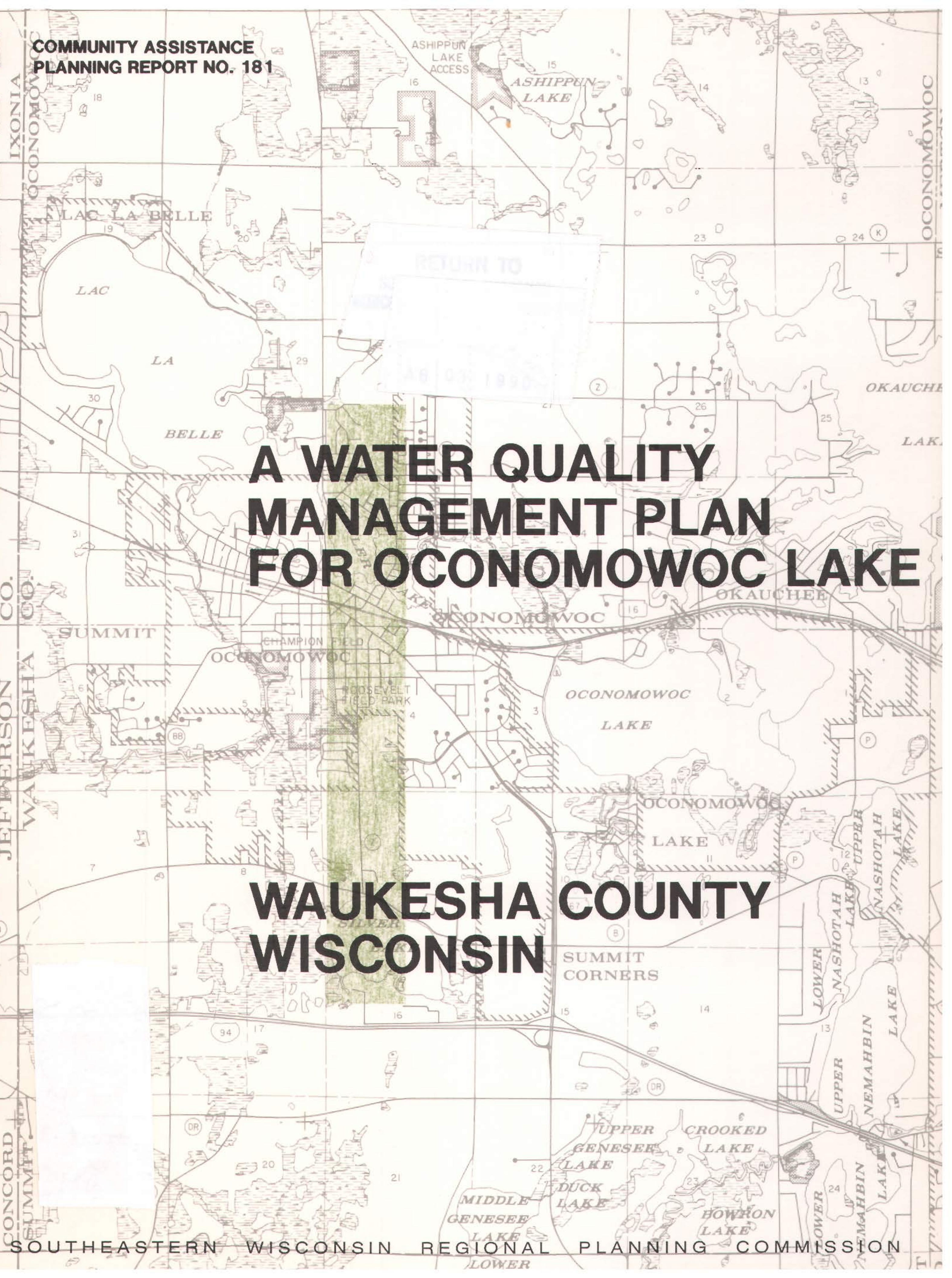
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 181



A WATER QUALITY MANAGEMENT PLAN FOR OCONOMOWOC LAKE

WAUKESHA COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due Thomas L. Wirth, Jack W. Mason, James Weckmueller, Richard Narf, Richard Lillie, James L. McNelly, Steven Mace, Richard Wedepohl, and Douglas Knauer of the Department staff for their contributions to this report.

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

Prepared by the

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In Cooperation With the
Wisconsin Department of Natural Resources
Madison, Wisconsin 53707

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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March 21, 1990

TO: All Units and Agencies of Government and Citizen Groups
Involved in Water Quality Management for Oconomowoc Lake

In 1984, the Regional Planning Commission, in cooperation with the Wisconsin Department of Natural Resources, undertook a study of water quality conditions in Oconomowoc Lake. The purpose of the study was to identify existing and potential water quality problems, and propose measures which could be taken to resolve those problems and to protect and enhance the water quality of this lake. The findings and recommendations of that study are presented in this report.

The report describes the physical properties of Oconomowoc Lake, the quality of its waters, and the conditions affecting that quality, including existing land use and the present utilization of the lake. All known sources of pollution to the lake are identified and, to the extent possible, quantified; and alternative, as well as recommended, means for the abatement of these sources of pollution and for the protection and enhancement of the water quality of the lake are described.

A preliminary draft of this report was reviewed and commented on by the City of Oconomowoc, the Village of Oconomowoc Lake, the Town of Summit, the Waukesha County Park and Planning Department, the Waukesha County Land Conservation Committee, and the Wisconsin Department of Natural Resources in 1985. This final report reflects the comments and suggestions made by these concerned units and agencies of government.

The water quality management plan presented herein constitutes a refinement of the areawide water quality management plan adopted by the Regional Planning Commission in July 1979. Accordingly, upon adoption by the local units and agencies of government concerned with water quality management for Oconomowoc Lake and subsequent adoption by the Regional Planning Commission, the plan presented in this report will become an element of the adopted, areawide water quality management plan.

The plan presented in this report should provide a sound guide to the making of development decisions concerning the wise management of Oconomowoc Lake as an aesthetic and recreational asset of immeasurable value. Accordingly, careful consideration and adoption of the plan presented herein by all of the concerned water quality management agencies is respectfully urged. In its continuing role in the coordination of water quality management planning and plan implementation within southeastern Wisconsin, the Regional Planning Commission stands ready to assist the various units and agencies of government concerned in carrying out the recommendations contained in this report.

Respectfully submitted,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

Thirteen major inland lakes in southeastern Wisconsin were studied under a special planning program conducted by the Southeastern Wisconsin Regional Planning Commission in cooperation with the Wisconsin Department of Natural Resources, local lake protection and rehabilitation districts, and other lake organizations. Eight of the 13 lakes—Eagle Lake, Friess Lake, Lac La Belle, North Lake, Oconomowoc Lake, Pewaukee Lake, Pike Lake, and Wandawega Lake—were studied by the Regional Planning Commission in cooperation with the Wisconsin Department of Natural Resources, Bureau of Research; and four of the lakes—Ashippun Lake, George Lake, Okauchee Lake, and Paddock Lake—were studied by the Regional Planning Commission in cooperation with the Wisconsin Department of Natural Resources, Office of Inland Lake Renewal, and the local lake protection and rehabilitation districts concerned. One of the 13 lakes—Geneva Lake—was studied by the Regional Planning Commission in cooperation with the Geneva Lake Watershed Environmental Agency. The objectives of all of these lake studies included the acquisition of definitive information on lake water quality and related land use and land management practices in the lake drainage area; the identification of the factors affecting lake water quality, particularly the amount, kind, and temporal distribution of pollutants contributed by the various sources; and the development of recommendations for the abatement of pollution in order to maintain or improve lake water quality conditions.

On May 20, 1976, the Southeastern Wisconsin Regional Planning Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources to study Oconomowoc Lake. The cooperative study included the design and conduct of a water quality sampling program to determine existing lake water quality conditions, and inventories and analyses of pertinent tributary watershed characteristics affecting water quality conditions, including land use and management practices, existing water uses, and sources of pollution. The lake water quality sampling program was conducted from May 1976 through April 1977. However, some additional inventory data collected as recently as 1984 are incorporated into this report. This report summarizes the results of the sampling program; describes the physical, chemical, and biological characteristics of the lake and the direct tributary drainage area; and provides an evaluation and interpretation of the data collected and collated. From these analyses, feasible alternative actions for the maintenance and enhancement of lake water quality are proposed and evaluated, and water quality management measures are recommended.

Oconomowoc Lake is an 804-acre[1] lake located primarily within U. S. Public Land Survey Sections 1, 2, and 3, Township 7 North, Range 17 East, Town of Summit, Waukesha County. The lake is fed and drained by the Oconomowoc River. Properly managed, the 2,020-acre drainage area directly tributary to this lake can contribute to the maintenance of the lake as an important asset to the residents of the County and the Region of which the County is an integral part. More importantly, however, the quality of the Oconomowoc River, which provides the singularly largest inflow to the lake, must be protected if Oconomowoc Lake is to retain its recreational value. Such protection should be provided to a large extent by the Wisconsin nonpoint source water pollution abatement priority watershed project for the Oconomowoc River watershed.

Primary management objectives for Oconomowoc Lake include: 1) providing water quality suitable for full body contact recreational use

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[1] *In SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, 1968, the area of Oconomowoc Lake was reported to be 767 acres, as measured from 1956 aerial photographs. Based on 1980 aerial photographs, the area of Oconomowoc Lake was estimated to be 804 acres. The differences in these measured areas may be attributed to the improved survey control available to accurately establish the scale of the latter, as opposed to the earlier, photographs; differences in the scales of the photographs; and some actual changes in lake water levels.*

and the maintenance of a healthy fishery and other desirable forms of aquatic life, and 2) improving opportunities for water-based recreation.

The local units of government concerned were asked to review a preliminary draft of this report, and comments received as a result of such review were incorporated into the final draft of this report, as appropriate. Accordingly, the lake water quality management plan herein presented should contribute a practical, as well as technically sound, guide for the management of the water quality of Oconomowoc Lake.

Chapter II

PHYSICAL DESCRIPTION

LAKE BASIN AND SHORE CHARACTERISTICS

Oconomowoc Lake is a flow-through lake which lies in two deep glacial depressions. The lake is composed of two basins separated by a bedrock sill. The water depth above the sill averages 3 feet. Basic hydrographic and morphometric data for Oconomowoc Lake are presented in Table 1. About 16 percent of Oconomowoc Lake has a water depth of 5 feet or less, 41 percent has a water depth of between 5 and 40 feet, and 43 percent of the lake has a water depth of more than 40 feet. The mean depth is about 30 feet and the maximum depth is about 62 feet. Oconomowoc Lake is 1.9 miles long and about 1.2 miles wide at its widest point. The major axis of the lake basin lies in a northeast-southwest direction. Oconomowoc Lake has a volume of approximately 23,099 acre-feet, and a surface area of about 804 acres. The lake has a shoreline length of 7.0 miles, with a shoreline development factor of 1.79, indicating that the shoreline is about 1.8 times as long as that of a circular lake of the same area. The morphometry of the Oconomowoc Lake basin is illustrated on Map 1. Figure 1 presents an aerial photograph of the lake and surrounding shoreline.

WATER CHARACTERISTICS

The drainage area directly tributary to Oconomowoc Lake—that is, that area which drains directly to the lake rather than draining to the lake through the Oconomowoc River—is 2,020 acres, or 3.2 square miles, in extent, and is shown in Figure 1. The total drainage area to the lake, including the area drained by the Oconomowoc River, is 48,332 acres, or 75.5 square miles, in extent, and is shown on Map 2. Oconomowoc Lake has a watershed-to-lake area ratio of 2.5 if only the direct drainage area is considered. The lake has a much higher watershed-to-lake area ratio—60.1—if the total drainage area is considered.

The Oconomowoc River is the major inlet and outlet. It enters the lake on the north shore through a natural channel. The Oconomowoc River leaves Oconomowoc Lake through a natural channel approximately 4,000 feet west of the inlet, where it flows north and west toward the City of Oconomowoc and into Fowler Lake. Further, there are numerous springs along the shoreline which flow into the lake. There is a control structure located approximately 1,000 feet downstream of where the Oconomowoc River leaves the lake, which is used to regulate the lake levels.

Table 1

HYDROLOGY AND MORPHOMETRY OF OCONOMOWOC LAKE: 1980

Parameter	Measurement
Size	
Area of Lake	804 acres
Area of Total Drainage Area	48,332 acres
Area of Direct Tributary Drainage Area	2,020 acres
Lake Volume	23,099 acre-feet
Residence Time[a]	0.53 year
Shape	
Length of Lake	1.9 miles
Length of Shoreline	7.0 miles
Width of Lake	1.2 miles
Shoreline Development Factor[b]	1.8
Depth	
Area of Lake Less than 5 Feet	16 percent
Area of Lake 5 to 40 Feet	41 percent
Area of Lake More than 40 Feet	43 percent
Mean Depth	30 feet
Maximum Depth	62 feet

[a] *The "residence time" is estimated as the time period required for the full volume of the lake to be replaced by inflowing waters during a year of normal precipitation. The residence time of the smaller basin of Oconomowoc Lake is likely to be at least as long as the larger basin because of the presence of a bedrock sill which significantly reduces the exchange of water between the two basins.*

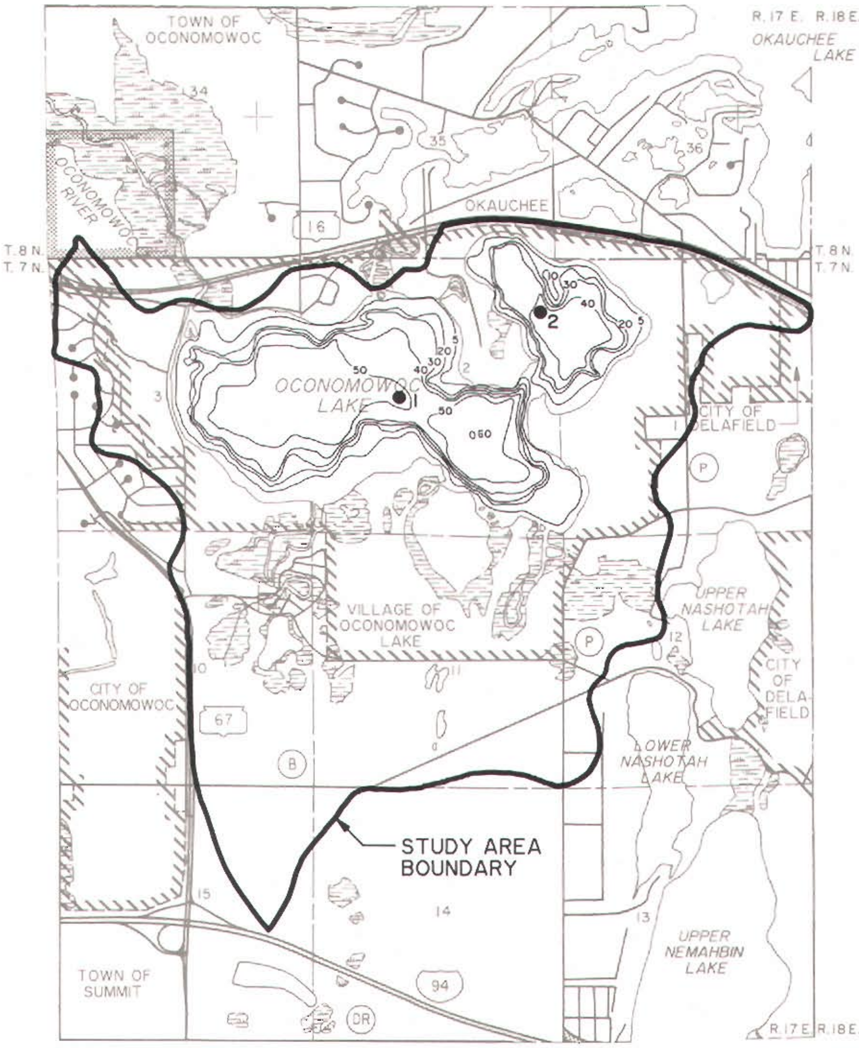
[b] *The shoreline development factor is the ratio of the shoreline length to that of a circular lake of the same area.*

Source: *Wisconsin Department of Natural Resources and SEWRPC.*

The predominant types of bottom substrate material in Oconomowoc Lake are sand, gravel, and marl. Aquatic plant growths on these bottom substrate types are typically limited; thus, the bottom substrates help prevent nui-

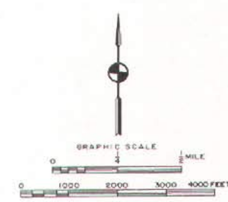
Map 1

HYDROGRAPHIC AND MORPHOMETRIC MAP OF, AND WATER QUALITY SAMPLNG SITES FOR, OCONOMOWOC LAKE



LEGEND

● WATER QUALITY SAMPLING SITE



Source: SEWRPC.

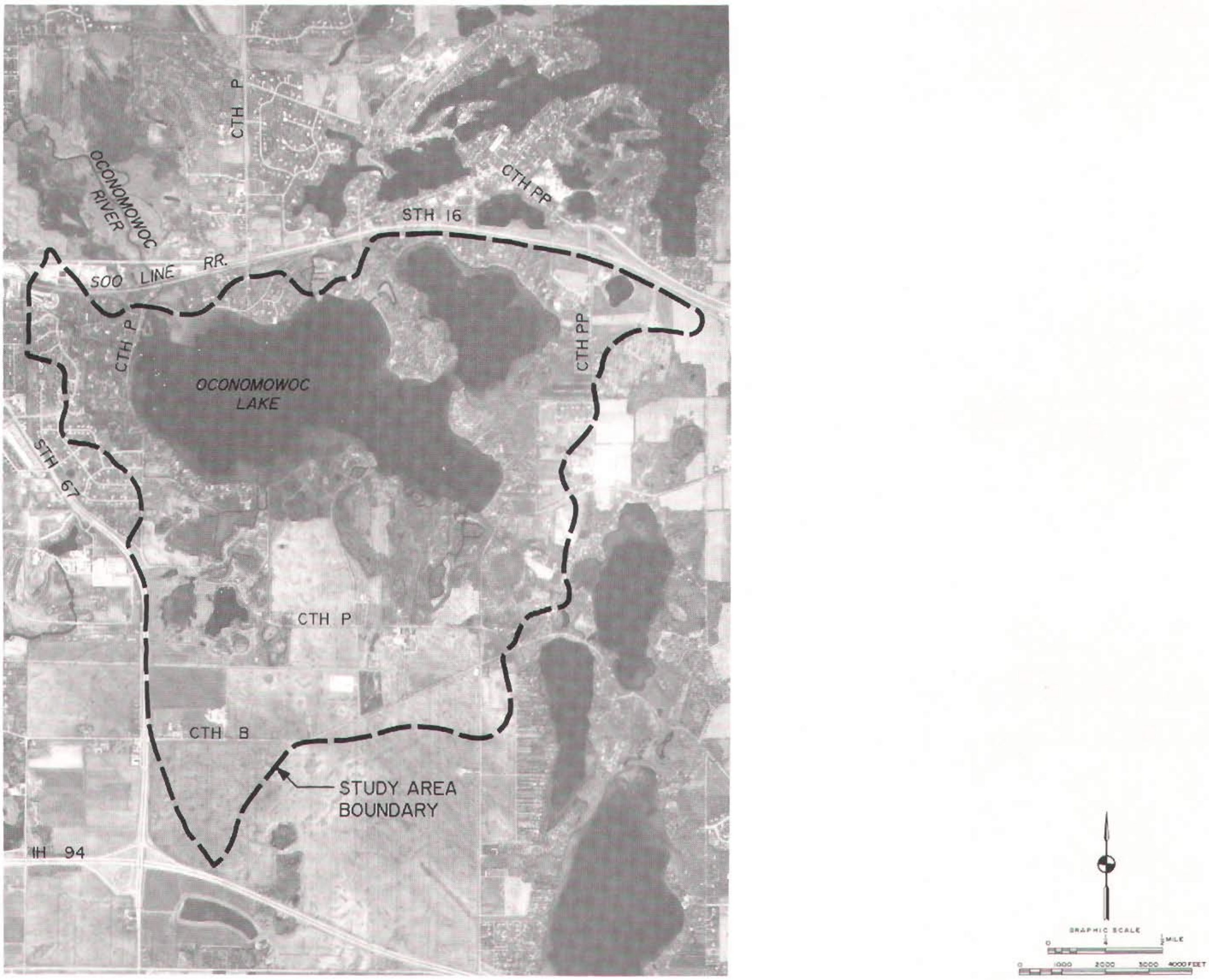
sance plant growths. The abundance of natural sand and gravel beach areas also provides excellent swimming opportunities. The bottom substrate types therefore influence both the character and use of Oconomowoc Lake.

Climate and Hydrology

Long-term average monthly air temperature and precipitation values for the Oconomowoc area are set forth in Table 2. These averages were taken from official National Oceanic and Atmospheric Administration (NOAA) records for the recording weather station located at Oconomowoc. The records of this station may be considered typical of the Oconomowoc Lake area. Table 2 also sets forth stormwater runoff values derived from U. S. Geological Survey (USGS) flow records for the Rock River at Afton—Jefferson County, Wisconsin—downstream of the confluence of the Oconomowoc and Rock Rivers. The mean annual temperature of 46.6°F at Oconomowoc is quite similar to that of other recording locations in southeastern Wisconsin. The mean annual precipitation at Oconomowoc is 29.60 inches, also quite similar to that of other recording locations. More than half the normal yearly precipitation falls during the growing season, from May to September. Runoff rates are generally low during this period, since evapotranspiration rates are high, vegetative cover is good, and soils are not frozen. Normally, less than 15 percent of the summer precipitation is expressed as surface runoff, but intense summer storms occasionally produce higher runoff fractions. Approximately 25 percent of the annual precipitation occurs during the winter or early spring when the ground is frozen, resulting in high surface runoff during those seasons.

Figure 1

AERIAL PHOTOGRAPH OF THE OCONOMOWOC LAKE DIRECT TRIBUTARY DRAINAGE AREA: 1985

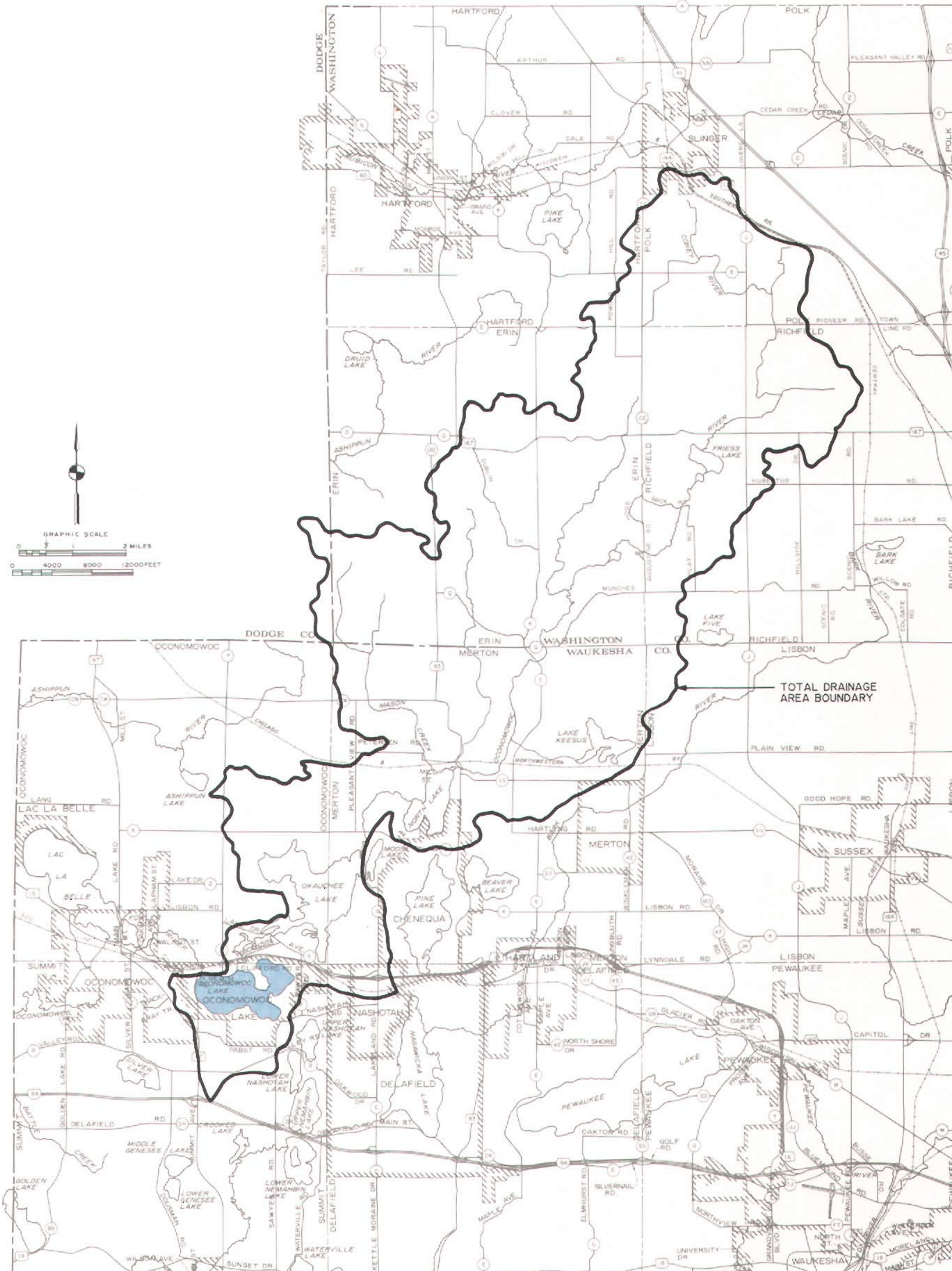


Source: SEWRPC.

The 12-month period over which the water quality sampling program for the Oconomowoc Lake study was carried out—May 1976 through April 1977—was a period of average temperatures and extreme drought in southeastern Wisconsin, as indicated in Table 2. Temperatures were generally below normal during the early winter of 1976, above normal in the spring of 1977, and about normal for the remainder of the study period. Precipitation at Oconomowoc during the sampling period was about 19.45 inches, or 34 percent below normal, with the greatest decrease from the averages occurring in July through December 1976. Nine of the 12 months of the study period—all months except January and February 1976 and March 1977—experienced below-normal amounts of precipitation. Groundwater levels were substantially reduced by this drought, and these reduced groundwater levels were, in turn, reflected in the below-normal flow levels in the Rock River. At Afton, Wisconsin, the flow of the Rock River during the study period was 56 percent below normal. Therefore, during the study period, the hydrologic regime of the lake was significantly affected by the drought period.

Map 2

THE TOTAL DRAINAGE AREA TO OCONOMOWOC LAKE
INCLUDING THAT PORTION DRAINED BY THE OCONOMOWOC RIVER



Source: SEWRPC.

Table 2

LONG-TERM AND 1976-1977 STUDY YEAR CLIMATOLOGICAL AND RUNOFF DATA FOR THE OCONOMOWOC LAKE AREA

Climatological Data	Long-Term Average Monthly Values												
	May	June	July	August	September	October	November	December	January	February	March	April	Annual
Mean Monthly Air Temperature—°F (Oconomowoc, 1954-1977)	58.1	67.3	72.1	70.3	61.8	51.2	36.8	23.5	16.9	22.0	32.2	46.9	46.6
Mean Monthly Precipitation—Inches (Oconomowoc, 1954-1977)	3.03	3.77	3.89	3.67	3.54	2.33	1.78	1.34	0.95	0.81	1.7	2.79	29.60
Mean Runoff—Inches (Rock River at Afton, 1914-1978)	0.85	0.56	0.45	0.34	0.37	0.41	0.45	0.46	0.42	0.46	1.14	1.36	7.27

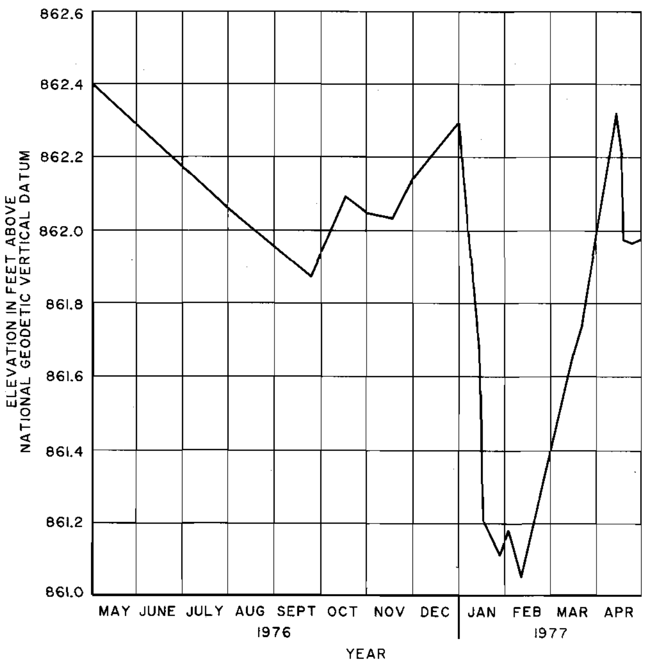
Climatological Data	Study Period Average Monthly Values												
	1976								1977				
	May	June	July	August	September	October	November	December	January	February	March	April	Annual
Mean Monthly Air Temperature—°F (Oconomowoc)	53.9	68.0	72.8	68.6	58.6	44.0	28.1	12.7	2.4	19.3	39.5	51.7	43.3
Departure from Normal Monthly Mean Air Temperature—°F (Oconomowoc)	-4.2	0.7	0.7	-1.7	-3.2	-7.0	-8.7	-10.8	-14.5	-2.7	7.3	4.6	-3.3
Precipitation—Inches (Oconomowoc)	3.32	2.23	1.80	1.86	0.44	1.91	0.39	0.29	0.63	0.49	3.48	2.61	19.45
Departure from Normal Precipitation—Inches (Oconomowoc)	0.29	1.54	-2.09	-1.81	-3.1	-0.42	-1.39	-1.05	-0.32	-0.32	1.78	-0.18	-10.15
Runoff—Inches (Rock River at Afton) . . .	1.31	0.37	0.18	0.18	0.15	0.16	0.19	0.17	0.17	0.15	0.42	0.65	4.10
Departure from Normal Runoff—Inches (Rock River at Afton) . . .	0.46	-0.19	-0.27	-0.16	-0.22	-0.25	-0.26	-0.29	-0.25	-0.31	-0.72	-0.71	-3.17

Source: National Oceanic and Atmospheric Administration, U. S. Geological Survey, and Wisconsin Department of Natural Resources.

The water level of Oconomowoc Lake is primarily determined by the rate of inflow and outflow of the Oconomowoc River. As established by the Wisconsin Department of Natural Resources, the level of the lake is to be maintained at an elevation ranging from 861.60 to 860.27 feet National Geodetic Vertical Datum (NGVD). The drought had little apparent effect on the water level of Oconomowoc Lake, as the control structure on the lake outlet permitted dam operators to maintain a fairly stable lake level during the study period. Lowered lake levels during the winter were the result of a drawdown to prevent ice damage to shorelines during the spring thaw. As set forth in Figure 2, the lake level dropped from an elevation of 862.40 feet NGVD in May 1976, to an elevation of 861.87 feet in September 1976, prior to winter drawdown. Above-average precipitation, snowmelt, and groundwater inflow raised the level of the lake to an elevation of 862.31 feet NGVD during the spring of 1977.

Figure 2

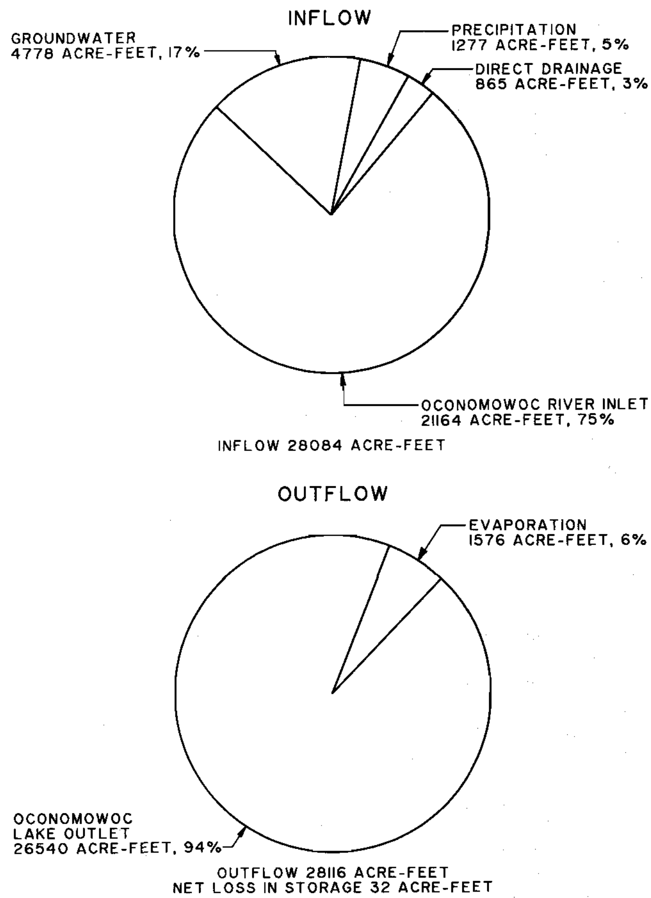
LAKE LEVEL FLUCTUATIONS FOR OCONOMOWOC LAKE: MAY 1976-APRIL 1977



Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 3

HYDROLOGIC BUDGET FOR OCONOMOWOC LAKE: MAY 1976-APRIL 1977

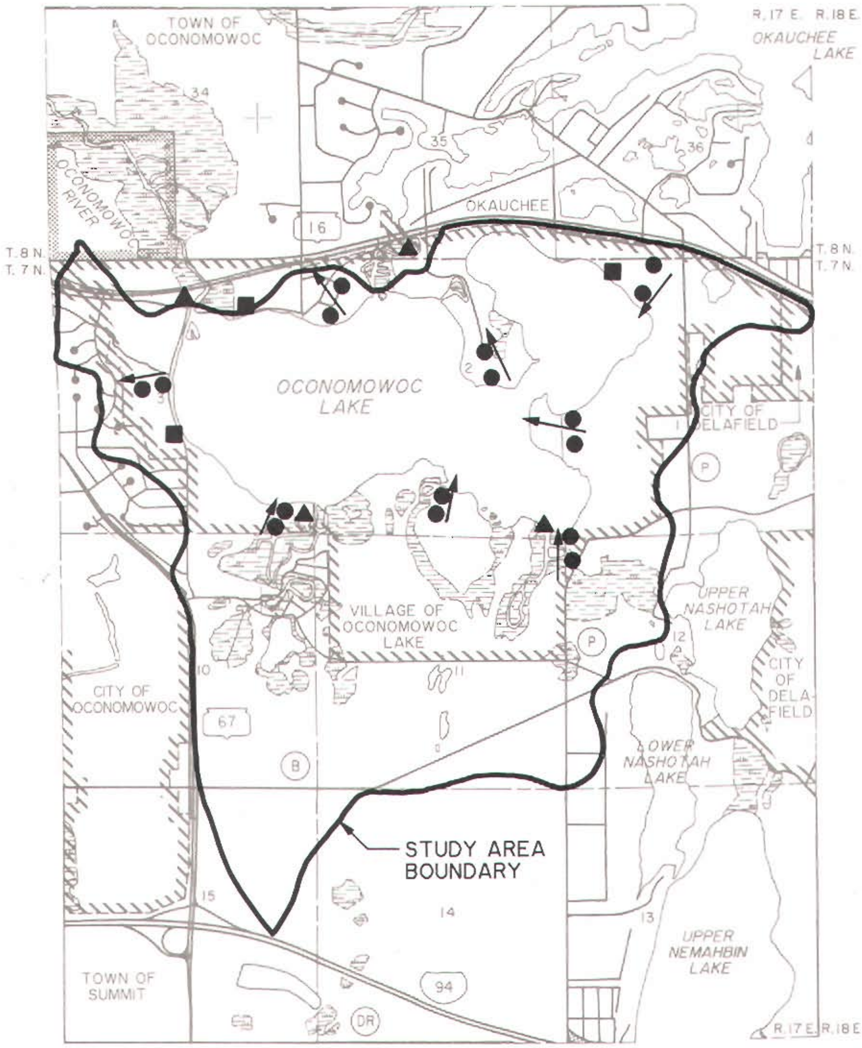


Source: Wisconsin Department of Natural Resources and SEWRPC.

A water budget for Oconomowoc Lake was computed from estimated precipitation, inflow from the Oconomowoc River, inflow from springs along the shoreline, direct tributary surface runoff, groundwater inflow and outflow, and outflow through the Oconomowoc River. This budget is set forth in Figure 3, along with pertinent evaporation, transpiration, and lake level data. During the year of the study, it was estimated that 28,084 acre-feet of water entered the lake. Of this total, about 21,164 acre-feet, or 76 percent, was contributed by inflow from the Oconomowoc River; about 4,778 acre-feet, or 16 percent, was contributed by groundwater; about 1,277 acre-feet, or 5 percent, was contributed by precipitation; and about 865 acre-feet, or 3 percent, was contributed by runoff from the direct drainage area. Of the total water output from Oconomowoc Lake of 28,116 acre-feet, about 26,540 acre-feet, or 93 percent, was discharged via the Oconomowoc River, and about 1,576 acre-feet, or 6 percent, evaporated from the surface of the lake. There was a net reduction of 32 acre-feet, or 1 percent, in the volume of water stored in the lake as a consequence of below-normal precipitation during the study period.

Eight pairs of groundwater level observation and groundwater quality sampling wells, located as shown on Map 3, were used to measure the direction and flow of groundwater around Oconomowoc Lake. At most of the sampling wells, the groundwater was observed to flow toward the lake. Groundwater flow for wells on the northwestern shore and on Hewitt Point, which is located on a peninsula on the northern shore, was generally away from the lake. The quality of the groundwater was also measured at these wells. It should be noted that low groundwater levels during the study period may have had an effect on the flow and quality observed at the test wells.

Map 3 also shows the location of outfalls from known storm sewers and drainage ditches discharging to the lake. There were three known

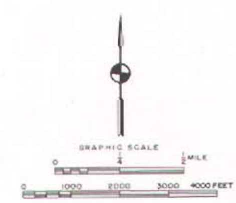


Map 3

LOCATION OF GROUNDWATER SAMPLING WELLS AND SURFACE DRAINAGE DISCHARGES AROUND OCONOMOWOC LAKE: MAY 1976-APRIL 1977

LEGEND

- ● OBSERVATION WELLS
- ■ SURFACE DRAINAGE DISCHARGE SITES
- ▲ INLET AND OUTLET SAMPLING STATIONS
- ← DIRECTION OF GROUNDWATER FLOW



Source: Wisconsin Department of Natural Resources and SEWRPC.

outfalls discharging surface water runoff at discrete locations to Oconomowoc Lake. The volume of water discharged from these outfalls was included in the direct tributary surface water volumes presented above.

The hydraulic residence time is important in determining the expected response time of the lake to increased or reduced nutrient and other pollutant loadings. The hydraulic residence time for Oconomowoc Lake during the study period of May 1976 through April 1977, which was, as already noted, a year of below-average precipitation, was approximately 0.8 year. During a year of average climatological conditions, the hydraulic residence time may be expected to approximate 0.5 year.

Soil Type and Conditions

Soil composition and slope, together with vegetative cover and management, are important factors affecting the rate, amount, and quality of stormwater runoff, and therefore of the receiving lake's water quality. Accordingly, data on soil types in the drainage area directly tributary to Oconomowoc Lake were collated from detailed soil surveys prepared for the Commission by the U. S. Soil Conservation Service, and analyzed in terms of the associated hydrologic characteristics. Also assessed were soil erodibility, and the limitations of the soils for use of onsite sewage disposal systems. These assessments were then used to identify areas of incompatible land use and management in the drainage area directly tributary to the lake.

Table 3

GENERAL HYDROLOGIC SOIL TYPES IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE

Group	Soil Characteristics	Extent (acres)	Percent of Total
A	High infiltration rates Well-drained and excessively drained sandy or gravelly soils High rate of water transmission and low runoff potential	None	- -
B	Moderate infiltration rates Moderately well drained Moderately coarse textures Moderate rate of water transmission	1,775	87.9
C	Slow infiltration rates Moderately fine or fine-textured or layers that impede downward movement of water Slow rate of water transmission	None	- -
D	Very slow infiltration rates Clay soils with high shrink-swell potential; soils with high permanent water table; soils with a clay layer at or near the surface; shallow soils over nearly impervious substrate Very slow rate of water transmission	232	11.5
Made Land	Open pit mining areas, man-made fill areas, dumps and landfills containing widely varying soils and other materials	13	0.6
Total	- -	2,020	100.0

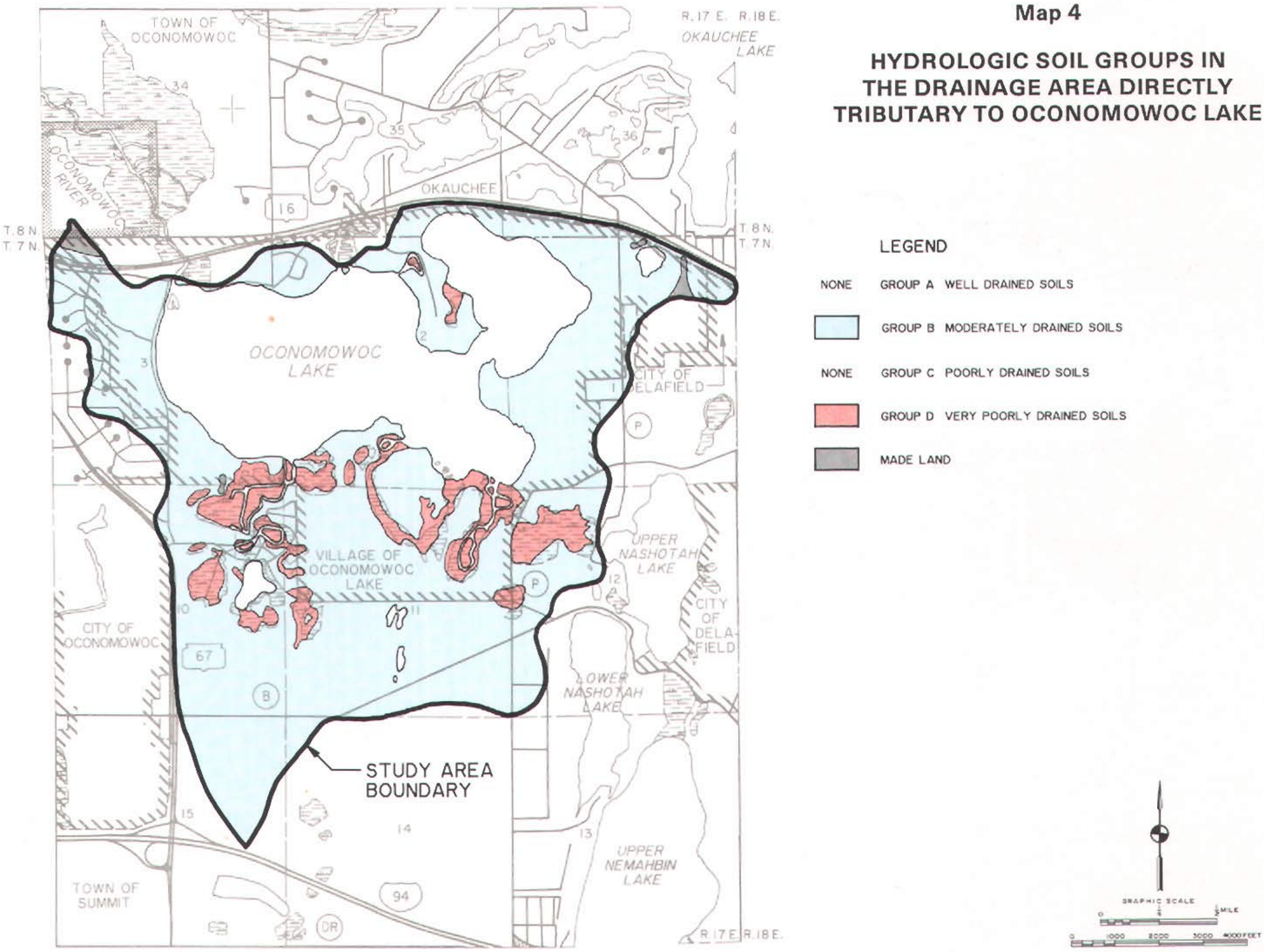
Source: SEWRPC.

Soils within the drainage area of the lake may be categorized into four principal hydrologic groups, as indicated in Table 3. The relative proportion of the total direct drainage area covered by each of these hydrologic soil groups is: Group A, well-drained soils, none; Group B, moderately drained soils, 88 percent; Group C, poorly drained soils, none; and Group D, very poorly drained soils, 11 percent. Approximately 1 percent was classified as made land and gravel pits and could not be categorized. The areal extent of these soils and their locations within the direct drainage area are shown on Map 4. The major soil types present within the direct drainage area are: Casco silt loam, Fox silt loam, Juneau silt loam, Warsaw silt loam, Casco loam, Casco Rodman loam, Houghton muck peat, and Palms muck.

As already noted, the limitations of the soils within the direct drainage area for use of onsite sewage disposal systems was evaluated. The limitations of the soils for such use on residential lots one acre or less in area is indicated on Map 5 according to three major groupings: soils with slight limitations, which cover 60 percent of the direct drainage area; soils with moderate limitations, which cover 15 percent; and soils

Map 4

HYDROLOGIC SOIL GROUPS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE



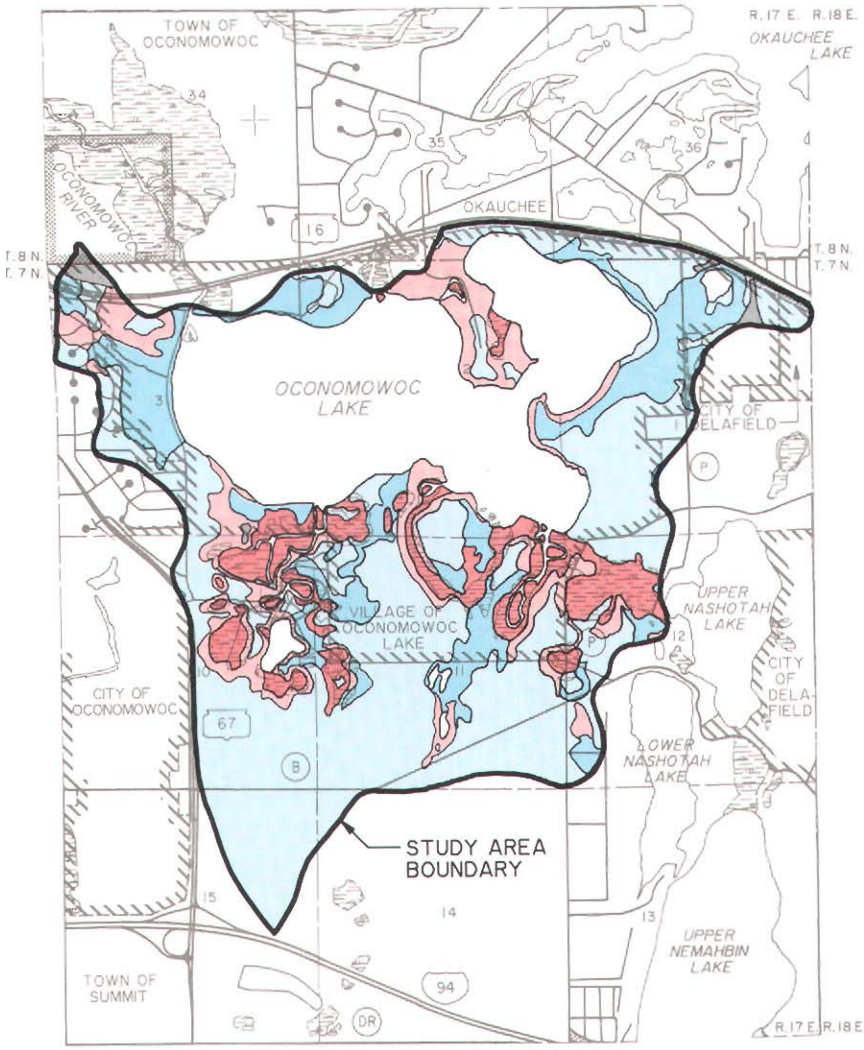
Source: U. S. Department of Agriculture, Soil Conservation Service; and SEWRPC.

with severe or very severe limitations, which cover 24 percent. Approximately 1 percent were classified as made land and gravel pits and could not be categorized. In the direct drainage area of the lake, 59 of the estimated 193 septic systems in use in 1980, or 36 percent, were located on soils having severe or very severe limitations for the use of such systems.

