# A water quality management plan for Lac La Belle, Waukesha County, Wisconsin.

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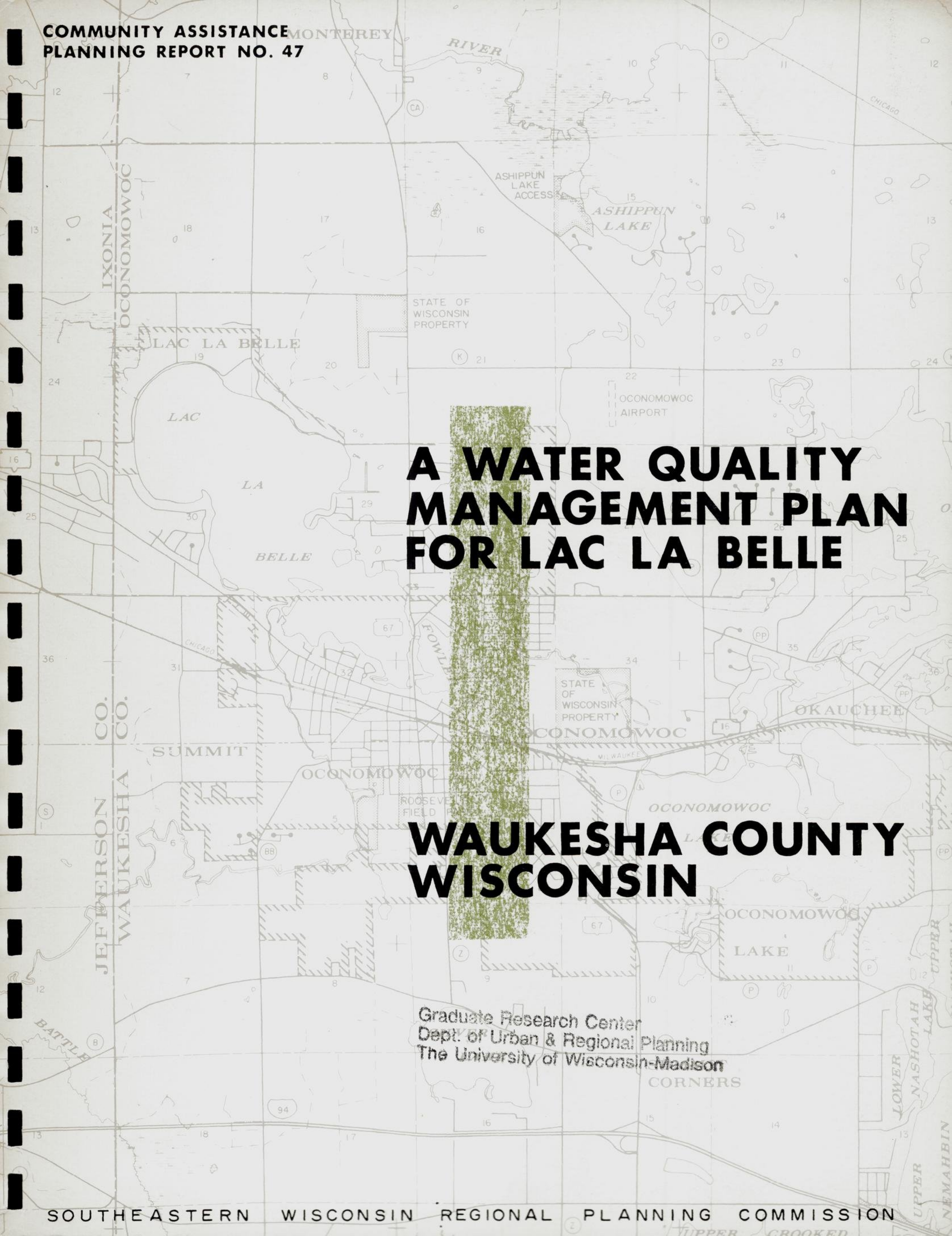
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 47




# A WATER QUALITY MANAGEMENT PLAN FOR LAC LA BELLE

# WAUKESHA COUNTY WISCONSIN



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NUMBER 47

# A WATER QUALITY MANAGEMENT PLAN FOR LAC LA BELLE
# WAUKESHA COUNTY, WISCONSIN

Prepared by the
Southeastern Wisconsin Regional Planning Commission
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In Cooperation with the
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December 21, 1980

TO: All Units and Agencies of Government and Citizen Groups
Involved in Water Quality Management for Lac La Belle

In 1976 the Southeastern Wisconsin Regional Planning Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources to study the water quality conditions of Lac La Belle, identify existing and potential problems related thereto, and propose measures which could be applied to resolve those problems and to protect and enhance the water quality of the lake. The findings and recommendations of that study are presented in this report.

The report describes the physical properties of Lac La Belle, the quality of its waters, and the conditions affecting that quality, including existing land use and the present utilization of the lake. All sources of pollution of 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.

During the preparation of this report, members of the Commission staff met with local elected officials and concerned citizens to discuss the preliminary findings and recommendations of the study and to receive the comments and suggestions of the local elected officials concerned, lakeshore property owners, and interested citizens. Five such meetings were held—on November 26, 1979, and on May 12, July 22, October 22, and December 2, 1980. The findings and recommendations of this report reflect the pertinent comments and suggestions made at those meetings.

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 Lac La Belle 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 is believed to provide a sound guide to the making of development decisions concerning the wise management of Lac La Belle 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 cooperative program between the Southeastern Wisconsin Regional Planning Commission, the Wisconsin Department of Natural Resources, local lake protection and rehabilitation districts and other lake organizations. Eight of the 13 lakes—Eagle Lake, Freiss 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 Bureau of Research, Wisconsin Department of Natural Resources; 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 respective lake protection and rehabilitation districts and the Wisconsin Department of Natural Resources, Office of Inland Lake Renewal. 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 these studies were to acquire definitive information concerning lake water quality and related land use and land management practices in each lake drainage area; to identify the factors affecting lake water quality, particularly the amount, kind, and temporal distribution of pollutants contributed by the various sources; and to develop recommendations for the abatement of pollution in order to maintain or improve water quality conditions.

On April 23, 1976, the Southeastern Wisconsin Regional Planning Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources to study Lac La Belle. The cooperative lake study for Lac La Belle included the design and conduct of a water quality sampling program and the inventory and analysis of tributary watershed characteristics, including land use and management practices, existing water use and water quality conditions, and sources of pollution. The detailed lake water quality sampling program was conducted from May 1976 through April 1977, although some inventory data collected as recently as 1980 are incorporated into this report. This report summarizes the results of the sampling program and inventories and provides interpretation of the data collected. From these analyses, feasible alternatives for the maintenance and enhancement of lake water quality are proposed and evaluated, and water quality management measures are recommended.

Lac La Belle is a 1,117-acre lake located entirely within U. S. Public Land Survey Township 8 North, Range 17 East, in Waukesha County. Lac La Belle is located downstream from a chain of seven other lakes formed by natural and man-modified surface water features of the Oconomowoc River system. The lake watershed is rapidly urbanizing. If properly managed, this urbanization can contribute to the maintenance of Lac La Belle as an important asset to the residents of the County and the Region of which the county is an integral part. This report discusses the physical, chemical, and biological characteristics of the lake and the pertinent characteristics of its tributary watershed, as well as the feasibility of various water quality management alternatives which may enhance water quality conditions in the lake. Specific management goals for Lac La Belle include achieving the recommended water quality standards in support of the objective of providing water quality suitable for 1) maintaining a healthy fishery, 2) reducing the severity of existing nuisance problems such as algae macrophyte growths which preclude intended uses, and 3) improving opportunities for water-based recreational activities.

The local units of government concerned were asked to review a preliminary draft of this report and comments based upon that review are incorporated in this final report. Accordingly, the lake water quality management plan presented herein should serve as a practical guide for the management of the water quality of Lac La Belle, and for the management of the land surfaces which drain into this important lake.

## Chapter II

## PHYSICAL DESCRIPTION

### LAKE BASIN AND SHORE CHARACTERISTICS

Lac La Belle lies in a glacial valley and is a flow-through lake, fed and drained by the Oconomowoc River. Lake levels are controlled by an outlet structure built in 1936. Basic hydrographic and morphometric data are presented in Table 1. About 38 percent of the lake area has a water depth of less than 5 feet, 28 percent of the lake area has a water depth between 5 and 10 feet, 12 percent has a water depth between 10 and 20 feet, and 22 percent has a depth of more than 20 feet. The mean depth is 9 feet and the maximum depth is 45 feet. Lac La Belle is 2.6 miles long (northwest-southeast) and 1.2 miles wide at its widest point. The lake contains two islands connected to the shore by roadways. The shore length is 11.2 miles, and the shoreline development factor is 2.01, indicating that the lake shoreline is irregular and about twice as long as that of a circular lake of the same area. The lake has a volume of approximately 12,924 acre-feet and a surface area of about 1,117 acres. The morphometry of the lake basin is illustrated on Map 1. Figure 1 presents an aerial photograph of the lake and surrounding shoreline. In addition, the Commission has color aerial photographs of the lake and surrounding shoreline on file and available for inspection.

Seventeen percent of the sampled lake bottom is estimated to be covered by sand; 17 percent by gravel and rubble; and 66 percent by silt. Sand is the dominant shore material, covering approximately 60 percent of the total littoral zone. The remainder of the littoral zone is covered by silt and muck deposits which are located primarily along the east and northeast shores.

### WATERSHED CHARACTERISTICS

Map 2 shows the drainage area directly tributary to Lac La Belle—that is the area which drains directly in to the lake rather than draining in to the Oconomowoc River and then to the lake. This drainage area is 6,607 acres, or 10.32 square miles, in areal extent. The total drainage area to the lake, including the area drained by the Oconomowoc River, is 55,349 acres, or 86.48 square miles. Lac La Belle has a low watershed-to-lake area ratio of 5.9:1 if only the direct tributary area is considered. A much higher watershed-to-lake area ratio of 49.6:1 exists when the total drainage area is included. The Oconomowoc River is the major inlet to the lake, and enters from the southeast. The Oconomowoc River exhibits continuous flow and has a resident fish population. Other inlets include: two on the north shore which are intermittent—Saeger Creek and La Belle Creek—and one on the east shore—Rosenow Creek—which is continuous and has a capacity for resident fish—including trout—populations. The lake outlet is also the Oconomowoc River, which joins the Rock River about 13 river miles downstream from the lake outlet at a point in Jefferson County.

