an authorized area established by regulatory markers to designate a swimming area.

F. “Village” means the incorporated Village of Twin Lakes. (Ord. 87-4-1 (part), 1987).

8.36.040 State Statutes Adopted.

The statutory provisions with respect to water traffic, boats, boating and related activities in the following enumerated Sections of Wisconsin Statutes, exclusive of any provision therein relating to penalties to be imposed or punishment for violation of such Statutes, and any amendments or additions, are adopted by reference and made a part of this Chapter.

§ 30.01	General Provisions--Definitions.
§ 30.50	Definitions.
§ 30.501	Capacity Plates on Boats.
§ 30.51	Certificate of Number and Registration.
§ 30.53	Certification or Registration Card to Be on Board. Display of Decals or Identification Number.
§ 30.541	Transfer of Ownership.
§ 30.60	Classification of Motor Boats.
§ 30.61	Lighting Equipment.
§ 30.62	Other Equipment.
§ 30.63	Sales and Use of Certain Outboard Motors Restricted.
§ 30.65	Traffic Rules.
§ 30.66	Speed Restrictions.
§ 30.675	Distress Signal Flag.
§ 30.68	Prohibited Operation.
§ 30.681	Intoxicated Boating.
§ 30.682	Preliminary Breath Screening Test.
§ 30.683	Implied Consent.
§ 30.684	Chemical Tests.
§ 30.686	Report Arrests to Department.
§ 30.687	Officer’s Action After Arrest.
§ 30.69	Water Skiing.
§ 30.70	Skin Diving.
§ 30.71	Boats Equipped With Toilets.
§ 30.80	Penalties.
§ 60.0495	Removal of Wharves and Piers.

(Editorially amended per approval by Village Board 7/8/96; Ord. 87-4-1 (part), 1987).

8.36.050 Additional Traffic Rules.

In addition to the traffic rules in Section 30.65 of the Wisconsin Statutes, the following rules shall apply to boats using the waters covered by this Chapter:

A. Boats leaving or departing from a pier, dock or wharf shall have the right-of-way over all watercraft approaching such dock, pier or wharf.

B. Boats propelled entirely by muscular power shall yield the right-of-way to sailboats when necessary to avoid the risk of collision.

C. Anchoring, drifting or mooring of houseboats is prohibited from twelve (12:00) midnight to sunrise, but where the houseboat is moored to shore, with written permission of the property owner, and where suitable shore sanitary facilities are available for use by the occupant, such use is permitted. The provision of this subsection is required in the interest of public health, safety and welfare.

D. No person shall operate a motorboat at a speed in excess of slow-no-wake speed in those bay waters of Lake Mary lying within the following described lines: Beginning at a point on the north line of Lot 11, Rosebud Subdivision which intersects Lake Mary and extending to the point on the easterly line of Lot 1 of Indian Point Subdivision which intersects Lake Mary, and from the southeast corner of Lot 16, Indian Point Subdivision Addition to the channel side of Lot 1 of Mount Moriah Subdivision.

1. No person shall operate a motorboat at a speed in excess of slow-no-wake in those bay waters of Lake Elizabeth lying to the west of the following line: Beginning at the southernmost point on Parcel Number 291-2075, Latitude N 42 30’56.62” Longitude W 088 16’23.85”, also known as Boy Scout Island, which intersects Lake Elizabeth and extending to the point where the north line of Parcel Number 294-3036, Latitude N 42 30’45.87” Longitude W 088 16’24.24”, (Hickory Point) intersects Lake Elizabeth.

E. No person shall operate a motor boat at a speed in excess of slow-no-wake between the hours of sunset or eight thirty (8:30) p.m., whichever occurs earliest, and nine (9:00) a.m., unless the operator of such boat has obtained a permit for a special activity as provided in Section 8.36.100. Further, no person shall operate a motor boat at a speed in excess of slow-no-wake at any time upon the waters of Lake Elizabeth when the water level exceeds eleven and one-half (11.5) inches above sea level elevation corresponding to the dam Board as measured at the staff gauge at the Jooss household and no person shall operate a motor boat at a speed in excess of slow-no-wake at any time upon the waters of Lake Mary when the water level exceeds eleven and one-half (11.5) inches above sea level elevation corresponding to the dam Board as measured at the staff gauge at the Porps household.

