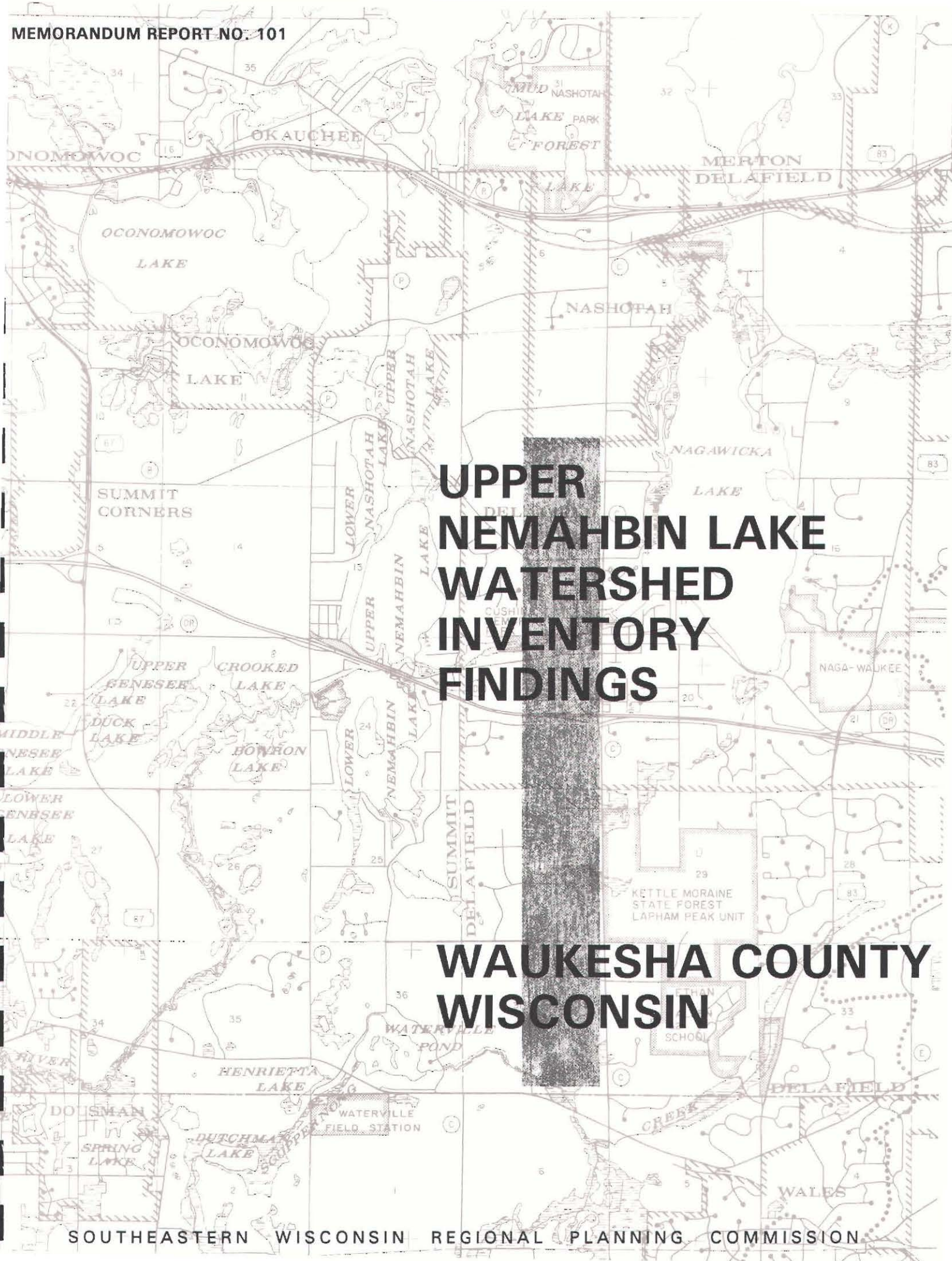
MEMORANDUM REPORT NO. 101



UPPER NEMAHBIN LAKE WATERSHED INVENTORY FINDINGS

WAUKESHA COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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Special acknowledgement is due Dr. Jeffrey A. Thornton, SEWRPC Principal Planner, Mr. Craig R. Webster, SEWRPC Planning Analyst, and Mr. Kenneth J. Lovelett, SEWRPC Research Aide, for their contributions to the conduct of this study and the preparation of this report.

MEMORANDUM REPORT
NUMBER 101

UPPER NEMAHBIN LAKE
WATERSHED INVENTORY FINDINGS

WAUKESHA COUNTY, WISCONSIN

Prepared by the
Southeastern Wisconsin Regional Planning Commission
for the
Upper Nemahbin Lake Management District

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

May 1995

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Outside Region $10.00

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WAUKESHA COUNTY, WISCONSIN

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INTRODUCTION

Upper Nemahbin Lake, located in the Town of Summit, Waukesha County, Wisconsin, is a valuable ecological resource offering a variety of recreational and visual opportunities to the community, comprised of urban development surrounding the lake and adjacent portions of the Town of Summit and City of Delafield, and its visitors. The lake is an integral part of this lake-oriented community. However, the recreational and visual value of the lake is perceived by lake residents as being adversely affected by urban growth in the Upper Nemahbin Lake watershed and by increasing lake usage. Thus, there is community concern over the potential of water quality degradation in this waterbody at a time when there is an increasing demand for high-quality recreational and residential experiences in the area.

Seeking to improve the usability of Upper Nemahbin Lake, and to prevent deterioration of the natural assets and recreational potential of Upper Nemahbin Lake, the residents of the watershed formed the Upper Nemahbin Lake Management District in the summer of 1992. Shortly thereafter, the District began a program of community involvement, education, and lake management aimed at maintaining and improving the aspect of this valuable lake. There have been a number of studies involving Upper Nemahbin Lake conducted by the Wisconsin Department of Natural Resources (DNR), various private consultants, and, most recently, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and U. S. Geological Survey (USGS). Several studies have been undertaken and financed by the District and its predecessor organization, the Nemahbin Conservation Club. This study has been funded in part by a Wisconsin Department of Natural Resources Lake Management Planning Grant awarded to the Upper Nemahbin Lake Management District under the Chapter NR 119 Lake Management Planning Grant Program.

This watershed inventory constitutes the first phase of investigations, and sets forth the background information needed to prepare a lake management plan for Upper Nemahbin Lake, and represents part of the on-going commitment of the Upper Nemahbin Lake Management District—and the Town of Summit—to sound environmental planning with respect to the Lake. This inventory was prepared during 1993 and 1994 by SEWRPC staff at the request of the Upper Nemahbin Lake Management District. Additional data were supplied from the files of the Lake Management District, the DNR, SEWRPC, and the USGS.

It is important to note that this report does not represent a comprehensive water quality management plan for Upper Nemahbin Lake.[1] Rather, this watershed inventory is meant to provide the watershed inventory information needed to meet the requirements of Chapter NR 119, Lake Management Planning Grant Program, of the Wisconsin Administrative Code and is designed to form an integral part of a future comprehensive lake management plan devised for Upper Nemahbin Lake. A comprehensive lake management plan for Upper Nemahbin Lake will require additional water quality and biological data collection and analysis than has been obtained for this watershed inventory. Only after such a complete inventory and analysis can a comprehensive lake management plan be prepared which specifies the land use, pollution control, and in-lake management techniques needed to protect or enhance lake water quality. The scope of this report is limited to the collection of those data which describe the pertinent characteristics of the watershed in which the lake is situated including land uses. These data are used in presenting a preliminary analysis of the pollutant loadings to which the lake is exposed. The estimates generated through this analysis have been verified using the available field data being gathered by the concurrent USGS water quality studies being conducted under this Grant program. The estimates contained herein provide an initial basis on which to begin to formulate a strategy to control and manage the external contaminant loads to Upper Nemahbin Lake.

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[1]*An example of a comprehensive lake management plan is SEWRPC Community Assistance Planning Report No. 198, A Management Plan for Wind Lake, Racine County, Wisconsin, December 1991.*

This inventory is comprised of four main sections: 1) a statement of lake management goals and objectives; 2) a description of existing and planned conditions in Upper Nemahbin Lake and its watershed; 3) a statement of the potential problems and concerns; and 4) a review of past and present watershed management practices.

STATEMENT OF LAKE MANAGEMENT GOALS AND OBJECTIVES

The lake use and management goals and objectives for Upper Nemahbin Lake were developed by the Upper Nemahbin Lake Management District in consultation with the Town of Summit. The goals and objectives are:

1. To protect and maintain public health, and promote public comfort, convenience, necessity and welfare, in concert with the natural resource, through the environmentally sound management of the vegetation, fishery, and wildlife populations in and around Upper Nemahbin Lake;

2. To promote a quality, water-based experience for residents and visitors to Upper Nemahbin Lake in a manner consistent with the other objectives;

3. To manage the Upper Nemahbin Lake in an environmentally sound manner and to preserve and enhance its water quality and biotic communities, biological habitats, and essential structure and function in the waterbody and adjacent areas; and

4. To effectively control water quality in the Upper Nemahbin Lake to better facilitate the conduct of water-related recreation; improve the aesthetic value of the resource to the communities; and enhance the resource value of the waterbody.

EXISTING AND PLANNED CONDITIONS IN UPPER NEMAHBIN LAKE AND ITS WATERSHED

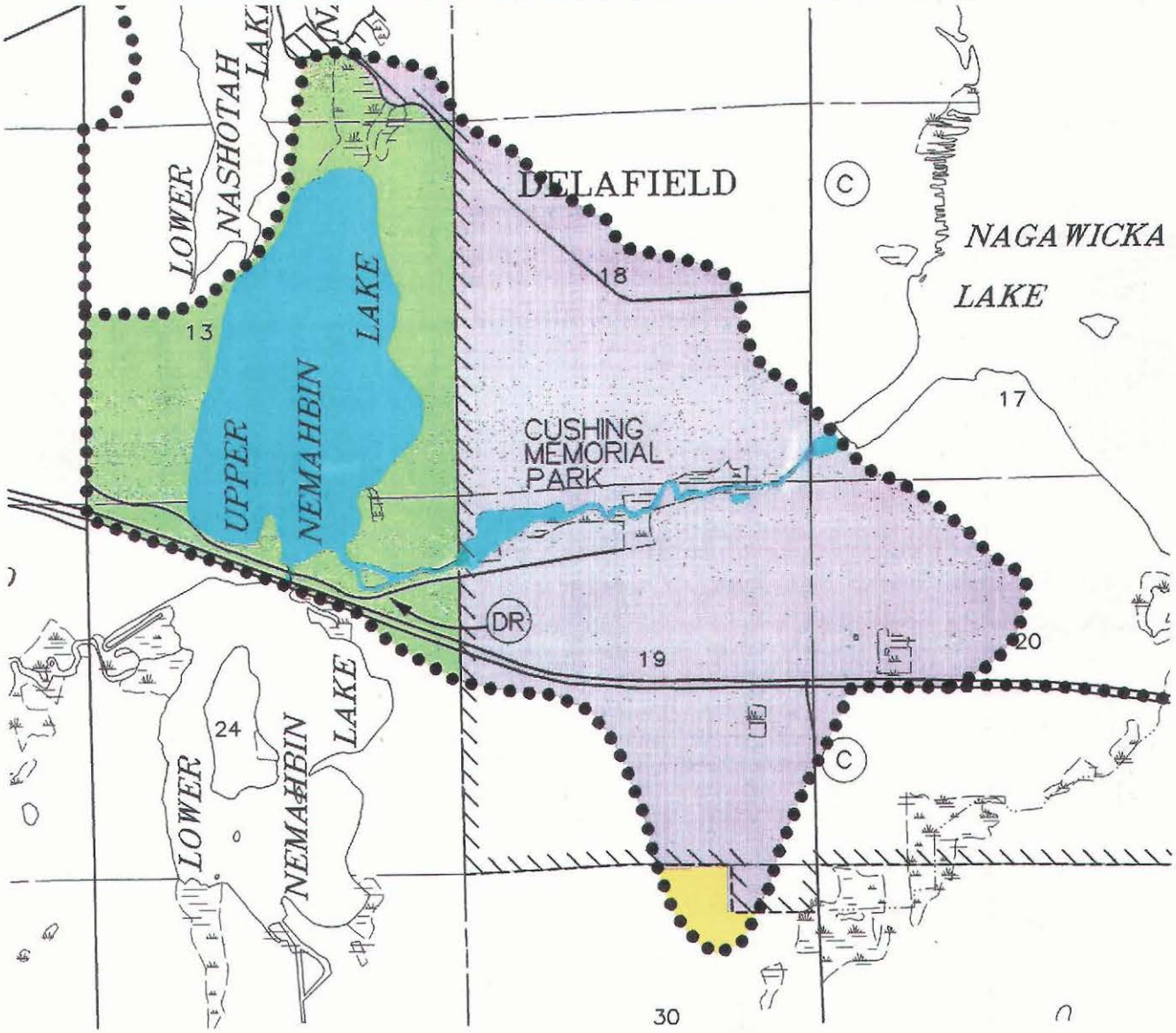
Physical Characteristics

Watershed Characteristics: Upper Nemahbin Lake is situated just west of the City of Delafield in the Town of Summit, Waukesha County, as shown on Map 1. The Lake is a through-flow, or drainage, lake located in the middle reaches of the Bark River. Bark Lake and Nagawicka Lake lie upstream of Upper Nemahbin Lake on the Bark River, while the spring-fed Upper and Lower Nashotah Lakes flow into the Upper Nemahbin Lake through an unnamed tributary. Upper Nemahbin Lake lies at the confluence of these waterways. The direct tributary drainage area of Upper Nemahbin Lake—defined as that area which drains directly to Upper Nemahbin Lake without passing through any of the upstream lakes and shown as the study area on Map 2—is situated wholly within Waukesha County, and is approximately 1,734 acres in areal extent. The total tributary drainage area—including those lands draining to Upper Nemahbin Lake through the upstream lakes—is 25,585 acres in size, as shown on Map 3. This total watershed area lies largely in Waukesha County, but also includes the small portion of Washington County tributary to the Bark River. This entire system drains via a short reach of the Bark River to Lower Nemahbin Lake and then through the Bark River to the Rock River system at Fort Atkinson, Wisconsin.

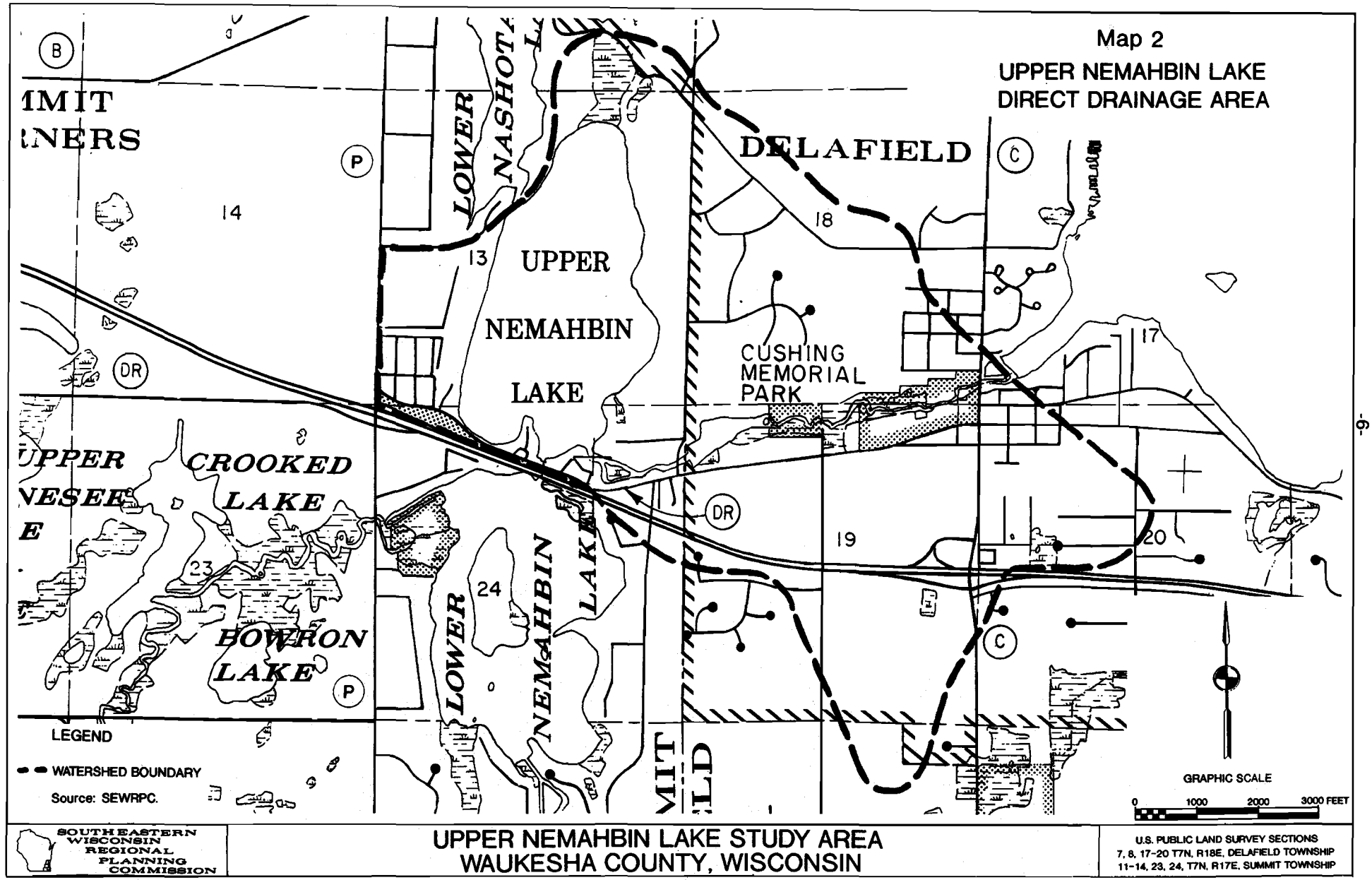
Field inspections of the direct tributary drainage area boundary conducted by Commission staff during August 1993 resulted in a refinement of the boundary as set forth in the areawide water quality management plan entitled, SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, Volume Two, Alternative Plans, February 1979. The refined boundary of the direct drainage area to Upper Nemahbin Lake is shown on Map 2. The only modification compared to earlier drainage area delineation consisted of the addition of 216 acres of land located south of IH 94. This area drains northerly toward the Bark River just upstream of Upper Nemahbin Lake, passing under IH 94 in the vicinity of the CTH C interchange. The Pabst Farms, Inc., property west of CTH P, including the CTH P/IH 94 interchange, presently drains in a westerly direction away from Upper Nemahbin Lake and thus does not affect the lake

Map 1

CIVIL DIVISION BOUNDARIES IN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA



Source: SEWRPC.