Another consideration important to lake management is the limitation of the soils for land application of residual wastewater treatment sludges. A Commission inventory of sewage sludge management practices within the Region in 1976, which for this watershed was updated in 1984, indicated that such sludges were not being applied in the direct drainage area of the lake. About 22 percent of the direct drainage area, however, is covered by soils having only slight limitations for wastewater sludge application, as shown on Map 6. About 69 percent of the direct drainage area was not rated for sludge application limitations because it was occupied generally by urban land uses, woodlands, or wetlands which would be incompatible with wastewater sludge application. The remaining 9 percent of the area is covered by soils that have moderate or severe limitations for sludge application; any such application in these areas could be detrimental to lake water quality.

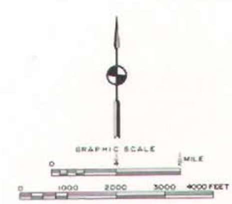
Map 5

SUITABILITY OF SOILS FOR USE WITH ONSITE SEWAGE DISPOSAL SYSTEMS ON LOTS ONE ACRE OR LESS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE



LEGEND

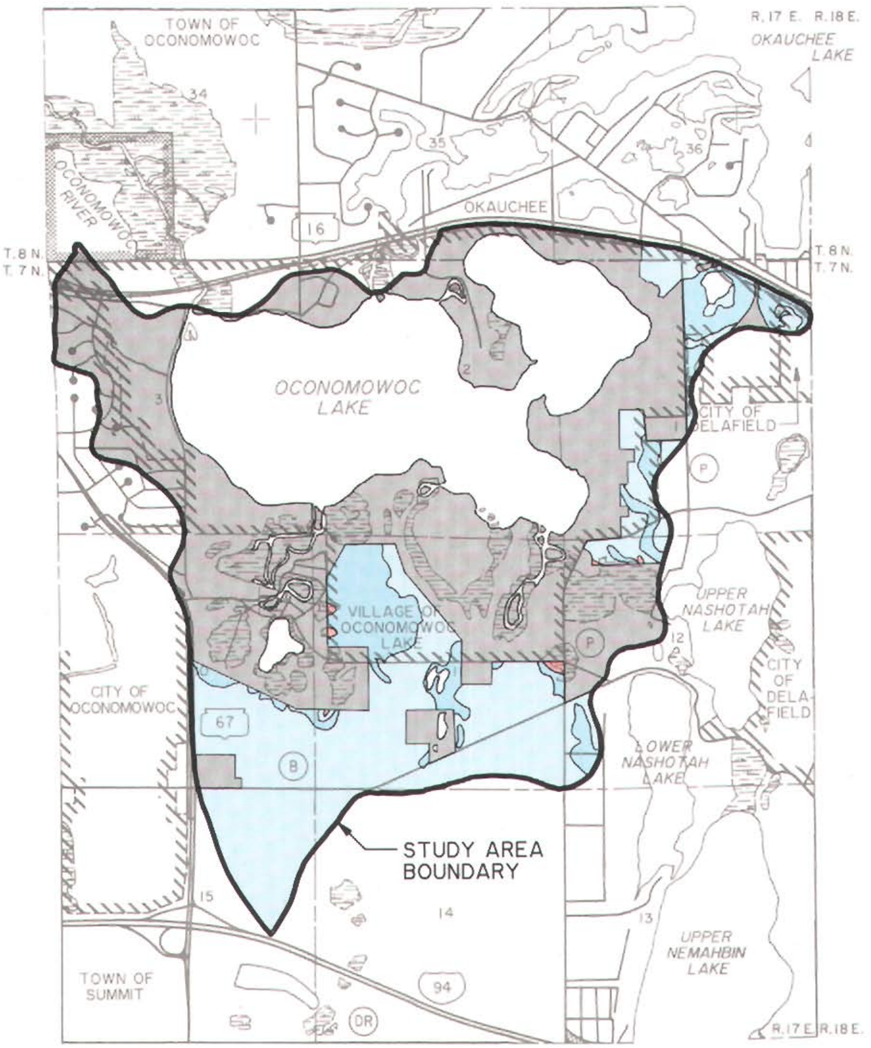
- VERY SEVERE
- SEVERE
- MODERATE
- SLIGHT
- MADE LAND



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

Map 6

SUITABILITY OF SOILS FOR WASTEWATER SLUDGE APPLICATION IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE



Source: *U. S. Department of Agriculture, Soil Conservation Service; and SEWRPC.*

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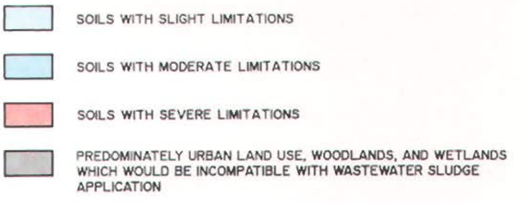

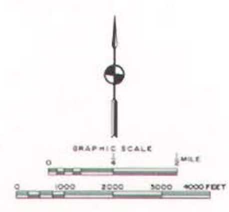

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Chapter III

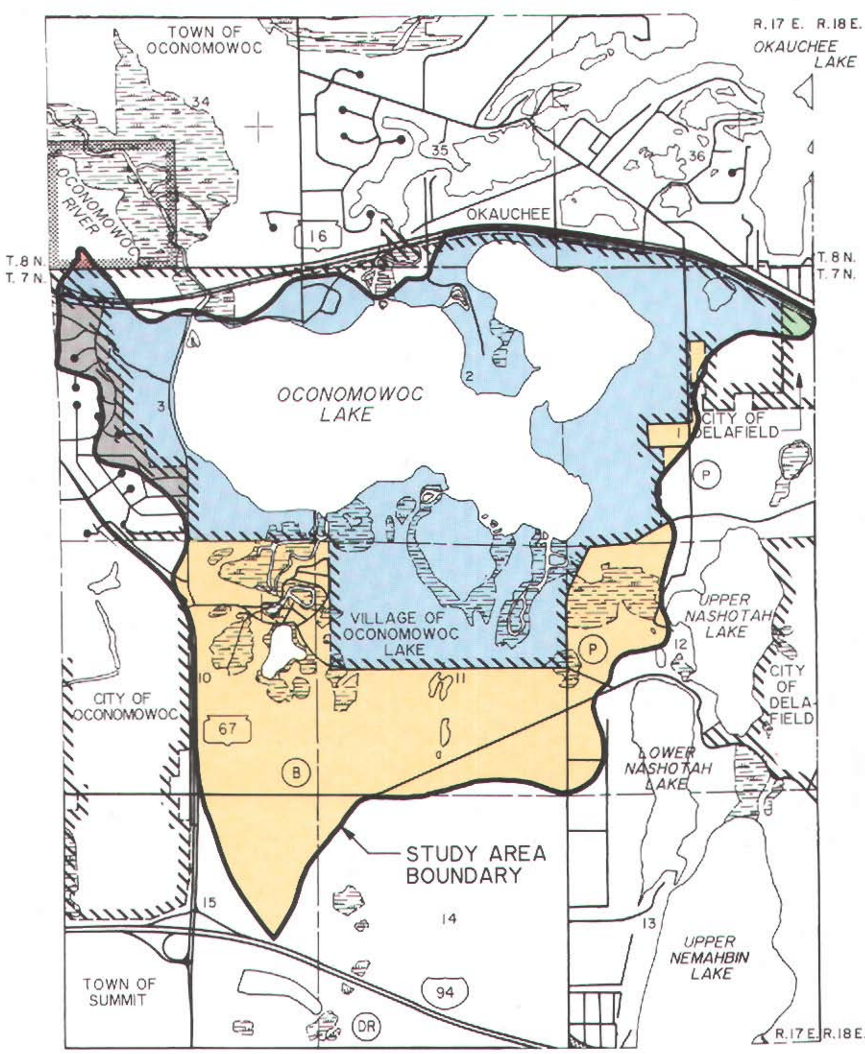
HISTORICAL AND EXISTING LAND USE AND POPULATION

INTRODUCTION

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

The geographic, as well as functional, jurisdictions of minor civil divisions and special-purpose units of government are also important factors which must be considered in a lake water quality management plan, since these local units of government provide the basic structure of the decision-making framework within which environmental problems must be addressed.

Superimposed on the irregular direct drainage area of Oconomowoc Lake are the local civil division boundaries shown on Map 7. Approximately 977 acres, or 48 percent, of the direct drainage area lie within the Village of Oconomowoc Lake; 947 acres, or 47 percent, lie within the Town of Summit; 85 acres, or 4 percent, lie within the City of Oconomowoc; 8 acres, or less



Map 7

CIVIL DIVISION BOUNDARIES IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1984

LEGEND

- VILLAGE OF OCONOMOWOC LAKE
- TOWN OF SUMMIT
- CITY OF OCONOMOWOC
- CITY OF DELAFIELD
- TOWN OF OCONOMOWOC

Source: SEWRPC.

Table 4

HISTORICAL AND FORECAST RESIDENT POPULATION LEVELS OF THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1950-2000

Year	Population
1950	330
1960	500
1970	663
1980	1,038
2000	1,013

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

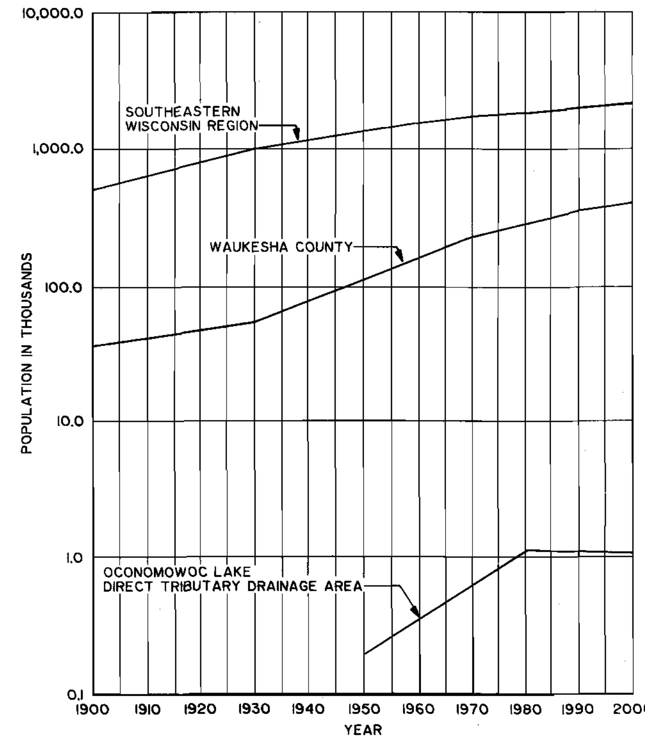
than 1 percent, lie within the City of Delafield; and 3 acres, or less than 1 percent, lie within the Town of Oconomowoc.

POPULATION

As indicated in Table 4, the resident population of the drainage area directly tributary to Oconomowoc Lake has increased steadily since 1950. In 1980 the resident population of the direct drainage area was estimated at 1,038 persons, or more than three times the estimated 1950 population of 330 persons. Population forecasts prepared by the Regional Planning Commission indicate, as shown in Table 4, that the population of the drainage area directly tributary to Oconomowoc Lake may be expected to decrease to about 1,013 persons by the year 2000. A comparison of historical, existing, and forecast population levels for the drainage area directly tributary to Oconomowoc Lake, for Waukesha County, and for the Southeastern Wisconsin Region is provided in Figure 4. Since 1950, the Oconomowoc Lake direct drainage area has experienced a higher rate of increase in resident population than Waukesha County and the Region. However, smaller family size and limited additional residential development in the direct drainage area may be expected to occur over the next two decades, and the population is thus anticipated to decrease slightly from existing levels.

Figure 4

COMPARISON OF HISTORICAL, EXISTING, AND FORECAST POPULATION TRENDS FOR OCONOMOWOC LAKE, WAUKESHA COUNTY, AND THE SOUTHEASTERN WISCONSIN REGION



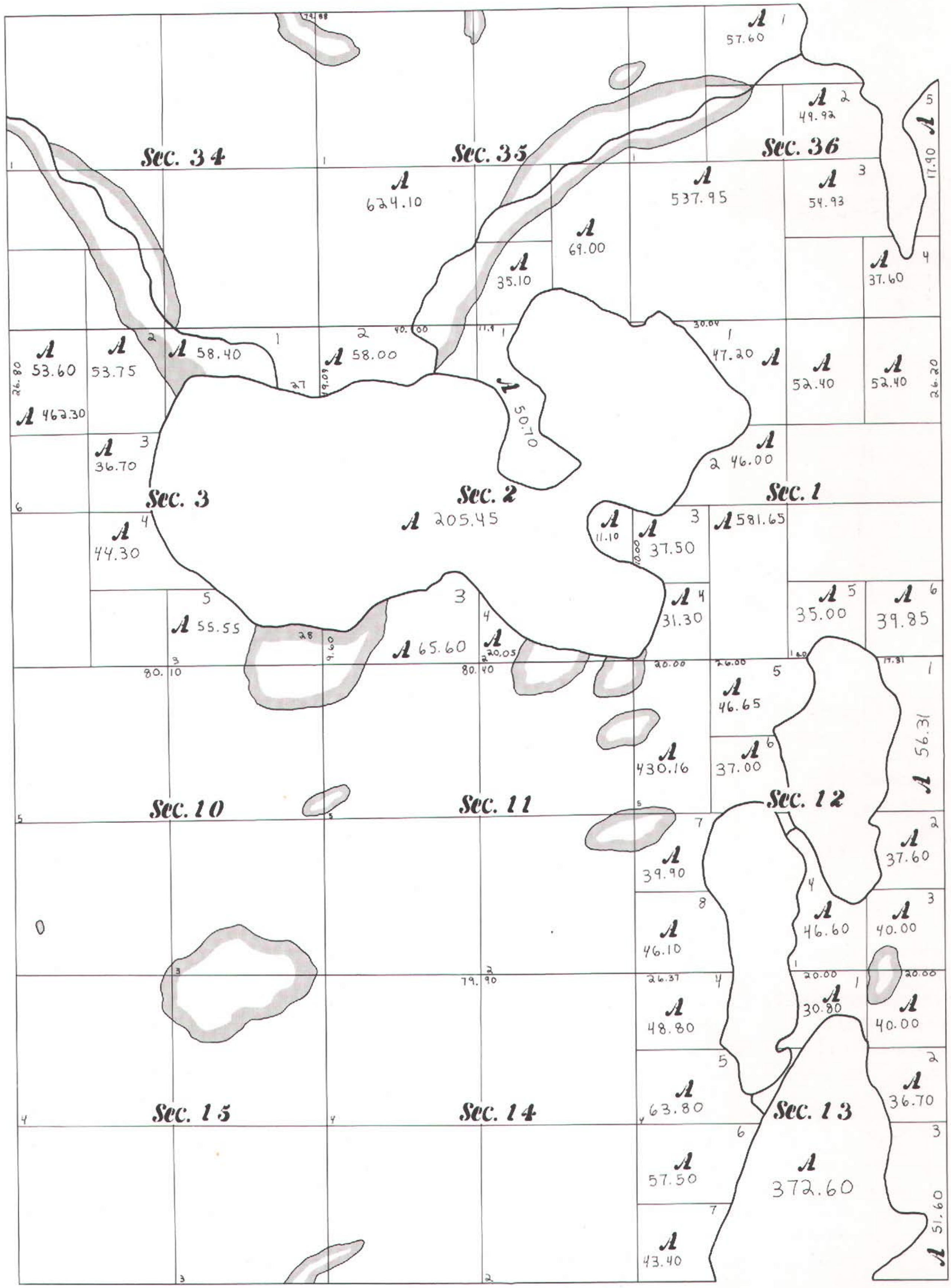
Source: SEWRPC.

LAND USE

The pattern of land use in the drainage area directly tributary to Oconomowoc Lake—that is, the intensity and spatial distribution of the various land uses—is an important determinant of lake water quality. The existing land use pattern can perhaps best be understood within the context of its historical development. The movement of European settlers into the Southeastern Wisconsin Region began in about 1830. Completion of the U. S. Public Land Survey in southeastern Wisconsin in 1836 and the subsequent sale of the public lands brought a rapid influx of settlers into the area. Map 8 shows the original plat of the U. S. Public Land Survey for the Oconomowoc Lake area.

Map 8

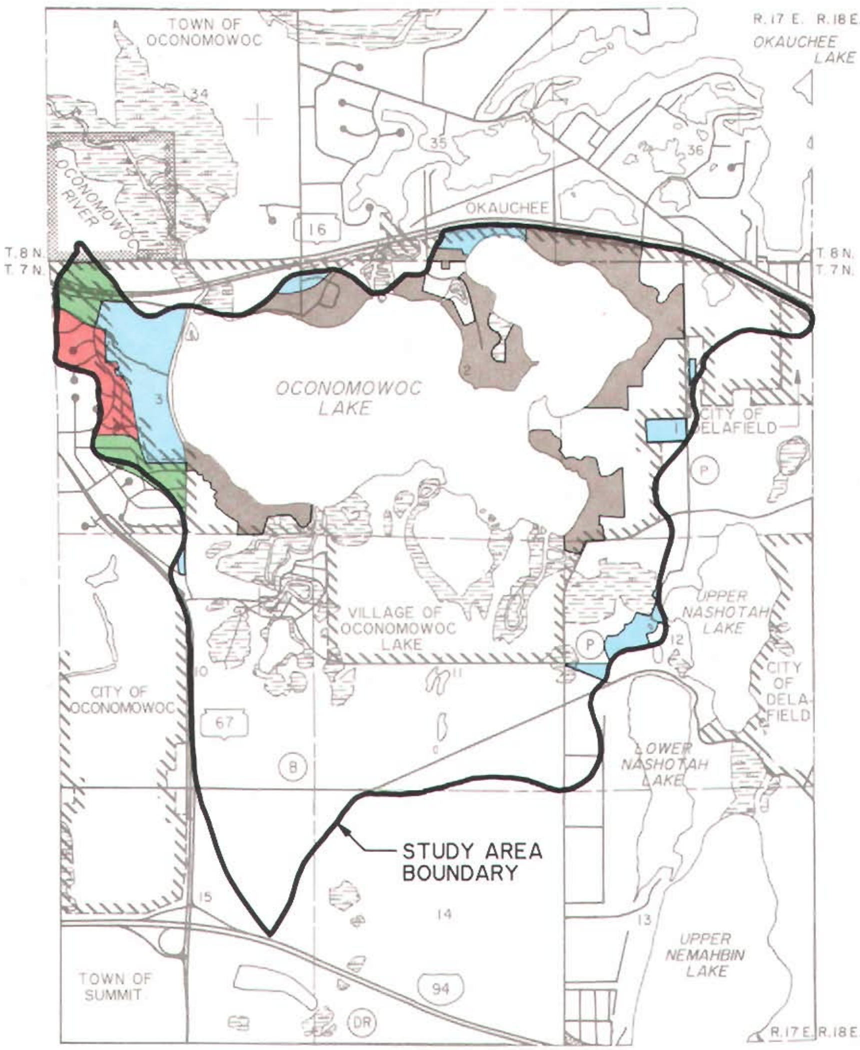
ORIGINAL UNITED STATES PUBLIC LAND SURVEY MAP FOR THE OCONOMOWOC LAKE AREA: 1836



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

Map 9

HISTORIC URBAN GROWTH IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1950-1980



LEGEND

- 1950
- 1963
- 1970
- 1980

Source: SEWRPC.

Significant urban land use development began in the Oconomowoc Lake area in about 1920. Map 9 and Table 5 indicate the historical urban growth pattern in the direct drainage area of the lake since 1950. The largest increases in the amount of land converted to urban use occurred between 1950 and 1963.

The existing land use pattern in the drainage area directly tributary to Oconomowoc Lake as of 1980 is shown on Map 10, and the existing land uses are quantified in Table 6. As indicated in Table 6, in 1980 about 1,375 acres, or 68 percent, of the total direct drainage area were still in various rural land uses, with the dominant rural land use being agricultural, encompassing 869 acres, or 43 percent, of the direct drainage area. Other rural land uses—water, wetlands, woodlands, and open lands—comprised 506 acres, or 25 percent, of the direct drainage area. Urban land uses, consisting of residential, commercial, governmental and institutional, transportation, and recreational land uses, encompassed about 645 acres, or 32 percent, of the direct drainage area, with residential being the dominant urban land use, comprising 447 acres, or 22 percent, of the direct drainage area. Commercial, industrial, governmental and institutional, transportation, communication and utilities, and recreational land uses combined comprised 198 acres, or about 10 percent of the direct drainage area.

Table 5

EXTENT OF HISTORIC URBAN GROWTH IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1950-1980

Year	Extent of Urban Development (acres)[a]
1950	236
1963	378
1970	423
1980	470

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

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

Table 6

EXISTING LAND USE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1980

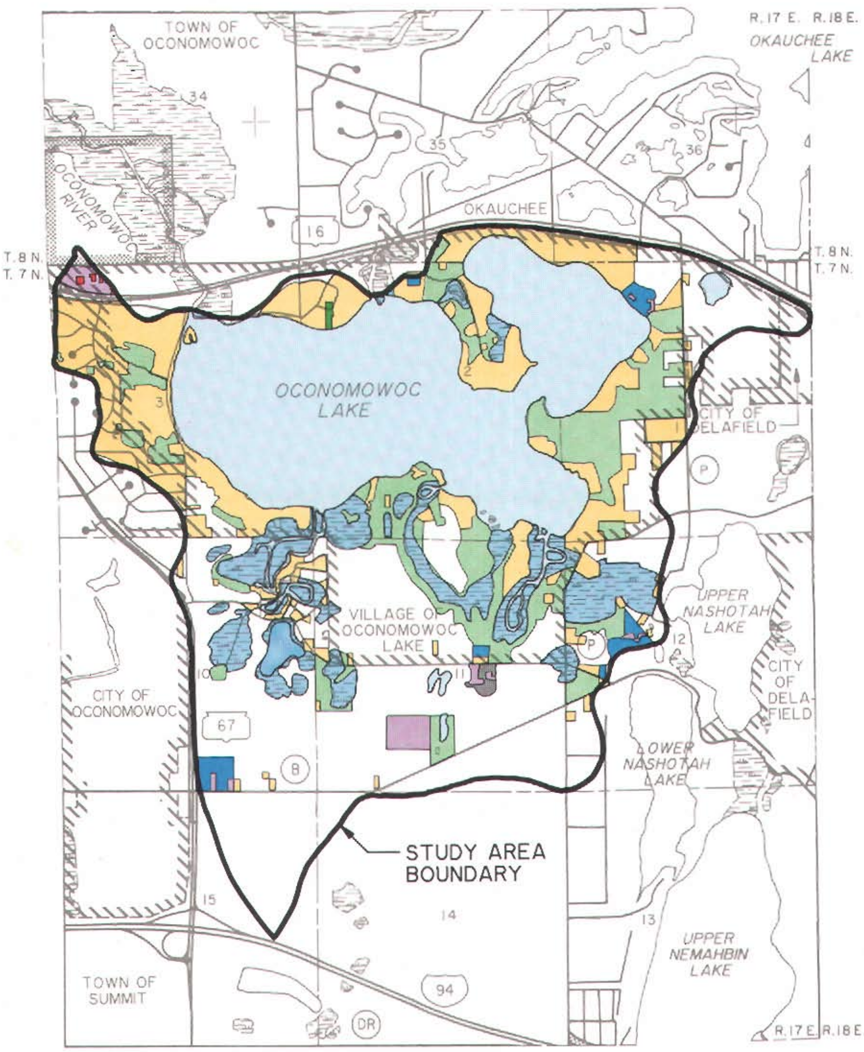
Land Use Category	Acres	Percent of Major Category	Percent of Study Area
Urban			
Residential	447	69.3	22.2
Commercial	7	1.1	0.3
Industrial	6	0.9	0.3
Governmental and Institutional	39	6.1	1.9
Transportation, Communications, and Utilities	144	22.3	7.1
Recreational	2	0.3	0.1
Urban Total	645	100.0	31.9
Rural			
Agricultural and Other Open Lands	869	63.2	43.0
Water[a]	30	2.2	1.5
Wetlands	248	18.0	12.3
Woodlands	228	16.6	11.3
Rural Total	1,375	100.0	68.1
Study Area Total	2,020	- -	100.0

[a]*Excludes the surface area of Oconomowoc Lake.*

Source: SEWRPC.

Map 10

EXISTING LAND USE IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1980



LEGEND

- RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- GOVERNMENTAL AND INSTITUTIONAL
- COMMUNICATION, TRANSPORTATION AND UTILITIES
- RECREATION
- WETLAND
- WOODLAND
- WATER
- AGRICULTURAL AND OPEN SPACE

Source: SEWRPC.

Chapter IV

WATER QUALITY

HISTORICAL DATA

Some data predating that provided by the 1976 to 1977 study of the water quality and biota of Oconomowoc Lake are available and were collated for this study. Most of these data, however, are relatively recent. Limnological studies of Oconomowoc Lake date back to the early 1900's, when E. A. Birge and C. W. Juday, widely recognized lake researchers, collected basic information on the lake.[1] In addition, R. J. Poff and C. W. Threinen assessed water quality conditions in Oconomowoc Lake in the early 1960's.[2] Other sources of historical water quality conditions in Oconomowoc Lake include miscellaneous data files and reports of the Wisconsin Department of Natural Resources. Selected historical water quality data for Oconomowoc Lake and the Oconomowoc River are set forth in Tables 7 and 8.

PHYSICAL AND CHEMICAL CHARACTERISTICS

The water quality of Oconomowoc Lake was monitored periodically during the May 1976 to April 1977 study period. The data collected were used to determine the condition of the lake and to characterize its suitability for recreational use and the support of fish and aquatic life. The primary station for most sampling activities was located at the deepest point in the lake. Water quality samples were taken in a vertical profile every two weeks from June through September, and monthly during the rest of the year. Monthly temperature and dissolved oxygen profiles taken at this station are shown in Figure 5. Water temperatures ranged from a minimum of 34°F (1°C) during the winter to a maximum of 78.8°F (26°C) during the summer.

Complete mixing of the lake is restricted by thermal stratification during the summer, and by ice cover during the winter. Thermal stratification is a result of differential heating of the lake water and of water temperature density relationships. Water is unique among liquids in that it reaches its maximum density—weight per unit volume—at about 39°F. As summer begins, the lake absorbs the sun's energy at the surface. Wind action and, to some extent, internal heat transfer transmit some of this energy to the underlying waters. As the surface of the water is heated by the sun's energy, however, a barrier begins to form between the upper, lighter, warmer water and the lower, heavier, colder water as shown in Figure 5-E for the month of June 1976. This "barrier" is marked by a sharp temperature gradient known as the metalimnion, or thermocline, which separates the warmer, lighter, upper layer of water—called the epilimnion—from the cooler, heavier, lower layer—called the hypolimnion. Although this barrier is easily crossed by fish, it essentially blocks the exchange of water between the two layers, a condition which, as will be discussed later, has important impacts on both chemical and biological conditions and activities in the lake. The development of the thermocline, which begins in early summer, reaches its maximum in late summer. This stratification period lasts until the fall, when air temperatures cool the surface water and wind action results in erosion of the thermocline.

As the surface water cools, it becomes heavier, sinking and displacing the warmer water below. The colder water sinks and mixes under wind action to erode the thermocline until the entire column of water is of uniform temperature, as indicated in Figure 5-II for the month of December 1976. This action, which follows summer stratification, is known as fall turnover. When the water temperature drops below 39°F, the upper layer of water again becomes lighter and "floats" near the surface. Eventually, the water near the surface is cooled to 32°F, at which time ice begins to form and cover the lake surface,

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[1] *E. A. Birge and C. W. Juday, "The Dissolved Cases of the Water and Their Biological Significance,"* The Inland Lakes of Wisconsin, *Wisconsin Geological Natural History Survey, Bulletin No. 22, 1911.*

[2] *R. J. Poff and C. W. Threinen,* Surface Water Resources of Waukesha County, *Wisconsin Conservation Department, 1963.*

Table 7

WATER QUALITY CONDITIONS OF OCONOMOWOC LAKE: 1973-1975, 1979

Water Quality Parameter[a]	1973		1973-1974		1974					
	Fall		Winter		Spring		Summer		Fall	
	Main Basin	Upper Basin	Main Basin	Upper Basin	Main Basin	Upper Basin	Main Basin	Upper Basin	Main Basin	Upper Basin
Nitrite Nitrogen	0.018	0.007	0.006	0.002	0.013	0.009	0.019	0.018	0.048	0.006
Nitrate Nitrogen	0.112	0.065	0.197	0.37	0.31	0.30	0.363	0.14	0.12	0.20
Ammonia Nitrogen	0.285	0.03	0.083	- -	0.14	0.06	0.119	0.10	0.195	0.035
Organic Nitrogen	0.524	0.5	0.063	0.117	0.96	0.71	0.77	0.935	0.69	0.75
Total Nitrogen	0.884	0.58	0.33	0.477	1.42	1.065	1.252	1.188	1.055	0.987
Phosphate Phosphorus	0.03	0.021	0.011	0.02	0.02	0.014	0.017	0.01	0.054	0.138
Total Phosphorus	0.036	0.038	0.027	0.04	0.036	0.04	0.02	0.04	0.06	0.06
Specific Conductance (micromhos/cm)	440.6	430.5	433.0	471.0	453.0	446.5	468.3	402.0	476.5	476.5
Sulfate	31.8	34.0	36.0	39.7	36.3	39.5	39.1	40.5	34.0	36.0
Chloride	12.2	13.7	13.7	12.3	13.3	13.5	15.3	14.5	14.0	13.0
pH (standard units)	8.0	8.4	8.1	8.0	8.2	8.3	8.3	8.5	8.2	8.4
Alkalinity	200.2	187.75	202.7	220.7	213.0	208.0	209.7	176.0	206.0	205.5
Turbidity (formazin units)	1.2	2.6	1.53	1.40	0.777	1.45	1.515	1.65	1.7	1.3
Calcium	48.8	55.5	44.3	48.0	100.7	52.0	54.1	64.0	78.0	87.5
Magnesium	37.2	40.3	27.0	30.0	49.3	27.5	43.6	52.0	44.0	44.0
Sodium	6.1	6.275	8.0	6.7	12.3	5.5	7.1	17.0	10.5	10.5
Potassium	2.86	2.4	0.5	0.7	2.13	3.2	2.59	0.85	3.45	3.4
Iron	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Manganese	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Water Quality Parameter[a]	1974-1975		1975					1979	
	Winter		Spring		Summer		Fall	Winter	Spring
	Main Basin	Upper Basin	Main Basin	Upper Basin	Main Basin	Upper Basin	Main Basin	Upper Basin	Main Basin
Nitrite Nitrogen	0.011	0.007	0.038	0.018	0.003	0.002	0.001	0.004	0.004
Nitrate Nitrogen	0.192	0.275	0.62	0.615	0.43	0.10	0.205	0.43	0.343
Ammonia Nitrogen	0.134	0.115	0.315	0.05	0.03	0.03	0.03	0.11	0.033
Organic Nitrogen	0.468	0.34	0.765	0.80	0.41	0.465	0.65	0.55	0.233
Total Nitrogen	0.804	0.70	1.745	1.475	0.81	0.545	0.845	1.09	0.61
Phosphate Phosphorus	0.025	0.029	0.036	0.01	0.009	0.005	0.012	0.023	0.005
Total Phosphorus	0.024	0.01	0.045	0.055	0.02	0.01	0.025	0.03	0.017
Specific Conductance (micromhos/cm)	471.8	513.0	458.0	374.0	474.3	415.5	419.0	588.0	566.0
Sulfate	38.6	40.5	42.0	26.5	34.7	34.0	37.5	- -	- -
Chloride	14.4	13.5	13.0	10.5	13.0	13.0	13.0	18.0	16.3
pH (standard units)	8.2	8.3	8.2	8.4	8.1	8.6	8.0	8.0	8.1
Alkalinity	207.8	219.0	202.5	161.0	205.7	182.5	190.0	220.0	206.7
Turbidity (formazin units)	1.6	1.35	1.8	2.25	2.93	1.7	2.15	1.23	1.47
Calcium	48.2	74.0	46.0	39.5	77.3	56.0	40.5	50.3	51.3
Magnesium	39.0	50.5	33.5	24.5	50.0	44.0	36.5	40.0	35.0
Sodium	5.8	5.5	8.5	5.0	12.3	10.0	15.0	7.7	6.33
Potassium	1.82	1.8	4.25	2.35	3.83	6.1	10.25	2.2	1.73
Iron	0.105	- -	- -	- -	0.38	0.485	0.12	0.08	0.08
Manganese	0.03	- -	- -	- -	0.53	0.06	0.045	0.04	0.03

[a]All values reported in mg/l unless otherwise specified.

Source: Wisconsin Department of Natural Resources.

Table 8

WATER QUALITY CONDITIONS OF THE OCONOMOWOC LAKE INLET AND OUTLET: 1973-1975

Water Quality Parameter[a]	1973	1974				1974-1975	1975	
	Fall	Spring	Summer		Fall	Winter	Spring	Summer
	Inlet	Inlet	Inlet	Outlet	Inlet	Inlet	Inlet	Inlet
Nitrite Nitrogen	0.002	0.009	0.013	0.015	0.013	0.012	0.014	0.002
Nitrate Nitrogen	0.115	0.29	0.026	0.095	0.21	0.41	0.55	0.14
Ammonia Nitrogen	0.03	0.35	0.057	0.045	0.29	0.065	0.03	0.03
Organic Nitrogen	0.59	0.87	0.77	0.707	0.78	0.48	0.62	0.49
Total Nitrogen	0.71	1.52	1.07	0.99	1.30	0.97	1.21	0.61
Phosphate Phosphorus	0.012	0.013	0.020	0.014	0.005	0.013	0.027	0.005
Total Phosphorus	0.04	0.04	0.03	0.017	0.06	0.02	0.03	0.02
Specific Conductance (micromhos/cm)	435.5	448.0	457.8	448.3	485.0	482.5	382.0	535.0
Sulfate	31.5	38.0	40.6	39.0	34.0	39.5	35.0	37.0
Chloride	12.5	13.0	15.0	14.7	13.0	15.0	11.0	13.0
pH (standard units)	8.2	8.3	8.4	8.5	8.1	8.2	8.4	8.3
Alkalinity	189	226	204	204	212	213	170	187
Turbidity (formazin units)	11.45	1.20	3.3	2.6	2.9	1.1	2.6	3.5
Calcium	39.2	- -	62.8	55.0	74.0	52.5	39.0	66.0
Magnesium	27.6	- -	46.2	52.5	44.0	39.0	28.0	50.0
Sodium	5.05	10.0	8.7	7.5	11.0	6.5	5.0	12.0
Potassium	3.15	0.6	2.6	2.6	2.9	2.55	4.1	3.6
Iron	- -	- -	- -	- -	- -	0.09	- -	0.39
Manganese	- -	- -	- -	- -	- -	0.03	- -	0.06

[a]*All values reported in mg/l unless otherwise specified.*

Source: Wisconsin Department of Natural Resources.

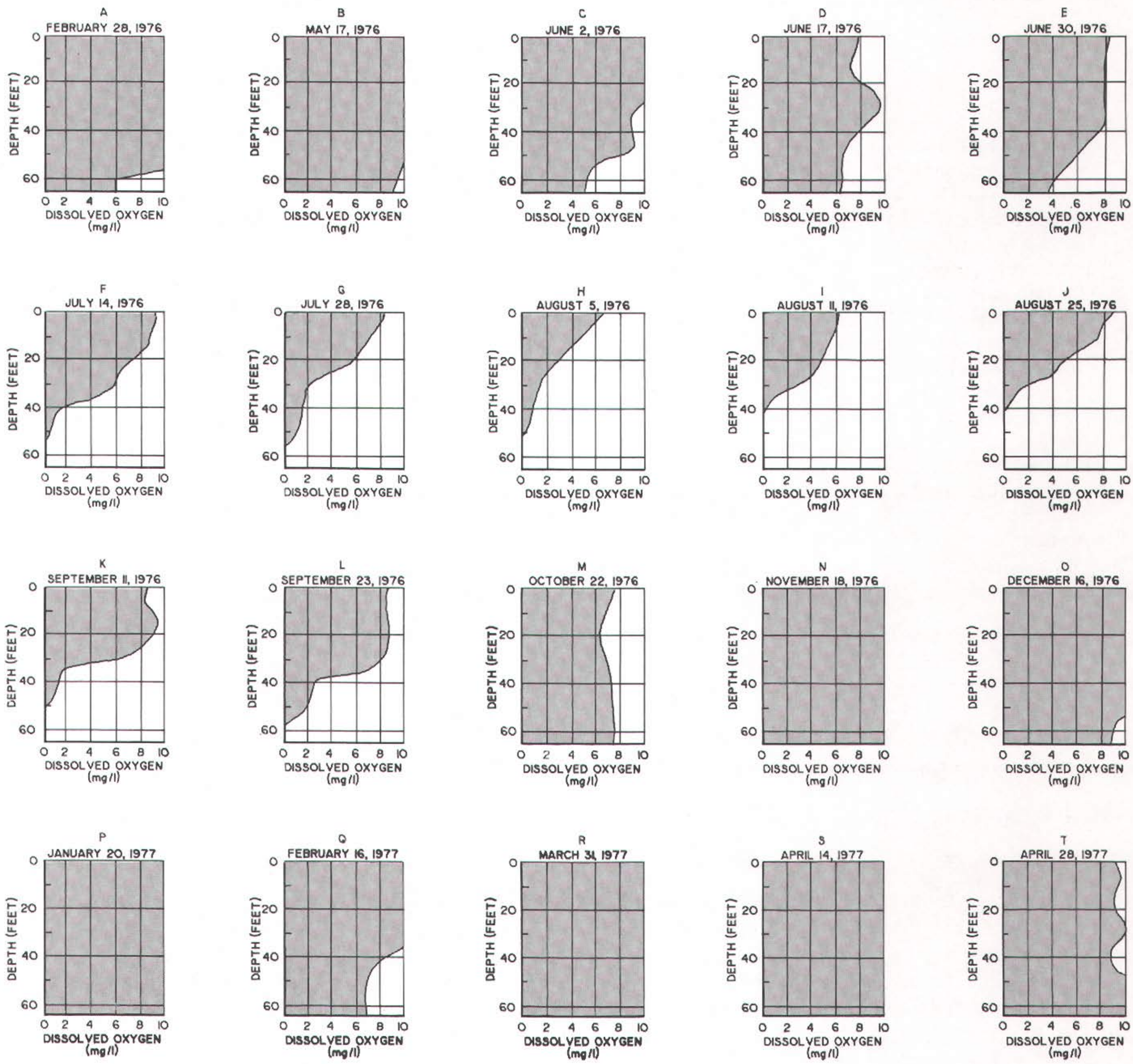
isolating it from the atmosphere for up to four months, the ice cover on Oconomowoc Lake typically existing from late December to early April. Winter stratification occurs as the colder, lighter water and ice remain at the surface, again separated from the relatively warmer, heavier water near the bottom of the lake. The ice shuts the water column off from the atmospheric source of oxygen.

Spring brings a reversal of the process. As the ice thaws and the upper layer of water warms, it becomes more dense and begins to approach the temperature of the warmer, lower water until the entire water column reaches the same temperature. Mixing, induced by the wind, continues until the water again reaches 39°F, shown in Figure 5-LL for the month of March 1977. This lake season, which follows winter stratification, is referred to as the spring turnover. Beyond this point, the water warms at the surface and again becomes lighter and floats above the colder water. Wind and resulting waves carry, to a limited extent, some of the energy of the warmer, lighter water to lower depths. Thus begins the formation of the thermocline and another summer thermal stratification.

Dissolved oxygen levels are one of the most critical factors affecting a lake ecosystem. In shallow, fertile lakes, winter brings the threat of dissolved oxygen depletion and fishkills under ice cover. If ice cover is thick and snow cover deep, light penetration is sometimes not sufficient to maintain oxygen production from the plants in the lake. When plant life dies and decays, dissolved oxygen is consumed in the process, resulting in oxygen depletion which will kill fish if the supply of dissolved oxygen is not sufficient to meet the total winter demand. This

Figure 5

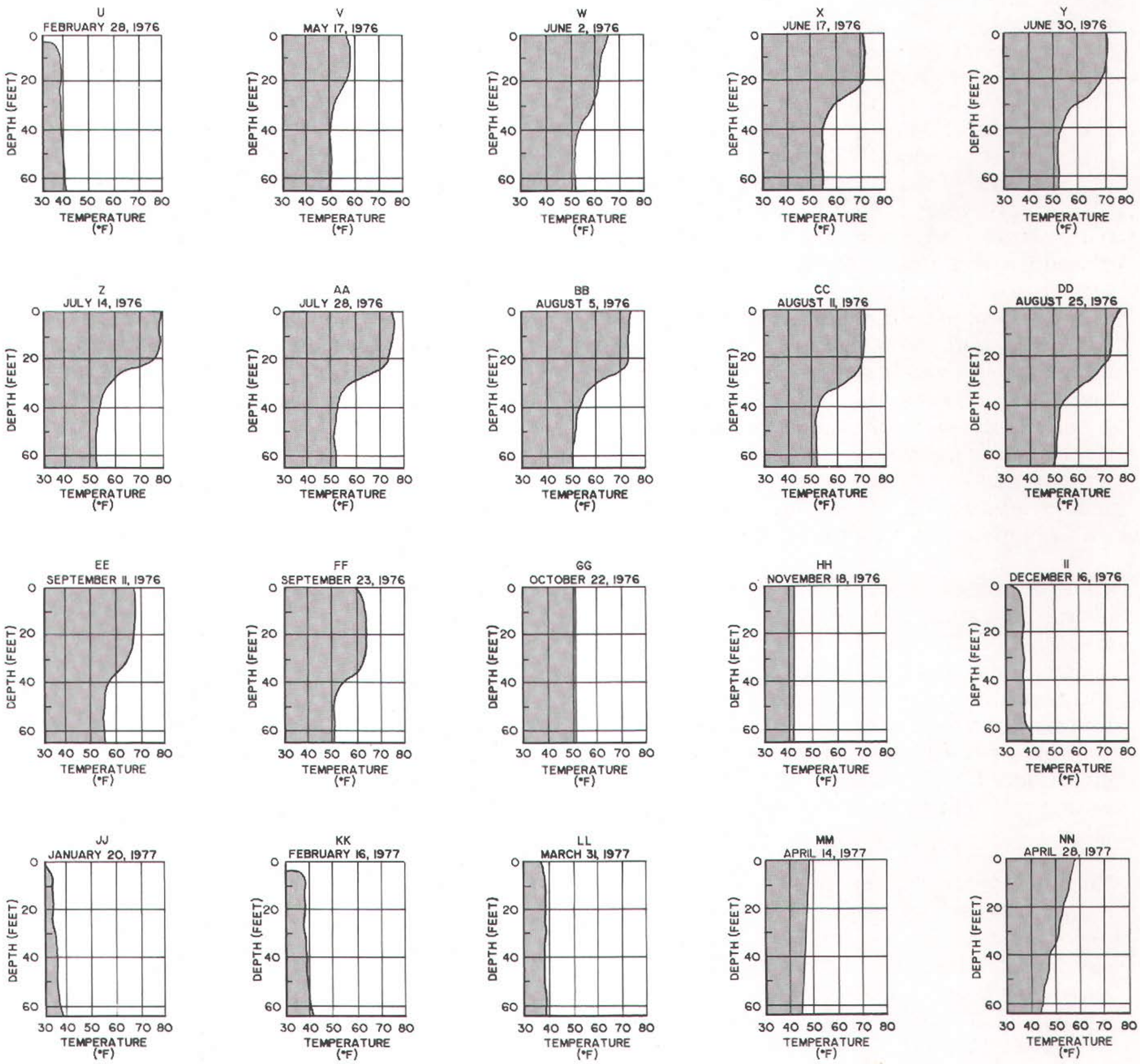
TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR OCONOMOWOC LAKE: 1976-1977



condition, commonly referred to as winterkill, has not been a severe problem in Oconomowoc Lake; however, there were some reports of winterkill of a portion of the cisco population in the 1970's. Dissolved oxygen levels at most depths appear adequate for the support of fish and other aquatic life throughout the winter, as shown in Figures 5-O, 5-P, 5-Q, and 5-A for the months of December 1976, and January, February, and March 1977.

Dissolved oxygen profiles during summer stratification on Oconomowoc Lake show total oxygen depletion in the hypolimnion. Beginning in early summer, as the thermocline develops, the lower, colder body of water (hypolimnion) becomes isolated from the upper, warmer layer (epilimnion), cutting off the surface supply of dissolved oxygen to the hypolimnion, while in the epilimnion, atmospheric equilibrium, wind turbulence, wave action, and plant photosynthe-

Figure 5 (continued)



Source: Wisconsin Department of Natural Resources and SEWRPC.

sis maintain an adequate supply of dissolved oxygen. Gradually, if there is not enough dissolved oxygen to meet the demand imposed by decaying material, the dissolved oxygen concentration in the hypolimnion may be reduced to zero. Such oxygen depletion was observed in Oconomowoc Lake, as shown in Figures 5-F, 5-G, 5-H, 5-I, 5-J, 5-K, and 5-L for the months of July, August, and September 1976, and is common for many lakes in southeastern Wisconsin. The low oxygen concentrations may cause many species of fish to move upward in the water column, where higher dissolved oxygen concentrations exist.