**Table 1**

**HYDROGRAPHY AND MORPHOMETRY OF LAC LA BELLE: 1975**

| Parameter | Measurement |
|---|---|
| Size | |
| Area of Lake | 1,117 acres |
| Area of Total Watershed | 55,349 acres |
| Area of Direct Drainage Area | 6,607 acres |
| Volume | 12,924 acre-feet |
| Residence Time[a] | 4.7 months |
| Shape | |
| Maximum Length of Lake | 2.6 miles |
| Length of Shoreline | 11.2 miles |
| Maximum Width of Lake | 1.2 miles |
| Shoreline Development Factor[b] | 2.01 |
| Depth | |
| Area of Lake Less Than 5 Feet | 38 percent |
| Area of Lake 5-10 Feet | 28 percent |
| Area of Lake 10-20 Feet | 12 percent |
| Area of Lake More Than 20 Feet | 22 percent |
| Mean | 9 feet |
| Maximum | 45 feet |

[a] *The hydraulic "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.*

[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.*

# Map 1

## MORPHOMETRY OF LAC LA BELLE


### LEGEND

**TOPOGRAPHIC SYMBOLS**

- B — BRUSH
- PW — PARTIALLY WOODED
- W — WOODED
- C — CLEARED
- P — PASTURED
- A — AGRICULTURAL
- BM — BENCH MARK
- ▪ — DWELLING
- ⊡ — RESORT
- STEEP SLOPE
- INDEFINITE SHORELINE
- MARSH
- SPRING
- INTERMITTENT STREAM
- PERMANENT INLET
- PERMANENT OUTLET
- DAM

**LAKE BOTTOM SYMBOLS**

- P — PEAT
- Mk. — MUCK
- C — CLAY
- M — MARL
- Sd. — SAND
- St. — SILT
- Gr. — GRAVEL
- R — RUBBLE
- BR — BEDROCK
- T — SUBMERGENT VEGETATION
- ⊥ — EMERGENT VEGETATION
- FLOATING VEGETATION
- STUMPS & SNAGS

◇ ACCESS ONLY ◆ ACCESS WITH PARKING ◆ BOAT LIVERY

| SPECIES OF FISH | ABUNDANT | COMMON | RARE |
|---|---|---|---|
| MUSKIE | | | |
| N. PIKE | | ● | |
| WALLEYE | | | |
| L.M. BASS | | ● | |
| S.M. BASS | | | |
| PANFISH | ● | | |
| TROUT | | | |
| | | | |

WATER AREA: 1,117 ACRES
DEPTH < 5 FT.: 38%
DEPTH >20 FT.: 22%
VOLUME: 12,924 ACRE FT.
TOTAL ALK.: 177 PPM
SHORELINE: 9.52 MI. - 11.22 W/ISLAND
MAX. DEPTH: 45 FT.

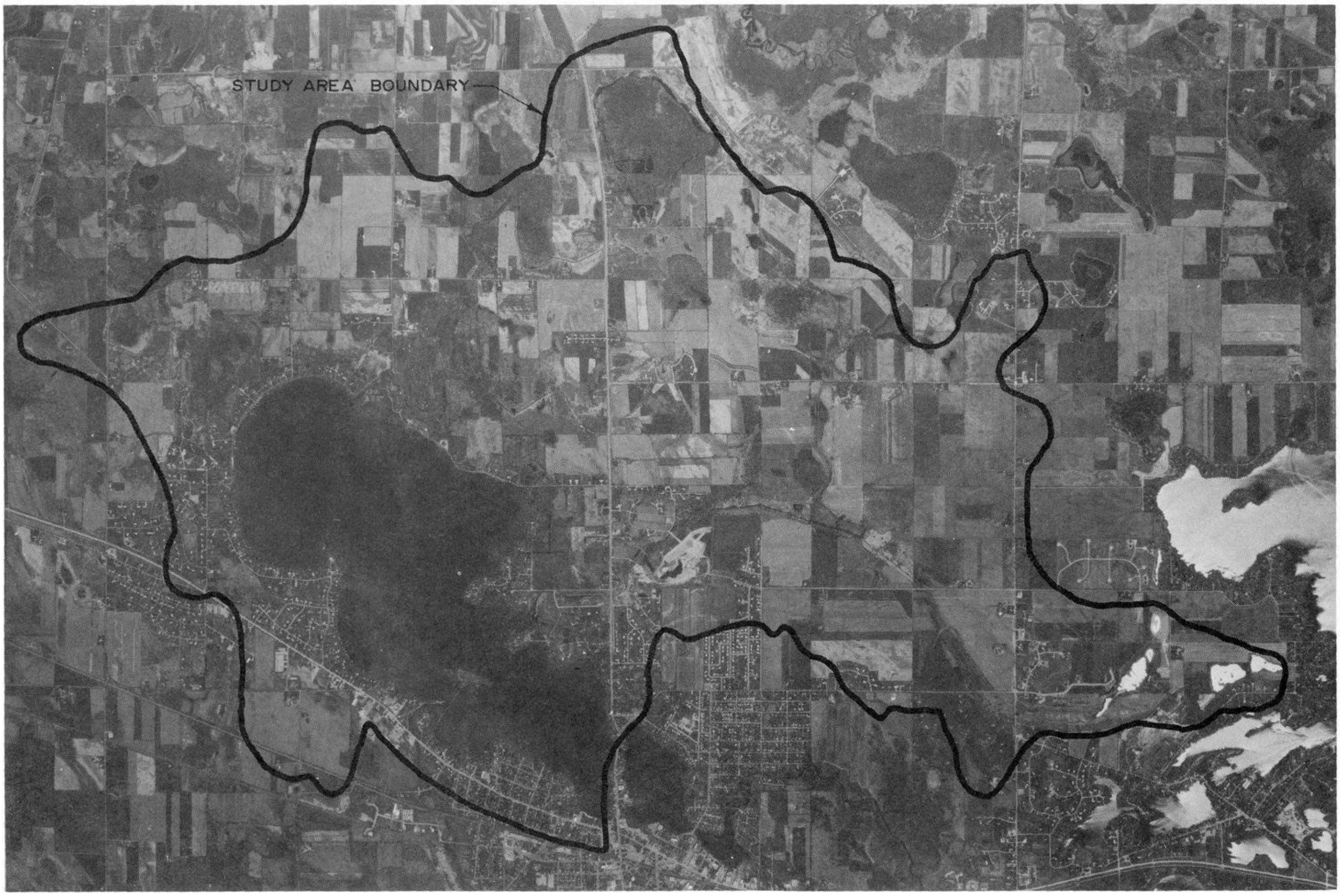
MAPPED: AUG. 1970

EQUIPMENT: SONAR

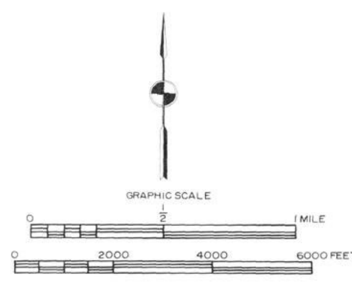
*Source: Wisconsin Department of Natural Resources.*

Figure 1

AERIAL PHOTOGRAPH OF LAC LA BELLE AND SURROUNDING SHORELINE




*Source: SEWRPC.*

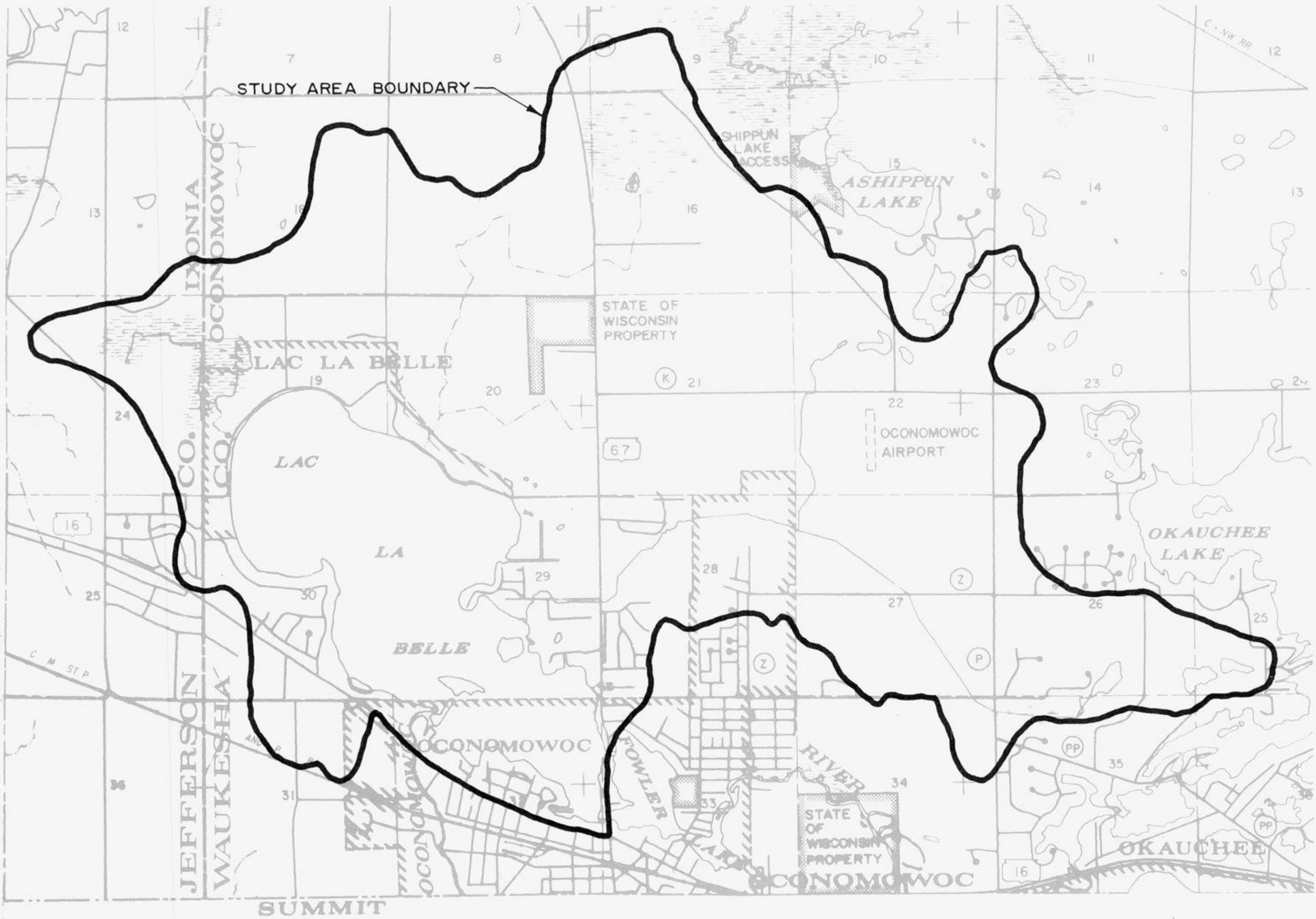


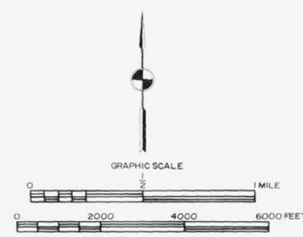

CLIMATE AND HYDROLOGY

Long-term average monthly air temperature and precipitation values for the Lac La Belle area are set forth in Table 2. These averages were taken from official National Oceanic and Atmospheric Administration (NOAA) records of temperature and precipitation for Oconomowoc, Wisconsin. Table 2 also sets forth storm water runoff values derived from U. S. Geological Survey (USGS) flow records for the Rock River at Afton. The mean annual temperature of 46.6°F at Oconomowoc is quite similar to that of other recording locations in southeastern Wisconsin. Mean annual precipitation at Oconomowoc is 29.60 inches. More than half the normal yearly precipitation falls during the growing season, from May to September. Runoff rates are generally low during this period,

Map 2

DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE




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

since evapotranspiration rates are high, vegetation 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 high runoff. Approximately 30 percent of the annual precipitation occurs during the winter or early spring when the ground is frozen, resulting in peak runoff during that period from snowmelt and/or rain. Impervious areas, such as street surfaces, parking lots, and rooftops, increase the amount of surface runoff and decrease soil infiltration.