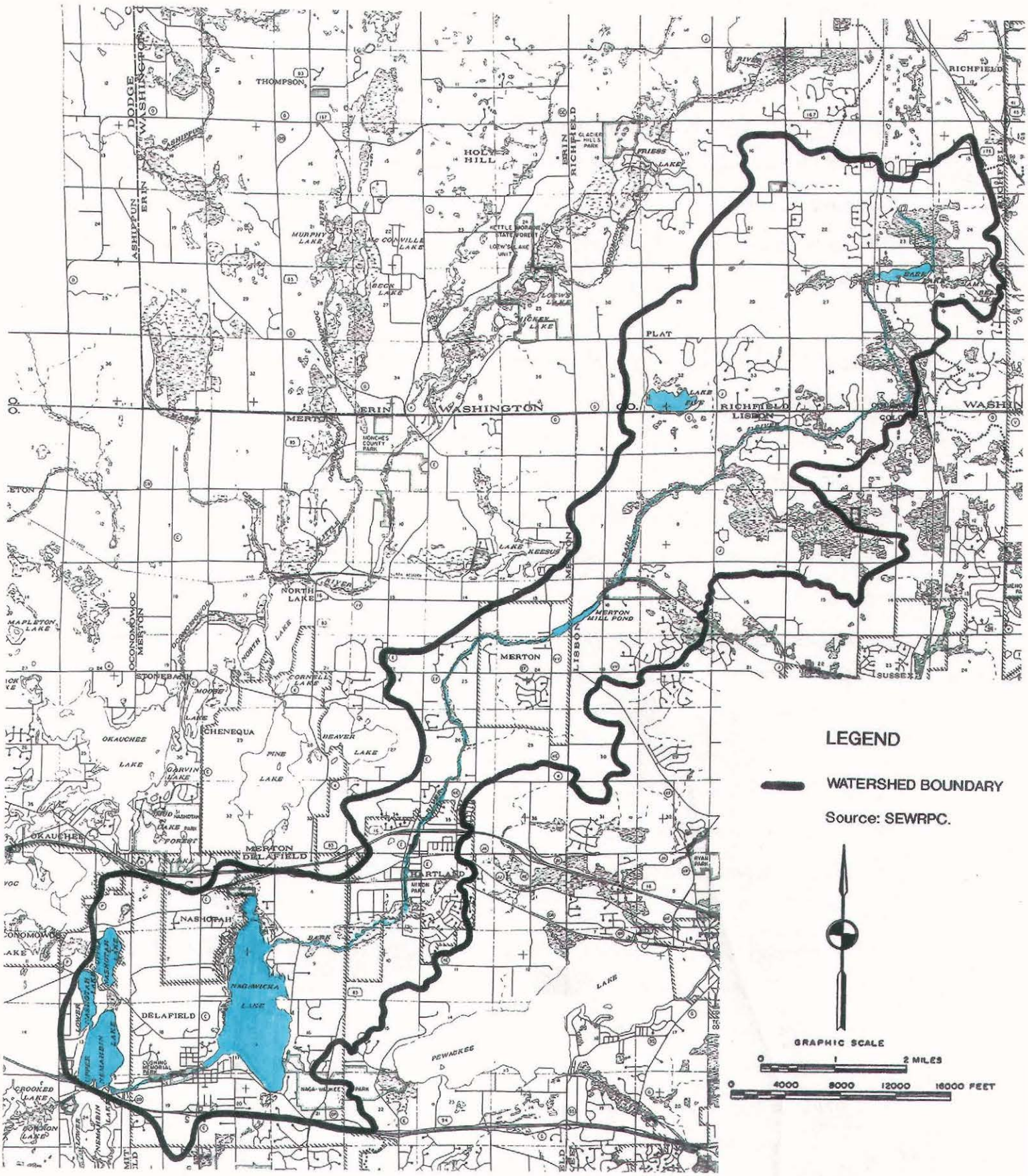
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

UPPER NEMAHBIN LAKE STUDY AREA
WAUKESHA COUNTY, WISCONSIN

U.S. PUBLIC LAND SURVEY SECTIONS
7, 8, 17-20 T7N, R18E, DELAFIELD TOWNSHIP
11-14, 23, 24, T7N, R17E, SUMMIT TOWNSHIP

Map 3

UPPER NEMAHBIN LAKE TOTAL TRIBUTARY DRAINAGE AREA



at this time. However, stormwater management proposals associated with any subsequent development of this area could potentially alter the drainage patterns.

Upper Nemahbin Lake is generally surrounded by lake-oriented urban development. The balance of the direct tributary drainage area is natural—wetlands, woodlands, other open lands, and transportation corridors—including the IH-94 and CTHs C, P, and DR corridors. A discussion of land use in the direct and total tributary drainage area is presented in the subsequent section of this report.

Waterbody Characteristics: Upper Nemahbin Lake is a 283-acre waterbody, the geomorphological characteristics of which are set forth in Table 1. The Lake is a drainage lake, roughly oval in shape, having a well-defined "deep hole" basin of about 60 feet in depth. This deep basin is situated just south of center and slightly to the east as shown on Map 4. This waterbody has a maximum depth of about 60 feet, a mean depth of 29.6 feet, and a volume of about 8,380 acre-feet. upper Nemahbin Lake has a maximum length of about 1.1 miles and is about 0.5 mile wide.

Land Use and Shoreline Development

Land Use: As shown on Map 5 and summarized in Table 2, urban land uses occupied about 32 percent of the 1,734-acre direct drainage area of Upper Nemahbin Lake in 1990. Woodlands occupied about 11 percent of the direct tributary drainage area, while wetlands occupied approximately another 3 percent. About 17 percent of the watershed was comprised of surface waters. These relatively large areas of natural vegetation and surface water provide lake residents with generally pleasing vistas across the lake.

Within the direct drainage area to Upper Nemahbin Lake, the riparian residential areas are largely developed, with some potential for infilling on a limited number of platted lots and for minor additional land divisions. Commercial and industrial sites cover less than 1 percent of the direct drainage area and are comprised largely of restaurant facilities and boat rental operations located at the southern end of Upper Nemahbin Lake. Within the direct drainage area, only limited new

Table 1

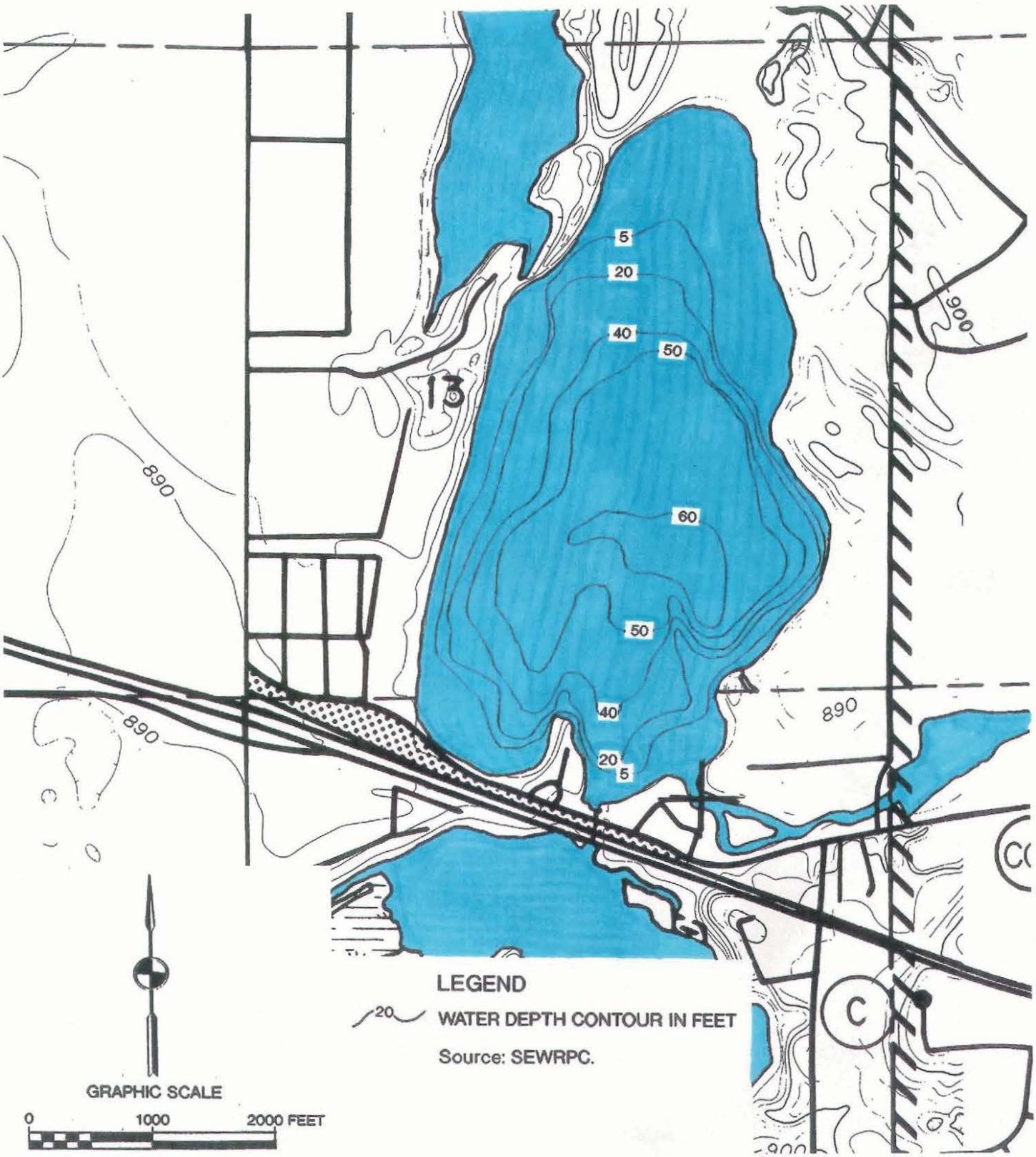
GEOMORPHOLOGICAL CHARACTERISTICS OF UPPER NEMAHBIN LAKE

Parameter	Measurement
Size (total)	
Surface Area (acres)	283
Volume (acre-feet)	8,377
Direct Tributary Drainage Area (acres)	1,734
Total Tributary Drainage Area (acres)	25,585
Shape	
Maximum Length of Lake (miles)	1.1
Length of Shoreline (miles)	2.9
Maximum Width of Lake (miles)	0.6
Depth	
Maximum Depth (feet)	60.0
Mean Depth (feet)	29.6

Source: SEWRPC.

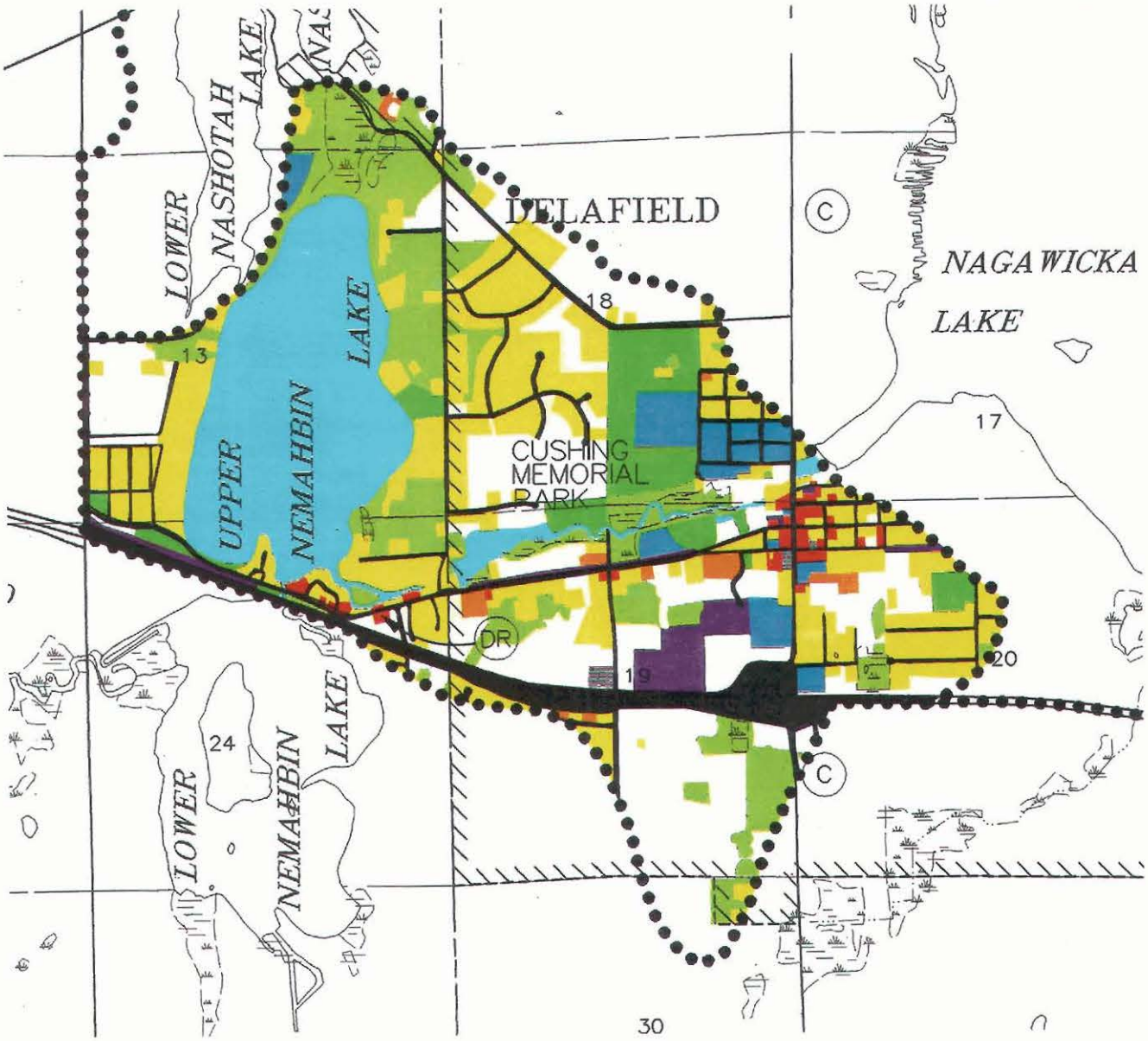
Map 4

UPPER NEMAHBIN LAKE MORPHOMETRY



Map 5

LAND USE IN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA: 1990



Source: SEWRPC.

Table 2

LAND USE IN THE UPPER NEMAHBIN LAKE WATERSHED: 1990

Land Use Category	Direct Drainage Area: 1990		Total Drainage Area: 1990	
	Acres	Percent	Acres	Percent
Urban				
Residential	244	14.0	4,057	15.9
Commercial	11	0.6	145	0.6
Industrial	<1	0.1	92	0.4
Transportation/Utilities	173	10.0	1,359	5.3
Governmental/Institutional	58	3.3	360	1.4
Recreational	71	4.1	322	1.3
Unused Urban	5	0.2	111	0.4
Subtotal	563	32.3	6,446	25.3
Rural				
Agricultural	544	31.4	10,027	39.2
Woodland	186	10.7	2,295	10.9
Wetland	61	3.5	2,779	8.9
Water	292	16.9	1,701	6.6
Extractive and Landfill	0	0.0	669	2.6
Other Open Lands	90	5.2	1,668	6.5
Subtotal	1,173	67.7	19,139	74.7
Total	1,734	100.0	25,585	100.0

Source: SEWRPC.

urban development is expected, as shown in Tables 2 and 3, with about 65 acres of rural land expected to be converted to urban use. However, the general area in the vicinity of Upper Nemahbin Lake direct drainage area has been identified as an area for low-density residential growth in SEWRPC Planning Report No. 40, A Regional Land Use Plan for Southeastern Wisconsin—2010, February 1992, and in the recommended land use plan for the IH 94 West Corridor.[2]

Current 1990 land uses in the total tributary drainage area to Upper Nemahbin Lake are shown on Map 6 and summarized in Table 2. Nearly 75 percent of the area remains in rural uses. As shown in Tables 2 and 3, the total tributary drainage area is expected to remain primarily in rural uses with only about 760 acres, or about 3 percent of the total area, being converted to urban uses by the year 2010. Additional urban development in the vicinity of the lake's direct tributary drainage area, especially to the south and west of the lake and on the Pabst Farms, Inc., property within the Town of Summit, is being planned for. That development immediately west of the direct tributary drainage area could potentially affect the boundary of the southwestern part of the Upper Nemahbin Lake direct tributary drainage area in the vicinity of CTH P. In addition, highway reconstruction projects and further subdivision development south of CTH DR could also have an impact on the quantity and quality of stormwater inflows to the Lake.

Recreational Uses: Upper Nemahbin Lake is a multi-purpose waterbody serving all forms of recreation, including boating, water-skiing, swimming, and open water fishing and ice-fishing. The lake is used year-round as a visual amenity—walking, bird-watching and picnicking being popular passive recreational uses of the waterbody. Field surveys of recreational lake use conducted by SEWRPC staff during the summer of 1993 indicated that the public boating access site at the southern end of Upper Nemahbin Lake generally reached capacity by mid-morning, with recreational boaters seeming to make use of both Upper and Lower Nemahbin Lakes in approximately equal proportion. Parking for 21 car-trailer units is provided at the launch site with an additional number

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[2]*SEWRPC Community Assistance Planning Report No. 201, A Land Use and Transportation System Development Plan for the IH 94 West Freeway Corridor: 2010, Waukesha County, Wisconsin; September 1994.*

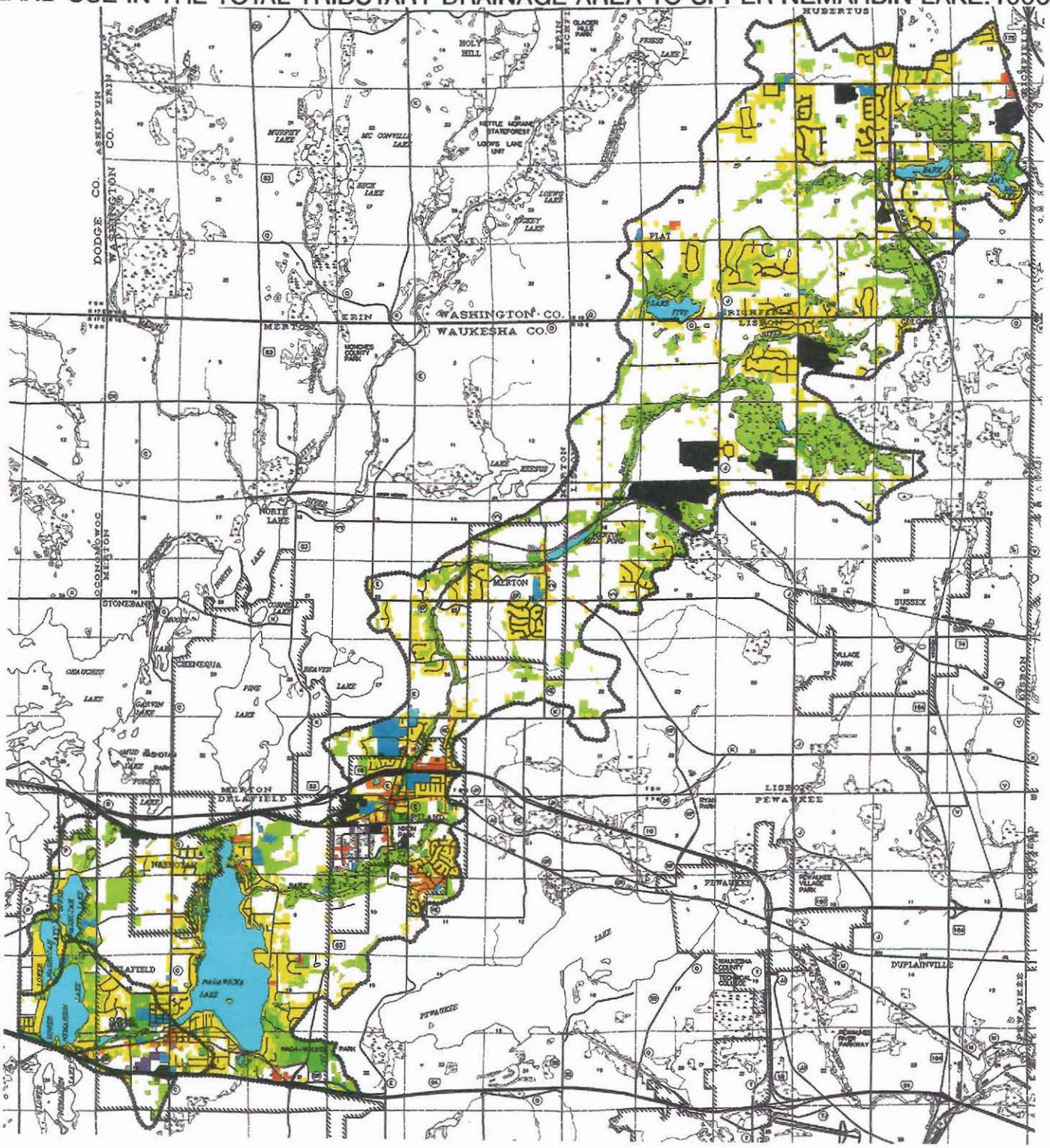
Table 3

PLANNED LAND USE IN THE UPPER NEMAHBIN LAKE WATERSHED: 2010

Land Use Category	Direct Drainage Area: 2010		Total Drainage Area: 2010	
	Acres	Percent	Acres	Percent
Urban				
Residential	284	16.4	4,176	16.3
Commercial	18	1.0	220	0.9
Industrial	<1	0.1	240	0.9
Transportation/Utilities	181	10.4	1,644	6.4
Governmental/Institutional	58	3.3	392	1.5
Recreational	86	5.0	429	1.7
Unused Urban	1	0.1	109	0.4
Subtotal	628	36.3	7,210	28.1
Rural				
Agricultural	490	28.3	10,163	39.1
Woodland	186	10.7	2,214	8.7
Wetland	61	3.5	2,779	10.9
Water	292	16.8	1,701	6.7
Extractive and Landfill	0	0.0	669	2.6
Other Open Lands	77	4.4	849	3.3
Subtotal	1,106	63.7	18,375	71.9
Total	1,734	100.0	25,585	100.0

Source: SEWRPC.