The range of depths within which photosynthetic activity occurs depends to a large extent on the transparency of the water. A Secchi Disc was used to measure water clarity. This is a black and white, eight-inch disc lowered to a depth where it is no longer visible. Water clarity in lakes is typically highly variable. In Oconomowoc Lake, the Secchi Disc readings ranged from a low of about seven and one half feet in July 1976, to a high of over 24 feet in April 1977.

Chlorophyll-a is the major photosynthetic pigment in algae. The amount of chlorophyll-a present in the water column is an indicator of the biomass of live algae, and its level of concentration is useful in determining the trophic status of lakes and hence the suitability for certain water uses. Chlorophyll-a values in Oconomowoc Lake ranged from a low of 0.1 milligram per cubic meter (mg/m^3) in February 1976, to a high of 8.4 mg/m^3 in June 1976. Chlorophyll-a levels in the 10 to 15 mg/m^3 range result from excessive algae growth which may be severe enough to impair recreational activities such as swimming and water skiing.[3] Consequently, the study results indicate that algae concentrations on Oconomowoc Lake are unlikely to interfere with recreational activities.

Water samples collected from Oconomowoc Lake during the study period were tested for pH (acidity), specific conductance (a measure of the amount of dissolved solids), magnesium, sodium, potassium, iron, manganese, sulfate, alkalinity, turbidity, chloride, suspended solids, and different forms of the plant nutrients nitrogen and phosphorus. Ranges and mean values found for these water quality parameters are set forth in Table 9.

Chloride concentrations ranged from 10 to 22 milligrams per liter (mg/l), which is somewhat lower than the concentrations found in most lakes in southeastern Wisconsin. Chloride concentrations are known to be increasing in southeastern Wisconsin lakes and streams. Sources of chlorides include road salt, sewage wastes, animal wastes, and water softeners, as well as natural leaching of rock minerals.

Conductivity ranged from 418 to 525 micromhos per centimeter, and pH fluctuated between 7.6 and 8.5 standard units. Conductivity recorded for Oconomowoc Lake was somewhat lower than for most other southeastern Wisconsin lakes.[4] The metals data collected are typical of the hard water lakes in the Region. Turbidity, another measure of water clarity, was low throughout the year.

The nutrients nitrogen and phosphorus, which are necessary for the growth of aquatic plants including algae, have a significant effect on the suitability of lakes for recreational activities. In lakes where supplies of nutrients are limited, plant growth is limited and the lakes are typically clear and classified as oligotrophic. Where abundant supplies of nutrients are available, aquatic plant growth is usually prolific, resulting in nuisance algae blooms and excessive macrophyte growth. Lakes experiencing these conditions are unattractive for certain recreational uses, and may be classified as eutrophic.

Phosphorus concentrations in Oconomowoc Lake were found to slightly exceed the levels believed necessary to support periodic nuisance algae blooms. The recommended water quality standard for full recreational use and for maintenance of a healthy warmwater fishery set forth in the Regional Planning Commission adopted regional water quality management plan indicates that algae blooms are likely to occur in lakes where the total phosphorus concentration exceeds 0.02 mg/l during spring turnover. This is the level considered in the regional plan as needed to limit algae and aquatic plant growth to levels consistent with the recreational, and warmwater fish and aquatic life, water use objectives. In Oconomowoc Lake the mean concentration of total phosphorus was found to be 0.03 mg/l on an annual basis and during spring turnover. Further, Sawyer has reported that algae blooms during the summer were likely to occur in lakes where the reactive phosphorus and inorganic nitrogen—nitrate nitrogen and ammonia—concentrations exceeded 0.01 mg/l and 0.30 mg/l, respectively, during spring.[5]

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[3] *M. O. Allum, et al., An Evaluation of the National Eutrophication Data, U. S. Environmental Protection Agency Working Paper No. 900, 1977.*

[4] *R. J. Poff and C. W. Threinen, op. cit.*

[5] *C. N. Sawyer, Fertilization of Lakes by Agricultural and Urban Drainage, Journal New England Water Works Association, Volume 61, No. 2, 1947.*

Table 9

SEASONAL WATER QUALITY CONDITIONS IN OCONOMOWOC LAKE: 1975-1977

Chemical Parameter[a]	Spring (mid-March to mid-June)		Summer (mid-June to mid-September)		Fall (mid-September to mid-December)		Winter (mid-December to mid-March)		Annual	
	Range	Mean[b]	Range	Mean[b]	Range	Mean[b]	Range	Mean[b]	Range	Mean[b]
Nitrite and Nitrate Nitrogen	0.13-0.31	0.21(30)	0.02-0.32	0.11(42)	0.03-0.27	0.12(24)	0.06-0.47	0.16(26)	0.02-0.47	0.15(122)
Ammonia Nitrogen	0.04-0.47	0.08(31)	0.03-0.83	0.19(42)	0.03-0.78	0.15(24)	0.03-0.24	0.09(26)	0.03-0.83	0.13(123)
Organic Nitrogen	0.22-1.38	0.54(31)	0.30-1.08	0.62(42)	0.29-0.78	0.56(24)	0.18-0.65	0.42(26)	0.18-0.38	0.55(123)
Total Nitrogen	0.40-1.67	0.83(31)	0.34-1.68	0.92(24)	0.40-1.45	0.83(24)	0.39-1.11	0.68(26)	0.34-1.68	0.83(123)
Reactive Phosphorus	0.01-0.02	0.01(31)	0.01-0.05	0.02(42)	0.01-0.05	0.02(24)	0.01-0.04	0.02(26)	0.01-0.05	0.02(123)
Total Phosphorus	0.01-0.05	0.02(31)	0.01-0.06	0.03(42)	0.01-0.09	0.03(24)	0.01-0.09	0.03(26)	0.01-0.09	0.03(123)
Chloride	10.0-19.0	15.0(31)	13.0-16.0	15.0(42)	13.0-22.0	17(24)	17-19	18(26)	10-22	16(123)
Total Suspended Solids	2.0-3.6	2.7(3)	0.0-13.0	5.4(4)	0.3-2.3	1.2(3)	1.3-1.7	1.5(2)	0-13	3.0(12)
Conductivity (micromhos/cm)	459-500	477(31)	418-491	460(42)	438-491	458(22)	472-525	510(25)	418-525	474(120)
pH (standard units)	7.9-8.4	- -	7.7-8.5	- -	7.6-8.5	- -	7.7-8.3	- -	7.6-8.5	- -
Calcium	43-49	46(2)	48-101	77(3)	39-40	40(2)	45-59	54(3)	39-101	56(10)
Magnesium	33-34	34(2)	50	50(3)	40-41	40(2)	31-42	38(3)	31-50	41(10)
Sodium	7-10	8(2)	10-15	12(3)	6	6(2)	4-7	6(3)	4-15	8(10)
Potassium	3.7-4.8	4.2(2)	3.4-4.4	3.8(3)	1.2-1.3	1.2(2)	2.7	2.2(3)	1.2-4.8	2.9(10)
Iron	- -	- -	- -	- -	0.09-0.12	0.10(2)	- -	- -	0.09-0.12	0.10(2)
Manganese	- -	- -	- -	- -	0.03	0.03(2)	- -	- -	0.03	0.03(2)
Sulfate	40-44	42(2)	33-37	35(3)	35-36	36(2)	40-41	41(3)	33-44	38(10)
Total Alkalinity	202-203	202(2)	191-224	206(3)	200	200(2)	211-217	213(3)	191-217	206(10)
Turbidity (formazin units)	1.8	1.8(1)	2.7-3.1	2.9(3)	1.3-3.6	2.4(2)	1.0-1.1	1.0(3)	1.0-3.6	2.0(9)

[a] *All values reported in mg/l unless otherwise specified; calcium, magnesium, sodium, potassium, iron, manganese, sulfate, total alkalinity, and turbidity collected and analyzed in 1975; all other parameters collected during the study period of May 1976 through April 1977.*

[b] *Number of samples in parentheses.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

It should be noted that Ibach and Remsen conducted a limnological study of Oconomowoc Lake in 1981.[6] The results of that study indicated that in-lake phosphorus concentrations were less than recorded for the 1976-1977 surveys. Internal lake processes as well as a decrease in the amount of phosphorus entering the lake from onsite septic systems were given as possible reasons for the decrease.

The ratio of total nitrogen to total phosphorus (N to P ratio) in lake water indicates which nutrient is the factor likely limiting aquatic plant growth in a lake.[7] Where the N to P ratio is 14 to 1 or greater, the lake is thought to be phosphorus-limited. If the ratio is less than 10 to 1, nitrogen is most likely to be the limiting nutrient. In Oconomowoc Lake the N to P ratio was observed to be always equal to or greater than 14 to 1, which indicates that aquatic plant growth is limited by phosphorus.

Sediment contributions also have an important effect on the condition of a lake. As the lake bottom is covered by material washed into the lake or by dead aquatic plant remains, valuable benthic habitats may be covered, macrophyte substrates increased, and fish spawning areas covered, and aesthetic nuisances may develop.

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[6] *M. J. Ibach and C. C. Remsen, A Limnological Study of the Two Basins of Oconomowoc Lake, Waukesha County, Wisconsin, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, 1984.*

[7] *M. O. Allum, et al., op. cit.*

In addition, sediment particles act as a transport mechanism for other pollutants, such as phosphorus, nitrogen, organic substances, pesticides, and heavy metals and other toxic substances.

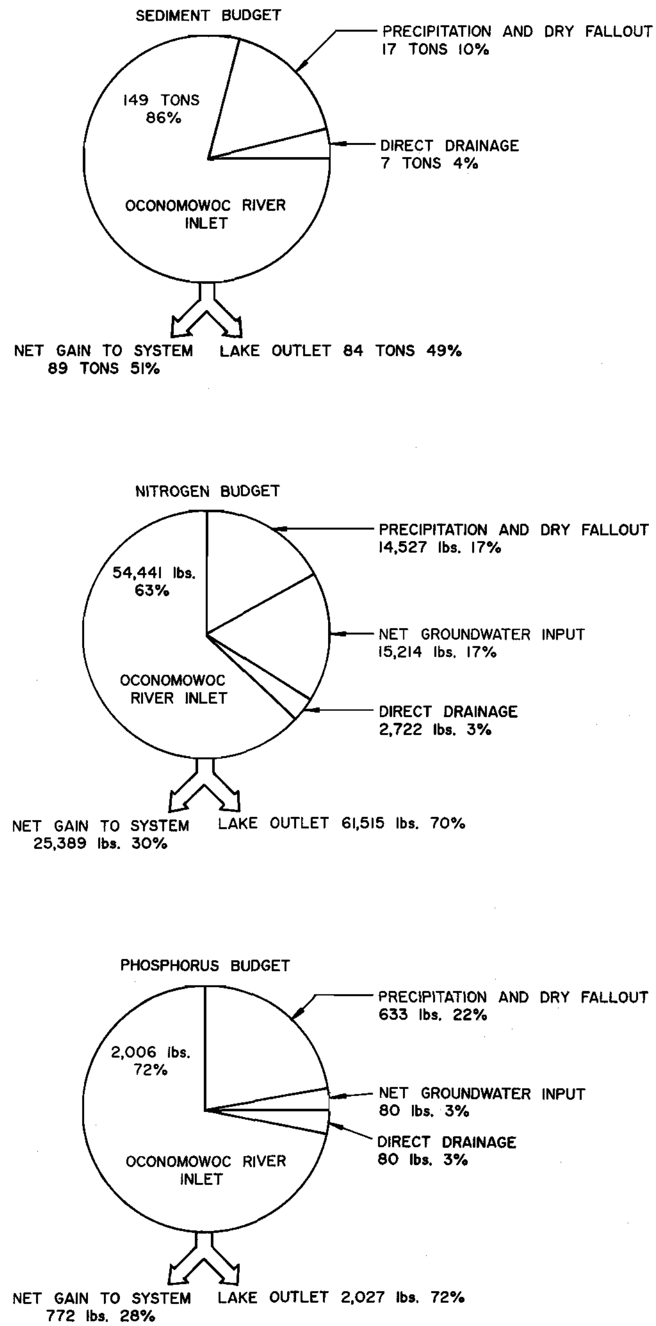
EXISTING AND PROBABLE FUTURE POLLUTION SOURCES AND LOADINGS

Estimates were made of the nitrogen, phosphorus, and suspended solid loadings to Oconomowoc Lake from direct drainage area runoff and atmospheric contributions, and of losses through the outlet during the study year. Input and output from surface water were based on flow and water quality data collected at the Oconomowoc River where it enters Oconomowoc Lake, at eight paired groundwater wells, and at the Oconomowoc River where it leaves Oconomowoc Lake. Atmospheric contributions of nitrogen, phosphorus, and suspended solids were calculated based on precipitation records and literature values for the different constituents which are considered to be the most representative for the Oconomowoc Lake region.[8,9]

The measured concentrations during the study period were used to develop annual loading budgets for nitrogen, phosphorus, and sediment as shown in Figure 6. During the year of the study, it was estimated that 3 percent of the phosphorus and 17 percent of the nitrogen entering the lake came from groundwater; 3 percent of the phosphorus and 3 percent of the nitrogen from direct drainage; 72 percent of the phosphorus and 63 percent of the nitrogen from the major inlet; and 29 percent of the phosphorus and 17 percent of the nitrogen from precipitation and dry fallout on the lake surface. The largest source of sediment loading input—86 percent—was the Oconomowoc River, with direct drainage contributing 4 percent, and precipitation and dry fallout contributing 10 percent. Of the total mass of nutrients and sediment entering Oconomowoc

Figure 6

NUTRIENT AND SEDIMENT BUDGETS FOR OCONOMOWOC LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources and SEWRPC.

Lake, it was estimated that 28 percent of the phosphorus, 30 percent of the nitrogen, and 51 percent of the sediment remained in the lake.

Groundwater quality was monitored in eight paired observation wells strategically located around Oconomowoc Lake. Groundwater contri-

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[8] *J. W. Kluesner, Nutrient Transport and Transportation in Lake Wingra, Wisconsin, Ph.D Thesis, University of Wisconsin-Madison, 1972.*

[9] *T. J. Murphy and P. V. Doskey, Inputs of Phosphorus from Precipitation to Lake Michigan, Journal of Great Lakes Research, Volume 2, No. 1, 1976, pp. 66-70.*

Table 10

ESTIMATED TOTAL PHOSPHORUS LOADS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1980 AND 2000

Source of Phosphorus	Existing 1980			Anticipated 2000[a]		
	Extent	Total Loading (pounds/year)	Percent Distribution	Extent	Total Loading (pounds/year)	Percent Distribution
Urban						
Residential Land	447	45	1.3	584	44	1.7
Commercial Land	7	4	0.1	9	4	1.0
Industrial Land	6	4	0.1	6	3	1.0
Governmental and Institutional Land	39	9	0.3	39	7	1.0
Transportation Land	144	58	1.6	187	56	2.2
Construction Activities	- -	- -	- -	7	35	1.3
Recreational Land	2	1	0.1	2	4	1.0
Onsite Disposal Systems[b]	59	220	6.2	6	22	1.0
Subtotal	- -	341	9.6	- -	175	6.9
Rural						
Agricultural and Open Land	869	58	1.6	680	34	1.3
Direct Atmospheric Contributions to Water Surfaces[c]	- -	630	17.7	- -	630	25.0
Woodlands	228	26	0.7	228	26	1.0
Wetlands	248	- -	- -	248	- -	- -
Livestock (animal units)[d]	50	5	0.2	5	5	1.0
Oconomowoc River	- -	2,500	70.2	- -	1,650	65.5
Subtotal	- -	3,219	90.4	- -	2,345	93.1
Total	- -	3,560	100.0	- -	2,520	100.0

[a] *Assumes implementation of minimum urban and rural nonpoint source pollution control practices and a continuation of a septic system inspection and maintenance program.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Includes the area of Oconomowoc Lake.*

[d] *An animal unit is the equivalent in waste production of a 1,000-pound dairy cow.*

Source: SEWRPC.

butions for nitrites (NO_2) and nitrates (NO_3) ranged from 0.1 to 4.17 mg/l; and for ammonia (NH_3) from 0.02 to 0.3 mg/l. Mean values of 1.15 mg/l for nitrites and nitrates, and 0.10 mg/l for ammonia, were also recorded. Total phosphorus values ranged from less than 0.01 to 0.04 mg/l, with a mean value of 0.02 mg/l. Because the study was conducted in a drought period, the percent of nutrient contribution attributed to groundwater during the study period—3 percent of the total phosphorus and 17 percent of the nitrogen—could be higher than during a year of normal precipitation.

Phosphorus has been identified as the factor generally limiting aquatic plant and algae growth in Oconomowoc Lake. Excessive levels of phosphorus in the lake are likely to result in conditions which interfere with the desired use of the lake. Existing and forecast year 2000 phosphorus sources to the lake were identified and quantified using Commission 1980 land use inventory data; 1984 field inventory data; plan year 2000 land use data, derived from the adopted regional land use plan; and Commission water quality simulation modeling.

Table 10 sets forth the estimated phosphorus loads to Oconomowoc Lake under existing 1980 conditions, and anticipated year 2000 conditions if nonpoint source pollution control measures are implemented in the direct drainage area and in that portion of the total Oconomowoc River watershed which drains to Oconomowoc Lake. The estimated annual total phosphorus load to Oconomowoc Lake is about 3,560 pounds under 1980 conditions. The major sources of phosphorus contributed to the lake under 1980 conditions are the influent Oconomowoc River—about 2,500 pounds, or 70 percent; direct atmospheric contributions—about 630 pounds, or 18 percent; and onsite sewage disposal systems—about 220 pounds, or 6 percent. The remaining phosphorus load, totaling about 210 pounds, or 6 percent, is contributed by stormwater runoff entering the lake from urban and rural lands in the direct drainage area. Under anticipated year 2000 conditions, and following the implementation of recommended water pollution control measures in the upstream and direct tributary drainage areas, the total phosphorus load to the lake is expected to decrease to about 2,520 pounds per year, representing about a 30 percent decrease from 1980 conditions.

TROPHIC CONDITION RATING

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

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

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

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

The trophic status of Oconomowoc Lake was evaluated by the application of two commonly used methods: the Lake Condition Index and the Dillon and Rigler Model.

Uttormark and Wall developed a method for lake classification based on four indicators of eutrophication: dissolved oxygen levels; water clarity (transparency); occurrence of fish winterkills; and recreational use impairment due to algae blooms or excessive macrophyte growth.[10] A measure—referred to as a Lake Condition Index—was devised in which points are assigned for undesirable symptoms of water pollution. Thus if a lake exhibits no undesirable symptoms of eutrophication, it receives no points and has a Lake Condition Index of zero. Conversely, a lake with all the undesirable characteristics in the most severe degree has a Lake Condition Index of 23. Using the Uttormark-Wall classification system, Oconomowoc Lake received a Lake Condition Index of 7—as set forth in Table 11—which is indicative of mesotrophic lakes. This value is higher—that is, more eutrophic—than 9 of the 23 other rated lakes in Waukesha County, and higher than 24 of the 65 rated lakes in the seven-county Southeastern Wisconsin Region, as shown in Table 12. Therefore, based on the Lake Condition Index, Oconomowoc Lake is less eutrophic than approximately 65 percent of the lakes in southeastern Wisconsin.

Dillon and Rigler developed a model for predicting the total phosphorus concentration of a lake during spring turnover based on the physical characteristics of the lake, hydrologic data, and

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[10] *P. D. Uttormark and J. P. Wall, Lake Classification—A Trophic Characterization of Wisconsin Lakes, Environmental Protection Agency Report No. EPA-6601 3-75-033, 1975.*

Table 11

LAKE CONDITION INDEX CALCULATION FOR OCONOMOWOC LAKE

Lake Conditions	Lake Condition Index Penalty Points
Dissolved Oxygen Concentrations: Zero During Some Periods in Portions of the Hypolimnion	4
Water Transparency: Good Water Clarity	1
Occurrence of Fish Winterkills: None	0
Recreational Use Impairments Due to Algae Blooms and/or Aquatic Macrophyte Growth: Occasional Blue-Green Algae Blooms	2
Total	7

Source: Wisconsin Department of Natural Resources and SEWRPC.

phosphorus loading data.[11] The predicted phosphorus concentrations can also be correlated to average summer chlorophyll-a and Secchi Disc (water transparency) levels. Using phosphorus loads estimated by the Commission's water quality simulation model, the Dillon and Rigler model was applied to Oconomowoc Lake under existing conditions. The model analysis resulted in a predicted total phosphorus concentration of 0.035 mg/l. This predicted value is above the recommended SEWRPC phosphorus standard of 0.02 mg/l established for lakes to support recreational use and warmwater fish and aquatic life, as discussed in Chapter VII. An average summer chlorophyll-a concentration of 6.8 milligrams per cubic meter and an average summer Secchi Disc depth of 13.5 feet are also predicted. These data indicate that the lake would be classified as a mesotrophic lake. Table 13 compares the predicted phosphorus concentration, chlorophyll-a concentration, and Secchi Disc depth to measured data during the study period. The table indicates that the predicted values compare reasonably well with measured values.

Based on the above, it may be concluded that the characteristics of Oconomowoc Lake are indicative of a mesotrophic lake, which may be becoming eutrophic.

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[11] *D. J. Dillon and F. H. Rigler, " A Simple Method for Predicting the Capacity of a Lake for Development Based on Lake Trophic Status," Journal of the Fisheries Research Board of Canada, Volume 32, 1975, pp. 1519-1531.*

Table 12

LAKE CONDITION INDEX OF SELECTED MAJOR LAKES IN SOUTHEASTERN WISCONSIN: 1980

Watershed	Major Lake Name	County	Lake Condition Index[a]	Category
Des Plaines	Benet and Shangrila	Kenosha	13	Very eutrophic
Des Plaines	Paddock	Kenosha	9	Mesotrophic
Fox	Beulah	Walworth	7	Mesotrophic
Fox	Big Muskego	Waukesha	12	Eutrophic
Fox	Bohners	Racine	6	Mesotrophic
Fox	Booth	Walworth	6	Mesotrophic
Fox	Browns	Racine	8	Mesotrophic
Fox	Buena	Racine	6	Mesotrophic
Fox	Camp	Kenosha	14	Very eutrophic
Fox	Center	Kenosha	6	Mesotrophic
Fox	Como	Walworth	13	Very eutrophic
Fox	Denoon	Waukesha	8	Mesotrophic
Fox	Eagle	Racine	20	Very eutrophic
Fox	Eagle Spring	Waukesha	5	Mesotrophic
Fox	Echo	Racine	6	Mesotrophic
Fox	Elizabeth	Kenosha	6	Mesotrophic
Fox	Geneva	Walworth	5	Mesotrophic
Fox	Green	Walworth	9	Mesotrophic
Fox	Little Muskego	Waukesha	12	Eutrophic
Fox	Long	Racine	17	Very eutrophic
Fox	Lower Phantom	Waukesha	9	Mesotrophic
Fox	Marie	Kenosha	8	Mesotrophic
Fox	Middle	Walworth	7	Mesotrophic
Fox	Mill	Walworth	8	Mesotrophic
Fox	North	Walworth	13	Very eutrophic
Fox	Pell	Walworth	12	Eutrophic
Fox	Pewaukee	Waukesha	13	Very eutrophic
Fox	Pleasant	Walworth	4	Oligotrophic
Fox	Potters	Walworth	12	Eutrophic
Fox	Powers	Kenosha	8	Mesotrophic
Fox	Silver	Kenosha	8	Mesotrophic
Fox	Spring	Waukesha	4	Oligotrophic
Fox	Tichigan	Racine	21	Very eutrophic
Fox	Upper Phantom	Waukesha	6	Mesotrophic
Fox	Wandawega	Walworth	13	Very eutrophic
Fox	Waubeesee	Racine	7	Mesotrophic
Fox	Wind	Racine	7	Mesotrophic
Milwaukee	Silver	Washington	3	Oligotrophic
Milwaukee	Big Cedar	Washington	5	Mesotrophic
Milwaukee	Little Cedar	Washington	5	Mesotrophic
Milwaukee	Mud	Ozaukee	10	Eutrophic
Rock	Ashippun	Waukesha	8	Mesotrophic
Rock	Beaver	Waukesha	7	Mesotrophic
Rock	Comus	Walworth	15	Very eutrophic
Rock	Delavan	Walworth	14	Very eutrophic
Rock	Druid	Washington	6	Mesotrophic
Rock	Five	Washington	12	Eutrophic
Rock	Friess	Washington	8	Mesotrophic
Rock	Golden	Waukesha	8	Mesotrophic
Rock	Keesus	Waukesha	8	Mesotrophic
Rock	Lac La Belle	Waukesha	10	Eutrophic
Rock	Loraine	Walworth	12	Eutrophic
Rock	Lower Nemahbin	Waukesha	5	Mesotrophic
Rock	Middle Genesee	Waukesha	3	Oligotrophic
Rock	Nagawicka	Waukesha	13	Very eutrophic
Rock	North	Waukesha	5	Mesotrophic
Rock	Oconomowoc	Waukesha	7	Mesotrophic
Rock	Okauchee	Waukesha	5	Mesotrophic
Rock	Pike	Washington	6	Mesotrophic
Rock	Pine	Waukesha	7	Mesotrophic
Rock	Silver	Waukesha	5	Mesotrophic
Rock	Tripp	Walworth	6	Mesotrophic
Rock	Turtle	Walworth	5	Mesotrophic
Rock	Upper Nashotah	Waukesha	4	Oligotrophic
Rock	Upper Nemahbin	Waukesha	7	Mesotrophic
Rock	Whitewater	Walworth	7	Mesotrophic

[a]*Lake Condition Index Trophic Classification*

0 - 1 = Very oligotrophic
2 - 4 = Oligotrophic
5 - 9 = Mesotrophic
10 - 12 = Eutrophic
13 - 23 = Very eutrophic

Source: SEWRPC.

Table 13

COMPARISON OF MEASURED AND PREDICTED TOTAL PHOSPHORUS, CHLOROPHYLL-a, AND SECCHI DISC LEVELS IN OCONOMOWOC LAKE FOR 1980 AND YEAR 2000 CONDITIONS

Water Quality Parameter	Measured[a]		Predicted by Simulation[b,c]	
	Range	Mean	1980	2000
Total Phosphorus Concentration (mg/l)	0.01-0.09	0.03	0.038	0.02
Chlorophyll-a Concentration[d] (mg/m^3)	0.1-8.4	3.9	6.8	4.1
Secchi Disc Depth (feet)	7.5-24	12.6	13.5	17.7

[a]*Based on measured data from June 1976 through April 1977.*

[b]*Based on the Dillon and Rigler (1974) model.*

[c]*Concentration during the spring turnover.*

[d]*Based on summer and fall values.*

Source: SEWRPC.

Chapter V

NATURAL RESOURCE BASE AND RECREATIONAL ACTIVITIES

AQUATIC PLANTS

Macrophytes

Aquatic macrophytes, such as pondweeds, coontails, water milfoils, rushes, and cattails, play an important role in the ecology of southeastern Wisconsin lakes. Depending on distribution and abundance, they can be either beneficial or a nuisance. Macrophytes growing in the proper locations and in reasonable densities in lakes are beneficial because they provide habitat for other forms of aquatic life and may remove nutrients from the water that otherwise could contribute to excessive algae growth. Aquatic plants may, however, become a nuisance when heavy densities interfere with swimming and boating activities. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate, wave action, and type and size of fish populations, determine the distribution and abundance of aquatic macrophytes in a lake.

To document the types, distribution, and relative abundance of aquatic macrophytes in Oconomowoc Lake, a survey was conducted on August 12, 1976. The vegetation was identified and the frequency of occurrence and the relative abundance of each species was recorded along the entire shoreline of the lake. Twelve distinct areas with different plant groups were identified. The macrophyte species present in the lake are indicated in Table 14, along with their frequency of occurrence and relative abundance. Illustrations of representative macrophyte species identified in Oconomowoc Lake are set forth in Appendix A.

In general, the macrophyte growth in Oconomowoc Lake was sparse to moderate during the study period and was also relatively diverse. The dominant species in all areas was stonewort (Chara sp.). An abundant growth of stonewort was present along the eastern shoreline, with a moderately dense population of coontail (Ceratophyllum sp.). Emergent species along the shoreline were primarily bulrush (Scirpus sp.) and rush (Juncus sp.). The sparsest growth of the 12 areas evaluated occurred along the western shoreline near the outlet.

The predominance of stonewort in Oconomowoc Lake can be attributed to the fact that this attached algal species has the ability to obtain nutrients primarily from the water column rather than bottom sediments. The bottom sediments in Oconomowoc Lake consist primarily of sand, gravel, marl, and rubble, and are not conducive to the growth of most rooted aquatic plants. However, stonewort has become established in much of the littoral or near-shore area of the lake. Floating plants, including water lilies (Nuphar sp. and Nymphaea sp.), were not common in Oconomowoc Lake. Isolated patches were recorded in the southeast and southwest corners of the main lake basin and along the shallow areas of the northern shoreline.

The beneficial nature of the aquatic plant community in Oconomowoc Lake, as well as the importance of this community in maintaining the ecological balance in the lake, is generally recognized by the lakeshore residents. The diversity of the plant community in and adjacent to the lake contributes to the use of the lake area by waterfowl, pheasant, muskrat, and other wetland wildlife species dependent on aquatic vegetation for feeding and nesting, brooding, or loafing areas. In addition, the aquatic vegetation in the lake is largely responsible for the maintenance of a healthy fish population in the lake, as it provides habitat for food organisms and cover for the fish themselves.

Algae

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

Green algae (Chlorophyta) are the most important source of food for zooplankton—or microscopic animals—in the lakes of southeastern Wisconsin. Blue-green algae (Cyanophyta) are

Table 14

OCONOMOWOC LAKE MACROPHYTE SPECIES AND RELATIVE ABUNDANCE BY LAKE AREA: AUGUST 12, 1976

Area[a] Number	Scientific Name	Common Name	Relative Abundance
1	Chara sp. Juncus sp.	Stonewort Rush	Moderate Very sparse
2	Chara sp. Potomogeton foliosus Potomogeton pectinatus Potomogeton natans Nuphar sp. Scirpus spp. Ceratophyllum sp.	Stonewort Leafy pondweed Sago pondweed Water smartweed Water lily Bulrush Coontail	Moderate Sparse Sparse Very sparse Very sparse Very sparse Very sparse
3	Chara sp. Ceratophyllum sp. Myriophyllum sp. Nuphar sp. Scirpus sp. Potomogeton foliosus Vallisneria sp.	Stonewort Coontail Milfoil Water lily Bulrush Leafy pondweed Eel grass	Abundant Moderate Sparse Very sparse Very sparse Very sparse Very sparse
4	Chara sp.	Stonewort	Very sparse
5	Chara sp. Juncus sp. Vallisneria sp.	Stonewort Rush Eel grass	Very sparse Very sparse Very sparse
6	Chara sp. Potomogeton pectinatus Myriophyllum exalbescens Potomogeton natans Vallisneria sp.	Stonewort Sago pondweed Water milfoil Water smartweed Eel grass	Moderate Very sparse Sparse Very sparse Very sparse
7	Chara sp. Myriophyllum exalbescens Vallisneria sp. Potomogeton natans Potomogeton richardsonii Potomogeton crispus Potomogeton pectinatus Nuphar sp. Scirpus sp.	Stonewort Water milfoil Eel grass Water smartweed Clasping-leaf pondweed Curly leaf pondweed Sago pondweed Water lily Bulrush	Moderate Sparse Sparse Sparse Sparse Very sparse Very sparse Very sparse Very sparse
8	Chara sp. Scirpus sp. Vallisneria sp. Myriophyllum sp. Potomogeton richardsonii	Stonewort Bulrush Eel grass Milfoil Clasping-leaf pondweed	Very sparse Very sparse Very sparse Very sparse Very sparse
9	Chara sp. Myriophyllum sp. Potomogeton natans Vallisneria sp.	Stonewort Milfoil Water smartweed Eel grass	Sparse Very sparse Very sparse Very sparse

Table 14 (continued)

Area[a] Number	Scientific Name	Common Name	Relative Abundance
10	Chara sp.	Stonewort	Moderate
	Potomogeton richardsonii	Clasping-leaf pondweed	Very sparse
	Juncus sp.	Rush	Very sparse
	Nuphar sp.	Water lily	Very sparse
	Nymphaea sp.	Water lily	Very sparse
	Myriophyllum sp.	Milfoil	Very sparse
11	Chara sp.	Stonewort	Moderate
	Potomogeton foliosus	Leafy pondweed	Sparse
	Potomogeton natans	Water smartweed	Very sparse
	Potomogeton pectinatus	Sago pondweed	Very sparse
12	Chara sp.	Stonewort	Moderate
	Juncus sp.	Rush	Very sparse
	Nuphar sp.	Water lily	Very sparse

[a]See map included in Appendix B.

Source: Wisconsin Department of Natural Resources.

not ordinarily utilized by zooplankton or fish populations, and may become over-abundant and out of balance with the organisms that feed on them. Dramatic population increases—blooms—of blue-green algae may occur when excessive nutrient supplies are available, optimum sunlight and temperature conditions exist, and there is a lack of competition from other aquatic plant species and insufficient grazing by zooplankton.

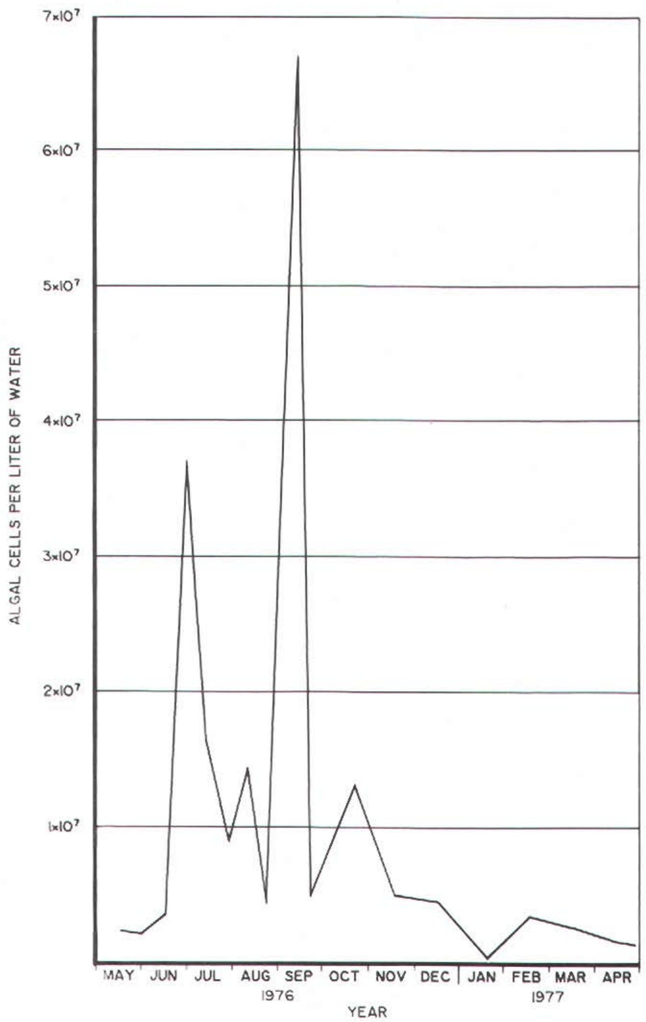
Algae blooms may reach nuisance proportions in fertile—or eutrophic—lakes, resulting in the accumulation of surface scum or slime. In some cases, heavy concentrations of wind-blown algae accumulate on shorelines, where they die and decompose, causing noxious odors and unsightly conditions. The decaying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

The types and concentrations of algae found in Oconomowoc Lake are presented in Figures 7 and 8. Oconomowoc Lake algae populations were highest in late August and mid-September 1976. The lowest concentrations of cells occurred during January 1977. Blue-green algae (Cyanophyta) were the most abundant group of algae observed in samples collected from May through October 1976. During the peak population periods, late June and mid-September, blue-green algae comprised 78 percent (23 million cells per liter [cells/l]) and 96 percent (49 million cells/l) of the population, respectively. During November, diatoms (Bacillariophyceae) increased in relative abundance to 65 percent of the total population, with Astrionella formosa, a star-shaped colony of diatoms—the dominant species present—occurring in concentrations of 2.75 million cells/1 of lake water. By mid-December, blue-green algae regained dominant status, totaling 43 percent of the total algae.

The number of algae decreased sharply to a low of 400,000 cells/1 during January 1977. The golden-brown algae (Cryptophyta) comprised 54 percent of the January algae community. Chroomonas sp. and Cryptomonas sp. were the principal species found. Blue-green algae again became the dominant species during the February sampling period. After "ice out" in March, the diatoms increased and became the dominant algal group, comprising 41 percent of the total population. This spring diatom increase is

Figure 7

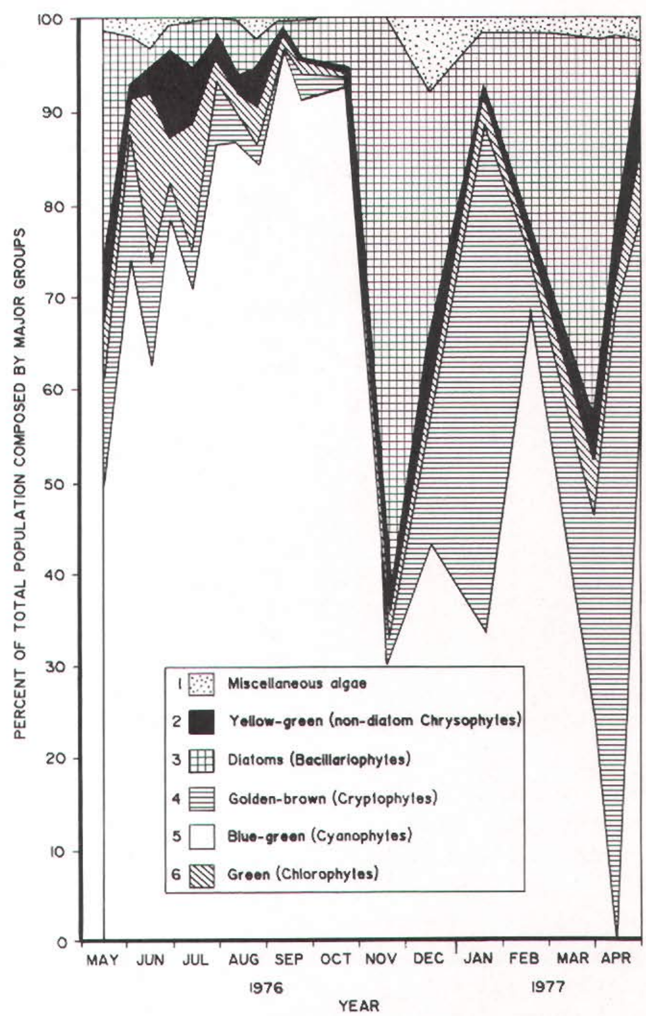
MONTHLY ALGAL POPULATIONS FOR OCONOMOWOC LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources.

Figure 8

TYPES OF ALGAE IN OCONOMOWOC LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources.

characteristic of northern lakes because diatoms thrive in cold water temperatures when adequate light and nutrients are available. By mid-April the population had shifted, with 67 percent of the total number of algae in the golden-brown group. By the end of April, the algal community had again shifted, being dominated by blue-green algae.

Algal concentrations in Oconomowoc Lake were generally lower than for other lakes in southeastern Wisconsin with similar in-lake nutrient concentrations. Ibach and Remsen[1] conducted a water quality study of Oconomowoc Lake in 1981 and found nutrient concentrations high enough to support high algae populations.

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[1] *M. J. Ibach and C. C. Remsen, "A Limnological Study of the Two Basins of Oconomowoc Lake, Waukesha County, Wisconsin," Center for Great Lakes Studies, University of Wisconsin-Milwaukee, 1984.*

Table 15

CRUSTACEAN ZOOPLANKTON PRESENT IN OCONOMOWOC LAKE: 1976-1977

Class: Crustaceae

Subclass: Copepoda

Order: Cyclopoid

<u>Acanthocyclops vernalis</u>
<u>Mesocyclops edax</u>
<u>Cyclops bicuspidatus thomasi</u>
<u>Ergasilis chautauquiensis</u>
<u>Tropocyclops prasinus</u>

Order: Calanoid

<u>Skistodiaptomus oregonensis</u>
<u>Leptodiaptomus siciloides</u>

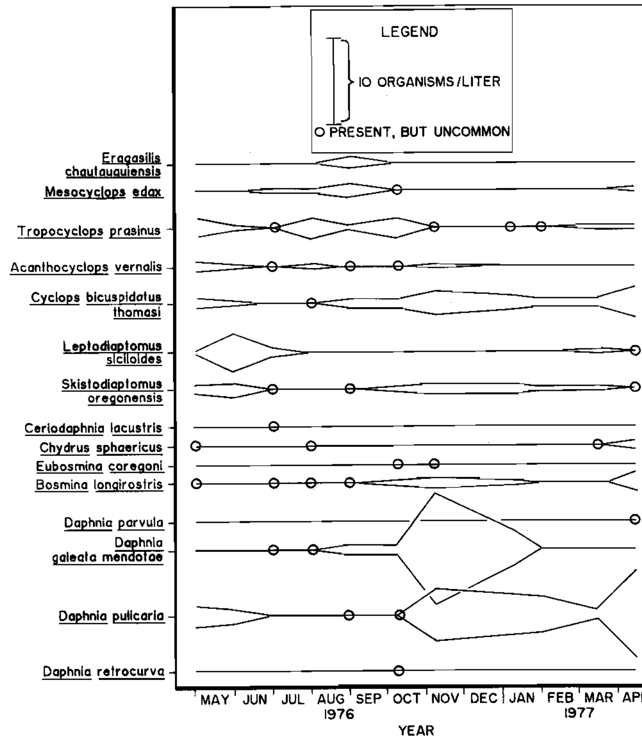
Subclass: Cladocera

<u>Daphnia geleata mendotae</u>
<u>Daphnia retrocurva</u>
<u>Daphnia parvula</u>
<u>Daphnia pulicaria</u>
<u>Bosmina longirostris</u>
<u>Ceriodaphnia lacustris</u>
<u>Chydorus sphaericus</u>

Source: Wisconsin Department of Natural Resources.

Figure 9

ABUNDANCE OF ZOOPLANKTON SPECIES IN OCONOMOWOC LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources.

However, they postulated that the diverse and healthy zooplankton population was effectively feeding on the algae, which controlled the population.

AQUATIC ANIMALS

<u>Zooplankton</u>

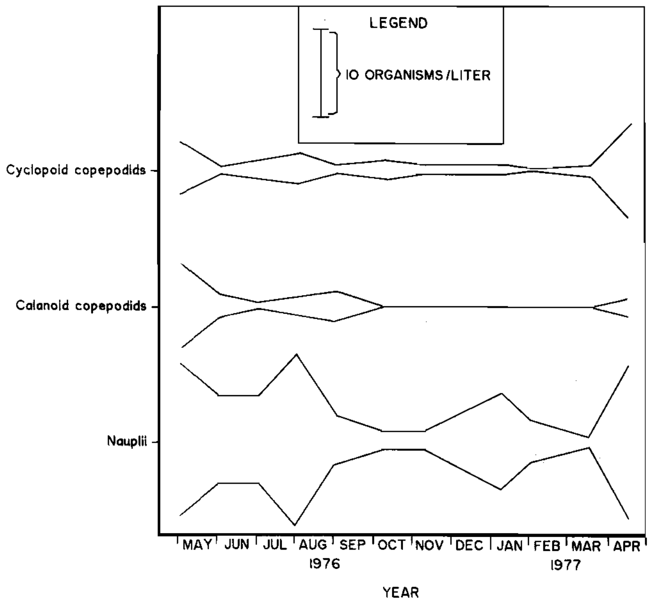
Zooplankton are microscopic animals which inhabit the same environment as phytoplankton—microscopic plants. An important link in the food chain, crustacean zooplankton feed mostly on algae and, in turn, are a good food source for fish. Zooplankton were collected in the deepest area of the lake, using a net hauled vertically from the bottom to the surface. The plankton collected in the net were immediately preserved in a 5 percent buffered formalin solution and later identified and counted using a compound microscope.

As shown in Table 15, 15 species of zooplankton were found in Oconomowoc Lake during the study period. The abundance of selected species of zooplankton in Oconomowoc Lake is shown in Figure 9. The populations of most species were at their peaks in spring, early summer, and fall. <u>Daphnia galeata mendotae</u> and <u>Daphnia pulicaria</u>, which are present in many Wisconsin lakes, were the dominant and largest animals in the zooplankton community throughout most of the year. These species, which are members of the subclass Cladocera, are major food items in the diets of plankton-eating fish.

<u>Cyclops bicuspidatus thomasi</u> was the most common copepod found and was present nearly year-round. Other Cyclopoid copepods found in Oconomowoc Lake during the survey were <u>Mesocyclops edax</u>, <u>Tropocyclops prasinus</u>, <u>Acanthocyclops vernalis</u>, and <u>Ergasilis chautauquien-</u>

Figure 10

ABUNDANCE OF NAUPLII AND COPEPODIDS IN OCONOMOWOC LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources and SEWRPC.

sis. The Calanoid copepods Heptodiaptomus siciloides and Skistodiaptomus oregonensis were also present in the lake during the study period.

There are three stages in the life cycle of copepods: egg stage; naupliar larva; and copepodid. Nauplii and copepodids are each, in turn, divided into six stages, with the sixth copepodid being the adult. In analyzing the Oconomowoc Lake collections, nauplii and copepodids were not separated into their different development groups within each stage, but were grouped into nauplii and copepodids. Unlike Cladocera, reproduction is strictly sexual, with males and females produced in approximately equal numbers. The abundance of nauplii and copepodids found in Oconomowoc Lake during the study year is presented in Figure 10.

Benthos

The benthic, or bottom dwelling, macroinvertebrate communities of lakes, which include such organisms as sludge worms, midges, and caddis fly larvae, may be used to assess the existing and recent past water quality of a lake. These organisms are an important part of the food chain, acting as processors of the organic material that accumulates on the lake bottom. Some benthic macroinvertebrate organisms are opportunistic in their feeding habits, while others are openly predaceous. The diversity of communities present is one of the factors that often reflects the trophic status of a lake. In general, greater diversity is indicative of a less eutrophic lake. There is no single "indicator organism" to indicate trophic status; rather, the entire community must be assessed. The time of year for this assessment is also an important consideration, and since these populations fluctuate widely during the summer months, early spring or winter sampling is best.

Oconomowoc Lake was sampled in early spring of 1976 and 1977 prior to metamorphosis and adult emergence. Samples were collected in the two deepest areas of the lake. The larvae were picked from the debris, counted, and classified. Larvae of the Chironomidae were not reared to adult stages; therefore, species names must be considered tentative.

The benthic community of Oconomowoc Lake consisted of five species. The predominant species were the two phantom midges, Chaoborus flavicans and Chaoborus punctipennis, which both feed on zooplankton and are typically found in mesotrophic lakes. Other species present included the midges Chironomus attenuatus, Procladius sp., and Paratendipes sp.

Fish

Oconomowoc Lake supports a large, diverse fish community. Studies conducted by the Wisconsin Department of Natural Resources indicated that 34 different fish species have been captured in the lake, as shown in Table 16. The fish population reflects both the good water quality of Oconomowoc Lake, and the influence of the overall river system from which individuals move into the lake.