F. No person shall engage in the act of powering a motor boat on or off a trailer at any Municipal boat launch site within the Village with the engine being operated at a speed greater than idle speed. No person shall continue to operate the engine while engaged in the act of launching or retrieving a motor boat after the motor boat is at rest on the trailer. A sign shall be posted at the Municipal boat launch sites advising of the requirement of this subsection, indicating no power loading, minimum one hundred dollars ($100.00) forfeiture.

G. Unless a specific penalty is provided elsewhere in this Section, any person violating the provisions of this Section shall, for each offense, be subject to a forfeiture of not less than the minimum penalty as provided in Section 1.12.010 nor more than one thousand dollars ($1,000.00), with each separate day to be considered a separate offense. (Ord. 2004-6-3 § 1, 2004; Ord. 2004-4-6 § 1, 2004; Ord. 2003-8-3 § 1, 2003; Ord. 2001-9-1 § 1, 2001; Ord. 95-4-1, 1995; Ord. 94-6-1, 1994; Ord. 94-5-1, 1994: Ord. 87-7-1, 1987; Ord. 87-4-1 (part), 1987).

8.36.060 Launch Permits.

A. Definitions and Terms. The following definitions shall apply to this Section:

1. The term “boat launch” shall include the public grounds, buildings thereon, waters therein and any other public property or facility which is under the jurisdiction of the Village of Twin Lakes whereon watercraft are launched;

2. The term “permit” shall mean written authorization for the use of boat launch facilities.

B. No person shall launch or remove any watercraft at any boat launch area in the Village between March 1st and September 30th inclusive of any year without first obtaining a boat launching permit and paying the appropriate fee for same, which fee shall be established by the Village Board. Such permit shall be displayed in or on the accompanying motor vehicle in such location as directed by the Village Board.

C. It is unlawful for any person launching or removing any watercraft at any boat launching area in the Village to park, stop or leave standing any motor vehicle, whether attended or unattended, unless such vehicle visibly displays a properly purchased permit as required in subsection B.

D. No person shall launch or remove any watercraft contrary to this Section or disobey reasonable order or direction of official Village enforcing personnel.

E. The Village Board is authorized to adopt additional or revised Rules and Regulations for the proper conduct and administration of boat launch facilities in the Village not inconsistent with this Section; to grant permits in conformity with the provisions hereof and to perform such other acts with reference to the management of such boat launch facilities as are lawful and as the Village Board may deem expedient; to promote beauty and usefulness of such boat launch facilities; and to increase the comfort, safety, convenience and public welfare of the citizens of the Village and of visitors to such boat launch facilities in their use of the same.

F. Any person violating the provisions of this Section shall, for each offense, be subject to a forfeiture of not less than ten dollars ($10.00) nor more than five hundred dollars ($500.00), with each separate day to be considered a separate offense. (Ord. 2000-7-3 § 1, 2000).

8.36.070 Swimming Regulations.

A. No person shall swim:

1. From any unmanned boat unless such boat is anchored;

2. More than two hundred (200) feet from the shore or more than fifty (50) feet from any pier, unless within marked authorized areas, nor more than twenty-five (25) feet from an anchored raft or boat unless such person is accompanied by a boat manned by a competent person and having readily available a ring buoy. Such boat shall stay reasonably close to and guard such swimmer;

3. More than two hundred (200) feet from the shoreline between sunset and sunrise;

4. With a snorkel within the traffic lane.

B. No person shall be engaged in SCUBA diving activities without the approval of the Police Department between the hours of sunset and sunrise nor at any of the public beaches, nor in such a manner as to interfere with the activities of fishermen, fishing lines or boats with anchors. This Section shall not apply to rescue units or law enforcement agencies using SCUBA diving equipment for rescue, emergencies or enforcement activities.