Map 6
LAND USE IN THE TOTAL TRIBUTARY DRAINAGE AREA TO UPPER NEMAHBIN LAKE: 1990



- SINGLE-FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- TRANSPORTATION, COMMUNICATIONS and UTILITIES
- GOVERNMENT and INSTITUTIONAL
- RECREATION
- SURFACE WATER
- WETLANDS and WOODLANDS
- AGRICULTURAL, UNUSED and OTHER OPEN LANDS
- EXTRACTIVE and LANDFILL

DRAWING SCALE IN FEET
0 2000 4000 6000 8000

Source: SEWRPC

provided at a remote overflow parking site that does not have demarcated stalls. A minimum of five boats were present on Upper Nemahbin Lake during these surveys.

Public and Private Access: The shoreland of Upper Nemahbin Lake is developed primarily for residential use, except for portions of the southern shore which are developed for commercial use and for the private housing estates on the northern and eastern shores. Two privately owned boat launch and access sites are situated within the commercial strip along the southern shore of the Lake, while a boat rental operation is located on the lower reaches of the Bark River. Two nonprofit religious organizations maintain year-round group housing on the northern and eastern shores of the Lake which have limited access to the lake. Private access is also provided at an additional site on the western shore of the Lake. In addition, several local retail outlets, as well as the downtown business area of the City of Delafield, exist in close proximity to the Lake. A number of these local retailers specialize in sporting goods, including angling and boating supplies, and cater to the needs of lake users and other recreational visitors.

Public access is provided by a County-owned boat launch and access site located on the channel between Upper and Lower Nemahbin Lakes adjacent to the southern shore of Upper Nemahbin Lake as shown on Map 7. A public beach was formerly located on the southern shore of the Lake, on the north side of CTH DR. This beach was closed in 1962[3] and is presently posted "no swimming". This prohibition recognizes the safety hazard posed by the CTH DR right-of-way which encompasses this shoreline. The Upper Nemahbin Lake Management District, Town of Summit, and Waukesha County are presently exploring ways of improving public safety in this area.

Environmental Corridors: One of the most important tasks undertaken by the Regional Planning Commission in its work program was the identification and delineation of those areas of the Region having 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. Primary

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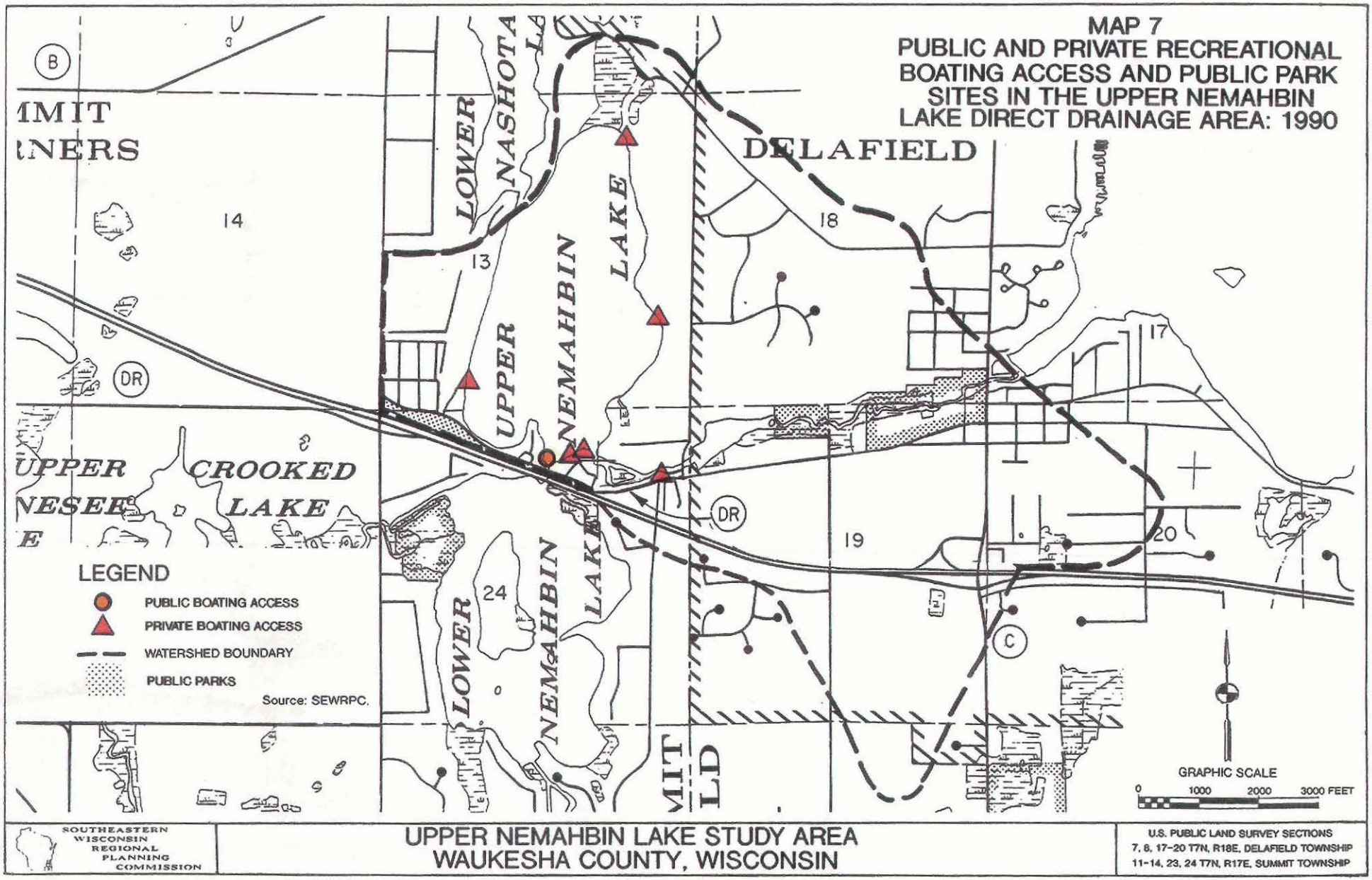
[3]*Summit Historical Group, The Summit of Oconomowoc: 150 Years of Summit Town, Parker Printing, 1987.*


MAP 7
PUBLIC AND PRIVATE RECREATIONAL BOATING ACCESS AND PUBLIC PARK SITES IN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA: 1990
DELAFIELD
LOWER NASHOTA LAKE
UPPER NEMAHBIN LAKE
LOWER NEMAHBIN LAKE
CROOKED LAKE
13
14
17
18
19
20
24
DR
C
LEGEND
PUBLIC BOATING ACCESS
PRIVATE BOATING ACCESS
WATERSHED BOUNDARY
PUBLIC PARKS
Source: SEWRPC.
GRAPHIC SCALE
0 1000 2000 3000 FEET
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
UPPER NEMAHBIN LAKE STUDY AREA
WAUKESHA COUNTY, WISCONSIN
U.S. PUBLIC LAND SURVEY SECTIONS
7, 8, 17-20 T7N, R18E, DELAFIELD TOWNSHIP
11-14, 23, 24 T7N, R17E, SUMMIT TOWNSHIP

environmental corridors in the Upper Nemahbin Lake direct tributary drainage area are shown on Map 8. About 246 acres, or 14 percent of the Lake direct tributary drainage area, are identified as primary environmental corridor lands. These areas consist of Upper Nemahbin Lake itself, the wetland complex located east of the Lake, the Bark River, and some undeveloped floodlands and shorelands.

Local Ordinances: Upper Nemahbin Lake is subject to both the general boating ordinance promulgated by the Town of Summit and a specific ordinance limiting times and days during which boats must operate at "slow-no-wake" speeds (Appendix A). The general ordinance provides rules applicable to all waters within the jurisdiction of the Town and limit the times during which boats may operate on Upper Nemahbin Lake. This ordinance also allowed for the enactment and enforcement of the specific boating restrictions and limitations contained in the Upper Nemahbin Lake ordinance. The ordinances conform to State of Wisconsin boating and water safety laws pursuant to Chapters 23, 30, and 159 of the Wisconsin Statutes.

The Upper Nemahbin Lake watershed lying within Waukesha County is also subject to the County Construction Erosion control ordinance, designed to minimize the water quality impacts of stormwater-related soil and pollutant runoff from construction sites. The Waukesha County ordinance is based on the model ordinance proposed by the Wisconsin League of Municipalities and the Wisconsin Department of Natural Resources.[4] The county ordinance does not apply to single- and two-family building sites. Washington County has a similar ordinance which pre-dates the model ordinance adopted by Waukesha County.

Water Quality

Historic Information: Water quality in Upper Nemahbin Lake is generally good, although localized degradation is apparent in the vicinity of the Bark River inlet and outlet. The lake is classified as

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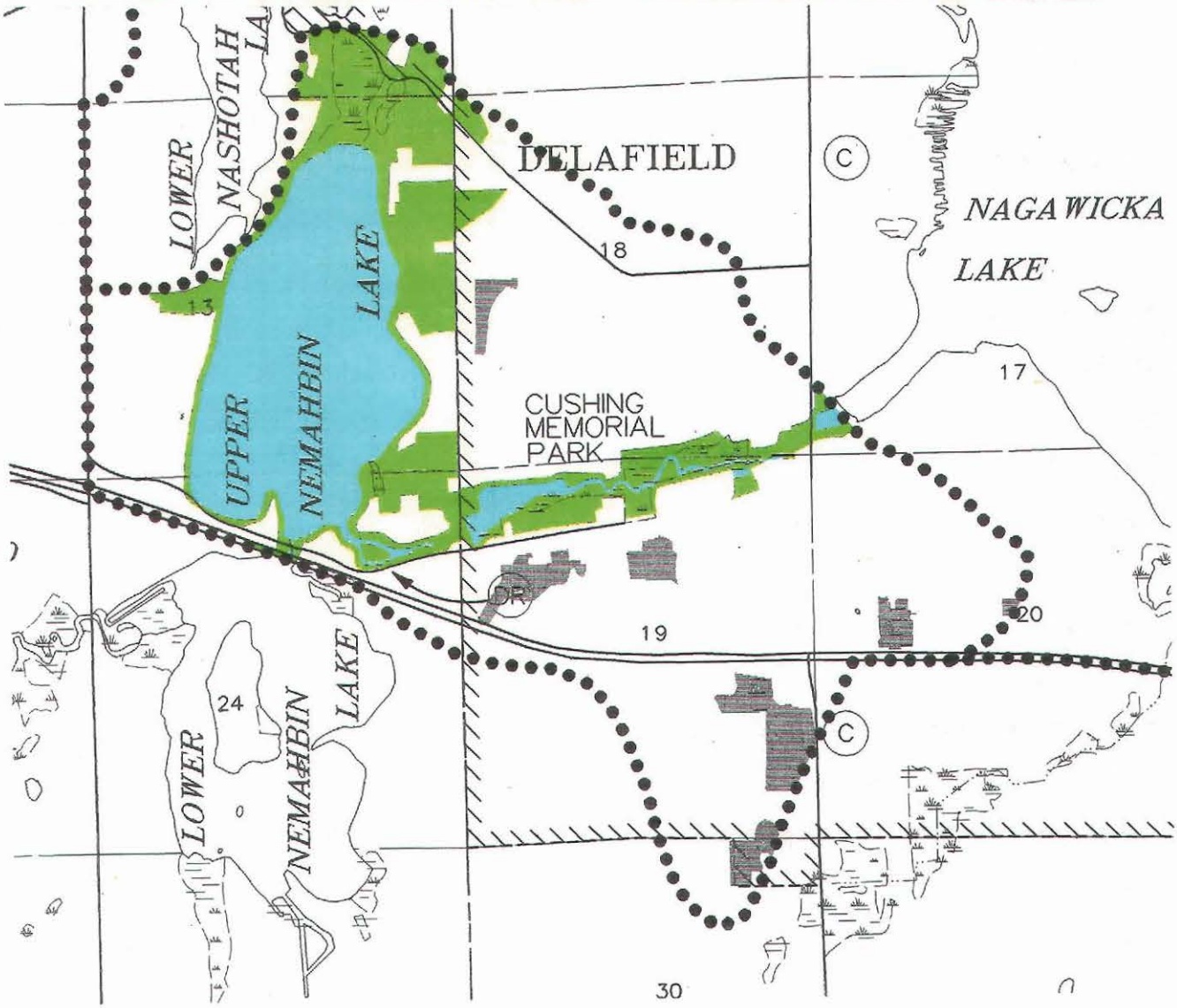
[4]*Wisconsin Department of Natural Resources, Wisconsin Construction Site Best Management Practices Handbook, 1989.*

Map 8

ENVIRONMENTAL CORRIDORS AND ECOLOGICALLY VALUABLE AREAS IN AND AROUND UPPER NEMAHBIN LAKE INCLUDING LANDS THAT MAY BE CONSIDERED FOR PROTECTION FOR CONSERVATION PURPOSES IN THE UPPER NEMAHBIN LAKE WATERSHED



Source: SEWRPC.

mesotrophic based on recent Secchi disc transparency measurements made by the Upper Nemahbin Lake Management District under the DNR Self-help Monitoring Program.

In contrast to the present mesotrophic classification, the lake had previously been assessed as eutrophic following investigations conducted by Aqua-Tech, Inc., during the late summer of 1970.[5] The apparent improvement in the water quality condition of the lake between these two assessments is likely to be due, at least in part, to the abandonment of a private sewage treatment plant which served the St. John's Military Academy and the abandonment of the Village of Hartland sewage treatment plant, both of which were abandoned in 1980 and had previously discharged effluent to the Bark River upstream of Upper Nemahbin Lake. The service areas of these sewage treatment plants are now connected to the Delafield-Hartland Water Pollution Control Commission sewerage system which provides centralized treatment and discharges treated effluent downstream of Crooked Lake.

The Aqua-Tech, Inc., study was conducted during August and September 1970. Water quality samples were obtained from 19 stations located throughout the lake. Samples were analyzed for 14 parameters, which included physical—temperature, chemical—soluble reactive phosphorus, nitrate-nitrogen, chloride, pH, alkalinity, biochemical oxygen demand (BOD_5), and dissolved oxygen; biological—phytoplankton, zooplankton, zoobenthos, and aquatic plants (macrophytes); and bacteriological—total and fecal coliforms—indicators. This study revealed that Upper Nemahbin Lake appeared to be an eutrophic, dimictic waterbody which is stratified during summer and was subject to hypolimnetic deoxygenation, similar to many other lakes in Southeastern Wisconsin. Anoxic conditions developed at about 30 feet during the study period, with hydrogen sulfide being present below this level. Both the BOD_5 and coliform bacterial counts were indicative of a

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[5]*Aqua-Tech, Inc., Report, "Limnological Survey of Upper Nemahbin Lake for the Determination of Water Quality," s.d.*

waterbody with a low level of impairment.[6] Similar results were obtained on the basis of the soluble reactive phosphorus and nitrate analyses.[7] All of these results suggested that the southern portion of the lake, and, particularly, the Bark River inlet, was considerably more polluted than the main body of the lake. The phytoplankton, zoobenthos, and zooplankton species compositions were also consistent with an enriched state.[8] The macrophytes species composition reflected the greater level of enrichment in the Bark River inlet area, with the nuisance species being found only in this area. Chloride, pH, and alkalinity values were similar to those measured elsewhere in the Region, although chloride concentrations were slightly higher than average,[9,10] but within acceptable levels.

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[6]*BOD_5 values ranged from 0 to 1.7 mg/l, with the higher demands occurring in the bottom waters at the two deep water stations. Total coliform counts ranged from 150 MFCC/100 ml in the northern portions of the lake to 13,900 MFCC/100 ml in the south. A fecal coliform count of 50 MFCC/100 ml was measured at the Bark River inlet, but was undetectable elsewhere.*

[7]*Phosphorus concentrations ranged from 0.14 mg/l to 0.40 mg/l in the lake with the higher concentrations measured at the Bark River inlet. SEWRPC recommends a surface water phosphorus concentration of less than 0.02 mg/l in order to avoid excessive algal and plant growth that interferes with the recreational use of the waterbody. Hypolimnetic phosphorus ranged from 0.20 mg/l to 0.53 mg/l. Nitrate concentrations ranged from not detectable to 0.05 mg/l.*

[8]*Bosmina longirostris and Cyclops bicuspidatus were the dominant zooplankters. Blue-green algae—Anabaena flos-aquae, A. spiroides, Lyngbya Birgei, L. perelegans, and Microcystis aeruginosa—were the dominant phytoplankton. Midge larvae—Chaoborus albipes, snails—Helisoma campanulatum, and leeches were common invertebrates in the southern part of the lake; the bivalve, Limnaea stagnalis, and H. campanulatum were abundant elsewhere. Chara vulgaris, Vallisneria americana, Nymphaea microphyllum, and various native Potamogeton and Myriophyllum species were present throughout the lake, with the Ceratophyllum demersum and nonnative Potamogeton and Myriophyllum species occurring in the Bark River inlet.*

[9]*The pH ranged from 7.0 to 8.4 Bronsted units; total alkalinity ranged from 154 mg/l $CaCO_3$ to 214 mg/l $CaCO_3$. No acidification problems are anticipated on the basis of these concentrations. Chloride concentrations ranged from 20 to 21 mg/l Cl.*

[10]*See Wisconsin Department of Natural Resources, Technical Bulletin No. 138, Limnological Characteristics of Wisconsin Lakes, 1983, and University of Wisconsin-Extension Publication, Interpreting Lake Water Quality Data: A Citizen's Guide, November 1989; and SEWRPC Technical Report No. 17, Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975, June 1978, for information on typical values for Southeastern Wisconsin.*

The conditions reported in the Aqua-Tech, Inc., report at the Bark River inlet were also noted during the present investigation—the major growths of nuisance aquatic plant species such as milfoil continue to occur primarily in this area where the lake sediments are considerably more silty and the lake waters more turbid than elsewhere in the waterbody. Those conditions may be related to environmental disturbances and the input of particulate materials from past failures of the Roller Mills Dam situated on the Bark River between Nagawicka and Upper Nemahbin lakes.[11] Up to "about a foot of silt" and other contaminants which have been reported to have been deposited in the Bark River debouchment into Upper Nemahbin Lake.[12] This allegedly inundated a pre-existing gravel bottom and now provide a suitable substrate for invasive macrophytes.

Current Information: During 1993 and 1994 the U. S. Geological Survey conducted a water quality investigation of Upper Nemahbin Lake, in a parallel study to this watershed inventory which is also funded in part through the Chapter NR 119 Lake Management Planning Grant Program. This latter study replicates, in part, the 1970 water quality survey and permits a current assessment of the current lake trophic state. Phosphorus concentrations reported by the USGS for 1993 and 1994 show improvement of water quality compared to the conditions found in the 1970 Aqua-Tech, Inc., study. Current conditions indicate the lake to be well within the mesotrophic quality class and bordering on the meso-oligotrophic quality class. Phosphorus concentrations in the lake surface waters at all stations in the lake were about 0.02 mg/l during 1993 and 1994. The improvement in this water quality indicator compared to findings of earlier studies is, at least in part, expected to be the result of implementation of point source recommendations set forth in the regional water quality management plan, including the installation of sanitary sewer systems and elimination of upstream sewage treatment plants as described earlier. Algal growth, estimated through chlorophyll-a analysis or the measurement of the amount of green pigment present in the water, was low, averaging about 3 µg/l. This concentration—although not decreased significantly from values of 4 µg/l reported in samples from Upper Nemahbin Lake taken by the DNR in 1980—is also consistent

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[11] *Wisconsin Department of Natural Resources, in litt., File Ref: 3564, letters dated July 19, 1989, July 27, 1989, and February 12, 1990.*

[12] *Lake Country Reporter, July 13, 1989, page 26.*

with a mesotrophic or oligo-mesotrophic state and very good water quality. Likewise, water clarity measured as Secchi disc transparency remained about two meters—roughly six feet—which is similar to, but slightly deeper than, the transparency readings obtained during the period from 1970 to 1979. This degree of clarity is also consistent with a mesotrophic quality classification. It should be noted, however, that Upper Nemahbin Lake continues to stratify with respect to dissolved oxygen during the summer months. This situation is not unusual in deeper waterbodies in southeastern Wisconsin.