As Table 2 shows, the 12-month period when the Lac La Belle study was carried out—May 1976 to April 1977—was a period of variable temperatures and extreme drought in southeastern Wisconsin. Temperatures were above normal during the spring

**Table 2**

**LONG TERM AND 1976-1977 STUDY YEAR CLIMATOLOGICAL DATA FOR THE LAC LA BELLE AREA**

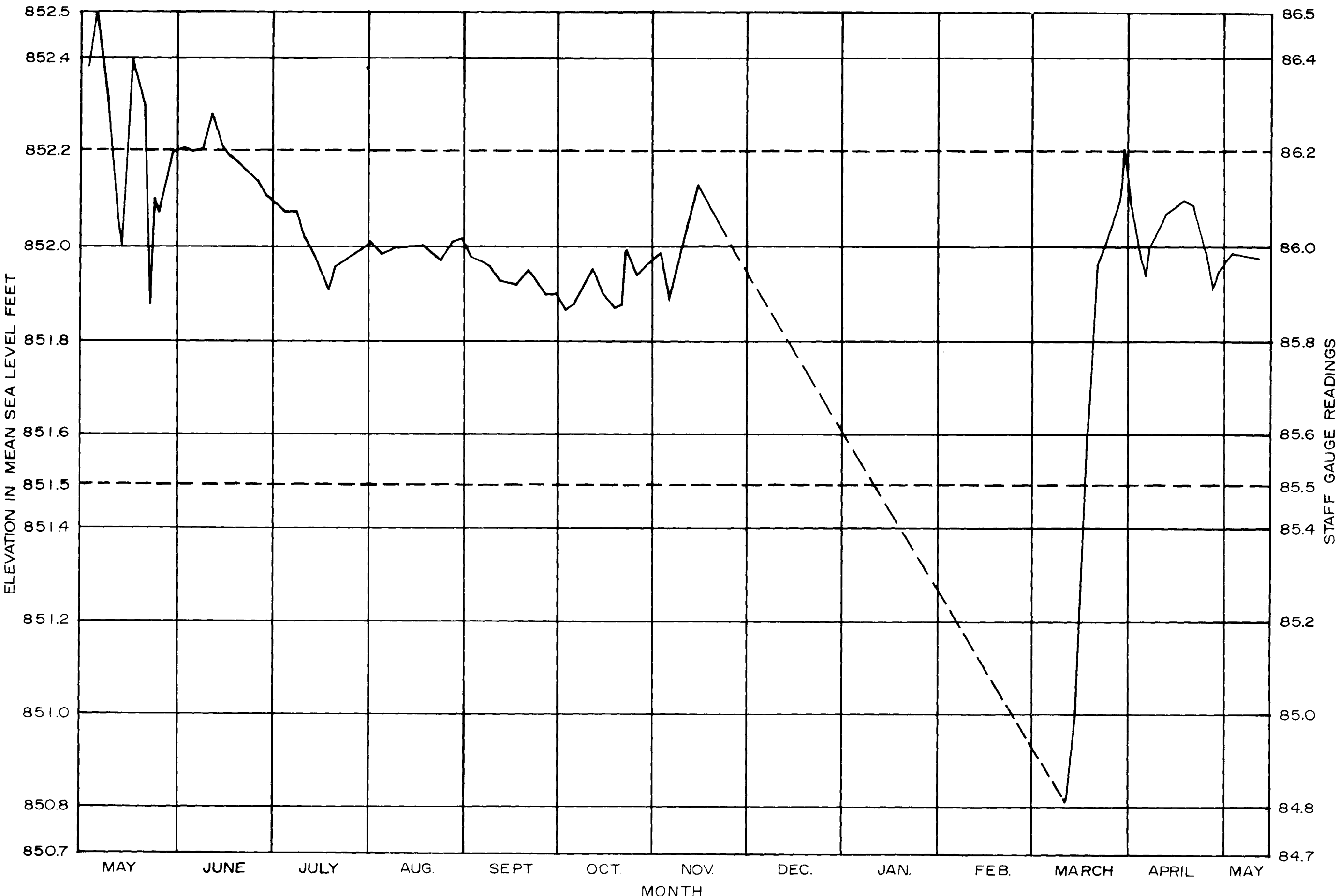
| Climatological Data | Long-Term Average Monthly Values | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | May | June | July | August | September | October | November | December | January | February | March | April | Annual |
| Mean monthly air temperature—°F (Oconomowoc) (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.*

Figure 2

LAKE LEVEL FLUCTUATIONS IN LAC LA BELLE: 1976-1977




*Source: Wisconsin Department of Natural Resources.*

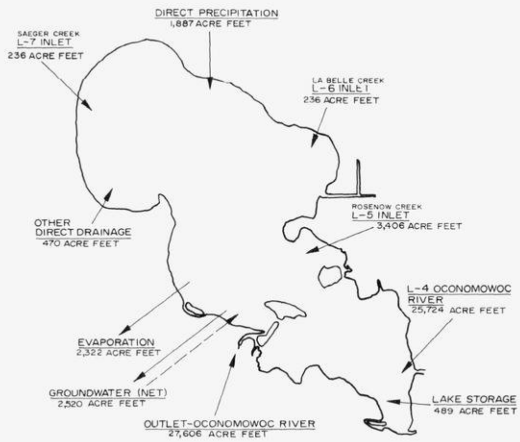
and early summer, but fell far below normal during fall and winter. Precipitation was about 10.15 inches below normal. The drought was reflected in reduced runoff and streamflow in the Lac La Belle drainage area. Flows in streams in southeastern Wisconsin where long-term USGS gaging records are available totaled only 40 to 60 percent of normal for the May 1976 through April 1977 period. At Afton, the flow of the Rock River for the study year was 56 percent of normal.

The drought had little apparent effect on the water level of Lac La Belle, as the control structure on the lake outlet permitted dam operators to maintain a fairly stable lake level during the study period. As set forth in Figure 2, the lake level dropped from a high elevation of 852.5 feet above National Geodetic Vertical Datum (NGVD) in early May 1976, to a low elevation of 850.8 feet in mid-March 1977, and then rose to an elevation of 852.2 feet during the spring runoff.

A water budget for Lac La Belle was computed from inflow, outflow, and lake level data as set forth in Figure 3. During the year of the study, 31,959 acre-feet of water entered the lake by Oconomowoc River inflow, surface runoff, and direct precipitation on the lake's surface. A loss of 29,928 acre-feet from the lake outlet and from evaporation was calculated, which if no groundwater flows were considered, should have resulted in a net water gain of 2,031 acre-feet, or in an increase in lake level of 1.75 feet. Instead, a drop in lake level of 0.42 foot—representing a volume of 489 acre-feet—was actually measured. This loss of 489 acre-feet, coupled with the calculated loss of 2,031 acre-feet as the difference between water inputs and outputs, indicates a net loss to groundwater during the study period of 2,520 acre-feet. It is important to note that although a net loss occurred over the entire study period, there was a net gain to the lake from groundwater during May and June 1976, and during the winter months. The

## Figure 3

### HYDROLOGIC BUDGET FOR LAC LA BELLE: 1976-1977




*Source: Wisconsin Department of Natural Resources.*

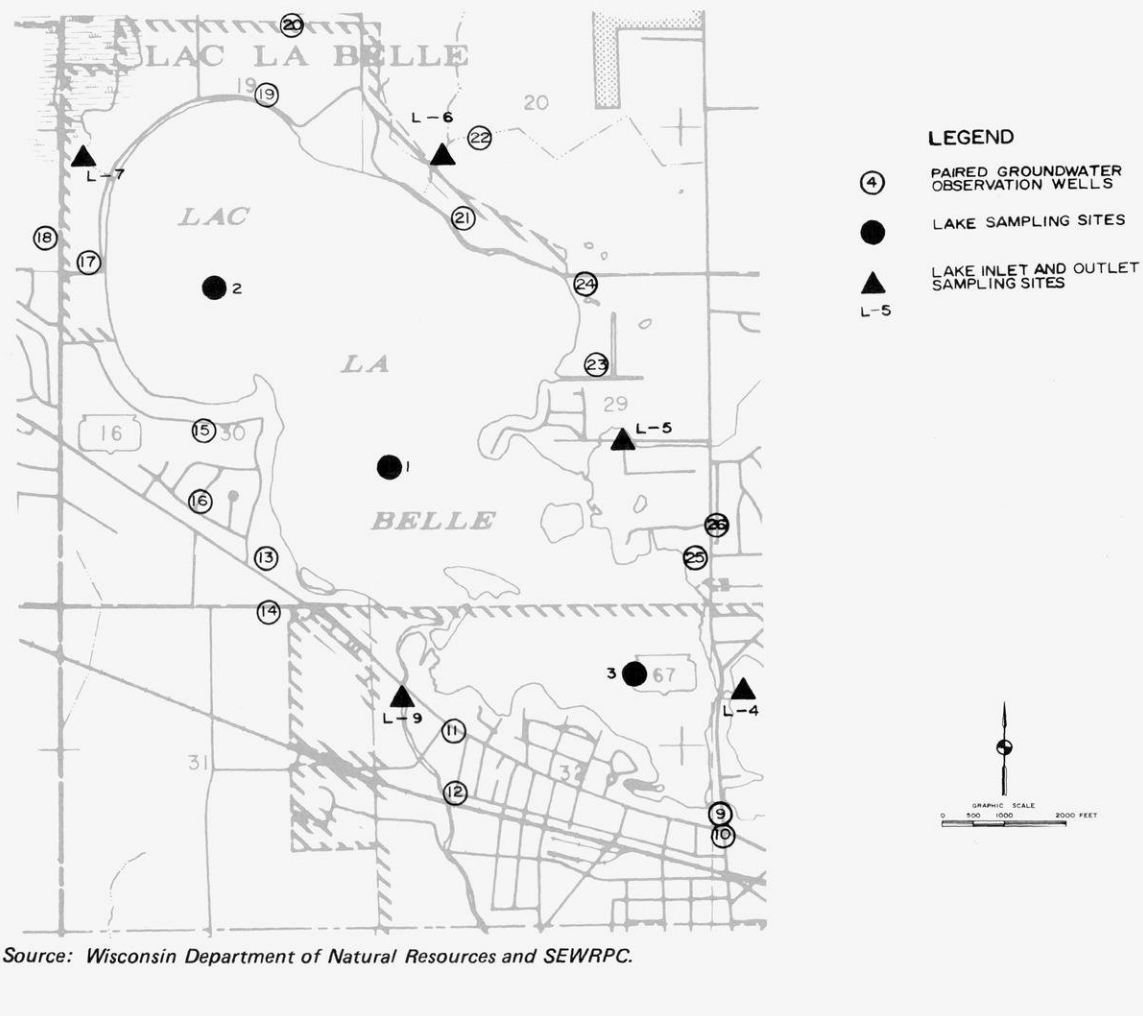
greatest losses occurred from July through October 1976, during the peak of the drought period.

Groundwater levels and direction of movement were measured at nine paired observation wells around the lake, as shown on Map 3. Consistent groundwater flows toward the lake from the west and southwest were generally indicated, while the remaining pairs indicated fluctuating flows with no consistency in direction.