C. Flotation devices of any type shall be prohibited at Musial Beach and Lance Park Beach, except for Coast Guard approved personal flotation devices utilized in the manner prescribed. (Ord. 92-6-1, 1992; Ord. 87-4-1 (part), 1987).

8.36.080 Public Swimming Areas Defined.

The following described areas are declared to be public swimming areas and shall be buoyed accordingly:

A. Lance Park. Commencing at a point located forty (40) feet east of the east line of Lance Park continuing along the shoreline for a distance of two hundred (200) feet and extending into the lake parallel to the shoreline for a distance of one hundred fifty (150) feet.

B. Musial Road. From the shoreline at the termination of Musial Road for one hundred fifty (150) feet and parallel to the shoreline for fifty (50) feet.

C. Sunset Park. Commencing at the north property line and the shoreline for a distance of fifty-six (56) feet south and extending into the lake parallel to the shoreline for a distance of one hundred fifty-five (155) feet.

D. Lucille Avenue. Commencing at the easterly property line of Parcel Number 294-3055 and the shoreline for a distance of fifty-six (56) feet west to the westerly property line and extending into the lake parallel to the shoreline for a distance of one hundred fifty (150) feet. (Ord. 2002-7-2 § 1, 2002; Ord. 88-6-1 (part), 1988; Ord. 87-4-1 (part), 1987).

8.36.081 Parasailing Prohibited.

No person shall engage in the activity known as parasailing or paragliding except as a special activity for which a permit has been obtained subject to Section 8.36.100. (Ord. 88-3-1 (part), 1988).

8.36.090 Water Skiing.

A. No person shall:

1. Operate a boat for the purpose of towing a water skier or engage in water skiing between the hours of sunset and nine (9:00) a.m.;

2. Operate a boat with more than two (2) tow lines or exceed or allow other persons to exceed the designed capacity of the manufactured device as a means of water skiing, aquaplaning or similar activity or sport. The persons being towed shall wear Type 1, Type 2 or Type 3 Coast Guard approved personal flotation devices, while being towed;

3. Engage in water skiing, aquaplaning, or similar sport or activity within one hundred fifty (150) feet of the shoreline as defined in this Chapter, and must operate in a counterclockwise pattern in the traffic lane, as well as conform to all Sections of this Chapter;

4. Use any tow rope of more than seventy-five (75) feet for towing a person for purposes of water skiing, aquaplaning, or similar activity;

5. The limitations of this Section shall not apply to participants in ski meets or exhibitions authorized and conducted as provided in Section 8.36.100;

6. There is established a drop-off area for water skiers, practicing or performing with a water ski show approved by the Village Board, commencing one hundred fifty (150) feet west of the west line of the buoyed swim areas of Lance Park and continuing to the west line of Lance Park and extending into the water parallel to the shoreline one hundred fifty (150) feet. (Ord. 2002-9-2 § 1, 2002; Ord. 94-9-2, 1994; Ord. 88-10-1, 1988; Ord. 88-6-1 (part), 1988; Ord. 87-4-1 (part), 1987).

8.36.100 Permit for Special Activity.

A. No person shall conduct or participate in any boat race, regatta, water ski meet or other water sporting event or exhibition unless such event has been approved by the Village Board and a permit issued therefor by the Chief of Police.

B. A permit issued under this Section shall specify the course or area of water to be used and participants in such event. The permittee shall be required to place markers, flags or buoys approved by the Chief of Police designating the specified area. Permits shall be issued only when, in the opinion of the Chief of Police, the proposed use of the water can be carried out safely and without danger to or substantial obstruction of other watercraft or persons using the lake. Permits shall specifically identify the Sections of this Chapter to which the permit applies and permits shall be issued annually for a continuing activity or for a special event.

C. Boats and participants in any such permitted event 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. (Ord. 87-4-1 (part), 1987).