A mesotrophic state is desirable in most major lakes in Southeastern Wisconsin from the point of view of maintaining good water quality for multiple uses including fishing, swimming and boating.[13]

Watershed Modeling: In order to guide future studies of Upper Nemahbin Lake and its watershed, an initial assessment of the impact of watershed land use on the water quality of Upper Nemahbin Lake was obtained through the use of simple empirical water quality models—specifically through the use of Unit Area Loads and the OECD models as described by Ryding and Rast.[14] This methodology is analogous to the Wisconsin Lake Model Spreadsheet (WILMS) methodology recently adopted by the Wisconsin Department of Natural Resources,[15] and differs only in its use of the OECD relationships—rather than the Canfield-Bachmann and Reckhow models. Selection of this methodology permitted estimation of a greater range of potential pollutants including those that had previously been identified as being of concern to the community.[16] The estimates generated through

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[13]*SEWRPC Planning Report No. 40, op. cit.*

[14]*Ryding, S.-O. and Rast, W., Chapter 7, "Estimating the Nutrient Load to a Waterbody", in UNESCO Man and the Biosphere Series Volume 1, The Control of Eutrophication of Lakes and Reservoirs, Parthenon Press, London, 1989. Also Organization for Economic Cooperation and Development, Eutrophication of Waters: Monitoring, Assessment and Control, OECD, Paris, 1982.*

[15]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-94, Wisconsin Lake Model Spreadsheet User's Manual, June 1994.*

[16]*Upper Nemahbin Lake Management District Report, Results of the Upper Nemahbin Lake Management District Survey, March 1992; Upper Nemahbin Lake Management District Report, Results of the Upper Nemahbin Lake Management District Survey, July 1992.*

the use of these relationships should be considered preliminary and further refined as data become available from a longer period of record through the USGS field studies.

The water quality of a lake is estimated by considering the summation of the contaminant inputs generated from all of the various land uses within the watershed. These inputs have been quantified in the form of Unit Area Loads which reflect the average amount of contaminant generated per unit area of watershed surface under a particular land use. Values for the Southeastern Wisconsin Region have been tabulated by SEWRPC and are set forth in SEWRPC Planning Report No. 30.[17] Estimates of river flow, the transport mechanism that moves the contaminants into the lakes, were also made. These two variables were used to derive a range of estimated values for the contaminant loading rates used in the OECD water quality models.

Because of the presence of several lakes in the Upper Nemahbin Lake total tributary drainage area, contaminant loads were modified for retention in these waterbodies—in effect, the inverse of the stream transmission coefficients described by Ryding and Rast—using the phosphorus retention model developed by Larsen and Mercier.[18] The results of this modeling under both existing and planned land uses are set forth in Tables 4 and 5, and shown schematically in Map 9. The methodology used and the conclusions of this modeling effort are discussed below.

River Flow Estimates: The estimated river flow, set forth in Table 4, of approximately 15,400 acre-feet per year—or an average annual discharge of about 21 cubic feet per second (cfs)—has been selected using typical rainfall-runoff relationships. This value was checked by comparison to flows calculated by adjusting the discharges measured at the U. S. Geological Survey gaging station No. 05426250 located on the Bark River at Rome, Wisconsin, in Jefferson County to account for the

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[17]*SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, Volume One, Inventory Findings, September 1978.*

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

Table 4

SUMMARIZED MODEL[a] INPUT VARIABLES USED IN THE UPPER NEMAHBIN LAKE STUDY

Parameter	Units	Magnitude	Comment
River Flow (Q)	Acre-feet per year	Q = 15,400[b]	Estimated from the annual average precipitation of 29.60 inches multiplied by the drainage area (AD) using a rainfall-runoff coefficient of 25 percent
Water Residence Time (Tw)	Year	Tw = 0.55	Calculated as lake volume (V) divided by river flow (Q)
Water Loading Rate (qs)	Feet per year	qs = 53.8	Calculated as mean depth in feet divided by the water residence time
Pollutant Loads (J)[c]	Pounds per year (1990 land use)	J_{sed} = 4,200,000[d] J_p = 4,498 J_{pb} = 400 J_{cu} = 52 J_{zn} = 520 J_{cd} = 1	Estimated as the product of watershed area, by land use category and the unit area load (UAL) pollutant export coefficients for sediment (J_{sed}), phosphorus (J_p), lead (J_{pb}), copper (J_{cu}), zinc (J_{zn}), and cadmium (J_{cd})
	Pounds per year (2010 land use)	J_{sed} = 1,860,000 J_p = 2,900 J_{pb} = 530[e] J_{cu} = 68 J_{zn} = 658 J_{cd} = 1.3	
Lake Pollutant Loading Rate (L)	Pounds per acre per year (1990 land use)	L_{sed} = 14,800 L_p = 16 L_{pb} = 1.4 L_{cu} = 0.2 L_{zn} = 1.8 L_{cd} = <0.01	Calculated as the pollutant load (J) divided by the lake surface area (A)
	Pounds per acre per year (2010 land use)	L_{sed} = 6,570 L_p = 10 L_{pb} = 1.9[e] L_{cu} = 0.2 L_{zn} = 2.3 L_{cd} = <0.01	

[a]The OECD nutrient loading model was used to estimate in-lake concentrations; the generalized form of this model is:

$$[C] = L / qs\ (1 + \{Tw\}^{0.5})$$

where [C] is the concentration in milligrams per liter, L is the pollutant loading rate in grams per square meter of lake surface per year, qs is the water loading rate in meters per year, and Tw is the water residence time in years; qs (1 + {Tw}$^{0.5}$) is a surrogate value for in-lake sedimentation. NOTE: Conversions of the data presented in this Table to the metric equivalents, used in the calculations, were made using factors published by the American Society of Civil Engineers.

[b]Based upon an estimated average annual Bark River discharge of 21 cfs. A second analysis was also conducted to consider the impacts of extended low flow period using an estimated flow rate of 9.0 cfs.

[c]The mass of pollutant transferred from the watershed to Upper Nemahbin Lakes has been adjusted for pollutant retention in the intervening lake basins, as shown on Map 7, using the Larsen & Mercier relationship:

$$R[C] = (Tw)^{0.5} / (1 + \{Tw\}^{0.5})$$

where R[C] is the retention coefficient--(1 - R[C]) = transmission coefficient--and Tw is the water residence time in years.

[d]Does not include 249 pounds of phosphorus estimated to be contributed from onsite sewage disposal systems in the direct drainage area. This loading is expected to be eliminated with the provision of a public sanitary sewer system to serve the area during the planning period.

[e]While the lead levels are calculated to increase due to changes in land use, the actual levels are expected to decrease after 1990 due to elimination of lead in motor fuels and other products.

Source: SEWRPC.

Table 5

FORECAST POLLUTANT LOADS TO UPPER NEMAHBIN LAKE BY LAND USE CATEGORY

Land Use	Pollutant Loads: 1990						Pollutant Loads: 2010					
	Sediment (tons)	Percent	Phosphorus (pounds)	Percent	Zinc (pounds)	Percent	Sediment (tons)	Percent	Phosphorus (pounds)	Percent	Zinc (pounds)	Percent
Bark River Nagawicka Lake	1,871	89	3,614	80	305	58	727	78	2,105	72	423	64
Tributary/ Nashotah Lakes	34	1	95	2	10	2	26	3	82	3	11	2
Urban												
Residential	2	<1	13	<1	4	1	2	<1	14	<1	5	1
Commercial/ Industrial	6	<1	18	<1	18	3	9	<1	28	1	28	4
Utilities/ Transportation Government[a]	25	1	132	3	185	35	26	3	136	5	191	29
Recreational	<1	<1	2	<1	<1	<1	<1	<1	3	<1	<1	<1
Unused Urban/ Construction	25	1	33	1	<1	<1	5	1	6	<1	<1	<1
Subtotal	58	3	198	4	207	39	42	4	187	6	224	34
Rural												
Agricultural	122	6	468	10	<1	<1	110	12	421	14	<1	<1
Woodland	<1	<1	6	<1	<1	<1	<1	<1	6	<1	<1	<1
Wetland	<1	<1	2	<1	<1	<1	<1	<1	2	<1	<1	<1
Water	27	1	38	1	<1	<1	27	3	38	1	<1	<1
Other Open Lands	<1	<1	77	1	<1	<1	<1	<1	66	2	<1	<1
Subtotal	149	7	591	12	<1	<1	137	15	533	17	<1	<1
Total Load	2,112	100	4,498	100	522	100	932	100	2,907	100	658	100
Estimated Outflow	1,086	--	2,232	--	267	--	468	--	1,423	--	226	--

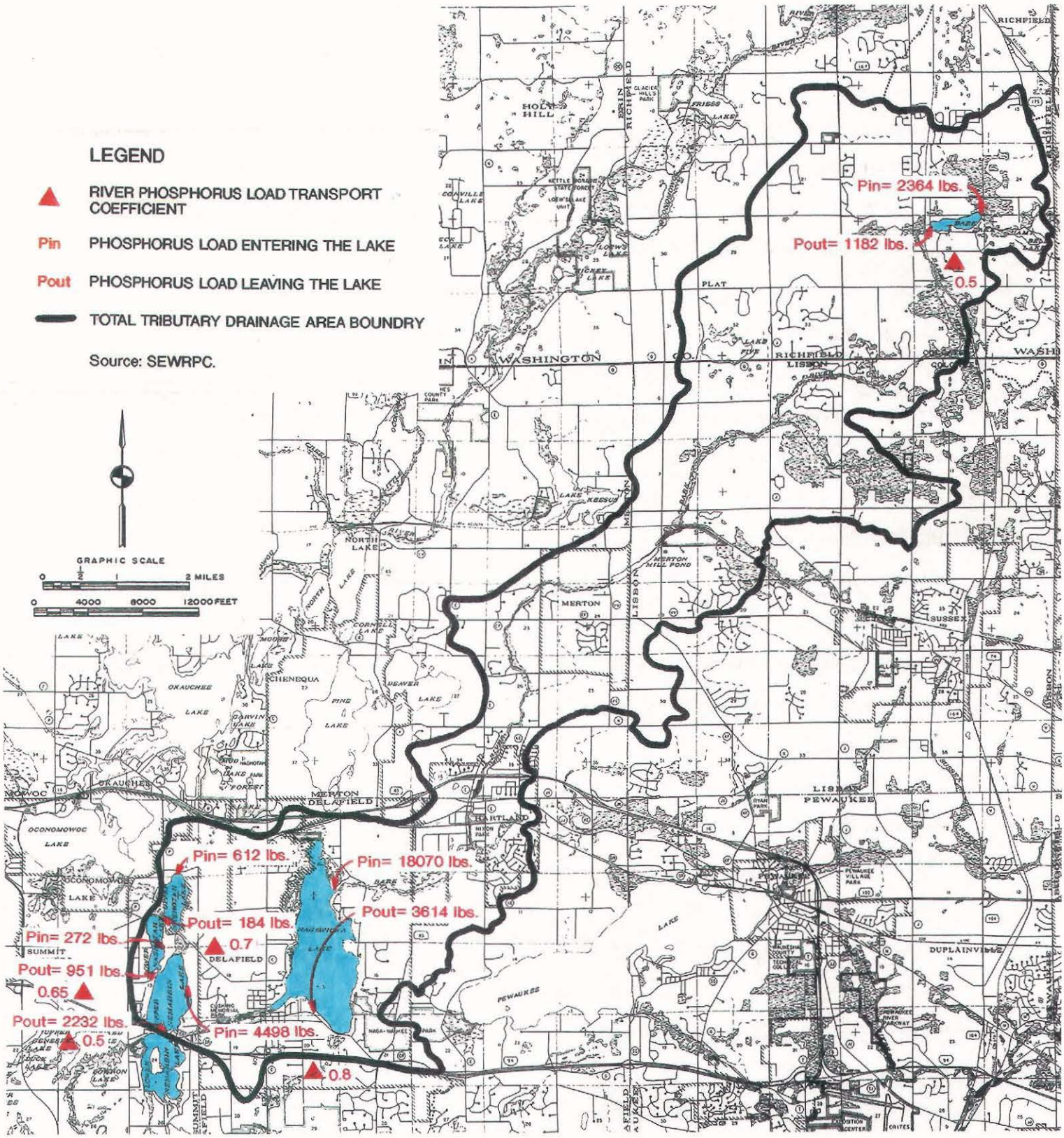
[a]*The loads calculated herein include a phosphorus loading of approximately 249 pounds expected onsite sewage disposal systems. This loading is based on estimates set forth in the regional water quality management plan, and is expected to be eliminated by the year 2010 as a result of the implementation of the recommended public sanitary sewer system in the direct drainage area of Upper Nemahbin Lake.*

[b]*Utilities/Transportation/Government includes transportation corridors, institutional uses, government facilities, and utility services.*

Source: SEWRPC.

Map 9

SCHEMATIC REPRESENTATION OF THE UPPER NEMAHBIN LAKE TOTAL ILLUSTRATING THE MOVEMENT OF TRIBUTARY DRAINAGE AREA POLLUTANTS: 1990



additional watershed area downstream of Upper Nemahbin Lake. Using this approach values of between 16.6 and 23.6 cfs were calculated for within years 1989 and 1990. In addition to the analyses conducted using the estimated average flow rate in the Bark River, a second model run was made using a flow rate of 9.0 cfs to consider the impacts of extended low flow periods.

Pollutant Loads and Pollutant Loading Rates: The pollutant loads to Upper Nemahbin Lake during 1990—the date of the land use inventory data used in the models—were estimated to be approximately 2,100 tons of sediment and 2.2 tons of phosphorus, as well as approximately 400 pounds of lead, 52 pounds of copper, 520 pounds of zinc, and one pound of cadmium, as set forth in Tables 4 and 5. Lead, copper, zinc, and cadmium are used in these analyses as surrogate values for metals and other pollutants that are contributed primarily from urban sources. The more important sources of metals in urban runoff are from the transportation and commercial land uses. This may be significant given the proximity of Upper Nemahbin Lake to the IH 94 corridor and other major roadways. The metal loadings are estimated to increase to 68 pounds of copper, 658 pounds of zinc, and 1.3 pounds of cadmium—in 2010. While lead levels are theoretically calculated to increase due to urbanization, the actual levels are expected to decline from 1990 on due to the elimination of lead from motor fuels and reductions in other products. The loads of the other pollutants—sediment and phosphorus—are forecast to decline during this period, primarily as the result of reduced construction activity and conversion of agricultural lands to low-density residential uses, and the expected installation of public sewer service in the Upper Nemahbin direct tributary drainage area.

Although the mass of pollutants is one of the critical determinants of pollutant concentrations and biotic responses in lakes—flow regime being the other primary determinant, the estimated pollutant loads and loading rates set forth in Table 4 reflect the external loadings of the contaminants only. As noted above, these estimates have accounted for the retention, or transmission losses, of the contaminants within the various waterbodies located on the Upper Bark River. These retention coefficients ranged from 50 to 80 percent of the influent load. The phosphorus loads estimated

using the above methodology were similar to the earlier estimates of year 2000 phosphorus loads to the Bark River lakes set forth in the regional water quality management plan.[19]

Forecast Pollutant Concentrations: The resultant concentrations of pollutants determined for the present and future land use scenarios using the OECD model are set forth in Table 6. Despite few comparative data being available, those that are suggest that the models generally forecast concentrations of the same order of magnitude as the observed values. No comparative data were available for metals.

Based on the fact that the 1990 estimates are reasonable representations of the observed pollutant concentrations in Upper Nemahbin Lake the 2010 forecasts would suggest that, at least insofar as these variables are concerned, the water quality of the lake should stabilize and remain of relative good quality.

Forecast In-Lake Responses: The net result of nutrient loadings to Upper Nemahbin Lake is the response of the lake biota, usually assessed in terms of algal growth determined as chlorophyll-a. In turn, the algal cells reduce the transparency of the water and reduce the observed Secchi disc transparency measurements—reductions in Secchi disc transparency can also be related to inorganic turbidity (silt) and/or water color (humic coloration). Using the former relationship—nutrient concentrations leading to a chlorophyll-a response--the in-lake chlorophyll-a concentrations and Secchi disc transparencies were predicted using the OECD models. The results are set forth in Table 6. As above, the predicted responses are on the same order of magnitude as the observed values. It would appear from these data that the water quality of Upper Nemahbin Lake should stabilize within present limits for the foreseeable future.

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

Table 6

SELECTED RESULTS FROM THE WATER QUALITY MODELS USED IN THE UPPER NEMAHBIN LAKE STUDY: 1990 AND 2010

Pollutant	Predicted Concentration[a]		Observed Concentration	
	1990	2010	Mean (range)	(Year)
Sediment (mg/l)	59-120	25-51	--	
Phosphorus (mg/l)	0.04-0.08	0.03-0.05	0.02 (0.01-0.07)	(1993-1994)
Lead (µg/l)	5-11	7-14	--	
Copper (µg/l)	0.7-1.5	1-2	--	
Zinc (µg/l)	7-14	9-18	--	
Cadmium (µg/l)	0.1-0.2	0.2-0.4	--	
Secchi Disc Transparency[b]	7.2-9.5	8.5-11.5	8.8 (5.9-16.4)	(1993-94)
Chlorophyll-a[b]	9-16	6-11	3 (1-5)	(1993-94)

[a]The predicted values show the range in mean values between the average flow of 21 cfs and a low flow of 9 cfs.

[b]Secchi Disc Transparencies (SDT) and Chlorophyll-a concentrations (CHL) have been predicted from the flushing-corrected in-lake total phosphorus concentrations using the 1982 OECD relationships:

$$SDT = 14.7\,[C]^{0.39} \qquad [CHL] = 0.37\,[C]^{0.79}$$

where [C] = the mean annual inflow total phosphorus concentration from Table 4, footnote a.

Source: SEWRPC.

Controllable Pollutant Loads

Table 5 shows the relative percentage contributions of the various contaminant source to the pollutant loads to Upper Nemahbin Lake, including the loads transmitted from the upstream lakes on both the Bark River and the unnamed tributary flowing through the Nashotah Lakes. The data in Table 5 indicate that the majority of the contaminants enter Upper Nemahbin Lake from the Bark River. Under 1990 conditions, including consideration of contributions from onsite sewage disposal systems, about 76 percent of the phosphorus loading to Upper Nemahbin Lake are carried into the lake by the Bark River. Under planned 2010 conditions, assuming the installation of a public sanitary sewer system to serve the urban development around the lake, the phosphorus loading from the Bark River is estimated to be about 72 percent of the total loading. This load can be considered to be noncontrollable from the point of view of actions taken within the Upper Nemahbin Lake direct drainage area. Similarly, the contaminant load entering the lake from the Nashotah Lakes can be considered to be noncontrollable from that point of view. The controllable contaminant loads are those that are most closely situated to Upper Nemahbin Lake and which occur within the direct drainage area of that lake.

Of the controllable pollutant sources, the most significant sources under existing land use conditions vary with the particular pollutants of concern. With regard to urban metals, the major controllable sources are transportation, utilities, and institutional land uses which contribute about 35 percent of the load, and commercial and industrial activities contributing about 4 percent of the load. With regard to the phosphorus load, onsite sewage disposal systems are estimated to be the largest current source. Under future conditions, assuming the installation of a public sanitary sewer system to serve the urban development around the lake, the largest controllable source of phosphorus and other nutrients is expected to be agricultural land use activities; agricultural activities will contribute about 14 percent of the load. With regard to sediments, construction and agriculture within the direct drainage area currently contributes about 5 percent of the load, with construction and transportation each contributing between 1 to 2 percent.. It is anticipated that, by the year 2010, agriculture will contribute about 12 percent of the load.

Trophic State Assessment

The forecast phosphorus and chlorophyll-a concentrations and Secchi disc transparencies were used to evaluate the trophic state of Upper Nemahbin Lake using the OECD trophic state models.[20] Based on these three indicators, Upper Nemahbin Lake has the greatest probability of being mesotrophic or meso-eutrophic. This is consistent with a water quality rating of fair to good based on relationships developed by Lillie and Mason for natural lakes in the State of Wisconsin,[21] and supported by the Wisconsin Trophic State Index value of about 51, indicative of a mesotrophic state.[22] However, the forecast annual average phosphorus concentration exceeds the guideline of 0.02 mg/l recommended by SEWRPC for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and full recreational use. Few water quality problems are foreseen for Upper Nemahbin Lake and the lake will probably remain a productive resource provided continued actions are taken to minimize pollutant loadings.

Aquatic Plants, Fisheries, Wildlife, and Waterfowl

The quality and chemical composition of the influent water entering a waterbody, in combination with the morphology of the lake basin, determines the nature and extent of the biological response observed. In parts of Upper Nemahbin Lake, abundant growths of emergent, floating leaved, and submerged aquatic plants occur, especially in and around the Bark River estuary and at the northeastern extreme of the lake. An aquatic plant survey has not been completed on this lake. However, a distribution survey was undertaken during the course of the inspection of shoreline protection structures conducted by SEWRPC staff in August 1993.