The Oconomowoc River contributed 80 percent of the known inflow to the lake during the study period, with 45 percent of that occurring during the months of March, April, and May. Rosenow Creek contributed approximately 11 percent of the total inflow to Lac La Belle during the study period. Direct precipitation on the lake's surface

## Map 3

### LOCATION OF GROUNDWATER OBSERVATION WELLS, LAKE SAMPLING SITES, AND LAKE INLET AND OUTLET SAMPLING SITES—LAC LA BELLE: 1976-1977




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

accounted for 6 percent of the total inflow, while direct drainage from elsewhere in the direct tributary area comprised the remaining 3 percent of the inflow to the lake.

The hydraulic residence time is important in determining the expected response time of the lake to increased or reduced nutrient loadings. The hydraulic residence time for Lac La Belle during the study period was approximately five and a half months, but this was an exceptionally dry period. The hydraulic residence time would be shorter—about four and a half months—during a year of normal precipitation.

## SOIL TYPE AND CONDITIONS

Soil composition, slope, and land management determine the effect of soils on stream and lake water quality. Soil composition and slope are important factors affecting the rate and amount of storm water runoff. The shape and stability of aggregates of soil particles—expressed as soil structure—influence the permeability, infiltration rate, and erodibility of soils. Slope is important in determining storm water runoff rates and hence susceptibility to erosion. Major specific soil types were inventoried in the lake watershed and analyzed by hydrologic characteristics. Soil erodibility and soil suitability were assessed for the feasibility of onsite septic tank sewage disposal systems and for the feasibility of land applications of wastewater sludge. These assessments were then used to identify areas of incompatible land use and management.

Soils within the Lac La Belle watershed can be categorized into the four main hydrologic groups and made land as indicated in Table 3. The relative proportion of the hydrologic soil groups found in the Lac La Belle watershed may be categorized as follows: well drained (Group A), 1 percent; moderately drained, (Group B) 73 percent; poorly drained (Group C), 7 percent; very poorly drained (Group D), 18 percent; and made land, 2 percent. The extent of these soils and their location within the watershed are shown on Map 4. The major specific soil types present within the Lac La Belle watershed are: Casco series, Hockheim series, Boyer sandy loam, Fox silt loam, Matherton silt loam, Oakley silt loam, Sleeth silt loam, Thackery silt loam, Theresa silt loam, Houghton muck, and Palms muck.

The suitability of soils for septic tank systems in the direct tributary area on lots of one acre or less in area is indicated on Map 5 according to three major groupings: suitable—68 percent, severely limited—5 percent, or very severely limited—27 percent. In the Lac La Belle drainage area, as of 1975, 80 of the 722 septic systems, or 11 percent, were located on soils having severe or very severe limitations for the use of such systems.

Land uses within the direct tributary watershed are generally compatible with the soil types, except for the sewage disposal uses noted above. Residential development in the Town of Oconomowoc is generally compatible with the soils, as is most of the residential development around the lake. An exception is the development located on a large area of muck soils north and east of Beggs Island. North of the lake lies a large area of soils used for muck farming, a compatible use. Areas covered by such soils are also located north-west of Lac La

**Table 3**

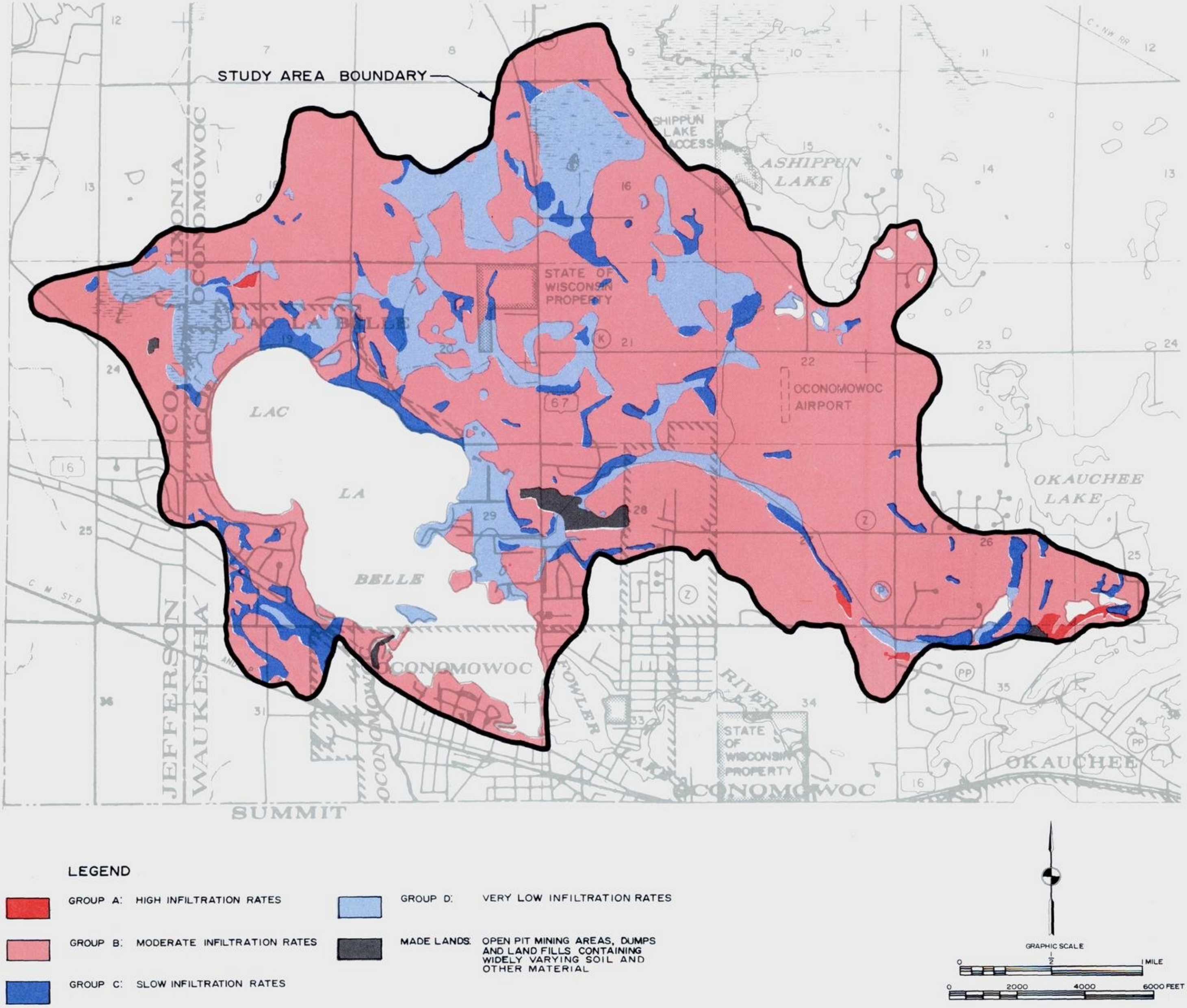
**GENERAL HYDROLOGIC SOIL TYPES WITHIN THE LAC LA BELLE DIRECT TRIBUTARY AREA**

| Group | Soil Characteristics | Extent (acres) | Percent of Total |
|---|---|---|---|
| A | High infiltration rates<br>Well drained and excessively drained sandy or gravelly soils<br>High rate of water transmission and low runoff potential | 37.0 | 0.56 |
| B | Moderate infiltration rates<br>Moderately well drained<br>Moderately coarse textures<br>Moderate rate of water transmission | 4,819.2 | 72.94 |
| C | Slow infiltration rates<br>Moderately fine or fine-textured layers that impede downward movement of water<br>Slow rate of water transmission | 461.8 | 6.99 |
| D | Very low infiltration rates<br>Clay soils with high shrink-swell potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; shallow soils over nearly impervious substrate<br>Very slow rate of water transmission | 1,172.1 | 17.74 |
| Made Land: | Open pit mining areas, man-made fill areas, dumps and landfills containing widely varying soils and other materials | 116.9 | 1.77 |
| Total | | 6,607.0 | 100.00 |

*Source: SEWRPC.*

## Map 4

### EXTENT AND LOCATION OF HYDROLOGIC SOIL GROUPS WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE



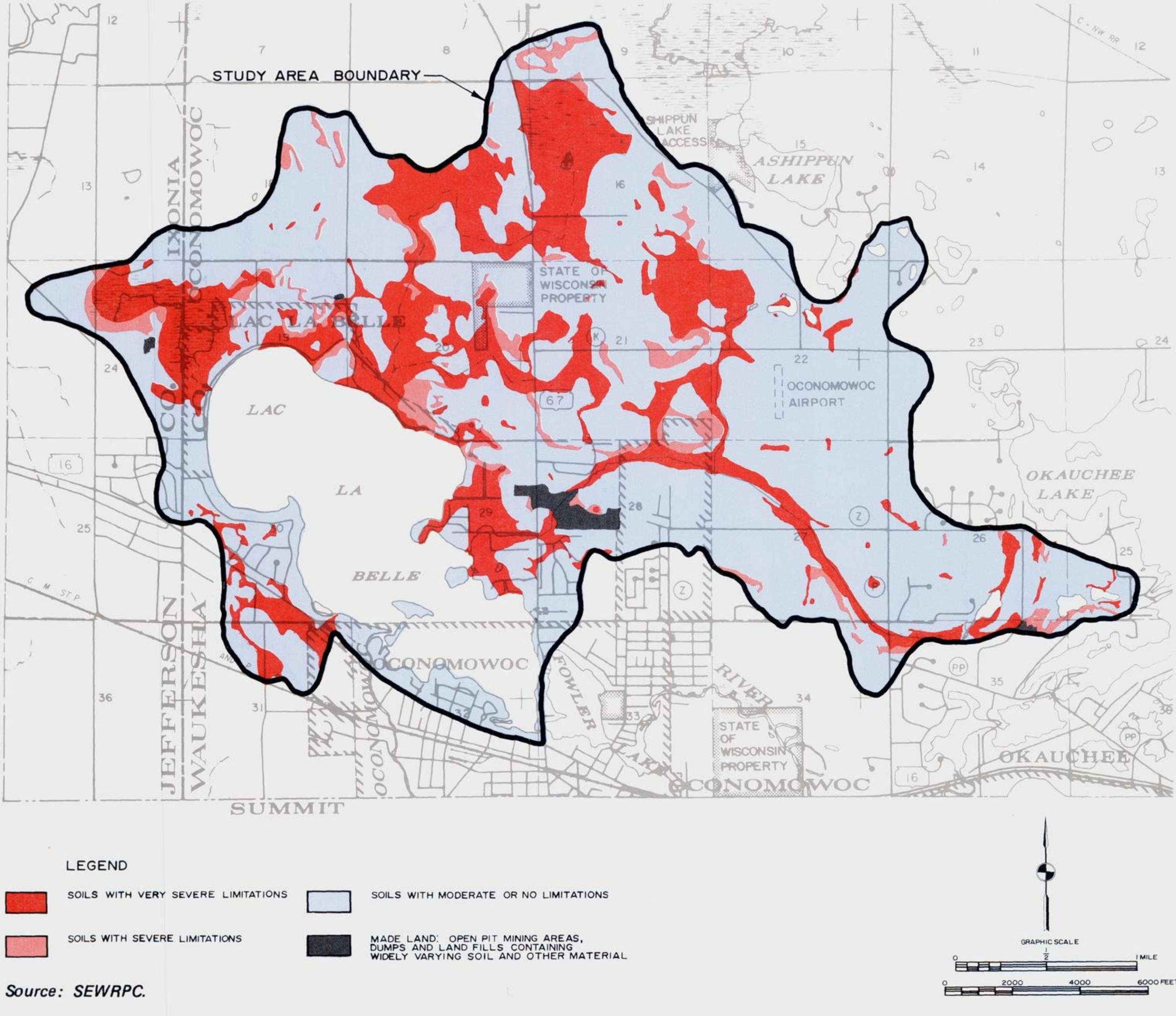

*Source: SEWRPC.*

Belle and east of Fowler Lake, and are not suitable for future residential development.