The distribution and relative abundance of the fish population was evaluated in 1975 by the Wisconsin Department of Natural Resources (DNR). As shown in Table 17, the bluntnose minnow (Pimephales notatus), white sucker (Catostomus commersoni), banded killifish (Fundulus diaphanus), and Iowa darter (Etheostoma exile) were reported to be the most numerous species captured. In 1970, Oconomowoc Lake was reported to have a generally well-balanced fish population of game- and

Table 16

FISH SPECIES CAPTURED IN OCONOMOWOC LAKE

Common Name	Scientific Name
Banded killifish	*Fundulus diaphanus*
Black crappie	*Pomoxis nigromaculatus*
Blackchin shiner	*Notropis heterodon*
Blackstripe topminnow	*Fundulus notatus*
Bluegill	*Lepomis macrochirus*
Bluntnose minnow	*Pimephales notatus*
Bowfin	*Amia calva*
Bullhead[a]	*Ictalurus* sp.
Carp	*Cyprinus carpio*
Cisco	*Coregonus artedii*
Common shiner	*Notropis cornutus*
Emerald shiner	*Notropis atherinoides*
Fantail darter	*Etheostoma flabellare*
Green sunfish	*Lepomis cyanellus*
Iowa darter	*Etheostoma exile*
Jonny darter	*Etheostoma nigrum*
Lake chubsucker	*Erimyzon sucetta*
Largemouth bass	*Micropterus salmoides*
Least darter	*Etheostoma microperca*
Logperch	*Percina caprodes*
Longnose gar	*Lepisosteus osseus*
Mimic shiner	*Notropis volucellus*
Northern pike	*Esox lucius*
Pugnose shiner[b]	*Notropis emiliae*
Pumpkinseed	*Lepomis gibbosus*
Rainbow darter	*Etheostoma caeruleum*
Redhorse[a]	*Moxostoma* sp.
Rock bass	*Ambloplites rupestris*
Smallmouth bass	*Micropterus dolomieui*
Walleye	*Stizostedion vitreum vitreum*
Warmouth	*Lepomis gulosus*
White sucker	*Catostomus commersoni*
Yellow perch	*Perca flavescens*

[a]*Species not determined.*

[b]*Listed by the Wisconsin Department of Natural Resources as a threatened species which appears likely, within the foreseeable future, to become endangered in the State.*

Source: Wisconsin Department of Natural Resources.

Table 17

DISTRIBUTION AND RELATIVE ABUNDANCE OF FISH IN OCONOMOWOC LAKE: 1975

Common Name	Scientific Name	Occurrence at Number of Stations	Total Number Caught
Banded killifish	Fundulus diaphanus	7	220
Blackchin shiner	Notropis heterodon	1	1
Blacknose shiner	Notropis heterolepi	6	118
Blackstripe topminnow	Fundulus notatus	1	8
Bluegill	Lepomis macrochirus	6	79
Bluntnose minnow	Pimephales notatus	8	683
Common shiner	Notropis cornutus	1	1
Emerald shiner	Notropis atherinoides	1	1
Fantail darter	Etheostoma flabellare	3	3
Green sunfish	Lepomis cyanellus	3	8
Iowa darter	Etheostoma exile	10	207
Jonny darter	Etheostoma nigrum	8	51
Least darter	Etheostoma microperca	3	19
Logperch	Percina caprodes	1	10
Mimic shiner	Notropis volucellus	6	182
Northern pike	Esox lucius	3	4
Pugnose shiner	Notropis emiliae	2	2
Pumpkinseed	Lepomis gibbosus	1	2
Rainbow darter	Etheostoma caeruleum	2	7
Rock bass	Ambloplites rupestris	4	20
White sucker	Catostomus commersoni	8	252
Yellow perch	Perca flavescens	5	38

Source: Wisconsin Department of Natural Resources.

panfish.[2] Walleye (Stizostedion vitreum vitreum), northern pike (Esox lucuis), largemouth bass (Micropterus salmoides), smallmouth bass (Micropterus dolomieui), bluegills (Lepomis macrochirus), and rock bass (Ambloplites rupestris) were reported to be abundant. The 1975 survey data compares reasonably well with the 1970 survey.

[2] *W. R. Byum, Wisconsin Department of Natural Resources, Intradepartmental Memorandum—Fish Inventory of Oconomowoc Lake, 1970.*

WILDLIFE RESOURCES

Wildlife habitat areas within southeastern Wisconsin were initially inventoried by the Wisconsin Department of Natural Resources, Bureau of Research, for the Regional Planning Commission in 1963, and this inventory was updated in 1970. The wildlife habitat areas were classified as deer, pheasant, waterfowl, muskrat-mink, songbird, or mixed habitat. These designations were applied to help characterize a particular habitat area as meeting the particular requirements of the indicated species. This classification does not imply that the named species is the most important or dominant species in that particular habitat. For example, an area designated as a deer habitat may provide squirrel and songbird habitat as well.

The five major criteria used to determine the value of these wildlife habitat areas are listed below:

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

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

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

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

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

On the basis of these five criteria, the wildlife habitat areas in the Oconomowoc Lake watershed were rated as high, medium, or low quality. The quality ratings used are defined below:

1. High-value wildlife habitat areas contain a good diversity of wildlife, are adequate in size to meet all of the habitat requirements for the species concerned, are generally located in proximity to other wildlife habitat areas, and meet all five criteria listed above.

2. Medium-value wildlife habitat areas generally lack one of the five criteria in the preceding list for a high-value wildlife habitat.

3. Low-value wildlife habitat areas are remnant in nature in that they generally lack two or more of the five criteria for a high-value wildlife habitat, but may, nevertheless, be important if located in proximity to medium- or high-value habitat areas, if they provide corridors linking higher value wildlife habitat areas, or if they provide the only available range in an area.

As shown on Map 11, in 1980 the Oconomowoc Lake direct drainage area contained only about 125 acres of wildlife habitat, which constituted approximately 6 percent of the direct drainage area. Wetlands south of the lake and adjacent to man-made channels provided most of the habitat identified in the direct drainage area.

WOODLANDS

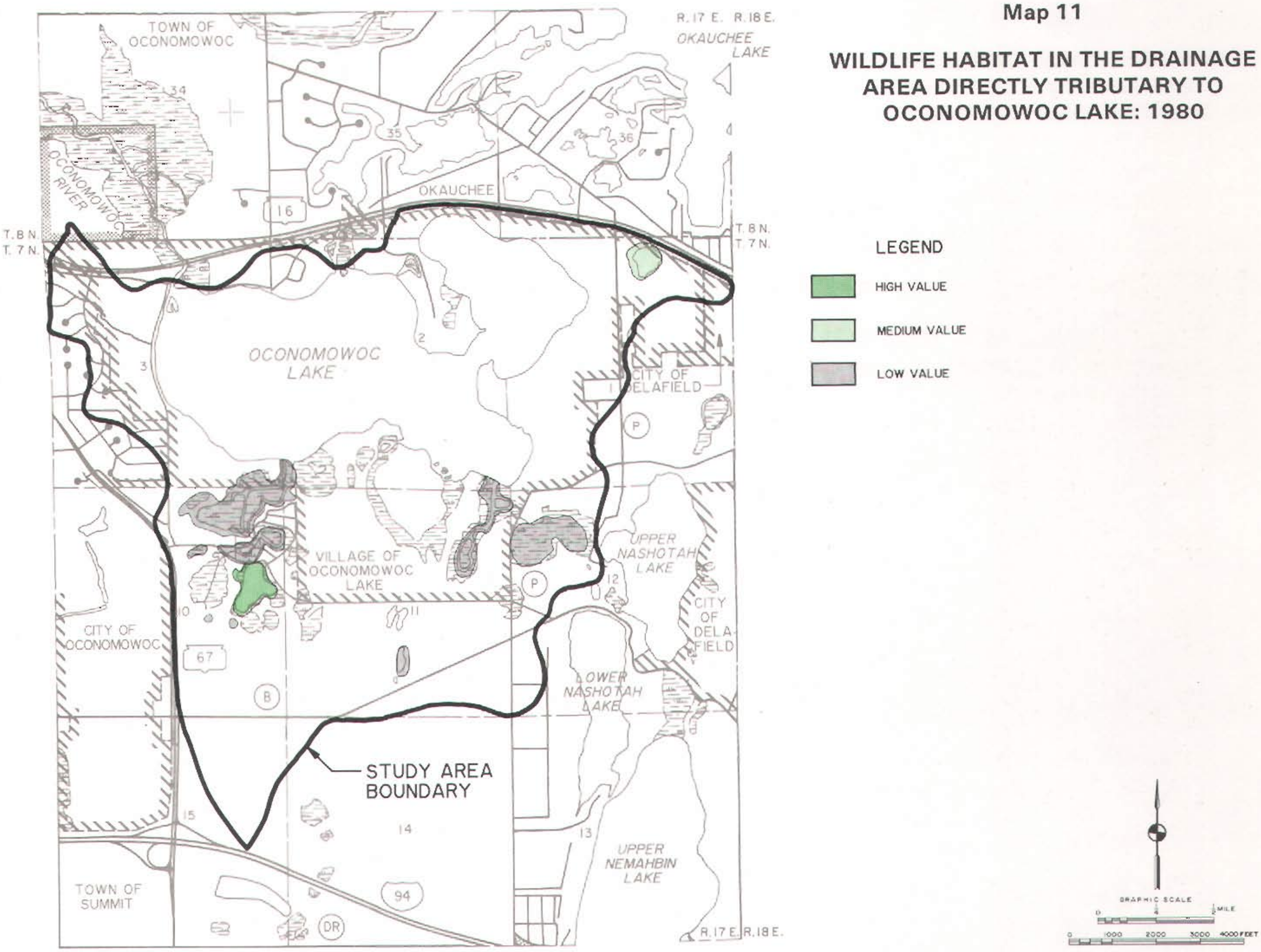
Woodlands in southeastern Wisconsin are defined as those areas containing 17 or more trees per acre which have at least a four-inch diameter at breast height—that is, at a height of 4.5 feet above ground. In addition, the native woodlands are classified as dry, dry-mesic, mesic, wet-mesic, and wet hardwoods, and conifer swamp forests. The latter three woodland classifications are also considered wetlands and, for the purposes of this report, are discussed in the section on wetlands. In 1980, the drainage area directly tributary to Oconomowoc Lake contained 228 acres of woodlands, or approximately 11 percent of the direct drainage area, consisting of all of the native upland woodland classifications. Specifically, as shown on Map 12, upland woods in the Oconomowoc Lake direct drainage area included southern dry hardwoods consisting primarily of white oak (Quercus alba), burr oak (Quercus macrocarpa), shagbark hickory (Carya ovata), and black cherry (Prunus serotina); southern dry-mesic hardwoods consisting primarily of northern red oak (Quercus borealis), paper birch (Betula papyrifera), and white ash (Fraxinus americana); and mesic hardwoods consisting primarily of sugar maple (Acer saccharum), American beech (Fagus grandifolia), and basswood (Tilia americana). Woodland tracts in the Oconomowoc Lake direct drainage area occurred primarily as scattered woodlots, although a relatively large contiguous upland woods was located on the eastern shore of the lake.

WETLANDS

Wetlands in southeastern Wisconsin are classified predominantly as deep marsh, shallow

Map 11

WILDLIFE HABITAT IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1980



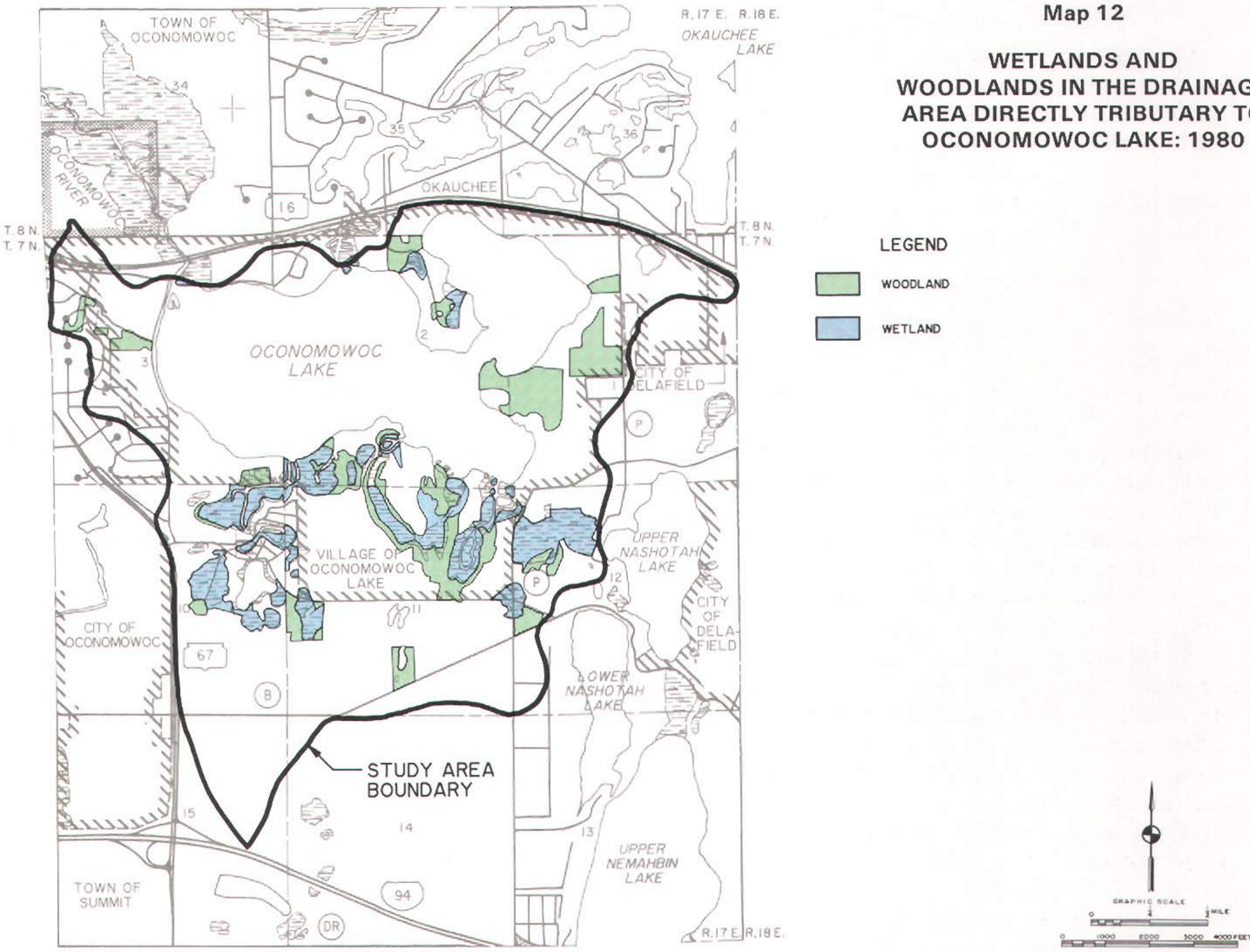
Source: Wisconsin Department of Natural Resources and SEWRPC.

marsh, bog, fen, low prairie, southern sedge meadow, fresh (wet) meadow, shrub carr, southern wet and wet-mesic hardwood forest, and conifer swamp. In 1980 the major wetland communities located in the drainage area directly tributary to Oconomowoc Lake, as shown on Map 12, encompassed approximately 248 acres, or 12 percent of the direct drainage area, and included sedge meadow, shrub carr, fresh (wet) meadow, deep and shallow marsh, and southern wet and wet-mesic hardwood forest. Wetlands were located south of the lake primarily adjacent to man-made channels and along the Oconomowoc River.

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

Map 12

WETLANDS AND WOODLANDS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1980



Source: SEWRPC.

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

Areas of deep and shallow marsh also occur in the Oconomowoc Lake direct drainage area, primarily adjacent to the man-made channels along the southern shore. These areas are dominated by broadleaf cattail (Typha latifolia), soft-stem bulrush (Scirpus validus), and hard-stem bulrush (Scirpus atrovirens). It is important to note that the quality and diversity of some of these deep and shallow marsh areas in the direct drainage area are threatened by the invasion of the aggressive, alien plant species called purple loosestrife (Lythrum salicaria). Significant concentrations of purple loosestrife are located in a wetland complex adjacent to the outlet of the lake and in a wetland complex adjacent to Hewitt's Point on the northern shore of the lake.

Southern wet and wet-mesic hardwood forest occurs in scattered areas adjacent to the eastern shoreline of the lake and in the south-central portion of the direct drainage area. These lowland forests are characterized by the prevalence of black willow (Salix nigra), cottonwood (Populus deltoides), green ash (Fraxinus pennsylvanica), silver maple (Acer saccharinum), and American elm (Ulmus americana). Several clumps of tamarack (Laris laricina) are also present.

ENVIRONMENTAL CORRIDORS

The Environmental Corridor Concept

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

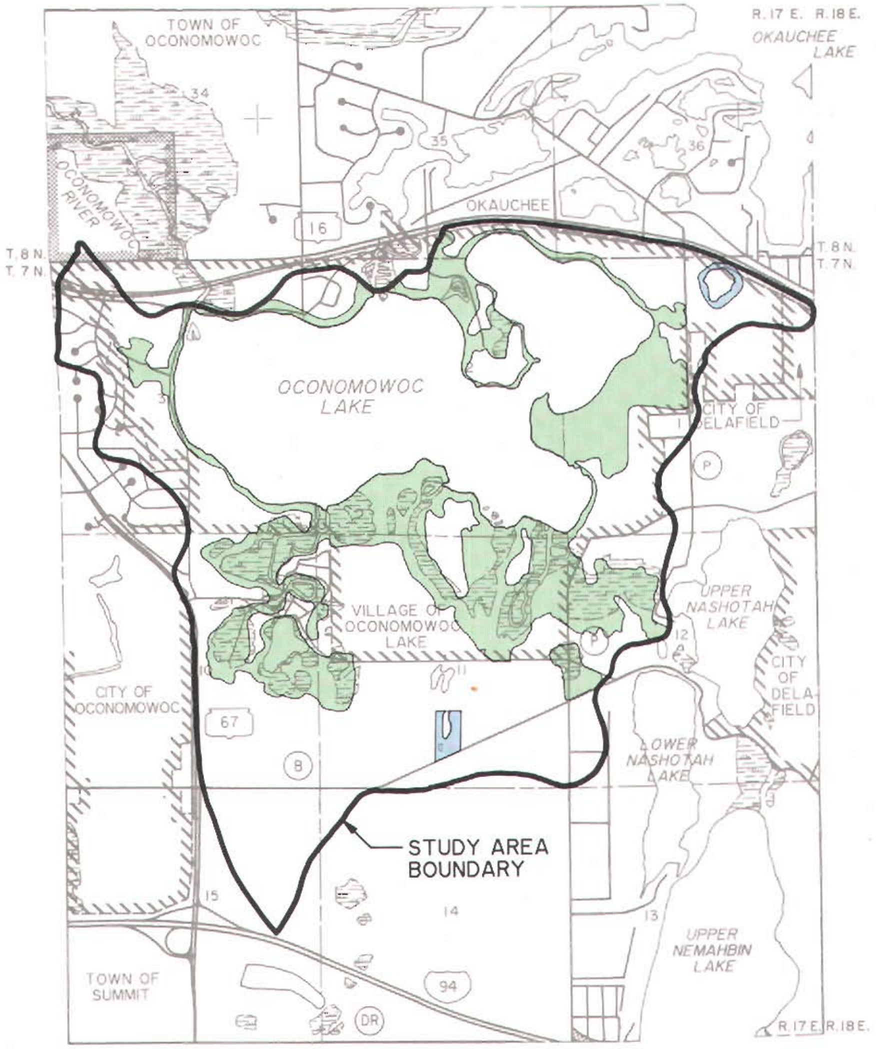
The delineation of these 12 natural resource and natural resource-related elements on a map results in an essentially linear pattern of relatively narrow, elongated areas which have been termed "environmental corridors" by the Commission. Primary environmental corridors include a wide variety of the above-mentioned important resource and resource-related elements and are, by definition, at least 400 acres in size, two miles in length, and 200 feet in width. The primary environmental corridors identified in the Oconomowoc Lake direct drainage area are contiguous with environmental corridors in isolated natural areas lying outside the lake drainage area boundary, and consequently do meet these size and natural resource element criteria.

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

Primary Environmental Corridors: Primary environmental corridors were first identified within the Region in 1963 as part of the original regional land use planning effort of the Regional Planning Commission, and were subsequently refined under the Commission watershed studies and regional park and open space planning program. The initial corridor delineations, even as subsequently modified under other major planning programs undertaken by the Commission, were made at the systems level of planning and were thus relatively general. A more detailed delineation of environmental corridors is needed for more detailed project level planning

Map 13

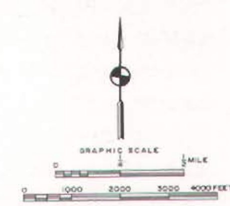
PRIMARY ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL AREAS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1980



LEGEND

PRIMARY ENVIRONMENTAL CORRIDOR

ISOLATED NATURAL AREA



Source: SEWRPC.

and other local planning efforts. The Commission, in 1980, completed such a detailed delineation of environmental corridors in the drainage area directly tributary to Oconomowoc Lake.

The primary environmental corridors in southeastern Wisconsin generally lie along major stream valleys and around major lakes, and contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all of the major bodies of surface water and related undeveloped floodlands and shorelands. As shown on Map 13, primary environmental corridors in the Oconomowoc Lake direct drainage area encompassed 621 acres in 1980, or 30 percent of the direct drainage area.

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

Isolated Natural Areas: In addition to the primary environmental corridors, other, small concentrations of natural resource base elements exist within the drainage area directly tributary to Oconomowoc Lake. These concentrations are isolated from the environmental corridors by urban development or agricultural lands and, although separated from the environmental corridor network, have important natural values. Isolated natural areas may provide the only available wildlife habitat in a localized area, provide good locations for local parks and nature study areas, and lend a desirable aesthetic character and diversity to an area. Important isolated natural features include a variety of isolated wetlands, woodlands, and wildlife habitat. These isolated natural features should also be protected and preserved in a natural state whenever possible. Isolated natural areas five or more acres in size within the drainage area directly tributary to Oconomowoc Lake as of 1980 are shown on Map 13. The combined area of the isolated natural areas identified on the map totals about 20 acres, or 1 percent of the direct drainage area.

RECREATIONAL USE

Oconomowoc Lake provides opportunities for a variety of water-based outdoor recreation activities, including fishing, boating, swimming, and nature study. Oconomowoc lake provides a high-quality habitat for walleye, northern pike, largemouth bass, and panfish. The size and numbers of fish in the lake provide a good resource to both the lake residents and other lake users.

Water skiing, pleasure boating, and swimming are popular recreational activities on Oconomowoc Lake during the summer. Ice fishing is a popular recreational activity during the winter.

A survey of the boating pressure on the lake conducted in 1976 indicated that the heaviest use of Oconomowoc Lake by anglers was during the spring and early autumn. On summer weekdays the lake was primarily used by fishing boats. Boating pressure on summer weekends was highest and was dominated by fishing boats, followed by sailing craft, and pleasure and water skiing boats. During the study period, boat traffic remained fairly constant throughout the boating season. Many of the boats in use were fishing boats which required less lake area than boats used for other recreational activities. Consequently, no conditions of crowding or unsafe boating pressures were apparent.

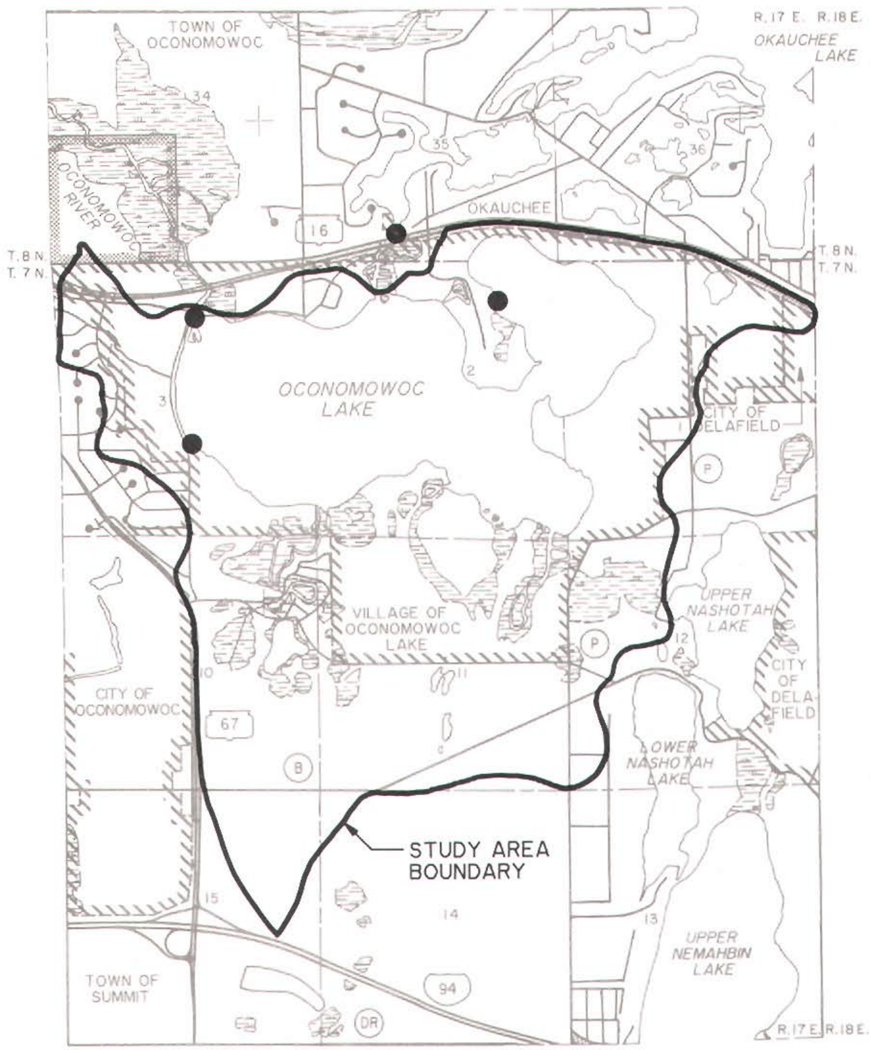
Because nonlake residents participate in some recreational activities on Oconomowoc Lake, adequate public access points to the lake are required. In the adopted regional park and open space plan—SEWRPC Planning Report No. 27, A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000—the Commission established objectives, principles, and standards for the provision of facilities to support participation by the residents of southeastern Wisconsin in extensive water-based outdoor recreational activities on the major inland lakes. The adopted standards provided a means of quantifying the number of public access points consistent with safe and enjoyable participation. Based on those adopted standards, which require that at least one boat access open to the general public be provided at each major inland lake, the existing facilities are adequate to provide boating access to the lake.

In 1976, the DNR surveyed lake access sites around Oconomowoc Lake. This information was updated by the Commission staff in 1984. The results of the survey are presented on Map 14 and in Table 18. Of four sites identified, one site was found to be in need of maintenance, and three sites were found to be well maintained and in good condition. The DNR also evaluated the adequacy of the existing public access sites for nonresident use. A site was judged to be adequate if it was publicly owned, had sufficient facilities for boat launching and parking, and had reasonable fees based on a comparison to the standard fees charged in state parks. Private sites were not considered adequate because there can be no assurance that the sites will remain open from one year to the next; nor can there be any assurance concerning the reasonableness of fees charged for access. Sites evaluated as marginal were judged to have inadequate parking, fees that were too high, or difficult launching sites, or were not publicly owned. Inadequate sites were basically unusable—that is, they were posted as closed, were blocked from access, had no parking available, or had an unusable boat launching site.

The DNR, under guidelines established in Chapters NR 1.90 and NR 1.92 of the Wisconsin Administrative Code, recommended that at least one access and public boat launching site be provided on all major inland lakes. The DNR recommendation for an adequate boat launch

Map 14

PUBLIC ACCESS SITES ON OCONOMOWOC LAKE: 1984



LEGEND

● PUBLIC ACCESS SITE

Source: Wisconsin Department of Natural Resources.

Table 18

PUBLIC ACCESS SITES ON OCONOMOWOC LAKE: 1984

Location	Owner	Type	Area (acres)	Lake Frontage Area (feet)	Parking Spaces for Car Trailers	Parking Spaces for Cars
T7N, R17E						
Section 2	Town of Summit	Walk-in-trail	0.1	40	0	0
Section 3	Waukesha County	Walk-in-trail	0.1	200	0	0
Section 3	Waukesha County	Walk-in-trail	0.1	100	0	3
T8N, R17E						
Section 35	Village of Oconomowoc Lake	Ramp, livery	1.5	N/A	20	30

NOTE: N/A indicates data not available.

Source: Wisconsin Department of Natural Resources.

Table 19

RECREATIONAL RATING OF OCONOMOWOC LAKE: 1976-1977

Fishing		
____ 9 High production	X 6 Medium production	____ 3 Low production
X 9 No problems	____ 6 Modest problems such as infrequent winterkill, small rough fish problems	____ 3 Frequent and overbearing problems such as winterkill, carp, excessive fertility
Subtotal: 15		
Swimming		
____ 6 Sand or gravel (75 percent or more)	X 4 Sand or gravel (25-75 percent)	____ 3 Sand or gravel (< 25 percent)
X 6 Clean water	____ 4 Moderately clean	____ 3 Turbid or darkly stained
____ 6 No algae or weed problems	X 4 Moderate algae or weed problems	____ 3 Frequent algae or weed problems
Subtotal: 14		
Boating		
X 6 Adequate depths (> 75 percent of basin more than five feet deep)	____ 4 Adequate depths (50-75 percent of basin more than five feet deep)	____ 3 Adequate depths (< 50 of basin more than five feet deep)
____ 6 Adequate size for extended boating (> 1,000 acres)	X 4 Adequate size for some boating (200-1,000 acres)	____ 3 Limit of boating challenge and space (< 200 acres)
X 6 Good water quality	____ 4 Some inhibiting factors such as weedy bays and algae blooms	____ 3 Overwhelming inhibiting factors such as weed beds throughout
Subtotal: 16		
Aesthetics		
X 6 Existence of 25 percent or more wild shore	____ 4 Less than 25 percent wild shore	____ 3 No wild shore
X 6 Varied landscape	____ 4 Moderately varied landscape	____ 3 Unvaried landscape
X 6 Few nuisances such as excessive algae, carp, and dumps	____ 4 Moderate nuisance conditions	____ 3 High nuisance conditions
Subtotal: 18		
Total Quality Rating 63 out of a possible 72 points		

Source: Wisconsin Department of Natural Resources.

facility is met on Oconomowoc Lake, with a boat access being located approximately 0.7 mile upstream of the lake, just below the outlet of Okauchee Lake. The facility is owned by the Village of Oconomowoc Lake and leased to a private operator. DNR policies normally require the presence of an adequate launching facility in order for technical assistance to be available from the DNR for in-lake and watershed management programs. Such programs could include lake rehabilitation, nonpoint source water pollution control, fish management, and water safety aids.

In general, Oconomowoc Lake provides opportunities for a variety of outdoor recreational activities in a high-quality setting. An outdoor recreational rating technique was developed by the DNR to summarize the outdoor recreational value of inland lakes. As shown in Table 19, Oconomowoc Lake scored 63 out of a possible 72 rating points, placing it among those lakes in southeastern Wisconsin providing diverse, high-quality outdoor recreational opportunities. To ensure that Oconomowoc Lake will continue to provide such opportunities, the resource values of the lake must be protected and preserved.

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Chapter VI

MANAGEMENT AND LEGAL CONSIDERATIONS AFFECTING WATER QUALITY

SEWAGE DISPOSAL

Onsite Sewage Disposal Systems

The sanitary and household wastewaters from the drainage area directly tributary to Oconomowoc Lake as of 1983 were treated and disposed of through the use of onsite systems. An onsite sewage disposal system may be a conventional septic tank system, a mound system, or a holding tank. As of 1983, 193 septic tank systems and six holding tanks were known to exist in the drainage area directly tributary to the lake.

The septic tank system consists of two components: a septic tank proper used to provide partial treatment of the raw wastes—by skimming, settling, and anaerobic decomposition, and the soil absorption field for final treatment and disposal of liquid discharged from the septic tank. Both components are installed below the ground surface. The septic tank is a water-tight tank intended to separate floating and settleable solids from the liquid fraction of domestic sewage and to discharge the liquid, together with its burden of dissolved particulate solids, into the biologically active zone of the soil mantle through a subsurface percolation system. The discharge system may be a tile field, a seepage bed, or an earth-covered sand filter. Liquid passing through the active soil zone percolates downward until it strikes an impervious layer or the groundwater. Thus, the purpose of the percolation system is to dispose of sewage effluents by utilizing the same natural phenomena which lead to the accumulation of groundwater.

Providing that the system is located, installed, used, and maintained properly, and that there is an adequate depth—four to five feet—of moderately permeable, unsaturated soil below the drainage field to bedrock or water table, it should operate with few problems for up to 20 years. However, as previously noted, not all residential areas within the Oconomowoc Lake direct drainage area are located in areas covered by soils suitable for septic tank use. It has been estimated that 59 septic systems, or about 31 percent, are located on soils with limitations for such use.

Failure of a septic tank system occurs when the soil surrounding the seepage area will no longer accept or properly stabilize the septic tank effluent, when the groundwater rises to levels which will no longer allow for uptake of liquid effluent by the soils, or when age or lack of proper maintenance cause the system to malfunction. Hence, septic system failure may result from installation in soils with severe limitations for system use, improper design or installation of the system, or inadequate maintenance. In many older, improper installations, the septic effluent may not receive the benefit of soil filtration, but rather discharges directly from the septic tank to a drain tile or culvert. A precise identification of septic system problems requires a sanitary survey. Such a survey has not, to date, been conducted.

Mound systems utilize mechanical facilities to pump septic tank effluent through one-inch-diameter perforated distribution pipes placed in fill on top of the natural soil. When in place, this fill takes on the appearance of a mound; hence, the systems are commonly called "mound systems." A typical installation designed to accommodate wastes from a four-bedroom, single-family home might have a mound 64 feet wide by 84 feet long, or 5,376 square feet in areal extent, and would represent about 12 percent of the total area of a one-acre lot. At its highest point, the mound would be approximately five feet in height. At the present time, there are three mound systems in the Oconomowoc Lake direct drainage area. Alternative methods for the treatment of household wastewaters in areas previously developed, such as cluster mounds, individual mound systems, or connection to sanitary sewers, could become necessary in the future to treat household sanitary wastes properly.

Sanitary Sewer Service

About 310 persons in the Oconomowoc Lake direct tributary drainage area, or about 30 percent of the resident population of the drainage area, receive sanitary sewer service from the City of Oconomowoc. The area served includes about 85 acres, or about 19 percent, of the residential development in the direct tributary drainage area. The City of Oconomowoc sewage treatment plant discharges to the Oconomowoc River downstream of Lac La Belle.

EXISTING ZONING REGULATIONS

The community zoning ordinance represents one of the most important and significant tools available to local units of government in directing the proper use of lands within their area of jurisdiction. As noted in Chapter II, the drainage area directly tributary to Oconomowoc Lake includes portions of the Cities of Delafield and Oconomowoc, the Village of Oconomowoc Lake, and the Towns of Oconomowoc and Summit, all in Waukesha County. Under Wisconsin law, any town zoning requires, at a minimum, county approval of the local ordinance or modification thereto. Consequently, five local zoning ordinances are administered within the Oconomowoc Lake direct drainage area. A summary of the applicable zoning districts available for use in the five local civil divisions is presented in Appendix C. The areas of land placed in each of the districts are delineated on Map 15.

In addition to the five local zoning ordinances administered in the Oconomowoc Lake direct drainage area, the Waukesha County Board of Supervisors adopted a Shoreland and Floodland Protection Zoning Ordinance in 1970. This ordinance, prepared pursuant to the requirements of the Wisconsin Water Resources Act of 1965, imposes special land use regulations on all lands located within 1,000 feet of the shoreline of any navigable lake, pond, or flowage, and within 300 feet of the shoreline of any navigable river or stream, or to the landward side of the floodplain if it extends beyond such distances. The shoreland and floodplain zoning jurisdictional area is applicable only to unincorporated areas within the Oconomowoc Lake direct drainage area.

Chapter 330 of the Wisconsin Statutes requires that counties regulate all wetlands within unincorporated areas five acres or larger located in shoreland areas—that is, within 300 feet of a stream and 1,000 feet of a lake or to the landward side of the floodplain, whichever is greater. Preliminary wetland maps for Waukesha County were prepared for the Wisconsin Department of Natural Resources (DNR) by the Commission. These maps were reviewed at a public hearing held in the County on October 4, 1982. The DNR provided final copies of these wetland maps to the County on September 6, 1984. In accordance with Chapter 115 of the Wisconsin Administrative Code, Waukesha County will be required to update the present shoreland zoning regulations within six months of the date they were received from the DNR to preclude further loss of wetlands in the shoreland areas.

Because 85 percent of the Oconomowoc Lake direct drainage area is available for essentially urban and suburban land uses under the existing zoning ordinances, the ordinances encourage the diffusion of urban-type development throughout the lake drainage area in a manner that conflicts with the recommendations of the adopted regional land use and water quality management plans. In order to prevent undesirable urban development in the lake drainage area, it will be necessary for the responsible officials in the five civil divisions and in the County to critically review the individual zoning ordinances and accompanying zoning district maps for the Oconomowoc Lake direct drainage area and amend the ordinances and maps so as to preserve and enhance the existing natural resource base of the drainage area. Preservation and enhancement of these natural areas will serve to protect and ultimately to improve the water quality of the lake.

AQUATIC PLANT MANAGEMENT

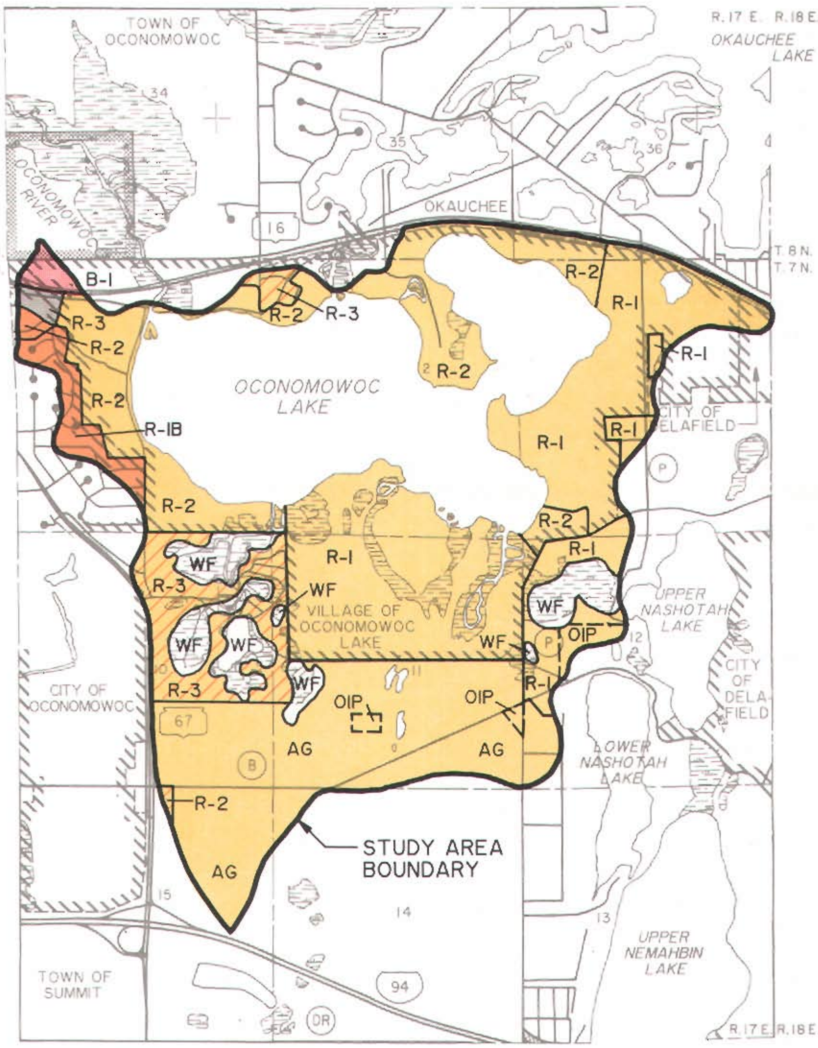
Records of aquatic plant management efforts were not maintained by the Wisconsin Department of Natural Resources prior to 1950. Efforts to manage the aquatic plants in Oconomowoc Lake were first recorded in 1950, when 40 pounds of sodium arsenite was applied to the lake to control macrophytes. Aquatic plant management for Oconomowoc Lake can be categorized as chemical macrophyte control, and chemical algae control. In addition, chemical treatments for swimmers' itch will be discussed below.

Chemical Macrophyte Control

Since 1941, the use of chemicals to control aquatic plants has been regulated in Wisconsin. Even prior to this date, chemicals had been used to control aquatic plant growth in lakes and streams. In 1926, sodium arsenite, an agricultural herbicide, was first applied to lakes in Madison, Wisconsin. By the 1930's, sodium arsenite was widely used for aquatic plant control; however, no other chemicals were applied in significant amounts to control macro-

Map 15

EXISTING ZONING DISTRICTS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 1984



LEGEND

- SUBURBAN RESIDENTIAL (CONTAINS DISTRICTS PERMITTING FROM 0.2 TO 0.6 DWELLING UNITS PER NET ACRE)
- LOW DENSITY URBAN RESIDENTIAL (CONTAINS DISTRICTS PERMITTING FROM 0.7 TO 2.2 DWELLING UNITS PER NET ACRE)
- MEDIUM DENSITY URBAN RESIDENTIAL (CONTAINS DISTRICTS PERMITTING FROM 2.3 TO 6.9 DWELLING UNITS PER NET ACRE)
- HIGH DENSITY URBAN RESIDENTIAL (CONTAINS DISTRICTS PERMITTING FROM 7.0 TO 17.9 DWELLING UNITS PER NET ACRE)
- BUSINESS (CONTAINS DISTRICTS PERMITTING NEIGHBORHOOD-ORIENTED, COMMUNITY-ORIENTED, HIGHWAY-ORIENTED, AND OFFICE DEVELOPMENT)
- NO URBAN DEVELOPMENT

ZONING DISTRICTS

VILLAGE OF OCONOMOWOC LAKE

R-1	SINGLE-FAMILY RESIDENTIAL DISTRICT
R-2	SINGLE-FAMILY RESIDENTIAL DISTRICT
R-3	SINGLE-FAMILY RESIDENTIAL DISTRICT
B-1	BUSINESS DISTRICT

TOWN OF SUMMIT

R-1	COUNTRY HOME
WF	WETLAND AND FLOODPLAIN
OIP	INSTITUTIONAL AND PUBLIC SERVICE
AG	AGRICULTURAL
R-2	COUNTRY HOME
R-3	COUNTRY HOME

CITY OF OCONOMOWOC

R-1B	ONE-FAMILY RESIDENCE DISTRICT
R-2	ONE- AND TWO-FAMILY RESIDENCE DISTRICT
R-3	MULTI-FAMILY RESIDENCE DISTRICT

CITY OF DELAFIELD

R-1	SINGLE-FAMILY RESIDENCE

TOWN OF OCONOMOWOC

B-1	RESTRICTED BUSINESS DISTRICT

Source: SEWRPC.

phytes. Recorded applications of sodium arsenite to Oconomowoc Lake were sporadic from 1950 to 1969, with a total of 33,322 pounds of sodium arsenite applied, a relatively small amount when compared to the amounts applied to other lakes in the State.

The sodium arsenite was usually sprayed within 200 feet of the shoreline. Treatment typically occurred between mid-June and mid-July. The amount of sodium arsenite used was calculated to result in a concentration of about 10 parts per million sodium arsenite in the treated lake water. Most of the sodium arsenite remained in the water column for less than 120 days. By natural processes, the arsenic residue was converted from a highly toxic trivalent form to a relatively less toxic—and less biologically active—pentavalent form. Much of the arsenic residue was deposited in the lake sediments. Algae, diatoms, and macrophytes have been known to concentrate arsenic in their tissue up to levels exceeding 2,000 micrograms per gram (ug/g) dry weight. However, biomagnification of arsenic through the food chain has not been known to occur. Analyses of fish tissue from some treated lakes by the Wisconsin Department of Natural Resources in 1960 and in 1971 indicated no excessive levels of arsenic.

The use of sodium arsenite was discontinued in the State in 1969, after it became apparent that arsenic was accumulating in the sediments of treated lakes. The application and accumulation of arsenic were concluded to present potential health hazards to human and aquatic life. In drinking water supplies arsenic is a suspended carcinogen and has been known to cause skin cancer and brain, liver, kidney, and bone marrow damage. Under certain conditions, arsenic may leach to and contaminate the groundwater, especially in sandy soils. The U. S. Environmental Protection Agency drinking water standard for arsenic is 0.05 milligram per liter (mg/l).

At these moderate rates of application to Oconomowoc Lake, it is highly unlikely that arsenic levels are currently excessive. During anaerobic conditions, arsenic may be released from the sediments to the water. In this way some arsenic continues to be "flushed out" through the outlet. In addition, the arsenic-laden sediments are continually being covered by new sediments. Therefore, the level of arsenic in the water and in the surface sediments can be expected to decrease with the passage of time.

As shown in Table 20, other aquatic herbicides including 2,4-D, Diquat, Endothal, and Aquathol were also applied in the past to Oconomowoc Lake to control macrophyte growth. However, these chemicals have not been used since 1974, when 40 pounds of Endothal was applied to 0.3 acre.

All aquatic plant control chemicals used must be approved by the U. S. Environmental Protection Agency and the Wisconsin Department of Natural Resources. Application of chemicals on Oconomowoc Lake requires a permit from the DNR under Chapter NR 107 of the Wisconsin Administrative Code. The Federal Insecticide, Fungicide, and Rodenticide Act as amended in 1972 requires that all pesticides be registered.