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[20]*Ryding and Rast, op. cit.; OECD, op. cit.*

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

[22]*The Wisconsin Trophic State Index was developed by the Wisconsin Department of Natural Resources as a refinement of the more common Carlson Trophic State Index; the formulation of the index is described by R. A. Lillie, S. Graham and P. Rasmussen in Research Management Findings No. 35, Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes, May 1993. See also SEWRPC Memorandum Report No. 93, A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, March 1995.*

The principle species observed at that time are set forth in Table 7. Vallisneria americana, the wild celery, was widespread in both of these areas and could be considered the dominant species in the lake. Other species observed included three species of exotic flora—Myriophyllum spicatum, Potamogeton crispus, and Lythrum sp.—which are regarded as interfering with the recreational use of waterbodies. The purple loosestrife, Lythrum sp., is a declared nuisance plant in Wisconsin—s. 66.955(2)(5), Wis. Stats.—and should be controlled by hand pulling or chemical control no later than early August, prior to the onset of seeding.[23] All of these plants occurred predominantly in the Bark River estuary as shown on Map 10. Both the plant community and its distribution within the lake are consistent with the information presented by Aqua-Tech, Inc., following their survey of 1970,[24] with the exception that the purple loosestrife appears to be a more recent invader.

Upper Nemahbin Lake is well-known for its sport and panfish fishing. The DNR Publication No. FM-800-91, Wisconsin Lakes, 1991, indicates that northern pike and large-mouth bass are common and that walleye and small-mouth bass are also present. Panfish are rated as being common. Numerous areas along the less steeply-sloping northern and western shores of the lake present suitable habitats for the spawning of bass and northern pike. Spawning takes place in spring, between the time of the spring thaw and mid-June.

Given the urban nature of much of the lake's shorelands, only small animals, such as muskrat, squirrel, raccoon and cotton-tailed rabbit, and limited numbers of waterfowl generally inhabit these areas. A somewhat more diverse animal community, including deer, and a greater number of waterfowl make use of the wetland areas adjacent to the less developed northern and northeastern shores of the Lake. During spring, migratory waterfowl make use of Upper Nemahbin Lake, including Canada Geese, Loons, Mallards, Mergansers, Ruddy Ducks, Buffelhead, and, occasionally, Wood Ducks. Class I wildlife habitat covers approximately 4 percent of the direct tributary

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[23]*Wisconsin Department of Natural Resources Publication No. PUBL-PM-005-90, Purple Loosestrife (Lythrum salicaria, L. virgatum, and their hybrids): An Attractive but Deadly Threat to Wisconsin's Wetlands and Waterways, 1990.*

[24]*Aqua-Tech, Inc., op. cit.*

Table 7

AQUATIC PLANT SPECIES PRESENT IN UPPER NEMAHBIN LAKE

Aquatic Plants
Emergent Vegetation
Lythrum salicaria (purple loosestrife)
Scirpus americanus (chairmaker's rush)
S. acutus (hard-stemmed bulrush)
Typha angustifolia (narrow-leaved cat-tail)
T. latifolia (broad-leaved cat-tail)
Submergent Vegetation
Chara vulgaris (muskgrass)[a]
Ceratophyllum demersum (coontail)[b]
Elodea canadensis (waterweed)
Myriophyllum exalbescens (water milfoil)[a]
M. spicatum (Eurasian water milfoil)[a]
Najas flexilis (bushy pondweed)[b]
Potamogeton sp. (pondweed)
P. amplifolius (large leaf pondweed)[a]
P. crispus (curly leaf pondweed)[a]
P. natans (floating leaf pondweed)
P. pectinatus (Sago pondweed)[a]
P. zosteriformis (flatstem pondweed)
Vallisneria americana (wild celery)[a]
Floating-Leaved Vegetation
Nuphar variegatum (yellow water lily)
Nymphaea tuberosa (white water lily)
N. microphyllum (yellow spatterdock water lily)[b]

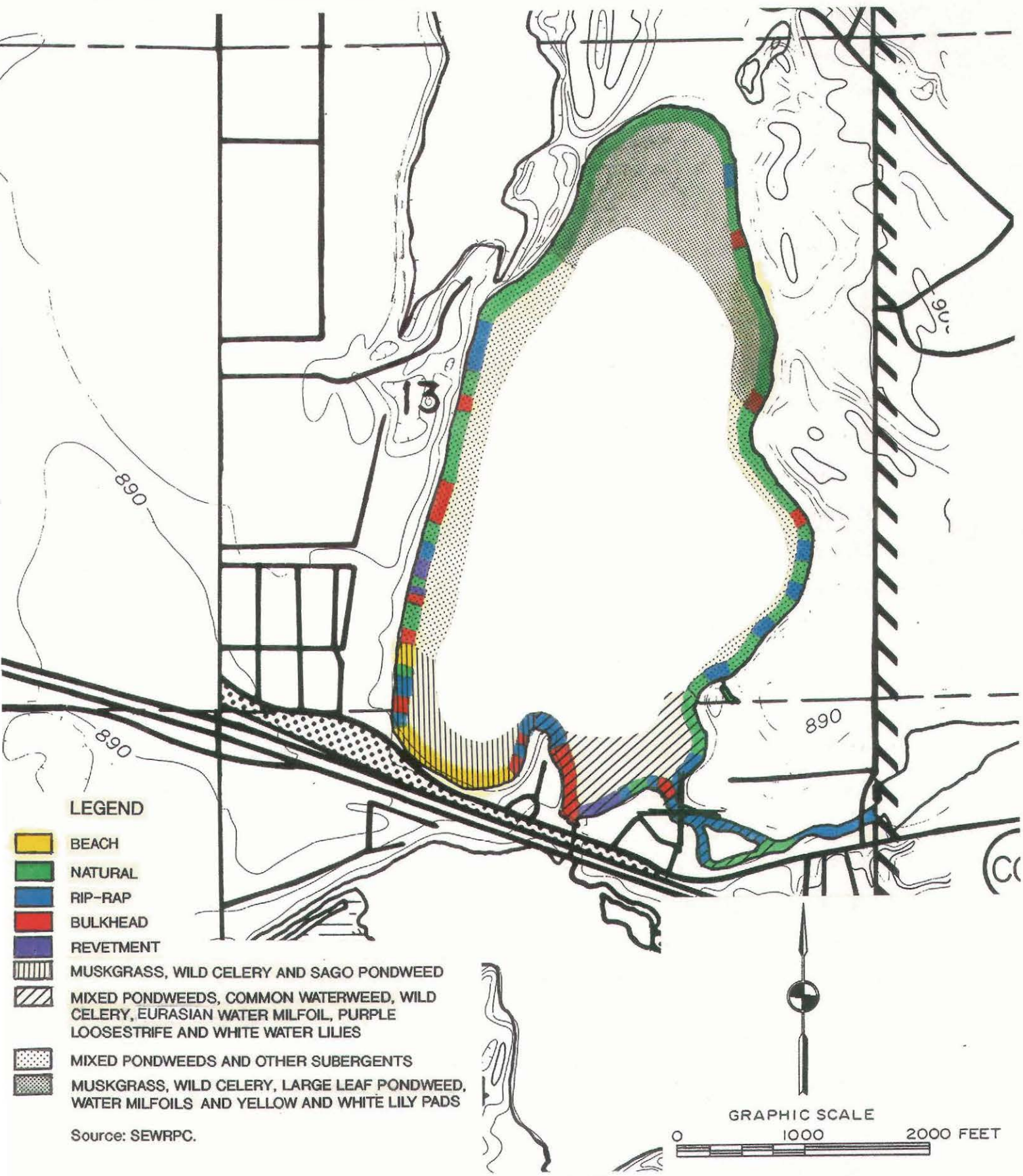
[a]*Species reported by Aqua-Tech, Inc., during their 1970 survey that were observed during the present study.*

[b]*Species reported by Aqua-Tech, Inc., as being present during their 1970 survey but not observed during this study.*

Source: SEWRPC.

Map 10

SHORELINE CONDITIONS AND GENERALIZED AQUATIC PLANT COMMUNITY DISTRIBUTION IN UPPER NEMAHBIN LAKE: 1993



drainage area; a licensed Wisconsin game farm is situated near the northeastern shores of the lake as shown on Map 11. There is a further 13 percent of the direct drainage area that has been classed as medium value wildlife habitat—Class II habitat—and 5 percent categorized as Class III good value habitat. Much of the remaining natural wildlife habitat is contained within the boundaries of the designated environmental corridors in the study area, which, together with isolated natural features, cover about 15 percent of the watershed, as shown on Map 8.

PROBLEMS AND CONCERNS

Although Upper Nemahbin Lake is in good condition and is capable of supporting a wide variety of water uses, there are a number of existing and potential future problems that warrant concern. These problems or issues of concern include the protection of ecologically valuable areas, construction site erosion control and stormwater management to reduce nonpoint source pollutant loadings, boating demands and public access, wastewater pollution control, and continued protection of the shoreline.[25] Inspection of the shorelands and the banks of the influent streams by SEWRPC staff during August 1993 did not reveal any areas of active erosion, although sites experiencing soil erosion within the watershed were observed—particularly to the south of the Lake in areas where there was on-going and recent construction activity.

Ecologically Valuable Areas

The ecologically valuable areas—woodlands and wetlands—of Upper Nemahbin Lake and its watershed are shown on Map 12. These areas are largely included in the primary environmental corridors within the Lake's drainage area as shown on Map 8. The environmental corridors in the Upper Nemahbin Lake drainage area contain almost all of the best remaining woodlands, wetlands, and wildlife habitat. In addition to providing habitat, these areas also provide the scenic vistas which characterize the ambience of the Upper Nemahbin Lake watershed and serve beneficial environmental purposes as buffers between the rapidly urbanizing lands east, south and west of the

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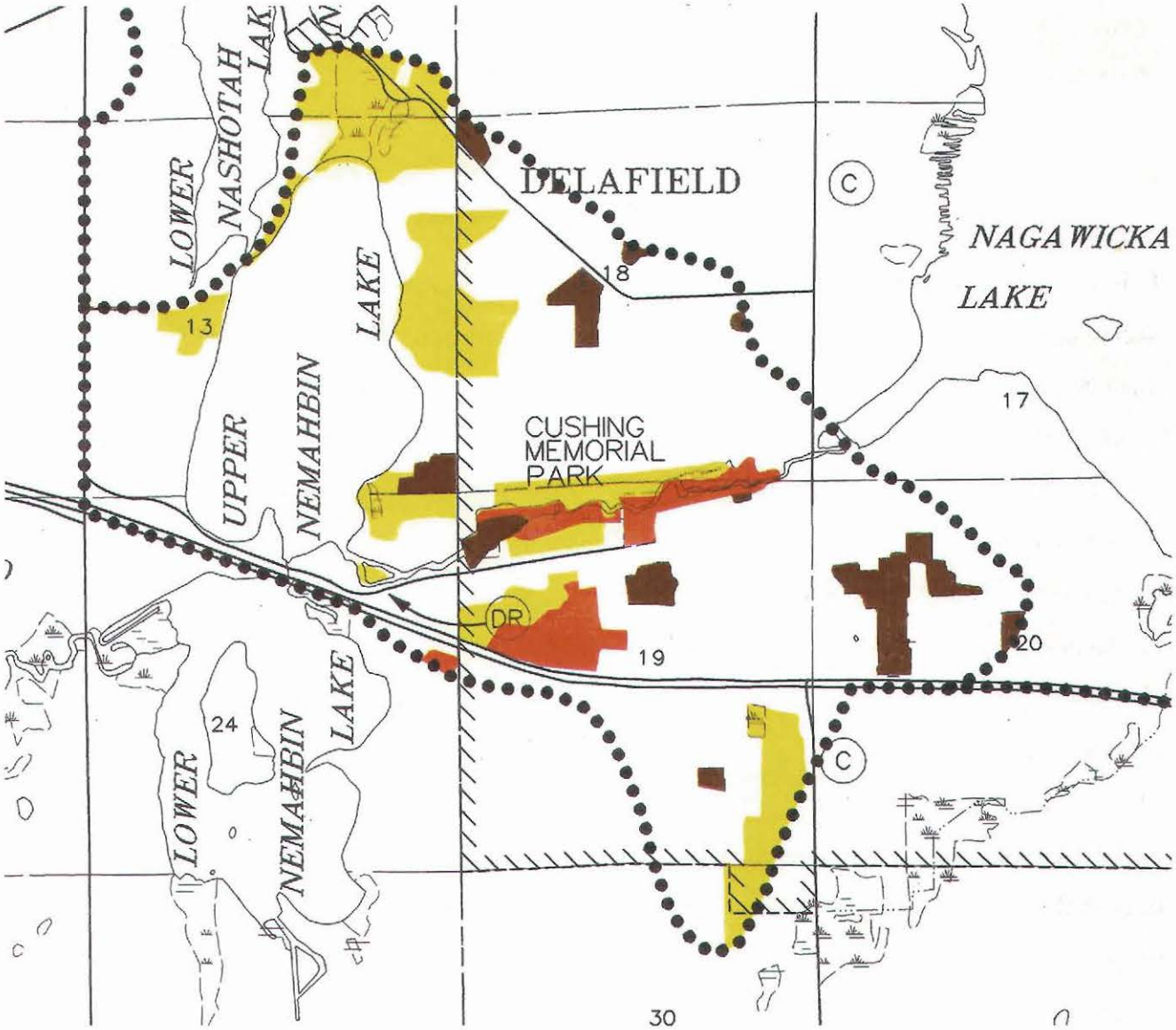
[25]*Upper Nemahbin Lake Management District Report, March 1992, op. cit.; Upper Nemahbin Lake Management District Report, July 1992, op. cit.*

Map 11

WILDLIFE HABITAT AREAS WITHIN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA



CLASS I, high value habitat

CLASS II, medium value habitat

CLASS III, good value habitat

GRAPHIC SCALE IN FEET

0 2000 4000

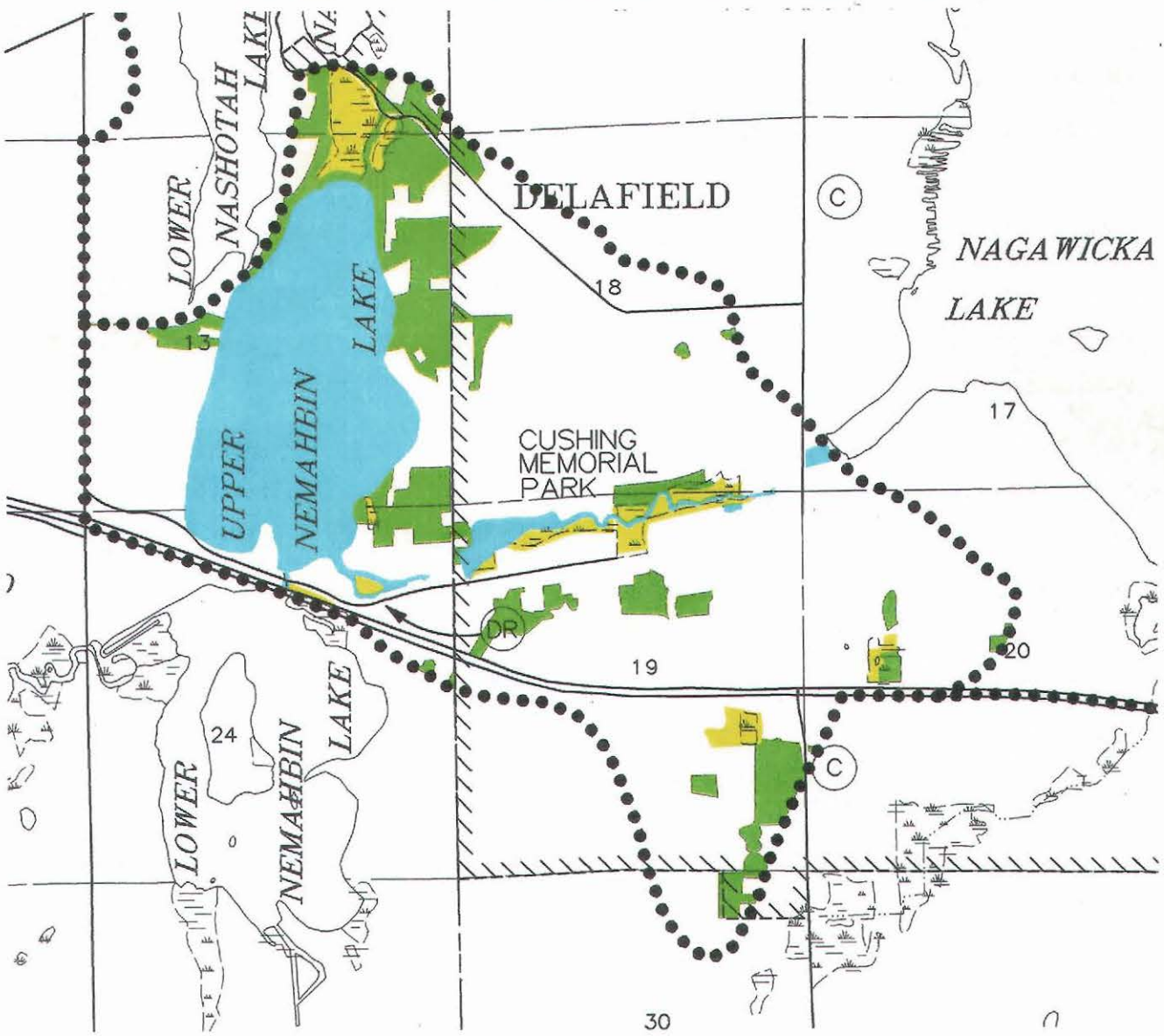
Source: SEWRPC.

watershed and the Lake. For these reasons, the protection of these resources from additional intrusion by incompatible land uses which degrade and destroy the environmental values of these sites, and the preservation of the corridors in an essentially open and natural state, is an important component to the maintenance of a high level of environmental quality, the protection of remaining natural beauty, and the provision of recreational and quality residential opportunities in the watershed.

It is recommended that all primary environmental corridor lands in the Upper Nemahbin Lake watershed be preserved in essentially-natural open-space uses, primarily through land use controls. Such preservation should be promoted through the placement of such resources in appropriate conservancy zoning districts, and through the enforcement of existing regulations intended to protect such natural resources, as noted above. Future management actions may also be necessary to ensure the habitat quality of the lands included in these corridors. Such actions could include measures such as the control of purple loosestrife or other invasive plants which might degrade the habitat quality of the wetlands and shorelands. For this reason and in order to prevent potential unplanned development of certain corridor lands, it is recommended that local units of government agencies consider the acquisition of primary environmental corridor lands as such lands become available. The purchase of specific critical properties as a means of protecting them from encroachment or further degradation, or as a means of facilitating their rehabilitation and restoration, is possible through the Chapter NR 50/51 Stewardship Grant Program or the Chapter NR 191 Lake Protection Grant Program. Lands that might be considered as being ecologically valuable and having potential water quality benefit for Upper Nemahbin Lake have been included within the environmental corridors and are highlighted on Map 8. Outright purchase, or the purchase of conservation easements, are both possible options. Both grant programs provide cost-share funds for purchase of lands up to a maximum state share of $100,000. In addition, it is recommended that the Nemahbin Lake District and the other local units of government involved promote the development of land use zoning which is consistent with the recommendations being developed in the ongoing Waukesha County Development Plan.

Map 12

EXISTING WOODLANDS AND WETLANDS IN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA



Source: SEWRPC.

Construction Site Erosion Control

Erosion from construction site in the direct and total tributary drainage areas of Upper Nemahbin Lake is a potential threat to the Lake's water quality. The Lake's drainage area and total drainage area are potentially subject to urban development pressures. There is historic urban growth activity in the Lake direct tributary drainage area, as illustrated on Map 13.

As previously indicated, the Town of Summit does not presently have an erosion control ordinance, while Waukesha County and the City of Delafield do have such ordinances in place.[26] In addition, the Wisconsin Department of Natural Resources currently requires permits under the Wisconsin Pollutant Discharge Elimination System (WPDES) for the discharge of runoff from construction sites of five acres in area or larger and selected industrial sites. These regulations provide for the issuance of permits based on the establishment and maintenance of a construction erosion control and stormwater management plan by the permit applicants and the regular inspection of the facilities outlined in the plan.