Another important consideration is the suitability of the soils for land application of sludge from wastewater treatment. The Commission inventory of sewage sludge management practices indicates that, in 1976, sludge was not being applied in the drainage area directly tributary to the lake. About 55 percent of the area of the watershed is covered by soils rated as having only slight limitations for wastewater sludge application, as shown on Map 6. The remaining areas are covered by soils which have limitations for sludge application, and any attempts at such application in these areas could be detrimental to stream, lake, and groundwater quality.

Map 5

## SUITABILITY OF SOILS FOR CONVENTIONAL PRIVATELY OWNED ONSITE SEWAGE DISPOSAL SYSTEMS ON LOTS ONE ACRE OR LESS IN SIZE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE



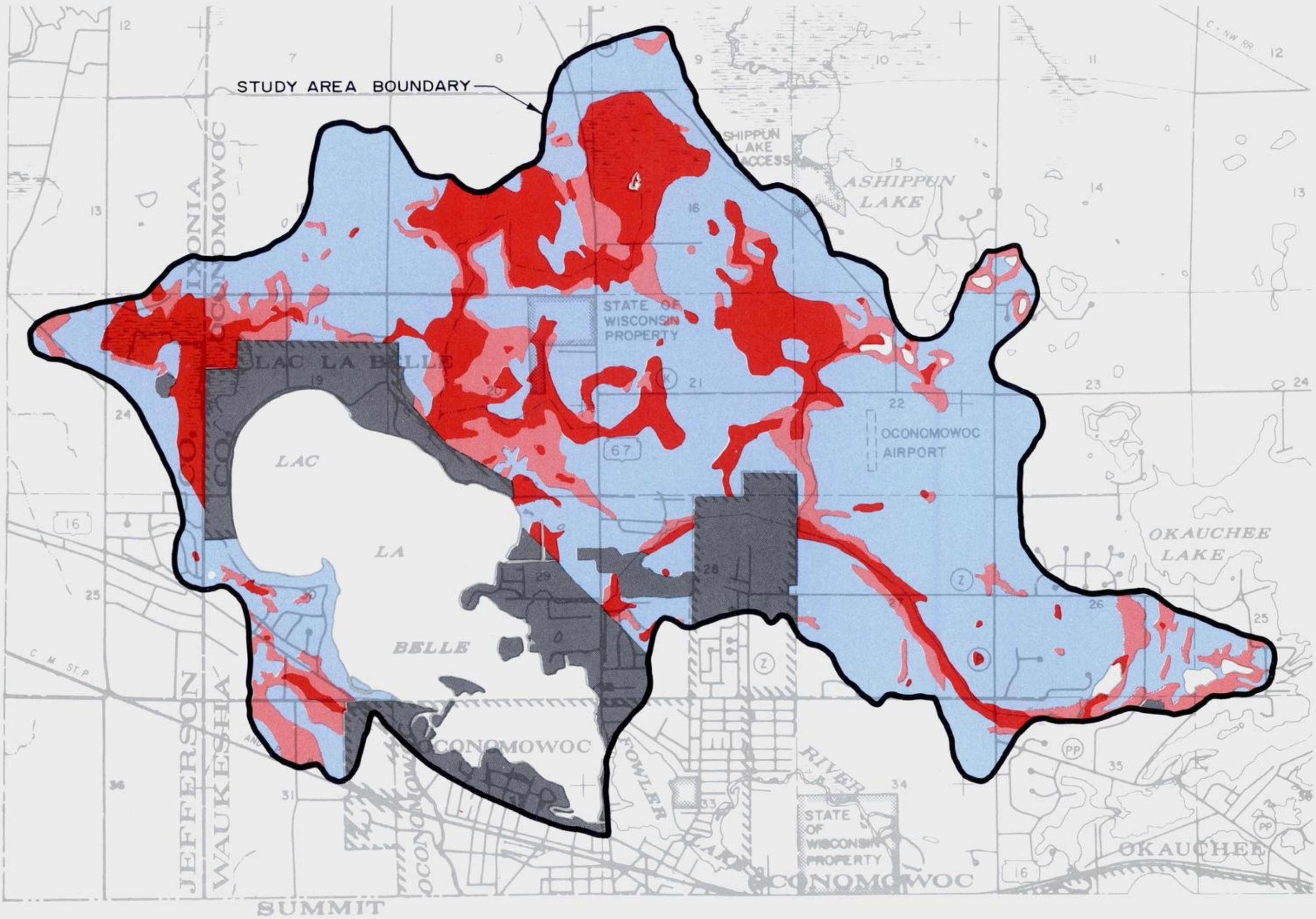

LEGEND

- SOILS WITH VERY SEVERE LIMITATIONS
- SOILS WITH SEVERE LIMITATIONS
- SOILS WITH MODERATE OR NO LIMITATIONS
- MADE LAND: OPEN PIT MINING AREAS, DUMPS AND LAND FILLS CONTAINING WIDELY VARYING SOIL AND OTHER MATERIAL

*Source: SEWRPC.*

## Map 6

## SUITABILITY OF SOILS FOR WASTEWATER SLUDGE APPLICATION WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE

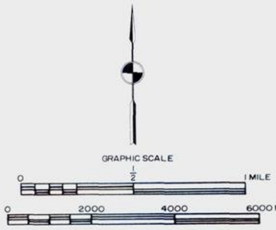



LEGEND

- SOILS WITH SEVERE LIMITATIONS
- SOILS WITH MODERATE LIMITATIONS
- SOILS WITH SLIGHT LIMITATIONS
- URBAN AND MADE LANDS

*Source: SEWRPC.*

NOTE: THE SUITABILITY OF AN AREA FOR SLUDGE APPLICATION AS INDICATED ON THIS MAP IS BASED UPON SOIL RATINGS WHICH CONSIDER SOIL CHEMISTRY, SOIL PERMEABILITY, DEPTH TO BEDROCK, AND DEPTH TO GROUNDWATER. SITE SPECIFIC INVESTIGATIONS SHOULD ALSO BE BASED UPON A SEPARATE CONSIDERATION OF SLOPE LIMITATION. AREAS WITHIN 0 TO 6 PERCENT SLOPES ARE CONSIDERED TO HAVE SLIGHT LIMITATIONS, WITHIN 7 TO 12 PERCENT SLOPES TO HAVE MODERATE LIMITATIONS, AND WITHIN SLOPES GREATER THAN 12 PERCENT TO HAVE SEVERE LIMITATIONS FOR APPLICATION OF WASTEWATER SLUDGE.



# Chapter III

# HISTORICAL, EXISTING, AND FORECAST LAND USE AND POPULATION LEVELS

## INTRODUCTION

Water pollution problems and ultimate solutions to those problems are the result of the interaction between the human activities within the drainage area of a water body and 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 more susceptible than streams to water quality degradation and because pollutants discharged to a lake are more likely to interfere with desired water uses.

Superimposed on the irregular direct tributary drainage area boundary to Lac La Belle is a generally rectilinear pattern of local municipal boundaries, as shown on Map 7. The drainage area directly tributary to the lake includes portions of the City of Oconomowoc and the Town of Oconomowoc, both in Waukesha County, and the Town of Ixonia, located in Jefferson County. The only civil division entirely within the drainage area directly tributary to the lake is the Village of Lac La Belle in Waukesha County. The area and proportion of the direct drainage area lying within the jurisdiction of each civil division, as of 1975, are set forth in Table 4. Geographic boundaries of the civil divisions are an important factor which must be considered in a water quality management planning effort for a lake, because the civil divisions form the basic foundation of the decision-making framework within which intergovernmental environmental problems must be addressed.

## POPULATION

As set forth in Table 5, the resident population of the directly tributary drainage area has steadily increased from 1950 to 1975. The 1975 resident population of the area directly tributary to the lake was estimated at 3,300 persons, or about 1 percent of the population of Waukesha County.

Population forecasts for the Southeastern Wisconsin Region have been prepared by the Regional Planning Commission to the year 2000. As shown in Table 5, the resident population of the drainage area directly tributary to Lac La Belle may be expected to increase to about 6,840 persons by the year 2000, an increase of about 3,540 persons, or 107 percent of the 1975 population level.

A comparison of historical, existing, and forecast population levels for the Lac La Belle direct drainage area, Waukesha County, and the Southeastern Wisconsin Region is set forth in Figure 4. Compared with that in the Southeastern Wisconsin Region, population growth in the Lac La Belle direct drainage area has historically increased at a higher rate. Historical population growth in the direct drainage area has increased at approximately the same rate as the population growth in Waukesha County. Population in the Lac La Belle direct drainage area is forecast to grow at a higher rate than that in either Waukesha County or the Region, reflecting the increasing value and importance of outlying lake-oriented development. Increasing population levels will place a correspondingly increased stress on the water resources and the natural resource base in the lake drainage area, and will increase water resource demand and use conflicts.