8.36.110 Littering.

No person shall leave, deposit, place or throw on the waterways, ice, shoreline of waterways or upon other public or private property adjacent to waterways, any cans, paper, bottles, debris, refuse or other solid or liquid waste material of any kind. (Ord. 87-4-1 (part), 1987).

8.36.120 Anchorages and Stationary Objects.

A. No person shall erect or maintain any raft, ski jump, stationary platform or other obstacles to navigation, except as provided in this Chapter.

B. Moorings--Permit Required. No person shall moor any boat within one hundred fifty (150) feet of the shoreline without first obtaining an annual permit from the Village Police Department and Village Board. Mooring buoys may be set without lighting within one hundred fifty (150) feet of the shoreline provided that such buoys are brightly colored and are made of materials that will not damage a boat if struck. Moorings beyond one hundred fifty (150) feet of the shoreline shall be prohibited except by application approved by the Department of Natural Resources.

C. Application for a mooring permit shall be upon forms provided by the Village which forms shall, insofar as is practicable, conform to applications provided by the department.

D. Permits shall be issued only upon application of a riparian owner and there shall be only one (1) mooring permit issued for the lake frontage of each riparian owner. No more than one (1) boat shall be attached to a single mooring and no boat shall be moored with a line that will permit the boat to drift or extend beyond one hundred fifty (150) feet of the shoreline unless said boat is lighted as required by Section 30.51 of the Wisconsin Statutes. Mooring lines or chains shall not exceed in length more than three (3) times the depth of the water in which the boat is moored. Mooring buoys may be set within one hundred fifty (150) feet of the shoreline without lighting, provided they are brightly colored and are covered with materials which will not damage watercraft if struck, and the Chief of Police determines that the mooring buoys are placed in such a manner as to not be a potential hazard to others using the lakes. All mooring buoys must conform to the conditions of Section 8.36.150 of this Chapter.

E. Before issuing a mooring permit, the Police Department shall inspect the location for the proposed mooring area and determine that said mooring will not be an obstruction to navigation and will not interfere with other properly marked swimming areas, structures, piers, ramps, docks or wharves, or the rights of other riparian owners.

F. The anchoring or mooring of any boat in the waters adjacent to public landings is prohibited except that boats may be tied to piers within such public landing areas upon approval of the Village Board.

G. Appeal Procedures. Chapter 68 of the Wisconsin Statutes shall apply to the granting, denial or revocation of any mooring permit issued by the Police Department.

H. Piers and Wharves. No person shall construct a pier extending into the water for a distance in excess of one hundred (100) feet from the shoreline without first obtaining an annual permit from the Village Police Department and Village Board. No pier may be constructed except within the lot lines of the riparian owner. Wharves may be constructed by the riparian owner without a permit but said wharves shall not interfere with the enjoyment of adjacent owners. All piers and wharves shall be constructed in accordance with the Wisconsin Statutes.

I. No person shall place or maintain any raft or platform on the waters of Lake Mary or Lake Elizabeth unless it is so anchored that at least eighteen (18) inches of freeboard extend above the water line, is painted white, and is attached thereto no more than twelve (12) inches from each corner or projection, a red reflector of not less than three (3) inches in diameter. Rafts or platforms shall only be placed within the lot lines of the riparian owner, and if placed more than fifty (50) feet from the shoreline must first obtain an annual permit from the Village Police Department and Village Board.

J. No pier shall be erected or mooring buoy permitted, nor shall any watercraft be beached, within the boundaries of any public street, highway, fire lane, Village easement or any other riparian lands owned by the Village.

K. There shall be a non-refundable annual fee for each permit requested pursuant to this Chapter. The fee for such permit shall be as provided in Section 3.06.010(G) of this Code and shall be paid at the time of application. All permits shall expire on December 1st of each year. (Ord. 2003-7-4 § 1, 2, 2003; Ord. 89-9-1, 1989; Ord. 88-8-1, 1988; Ord. 88-3-1 (part), 1988; Ord. 87-10-1, 1987; Ord. 87-4-1 (part), 1987).