As a consequence of these planning and permitting requirements, construction erosion controls will now be required for most of the development occurring in the total tributary area to Upper Nemahbin Lake. Guidance on the nature and cost of these construction erosion control practices is available from the DNR, the Waukesha County Land Conservation Department, and SEWRPC.[27]

Stormwater Management

The urban nature of the Upper Nemahbin Lake direct drainage area, including the extensive roadway system and related land uses on the southern end of the lake, indicate that urban stormwater nonpoint sources of pollution are a potential concern. Applicable stormwater management practices

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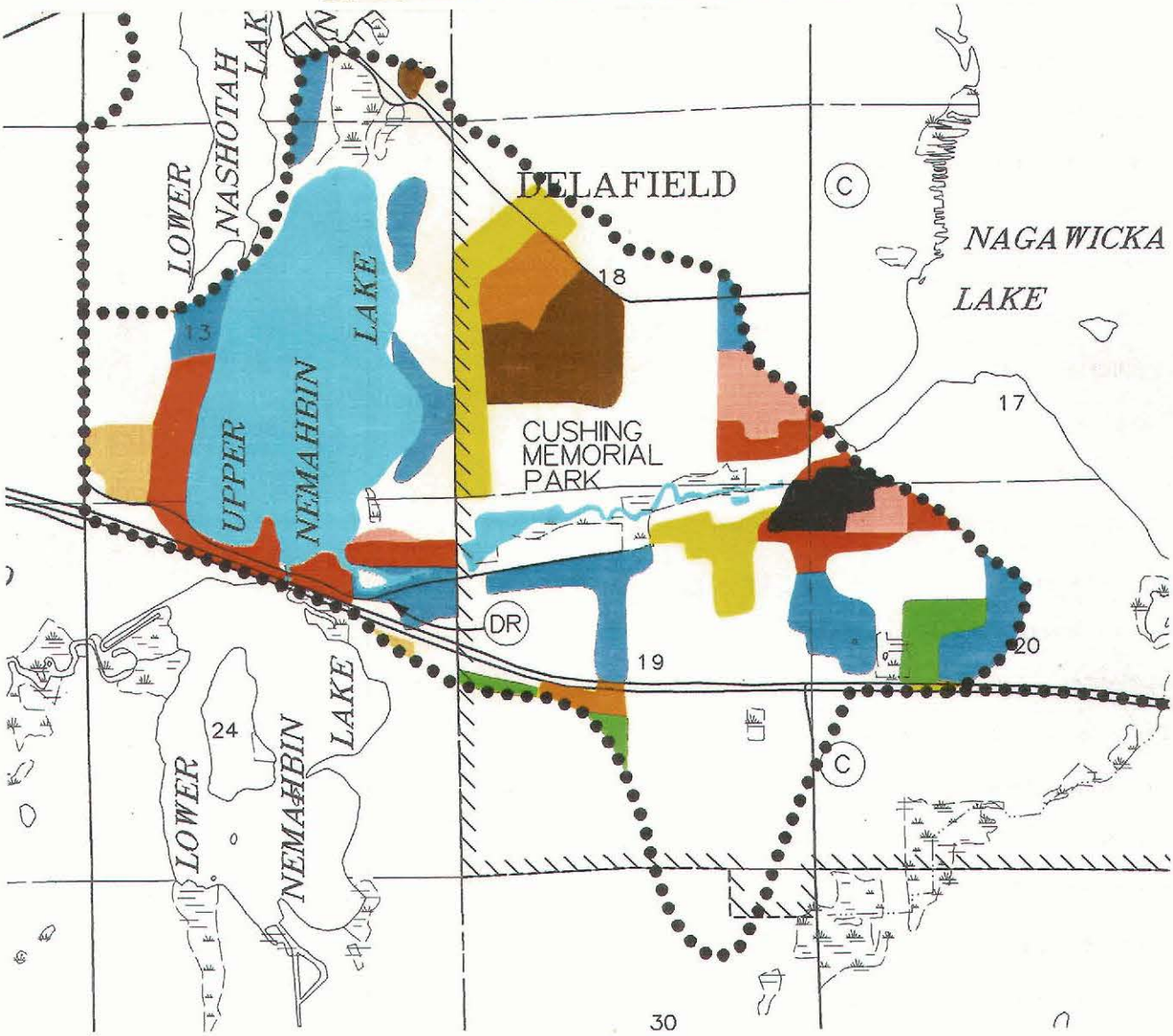
[26]*A model erosion control ordinance has been developed by the League of Wisconsin Municipalities and the Wisconsin Department of Natural Resources, and is presented in the Wisconsin Department of Natural Resources Publication No. WR-222-92, Wisconsin Construction Site Best Management Practice Handbook, 1992.*

[27]*SEWRPC Technical Report No. 31, Costs of Urban Nonpoint Source Water Pollution Control Measures, June 1991.*

Map 13

HISTORIC URBAN GROWTH IN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA: 1880-1990



Source: SEWRPC.

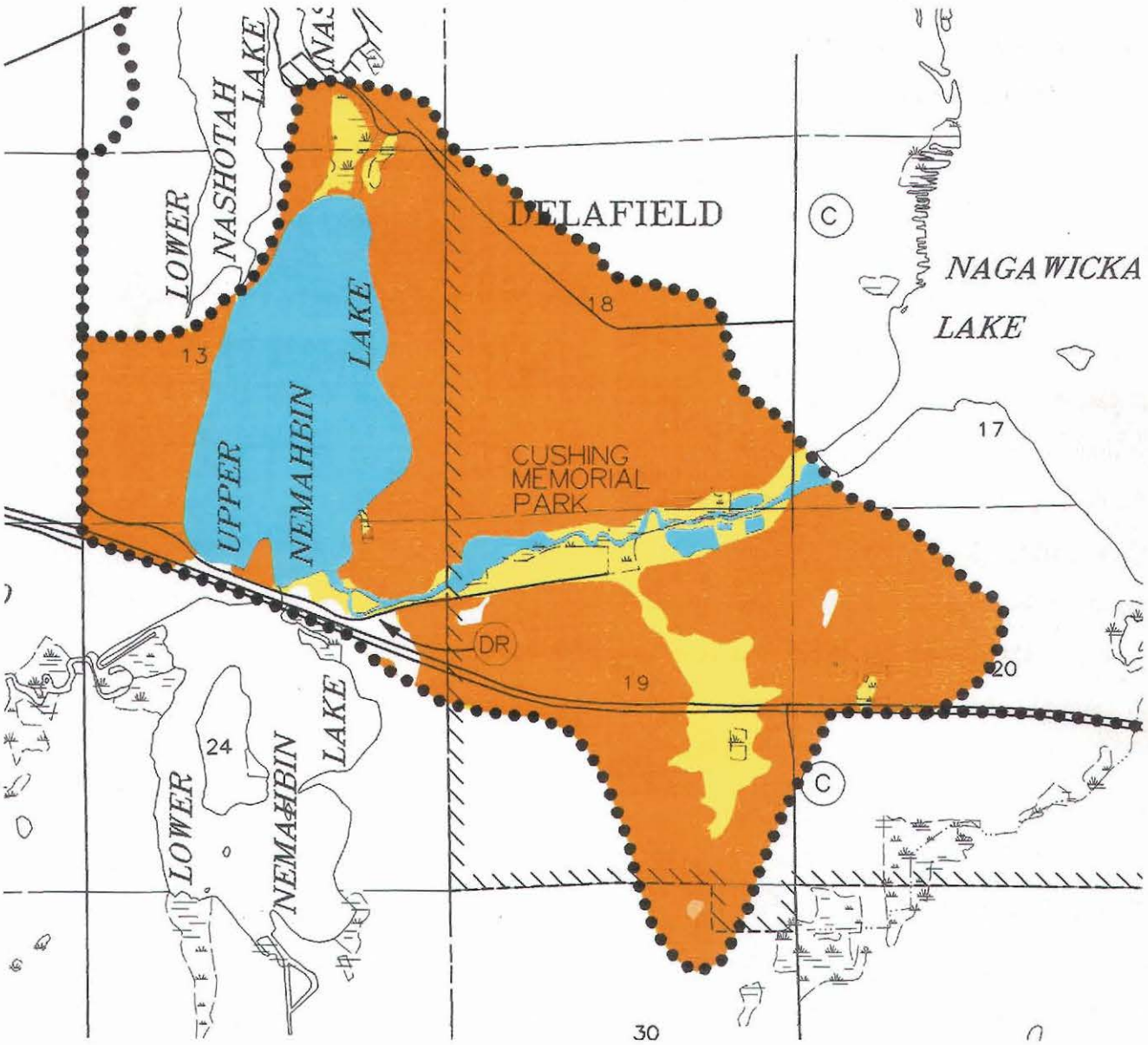
include both structural measures such as wet or dry detention basins, grassed waterways, flow barriers, and sedimentation ponds, and nonstructural measures such as improved "housekeeping" and public education programs. As an example, properly designed wet detention basins can remove up to 80 percent of the loading of particulate pollutants and may also allow biological uptake of nutrients. The minimum basin size would be about 0.25 acre, and all basins would retain a mean permanent pool depth of about five feet.

Grassed swales, usually placed along roadways, reduce pollutant loadings through both filtering and infiltration. Properly designed grassed swales may remove 10 to 25 percent of the particulate pollutant loadings which drain to the swales, although reductions for metals and dissolved pollutants are lower.

Infiltration facilities and increased street sweeping which may be effective nonpoint source controls in some urban areas, would not likely provide significant benefits in the Upper Nemahbin Lake direct drainage area. Infiltration facilities, such as infiltration trenches and basins, porous pavement, and onsite seepage pits, remove waterborne pollutants by capturing surface runoff and filtering it through the soil or other substrate material. Such facilities have been found to be somewhat effective in certain urban areas where the soils and drainage system are suitable and there are no significant sources of toxic pollutants which could contaminate underlying groundwater resources. Within the direct drainage areas to Upper Nemahbin Lake, however, infiltration facilities are expected to have only limited application due to the nature of the soils, the limitation on space along urbanized areas drainageways, and the concern over groundwater protection. As shown on Map 14, approximately 88 percent of the direct drainage area is covered by moderately drained soils, 2 percent of the area is covered by poorly drained soils, and about 9 percent of the area is covered by very poorly drained soils. The remaining areas of the area being unclassified. Increased street sweeping is generally effective only in commercial and industrial areas with curb and gutter, conditions which are limited in the direct drainage areas to Upper Nemahbin Lake.

Map 14

HYDROLOGIC SOIL GROUPS IN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA



GROUP A: Well-drained soils

GROUP B: Moderately-drained soils

GROUP C: Poorly-drained soils

GROUP D: Very poorly-drained soils

Hydrologic soil group not determined

SURFACE WATER

GRAPHIC SCALE IN FEET
0 2000 4000

Source: SEWRPC.

A site-specific analysis is required to properly locate, design, and size structural practices. The availability of suitable sites is a constraint on the use of such measures. Sites suitability is dependent upon adequate open land area for the development of the basin, adjacency of a well-defined drainage system, and size and land uses of the tributary drainage area.

Public education programs can be developed to encourage good urban housekeeping practices, to promote the acceptance and understanding of the pollution abatement measures and the importance of lake water quality protection. Urban housekeeping practices and source controls include restricted use of fertilizers and pesticides, improved pet waste and litter control, the substitution of plastic for galvanized steel and copper roofing materials and gutters, proper disposal of motor vehicle fluids, increased leaf collection, and reduced use of street-deicing salts. Particular attention should be given to reducing pollutant loadings from high pollutant loading areas, such as commercial sites, parking lots, and material-storage areas. Areas for material storage may be enclosed or periodically cleaned; diversion of stormwater away from these sites may further reduce pollutant loadings. The reduced use since 1974 and subsequent elimination of leaded gasoline has contributed to reduced levels of lead in the surface waters.[28]

A concern was expressed in the updated report prepared by Aqua-Tech, Inc., over elevated chloride concentrations in Upper Nemahbin Lake. The reported observed chloride concentrations of between 20 and 21 mg/l are, however, consistent with the observation by the Wisconsin Department of Natural Resources, reported in the aforereferenced Technical Bulletin No. 138, that concentrations exceed 10 mg/l throughout the Southeastern Wisconsin area. At present, a portion of the runoff from IH 94 and CTH DR, which likely generate the largest component of the highway runoff affecting the lake, passes across grassed waterways to concrete culverts and thence into the Bark River. Construction of structural measures to reduce the potential impacts of highway runoff could prove beneficial and is recommended to be investigated further. The proposed reconstruction of

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[28]*R. B. Alexander and R. A. Smith, "Trends in Lead Concentrations in Major U. S. Rivers and Their Relation to Historical Changes in Gasoline Lead Consumption," Water Resources Bulletin, Vol. 24, No. 3, June 1988.*

CTH DR may also provide an opportunity to implement structural measures to minimize these stormwater impacts on the Bark River and Upper Nemahbin Lake.

Onsite Sewage Disposal System Management

The Upper Nemahbin Lake direct drainage area is located within the Delafield-Nashotah Sanitary Sewer Service Area, as set forth in the regional water quality management plan[29] and shown on Map 15. At present, however, the urban development within the Upper Nemahbin Lake direct drainage area is served by private onsite sewage disposal systems. As shown on Map 16, about 63 percent of the direct drainage area is covered by soils generally considered suitable for conventional onsite sewage treatment. However, about 20 percent of the area is covered by soils unsuited for conventional onsite sewage disposal systems under Chapter ILHR 83 of the Wisconsin Administrative Code, with the remaining 17 percent being unclassified or undetermined.

As shown on Map 17, about 12 percent of the direct drainage area is covered by soils unsuitable for onsite sewage disposal using mound systems, and about 17 percent of the area has soil undetermined or unclassified for mound-type onsite sewage disposal systems and the remaining areas being covered by soils considered suitable for such systems.

About 16 percent of the direct tributary drainage area has soils with severe limitations for residential development even with public sanitary sewerage, as shown on Map 18. As reported earlier, onsite sewage disposal systems are estimated to be the source of a significant proportion of the controllable phosphorus loading to Upper Nemahbin Lake.

A public sanitary sewer system is recommended to be provided to the urban development around Upper Nemahbin Lake residential areas by the year 2010 under the current regional plan.[30] Under

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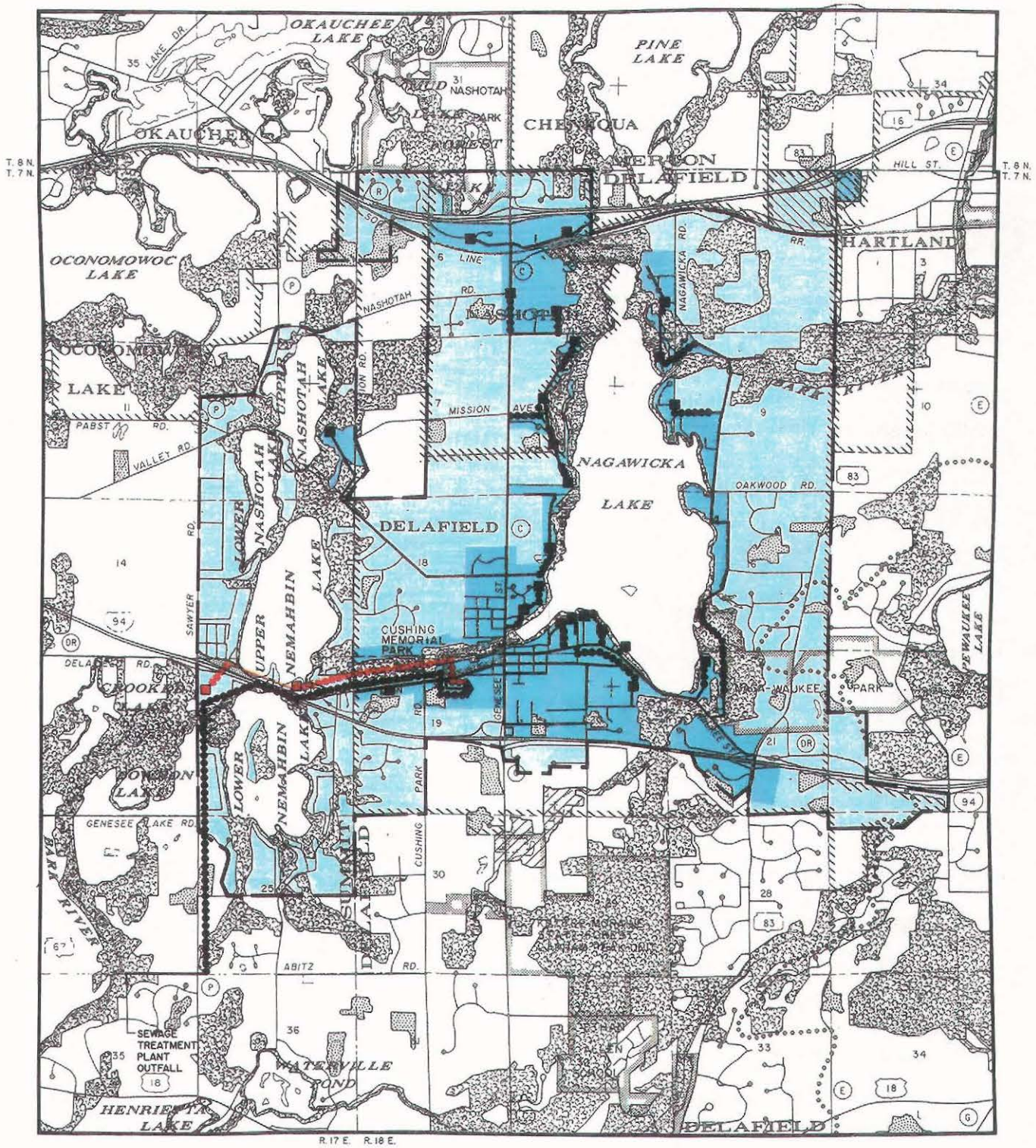
[29]*SEWRPC Planning Report No. 30, op cit.*

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

Map 15

DELAFIELD-NASHOTAH SANITARY SEWER SERVICE AREA



LEGEND

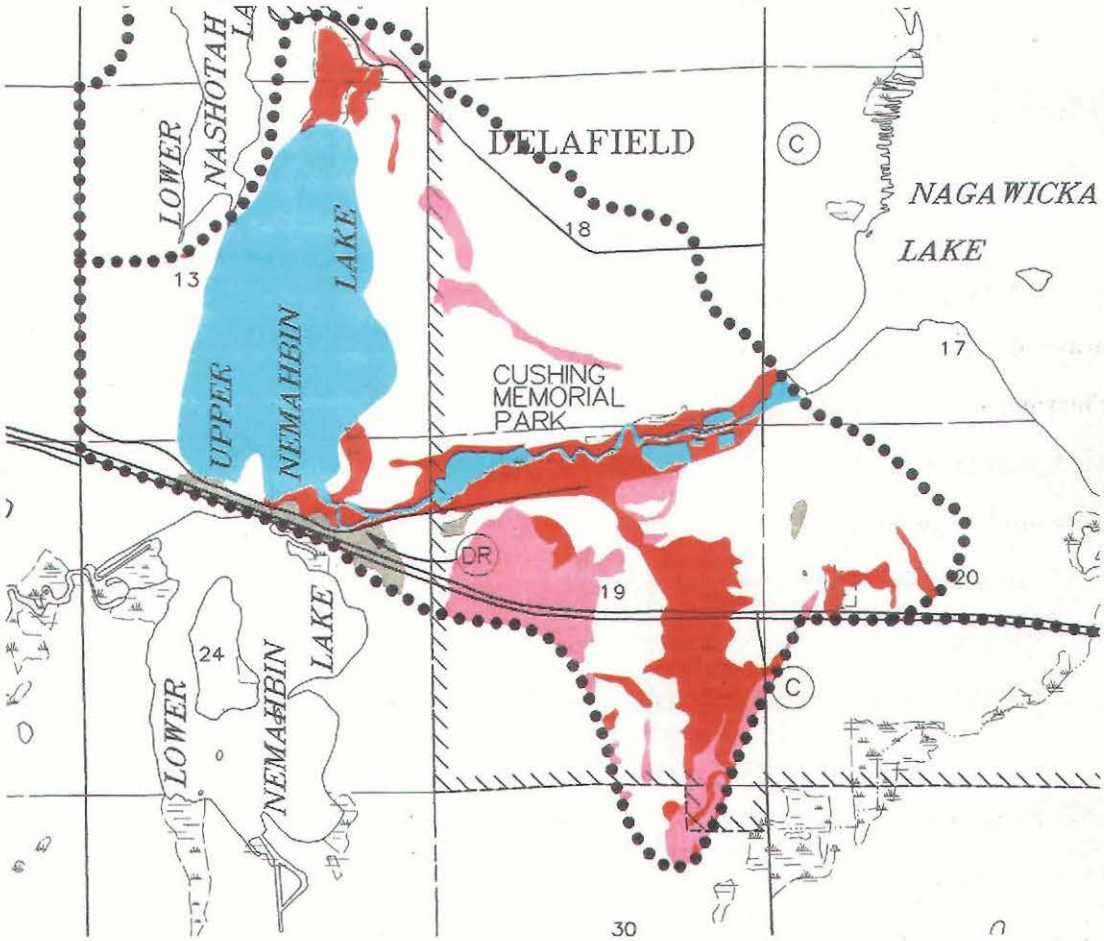
- PRIMARY ENVIRONMENTAL CORRIDOR
- SECONDARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL RESOURCE AREA
- NET SANITARY SEWER SERVICE AREA (EXISTING)
- NET SANITARY SEWER SERVICE AREA (2010)
- GROSS SANITARY SEWER SERVICE AREA BOUNDARY
- EXISTING PUBLIC SEWAGE TREATMENT FACILITY
- EXISTING PUMPING STATION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

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

Source: SEWRPC.