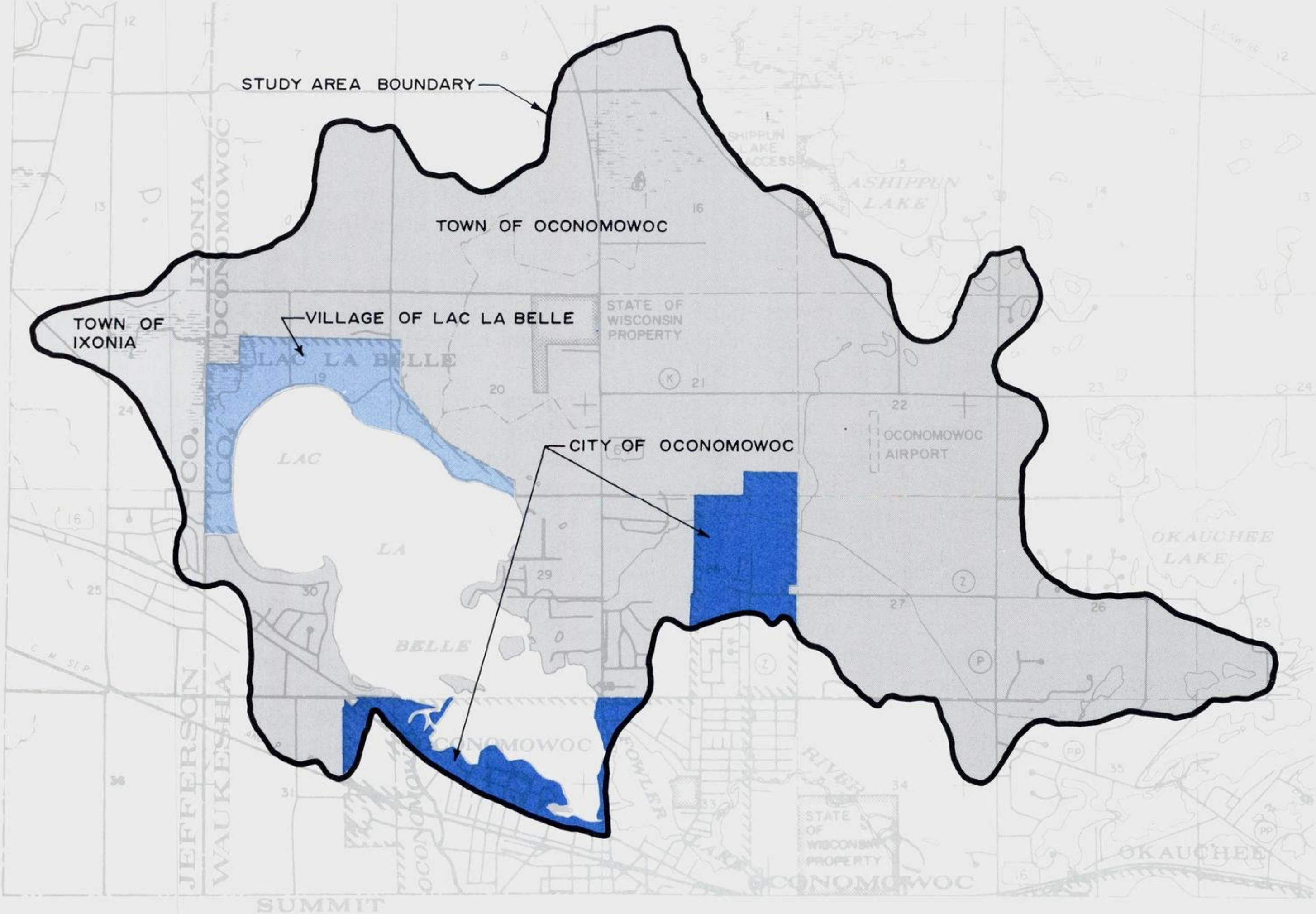
## LAND USE

The type, intensity, and spatial distribution of land uses also determine the resource demands in the drainage area. The existing land use pattern can best be understood within the context of its historical development.

The movement of European settlers into the Southeastern Wisconsin Region began about 1830. The completion of the U. S. Public Land Survey in southeastern Wisconsin by 1836 and the subsequent sale of public lands brought many settlers into the area. Map 8 shows the original 1836 U. S. Public Land Survey map for the Lac La Belle area. Urban development in the drainage area directly tributary to Lac La Belle began prior to 1850. Map 9 and

Map 7

CIVIL DIVISIONS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1976




Source: SEWRPC.

Table 4

AREAL EXTENT OF CIVIL DIVISIONS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: JANUARY 1, 1976

| Civil Division | Civil Division Area Within Direct Drainage Area (square miles) | Percent of Direct Drainage Area Within Civil Division | Percent of Civil Division Within Direct Drainage Area |
|---|---|---|---|
| Jefferson County | | | |
| Town of Ixonia . . . . . . . | 0.52 | 4.31 | 1.44 |
| County Subtotal | 0.52 | 4.31 | 0.01 |
| Waukesha County | | | |
| City of Oconomowoc . . . . | 0.94 | 7.79 | 17.12 |
| Village of Lac La Belle . . . | 0.48 | 3.97 | 100.00 |
| Town of Oconomowoc . . . | 10.13 | 83.93 | 30.18 |
| County Subtotal | 11.55 | 95.69 | 1.99 |
| Total | 12.07[a] | 100.00 | - - |

[a] *Includes approximately 1.75 square miles of the lake's surface water area.*

*Source: SEWRPC.*

Table 5

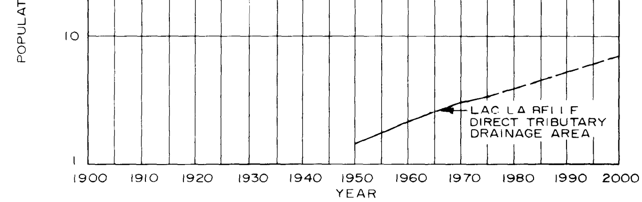
HISTORICAL AND FORECAST POPULATION LEVELS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1950-2000

| Year | Population |
|---|---|
| 1950 | 1,380 |
| 1960 | 2,000 |
| 1970 | 2,950 |
| 1975 | 3,300 |
| 2000 (forecast) | 6,840 |

*Source: SEWRPC.*

Figure 4

COMPARISON OF HISTORICAL, EXISTING, AND FORECAST POPULATION LEVELS FOR THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE, WAUKESHA COUNTY, AND THE SOUTHEASTERN WISCONSIN REGION: 1900-2000

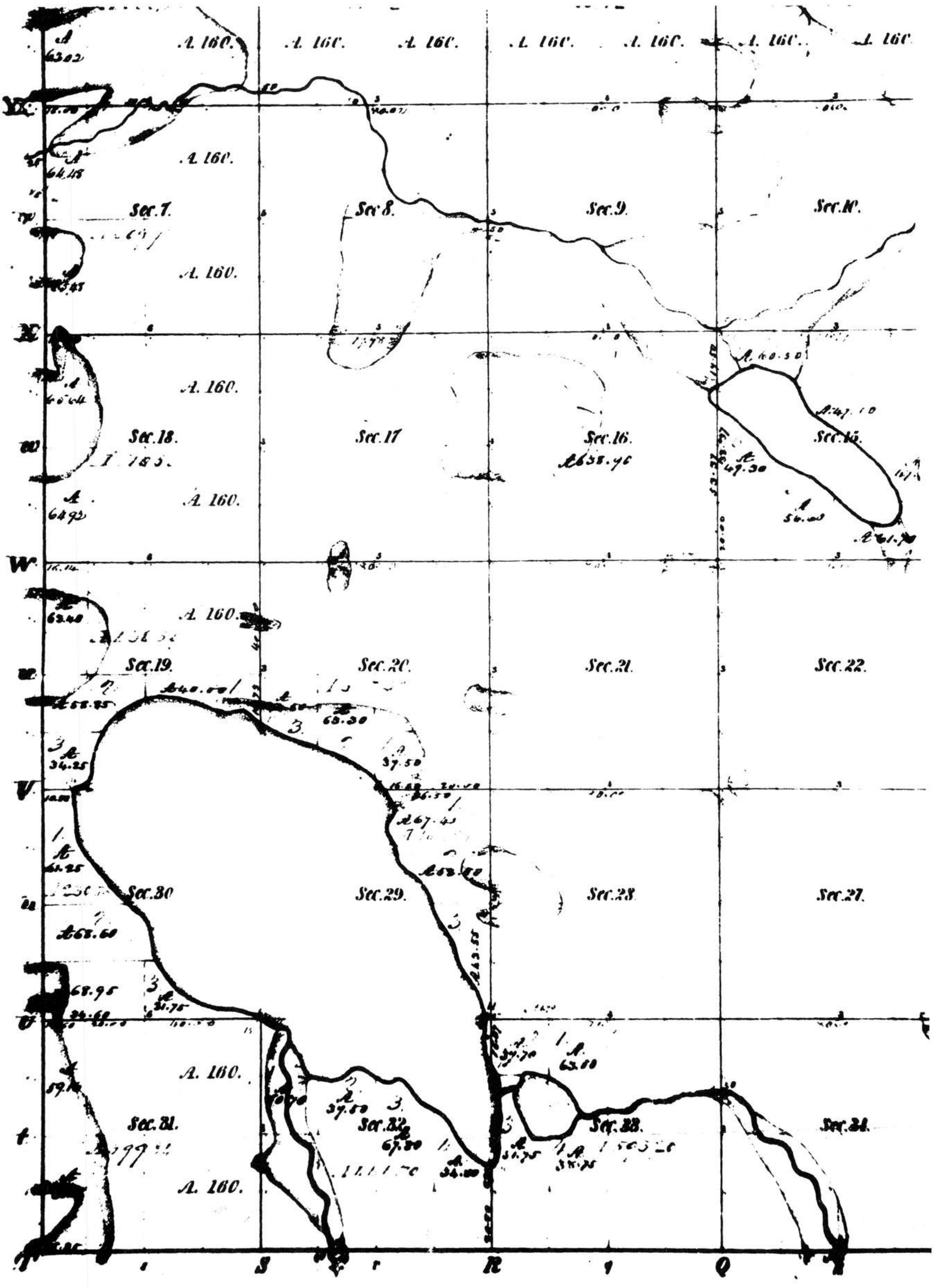



*Source: SEWRPC.*

Table 6 set forth the historical urban growth in the Lac La Belle direct tributary drainage area. The largest increases in urban development have occurred since 1950, with the highest increase occurring between 1970 and 1975. Prior to 1940, most urban development had occurred in what is now the City of Oconomowoc and in the Village of Lac La Belle. During the 1940's, 1950's, and early 1960's, urban development was extended around almost the entire lake shoreline. Since 1963, urban development has occurred in a generally outward pattern from the lake shoreline itself and at scattered locations within the lake drainage area.

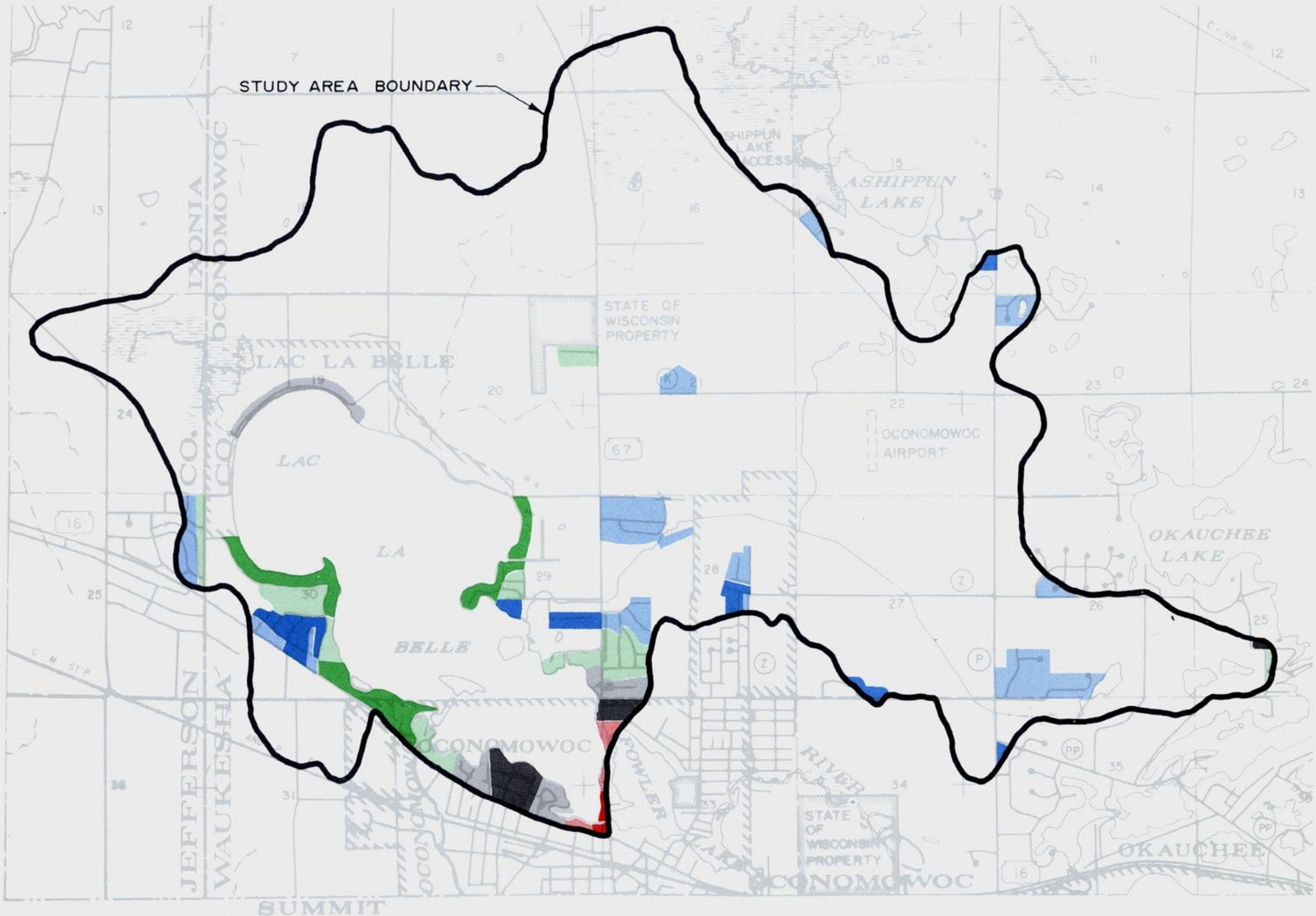
The existing 1975 land use pattern in the drainage area directly tributary to Lac La Belle is shown on Map 10 and existing land uses are quantified in Table 7. As indicated in Table 7, about 25 percent of the total area is in urban land use, with the dominant urban land use being residential, which encompasses 54 percent of the urban land area. The lower-density residential development is located in the Village of Lac La Belle and around most of the lake shoreline. The medium-density residential development is primarily within the City of Oconomowoc. Over half of the drainage area is in agricultural land use, and woodlands and open land areas comprised 5 percent of the drainage area. Wetlands and water areas, excluding the lake itself, account for 15 percent of the total direct tributary area.