8.36.130 Marker and Navigation Aids-- Posting Chapter.

The Chief of Police is authorized and directed to place markers, navigation aids and signs in such water areas as shall be appropriate to advise the public of the provisions of the Ordinance codified in this Chapter and to post and maintain a copy of this Chapter at all public access points within the jurisdiction of the Village. (Ord. 87-4-1 (part), 1987).

8.36.140 Buoy Permits.

No bathing beach marker, speed zone information marker, mooring buoy, fishing buoy or other markers shall be anchored on any waters of this Village beyond one hundred fifty (150) feet from the shoreline by any individual unless a written application therefor is made to the Village Board and approved by the Department of Natural Resources. (Ord. 87-4-1 (part), 1987).

8.36.150 Buoys and Piers.

A. All buoys, regulatory markers, aids to navigation or waterway markers shall conform to requirements of NR 5.09 Wisconsin Administrative Code and shall have affixed thereto such numbers as are assigned to them by the Village Chief of Police; such numbers are to be located at least twelve (12) inches above the waterline. Twin Lakes Water Patrol will from time to time inspect for properly applied numbers.

B. All piers and their supports and all shore stations shall either be completely removed from the water by December 1st of each year, or allowed to remain completely intact in the water through the winter months. If left in the water after December 1st, the pier or shore station shall be marked by readily visible red reflectors at least three (3) inches in diameter, spaced at intervals of not less than three (3) feet, facing the water and affixed to the sides and ends of the pier or station in such a manner as to give a warning to other users of the lake. If a pier is removed from the water, it shall be completely removed. If a pier remains in the water it shall not be left in a partially dismantled state. All buoys shall be removed from the water by December 1st of each year. Any pier, shore station or buoy removed from the water pursuant to this Section may be replaced in the ensuing year after the ice is out of the waters. (Ord. 2003-7-4 § 3, 2003; Ord. 87-4-1 (part), 1987).

8.36.160 Seaplanes.

Landing, taking off or anchoring of a seaplane is prohibited. (Ord. 87-4-1 (part), 1987).

8.36.170 Driving Automobiles or Other Motor Driven Vehicles on the Ice.

A. No person shall:

1. Use or operate any automobile or other motor driven vehicle in any manner so as to endanger persons engaged in skating or any other winter sport or recreational activity upon the ice, nor shall any person, while using or operating an automobile or motor driven vehicle, tow, pull or push any person or persons on skates, sled, skis, toboggan, or device or thing of any kind designed or utilized to carry or support one or more persons;

2. Use or operate any automobile at a speed in excess of ten (10) miles per hour on the ice;

3. Operate any aerodynamic propeller driven vehicle, device or thing, whether or not designed for the transportation of a person or persons, on the ice of Lake Mary or Lake Elizabeth;

4. Use or operate any automobile on the ice after nine (9:00) p.m.

B. "Automobile" as used in this Chapter shall be construed to mean all motor vehicles of the type and kind permitted to be operated on the highways in the State.

C. All traffic on the ice bound water of Lake Mary or Lake Elizabeth shall be at the risk of the traveler as set forth in Section 30.81(3) of Wisconsin Statutes; nothing in this Chapter shall be construed as rendering the enacting authority liable for any accident to those engaged in permitted traffic while the Ordinance codified in this Chapter is in effect. (Ord. 87-4-1 (part), 1987).

8.36.180 Penalties.

A. Any person who shall be convicted of violating any of the provisions of this Chapter shall pay a forfeiture not to exceed the amounts set forth in Section 30.80 Wisconsin Statutes.

B. Any person convicted of violation of any Section of this Chapter not included on Section 30.80 Wisconsin Statutes shall forfeit not less than fifty dollars ($50.00) nor more than one hundred dollars ($100.00) and upon conviction of a second violation of this Chapter within one (1) year, shall forfeit not less than one hundred dollars ($100.00) nor more than two hundred dollars ($200.00). Any person who fails to pay the forfeiture set forth herein may be confined to the County Jail for a period not to exceed fifteen (15) days. (Ord. 87-4-1 (part), 1987).