The advantages of chemical use are their relatively low cost and the ease, speed, and convenience of application. Disadvantages associated with chemical control include the following:

1. Although the short-term, lethal effects of chemicals are relatively well known, potential long-term, sublethal effects—especially on fish and fish-food organisms—are relatively unknown.
2. The elimination of macrophytes reduces the competition with algae for light and nutrients. Thus, increased algae blooms may develop.
3. Since the plant bodies are not removed from the lake, upon decomposition the nutrients will be released to the water. Decomposition of the plant bodies also consumes dissolved oxygen and increases the potential for fishkills.
4. The elimination of macrophyte beds destroys important cover, food sources, and spawning areas for desired fish species.
5. Adverse impacts on other aquatic organisms may be expected. Diquat has been shown to kill the zooplankton Daphnia (water fleas) and Hyalella (scuds) at the level applied for macrophyte control. Both Daphnia and Hyalella are important fish foods, and Daphnia is a primary food for the young of nearly all fish species.[1]

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

Table 20

SUMMARY OF AQUATIC NUISANCE CONTROL ACTIVITIES ON OCONOMOWOC LAKE: 1950-1984

		Algae Control			Macrophyte Control					
Year	Area Treated (acres)	Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine-+	Sodium Arsenite (pounds)	2,4-D	Diquat (gallons)	Endothal	Aquathol	Swimmers' Itch Control
1950	N/A	--	--	--	40	--	--	--	--	--
1951	--	--	--	--	--	--	--	--	--	--
1952	--	--	--	--	--	--	--	--	--	--
1953	N/A	--	--	--	416	--	--	--	--	--
1954	N/A	--	--	--	498	--	--	--	--	--
1955	N/A	--	--	--	420	--	--	--	--	--
1956	--	--	--	--	--	--	--	--	--	--
1957	N/A	--	--	--	6,160	--	--	--	--	--
1958	36.0	--	200	--	3,756	--	--	--	--	--
1959	13.9	--	100	--	1,440	--	--	--	--	--
1960	--	--	--	--	--	--	--	--	--	--
1961	5.7	--	--	--	540	--	--	--	--	--
1962	--	--	--	--	--	--	--	--	--	--
1963	40.0	--	--	--	7,020	--	--	--	--	--
1964	--	--	--	--	--	--	--	--	--	--
1965	6.5	--	--	3 pounds/ 1 gallon	--	--	--	--	--	700 pounds copper sulfate and 350 pounds lime
1966	117.0	1,170	--	--	--	--	--	--	--	--
	35.0	--	--	--	6,732	--	--	--	--	--
	14.0	--	--	--	--	--	--	--	--	800 pounds copper sulfate and 400 pounds calcium carbonate
1967	120.0	1,200	--	--	--	--	--	--	--	--
	49.0	--	--	--	6,300	--	--	--	--	--
	12.0	--	--	--	--	--	--	--	--	800 pounds copper sulfate and 400 pounds calcium carbonate
1968	10.0	--	--	--	--	--	--	--	--	820 pounds copper sulfate, 100 pounds lime, and 310 pounds calcium carbonate
	33.0	--	--	--	--	25 gallons	1	100 gallons	--	--
1969	40.0	300	--	--	--	--	--	--	--	--
	4.0	27	--	--	--	--	--	--	--	--
	0.2	--	--	--	--	--	--	--	50 pounds	--
	5.0	--	--	--	--	--	10	--	--	--
	7.0	--	--	--	--	35 gallons	--	--	--	--
	0.5	--	--	--	--	90 pounds	--	--	--	--
	10.0	--	--	--	--	--	--	--	--	1,000 pounds copper sulfate and 500 pounds lime
1970	44.0	225	--	--	--	15 gallons	2	15 gallons	--	1,060 pounds copper sulfate and 500 pounds lime
1971	3.2	--	--	--	--	391 pounds	--	--	--	--
	1.0	--	--	--	--	--	--	--	200 pounds	--
	0.25	--	--	--	--	--	--	--	55 pounds	--
	7.5	--	--	--	--	--	--	--	--	600 pounds copper sulfate and 300 pounds lime
	41.4	--	268	--	--	--	--	--	--	--
1972	10.1	--	--	--	--	--	--	--	--	900 pounds copper sulfate and 450 pounds lime
	7.7	--	66	--	--	--	--	--	--	--
	3.1	--	--	--	--	--	--	--	15 gallons	--
1973	1.5	--	--	--	--	--	2	--	--	--
	12.3	--	--	--	--	--	--	45 gallons	--	--
	3.9	--	445	--	--	--	--	--	--	--
	11.0	--	--	--	--	--	--	--	--	900 pounds copper sulfate and 450 pounds calcium carbonate
1974	0.3	--	--	--	--	--	--	40 pounds	--	--
	14.4	--	--	--	--	--	--	--	--	1,200 pounds copper sulfate and 600 pounds lime
1975	8.3	--	157	--	--	--	--	--	--	--
	16.0	--	--	--	--	--	--	--	--	1,520 pounds copper sulfate and 815 pounds lime
	18.0	--	190	--	--	--	--	--	--	--

Table 20 (continued)

Year	Area Treated (acres)	Algae Control: Copper Sulfate (pounds)	Algae Control: Blue Vitriol (pounds)	Algae Control: Cutrine or Cutrine-+	Macrophyte Control: Sodium Arsenite (pounds)	Macrophyte Control: 2,4-D	Macrophyte Control: Diquat (gallons)	Macrophyte Control: Endothal	Macrophyte Control: Aquathol	Swimmers' Itch Control
1976	14.0	--	--	--	--	--	--	--	--	1,380 pounds copper sulfate and 680 pounds lime
	1.5	--	--	--	--	--	--	--	--	100 pounds copper sulfate and 50 pounds calcium carbonate
1977	16.1	--	--	--	--	--	--	--	--	1,240 pounds copper sulfate and 620 pounds lime
1978	4.2	--	--	--	--	--	--	--	--	400 pounds copper sulfate
	4.0	--	--	--	--	--	--	--	--	360 pounds copper sulfate and 200 pounds lime
	1.0	--	--	--	--	--	--	--	--	120 pounds copper sulfate and 60 pounds lime
	4.5	--	--	--	--	--	--	--	--	360 pounds copper sulfate and 180 pounds lime
	2.5	--	--	--	--	--	--	--	--	300 pounds copper sulfate and 150 pounds lime
1979	9.0	--	--	--	--	--	--	--	--	640 pounds copper sulfate and 320 pounds lime
1980	5.7	--	--	--	--	--	--	--	--	800 pounds copper sulfate and 400 pounds calcium carbonate
1981	3.2	--	--	--	--	--	--	--	--	680 pounds copper sulfate
1982	4.02	--	--	--	--	--	--	--	--	560 pounds copper sulfate
1983	4.02	--	--	--	--	--	--	--	--	600 pounds copper sulfate
1984	1.15	--	--	--	--	--	--	--	--	280 pounds copper sulfate and 140 pounds calcium carbonate
	0.86	--	--	--	--	--	--	--	--	160 pounds copper sulfate and 80 pounds calcium carbonate
	0.43	--	--	--	--	--	--	--	--	120 pounds copper sulfate and 60 pounds calcium carbonate
	1.30	--	--	--	--	--	--	--	--	200 pounds copper sulfate and 100 pounds calcium carbonate
Total	--	3,447 pounds	4,456 pounds	3 pounds/ 1 gallon	33,322 pounds	75 gallons/ 481 pounds	15 gallons	115 gallons/ 40 pounds	305 pounds/ 15 gallons	18,600 pounds copper sulfate 4,875 pounds lime 2,430 pounds calcium carbonate

NOTE: N/A indicates data not available.

Source: Wisconsin Department of Natural Resources.

Chemical Algae Control

Table 20 indicates that copper sulfate, blue vitriol, and cutrine have been applied sporadically to Oconomowoc Lake since 1958 for algae control. Many of the disadvantages of chemical macrophyte control discussed above also apply to chemical algae control. Further, copper, the active ingredient in many algicides, may accumulate in bottom sediments. Excessive levels of copper are toxic to fish and benthic animals.

Chemical Control for Swimmers' Itch

Since 1965, a mixture of copper sulfate and lime or calcium carbonate has been utilized on certain areas of Oconomowoc Lake to kill snails. Snails are the intermediate host of a microscopic parasite of waterfowl which occurs in some lakes in southeastern Wisconsin. At certain times of the year, this parasite inbeds in the skin of humans, causing temporary itching and discomfort. Chemical treatment of swimming areas usually occurs in June and July, when snail populations are highest and the organisms are present in the water column in the greatest concentrations. On Oconomowoc Lake, areas along the eastern shoreline are the most commonly treated.

GOVERNMENTAL AGENCIES WITH WATER QUALITY MANAGEMENT RESPONSIBILITIES

A number of local, state, and federal agencies have water quality management responsibilities relative to Oconomowoc Lake. These agencies include an inland lake protection and rehabilitation district, a town sanitary district, the civil town, the County, the county land conservation committee (former county soil and water conservation district), the Regional Planning Commission, the Wisconsin Department of Natural Resources, the Wisconsin Department of Health and Social Services, the University of Wisconsin-Extension, the U. S. Environmental Protection Agency, the U. S. Department of Agriculture, Soil Conservation Service, and the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service. A brief discussion of the role of these agencies in water quality management follows. A more detailed discussion is presented in Chapter VI, Volume One, of SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000.

Inland Lake Protection
and Rehabilitation District

Inland lake protection and rehabilitation districts are special-purpose units of government created pursuant to Chapter 33 of the Wisconsin Statutes. In its declaration of intent, the Wisconsin Legislature summarized the underlying philosophy behind the creation of these special-purpose districts:

> The legislature finds environmental values, wildlife, public rights in navigable waters, and the public welfare are threatened by the deterioration of public lakes; that the protection and rehabilitation of the public inland lakes of this state are in the best interest of the citizens of this state; that the public health and welfare will be benefited thereby; that the current state effort to abate water pollution will not undo the eutrophic and other deteriorated conditions of many lakes; and that the positive public duty of this state as trustee of waters requires affirmative steps to protect and enhance this resource and protect environmental values.

Inland lake protection and rehabilitation districts are formed at the local level. The district organizers, who may be any local lake property owners, propose appropriate boundaries encompassing the riparian property and as much of the lake watershed as deemed necessary. Once the district boundary has been so proposed, the organizers must obtain a petition signed by at least 51 percent of the property owners or by the owners of at least 51 percent of the land within the proposed district boundaries. The petition is presented to the County Board which holds a hearing after notifying all property owners in the proposed district. Following the hearing, the county board may form an inland lake protection and rehabilitation district.

The lake district has powers to enter into contracts; own property; disburse money; and bond, borrow, and levy special assessments to raise money. Its specific lake management powers include:

1. Study of existing water quality conditions to determine the causes of existing or expected water quality problems.
2. Control of aquatic macrophytes and algae.
3. Implementation of lake rehabilitation techniques, including aeration, diversion, nutrient removal or inactivation, dredging, sediment covering, and drawdown.
4. Construction and operation of water level control structures.
5. Control of nonpoint source pollution.

The districts do not have police powers but may ask counties, towns, villages, or cities to enact ordinances necessary to improve or protect the lake. The governing body of a lake district is a board of commissioners, which consists of:

- Three property owners from within the district, elected by all property owners within the district.
- A county board member who is also on the land conservation committee who is appointed by the county board.
- A representative of the town, village, or city having the highest assessed valuation within the district who is appointed by the governing body of that unit of government.

Sanitary Districts

Sanitary districts may be created under Chapter 60 of the Wisconsin Statutes to plan, construct, and maintain centralized sanitary sewerage systems. Town sanitary districts have limited authority to construct and maintain storm sewer systems and provide garbage and refuse collection and disposal. Such districts have also been used as an organizational vehicle for lake macrophyte harvesting.

Towns

Towns have authority to undertake a wide variety of activities geared toward the abatement of pollution from both point and nonpoint sources. Towns that contain both urban and rural areas generally have elected to establish separate sanitary and utility districts for the provision of services to urban development, including in particular sanitary sewer and storm water management services. Towns may also undertake stream and lake improvements and watershed protection projects.

Counties

Counties are authorized to engage in soil and water conservation projects, lake and river improvements, property acquisitions, water protection, and solid waste management. In addition, counties may regulate nonpoint source pollution through their planning, zoning, subdivision, building, and health code authorities. County shoreland regulations apply to all areas within 1,000 feet of a lake, pond, or flowage, and 300 feet of a river or stream, or to the landward side of the floodplain, whichever is greater. Shoreland regulations impose special restrictions on the location of certain structures and establish restrictions on tree cutting, filling, grading, and certain agricultural practices within the shoreland areas. Under rules promulgated by the Wisconsin Department of Natural Resources, county shoreland regulations must also seek to protect and preserve wetlands that are at least five acres in size in shoreland areas within unincorporated areas. The Department of Natural Resources is also in the process of promulgating rules that will extend such shoreland-wetland zoning requirements to incorporated cities and villages.

In implementation of the areawide water quality management plan, it would be necessary for county boards and the county land conservation committees to work cooperatively.

County Land Conservation Committees

In 1982 the State Legislature abolished the former system of county soil and water conservation districts. These districts, while closely allied with county government operations, were, in fact, separate governmental units. In place of that system, the new legislation requires that the county boards of supervisors create within each county of the State a land conservation committee. In so doing, the State Legislature recognized that the county is the primary unit of government responsible for natural resource protection programs, particularly soil and water conservation programs. The new land conservation committees have a broad range of powers and duties, including the development and adoption of standards and specifications for management practices to control erosion, sedimentation, and nonpoint sources of water pollution; the distribution and allocation of available federal and state cost-sharing funds relating to soil and water conservation; the conduct of research and educational information programs relating to soil and water conservation; the conduct of programs designed to prevent flood damage, and drainage, irrigation, groundwater, and surface water problems; the provision of financial, technical, and other assistance to landowners; the acquisition of land and other interests and property; the acquisition of machinery, equipment, and supplies required to carry out various land conservation programs; the construction, improvement, operation, and maintenance of structures needed for land conservation, flood prevention, and nonpoint source pollution control; and the preparation of a long-range natural resource conservation plan for the county, including an erosion control plan and program. As a committee of the county board, all of its activities are closely supervised by the county board and subject to the fiscal resources made available by the county board. Pursuant to the new law, Waukesha County has created a land conservation committee to perform these various functions. Through this committee, Waukesha County could have important implementation responsibilities not only for land conservation, but for a comprehensive lake management program for Oconomowoc Lake.

Regional Planning Commission

In its role as a coordinating agency for water pollution control activities within southeastern Wisconsin, the Regional Planning Commission utilizes the legally adopted and certified regional plan elements as a basis for review of federal and state grants-in-aid, discharge permits, and sanitary sewer extensions. The Commission provides technical assistance pertaining to water quality management topics, and further promotes plan implementation through community assistance planning services, as appropriate. In addition, the Commission stands ready to provide a forum for the discussion of intergovernmental issues which may become critical to the orderly and timely implementation of water quality management projects. These indirect plan implementation functions must be distinguished from the direct plan implementation responsibilities of the other management agencies, through whose actions the plans are converted to reality.

Wisconsin Department of Natural Resources

The responsibility for water pollution control in Wisconsin is centered in the Wisconsin Department of Natural Resources. The basic authority and accompanying responsibilities relating to the water pollution control functions of the Department are set forth in Chapter 144 of the Wisconsin Statutes. Under this chapter, the Department is given broad authority to prepare as well as to approve or endorse water quality management plans; to establish water use objectives and supporting water quality standards; to review and approve all plans and specifications for components of sanitary sewerage systems; to conduct research and demonstration projects on sewerage and waste treatment matters; to operate an examining program for the certification of sewage treatment plant operators; to order the installation of centralized sanitary sewerage systems; to review and approve the creation of joint sewerage systems and metropolitan sewerage districts; to regulate water level elevations; and to administer a financial assistance program for the construction of pollution prevention and abatement facilities, or for the application of land management measures. The Wisconsin Statutes also authorize the Department to consider conformance with an approved areawide water quality management plan when reviewing locally proposed sanitary sewer extensions. This permissive authority is in addition to the Department's mandatory review for engineering soundness and for relation to public health and safety.

Under Chapter 147 of the Wisconsin Statutes, the Department is given broad authority to establish and carry out a pollutant discharge elimination program in accordance with the policy guidelines set forth by the U. S. Congress under the Federal Water Pollution Control Act. Pursuant to this authority, the Department has established a waste discharge permit system. No permit may be issued by the Department for any discharge from a point source of pollution that is in conflict with an areawide water quality management plan approved by the Department. Also under this authority, the Department has rule-making powers to establish effluent limitations, water quality-related limitations, performance standards related to classes or categories of pollution, and toxic and pretreatment effluent standards. All permits issued by the Department must include conditions that waste discharges are to meet, in addition to effluent limitations, performance standards, effluent prohibitions, pretreatment standards, and any other limitations needed to meet the adopted water use objectives and supporting water quality standards. As appropriate, the permits may include a timetable for appropriate action on the part of the owner or operator of any point source waste discharge.

Wisconsin Department of Health and Social Services, Division of Health

In performing its functions relating to the maintenance and promotion of public health, the Wisconsin Division of Health is charged with the responsibility of regulating the installation and operation of private septic tank sewage disposal systems. The Division reviews plats of all land subdivisions not served by public sanitary sewerage systems and may object to such plats if onsite sanitary waste disposal facilities are not properly provided for in the plat layout.

University of Wisconsin-Extension

The Extension Service operates on a contractual basis with counties to provide technical and educational assistance within the counties. Of particular importance to implementation of the areawide water quality management plan is the provision of technical assistance by the Extension Service to county land conservation committees, county boards, and county zoning and planning committees. In addition, the Extension Service is well equipped to provide educational services, especially in the areas of nonpoint source pollution and sludge management.

U. S. Environmental Protection Agency

The U. S. Environmental Protection Agency has broad powers under the Federal Water Pollution Control Act to administer federal grants-in-aid for the construction of publicly owned waste treatment works and related sewerage facilities; to promote and fund areawide waste treatment planning and management; to set and enforce water quality standards, including effluent limitations, through the establishment of water use objectives and supporting water quality standards and the conduct of water quality inventories and inspection and monitoring programs; and to establish a national pollutant discharge elimination system. The Environmental Protection Agency thus acts as the key federal water pollution control agency and must approve all basin and areawide water quality management plans as certified to it by appropriate state agencies.

U. S. Department of Agriculture, Soil Conservation Service

The U. S. Department of Agriculture, Soil Conservation Service, administers resource conservation and development projects under Public Law 566 and provides technical and financial assistance, through soil and water conservation districts, to landowners in the planning and construction of measures for land treatment, agricultural water management, and flood prevention, and for public fish, wildlife, and recreational development. The Soil Conservation Service also conducts detailed soils surveys and provides interpretations as a guide to the use of soil survey data in local planning and development. The technical assistance programs of the Soil Conservation Service are of great importance to implementation of the areawide water quality management plan.

U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service

The U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, administers the federal Agricultural Conservation Program (ACP), which provides grants to rural landowners in partial support of carrying out approved soil, water, woodland, wildlife, and other conservation practices. These grants are awarded under yearly and long-term assistance programs, providing guaranteed funds for carrying out approved conservation work plans. Grants from the federal Agricultural Conservation Program are important to implementation of the areawide water quality management plan. In addition, the Agricultural Stabilization and Conservation Service has relatively new authority under Section 205(J) of the Federal Water Pollution Control Act to administer a cost-sharing grant program for the purpose of installing and maintaining agricultural measures found needed to control nonpoint source pollution.

Private Action for Water Control

The foregoing discussion deals exclusively with water quality management by units and agencies of government. Direct action may also be taken by private individuals or organizations to effectively abate water pollution. As discussed in Chapter VIII, some of the most important, yet least costly, management practices can be readily carried out by individual citizens. In addition, most of the activities of the agencies discussed require the cooperation and support of individual citizens and of citizen groups in order to be effectively implemented.

Chapter VII

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS

The areawide water quality management plan adopted by the Regional Planning Commission, as set forth in SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, recommends water use objectives and supporting water quality standards for all major lakes and streams in the Region. The water use objectives recommended for Oconomowoc Lake are full recreational use and support of a healthy warmwater fishery. The water quality standards which support these objectives are set forth in Table 21. Standards are recommended for temperature, pH, dissolved oxygen, fecal coliform, residual chlorine, un-ionized ammonia nitrogen, and total phosphorus.

Table 21

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

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

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

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

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

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

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

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

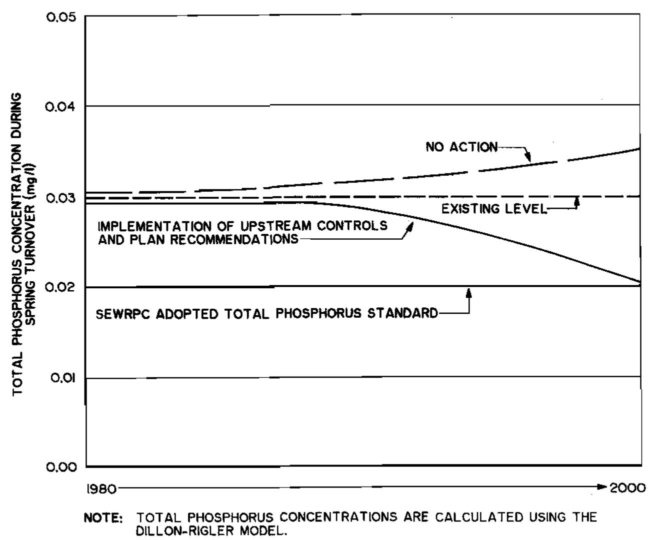
Source: SEWRPC.

The total phosphorus standard of 0.02 milligram per liter (mg/l) applies to lakes during spring turnover, when the lakes are not stratified and maximum vertical mixing is occurring. The achievement of this standard is expected to prevent excessive macrophyte and algae growths in most lakes, although lake rehabilitation techniques may also be required to avoid seasonal problems associated with the recycling of phosphorus from the bottom sediments. Excessive total phosphorus levels may stimulate large growths of algae and aquatic macrophytes, which interfere with recreational use. As these plant masses die and decompose, dissolved oxygen depletions may result, which also threaten the survival of fish and aquatic life. Although many factors are involved, one pound of phosphorus may produce from 1,000 to 10,000 pounds wet weight of aquatic plant material. The decomposition of this amount of plant material would consume 100 pounds or more of dissolved oxygen.

The phosphorus concentration in the lake is directly related to the phosphorus load contributed to the lake by the Oconomowoc River, stormwater runoff from urban and rural lands in the direct drainage area, onsite sewage disposal systems, and atmospheric sources, although some recycling of phosphorus from the lake bottom sediments may also occur. Figure 11 indicates the total phosphorus concentrations expected to occur during spring turnover under alternative water quality management actions in the lake watershed, as estimated by Regional Planning Commission water quality analyses. Failure to implement management measures in the direct drainage area and in the Oconomowoc

Figure 11

TOTAL PHOSPHORUS LEVELS IN OCONOMOWOC LAKE UNDER ALTERNATIVE POLLUTION CONTROL ACTIONS



NOTE: TOTAL PHOSPHORUS CONCENTRATIONS ARE CALCULATED USING THE DILLON-RIGLER MODEL.

Source: SEWRPC.

River watershed upstream of Oconomowoc Lake may be expected to result in continued excessive phosphorus levels and a decrease in water quality and water use potential.

Complete implementation of the plan recommendations, including the watershed management measures and in-lake management techniques set forth in this report, may be expected to result in the achievement of the phosphorus standard for recreational use opportunities and for support of a healthy warmwater fishery.

Chapter VIII

ALTERNATIVE WATER QUALITY MANAGEMENT MEASURES

INTRODUCTION

Potential measures for water quality management of Oconomowoc Lake include land use and zoning ordinance modifications, point source pollution control, nonpoint source pollution control, and lake rehabilitation techniques. Land use and zoning modifications consist of anticipated land use changes to provide for development in an environmentally sound manner. Point source pollution control measures consist of the design, construction, and operation of sanitary sewerage systems. Nonpoint source pollution control consists of the improved management of both urban and rural land uses to reduce pollutants discharged to the lake by direct overland drainage, by drainage through natural or man-made channels, and by groundwater inflow. Lake rehabilitation techniques either directly treat the symptoms of lake eutrophication or alter the characteristics of the lake basin which may be interfering with the achievement of the desired water use objectives.

FUTURE LAND USE AND ASSOCIATED ZONING ORDINANCE MODIFICATIONS

A fundamental and basic element of water quality management for Oconomowoc Lake is the promotion of a sound land use pattern in the tributary watershed. The type and location of future urban and rural land uses in the watershed will determine to a large degree the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, various forms of land management; and, ultimately, the water quality of the lake. Existing 1980 and proposed year 2000 land use patterns in the direct drainage area are discussed in Chapters V and IX, while existing zoning regulations in the area are discussed in Chapter VI. Recommended modifications in the existing zoning designed to protect the water quality of Oconomowoc Lake while accommodating anticipated population growth and attendant development are also presented in Chapter IX.

POINT SOURCE POLLUTION CONTROL

As recommended in the regional sanitary sewerage system plan adopted by the Commission in 1974, the Oconomowoc sewage treatment plant would serve as a regional facility to provide wastewater treatment service to the Oconomowoc—Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake—sewer service areas. That recommendation was reaffirmed in the regional water quality management plan adopted by the Commission in 1979.

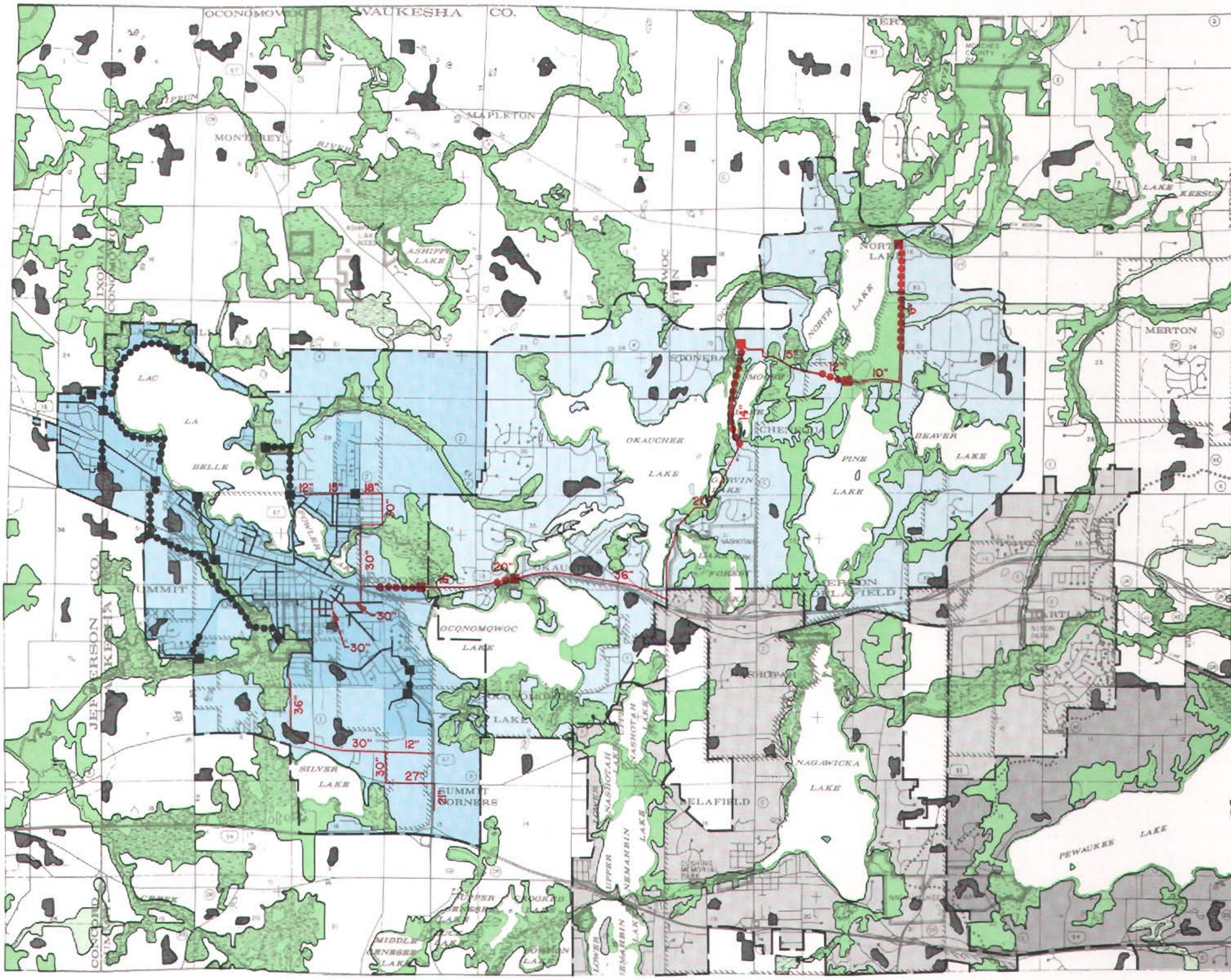
In 1978, the wastewater treatment facility serving the City of Oconomowoc was upgraded to provide secondary waste treatment, tertiary waste treatment, and auxiliary waste treatment for effluent disinfection, and expanded to provide an average hydraulic design capacity of 4.0 million gallons per day (mgd). The extension of service to existing and proposed urban development around Lac La Belle, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, Silver Lake, and Oconomowoc Lake and the flow from the existing and proposed sewer service area of the City of Oconomowoc would require an average hydraulic capacity of 3.1 mgd, based on 1985 population levels. In order to extend sanitary sewer service to urban development around Okauchee Lake, Pine Lake, Beaver Lake, North Lake and Silver Lake, the City of Oconomowoc sewage treatment plant will need to provide an average hydraulic design capacity of 6.5 mgd by the year 2000. Therefore, additional capacity may be expected to be required at the Oconomowoc facility before the year 2000. The proposed sewer service area and trunk sewer system are shown on Map 16. As of 1984, there were no known industrial point sources of wastewater tributary to Oconomowoc Lake or to streams draining to the lake which required treatment or elimination.

NONPOINT SOURCE POLLUTION CONTROL

Nonpoint sources of water pollution include urban sources such as runoff from residential,

Map 16

RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE OCONOMOWOC-LAC LA BELLE, OCONOMOWOC LAKE, OKAUCHEE LAKE, NORTH LAKE, PINE LAKE, BEAVER LAKE, AND SILVER LAKE SEWER SERVICE AREAS: 2000



LEGEND

ENVIRONMENTALLY SIGNIFICANT LANDS

- PRIMARY ENVIRONMENTAL CORRIDOR
- SECONDARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL AREA

OCONOMOWOC SEWER SERVICE AREA

- EXISTING
- PROPOSED-REFINED AND DETAILED
- PROPOSED-TO BE REFINED AND DETAILED

OTHER SEWER SERVICE AREAS

- DELA-HART SEWERAGE COMMISSION
- LAKE PEWAUKEE SANITARY DISTRICT

SEWERAGE FACILITIES

- EXISTING SEWAGE TREATMENT FACILITY
- EXISTING LIFT OR PUMPING STATION
- EXISTING TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED PUMPING STATION
- PROPOSED TRUNK SEWER
- PROPOSED FORCE MAIN

Source: SEWRPC.

commercial, industrial, transportation, and recreational land uses, construction activities, and septic tank systems; and rural sources such as runoff from cropland and pastureland, and woodland and livestock wastes.

The water quality analyses presented in this report indicated that a reduction in nutrient loads from nonpoint sources in the drainage area tributary to Oconomowoc Lake will be needed to meet the recommended water use objectives and supporting standards. A detailed field survey is required to properly evaluate the nonpoint source pollution problems in a specific area and to formulate recommendations and estimate costs for abating pollution from such sources. In October 1984 the Commission staff and the Waukesha County Office of the U. S. Soil Conservation Service conducted an inventory of the Oconomowoc Lake direct drainage area to identify any urban nonpoint sources of pollution in the drainage basin. No gross sources of urban nonpoint source pollution were identified. However, an important urban nonpoint pollution source identified was stormwater runoff associated with the construction of an upgraded STH 16 north of Oconomowoc Lake. A rural inventory of the direct drainage area was conducted as part of the Oconomowoc River priority watershed project. The results of that inventory are documented in the Oconomowoc River priority watershed strategy document prepared by the Wisconsin Department of Natural Resources (DNR) in cooperation with the Jefferson, Washington, and Waukesha County Land Conservation Committees. Some alternative nonpoint source control measures applicable to the abatement of pollution from these sources are set forth in Table 22.

LAKE REHABILITATION TECHNIQUES

Although it would prevent the further deterioration of lake water quality conditions, the reduction of nutrient inflows to Oconomowoc Lake alone may not eliminate existing water quality problems. In mesotrophic lakes such as Oconomowoc Lake, especially in the presence of anaerobic conditions in the hypolimnion, significant amounts of phosphorus may be released from the bottom sediments to the overlying water column. Therefore, the water quality improvements expected from a reduced nutrient input may be inhibited or prevented by these conditions. If this occurs, or if other characteristics of the lake result in restricted water use potential, the application of lake rehabilitation techniques should be considered.

The applicability of specific lake rehabilitation techniques is highly dependent on lake characteristics. The success of any lake rehabilitation technique can seldom be guaranteed since the state-of-the-art is still in the early stages of development. Because of the relatively high cost of applying most techniques, a cautious approach is recommended. Certain lake rehabilitation techniques should be applied only to lakes in which: 1) nutrient inputs to the lake have been reduced below the critical level; 2) there is a high probability of success; and 3) the possibility of adverse environmental impacts is minimal.

Alternative lake rehabilitation and in-lake management measures applicable to Oconomowoc Lake are discussed below and include hypolimnetic aeration, dredging, sediment covering, drawdown, nutrient inactivation, dilution/flushing, macrophyte harvesting, algae harvesting, chemical controls, and fish management. Attendant costs are presented in January 1985 dollars.

Hypolimnetic Aeration

The purpose of hypolimnetic aeration is to provide oxygen to the hypolimnion of a stratified lake without disrupting the stratification. The hypolimnion of Oconomowoc Lake typically underlies about 416 acres, or 52 percent of the lake area, and may be expected to be completely devoid of oxygen during at least a portion of each summer. To provide hypolimnetic aeration, typically the bottom water is airlifted up a vertical tube, with the oxygenated water being returned to the hypolimnion, as shown in Figure 12 and on Map 17. Aeration of the hypolimnion increases the decomposition of organic matter and promotes sorption of phosphorus by the hydrous-oxides of iron and manganese present in the lake bottom sediments. As a result, the concentration of phosphorus in the bottom waters may be reduced and oxygen levels improved, providing better conditions for fish and aquatic life. In Oconomowoc Lake, significantly improved oxygen concentrations in the hypolimnion would require the use of two aerators. Hypolimnetic aeration also provides additional habitat for zooplankton, which can seek refuge from feeding fish during the day in the dark, bottom lake waters and migrate toward

Table 22

GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF NONPOINT SOURCE POLLUTION ABATEMENT MEASURES

Applicable Land Use	Control Measures[a]	Summary Description[b]	Approximate Percent Reduction of Released Pollutants[c]	Assumptions for Costing Purposes
Urban	Litter and pet waste control ordinances	Prevent the accumulation of litter and pet wastes on streets and residential, commercial, industrial, and recreational areas	2-5	Ordinance administration and enforcement costs are expected to be funded by violation penalties and related revenues
	Improved timing and efficiency of street sweeping, leaf collection and disposal, and catch basin cleaning	Improve the scheduling of these public works activities, modify work habits of personnel, and select equipment to maximize the effectiveness of these pollution control measures	2-5	No significant increase in current expenditures is expected
	Management of onsite sewage treatment systems	Regulate septic system installation, monitoring, location, and performance; replace failing systems with new septic systems or alternative treatment facilities; develop alternatives to septic systems; eliminate direct connections to drain tiles or ditches; dispose of septage at sewage treatment facility	10-30	Replace one-half of estimated existing failing septic systems with properly located and installed systems and replace one-half with alternative systems, such as mound systems or holding tanks; all existing and proposed onsite sewage treatment systems are assumed to be properly maintained; assume system life of 25 years. The estimated cost of a septic tank system is $2,300 and the cost of an alternative system is $4,500. The annual maintenance cost of a disposal system is $45. A holding tank would cost $1,300 with an annual operation and maintenance cost of $1,200. However, because septic system management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, these costs are not included as part of the areawide water quality maintenance plan
	Increased street sweeping	On the average, sweep all streets in urban areas an equivalent of once or twice a week with vacuum street sweepers; require parking restrictions to permit access to curb areas; sweep all streets at least eight months per year; sweep commercial and industrial areas with greater frequency than residential areas	30-50	Estimate curb miles based on land use, estimated street acreage, and Commission transportation planning standards; assume one street sweeper can sweep 2,000 curb miles per year; assume sweeper life of 10 years; assume residential areas swept once weekly, commercial and industrial areas swept twice weekly. The cost of a vacuum street sweeper is approximately $38,000. The cost of operation and maintenance of a sweeper is about $10 per curb mile swept

Table 22 (continued)

Applicable Land Use	Control Measures[a]	Summary Description[b]	Approximate Percent Reduction of Released Pollutants[c]	Assumptions for Costing Purposes
Urban (continued)	Increased leaf and clippings collection and disposal	Increase the frequency of leaf collection procedures in fall; use vacuum cleaners to collect leaves; implement ordinances for leaves, clippings, and other organic debris to be mulched, composted, or bagged for pickup	2-5	Assume one equivalent mature tree per residence plus five trees per acre in recreational areas; 75 pounds of leaves per tree; 20 percent of leaves in urban areas not currently disposed of properly. The cost of the collection of leaves in a vacuum sweeper and disposal is estimated at $25 per ton of leaves
	Increased catch basin cleaning	Increase frequency and efficiency of catch basin cleaning; clean at least twice per year using vacuum cleaners; catch basin installation in new urban development not recommended as a cost-effective practice for water quality improvement	2-5	Determine curb miles for street sweeping; vary percent of urban areas served by catch basins by watershed from Commission inventory data; assume density of 10 catch basins per curb mile; clean each basin twice annually by vacuum cleaner. The cost of cleaning a catch basin is approximately $8
	Reduced use of deicing salt	Reduce use of deicing salt on streets; salt only intersections and problem areas; prevent excessive use of sand and other abrasives	Negligible for pollutants addressed in this chapter but helpful for reducing chlorides and associated damage to vegetation	Increased costs, such as for slower transportation movement, are expected to be offset by benefits such as reduced automobile corrosion and damage to vegetation
	Improved street maintenance and refuse collection and disposal	Increase street maintenance and repairs; increase provision of trash receptacles in public areas; improve trash collection schedules; increase cleanup of parks and commercial centers	2-5	Increase current expenditures by approximately 15 percent. The annual cost per person is about $4
	Parking lot stormwater temporary storage and treatment measures	Construct gravel-filled trenches, sediment basins, or similar measures to store temporarily the runoff from parking lots, rooftops, and other large impervious areas; if treatment is necessary, use a physical-chemical treatment measure such as screens, dissolved air flotation, or a swirl concentrator	5-10	Design gravel-filled trenches for 24-hour, five-year recurrence interval storm; apply to off-street parking acreages. For treatment—assume four-hour detention time. The capital cost of stormwater detention and treatment facilities is estimated at $9,000 per acre of parking lot area, with an annual operation and maintenance cost of about $100 per acre
	Onsite storage—residential	Remove connections to sewer systems; construct onsite stormwater storage measures for subdivisions	5-10	Remove roof drains and other connections to sewer system wherever needed; use lawn aeration if applicable; apply dutch drain storage facilities to 15 percent of residences. The capital cost would approximate $200 per house, with an annual maintenance cost of about $10

Table 22 (continued)

Applicable Land Use	Control Measures[a]	Summary Description[b]	Approximate Percent Reduction of Released Pollutants[c]	Assumptions for Costing Purposes
Urban (continued)	Stormwater storage—urban	Store stormwater runoff from urban land in surface storage basins or, where necessary, subsurface storage basins	10-35	Design all storage facilities for a 1.5 inch runoff event, which corresponds approximately to a five-year recurrence interval event, with a storm event being defined as a period of precipitation with a minimum antecedent and subsequent dry period of from 12 to 24 hours; apply subsurface storage tanks to intensively developed existing urban areas where suitable open land for surface storage is unavailable; design surface storage basins for proposed new urban land, existing urban land not storm sewered, and existing urban land where adequate open space is available at the storm sewer discharge site. The capital cost for stormwater storage would range from $1,000 to $10,000 per acre of tributary drainage area, with an annual operation and maintenance cost of $20 to $40 per acre
	Stormwater treatment	Provide physical-chemical treatment which includes screens, microstrainers, dissolved air flotation, swirl concentrator, or high-rate filtration, and/or disinfection, which may include chlorination, high-rate disinfection, or ozonation to stormwater following storage	10-15	To be applied only in combination with stormwater storage facilities above; general cost estimates for microstrainer treatment and ozonation were used; same costs were applied to existing urban land and proposed new urban development. Stormwater treatment has an estimated capital cost of from $900 to $7,000 per acre of tributary drainage area, with an average annual operation and maintenance cost of about $35 per acre
Rural	Conservation practices	Includes such practices as strip cropping, contour plowing, crop rotation, pasture management, critical area protection, grading and terracing, grassed waterways, diversions, wood lot management, fertilization and pesticide management, and chisel tillage	Up to 50	Costs for Soil Conservation Service (SCS)-recommended practices are applied to agricultural and related rural land; the distribution and extent of the various practices were determined from an examination of 56 existing farm plan designs within the Region. The capital cost of conservation practices ranges from $0.30 to $14 per acre of rural land, with an average annual operation and maintenance cost of from $2 to $4 per rural acre

Table 22 (continued)

Applicable Land Use	Control Measures[a]	Summary Description[b]	Approximate Percent Reduction of Released Pollutants[c]	Assumptions for Costing Purposes
Rural (continued)	Animal waste control system	Construct stream bank fencing and crossovers to prevent access of all livestock to waterways; construct a runoff control system or a manure storage facility, as needed, for major livestock operations; prevent improper applications of manure on frozen ground, near surface drainageways, and on steep slopes; incorporate manure into soil	50-75	Cost estimated per animal unit; animal waste storage (liquid and slurry tank for costing purposes) facilities are recommended for all major animal operations within 500 feet of surface water and located in areas identified as having relatively high potential for severe pollution problems. Runoff control systems recommended for all other major animal operations. It is recognized that dry manure stacking facilities are significantly less expensive than liquid and slurry storage tanks and may be adequate waste storage systems in many instances. The estimated capital cost and average operation and maintenance cost of a runoff control system are $90 per animal unit and $10 per animal unit, respectively. The capital cost of a liquid and slurry storage facility is about $425 per animal unit, with an annual operation and maintenance cost of about $30 per unit. An animal unit is the weight equivalent of a 1,000-pound cow
	Base-of-slope detention storage	Store runoff from agricultural land to allow solids to settle out and reduce peak runoff rates. Berms could be constructed parallel to streams	50-75	Construct a low earthen berm at the base of agricultural fields, along the edge of a floodplain, wetland, or other sensitive area; design for 24-hour, 10-year recurrence interval storm; berm height about four feet. Apply where needed in addition to basic conservation practices; repair berm every 10 years and remove sediment and spread on land. The estimated capital cost of base-of-slope detention storage would be $250 per tributary acre, with an annual operation and maintenance cost of $10 per acre
	Bench terraces	Construct bench terraces, thereby reducing the need for many other conservation practices on sloping agricultural land	75-90	Apply to all appropriate agricultural lands for a maximum level of pollution control. Utilization of this practice would exclude installation of many basic conservation practices and base-of-slope detention storage. The capital cost of bench terraces is estimated at $625 per acre, with an annual operation and maintenance cost of $45 per acre

Table 22 (continued)

Applicable Land Use	Control Measures[a]	Summary Description[b]	Approximate Percent Reduction of Released Pollutants[c]	Assumptions for Costing Purposes
Urban and Rural	Public education programs	Conduct regional- and county-level public education programs to inform the public and provide technical information on the need for proper land management practices on private land, the recommendations for management programs, and the effects of implemented measures; develop local awareness programs for citizens and public works officials; develop local contact and education efforts	Indeterminate	For first 10 years includes cost of one person, materials, and support for each 25,000 population. Thereafter, the same cost can be applied for every 50,000 population. The cost of one person, materials, and support is estimated at $33,000 per year
	Construction erosion control practices	Construct temporary sediment basins; install straw bale dikes; use fiber mats, mulching and seeding; install slope drains to stabilize steep slopes; construct temporary diversion swales or berms upslope from the project	20-40	Assume acreage under construction is the average annual incremental increase in urban acreage; apply costs for a typical erosion control program for a construction site. The estimated capital cost and operation and maintenance cost for construction erosion control are $2,200 and $400 per acre under construction, respectively
	Materials storage and runoff control facilities	Enclose industrial storage sites with diversions; divert runoff to acceptable outlet or storage facility; enclose salt piles and other large storage sites in crib and dome structures	5-10	Assume 40 percent of industrial areas are used for storage and to be enclosed by diversions; assume existing salt storage piles enclosed by cribs and dome structures. The estimated capital cost of industrial runoff control is $1,100 per acre of industrial land. Material storage control costs are estimated at $30 per ton of material
	Stream protection measures	Provide vegetative buffer zones along streams to filter direct pollutant runoff to the stream; construct stream bank protection measures, such as rock riprap, brush mats, tree revetment, jacks, and jetted willow poles where needed	5-10	Apply a 50-foot-wide vegetative buffer zone on each side of 15 percent of the stream length; apply stream bank protection measures to 5 percent of the stream length. Vegetative buffer zones are estimated to cost $21,200 per mile of stream, and stream bank protection measures cost about $37,000 per stream mile
	Pesticide and fertilizer application restrictions	Match application rate to need; eliminate excessive applications and applications near or into surface water drainageways	0-3	Cost included in public education program
	Critical area protection	Emphasize control of areas bordering lakes and streams; correct obvious erosion and other pollution source problems	Indeterminate	Indeterminate

[a]*Not all control measures are evaluated for each watershed. The characteristics of the watershed, the estimated required level of pollution reduction needed to meet the applicable water quality standards, and other factors will influence the estimation of costs of specific practices for any one watershed. Although the control measures costed represent the recommended practices developed at the regional level on the basis of the best available information, the local implementation process should provide more detailed data and identify more efficient and effective sets of practices to apply to local conditions.*

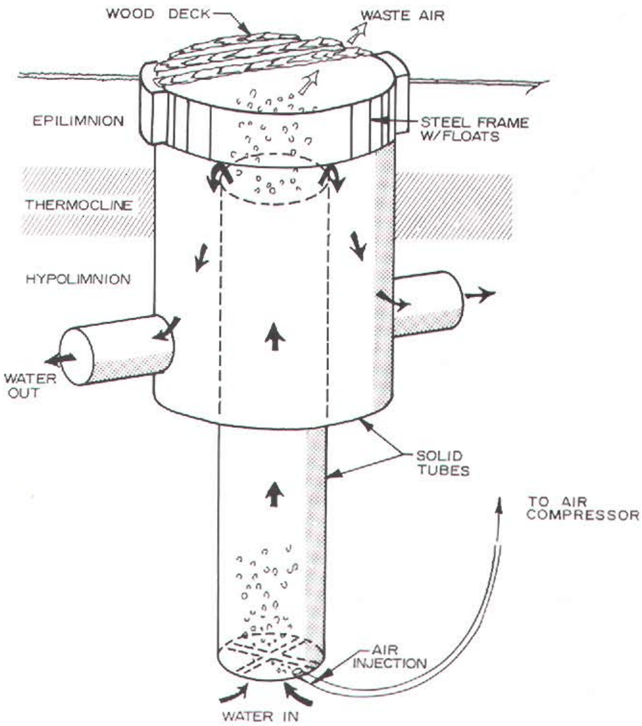
[b]*For a more detailed description of pollution control measures for diffuse sources, see SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume Three, Urban Storm Water Runoff, and Volume Four, Rural Storm Water Runoff.*

[c]*The approximate effectiveness refers to the amount of pollution produced by the contributing category (urban or rural) that could be expected to be reduced by the implementation of the practice. The effectiveness rates would vary greatly depending on the characteristics of the watershed and individual diffuse sources. It should be noted that practices can have only a "sequential" effect, since the percent pollution reduction of a second practice can only be applied against the residual pollutant load which is not controlled by the first practice. For example, two practices of 50 percent effectiveness would achieve a theoretical total effectiveness of only 75 percent control of the initial load. Further, the general levels of effectiveness reported in the table are not necessarily the same for all pollutants associated with each source. Some pollutants are transported by dissolving in water and others by attaching to solids in the water; the methods summarized here reflect typical pollutant removal levels.*

Source: SEWRPC.