ORIGINAL UNITED STATES PUBLIC LAND SURVEY MAP FOR THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1836

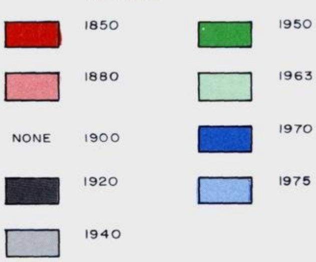


## Map 9

### HISTORIC URBAN GROWTH IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1850-1975




LEGEND




*Source: SEWRPC.*

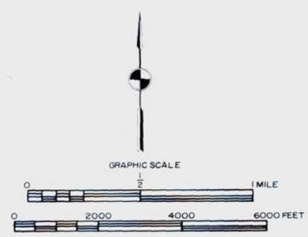


Table 6

EXTENT OF HISTORIC URBAN GROWTH IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1850-1975

| Year | Extent of Urban Development[a] (acres) |
|---|---|
| 1850 | 7 |
| 1880 | 24 |
| 1920 | 75 |
| 1940 | 159 |
| 1950 | 248 |
| 1963 | 379 |
| 1970 | 457 |
| 1975 | 664 |

[a] *Urban development, as defined for the purpose of this analysis, includes those areas in which houses or other buildings have been constructed in relatively compact groups, thereby indicating a concentration of urban land uses.*

*Source: SEWRPC.*

The year 2000 land use plan adopted by the Regional Planning Commission, as set forth on Map 11 and quantified in Table 7, recommends that most new residential development occur at medium densities contiguous to existing medium-density development. The plan also recommends that much of the remaining prime agricultural lands and all of the remaining primary environmental corridor be preserved. Compared with existing land uses, a 31 percent increase in urban land uses and a 36 percent increase in residential land use are recommended to occur by the year 2000. The agricultural areas north and east of the lake are designated as prime agricultural land to be preserved in agricultural use. It is recommended that the primary environmental corridors which include the remaining wetland areas, the lands immediately adjoining the Oconomowoc River and other streams, and the land immediately surrounding the lake be preserved in essentially open, natural land uses.

Table 7

EXISTING AND FORECAST LAND USE IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1975-2000

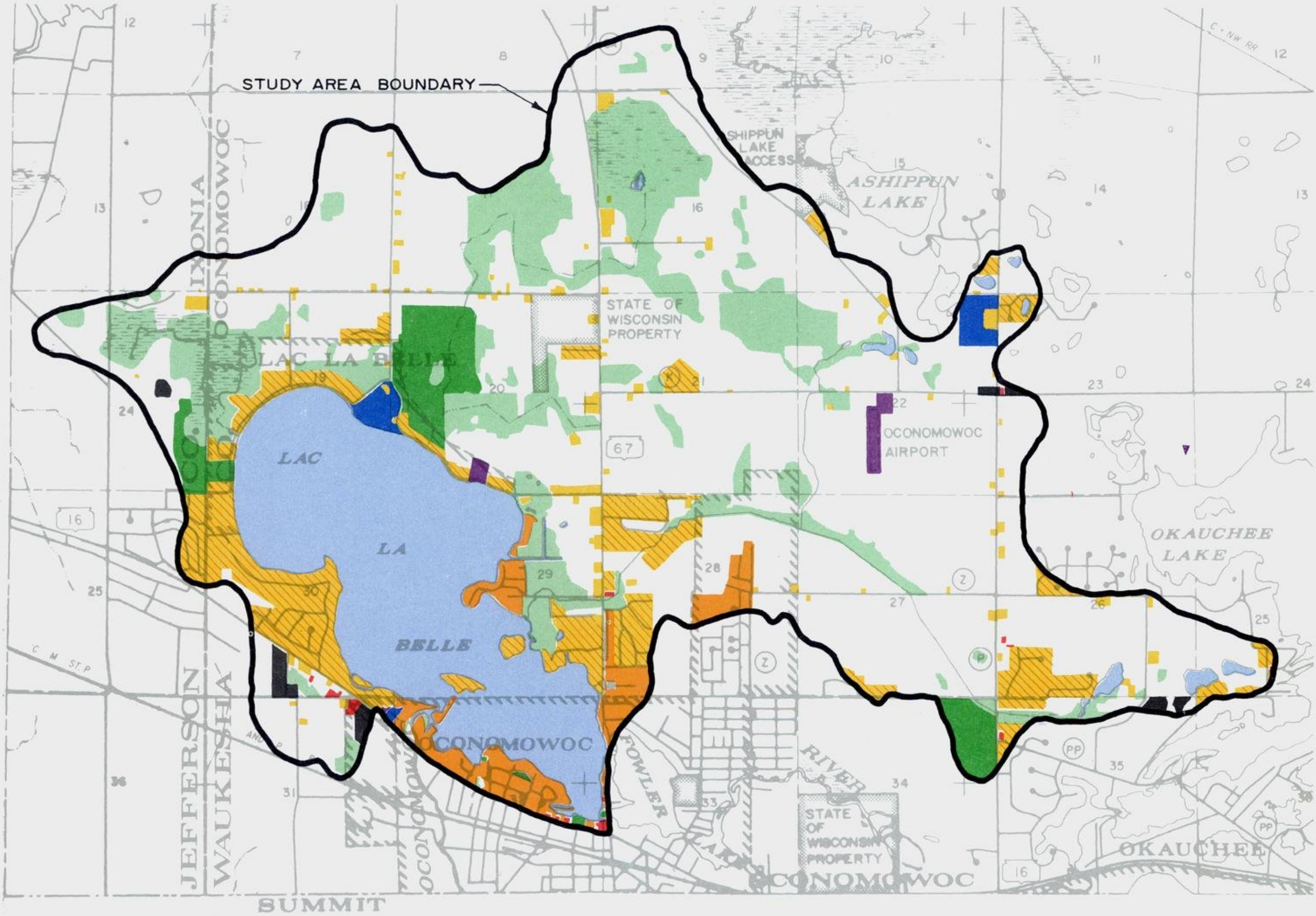
| Land Use Categories | Existing 1975 | | | Planned 2000 | | |
|---|---|---|---|---|---|---|
| | Acres | Percent of Major Category | Percent of Study Area | Acres | Percent of Major Category | Percent of Study Area |
| Urban | | | | | | |
| Residential | | | | | | |
| High Density | 0 | -- | -- | 0 | -- | -- |
| Medium Density | 192 | 11.8 | 2.9 | 358 | 16.8 | 5.4 |
| Low Density | 586 | 36.0 | 8.9 | 733 | 34.5 | 11.1 |
| Suburban Density | 100 | 6.2 | 1.5 | 100 | 4.7 | 1.5 |
| Residential Subtotal | 878 | 54.0 | 13.3 | 1,191 | 56.0 | 18.0 |
| Commercial | 10 | 0.6 | 0.2 | 11 | 0.5 | 0.2 |
| Industrial | 23 | 1.4 | 0.3 | 84 | 4.0 | 1.3 |
| Governmental and Institutional | 56 | 3.4 | 0.8 | 65 | 3.1 | 1.0 |
| Transportation, Communication, and Utilities | 433 | 26.6 | 6.6 | 542 | 25.4 | 8.2 |
| Recreational | 227 | 14.0 | 3.4 | 233 | 11.0 | 3.5 |
| Urban Land Use Total | 1,627 | 100.0 | 24.6 | 2,126 | 100.0 | 32.2 |
| Rural | | | | | | |
| Agricultural | 3,664 | 73.6 | 55.5 | 3,177 | 70.9 | 48.1 |
| Water[a] | 138 | 2.8 | 2.1 | 138 | 3.1 | 2.1 |
| Wetlands | 836 | 16.8 | 12.6 | 836 | 18.6 | 12.6 |
| Woodlands | 195 | 3.9 | 3.0 | 183 | 4.1 | 2.8 |
| Other Open Lands | 147 | 2.9 | 2.2 | 147 | 3.3 | 2.2 |
| Rural Land Use Total | 4,980 | 100.0 | 75.4 | 4,481 | 100.0 | 67.8 |
| Direct Drainage Area Total | 6,607 | -- | 100.0 | 6,607 | -- | 100.0 |