Map 16

SUITABILITY OF SOILS WITHIN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA FOR CONVENTIONAL ON-SITE SEWAGE DISPOSAL SYSTEMS UNDER CURRENT ADMINISTRATIVE RULES: FEBRUARY 1991



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

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

SUITABLE: Areas covered by soils having a high probability of meeting the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing conventional onsite sewage disposal systems

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

SURFACE WATER

GRAPHIC SCALE IN FEET
0 2000 4000

Source: SEWRPC.

this plan, sanitary sewage collected from the wastewater of the Upper Nemahbin Lake area would be conveyed to the Delafield-Hartland Water Pollution Control Commission sewage treatment facility for treatment and disposal. The provision of public sanitary sewer system to serve urban development around the Upper Nemahbin Lake would eliminate any significant nutrient loading to Upper Nemahbin Lake from onsite sewage disposal systems within the direct drainage area to the Lake.

Boating Demands and Public Access

Overcrowding and excessive recreational boating use have been a problem on many lakes in the Southeastern Wisconsin Region, especially those offering high quality recreational opportunities within a one- to two-hour drive of the Chicago-Milwaukee metroplex. On Upper Nemahbin Lake this demand is generally reflected by rental of all available watercraft, and the occupation of all available boat trailer parking spaces, by early afternoon during June, July, and August.[31] Given the situation and the relatively good water quality of Upper Nemahbin Lake, recreational and boating uses of the lake can only be expected to increase substantially in the near future.

Potential ecosystem impacts arising from heavy boating and recreational use include depletion of the sport fish resource, due to angling pressures, leading to the development of stunted populations of panfish and an increase in rough fish abundance through lack of predation; intensification of the risk of boating accidents associated with the high speed operation of power boats; interruption of sport fish spawning patterns due to increased turbidities arising from resuspension of the lake bottom, increased shoreline erosion, and modification of plant community structure due to use-related damages; and, contamination of the lake waters by motor fuels and lubricants, exhaust fumes and other substances released from or exposed on the lake bottom due to the erosional effects of high speed boat traffic, and depleted oxygen levels caused by contaminant-related and other mortality amongst benthic organisms, fish, and aquatic plants.

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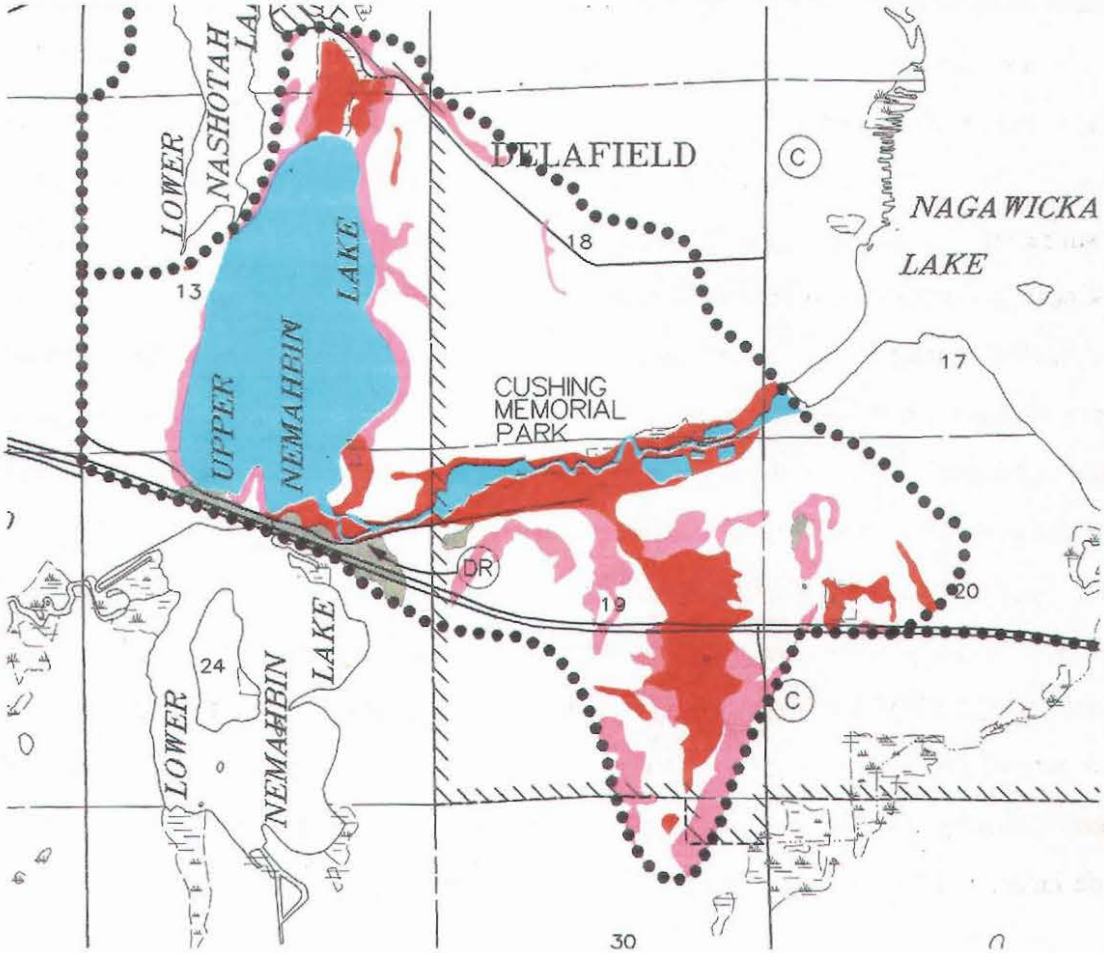
[31] *William Barthel, Chairman: Water Quality Committee, Upper Nemahbin Lake Management District, in litt., May 1994.*

Map 17

SUITABILITY OF SOILS WITHIN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA FOR MOUND SEWAGE DISPOSAL UNDER CURRENT ADMINISTRATIVE RULES: FEBRUARY 1991



UNSUITABLE: Areas covered by soils which have a high probability of not meeting the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing mound sewage disposal systems

UNDETERMINED: Areas covered by soils having a range of characteristics and/or slopes which span the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing mound sewage systems so that no classification can be assigned

SUITABLE: Areas covered by soils having a high probability of meeting the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing mound sewage disposal systems

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

SURFACE WATER

GRAPHIC SCALE IN FEET
0 2000 4000

Source: SEWRPC

The promulgation of more stringent controls on the use of powered water craft along the shallow northern and southern shores of Upper Nemahbin Lake could restrict high speed boat traffic in the areas where the highest potential for spreading of undesirable aquatic plants exist, such as the shallow beach area and the extensive aquatic plant communities on the southeastern shore at the "inlet" of the Lake. Control of boat traffic could be effected either within a specified distance of the shoreline—for example, the "shore zone", within 200 feet of the shoreline, as defined in the DNR boating ordinance guidelines[32]—or in specific areas of the lake and inlet river—for example, "boat excluded areas" or a "motorboat prohibition"—or by limiting the speed at which high speed boat traffic travels in specific areas of the lake or river—such as, "slow-no-wake" or some other "speed restriction". Boat excluded areas must be designated by approved regulatory markers. These areas are preferable to motorboat prohibition areas as the latter can lead to legal challenges based on the right of free use of navigable waters; similarly, slow-no-wake restrictions are preferable to speed limits designated in miles per hour terms.[33] Placement of regulatory markers must conform to Section NR 5.09 of the Wisconsin Administrative Code, and all restrictions placed on the use of the waters of the State must be predicated upon the protection of public health, safety or welfare. Where a boating ordinance is enacted in conformity with State law, it must be clearly posted at public landings in accordance with Section 30.77(4) of the Wisconsin Statutes.

Buoyage can be expensive to obtain, install, and maintain, but has the advantage of being visible to recreational boaters. It also clearly demarcates the affected areas. Two options exist; the establishment of regulated areas—the slow-no-wake or exclusionary areas—or the enhancement of public awareness. The establishment of slow-no-wake areas within Upper Nemahbin Lake will require amendment of the boating ordinance, the authorization of the local municipality having jurisdiction over the waters involved, and a DNR permit. Only regulatory markers are enforceable. The buoys used to demarcate regulated areas must be cylindrical in shape, seven or more inches in

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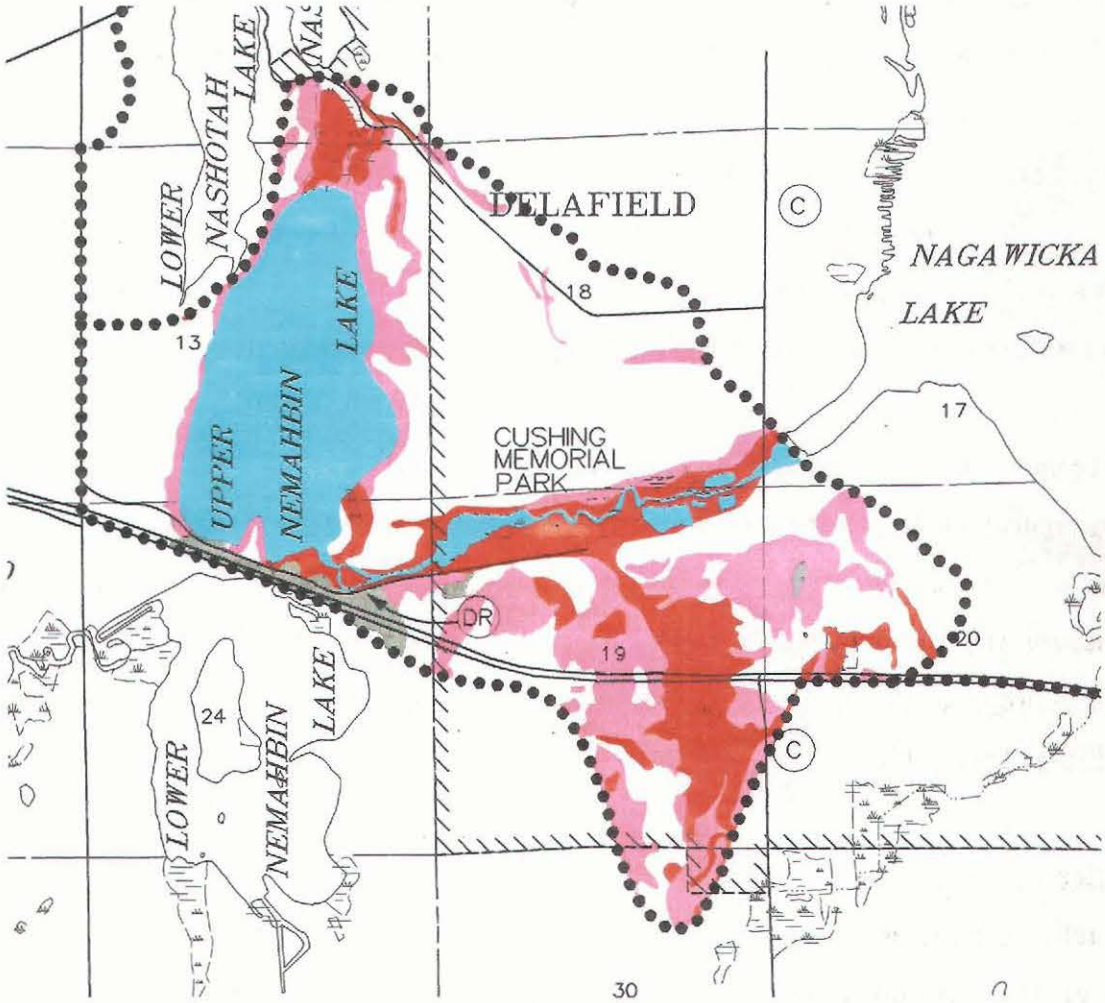
[32]*Wisconsin Department of Natural Resources, Guidelines: Ordinance Writing and Buoy Placement for Wisconsin Waters, s.d.*

[33]*Ibid.*

Map 18

SUITABILITY OF SOILS WITHIN THE UPPER NEMAHBIN LAKE DIRECT DRAINAGE AREA FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER



- Areas covered by soils which have SEVERE limitations for residential development with public sanitary sewer service
- Areas covered by soils having MODERATE limitations for residential development with public sanitary sewer service
- Areas covered by soils having SLIGHT limitations for residential development with public sanitary sewer service
- UNCLASSIFIED SOILS
- SURFACE WATER

GRAPHIC SCALE IN FEET
0 2000 4000

Source: SEWRPC.

diameter, and extend 36 or more inches above the waterline. The buoys would be white, with instructions provided in black lettering; prohibition buoys would display an orange diamond with an orange cross inside, while control buoys would display an orange circle. Alternatively, Chapter 30, Wis. Stats., allows local authorities having jurisdiction over the waters involved to place danger buoys or informational buoys without an ordinance, although a DNR permit is still required. Informational buoys should be similar in construction to the prohibition and control buoys, but would contain an orange square on the white background. Informational buoys are not enforceable.

It is recommended that provision be made at the access sites on the Lake for the posting of the boating regulations adopted by the Town of Summit and other notices as necessary. The facilities at these access points should also be up-graded to conform to the guidance on accessibility contained in Wisconsin Department of Natural Resources Publication No. CA-003-88, Handbook for Accessibility: A Reference Manual to Help Develop Outdoor Recreation Areas to Include People with Disabilities, Spring 1989.

Shoreline Protection

Although shoreland erosion is not a major problem on Upper Nemahbin Lake, the southwestern shore of the lake—the former public beach area—is susceptible to recession, and should be protected. The CTH DR right-of-way is currently badly eroded and installation of erosion control measures is being contemplated by the Town, County and Lake Management District. It is noteworthy that many structures have been built in other areas of the lake to protect the shoreline. These structures, shown on Map 10, were generally well maintained when inspected during August 1993 by Commission staff. However, shoreline erosion could be expected to increase as lake usage increases, and erosion-related problems could worsen in future. While construction of visually-intrusive shoreland protection structures may be considered, other options may be preferred by lake residents seeking to conserve the ambience of Upper Nemahbin Lake.

Shoreline protection can be enhanced by providing lakeshore residents with information on the methods of proper construction and maintenance of shoreland protection structures; on the problems

commonly associated with such structures; and alternatives and their costs to traditional shoreland protection structures—such as, the use of vegetated buffer strips, rip-rap, etc. versus retaining walls and bulkheads. Such information is commonly available from the Wisconsin Department of Natural Resources, University of Wisconsin-Extension and U. S. Army Corps of Engineers. In addition, the proposed promulgation of a boating ordinance should provide a further degree of protection to the shallow areas of the Lake and to the shorelands by limiting boat usage in these areas.

PAST AND PRESENT LAKE MANAGEMENT PRACTICES

Background

The residents of Upper Nemahbin Lake, in conjunction with the Town of Summit, have long recognized the importance of informed and timely action in the protection of the water quality of Upper Nemahbin Lake. Their initial concern resulted in the formation of the Upper Nemahbin Lake Management District which provides the forum for many of the lake management activities of the Lake's residents. To date, the District undertakes regular water quality measurements under the auspices of the DNR Self-help Monitoring Program. These citizen-based measurements are presently being augmented by a U. S. Geological Survey water quality investigation being conducted through the Chapter NR 119 Lake Management Planning Grant Program. The District holds a Phase I Lake Management Planning Grant to cost-share water quality and watershed inventory studies of Upper Nemahbin Lake and its drainage basin. The latter study forms the basis of this report. Both studies will eventually become part of a comprehensive lake management plan for Upper Nemahbin Lake. It is recommended that the District continue with its lake management program leading to this end, and make application to the Wisconsin Department of Natural Resources for a Phase II Lake Management Planning Grant to support additional water quality monitoring and, at a minimum, an aquatic plant survey of the lake.

Public Information

It is the policy of the Town of Summit and the Upper Nemahbin Lake Management District to maintain an active dialogue with the community. This dialogue is carried out through the medium

of the public press and in public fora through various Town Committees, public meetings and other scheduled hearings. Further, the District holds regular public meetings and sends a newsletter to electors and riparian property owners. Informational issues identified above should be dealt with at subsequent District meetings or through articles in the District newsletter.

Public information and involvement remains an important component of the lake management planning program plan. It is recommended that the Town of Summit, in conjunction with the Upper Nemahbin Lake Management District, conduct a public education and information program providing riparian residents with information on alternative forms of lawn and garden care, household chemical usage, shoreland protection structures, and other relevant information as may be obtained from the U. S. Environmental Protection Agency, the U. S. Army Corps of Engineers, Wisconsin Department of Natural Resources, and University of Wisconsin-Extension Service. It is suggested that the aforementioned organizations seek the collaboration of other communities and organizations in distributing similar information within the Upper Nemahbin Lake watershed. When possible, it is suggested that informational programming be included at the annual meetings of the Upper Nemahbin Lake Management District and other agencies as appropriate.

SUMMARY

This inventory report documents the findings of a study requested by the Upper Nemahbin Lake Management District, examines existing and anticipated future land uses and potential water quality and lake use problems in the Upper Nemahbin Lake watershed. The report is complementary to USGS water quality investigations being carried out on Upper Nemahbin Lake.

Upper Nemahbin Lake has been found to be a 283-acre mesotrophic, deep water lake of relatively good quality, located in close proximity to the Milwaukee metropolitan area and adjacent to a rapidly urbanizing part of Waukesha County in which the Upper Nemahbin Lake direct drainage area is wholly located. The Lake is a through flow or drainage lake which receives inflow from an unnamed tributary flowing from spring-fed Upper and Lower Nashotah Lakes and from the Bark

River and outlets to Lower Nemahbin Lake and the Bark River. The Lake has a direct drainage area of 1,734 acres and a total drainage area of about 25,600 acres.

Urban land uses occupy about 32 percent of the Upper Nemahbin Lake direct drainage area, including most of the shoreline area. Only limited new development in the form of infilling or small land divisions is recommended to occur within the direct drainage area.

Public access is provided by a county-owned boat launch and access site located on the channel between Upper Nemahbin and Lower Nemahbin Lakes. That site generally reaches capacity by mid-morning during the summer periods of good weather.

Surveys conducted under this planning project indicated that the areas of ecological value exist, both within the Lake and within the direct drainage area, which are predominantly located in the primary environmental corridor lands delineated by the Regional Planning Commission. To protect the Upper Nemahbin Lake and environs from human encroachment and reduce adverse human impacts on the ecologically valuable areas within the watershed, specific actions should be considered, including amendment of Town ordinances relating to boating on Upper Nemahbin Lake, stormwater and construction site erosion management in the watershed, and installation of a public sanitary sewer system to serve the urban development around the Lake. These actions should be linked with an on-going program of public information and education providing riparian residents and lake users with, for example, additional options to household chemical usage, lawn and garden care, shoreland protection, and recreational usage of the Lake. Further consideration should be given to the public acquisition of, the conservation easements over, or other means of protection of the lands within the primary environmental corridors to ensure preservation of these ecologically valuable areas. In this way, a balance can be obtained of the demand for high-quality residential and recreational opportunities at Upper Nemahbin Lake and the protection of the environment that creates this sought-after high-quality experience.

With the exception of the provision of buoyage to demarcate ecologically valuable areas within the Lake, such costs of the lake management activities considered are primarily administrative costs, to be borne by the local units of government, including the Lake Management District. The cost of buoyage could potentially be off-set through the use of grants-in-aid provided under a cost-share program—the Recreational Boating Fund—operated by the Wisconsin Waterways Commission and the DNR. More detailed cost analyses for stormwater management and measures to be considered should be conducted during subsequent phases of this planning program. In addition, the cost for the installation of a public sanitary sewer system would have to be considered in more detail on a subsequent facility planning effort designed to meet the requirements of Chapter NR 110 of the Wisconsin Administrative Code.

This plan is consistent with existing planning guidelines for the Town of Summit and Waukesha County, and with the recommendations contained in the regional water quality management plan. Continuation of the lake management planning program is recommended through the conduct of additional in-lake investigations relating to the aquatic biota, continued monitoring, and the formulation of a comprehensive lake management plan for Upper Nemahbin Lake.