Figure 12

TYPICAL HYPOLIMNETIC
AERATION SYSTEM FOR AN INLAND LAKE



Source: Source: A. W. Fast, "The Effects of Artificial Aeration on Lake Ecology," in U. S. EPA Water Pollution Control Research Series 16010EXE, 1971.

the surface at night to graze on algae. Increased zooplankton populations can effectively reduce certain species of algae.

Hypolimnetic aeration in Oconomowoc Lake would involve a capital cost of about $158,000, with an annual operation and maintenance cost of about $7,900. Hypolimnetic aeration in the smaller eastern basin of Oconomowoc Lake, which is separated from the main lake basin by a bedrock sill, could provide some water quality benefits. The amount of mixing between the two basins is limited by the sill; consequently, nonpoint source pollutants entering the smaller basin are retained for a longer time period and can have a more adverse water quality impact. Aeration of this basin would have a capital cost of approximately $48,000, and an annual operation and maintenance cost of about $2,400. It is unlikely that nonpoint source pollution control measures in the lake watershed alone would—at least for some years—substantially improve dissolved oxygen conditions in the hypolimnion. Therefore, hypolimnetic aeration could be implemented even prior to the control of nonpoint pollution sources in order to provide additional and immediate water quality improvement. Installation of a hypolimnetic aerator would require a permit from the Wisconsin Department of Natural Resources under Chapter 33 of the Wisconsin Statutes.

Measures for Controlling Sediment Effects on Water Column and Macrophyte Growth

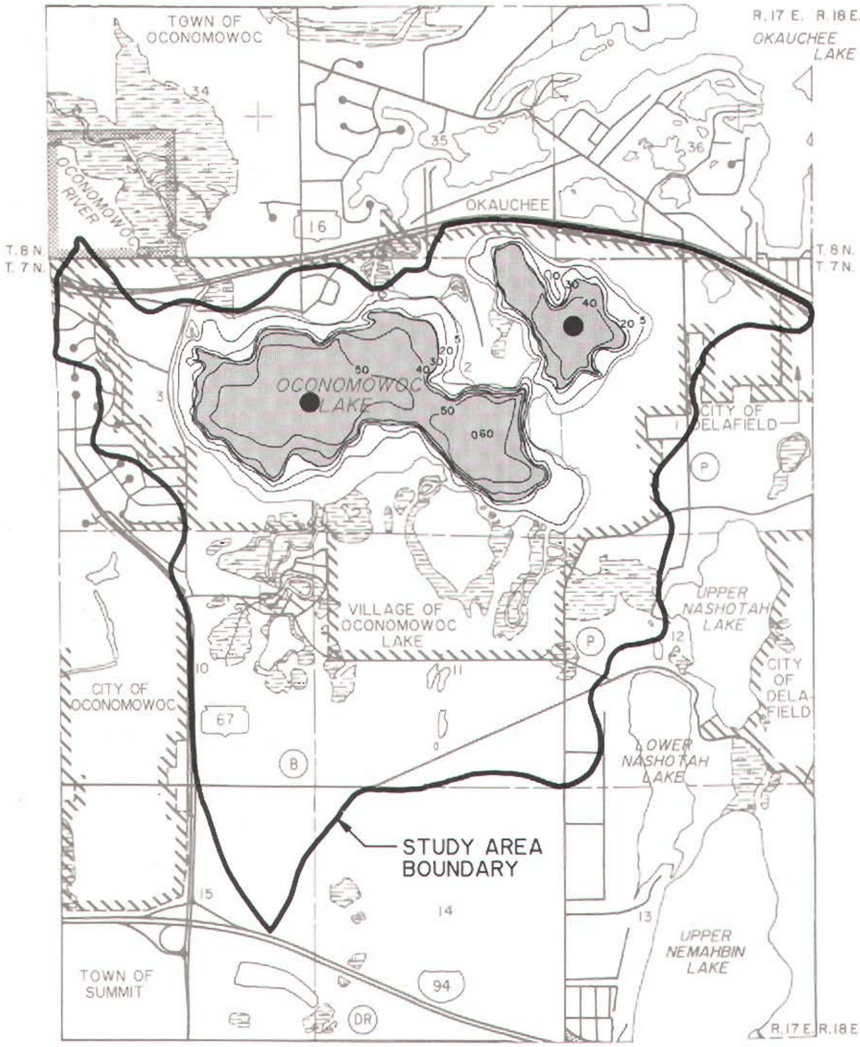
Dredging, sediment covering, and drawdown for sediment consolidation serve to deepen a lake and to provide bottom sediments that are less likely to release nutrients to the water column or support excessive macrophyte growth. Because of the relatively high cost of these practices, and the disruption to the lake community that occurs when these techniques are utilized on a large scale, implementation of these practices should be reserved only for lakes with severe water quality problems.

Rooted aquatic vegetation generally does not grow in nuisance concentrations in deep water where bottom sediments are predominantly composed of sand and gravel. The bottom stratum in Oconomowoc Lake in the littoral zone is composed primarily of sand, gravel, and marl. As discussed in Chapter V, a macrophyte survey conducted by the Wisconsin Department of Natural Resources in August 1976, as well as subsequent field observations, indicated that the lake generally supports sparse vegetative growth. Some moderate vegetative growths were observed along the eastern shoreline of the lake basin as a result of the deposition of silt and sediment where artificial channels enter the lake, resulting in a substrata more conducive to macrophyte growth. However, areas exhibiting aquatic macrophyte growth are limited and provide necessary food, cover, and nesting habitat for many species of fish and other wildlife. In addition, the growth of macrophytes in desirable locations can remove a portion of the excessive nutrients from the water column, and consequently may reduce excessive algae growth.

Dredging, sediment covering, and drawdown to control macrophyte growth or the release of nutrients from bottom sediments should not be necessary in Oconomowoc Lake. Because of the modest aquatic macrophyte growth, adequate lake depth, and predominant sand and gravel substrate, these in-lake management practices are not warranted for Oconomowoc Lake.

Map 17

PLAN ALTERNATIVE FOR PLACEMENT OF A HYPOLIMNETIC AERATION SYSTEM IN OCONOMOWOC LAKE AND ZONE OF ARTIFICIAL AERATION



LEGEND

ZONE OF ARTIFICIAL AERATION

HYPOLIMNETIC AERATOR

Source: SEWRPC.

Nutrient Inactivation

The purpose of nutrient inactivation is to: 1) change the form of a nutrient to make it unavailable to plants; 2) remove the nutrient from the photic (light-penetrated) zone; and 3) prevent release or recycling of nutrients from the lake sediments. Nutrient inactivation of phosphorus, which is usually accomplished by application of aluminum sulfate or another metallic salt, can be conducted for an entire lake if nutrients from the epilimnion as well as the hypolimnion are to be removed, or for just the hypolimnion if nutrients from only the hypolimnion are to be removed. Nutrient inactivation is the most applicable to lakes that have long hydraulic residence times or in which recycling of phosphorus from the bottom sediments is significant. The hydraulic residence time of Oconomowoc Lake is relatively short—approximately six months. There is currently no indication that the amounts of phosphorus being released from the bottom sediments are having a significant effect on water quality. However, nutrient inactivation may be effective for reducing nutrients in the hypolimnion of Oconomowoc Lake if, following the implementation of land management practices in the direct tributary drainage area to reduce external phosphorus loads on the lake, phosphorus released from the bottom sediments is found to constitute a problem.

The application of nutrient inactivation to the entire lake would cost about $80,400; application to the hypolimnion would cost only about $41,600. The treatment may need to be repeated periodically, but may not be very effective owing to the relatively brief hydraulic residence time.

Dilution/Flushing

Dilution/flushing is intended to alleviate excessive algal growths and associated problems by replacing nutrient-rich waters with nutrient-poor waters, thereby flushing phytoplankton and the nutrients contained therein from the lake. Lake restoration projects have attempted nutrient dilution by two procedures: 1) pumping water out of the lake, thus permitting the increased flow of nutrient-poor groundwater; and 2) routing additional quantities of nutrient-poor surface waters into the lake. Dilution/flushing is most applicable for lakes which have very long hydraulic residence times, for lakes in which significant natural flushing does not occur, and for lakes in which excessive pollutant loadings have resulted in highly eutrophic conditions. In the latter case, once the pollution source has been removed, dilution/flushing may be effective in reducing the time required for the water quality of the lake to improve.

Oconomowoc Lake is not highly eutrophic and does not have a relatively long hydraulic residence time. Therefore, dilution/flushing would not be expected to result in a significant long-term increase in water quality conditions in the lake.

Aquatic Plant Harvesting

Macrophyte harvesting to control excessive growth of aquatic vegetation has not been required for Oconomowoc Lake. As already noted, moderate concentrations of macrophytes sometimes occur in isolated sections of the lake. However, the overall modest aquatic macrophyte growth characteristic of Oconomowoc Lake does not warrant initiation of a harvesting program.

Chemical Control of Algae

Chemical control of algae has been carried out on a very limited basis on Oconomowoc Lake. Typically, the costs for chemical control of algae range between $50 and $150 per acre. Chemical control alone is not recommended over the long term unless other practices—such as septic system rehabilitation or land management practices intended to reduce nutrient levels—prove to be impractical or ineffective. All chemical treatment programs require a permit from the Wisconsin Department of Natural Resources; and treatment of areas larger than one acre requires supervision by DNR staff.

Chemical Control for Swimmers' Itch

The use of chemicals on Oconomowoc Lake for the control of snails in an effort to reduce the occurrence of swimmers' itch is expected to be continued. However, the amount of chemicals that will need to be applied and the frequency of application will vary from year to year, as will the severity of the problem. However, certain measures can be taken to alleviate the risk of infestation, including showering or toweling off after leaving the water. As an alternative, individuals may want to avoid entering the water in those areas of the lake where the organisms are present during the two-week period when the infestation is likely to occur. As noted above, chemical treatment programs require a permit from the Wisconsin Department of Natural Resources.

Fish Management

Oconomowoc Lake generally supports a well-balanced fishery characterized by a high diversity of gamefish and panfish. Presently, there is an approved public access site on Oconomowoc Lake, and fish management assistance can be provided by the Department of Natural Resources. Is it recommended that the following alternative fishery management efforts be considered.

1. The Wisconsin Department of Natural Resources should develop a fish surveillance program for Oconomowoc Lake, including a schedule for periodic fishery surveys.

2. The Wisconsin Department of Natural Resources should stock fish species, as appropriate, following detailed evaluations of the existing fishery, to provide continued gamefish resources.

3. The Wisconsin Department of Natural Resources should consider purchasing the best remaining spawning areas in the lake and shoreline areas along the Oconomowoc River upstream and downstream of Oconomowoc Lake.

4. The Wisconsin Department of Natural Resources should conduct a creel census, or survey of sport fishing, to determine the composition of the angler catch and the numbers of each species harvested. This information could be correlated with the relative abundance of each species to determine the effects on the fishery resource.

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Chapter IX

RECOMMENDED PLAN

INTRODUCTION

This chapter presents a recommended management plan for Oconomowoc Lake. The plan is based upon the land use, land and water management, and biological and water quality inventory findings; pollution source analyses; land use and population forecasts; and alternative water quality management plan evaluations presented in the previous chapters of this report. The plan sets forth the recommended means for: 1) providing water quality suitable for full body contact recreational use and the maintenance of fish and other desirable forms of aquatic life; and 2) improving opportunities for water-based recreational activities. The primary water-based recreational activities on the lake are fishing, swimming, and pleasure boating. An analysis of the status of these activities revealed that the lake supports a viable warmwater fishery, but that excessive in-lake nutrient concentrations threaten to further degrade the lake's water quality. Consequently, the recommended management plan contains recommendations particularly directed toward improving swimming opportunities, as well as to the maintenance and improvement of other uses. The development of the recommended plan involved careful consideration of many tangible and intangible factors bearing upon water quality management and water pollution control, with primary emphasis upon the degree to which the desired water use objectives may be expected to be met, and upon the cost-effectiveness of the recommended measures. The plan development process involved review of preliminary drafts of the recommended plan by local and state agencies and units of government.

LAND USE

The basis for the land use recommendations set forth in this report is the adopted regional land use plan, as set forth in SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000. The regional land use plan recommends that no significant additional urban land use development be encouraged to occur in the lake watershed through the year 2000. The land use plan recommendations are shown on Map 18 and described in Table 23.

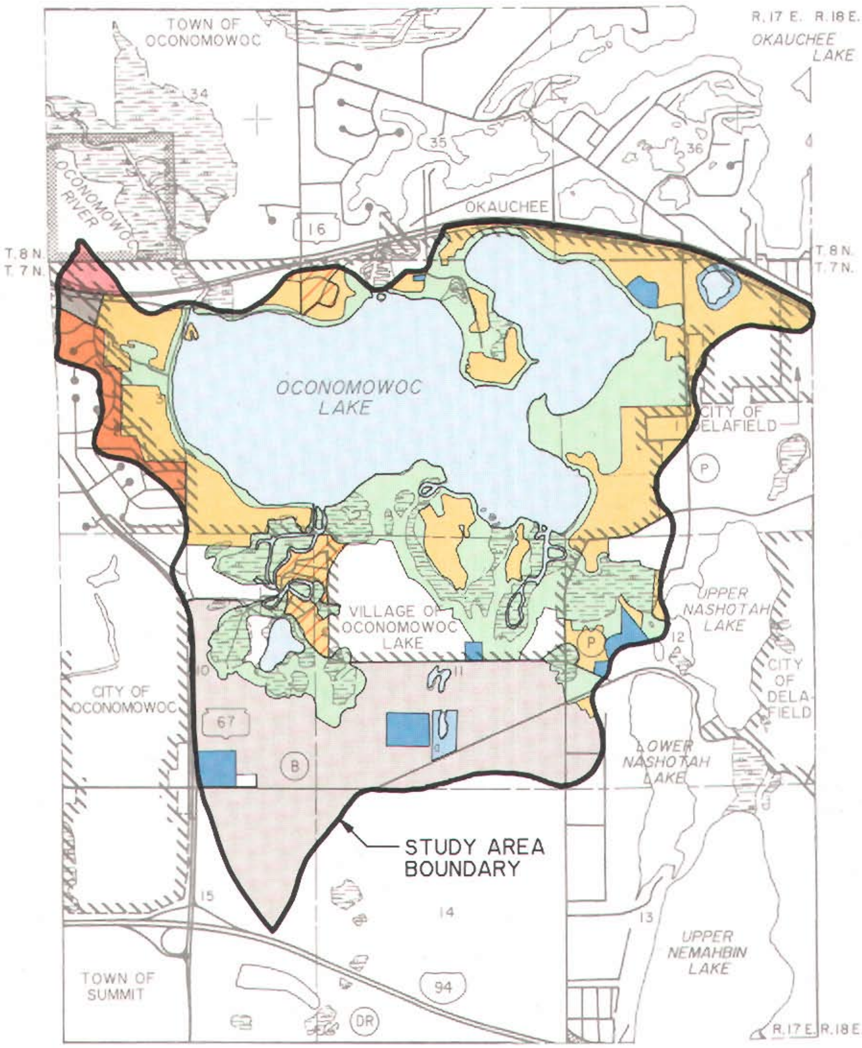
The plan recommends that the agricultural lands in the southern portion of the lake watershed, totaling about 540 acres, or about 19 percent of the direct drainage area, be preserved in agricultural use. The plan further recommends that the undeveloped lands immediately surrounding the lake be preserved in essentially natural, open uses as environmental corridor, together with certain connected areas containing a concentration of high-value woodlands, wetlands, and wildlife habitat, which together encompass about 592 acres, or about 21 percent of the direct drainage area. It is also recommended that certain isolated natural areas in the direct drainage area—consisting of concentrations of woodlands, wetlands, and wildlife habitat which encompass about 26 acres, or about 1 percent of the direct drainage area—be preserved in essentially natural, open uses. The remaining 1,666 acres, or about 59 percent of the direct drainage area, would be comprised of open land, surface water, parkland, and residential, commercial, governmental, institutional, and transportation land uses. The regional land use plan can be an effective tool for water quality protection only if local action is taken to adopt and implement the plan. The Cities of Oconomowoc and Delafield, and the Village of Oconomowoc Lake, have direct authority for local land use planning and plan implementation for lands within their corporate limits in the Oconomowoc Lake direct drainage area. The Towns of Oconomowoc and Summit, along with Waukesha County, are jointly responsible for local land use planning and plan implementation activities in the Town of Oconomowoc and Town of Summit portions of the direct drainage area.

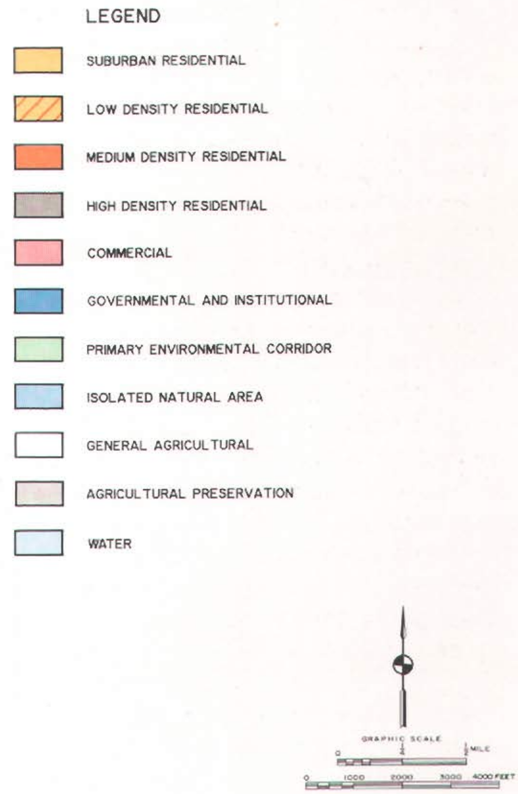
ZONING ORDINANCE MODIFICATIONS

As documented in Chapter V, the Oconomowoc Lake direct drainage area contains an abundance of valuable natural resources. In order for the existing zoning ordinances to effectively contribute to the protection and wise use of these resources, as recommended in the water quality

Map 18

PROPOSED LAND USE IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 2000





Source: SEWRPC.

management plan for Oconomowoc Lake, certain modifications to those ordinances are required. As noted in Chapter VI, the Cities of Oconomowoc and Delafield, the Towns of Oconomowoc and Summit, and the Village of Oconomowoc Lake should critically review their respective zoning ordinances and accompanying zoning district maps as they pertain to lands and surface water bodies within the direct drainage area, and amend and modify the ordinances and district maps, as necessary, to better protect and enhance the natural resource base of the lake watershed. The following modifications should be made to the zoning ordinances and district maps. The existing zoning districts are shown on Map 15 in Chapter VI. The proposed zoning districts are shown on Map 19. The proposed changes are quantified in Table 24.

<u>Lowland Conservancy and Lowland Conservancy Overlay Districts</u>

It is recommended that about 122 acres, or about 6 percent of the direct drainage area, be included in a lowland conservancy district. An additional 140 acres is recommended to be included in a lowland conservancy overlay district. Such districts should be used to preserve, protect, and enhance the remaining wetland areas of the Oconomowoc Lake direct drainage area.

All 140 acres of the direct drainage area recommended for inclusion in a lowland conservancy overlay district are located in the Town of Summit. Of these 140 acres, about 3 acres, or 2 percent, are zoned R-3 Residential District, about 15 acres, or 11 percent, are zoned Agricultural District, and about 122 acres, or 87 percent, are zoned Wetland/Floodland District. The one-

Table 23

GENERALIZED PLANNED LAND USE IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 2000

Proposed Land Use	Town of Oconomowoc		City of Delafield		Town of Summit		City of Oconomowoc		Village of Oconomowoc Lake		Total Direct Tributary Drainage Area	
	Acreage	Percent of Civil Division	Acreage	Percent of Civil Division	Acreage	Percent of Civil Division	Acreage	Percent of Civil Division	Acreage	Percent of Civil Division	Acreage	Percent
Suburban Residential	--	--	8	100.0	61	6.5	5	5.8	385	21.5	459	16.3
Low-Density Residential	--	--	--	--	37	3.9	--	--	15	0.8	52	1.8
Medium-Density Residential	--	--	--	--	2	0.2	70	82.4	--	--	72	2.5
High-Density Residential	--	--	--	--	--	--	10	11.8	--	--	10	0.3
Business	3	100.0	--	--	--	--	--	--	17	0.9	20	0.7
Governmental and Institutional	--	--	--	--	44	4.6	--	--	16	0.8	60	2.1
Primary Environmental Corridor	--	--	--	--	182	19.4	--	--	410	22.9	592	21.0
Isolated Natural Area	--	--	--	--	12	1.3	--	--	14	0.8	26	0.9
General Agriculture	--	--	--	--	58	6.2	--	--	131	7.3	189	6.7
Agricultural Preservation	--	--	--	--	540	57.9	--	--	--	--	540	19.1
Surface Water[a]	--	--	--	--	--	--	--	--	804	45.0	804	28.6
Total	3	100.0	8	100.0	936	100.0	85	100.0	1,792	100.0	2,824	100.0

[a] *Includes Oconomowoc Lake.*

Source: SEWRPC.

half-acre and one-and-one-half-acre minimum lot size requirements of the R-1 and R-3 Districts, respectively, permit low-density urban residential development, and therefore provide little, if any, protection to wetlands.

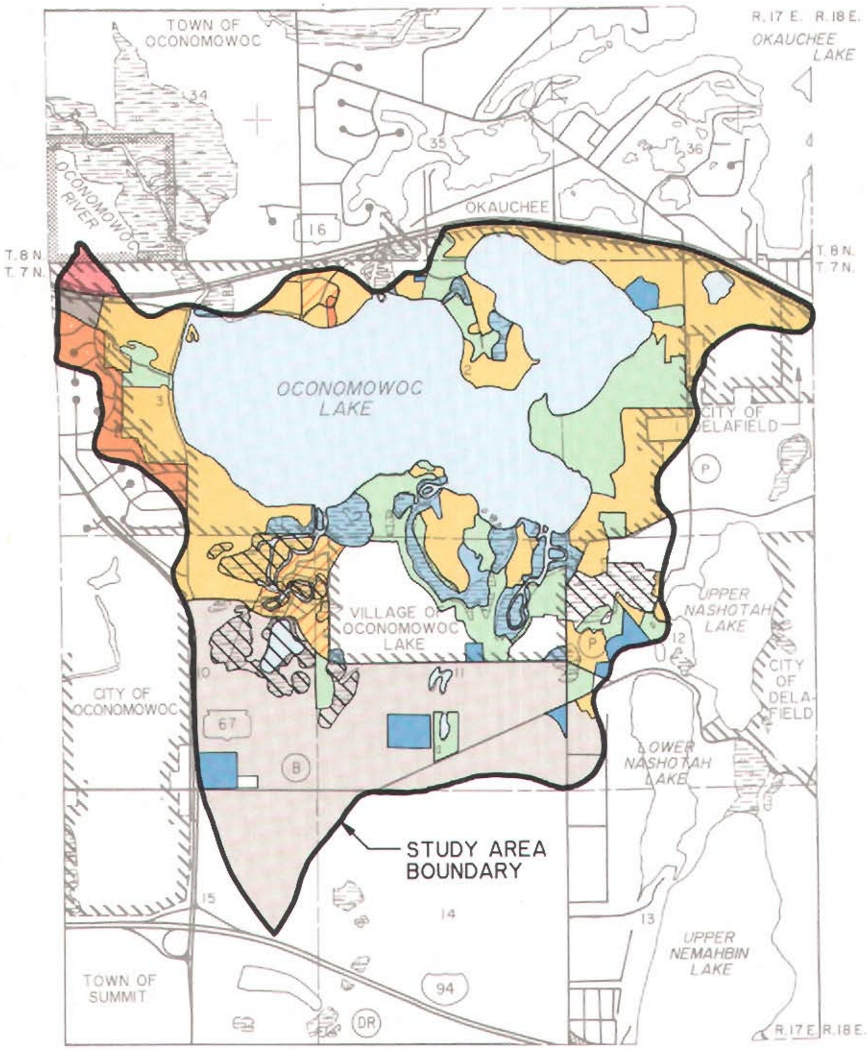
The Wetland/Floodland District regulation within the Town of Summit zoning ordinance is capable of providing adequate protection to wetlands. The existing Wetland/Floodland District regulation, however, does not comply with the zoning requirements of Chapter NR 117 of the Wisconsin Administrative Code pertaining to the protection of shoreland/wetlands. The recommended lowland conservancy overlay district should be formulated to meet the requirements of the code.

On December 1, 1982, Chapter NR 117 of the Wisconsin Administrative Code became effective. This new code sets forth rules for protecting wetlands within the shoreland areas of lakes, rivers, and streams in cities and villages, as well as in unincorporated areas in Wisconsin. The Wisconsin Department of Natural Resources (DNR) is administering the process through which local units of government achieve compliance with the new code.

A key provision of the new code requires that all wetlands five acres or greater in size, within the shoreland/wetland jurisdictional area, be protected by the wetland zoning provisions set for in the code. The Town of Summit portion of the direct drainage area included within the shore-

Map 19

PROPOSED ZONING IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE: 2000



Source: SEWRPC.

land/wetland jurisdictional area is shown on Map 19. Even though the new lowland conservancy overlay district zoning would be required to be applied only to wetlands within the aforementioned jurisdictional area, the provisions of NR 117 would not preclude the Town of Summit from placing all of its wetlands within the direct drainage area in a lowland conservancy overlay district. Such an action would be highly supportive of the water resource management objectives for the direct drainage area. Accordingly, the Town of Summit zoning ordinance should be modified to include a lowland conservancy overlay district. This new district should then be applied within the direct drainage area as recommended herein.

It should be noted that while the wetlands in the Town of Summit portion of the direct drainage area are recommended for inclusion in a lowland conservancy overlay district, the remaining wetlands in the direct drainage area, located in the Village of Oconomowoc Lake, are recommended for inclusion in a lowland conservancy district—that is, a basic use district. The wetlands within the Town of Summit are herein recommended for inclusion in a lowland conservancy overlay district, rather than a lowland conservancy district, because the use of such an overlay district would prevent regulatory conflicts between the shoreland/wetland protection regulations that are to be implemented by the Department of Natural Resources and the zoning regulations that are already being applied to the rural and agricultural lands of landowners participating in the state Farmland Preservation Program.

About 122 acres in the Village of Oconomowoc Lake portion of the direct drainage area are recommended for inclusion in a lowland conser-

Table 24

PROPOSED ZONING DISTRICTS BY CIVIL DIVISION IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO OCONOMOWOC LAKE

Proposed Zoning District	Town of Oconomowoc		City of Delafield		Town of Summit[a]		City of Oconomowoc		Village of Oconomowoc Lake		Total Direct Tributary Drainage Area	
	Acreage	Percent of Civil Division	Acreage	Percent of Civil Division	Acreage	Percent of Civil Division	Acreage	Percent of Civil Division	Acreage	Percent of Civil Division	Acreage	Percent
Suburban Residential	--	--	8	100.0	120	12.8	5	5.9	421	42.6	554	27.4
Low-Density Residential	--	--	--	--	56	6.0	--	--	18	1.8	74	3.7
Medium-Density Residential	--	--	--	--	--	--	70	82.3	14	1.4	84	4.2
High-Density Residential	--	--	--	--	--	--	10	11.8	--	--	10	0.5
Business	3	100.0	--	--	--	--	--	--	17	1.7	20	1.0
Governmental and Institutional	--	--	--	--	49	5.2	--	--	16	1.6	65	3.2
Lowland Conservancy . . .	--	--	--	--	--	--	--	--	122	12.3	122	6.0
Upland Conservancy	--	--	--	--	46	4.9	--	--	245	24.8	291	14.4
General Agriculture	--	--	--	--	66	7.1	--	--	135	13.8	201	9.9
Agricultural Preservation	--	--	--	--	599	64.0	--	--	--	--	599	29.7
Total	3	100.0	8	100.0	936	100.0	85	100.0	988	100.0	2,020	100.0

[a]140 acres in Lowland Conservancy Overlay District.

Source: SEWRPC.

vancy district. The lowland conservancy district, like the lowland conservancy overlay district, should be formulated to meet the minimum requirements of Chapter NR 117 of the Wisconsin Administrative Code. These 122 acres are currently zoned either R-1 or R-2 Residential District, both of which permit suburban residential development. The minimum lot size requirements of the R-1 and R-2 Districts are three acres and two acres, respectively. The minimum lot size requirements help to limit the density of residential development; however, these districts do not prevent development in wetland areas, and therefore do not provide adequate zoning protection in these valuable natural areas. The application of the lowland conservancy district to the Village of Oconomowoc Lake portion of the direct drainage area, in the manner shown on Map 19, would provide a higher level of zoning protection for the valuable wetlands in the area.

Upland Conservancy District

It is recommended that about 291 acres, or about 14 percent, of the direct drainage area be included in an upland conservancy district. Such a district may be used to preserve, protect, and enhance the significant woodlands, related scenic areas, and marginal farmlands of the direct drainage area, while allowing for rural estate-type residential development that would help to maintain the rural character of the Oconomowoc Lake drainage area. All 291 acres are located in the Town of Summit and in the Village of Oconomowoc Lake.

Of the 291 acres recommended for inclusion in an upland conservancy district, about 245 acres, or 84 percent, are zoned either R-1 Residential District or R-2 Residential District in the Village of Oconomowoc Lake. The remaining 46 acres, or 16 percent, are zoned R-1 Residential District, R-3 Residential District, or AG Agricultural

District in the Town of Summit. None of the existing zoning districts provide adequate protection to the significant woodlands and related features of the direct drainage area. An upland conservancy district should therefore be included as a new zoning district in both the Village of Oconomowoc Lake zoning ordinance and the Town of Summit zoning ordinance. These new zoning districts should then be applied within the direct drainage area as recommended herein.

Agricultural Preservation District

It is recommended that about 599 acres, or 30 percent, of the direct drainage area be included in an agricultural preservation district. An agricultural preservation district is used to preserve and enhance the agricultural use of land having a minimum parcel of 35 acres. The acreage herein recommended for agricultural preservation district zoning is the same area recommended to be preserved for agricultural purposes in the Waukesha County agricultural land preservation plan. All 599 acres are located within the corporate limits of the Town of Summit.

The 599 acres recommended for inclusion in an agricultural preservation district are zoned WF Wetland/Floodland District, R-3 Residential District, and AG Agricultural District. None of the existing zoning districts provide protection to prime farmlands in the direct drainage area from premature conversion to urban development. The Town of Summit zoning ordinance should therefore be modified to include an agricultural preservation district. This new zoning district should then be applied within the direct drainage area as recommended herein.

General Agricultural District

It is recommended that 201 acres, or about 10 percent, of the direct drainage area be included in a general agricultural district. Such a district may be used to preserve and protect open space lands in areas having marginal farmland value, while at the same time allowing for estate-type residential development that maintains the rural character of the countryside. Such a district should provide for a minimum lot size of five acres and permit a mixture of farm site and estate-type residential uses. The 201 acres are located within the corporate limits of the Town of Summit and the Village of Oconomowoc Lake.

Of the 201 acres recommended for inclusion in a general agricultural district, about 135 acres, or 67 percent, are zoned R-1 Residential District in the Village of Oconomowoc Lake, and about 66 acres, or 33 percent, are zoned R-1 and R-3 Residential District in the Town of Summit. Both R-1 Districts permit suburban residential development. The R-3 District in the Town of Summit permits low-density residential development. These districts do not prevent urban development of agricultural and other open lands. The districts, as a result, may foster scattered and unplanned urban development, which could have an adverse effect on the water quality of Oconomowoc Lake. The Village of Oconomowoc Lake zoning ordinance should therefore be modified to include a general agricultural district, which should be applied to the areas in the Village as recommended herein. The AG Agricultural District in the Town of Summit zoning ordinance is deemed adequate and should be applied to areas in the Town of Summit portion of the direct drainage area as recommended herein.

Suburban, Low-Density, Medium-Density, and High-Density Districts

It is recommended that about 722 acres, or 35 percent, of the direct drainage area be included in suburban, low-density urban, medium-density urban, and high-density urban residential districts. These residential districts are used to preserve and protect existing and proposed residential areas within a physical environment that is healthy, safe, convenient, and attractive. The Commission defines suburban, low-density urban, medium-density urban, and high-density urban residential land use as containing 0.2 to 0.6, 0.7 to 2.2, 2.3 to 6.9, and 7.0 to 17.9 dwelling units per net residential acre, respectively.

It is recommended that residential zoning in the direct drainage area be comprised of about 554 acres, or 77 percent, in suburban districts; about 74 acres, or 10 percent, in low-density districts; about 84 acres, or 12 percent, in medium-density districts; and about 10 acres, or 1 percent, in high-density districts. Of the 554 acres recommended for inclusion in suburban districts, about 421 acres are already zoned R-1 and R-2 Residential District in the Village of Oconomowoc Lake, about 57 acres are zoned R-1 Residential District in the Town of Summit, and about eight acres are zoned R-1 Residential District in the City of Delafield. The zoning in these areas is deemed adequate for the regulation of suburban residential development and should be maintained in its present form. The remaining 68 acres recommended for inclusion in suburban districts are zoned R-3 Residential District and WF Wetland/Floodland District in the Town of Summit. These 68 acres should be rezoned to the R-1 Residential District in the Town of Summit zoning ordinance, as shown on Map 19. The remaining 168 acres recommended for inclusion in low-density residential, medium-density residential, and high-density residential are already zoned R-3 Residential District in the Village of Oconomowoc Lake, and R-1B One-Family Residence District, R-2 One- and Two-Family Residence District, and Multi-Family Residence District in the City of Oconomowoc. The zoning in these areas is deemed adequate for the regulation of low-density, medium-density, and high-density urban development and should be retained as depicted on the city and village zoning maps.

Business Districts

It is recommended that about 20 acres, or 1 percent, of the direct drainage area be included in business districts. About 17 acres are zoned B-1 Business District in the Village of Oconomowoc Lake and the remaining three acres are zoned B-3 General Business District in the Town of Oconomowoc. The B-1 and B-3 Districts are deemed adequate for the regulation of business development and should continue to be applied to the direct drainage area as depicted on the zoning maps for the Town of Oconomowoc and the Village of Oconomowoc Lake.

Governmental and Institutional District

It is recommended that about 65 acres, or 3 percent, of the direct drainage area be included in a governmental and institutional district. Such a district should be used to protect governmental and institutional land uses from encroachment by less desirable or incompatible land uses. Also, such a district eliminates the ambiguity of maintaining, in unrelated use, districts areas that are anticipated to remain in permanent public or quasi-public ownership.

Of the 65 acres recommended for inclusion in an governmental and institutional district, about 16 acres, or 25 percent, are zoned R-1 Residential District in the Village of Oconomowoc Lake, and about 24 acres, or 37 percent, are zoned AG Agricultural District in the Town of Summit. The remaining 25 acres, or 38 percent, are zoned both AG Agricultural District and OIP Institutional-Park Overlay District in the Town of Summit.

The R-1 Residential District does not provide for proper regulation of governmental and institutional development. The Village of Oconomowoc Lake zoning ordinance should therefore be modified to include a governmental and institutional zoning district, which should then be applied to the village portion of the direct drainage area as recommended herein.

The AG Agricultural District regulation in the Town of Summit zoning ordinance also does not, in and of itself, provide for the proper regulation of governmental and institutional development. The OIP Institutional-Park Overlay District regulation within the ordinance does, however, provide for the adequate regulation of such development. Therefore, when the OIP Overlay District zoning is combined with agricultural or residential district zoning, proper regulation of governmental and institutional development can be achieved. Accordingly, OIP Overlay District zoning should be applied to governmental and institutional land uses in the Town of Summit portion of the direct drainage area, as recommended herein.

POINT SOURCE POLLUTION CONTROL

The provision of sanitary sewer service to the drainage area directly tributary to Oconomowoc Lake, as described in the preceding chapter, is recommended to eliminate malfunctioning septic tank systems and to provide an appropriate means of sanitary sewage collection and treatment for existing and planned urban development. Sewage treatment would be provided by the City of Oconomowoc sewage treatment facility. These recommendations were originally set forth in the adopted regional water quality management plan, documented in SEWRPC Planning Report No. 30.

NONPOINT SOURCE POLLUTION CONTROL

The recommended water quality management plan for Oconomowoc Lake addresses both the

Table 25

LOCAL GOVERNMENT MANAGEMENT AGENCIES AND RESPONSIBILITIES FOR URBAN NONPOINT SOURCE WATER POLLUTION CONTROL

Urban Nonpoint Source Management Agency	Conduct Local Land Use Planning and Zoning	Undertake Septic System Management Program	Undertake Construction Erosion Control Program	Review Public Works Maintenance Practices	Conduct Educational and Informational Program	Provide Technical Assistance
Waukesha County Board of Health	--	X	--	--	X	--
Waukesha County Land Conservation Committee	--	--	--	X	--	X
Waukesha County Park and Planning Commission	X	--	X	--	X	X
Cities						
Delafield	X	--	X	X	X	--
Oconomowoc	X	--	X	X	X	--
Village						
Oconomowoc Lake	X	--	X	X	X	--
Towns						
Oconomowoc	X	--	X	--	X	--
Summit	X	--	X	--	X	--

Source: SEWRPC.

means for reducing the nutrient loading to the lake from nonpoint sources, and techniques for lake rehabilitation. As described below, the former include both urban nonpoint source control practices and agricultural land management practices. The latter include water quality monitoring and fishery management efforts. These measures are in addition to the local zoning actions recommended in the preceding section, which are, in effect, the most basic of all nonpoint source pollution abatement measures.

Urban Nonpoint Source Pollution Controls

The implementation of nonpoint source controls in urban areas requires the cooperative efforts of the Waukesha County Board of Supervisors, the Waukesha County Land Conservation Committee, the Waukesha County Park and Planning Commission, the Waukesha County Health Department, the Cities of Delafield and Oconomowoc, the Village of Oconomowoc Lake, and the Towns of Oconomowoc and Summit. It should be noted that the Oconomowoc River watershed, which includes the Oconomowoc Lake direct drainage area, has been designated a priority watershed under the Department of Natural Resources priority watershed program. As previously discussed, an urban nonpoint pollution source that was of concern to Oconomowoc Lake was the renovation of STH 16 north of the lake. The Wisconsin Department of Transportation, working cooperatively with the Regional Planning Commission and the DNR, determined measures to preclude the deposition of an excessive amount of sediment and other pollutants into the Oconomowoc River upstream of the lake both during construction and following completion of the highway. Waukesha County was designated the lead management agency for the conduct of the priority watershed project, and, as such, will coordinate future urban nonpoint source pollution abatement efforts carried out under this program. The recommended responsibilities of each of these governmental agencies—consistent with their legal authorities under state and federal laws—are summarized in Table 25. Below is a discussion of the various methods of urban nonpoint source pollution control in the direct drainage area of the lake, including a septic system management program, a construction erosion control program, and certain additional urban land management practices.

Septic Tank System Management Program: The basic objective of a septic system management program is to ensure the proper installation, operation, and maintenance of existing septic tank systems, and of any new systems that may be required to serve urban development in the drainage area directly tributary to Oconomowoc Lake. A number of options are available for the institution and operation of a septic system management program in the Oconomowoc Lake direct drainage area, including the formation of a sanitary district; and the initiation of a voluntary inspection and maintenance program by the lake residents, supplementing the present county-administered program. Currently, Waukesha County is participating in the Wisconsin Fund septic system rehabilitation program and has initiated septic system management efforts to abate the water quality problems associated with such systems on a countywide basis.

Construction Erosion Control Program: It is recommended that Waukesha County, the Cities of Delafield and Oconomowoc, the Village of Oconomowoc Lake, and the Towns of Oconomowoc and Summit undertake steps to ensure the reduction of water pollution—particularly nutrient pollution associated with the introduction of phosphorus—as a result of soil erosion from land undergoing a change in use and related construction activity. It is recommended that the County and these designated urban management agencies establish construction erosion control programs and review their subdivision regulations, zoning ordinances, and building codes to assure that such regulations, ordinances, and codes taken together address administrative procedures, erosion control performance standards, and enforcement provisions.

It is recommended that the ordinances be expanded to require the submittal of an erosion control plan by land developers, and that the erosion control plan be reviewed and approved by the Park and Planning Commission. It is recommended that each designated agency adopt the appropriate ordinance modifications, require the submittal of erosion control plans for all construction projects, and review such plans with technical assistance from the Land Conservation Committee in conjunction with local municipal engineers. Further, each designated management agency should provide for the proper enforcement, through inspection, of the erosion control measures implemented. The review and evaluation of the plans and control measures implemented should be based on criteria set forth in the Soil and Water Technical Guide of the U. S. Department of Agriculture, Soil Conservation Service. Enforcement would be through the land subdivision, zoning, and building code approval authorities of each designated management agency. The Wisconsin Department of Natural Resources report Wisconsin Construction Site Best Management Practice Handbook, 1989, describes methods of controlling construction site erosion and presents a model ordinance prepared by the Department and by the Wisconsin League of Municipalities.

Development and Implementation of Urban Land Management Practices: The development of urban nonpoint source pollution abatement practices should be a highly localized, detailed, and individualized effort. It requires highly specific knowledge of the physical, managerial, social, and fiscal considerations that affect the local landowners concerned. Accordingly, it is recommended that the Land Conservation Committee work with municipalities and property owners to attain application of the land management practices recommended herein, as necessary to achieve about a 25 percent reduction in urban nonpoint source pollution runoff. Such a program of urban nonpoint source pollution control can, in part, be facilitated under the Oconomowoc River priority watershed project.

It is further recommended that the following urban nonpoint source control measures be implemented as applicable within the drainage area tributary to Oconomowoc Lake: a public education program to provide information on the relationship of land management practices to water quality; improved street maintenance; the proper collection and disposal of leaves and grass clippings, and other lawn care measures; improved refuse collection and disposal; the proper vegetative management of shoreland areas; the adequate maintenance of stormwater drainage systems, including discharge sites; the proper disposal of litter and pet wastes; and other measures as may be locally identified. It is recommended that a publication identifying

Table 26
LOCAL GOVERNMENTAL MANAGEMENT AGENCIES AND RESPONSIBILITIES
FOR RURAL NONPOINT SOURCE WATER POLLUTION CONTROL

Rural Nonpoint Source Management Agency	Conduct Local Land Use Planning	Develop and Implement Detailed Plan for Rural Practices	Conduct Educational and Informational Program	Provide Technical Assistance
Waukesha County Land Conservation Committee	--	X	X	X
Waukesha County Park and Planning Commission	X	X	X	X

Source: SEWRPC.

specific residential land management practices beneficial to water quality be prepared and distributed to property owners with the assistance of the University of Wisconsin-Extension Service. It is further recommended that the designated agencies seek technical assistance in the preparation and implementation of the above-mentioned practices from the Waukesha County Land Conservation Committee, and also seek assistance in the form of public education and information programs from the Waukesha County office of the University of Wisconsin-Extension Service.

Rural Nonpoint Source Pollution Controls

The implementation of nonpoint source pollution control measures in rural areas requires the cooperative efforts of the Waukesha County Land Conservation Committee and the Waukesha County Park and Planning Commission. The recommended responsibilities of each governmental agency are set forth in Table 26. As previously noted, the Oconomowoc River watershed, which includes the Oconomowoc Lake direct drainage area, has been designated a priority watershed under the Wisconsin Fund priority watershed program. Detailed rural nonpoint source inventory data have been assimilated for the Oconomowoc Lake direct drainage area. The priority watershed project can be a most effective means of abatement of rural nonpoint sources.

Agricultural nonpoint source abatement measures that are appropriate for the Oconomowoc Lake drainage area include crop rotation, conservation tillage, grassed waterways, vegetative buffer strips, and contour strip-cropping. Implementation of those practices necessary to obtain about a 25 percent reduction in rural nonpoint source pollution runoff should be sought.

Following the selection of detailed practices for the abatement of nonpoint source pollution in rural areas, it is recommended that the management agencies take appropriate steps to install the practices. This would include the establishment of public education programs by the University of Wisconsin-Extension Service, continued work with the farm operators, and the undertaking of actions to protect critical areas from erosion. It is further recommended that the Waukesha County Land Conservation Committee provide all necessary technical assistance in installing the practices.

LAKE PROTECTION AND REHABILITATION

As discussed in Chapter VIII, the applicability of specific in-lake management techniques is dependent on the physical and chemical characteristics of a lake, the effectiveness of the method for improving the lake water quality, and the need for implementation of a lake management program, as well as the costs of using the techniques. Accordingly, an evaluation of potential in-lake management techniques was conducted. That evaluation indicated that many in-lake rehabilitation techniques used to improve water quality—dredging, drawdown, nutrient inactivation, diversion, dilution flushing, and selective discharge—would be neither technically or financially feasible nor effective in improving the water quality of Oconomowoc Lake. However, in-lake management measures designed to alleviate occasional nuisance conditions caused by excessive algae growth should be considered. For example, a hypolimnetic aeration system could be installed in the smaller basin of the lake to alleviate or reduce some adverse water quality conditions in this area. The capital cost of installing this equipment would be approximately $48,000, with an annual operation and maintenance cost of about $2,400. Further, management techniques designed to assess the condition of the fishery and to maintain the viability of the sport fishing resources are also recommended.

It is recommended that a continuing in-lake water quality sampling program to assess the effects of lake management measures be implemented. This sampling program could consist of measurements of total phosphorus, chlorophyll-a, and water clarity, and the development of temperature and dissolved oxygen profiles at least once during summer and once during spring turnover every three years. These data should be obtained at the deepest point in both basins of the lake. Such a data collection program would have a cost of about $2,000 per year. The U. S. Geological Survey (USGS) will conduct in-lake water quality monitoring programs, under which lake organizations, including lake districts, share the costs of water quality sampling and analyses on a 50-50 cost-share basis with the USGS. Surveys of fish, macrophytes, and algae should periodically be conducted by, or with technical assistance from, the Wisconsin Department of Natural Resources.

Because of the potential environmental hazards and unknown ecological consequences of using chemicals to control occasional excessive algae growth and snails associated with swimmers' itch, it is recommended that such chemicals be used only where localized nuisance growths of these plants occur, and then sparingly and with great care. Accurate records of amounts and dates used should be kept for future use. The institution of watershed management practices in the direct tributary drainage area and upstream of the lake should reduce the excessive in-lake phosphorus concentrations and the concomitant excessive algae growth.