APPENDICES

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Appendix A

BOATING ORDINANCES APPLICABLE TO UPPER NEMAHBIN LAKE

STATE OF WISCONSIN TOWN OF SUMMIT WAUKESHA COUNTY

ORDINANCE NO. 181

AN ORDINANCE REGULATING THE USE AND OPERATION OF MOTORBOATS ON UPPER NEMAHBIN LAKE IN THE TOWN OF SUMMIT

WHEREAS, the Town Board of the Town of Summit, Waukesha County, Wisconsin, deems it necessary to regulate the use and operation of motor operated boats for the protection of life, person and property on Upper Nemahbin Lake;

WHEREAS, the Town Board of the Town of Summit, Waukesha County, Wisconsin intends by this ordinance to provide safe and healthful conditions for the enjoyment of aquatic recreation consistent with public rights and interests and the capability of the water resource,

NOW, THEREFORE, the Town Board of the Town of Summit, Waukesha County, Wisconsin DOES ORDAIN AS FOLLOWS:

SECTION 1: The general ordinance regulating the use and operation of motorboats on the waters in the Town of Summit is hereby repealed as it relates to Upper Nemahbin Lake and an ordinance to regulate the use and operation of motorboats, and to regulate water sports upon and under the water of Upper Nemahbin Lake is hereby created to read as follows:

1. APPLICATION AND INTENT: The provisions of this ordinance shall apply to the waters of Upper Nemahbin Lake within the jurisdiction of the Town of Summit. The provisions of this ordinance shall be enforced by the officers of the Water Safety Patrol Unit and police of the jurisdiction of the Town of Summit. The intent of this ordinance is to provide safe and healthful conditions for the enjoyment of aquatic recreation consistent with public rights and interest, and the capability of the water resources.

2. STATE BOATING AND WATER SAFETY LAWS ADOPTED:

   A. Except as otherwise specifically provided in this ordinance, the current and future statutory provisions describing and defining regulations with respect to water traffic, boats, boating, and relating water activities in Secs. 30.50 up to and including 30.71, of the Wisconsin Statutes, exclusive of any provisions therein relating to the penalties to be imposed or the punishment for

violation of said statutes, are hereby adopted and by reference made a part of this ordinance as if fully set forth herein. Any act required to be performed or prohibited by any current or future statute incorporated herein by reference is required or prohibited by this ordinance. Any further additions, amendments, revisions or modifications of the statute incorporated herein are intended to be made part of this ordinance in order to secure uniform state-wide regulation of the waterways of the State.

B. All rules and orders created by the Wisconsin Department of Natural Resources, modifying or supplementing the foregoing provisions of State Law or which may be adopted or made in the future, are hereby incorporated in and made a part of this ordinance by deferring to the same as if they are or were to be set out herein verbatim.

3. SPEED RESTRICTIONS:

A. No motorboat shall be operated on Upper Nemahbin Lake from sunrise until sunset at a speed in excess of 45-miles per hour unless otherwise further restricted by this ordinance or State Statute.

B. No motorboat shall be operated on Upper Nemahbin Lake on Sundays and Wisconsin Statutory legal holidays between the hours of 12:00 noon and 3:00 p.m. local time, at a speed in excess of SLOW-NO WAKE. Slow-no wake means operating a motorboat at a speed no faster than needed to maintain steerage.

C. No motorboat shall be operated on Upper Nemahbin Lake from sunset until sunrise at a speed in excess of slow-no wake.

4. SWIMMING REGULATIONS: No person, unless said person is engaging in activities and subject to the provisions of Section 30.70, Wisconsin Statutes, entitled Skin Diving, shall:

A. Swim from any unmanned boat, unless such boat is anchored, or

B. Swim more than 150 feet from the shoreline unless it is a designated swimming zone or unless accompanied by a competent person in a boat, or

C. Swim more than 150 feet from the shoreline between sunset and sunrise.

5. LOCAL REGULATION ON ICEBOUND INLAND WATERS:

A. No person shall operate or park or permit, authorize, direct or control the operation or parking of or ride as a passenger on any motorized vehicle or motor-driven vehicle, including but not limited to motor vehicles, snowmobiles, or all-terrain vehicles on the ice on any portion of Upper Nemahbin Lake.

B. The Chief of Police of the Town of Summit, upon application to him and payment of a license fee established by the Town Board, being satisfied that ice conditions do and will permit operation of a motorized vehicle or motor-driven vehicle upon a designated potion of the lake without material risk or hazard, may issue a written permit expiring within 24 hours after issuance authorizing operation of a motorized vehicle or motor-driven vehicle on the lake for particular purposes to be specified in such permit. Said particular purposes shall be limited to: snowplowing of a portion of the lake for an ice skating rink, transporting of property to an island or conducting official lake studies. No such permit shall authorize speed or acrobatic contests, exhibitions or performances; racing; fishing; nor shall any such permit authorize joyriding, sightseeing or any other activity not deemed necessary by the Chief of Police.

6. PENALTY:

A. STATE BOATING AND WATER SAFETY LAWS AND ALL OTHER VIOLATIONS AS SET FORTH IN SECTION 3 OF THIS ORDINANCE.

Any forfeiture for violation of the State statute, rule or order adopted by reference in Section 3 of this ordinance shall conform to the forfeiture permitted to be imposed for violation of such statutes as set forth in the Uniform Wisconsin Deposit and Bail Schedule for Conservation, Boating, Snowmobile, and ATV Violations, including any variations or increases for subsequent offenses, which schedule is adopted by reference.

B. LOCAL BOATING LAWS AS SET FORTH IN SECTION 4 OF THIS ORDINANCE

Any person 16 years or older violating the provisions of this ordinance shall be subject to a forfeiture of not more than $50 for a first offense and not greater than $100 for each subsequent offense, plus court costs and penalty assessment. Failure to pay any forfeiture hereunder shall subject the violator to imprisonment in the County Jail or loss of license.

Any person 14 or 15 years of age shall be subject to a forfeiture of not less than $10 nor more than $25 plus court costs and penalty assessment per each offense or referred to the proper authorities as provided in Chapter 48, Wisconsin Statutes. Failure to pay any forfeiture hereunder shall subject the violator to the provisions of Section 48.17(2), Wisconsin Statutes.

Any person under the age of 14 shall be referred to the proper authorities as provided in Chapter 48, Wisconsin Statutes.

7. ENFORCEMENT.

A. ENFORCEMENT PROCEDURE. The statute provisions of Sections 66.115, 66.119, 66.12, and 30.50 to 30.71, are adopted and by reference made a part of this ordinance as if fully set herein. Any act required to be performed or prohibited by any statute incorporated herein by reference is required or prohibited by this ordinance. Any future additions, amendments, revisions or modifications of the statutes incorporated herein are intended to be made part of this ordinance in order to secure uniform state-wide regulation and enforcement of boating ordinance violations. Further, the Town of Summit specifically elects to use the citation method of enforcement.

B. DEPOSITS.

1. Schedule of Deposits. The schedule of cash deposits shall be as follows:

Section 2: Applicable sections of Uniform Wisconsin Deposit and Bail Schedule for Conservation, Boating, Snowmobile and ATV Violations plus current assessment fees and current court costs if applicable.

Sections 3, 4 and 5: $50 plus court costs and assessments plus current assessment fees and current court costs if applicable.

2. Deposit for Repeat Offenses. Any person found guilty of violating this ordinance or any part thereof who was previously convicted of the same section within the last year shall forfeit twice the deposit delineated above plus court costs and penalty assessment.

3. Non-Scheduled Deposit. If a deposit schedule has not been established for a specific violation, the arresting officer shall require the alleged offender to deposit not less than the maximum forfeiture permitted hereunder.

4. Depository. Deposits should be made in cash, money order, or certified check to the clerk of Municipal Court, who shall issue a receipt therefore as required by Wisconsin Statute. If the deposit is mailed, the signed statement required by Wisconsin Statute shall be mailed with the deposit.

C. NON-EXCLUSIVITY.

1. Other Ordinances. Adoption of this ordinance does not preclude the Town Board from adopting any other ordinance or providing for the enforcement of any other law or ordinance relating to the same or other matter.

2. Other Remedies. The issuance of a citation hereunder shall not preclude the Town Board or any authorized office from proceedings under any other ordinance of law or by any other enforcement method to enforce any ordinance, regulation or order.

SECTION 2: SEVERABILITY.

The several sections of this ordinance are declared to be severable. If any section nor potion thereof shall be declared by a court of competent jurisdiction to be invalid, unlawful or unenforceable, such decision shall apply only to the specific section nor portion thereof directly specified in the decision, and shall not affect the validity of any other provisions, sections or portions thereof of the ordinance. The remainder of

the ordinance shall remain in full force and effect. Any other ordinances whose terms are in conflict with the provisions of this ordinance are hereby repealed as to those terms that conflict.

SECTION 3: EFFECTIVE DATE.

This ordinance shall take effect immediately upon passage and posting or publication as provided by law.

This ordinance passed this 1st day of April, 1993.

BY ORDER OF THE TOWN BOARD OF THE TOWN OF SUMMIT, WAUKESHA COUNTY, WISCONSIN

EDWIN H. ROHLOFF, TOWN CHAIRMAN

ATTEST:

ELIZABETH L. DOW, TOWN CLERK

Published or posted on the 14 day of May, 1993.

Appendix B

ILLUSTRATIONS OF COMMON AQUATIC PLANTS IN UPPER NEMAHBIN LAKE

Broad-leaved Cat-tail (Typha latifolia)

Muskgrass (Chara vulgaris)

Coontail (Ceratophyllum demersum)

Flatstem Pondweed

(Potamogeton zosteriformis)

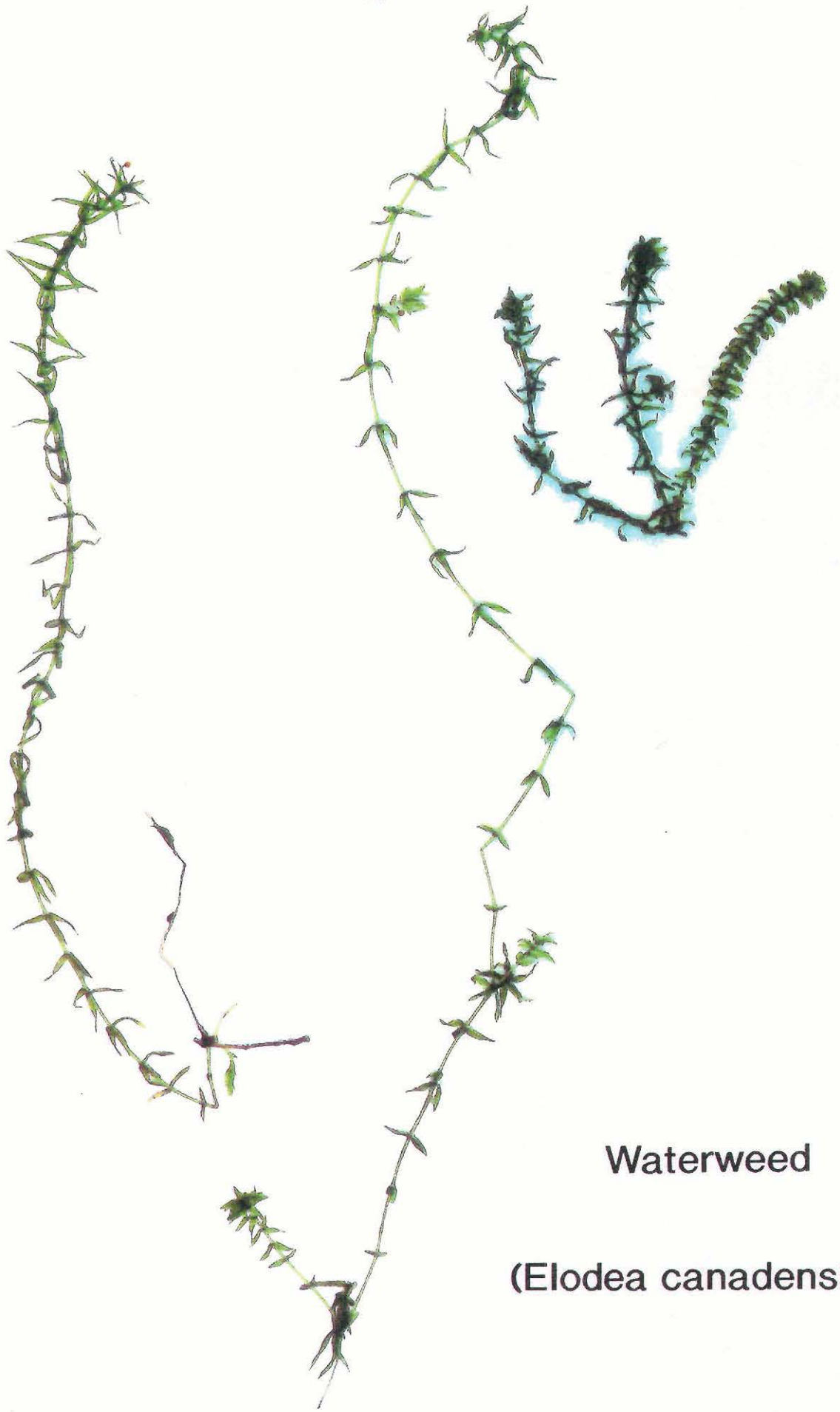
Wild Celery (Vallisneria americana)

Yellow Water Lily

(Nuphar variegatum)

White Water Lily

(Nymphaea tuberosa)



Waterweed

(Elodea canadensis)

Eurasian Water Milfoil

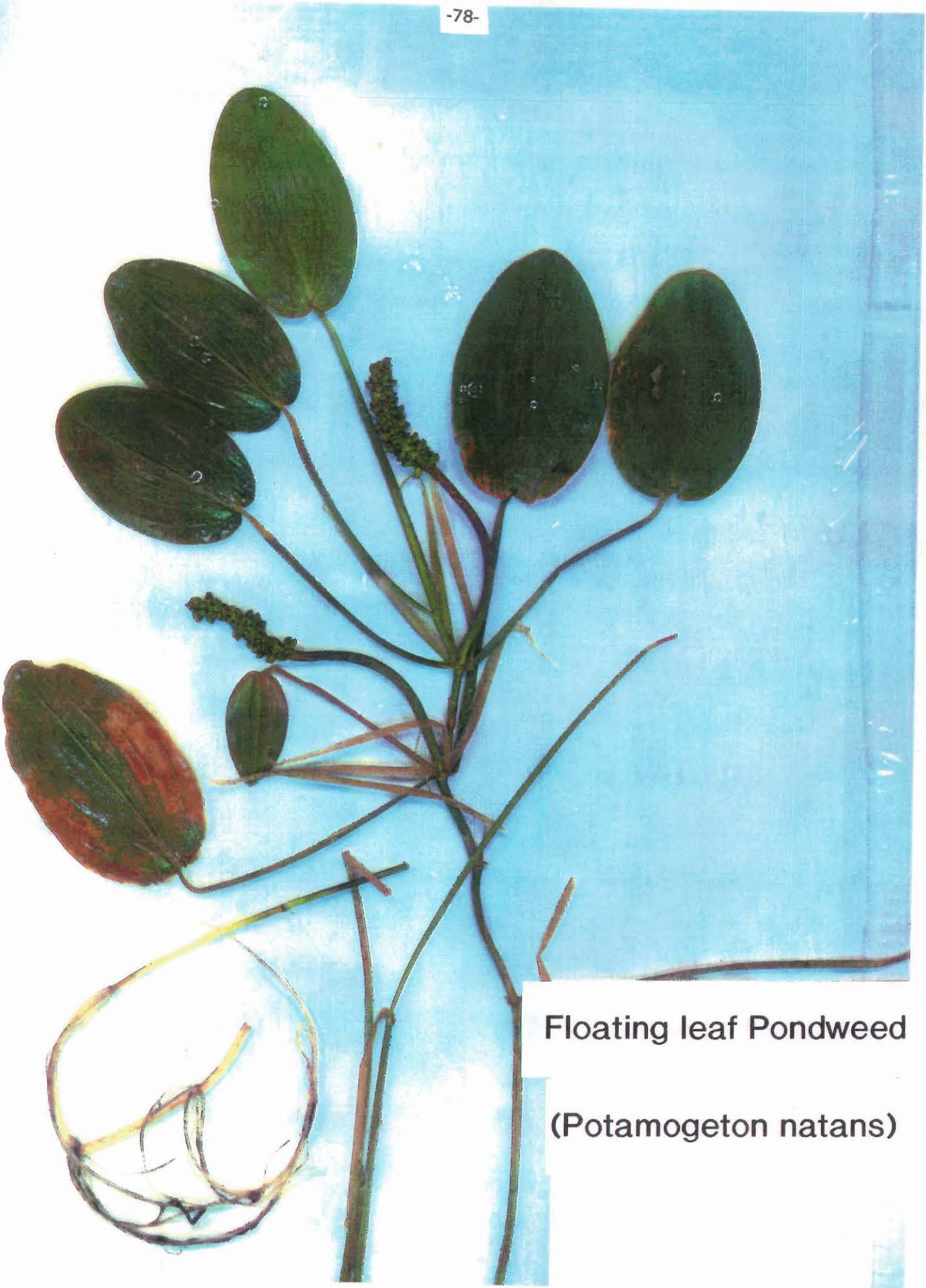
(Myriophyllum spicatum)

Eurasian Water Milfoil

(Myriophyllum spicatum)

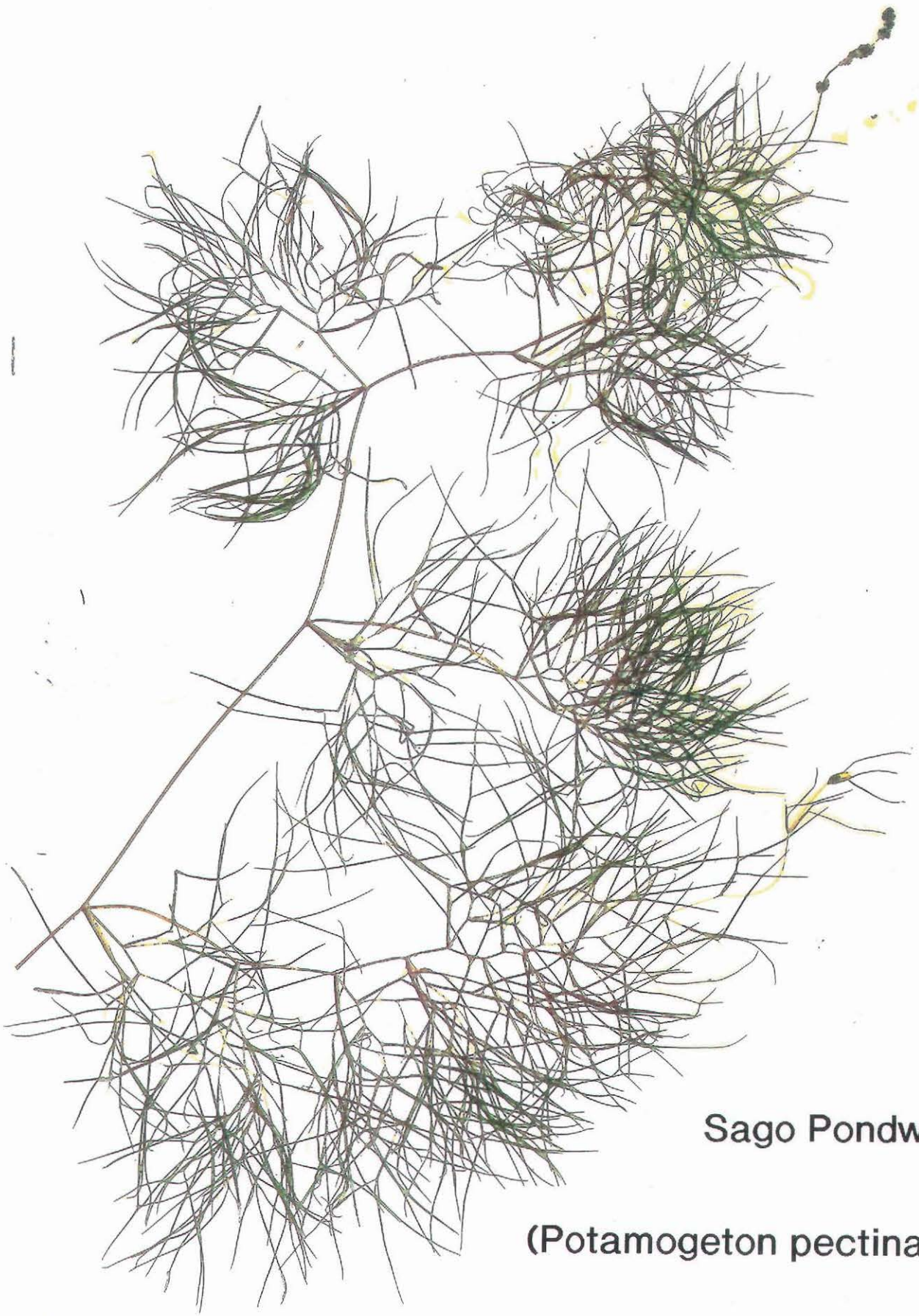
Bushy Pondweed (Najas flexilis)

Curly leaf Pondweed (Potamogeton crispus)



Floating leaf Pondweed

(Potamogeton natans)



Sago Pondweed

(Potamogeton pectinatus)