The most important in-lake management consideration for Oconomowoc Lake is the fishery resource. The Wisconsin Department of Natural Resources is the state agency responsible for managing fishery resources; however, under Chapter NR 190 of the Wisconsin Administrative Code, public access is a factor considered by the Department in determining the emphasis and locale of fish management efforts. As discussed in Chapter V, under the Commission-adopted park and open space plan, additional public boat access was not found to be required at Oconomowoc Lake upon application of the access standards developed as a part of the regional planning effort. Under Department guidelines, Oconomowoc Lake has adequate public boat access. Consequently, technical assistance for fishery management can be provided by the Department. It is recommended that the Wisconsin Department of Natural Resources conduct a fish surveillance program to determine the condition of the sport fishery in the lake and subsequent stocking of appropriate gamefish species, if such a program is found to be needed. Further, it is recommended that the Department conduct a creel census to determine the composition of the angler catch and determine if over-harvest of some game species is occurring. In addition, specific schedules for periodic fishery surveys should be established in order to assess and evaluate long-term trends in the total fishery resource in the lake.

COST ANALYSIS

Cost estimates—expressed in 1985 dollars—for the nonpoint source pollution abatement measures and in-lake management techniques recommended for the Oconomowoc Lake tributary drainage area are set forth in Table 27. The total capital cost of the recommended plan, as shown in Table 27, is about $132,500 over a 15-year plan implementation period, with an average annual operation and maintenance cost of $9,600, resulting in a total annual average cost of about $18,600. Of these totals, about $9,500, or 7 percent, of the capital cost; about $3,400, or 35 percent, of the annual operation and maintenance cost; and about $4,500, or 24 percent, of the total annual cost would be borne by either state and federal cost-sharing programs or by local units of government. The in-lake manage-

Table 27

ESTIMATED COST OF RECOMMENDED WATER QUALITY AND LAKE MANAGEMENT MEASURES FOR OCONOMOWOC LAKE

Water Quality or Lake Management Measure[b]	Estimated Cost 1985-2000[a]					
	Capital		Average Annual Operation and Maintenance		Total Average Annual	
	Total	Public Sector	Total	Public Sector	Total	Public Sector
Sanitary Sewer Service[c]	$ --	$ --	$ --	$ --	$ --	$ --
Septic System Management[d]	--	--	--	--	--	--
Rural Land Management	2,000	1,500	1,800	--	2,000	100
Livestock Waste Control	1,500	1,000	600	--	700	300
Urban Land Management	3,000	2,000	1,000	800	1,300	1,200
Construction Erosion Control	78,000	5,000	1,200	1,000	6,400	1,300
Subtotal	$ 84,500	$9,500	$4,600	$1,800	$10,400	$2,900
Fish Management[e]	$ --	$ --	$ --	$ --	$ --	$ --
Hypolimnetic Aeration	48,000	--	2,400	--	5,600	--
Water Quality Sampling Program[f]	--	--	2,000	1,000	2,000	1,000
Public Education Program	--	--	600	600	600	600
Subtotal	$ --	$ --	$2,600	$1,600	$ 2,600	$1,600
Total	$132,500	$9,500	$9,600	$3,400	$18,600	$4,500

[a] *All costs expressed in January 1985 dollars.*

[b] *Land use plan element costs are not presented.*

[c] *Nearly all urban development in the drainage area directly tributary to Oconomowoc Lake is recommended to be served by sanitary sewers by the year 2000. The sewage generated in this area would be conveyed to and treated at the City of Oconomowoc sewage treatment plant. The estimated cost for a portion of the treatment facility and major trunk sewers serving the drainage area, together with local hookup and operation and maintenance of the system, includes a total capital cost of about $1.9 million, with an annual operation and maintenance cost of about $90,000.*

[d] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Oconomowoc Lake. However, because septic tank system management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Oconomowoc Lake drainage basin include a capital cost over the period 1985 to 2000 of $70,000, with an average annual operation and maintenance cost of $8,500.*

[e] *The costs for fish management will be borne by the Wisconsin Department of Natural Resources.*

[f] *Costs based on a sampling frequency of once every three years.*

Source: SEWRPC.

ment costs include an average annual cost of $5,600 for hypolimnetic aeration of the smaller basin of the lake, $2,000 for an in-lake water quality sampling program, and an average annual cost of $600 for the conduct of a public education program. Based on the expected 1995 population of the lake drainage area, the total average annual cost for each lake watershed resident would be about $19, or about $45 per household. The average annual public sector cost would be about $5.00 per resident, or about $12 per household.

Chapter X

SUMMARY

The preparation of a water quality management plan for Oconomowoc Lake was a cooperative effort by the Southeastern Wisconsin Regional Planning Commission and the Wisconsin Department of Natural Resources. The planning effort included the design and conduct of a water quality sampling program—conducted from May 1976 through April 1977—encompassing sampling of not only the lake water itself, but the quality of the inflows, the outflows, and the groundwater; together with inventories and analyses of the existing land use pattern; the physiography and natural resource base of the direct drainage area; the recreational use of the lake; and the management practices in the watershed. The objectives of the plan are to provide a level of water quality in Oconomowoc Lake suitable for the maintenance of a healthy warmwater fishery, to reduce the severity of nuisance conditions caused by excessive algae growth, and to improve opportunities for water-based recreational activities.

Oconomowoc Lake is a 804-acre lake located within U. S. Public Land Survey Sections 1, 2, and 3, Township 7 North, Range 17 East, Town of Summit, Waukesha County. The lake has a maximum depth of 62 feet, and a mean depth of 30 feet. Oconomowoc Lake has a direct tributary drainage area of 2,020 acres, or 3.2 square miles, and a total watershed area of 48,332 acres, or 75.5 square miles.

As of 1980, the resident population of the drainage area directly tributary to the lake was estimated by the Commission at 1,038 persons. The type, intensity, and spatial distribution of land uses are important factors determining resource demand in the tributary drainage area. As of 1980, approximately 1,375 acres, or 68 percent, of the 2,020-acre direct tributary drainage area was still in rural land uses, with the dominant rural land use being agricultural, accounting for 869 acres, or 43 percent, of the direct drainage area. The remaining rural land uses—wetlands, woodlands, and open lands—constituted about 506 acres, or 25 percent, of the direct drainage area. Approximately 645 acres, or 32 percent, of the direct drainage area was in urban land uses, with the dominant urban land use being residential, accounting for 447 acres, or 22 percent, of the direct drainage area. Commercial; industrial; governmental and institutional; transportation, communication, and utility; and recreational land uses comprised 198 acres, or 10 percent of the direct drainage area.

As of 1984, the sanitary and household wastewaters from the drainage area directly tributary to the lake were treated and disposed of through the use of onsite systems. There are approximately 193 septic tank systems in the direct drainage area—59, or 36 percent, of which are located in areas covered by soils having severe or very severe limitations for the use of such systems.

For the May 1976 through April 1977 study period, it was estimated that 28,084 acre-feet of water entered Oconomowoc Lake. Of this total, about 21,164 acre-feet of water, or about 76 percent, was contributed by inflow from the Oconomowoc River; about 4,778 acre-feet, or about 16 percent, was contributed by groundwater inflow; about 1,277 acre-feet, or about 5 percent, was contributed by direct precipitation on the lake surface; and about 865 acre-feet, or 3 percent, was contributed by surface runoff from the direct drainage area. Of the total 28,116 acre-feet of water leaving the lake, approximately 26,540 acre-feet, or about 93 percent, was discharged via the Oconomowoc River; and about 1,576 acre-feet, or about 6 percent, evaporated from the surface of the lake. About 32 acre-feet, or about 1 percent, went into storage, resulting in a slightly higher lake level.

Monthly temperature and dissolved oxygen profiles indicate that complete mixing of Oconomowoc Lake is restricted during the summer by thermal stratification. The data indicate that Oconomowoc Lake, like other mesotrophic or eutrophic lakes in southeastern Wisconsin, experiences oxygen depletion in the hypolimnion, or bottom water layer. Oxygen depletion in the hypolimnion may increase the release of phosphorus from the bottom sediments and cause fish to migrate upward in the water column to where higher dissolved oxygen concentrations exist.

Based on the study data, Oconomowoc Lake is classified as mesotrophic, a term used to describe a moderately fertile lake which is undergoing an increased rate of nutrient enrichment and which may support abundant fisheries and aquatic plant growth. Oconomowoc Lake supports a relatively large and diverse fish community. Surveys conducted by the Wisconsin Department of Natural Resources during the study period indicated that there are 34 fish species in the lake.

Commission analyses indicated that under the existing conditions, the total phosphorus load to Oconomowoc Lake during an average year was approximately 3,560 pounds. Of this total, about 2,500 pounds, or about 70 percent, was estimated to be contributed by the inflow from the Oconomowoc River. In addition, direct atmospheric deposition contributed about 630 pounds, or about 18 percent. Malfunctioning onsite septic systems were estimated to contribute 220 pounds, or about 6 percent, of the total phosphorus load to the lake. The remaining phosphorus load, totaling about 210 pounds, or about 6 percent, was contributed by stormwater runoff entering the lake from urban and rural lands in the direct drainage area.

The Commission-recommended water quality standard for recreational use and warmwater fish and aquatic life indicates that nuisance aquatic plant growth is likely to occur in lakes where the total phosphorus concentration exceeds 0.02 milligram per liter (mg/l) during the spring turnover. In Oconomowoc Lake, the mean concentration of total phosphorus in the spring was about 0.03 mg/l, which indicates that there is the potential for nuisance aquatic plant growth to occur in the lake, with an associated increase in the rate of eutrophication. In general, the aquatic plant growth in Oconomowoc Lake is sparse; however, populations of blue-green algae do occasionally reach bloom conditions, with associated adverse impacts on the recreational uses of the lake. Research indicates that the prevalence of a healthy and diverse zooplankton population which feeds on algae may be responsible for the present lack of significant algae blooms in the lake.

The resident population of the Oconomowoc Lake direct drainage area may be expected to decrease slightly, from about 1,038 residents in 1980 to 1,013 residents by the year 2000. The adopted regional land use plan recommends that the agricultural lands in the southern portion of the lake watershed, totaling about 540 acres, or about 19 percent of the direct drainage area, be preserved in agricultural use. The plan further recommends that the undeveloped lands immediately surrounding the lake, together with certain connected areas containing a concentration of high-value woodlands, wetlands, and wildlife habitat which together encompass about 592 acres, or about 21 percent of the direct drainage area, be preserved in essentially natural, open uses as environmental corridor. It is also recommended that certain isolated natural areas in the direct drainage area—consisting of concentrations of woodlands, wetlands, and wildlife habitat which encompass about 26 acres, or about 1 percent of the direct drainage area—be preserved in essentially natural, open uses. The remaining 1,666 acres, or about 59 percent, of the direct drainage area would be comprised of open land, surface water, parkland, and residential, commercial, governmental, institutional, and transportation land uses.

The Commission estimated that under planned, year 2000 land use conditions, the total phosphorus load to the lake would be 2,520 pounds, or about 30 percent less than the estimated 1980 loadings. Of this total, approximately 1,650 pounds, or about 65 percent, would be contributed by the Oconomowoc River. The anticipated decrease of about 850 pounds, or about 34 percent, would result from the implementation of upstream nonpoint source water pollution control measures recommended in the regional water quality management plan and primarily implemented under the priority watershed program. Further, phosphorus entering the lake from malfunctioning onsite septic systems would decrease by 198 pounds, or about 90 percent—from 220 pounds to 22 pounds—as a result of the provision of sanitary sewer service, and better maintenance of the remaining systems. The other major sources of phosphorus to Oconomowoc Lake—which include stormwater runoff carrying sediments and nutrients from livestock operations, and rural and urban land uses—are expected to contribute about 218 pounds, or about 10 percent of the total load, in the year 2000. The amount of phosphorus loading attributed to atmospheric fallout and washout in 1980, approximately 630 pounds, or about 25 percent, is assumed to remain about the same.

Management measures required to meet the water use objectives for Oconomowoc Lake must address the point and nonpoint source pollution controls needed. Commission estimates indicated that a 30 percent reduction in phosphorus loads to the lake would be required in order to meet the recommended water use objectives and supporting standards. As previously noted, the provision of sanitary sewer service to the direct drainage area is recommended as a point source control measure in the adopted regional water quality management plan. Nonpoint source pollution control measures consist of a variety of both urban practices, including septic system management, construction erosion control, and roadside erosion control; and rural practices, including conservation tillage and contour strip-cropping. Nonpoint source pollution control measures would also include a public education program to inform lake area residents of the importance of proper disposal methods of yard wastes and other household waste materials, landscaping practices, and the proper use of household chemicals in reducing the amount of pollutant loading to lakes and streams by direct overland drainage, drainage from natural or man-made channels, and groundwater inflow. These actions would be designed to reduce the in-lake concentration of total phosphorus during spring turnover to the Commission-recommended standard of 0.02 mg/l. It should be noted that implementation of urban and rural nonpoint source pollution control practices upstream of Oconomowoc Lake as a result of the priority watershed project will be critical to the achievement of the in-lake total phosphorus standard.

Alternative lake rehabilitation and in-lake management techniques were evaluated to examine the feasibility of conducting an in-lake management program. Techniques assessed included hypolimnetic aeration, dredging, sediment covering, drawdown, nutrient inactivation, dilution/flushing, selective discharge, diversion, aquatic plant harvesting, chemical control of algae, water quality sampling, and fish management. As a result of these evaluations, it is recommended that hypolimnetic aeration be used in the small basin of the lake and that the fishery resources of Oconomowoc Lake be evaluated and managed, and that a continuing in-lake water quality monitoring program be established in conjunction with the Department of Natural Resources.

In summary, the water quality management recommendations for Oconomowoc Lake were developed within the framework of the adopted regional water quality management plan and include:

1. The modification of local land use zoning ordinances to bring local planning and zoning into conformance with the adopted regional land use plan as that plan applies to the drainage area tributary to Oconomowoc Lake.

2. The implementation of nonpoint source pollution controls in both urban and rural areas, including a public education program, improved public works activities, improved urban "housekeeping" practices, and improved agricultural land management, with technical and financial assistance from state and federal units of government.

3. The conduct of an onsite sewage disposal inspection program by the Waukesha County Board of Health.

4. The modification of construction erosion control requirements by Waukesha County and the respective municipalities.

5. The installation of a hypolimnetic aeration system in the small basin of the lake and initiation of a continuing in-lake water quality and fishery resource monitoring program.

Implementation of the recommended nonpoint source pollution controls in the drainage area directly tributary to Oconomowoc Lake and in-lake management would entail a total capital cost of about $132,500, with an average annual operation and maintenance cost of about $9,600, and a total average annual cost of $18,600 over a 15-year plan period. The in-lake management costs, which are included in the above costs, include a total average annual cost of $5,600 for hypolimnetic aeration, $2,000 for an in-lake water quality monitoring program, and $600 for a public education program. Based on the expected 1995 population of the drainage area directly tributary to the lake, the total average annual cost of full implementation of the plan would be about $19 per resident, or $45 per household.

Oconomowoc Lake is a valuable natural resource in the Southeastern Wisconsin Region. There is a delicate, complex relationship between the water quality conditions of a lake and the land uses within the drainage area directly tributary to a lake. The increases in population, urbanization, income, leisure time, and individual mobility forecast for the Region may be expected to result in additional pressure for development in the direct drainage area of lakes in southeastern Wisconsin and for water-based recreation on the lakes themselves. Without the adoption and administration of an effective water quality management program for Oconomowoc Lake, based upon comprehensive water quality management and related land use plans, the water quality protection needed to maintain conditions in Oconomowoc Lake suitable for recreational use and for the maintenance of fish and other aquatic life will not be provided.

APPENDICES

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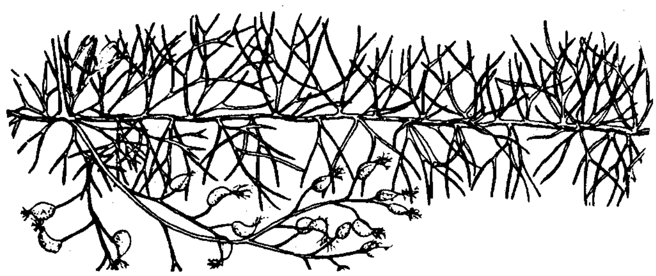
Appendix A

ILLUSTRATIONS OF REPRESENTATIVE BIOTA WHICH MAY BE FOUND IN OCONOMOWOC LAKE

Appendix A-1

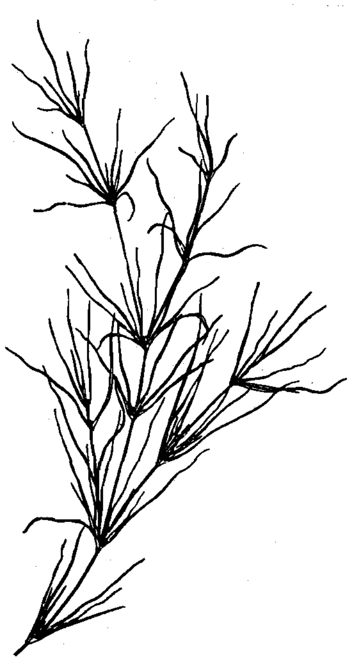
REPRESENTATIVE MACROPHYTES FOUND IN SOUTHEASTERN WISCONSIN LAKES

BLADDERWORT (Utricularia sp.)



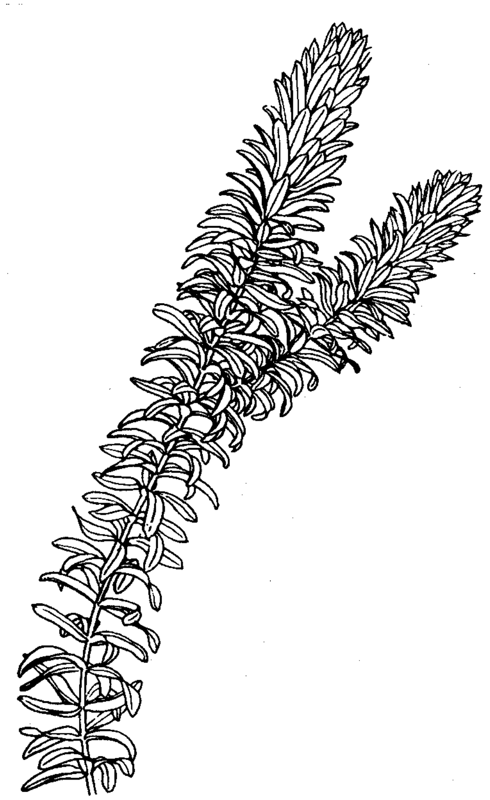
Bladderwort is a carnivorous plant which occurs in shallow ponds and lakes or on wet soils. The small bladders are traps which catch tiny animal life, particularly crustaceans. Bladderwort provides some food and cover for fish. It is never abundant enough to become a nuisance.

BUSHY PONDWEED (Najas flexilis)



Bushy pondweed is a common species in ponds, small lakes, and slow-moving streams in southeastern Wisconsin. It provides food and cover for fish. Bushy pondweed may become a nuisance during late summer in some lakes.

COMMON WATERWEED (Anacharis canadensis)



Common waterweed is a submerged plant which usually occurs in hard water. It provides cover for many small aquatic organisms which serve as food for the fish population. Waterweed is an aggressive plant and may suppress the growth of other aquatic plants.

COONTAIL (Ceratophyllum demersum)

Coontail is a submerged plant which prefers hard water. It supplies cover for shrimp and young fish and supports insects which are valuable as fish food. A heavy growth of coontail is an indication of very fertile lake conditions.

CURLY LEAF PONDWEED (Potamogeton crispus)

Curly leaf pondweed is an introduced plant species which does well in hard or brackish water which is usually polluted. However, curly leaf pondweed does provide good food, shelter, and shade for fish and is valuable for early spawning fish.

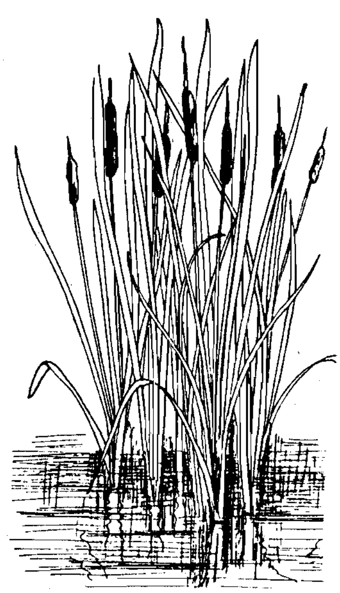
FLOATING LEAF PONDWEED (Potamogeton natans)

Floating leaf pondweed has leaves which float on the surface with the rest of the plant submerged. It provides food and shelter for fish and other aquatic species.

LARGE LEAF PONDWEED (*Potamogeton amplifolius*)

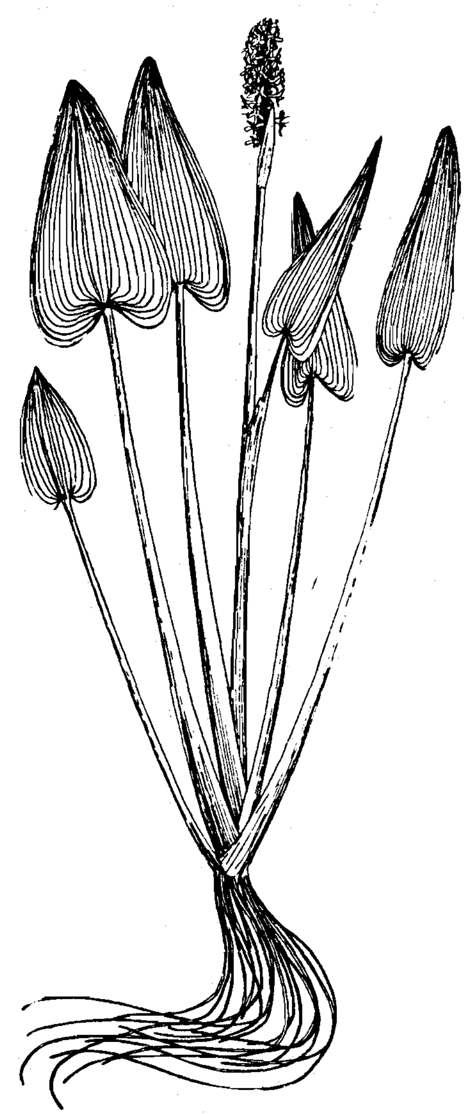
Large leaf pondweed is usually found in relatively hard water. Submersed, it supports insects and provides a good food supply for fish.

NARROW-LEAVED CATTAIL (*Typha angustifolia*)



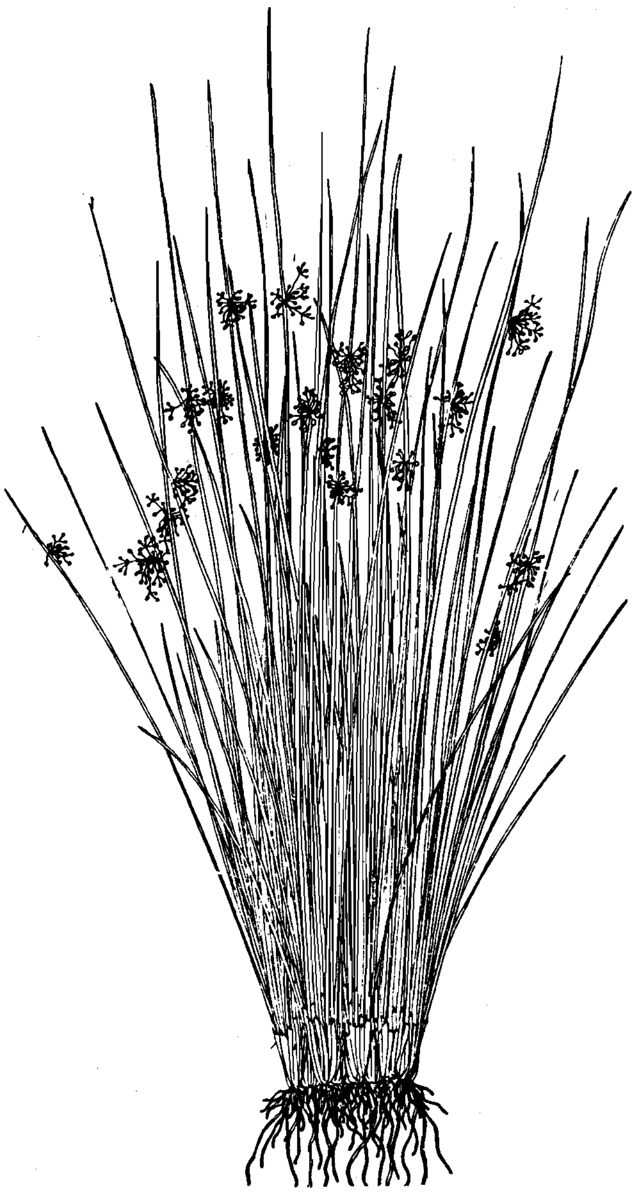
Narrow-leaved cattail may appear in almost any wet place. It is used as a spawning area for sunfish and shelter for various species of young fish, as well as a variety of other forms of wildlife. Cattails often occur in dense stands and therefore may become a nuisance.

PICKEREL WEED (*Pontederia cordata*)



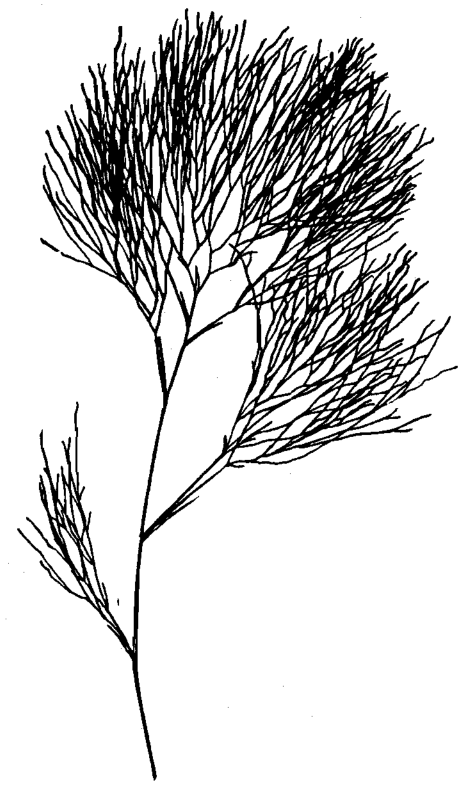
Pickerel weed is common in shallow water with muddy shores. It provides shade and shelter for fish but has only slight value as food and cover. Pickerel weed usually is not abundant enough to be a nuisance.

RUSH (Juncus sp.)



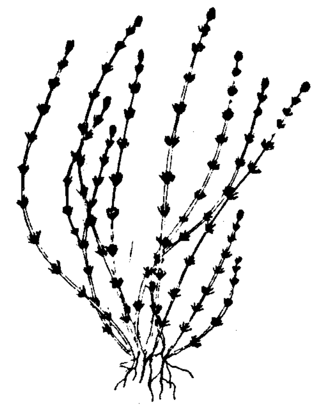
Rushes are an emergent aquatic plant with a widespread habitat which ranges from wet meadows and lakeshores to shallow pools. Thick growths of rushes often form spawning grounds for rock bass, bluegills, and other sunfish.

SAGO PONDWEED (Potamogeton pectinatus)



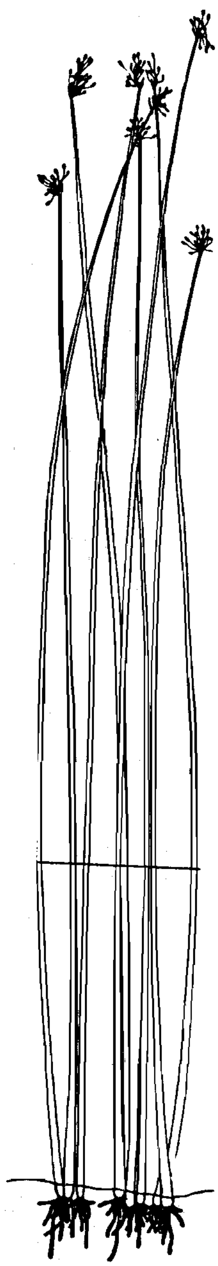
Sago pondweed is found in hard or brackish water of lakes and slow-flowing streams. Sago pondweed provides food and shelter for young trout and other fish.

STONEWORT (*Chara aspera*)



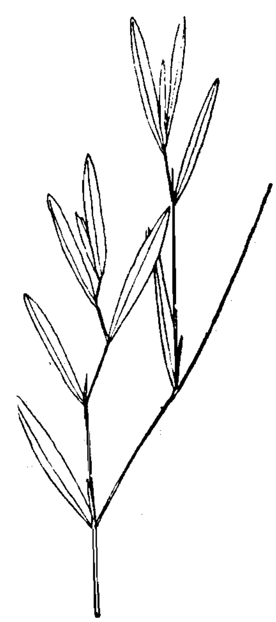
Stonewort is a type of algae which usually occurs in hard water. It provides fair cover for fish and produces excellent food for young trout, large and small mouth bass, and black bass.

SOFTSTEM BULRUSH (*Scirpus validus*)



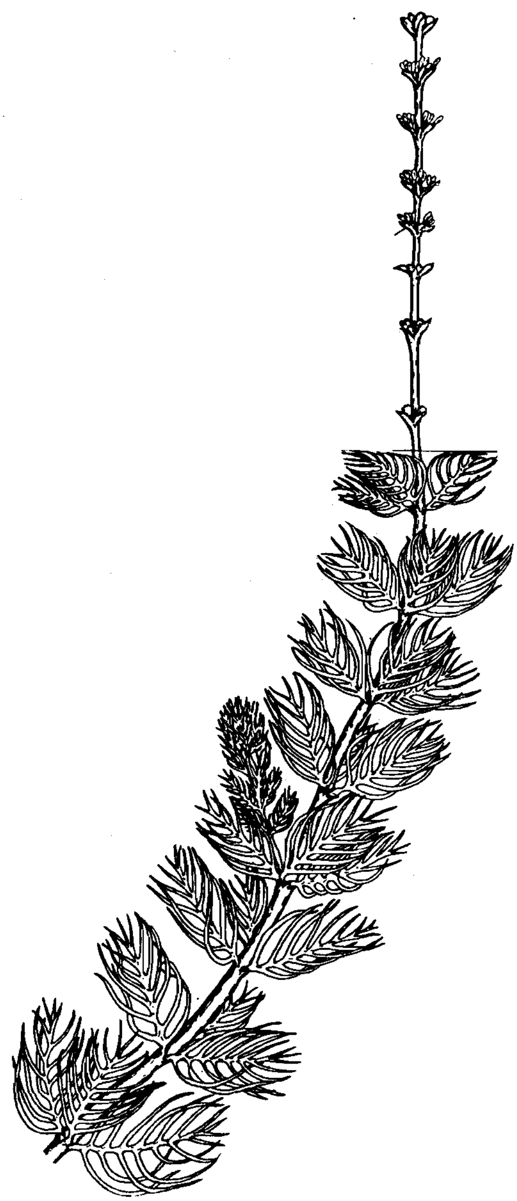
Softstem bulrush is an emergent aquatic species. It supports insects and provides food for young fish and many species of waterfowl.

VARIABLE PONDWEED (*Potamogeton gramineus*)



Variable pondweed is a submergent species. However, it will occasionally grow on muddy shores. Variable pondweed provides food and cover for fish.

WATER MILFOIL (*Myriophyllum exalbescens*)

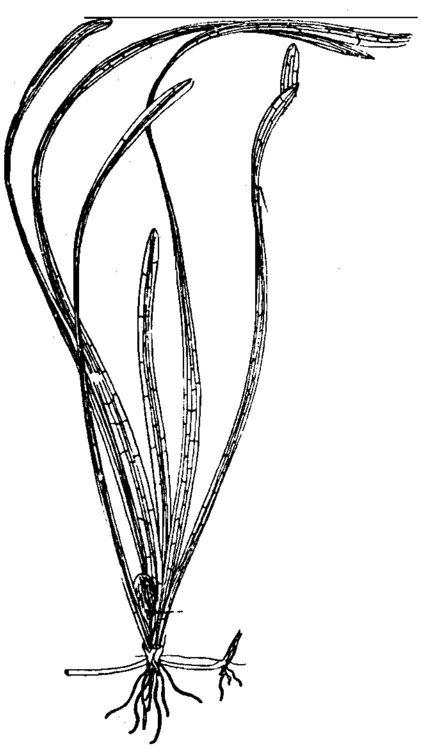


Water milfoil is a submergent plant which may cause extensive weed problems in lakes and streams. However, when not overabundant, water milfoil provides cover for fish and is a valuable food source for many forms of aquatic life.

WATER SMARTWEED (*Polygonum natans*)

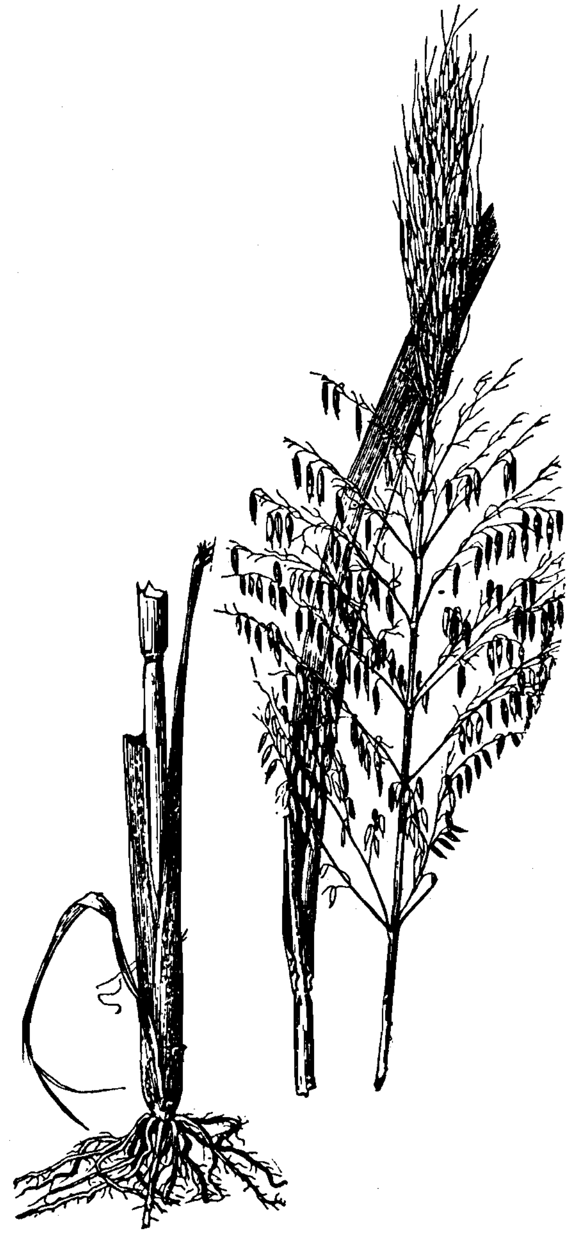
Water smartweed is found along the shoreline of shallow water. It provides food and cover for fish and wildlife. Water smartweed is never abundant enough to cause aquatic nuisance problems.

WILD CELERY OR EEL GRASS (Vallisneria americana)



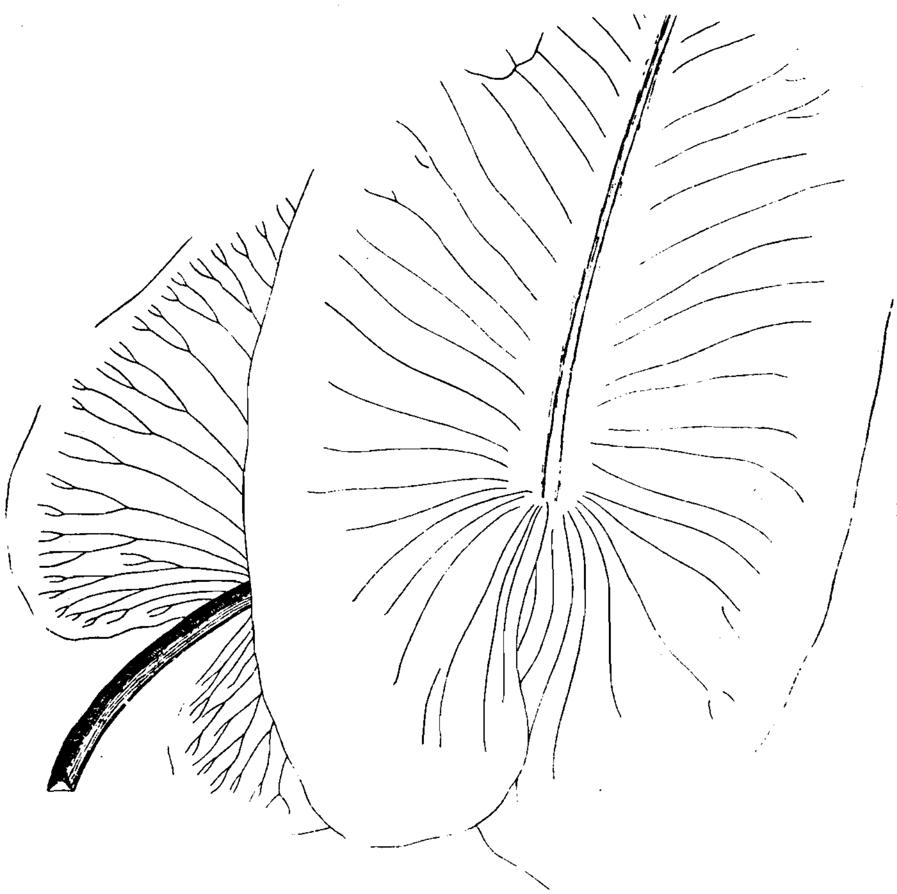
Eel grass is a submersed plant which provides shade, shelter, and food for fish. It supports insects and is a valuable food source for waterfowl. Sometimes forming dense growths, eel grass may be undesirable in swimming areas.

WILD RICE (Zizania aquatica)



Wild rice is a valuable emergent aquatic grass. Wild rice prefers clean water with low turbidity during the growing season. Wild rice is an annual grass with seeds that depend on sufficient light penetration in spring and early summer for germination. Wild rice is an important food source for many species of fish and waterfowl. It is also a food source for humans.

YELLOW WATER LILY (Nuphar variegatum)

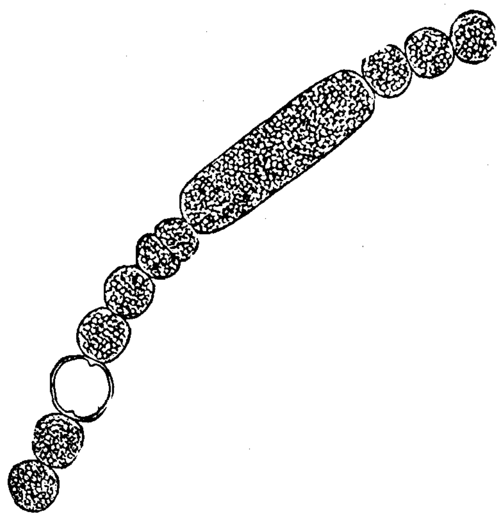


Yellow water lily and white water lily are found in shallow portions of lakes and ponds. The leaves float on the surface of the water and algae and insects often grow under the leaves. Yellow and white water lilies provide shade and shelter for fish but may cause problems because of the extensiveness of their beds in shallow portions of lakes.

Appendix A-2

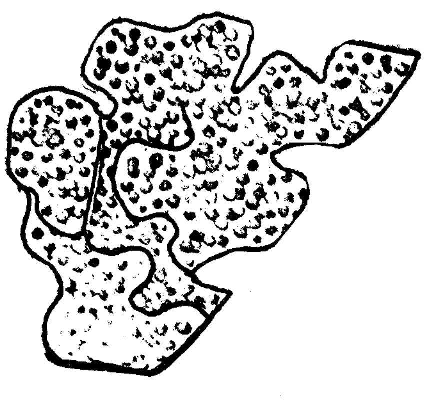
REPRESENTATIVE PHYTOPLANKTON FOUND IN SOUTHEASTERN WISCONSIN LAKES

Anabaena



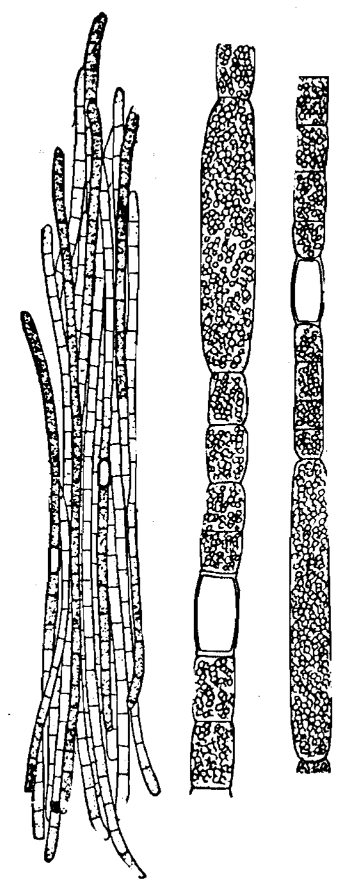
There are many individual species of the bluegreen algae, Anabaena. Some species are solitary while others form aggregated masses of indefinite shape. Anabaena seldom cause disagreeable conditions in lakes and reservoirs when they bloom, as they remain suspended throughout the water column and do not form surface scums. However, some species of Anabaena have been known to cause toxic water supplies which have caused animal fatalities.

Anacystis



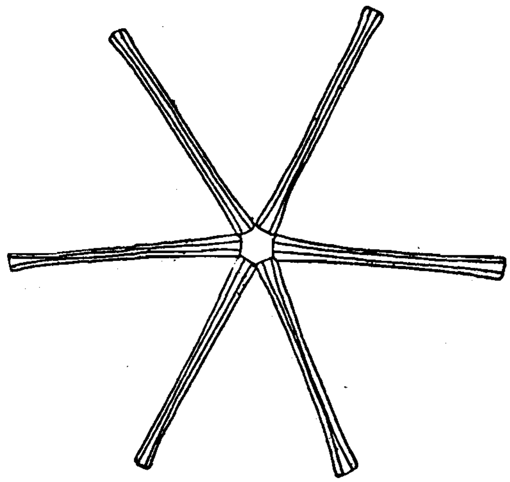
Anacystis is a loose colony of small spherical bluegreen algae cells contained in a gelatinous mass. The colony floats in the water column and is visible to the naked eye. Like Anabaena, Anacystis have been known to cause toxic water supplies.

Aphanizomenon



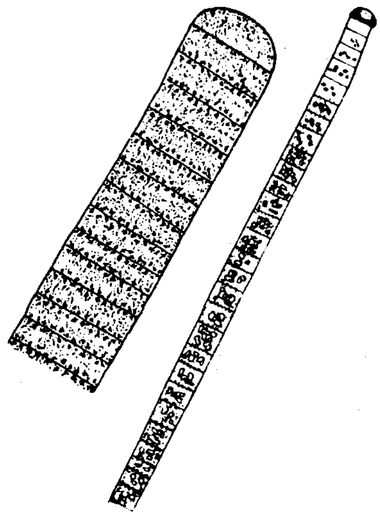
Individual cells of Aphanizomenon form strands which lie parallel in bundles and often occur so abundantly that the water appears to be filled with bits of chopped grass. The individual cells contain air spaces which give the plants great bouyancy. This accounts for the abundant growths of this bluegreen algae becoming concentrated on or near the surface where floating scum results. Dense growths may lead directly or indirectly to the death of fish through oxygen depletion or the secretion of toxins.

Asterionella



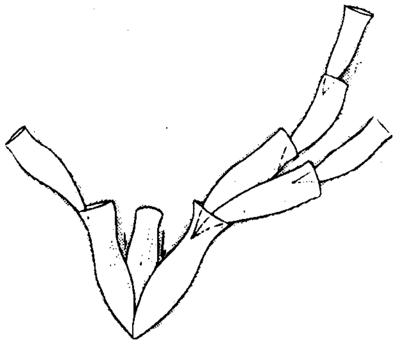
The diatom, Asterionella, usually occurs as a member of lake plankton. It prefers hard-water lakes and is readily identified by the spoke-like arrangement of the rectangular arms about a common center. Asterionella may be so abundant that lake water used for domestic water supplies may have a fishy taste.

Oscillatoria



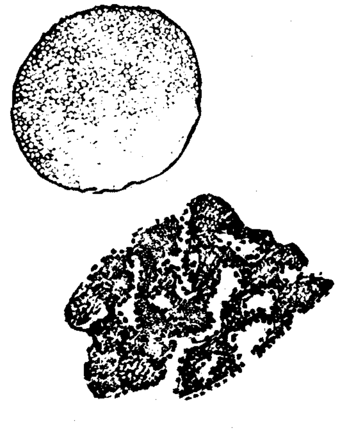
Oscillatoria is a filamentous bluegreen algae that grows in dense darkly colored clumps or mats. A characteristic of this bluegreen algae is the active oscillating movement for which it is named.

Dinobryon



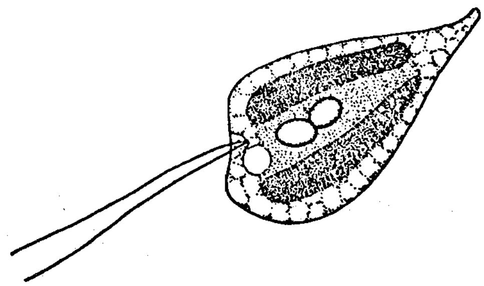
Dinobryon typically inhabit hard water lakes and, under certain conditions, may bloom. Dinobryon may produce disagreeable odors and tastes in domestic water supplies.

Microcystis



The cells of Microcystis, a bluegreen algae, are closely compacted and irregularly arranged in colonies enclosed in mucilage. Where some species of Microcystis occur, the habitat is completely dominated by this algae to the exclusion of all other forms of algae. Dense growths of Microcystis may cause oxygen depletion or secrete toxins which cause fish kills.

YELLOW GREEN ALGAE (Chrysophyta)

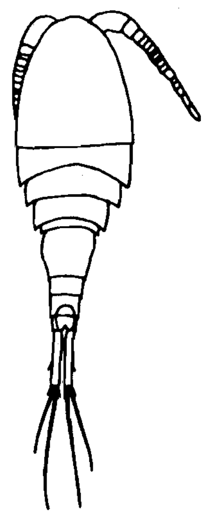


Many freshwater Chrysophyta are restricted to cold brooks, especially mountain streams, springs, and lakes during cool seasons. Most thrive in water relatively free of pollution.

Appendix A-3

A FORM OF ZOOPLANKTON FOUND IN SOUTHEASTERN WISCONSIN LAKES

COPEPODS (Diacyclops thomasi)



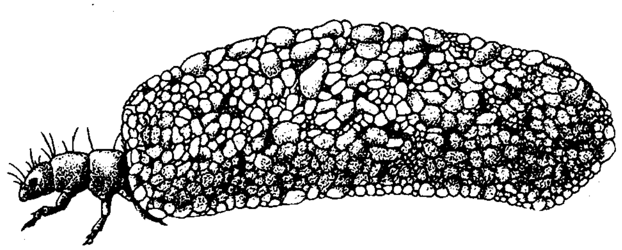
A common example of copepods found in permanent bodies of water of all types from shallow ponds and marshes to lakes is Diacyclops thomasi. The adults are predaceous on other zooplankton and can injure fish fry.

Appendix A-4

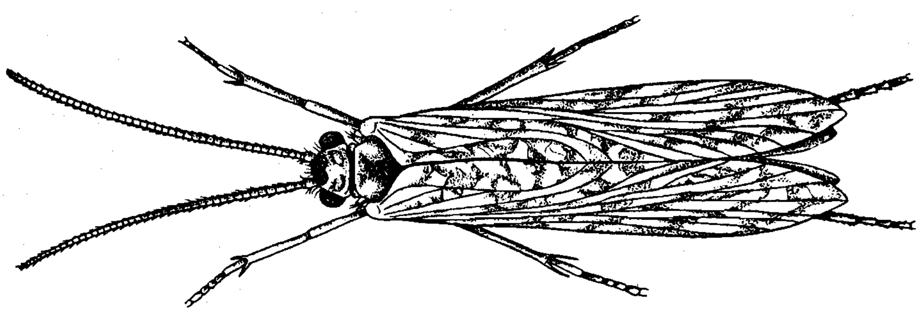
A FORM OF BENTHIC OR BOTTOM DWELLING ORGANISM FOUND IN SOUTHEASTERN WISCONSIN LAKES

CADDISFLIES (Trichoptera)

Caddisfly Larvae and Case



Adult Caddisfly

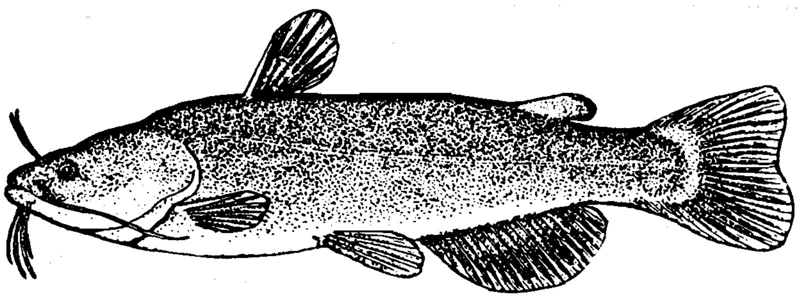


Caddisflies are found in most types of freshwater habitat, including streams, spring seepages, rivers, lakes, marshes, and temporary pools. Their tolerance to organic pollution varies widely, with some species being quite tolerant. Caddisflies are a food source for many species of fish.

Appendix A-5

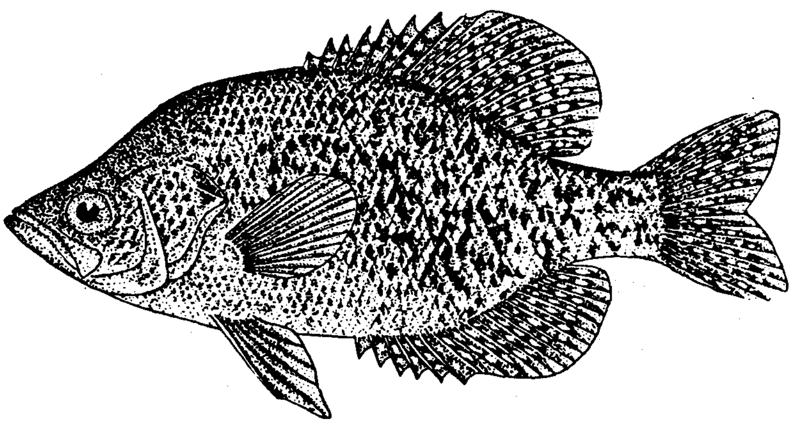
REPRESENTATIVE FISH SPECIES FOUND IN SOUTHEASTERN WISCONSIN LAKES

BLACK BULLHEAD (Ictalurus melas)



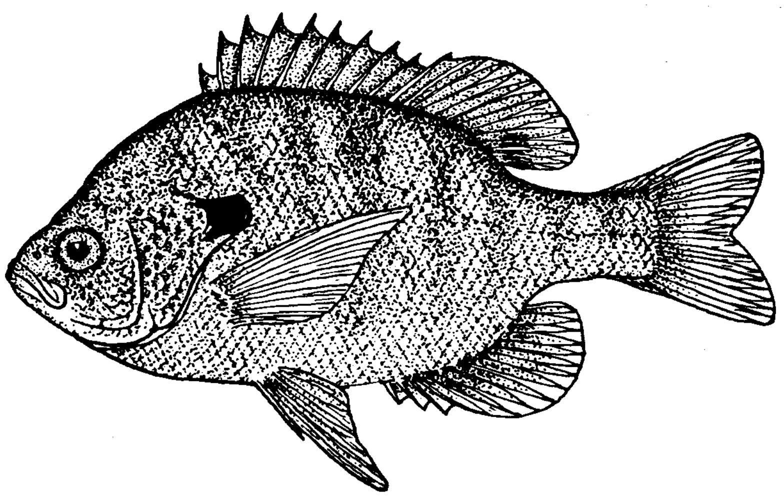
The black bullhead is common in shallow lakes and muddy streams. It nests in shallow water on either a sand or mud bottom. Bullheads are scavengers and will eat whatever food is available, such as minnows, leeches, crayfish, and amphipods.

BLACK CRAPPIE (Pomoxis nigromaculatus)



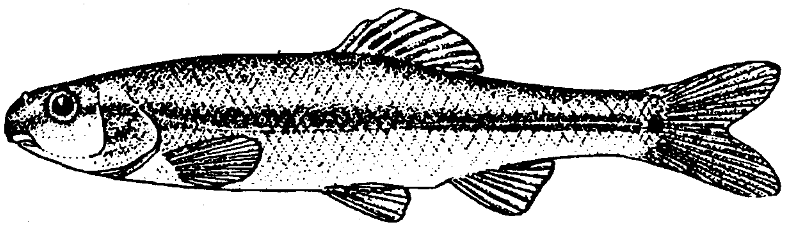
The black crappie prefers large streams and medium-sized lakes. It nests in water between three and six feet deep with a somewhat muddy bottom. Crappies feed on aquatic insects, small crustaceans, minnows, and other small fish.

BLUEGILL (Lepomis macrochirus)



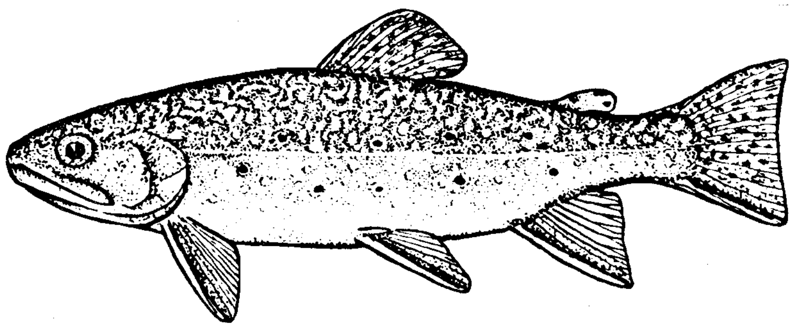
The bluegill is found in nearly all clear water lakes and streams. It nests in shallow areas with sandy bottoms; nests are often crowded together. Bluegills feed on small aquatic insects, worms, snails, and amphipods.

BLUNTNOSE MINNOW (*Pimephales notatus*)



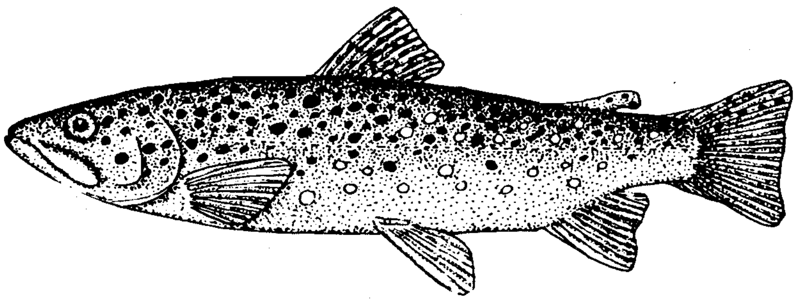
The bluntnose minnow is common in lakes and streams, but not in large rivers. The nest is built under an object, such as a rock or log. Bluntnose minnows feed mainly on algae.

BROOK TROUT (*Salvelinus fontinalis*)



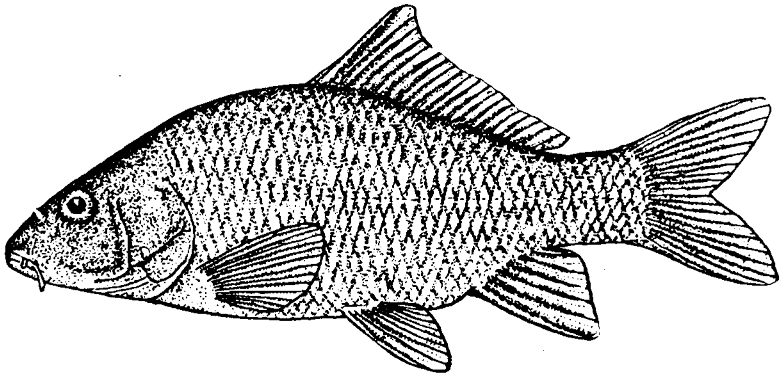
The brook trout, a native species in southeastern Wisconsin, prefers clear brooks and rivers in which the mean annual temperature rarely exceeds 50°F. The nest or redd is built on gravel bottoms in shallow riffle areas. Brook trout feed on adult aquatic insects and their larvae.

BROWN TROUT (*Salmo trutta*)



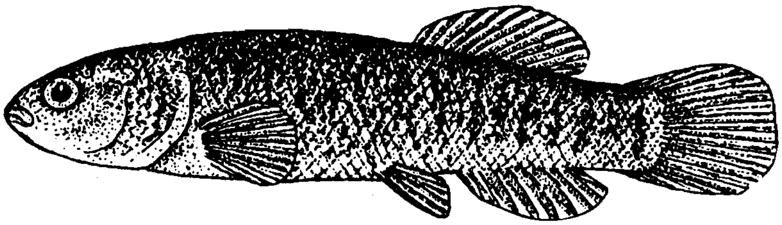
The brown trout is an introduced trout species which has become common in cold water streams. Nests or redds are built on sand and gravel bars at the mouths of tributaries. Young brown trout feed on small crustaceans and aquatic insects. Adults eat small fish, snails, crayfish, and terrestrial insects.

CARP (*Cyprinus carpio*)



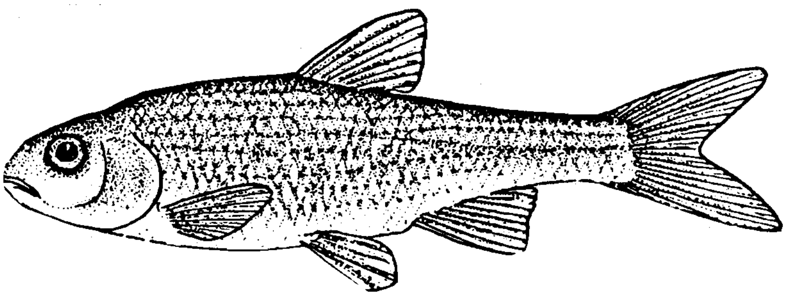
The carp is an introduced species which is tolerant of low dissolved oxygen conditions and prefers warm waters, with shallow mud-bottom lakes. Carp eat a wide variety of food. The uprooting of vegetation during feeding results in suspension of bottom sediments into the water column and a loss of aquatic plant beds which other fish species depend on.

CENTRAL MUDMINNOW (Umbra limi)



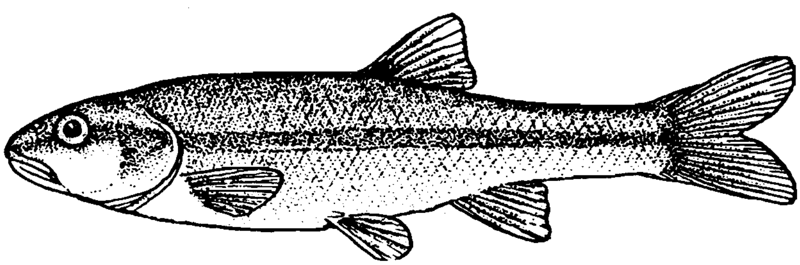
The central mudminnow prefers bog habitats, ditches, and streams with mud bottoms supporting dense aquatic vegetation. Spawning occurs in late spring and early summer. Mudminnows feed on insects, small crustaceans, and worms.

COMMON SHINER (Notropis cornutus)



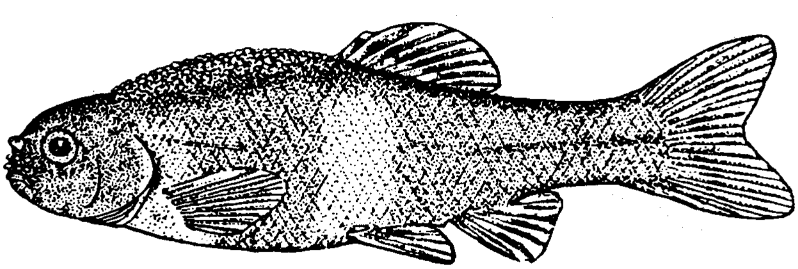
The common shiner occurs in habitats ranging from intermittent streams to large rivers and lakes. Common shiners are a forage fish that have value as a food source for game species. Shiners feed on small insects, crustaceans, and some algae.

CREEK CHUB (Semotilus atromaculatus)



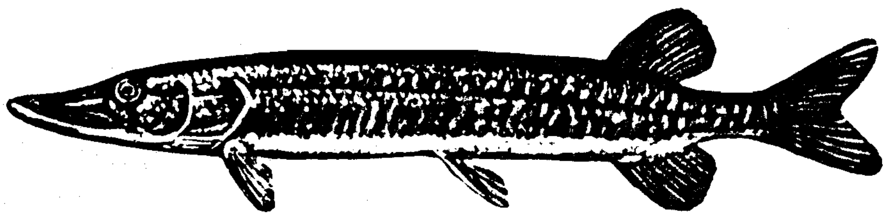
The creek chub prefers small streams and rivers but occasionally is found in lakes and large rivers. Creek chubs are quite common in beaver dam pools and may compete with trout for food. Chubs feed on all types of insects, amphipods, vegetation, and other, smaller fish.

FATHEAD MINNOW (Pimphales promelas)



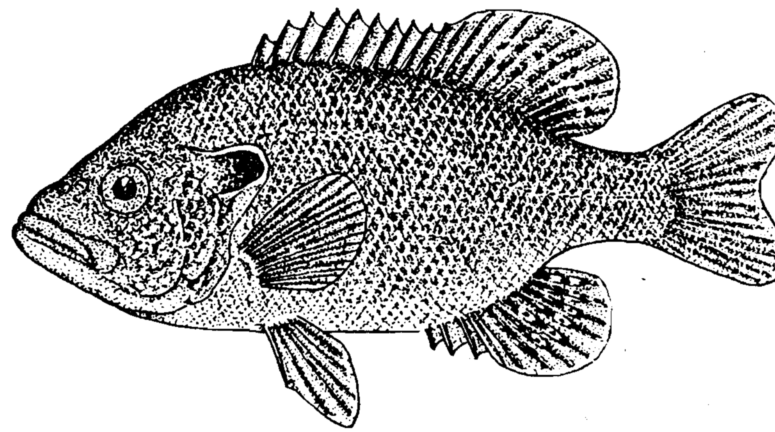
The fathead minnow prefers shallow lakes, ponds, and ditches. Nests are built on the underside of sticks, boards, and rocks in water between 3 and 12 inches deep. The fathead minnow can withstand very low oxygen conditions and, therefore, are very tolerant to pollution. Young fathead minnows feed on algae, while adults feed on a variety of aquatic insects, worms, and plants. The fathead minnow is a forage species and serves as a food source for many types of game fish.

GRASS PICKERAL (Esox americanus vermiculatus)



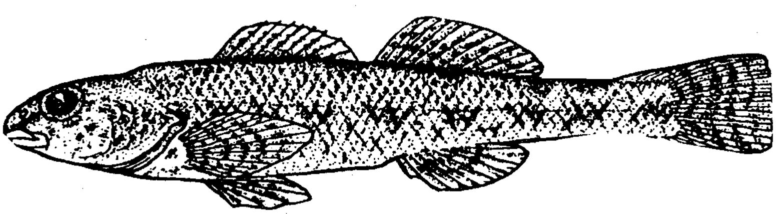
The grass pickerel is common in weedy portions of lakes and rivers. Pickerels are predators and as such feed almost exclusively on other fish. Grass pickerel are too small to have much value as a game fish.

GREEN SUNFISH (Lepomis cyanellus)



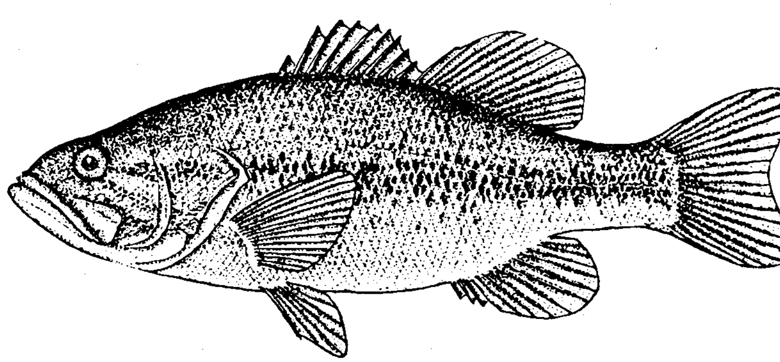
The green sunfish prefers small, shallow lakes and is common in creeks. Green sunfish feed on aquatic insects and any flying insects that happen to fall into the water. Large numbers of stunted adults may occur in some lakes and as such may decrease the viability of the existing fishery.

JOHNNY DARTER (Etheostoma nigrum)



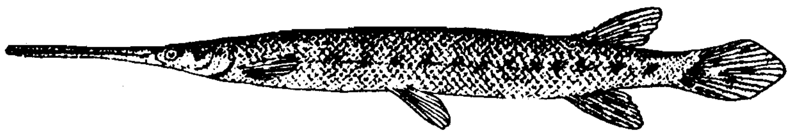
The johnny darter occurs in relatively clean lakes and streams. Nests are built under sticks and stones. The johnny darter feeds on algae and small, immature insects.

LARGEMOUTH BASS (Micropterus salmoides)



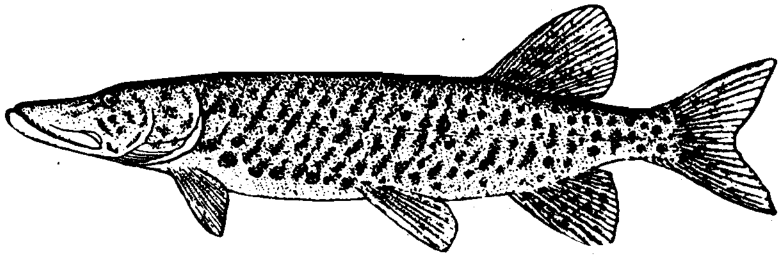
The largemouth bass prefers small- to medium-sized hardwater lakes with clear water, sandy shores, and marginal weed beds. The largemouth bass is carnivorous and as an adult feeds on perch, minnows, and small sunfish.

LONGNOSE GAR (Lepisosteus osseus)



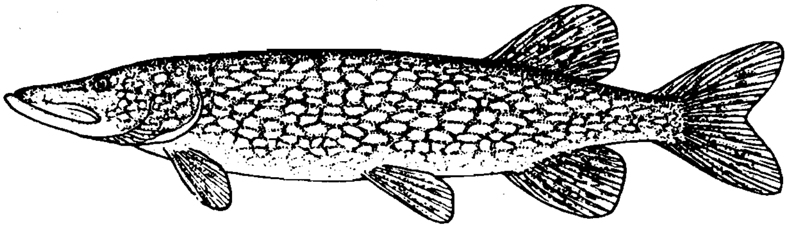
The longnose gar is a warmwater fish that often can tolerate surface waters which are too polluted for other species. Gars feed on game and forage fish and in some instances may alter fish populations enough to damage a fishery resource.

MUSKELLUNGE (Esox masquinongy)



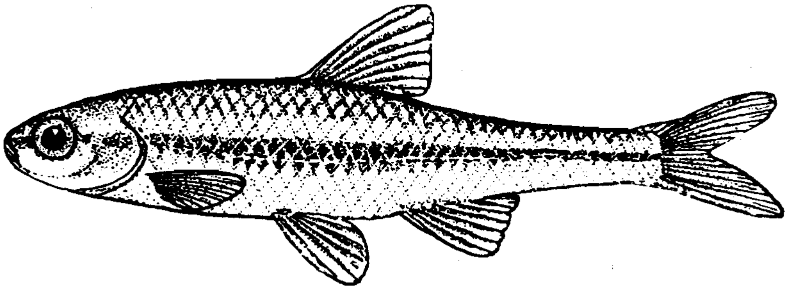
The muskellunge is common in lakes but is seldom abundant because it requires a large area of water to supply enough food for its voracious appetite. Spawning occurs in early May in tributary streams and shallow lake channels. Muskellunge are strictly carnivorous, feeding primarily on perch and suckers. A hybrid strain (tiger muskie) is stocked in many lakes in southeastern Wisconsin.

NORTHERN PIKE (Esox lucius)



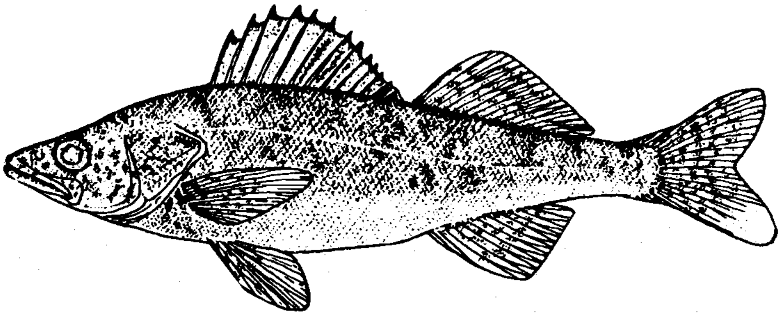
The northern pike is common in southeastern Wisconsin lakes. It feeds on a variety of fish, including perch, small suckers, sunfish, and even smaller northern pike. Spawning occurs immediately after the ice melts in April or early May in wetlands adjacent to lakes and streams.

PUGNOSE SHINER (Notropis anogenus)



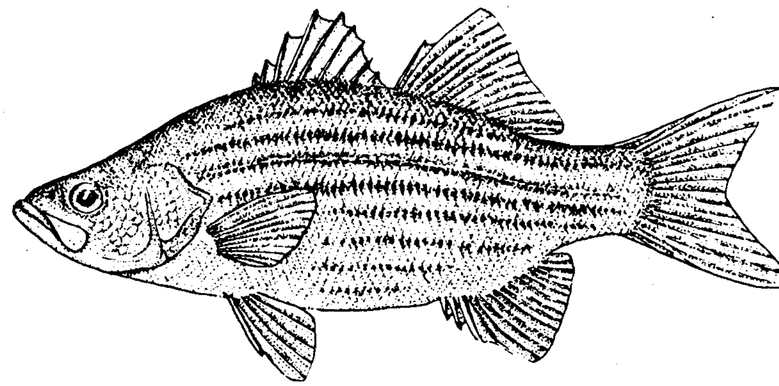
The pugnose shiner is threatened in Wisconsin. This small fish—up to two inches in length—prefers weedy waters in streams and lakes. Little is known about its life history as it is one of the rarest shiners. Changes by man in streams, rivers, and lakes have been responsible for its disappearance and resulting inclusion on the threatened species list in Wisconsin.

WALLEYE (Stizostedion vitreum vitreum)



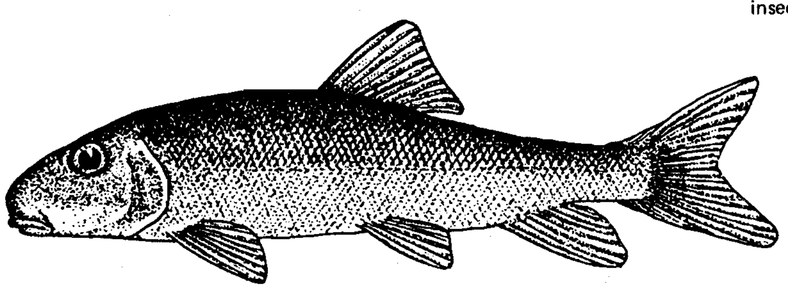
The walleye prefers clean and moderately warm to cold lakes and rivers. Spawning occurs in early spring on sand bars and shoals. Walleye feed on small minnows, small bullheads, and leeches. Walleye are a very desirable game fish.

WHITE BASS (Morone chrysops)



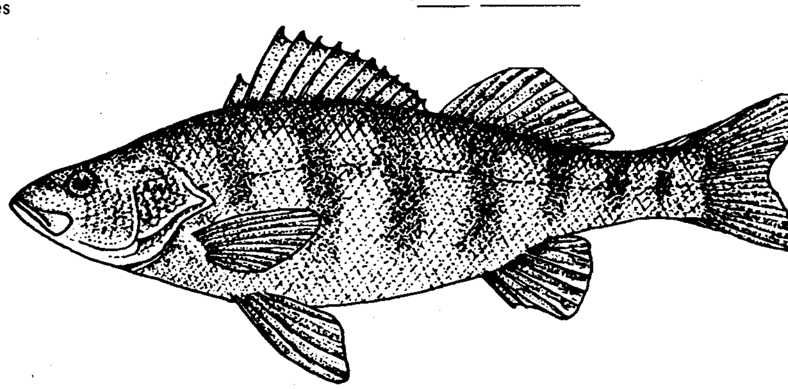
The white bass occurs in large rivers and connected lakes. White bass usually travel in large schools near the surface. Eggs are scattered randomly on shallow bars and gravelly reefs. White bass feed on insects and small fish.

WHITE SUCKER (Catostomus commersoni)



The white sucker occurs in almost every permanent body of fresh water, from small streams to large lakes. White suckers have an important role in cleaning lakes and streams. White suckers are a forage species and serve as a food source for many other species of fish.

YELLOW PERCH (Perca flavescens)



Yellow perch are schooling fish common to lakes and streams which do not experience winter kills. Eggs are deposited in a gelatinous, ribbonlike bank over submerged aquatic plants or branches. Perch are predaceous and feed on minnows, aquatic insects, crayfish, leeches, and snails. In addition, perch may compete with other game fish for food and space if populations get too large.

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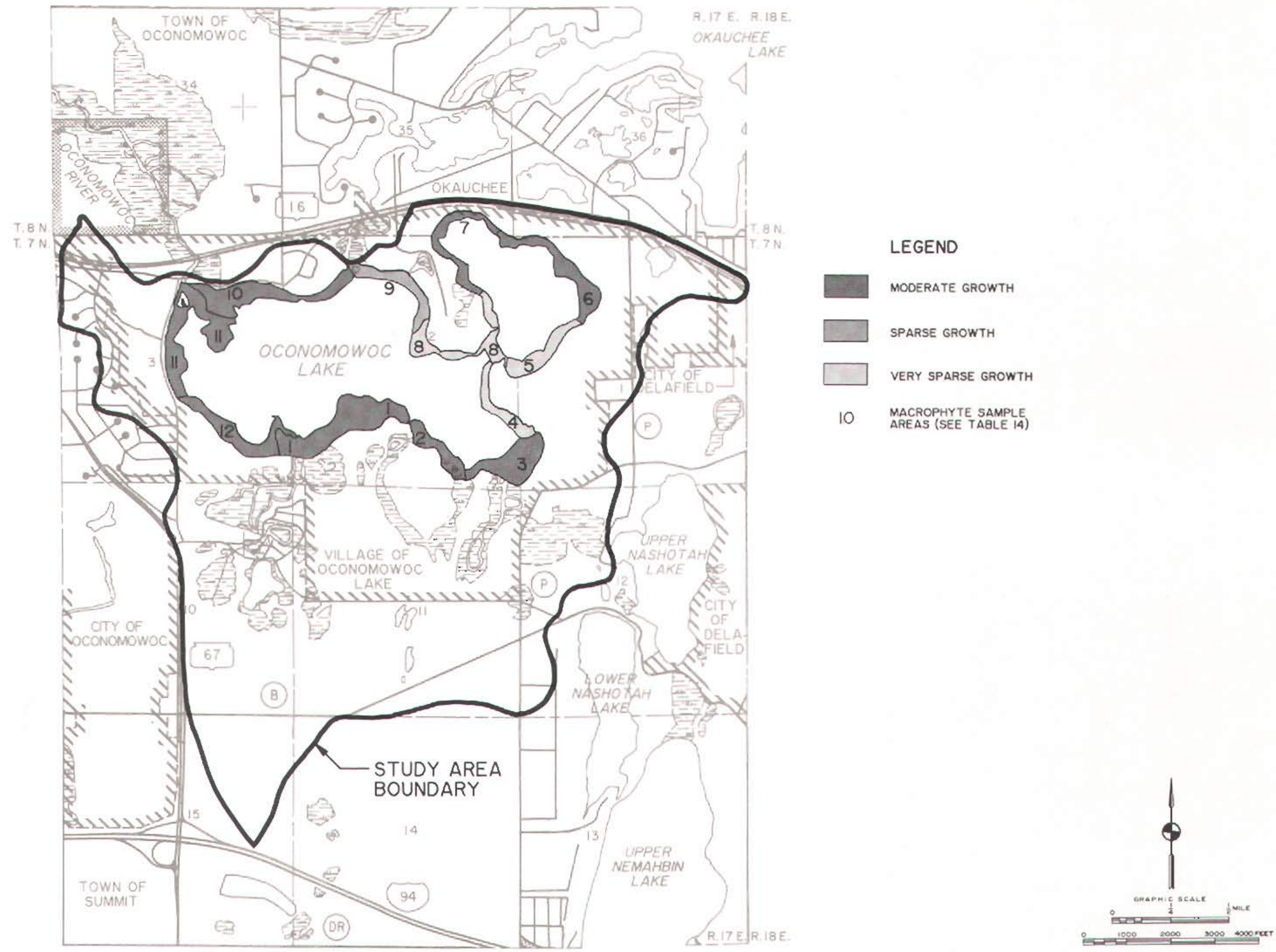
Appendix B

RELATIVE ABUNDANCE OF AQUATIC MACROPHYTES IN OCONOMOWOC LAKE: AUGUST 12, 1976



Source: SEWRPC.

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Appendix C

SUMMARY OF EXISTING ZONING DISTRICTS AVAILABLE FOR USE IN THE DIRECT DRAINAGE AREA TO OCONOMOWOC LAKE

Zoning District		Principal Permitted Uses	Conditional/Special Uses	Lot Size	
				Minimum Area	Minimum Width
CITY OF DELAFIELD ZONING ORDINANCE					
C-1	Conservancy	Harvesting of wild crops, sustained yield forestry, hydroelectric power stations, utility conduits and lines, nonresidential buildings in conjunction with raising of animals, public parks and building uses	Developments that are compatible and harmonious with the natural features of the conservancy district area	None	None
A-1	Agricultural	One-family dwellings in conjunction with farm operation, accessory uses and buildings, nurseries, greenhouses, hatcheries, roadside stands	Legal nonconforming uses, commercial kennels, cemeteries, noncommercial clubs and outdoor recreation areas, riding academies, public and semipublic governmental buildings, solar energy collection devices, quarrying and mineral extraction	3 acres	200 feet
A-1E	Exclusive Agricultural	One-family dwellings in conjunction with farm operation, ordinary farm uses, accessory uses and buildings, nurseries, greenhouses, horticulture, roadside stands	Same as A-1 District	3 acres	200 feet
RE-3	Three-Acre Rural Estate	Single-family dwellings, essential services, keeping of horses for noncommercial purposes	Legal nonconforming uses; commercial kennels; cemeteries; noncommercial clubs and outdoor recreation areas; riding academies; public, semi-public, and governmental buildings; temporary model home and sales office; solar energy collection devices; planned developments; quarrying and mineral collection	3 acres	200 feet
RE-2	Two-Acre Rural Estate	Single-family dwellings, essential services	Same as RE-3 District	2 acres	200 feet
RE-1	One-Acre Rural Estate	Single-family dwellings, essential services	Same as RE-3 District	1 acre	140 feet
RL-1	Residential Lake	Single-family dwellings, essential services	Same as RE-3 District	40,000 square feet	100 feet
RL-1A	Residential Lake	Single-family dwellings, essential services	Same as RE-3 District	20,000 square feet	80 feet
R-1	Single-Family Residence	Single-family dwellings, essential services	Same as RE-3 District	30,000 square feet	120 feet

Appendix C (continued)

Zoning District		Principal Permitted Uses	Conditional/Special Uses	Lot Size	
				Minimum Area	Minimum Width
CITY OF DELAFIELD ZONING ORDINANCE (continued)					
R-2	Single- and Two-Family Residence	Single- and two-family dwellings, essential services	Same as RE-3 District	30,000 square feet	120 feet
R-3	Single- and Two-Family Residence	Single- and two-family dwellings, essential services	Same as RE-3 District	20,000 square feet	100 feet
R-4	Single- and Two-Family Residence	Single- and two-family dwellings, essential services	Same as RE-3 District	7,900 square feet	66 feet
R-5	Planned Development	Single- and two-family residences	See St. John's-on-the-Lake Subdivision Documents	None	None
R-6	Multiple-Family Residence	Attached multiple-family dwellings, essential services	Same as RE-3 District	2,500 square feet for efficiency units; 3,000 square feet for one-bedroom units; 4,000 square feet for two-bedroom units	100 feet
R-7-EH	Multiple-Family Elderly Housing	Attached multiple-family dwellings, essential services	Same as RE-3 District	Same as R-6 District	100 feet
CED-1	Central Business	Convenience and general retail commercial use (see Ordinance)	One- and two-family residential dwellings; multiple-family dwellings; public and semi-public buildings; automobile service stations; boat sales, service, and repairs; quarrying and mineral extraction	4,500 square feet	45 feet
B-1	Local Business Residence	Generally recognized retail business personal service establishments, dry cleaning, business service establishments, professional services, sales and service establishments, post offices, residential dwelling units in a commercial building, single-family residences, essential services	Legal nonconforming uses; cemeteries; noncommerical clubs and outdoor recreation facilities; riding academies; public, semi-public, and governmental buildings; boat sales, service, and repairs; quarrying and mineral extraction	5,000 square feet	100 feet

Appendix C (continued)

Zoning District		Principal Permitted Uses	Conditional/Special Uses	Lot Size	
				Minimum Area	Minimum Width
CITY OF DELAFIELD ZONING ORDINANCE (continued)					
B-1A	Business and Limited Residence	Uses similar to those in the B-1 District (see Ordinance)	Same as B-1 District	10,000 square feet	100 feet
B-2	Local Business	Same as B-1 District	Same as B-1 District, drive-in restaurants	15,000 square feet	120 feet
B-3	Local and Highway Business	Same as B-2 District, amusement establishments, animal hospitals, auction rooms, blueprinting, garden supplies, medical laboratories, motels and hotels, offices, printing establishments, research laboratories, private schools, taxidermists, and similar uses	Same as B-2 District, dumps, landfills, incinerators, and pool halls and dance halls	20,000 square feet	120 feet
B-4	General Business	Same as B-3 District, warehousing, wholesaling and distribution operations, and permitted uses in the M-1 District	Same as B-3 District, sales and service of mopeds	20,000 square feet	120 feet
B-5	Office and Research Commercial	Professional offices, business offices, and office research uses	Same as B-1 District	40,000 square feet	120 feet
M-1	Limited Industrial	Wholesale and warehouse activities and light industrial uses	Same as B-4 District	1 acre	150 feet
CITY OF OCONOMOWOC ZONING ORDINANCE					
C-1	Conservancy	Management of forestry, wildlife, and fish; harvesting of any wild crops; hunting, fishing, and trapping; dams, power stations, and transmission lines; gravel or sand pits and quarries, including washing and grading of products	Water pumping or storage facilities, amusement parks, golf courses, and driving ranges	None	None
A-1	Agricultural	Single-family dwellings, general agricultural uses	Housing for farm laborers, seasonal or migratory farm workers; land restoration; parks and playgrounds	35 acres	None

Zoning District		Principal Permitted Uses	Conditional/Special Uses	Lot Size	
				Minimum Area	Minimum Width
CITY OF OCONOMOWOC ZONING ORDINANCE (continued)					
A-2	Agricultural	Single-family dwellings, general agricultural uses, nurseries, greenhouses, and hatcheries	All uses permitted in the A-1 District; grazing and paddocks; schools and churches; governmental and cultural uses such as fire and police stations, community centers, libraries, public emergency shelters, and museums	5 acres	None
R-1	Residential	Single-family dwellings, municipal buildings except garbage incinerators, public warehouses, public garages, public shops and storage yards, and penal or correctional institutions and asylums	All uses permitted in the A-2 District, churches, public and and parochial schools, colleges, universities including dormitories, public libraries, museums and art galleries, utility stations, hospitals, and professional offices	8,000 square feet	66 feet
R-1A	Residential	Single-family detached dwellings	All uses permitted in the A-2 and R-1 Districts	9,600 square feet	80 feet
R-1B	Residential	Single-family detached dwellings	All uses permitted in the A-2 and R-1 Districts	12,000 square feet	100 feet
R-1C	Residential	Single-family detached dwellings	All uses permitted in the A-2 and R-1 Districts	15,000 square feet	100 feet
R-2	Residential	Single- and two-family dwellings, hospitals	All uses permitted in the A-2 and R-1 Districts, dwelling groups, philanthropic and eleemosynary institutions	8,000 square feet	66 feet
R-3	Residential	Multiple-family dwellings	All uses permitted in the A-2 District, motels and motor hotels, private clubs, community development projects, health care clinics	8,000 square feet	100 feet
B-1	Business	Retail business, personal service establishments, professional services, sales and service establishments	Drive-in establishments and theaters, automotive services, farm implement buildings and related trades, animal hospitals, commercial recreation, automotive service stations, eating and drinking establishments	8,000 square feet	66 feet
B-2	Business	All uses permitted in the B-1 and R-3 Districts, building and related trades, banks, eating and drinking establishments, entertainment, trade or business schools, commercial art studios, publishing, hotels, funeral homes, automotive services, animal clinics	All uses permitted in the B-1 District, video amusement establishments	13,000 square feet	100 feet

Zoning District		Principal Permitted Uses	Conditional/Special Uses	Lot Size	
				Minimum Area	Minimum Width
CITY OF OCONOMOWOC ZONING ORDINANCE (continued)					
M	Manufacturing	All principal uses permitted in the B-2 District and all uses conditionally permitted in the B-1 District	Wholesale and warehouse activities and industrial operations	None	None
VILLAGE OF OCONOMOWOC LAKE ZONING ORDINANCE					
R-1	Residential	Single-family dwellings	Raising of horses, poultry, most domestic livestock; municipal and public utility buildings, churches, schools, public clubs, planned unit development	3 acres	250 feet
R-2	Residential	Single-family dwellings	All uses permitted in the R-1 District, planned unit development	2 acres	200 feet
R-3	Residential	Single-family dwellings	All uses permitted in the R-1 District, planned unit development	1 acre	150 feet
B-1	Business	Business	Highway-oriented uses including drive-in banks, vehicle sales and service, bowling alleys, retail establishments	1 acre	150 feet
I-1	Industrial	Industries	Industries of a restrictive character	1 acre	150 feet
F-1	Floodplain	Wildlife and nature preserves, game farms, fish hatcheries, fishing and hiking areas, roads, driveways, ponds, and fences	None	None	None
TOWN OF OCONOMOWOC ZONING ORDINANCE					
C-1	Conservancy	Open space uses	Outdoor recreation facilities, quarrying, refuse disposal sites, fish hatcheries	None	None
A-E	Exclusive Agricultural	Open space uses, agricultural uses	Outdoor recreation facilities, quarrying, refuse disposal sites, fish hatcheries	None	None
A-1	Agricultural	Single-family residence, agricultural uses	Airports, gift shops, kennels, churches, cemeteries, fish hatcheries, special agricultural uses, laboratories, mobile home parks, motels and hotels, outdoor theaters, planned unit development, outdoor recreation facilities, public buildings, quarrying, refuse disposal sites, restaurants, and taverns	3 acres	200 feet
A-1a	Agricultural	Single-family residence, agricultural uses	Airports, churches, cemeteries, fish hatcheries, special agricultural uses, laboratories, mobile home parks, motels and hotels, outdoor theaters, planned unit development, outdoor recreation facilities, public buildings, quarrying, refuse disposal sites	1 acre	150 feet

Zoning District		Principal Permitted Uses	Conditional/Special Uses	Lot Size	
				Minimum Area	Minimum Width
TOWN OF OCONOMOWOC ZONING ORDINANCE (continued)					
A-2	Rural Home	Single-family residence, agricultural uses	Gift shops, churches, cemeteries, fish hatcheries, laboratories, planned unit development, outdoor recreation facilities, public buildings, refuse disposal sites, restaurants, and taverns	3 acres	200 feet
A-3	Suburban Estate	Single-family residence, agricultural uses	Gift shops, churches, cemeteries, fish hatcheries, planned unit development, outdoor recreation facilities, public buildings, refuse disposal sites, restaurants, and taverns	2 acres	175 feet
R-1	Residential	Single-family residence	Gift shops, churches, cemeteries, fish hatcheries, motels and hotels, planned unit development, outdoor recreation facilities, public buildings, restaurants, and taverns	1 acre	150 feet
R-1a	Residential	Single-family residence	Gift shops, churches, cemeteries, fish hatcheries, motels and hotels, planned unit development, outdoor recreation facilities, public buildings, restaurants, and taverns	1 acre	150 feet
R-2	Residential	Single-family residence	Gift shops, churches, cemeteries, fish hatcheries, motels and hotels, planned unit development, outdoor recreation facilities, public buildings, restaurants, and taverns	30,000 square feet	120 feet
R-3	Residential	Single-family residence	Gift shops, churches, cemeteries, fish hatcheries, motels and hotels, multiple-family dwellings, planned unit development, outdoor recreation facilities, public buildings, restaurants, and taverns	20,000 square feet	120 feet
P-1	Public	Recreational, governmental, institutional uses	Churches, cemeteries, fish hatcheries, laboratories, motels and hotels, planned unit development, outdoor recreation facilities, public buildings, quarrying, refuse disposal sites	None	None
B-1	Restricted	Single-family, multiple-family, limited retail and service uses	Churches, cemeteries, fish hatcheries, mobile home parks, planned unit development, outdoor recreation facilities, public buildings, refuse disposal sites, restaurants, and taverns	20,000 square feet	120 feet

Zoning District		Principal Permitted Uses	Conditional/Special Uses	Lot Size	
				Minimum Area	Minimum Width
TOWN OF OCONOMOWOC ZONING ORDINANCE (continued)					
B-2	Local Business	Retail and service, single-family residence uses	Service stations, kennels, churches, cemeteries, fish hatcheries, drive-in foods, mobile home parks, motels and hotels, multiple-family dwellings, outdoor theaters, planned unit development, recreation facilities, public buildings, quarrying, refuse disposal sites	20,000 square feet	120 feet
B-3	General Business	Commercial uses	Service stations, kennels, churches, cemeteries, fish hatcheries, drive-in foods, mobile home parks, motels and hotels, multiple-family dwellings, outdoor theaters, planned unit development, outdoor recreation facilities, public buildings, quarrying, refuse disposal sites	20,000 square feet	120 feet
Q-1	Quarrying	Quarrying, open space, agricultural, single-family residence uses	Churches, cemeteries, fish hatcheries, mobile home parks, motels and hotels, planned unit development, outdoor recreation facilities, public buildings, quarrying, refuse disposal sites	3 acres	200 feet
M-1	Limited Industrial	Commercial, limited industrial (low impact on surrounding residential uses)	Service stations, kennels, cemeteries, fish hatcheries, drive-in foods, special agricultural uses, laboratories, mobile home parks, motels and hotels, outdoor theaters, planned unit development, outdoor recreation facilities, public buildings, quarrying, refuse disposal sites	1 acre	150 feet
M-2	General Industrial	Quarrying, industrial, commercial uses	Service stations, kennels, cemeteries, fish hatcheries, drive-in foods, special agricultural uses, laboratories, mobile home parks, motels and hotels, outdoor theaters, planned unit development, outdoor recreation facilities, public buildings, quarrying, refuse disposal sites	1 acre	150 feet
TOWN OF SUMMIT ZONING ORDINANCE					
RCE	Country Estate	Single-family dwellings, public parks and recreation areas, crop tree farming and horticulture, public utility facilities	Public and private schools, churches and religious institutions, public administrative offices and service buildings, private lodges and clubs, commercial development and historic restorations, country inns, country restaurants, nursing and rest homes for the aged, summer theaters, public utility offices, and commercial riding stables	3 acres	300 feet

Zoning District		Principal Permitted Uses	Conditional/Special Uses	Lot Size	
				Minimum Area	Minimum Width
TOWN OF SUMMIT ZONING ORDINANCE (continued)					
RRE	Rural Estate	Any use permitted in the RCE District	Any conditional use permitted in the RCE District	2 acres	200 feet
R-1	Country Home	Any use permitted in the RCE District	Any conditional use permitted in the RCE District	1 acre	200 feet
R-2	Country Home	Any use permitted in the RCE District	Any conditional use permitted in the RCE District	¾ acre	150 feet
R-3	Country Home	Any use permitted in the RCE District	Any conditional use permitted in the RCE District	½ acre	120 feet
C-1	Neighborhood Convenience	Any use permitted in the RCE District except residential use only in conjunction with an accessory to another permitted principal use; retail shops; business and professional offices and studies	Automobile service stations, drive-in establishments serving food or beverages	12,000 square feet sewered; 20,000 square feet unsewered	80 feet sewered; 120 feet unsewered
C-2	Local Service Center	Banks, savings and loan offices, commercial entertainment facilities, laundromats, post offices, restaurants, taverns, dental and medical clinics, commercial photography, advertising and art studios	Any conditional use permitted in the C-1 District, animal hospitals, appliance and small machinery repair establishments	9,000 square feet sewered; 20,000 square feet unsewered	60 feet sewered; 100 feet unsewered
C-3	General Commercial Center	General merchandising establishments, printing and publishing houses and related activities, hotels and transportation terminals	Lumber and building supply yards, experimental testing and research galleries, general warehousing, service and sales establishments	9,000 square feet sewered; 20,000 square feet unsewered	60 feet sewered; 100 feet unsewered
I	Industrial	Manufacture, assembly, processing, and fabrication plants, general warehousing	Quarrying, animal hospitals, kennels, junk or salvage yards	1 acre	150 feet
A	Agricultural	Any use permitted in the RCE District, outdoor recreation facilities	Any conditional use permitted in the RCE District; hog, goat, or fur farms; animal hospitals; kennels; dairy processing plants; quarrying	2 acres	250 feet
WF	Wetland and Floodplain	Grazing, harvesting of wild crops, hunting and fishing, tree farms, dams and hydroelectric power stations, recreation facilities	Public, private commercial and private noncommercial group outdoor recreation facilities	None	None

Source: SEWRPC.