[a] *Excludes the surface area of Lac La Belle.*

*Source: SEWRPC.*

## Map 10

### EXISTING LAND USE IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1975




LEGEND

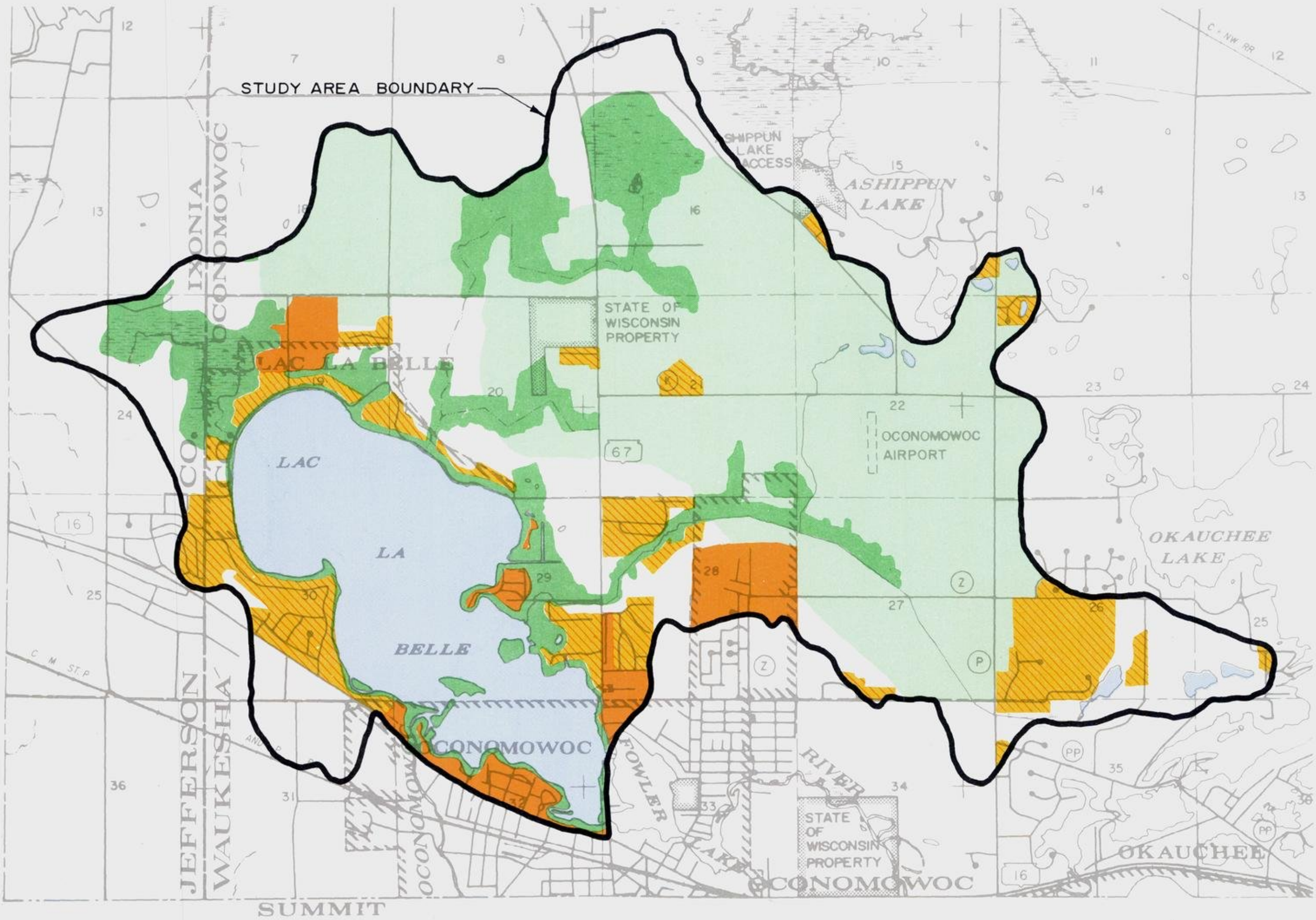
- SUBURBAN RESIDENTIAL (0.2–0.6 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- LOW DENSITY URBAN (0.7–2.2 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MEDIUM DENSITY URBAN (2.3–6.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- COMMERCIAL
- INDUSTRIAL
- TRANSPORTATION, COMMUNICATION, AND UTILITIES
- GOVERNMENT AND INSTITUTION
- RECREATION
- WETLAND AND WOODLAND
- WATER
- AGRICULTURE AND OTHER OPEN LAND

GRAPHIC SCALE: 0 – ½ – 1 MILE; 0 – 2000 – 4000 – 6000 FEET

*Source: SEWRPC.*

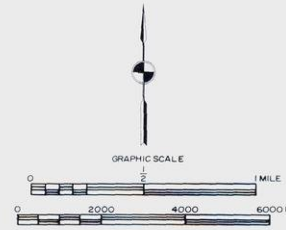
Map 11

## PLANNED LAND USE IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 2000




LEGEND

- LOW DENSITY URBAN (0.7–2.2 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MEDIUM DENSITY URBAN (2.3–6.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- PRIMARY ENVIRONMENTAL CORRIDOR
- PRIME AGRICULTURAL LAND
- WATER
- OTHER AGRICULTURAL AND OPEN RURAL LAND




*Source: SEWRPC.*

## Chapter IV

## WATER QUALITY

### HISTORICAL DATA

Some data predating the current study on the water quality and biota of Lac La Belle are available, but most of the information is relatively recent. Known data sources include A Catalog of Chemical Analyses of Lake Water Samples 1925-66 (Wisconsin Conservation Department, Fish Management Report No. 11, 1967); A Biological Survey of Lac La Belle (Wisconsin Conservation Department, Fish Management Report No. 491, 1946); Report on Lac La Belle, Waukesha County, Wisconsin (U. S. Environmental Protection Agency, Working Paper No. 62, 1975); and miscellaneous Wisconsin Department of Natural Resources file data and reports. Generally, the existing data base on water quality is not sufficient to permit documentation of any long-term trends or changes which may be occurring.

### PHYSICAL AND CHEMICAL CHARACTERISTICS

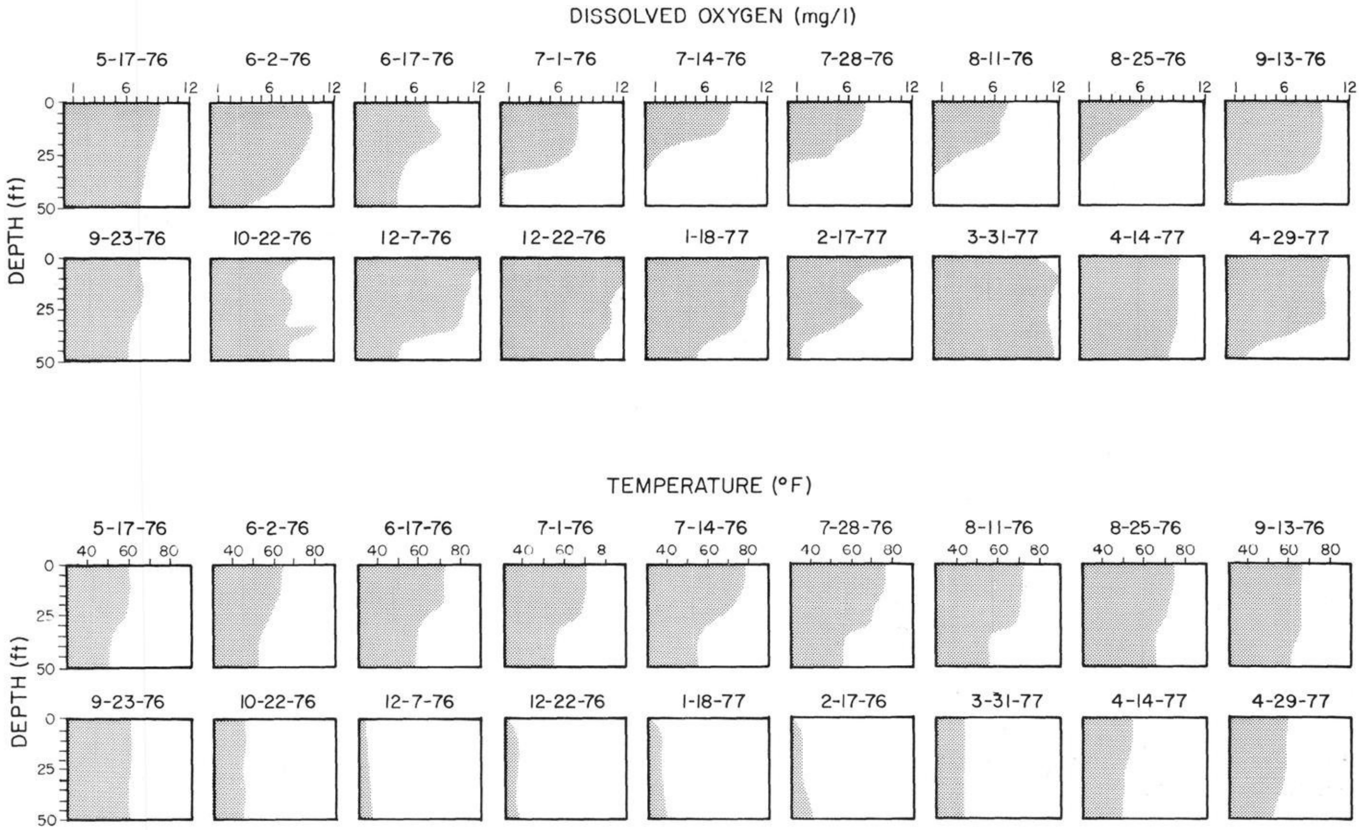
The water quality of Lac La Belle was monitored from May 1976 through April 1977 to determine the condition of the lake and to characterize its suitability for recreational use and for the support of fish and aquatic life. Water quality samples from the lake were taken every two weeks from May through September 1976, and monthly during the rest of the study period. The primary sampling station was located at the deepest point in the lake, as shown on Map 3. Monthly temperature and dissolved oxygen profiles are shown in Figure 5. Water temperatures ranged from a minimum of 32°F during the winter to a maximum of 79°F during the summer.

Complete mixing of the lake is restricted by thermal stratification in the summer and by ice cover in the winter. Thermal stratification is a result of differential heating of the lake water and 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 this energy to underlying water. As the upper layer of water is heated by the sun's energy, a physical barrier begins to form between the warmer surface water and the lower, heavier, colder water. 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 prohibits the exchange of water between the two layers, a condition which, as will be discussed later, has a great impact on both the chemical and biological activity in the lake. The development of the thermocline begins in early summer, reaches its maximum in late summer, and disappears in the fall, as is illustrated in Figure 5. This stratification period lasts until the fall, when air temperatures cool the surface water and wind action results in the erosion of the thermocline.

As 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. This lake season, which follows summer stratification, is known as fall turnover. When the water temperature drops below 39°F, it again becomes lighter and "floats" near the surface. Eventually the surface of the water is cooled to 32°F at which temperature ice begins to form and cover the surface of the lake, isolating it from the atmosphere for up to four months. During the study period, ice cover existed from late November 1976 through March 1977. 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. Spring brings a reversal to 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. This lake season, which follows winter stratification, is referred to as spring turnover. Beyond this point, the water at the surface warms, again becoming lighter, and floats above the colder water. Wind and resulting waves carry some of the energy of the warmer, lighter water to lower depths, but only to a limited extent. Thus

Figure 5

**DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR LAC LA BELLE: 1976-1977**




*Source: Wisconsin Department of Natural Resources.*

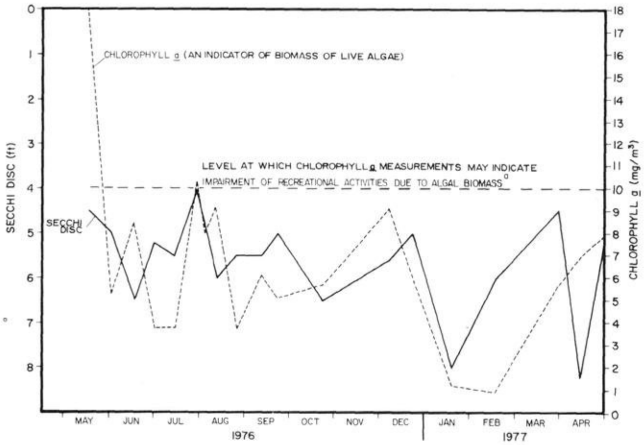
begins the formation of the thermocline and another summer thermal stratification.

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 fish mortality under ice cover. If ice cover is thick and snow cover deep, light penetration is sometimes insufficient to maintain oxygen production from the plants in the lake. When plant life dies and it, along with organic bottom muck, decays, the process consumes dissolved oxygen. These processes result in oxygen depletion which will kill most species of fish if the supply of dissolved oxygen is not sufficient—greater than 5 milligrams per liter (mg/l)—to meet the total winter demands. This condition, commonly referred to as winterkill, has not been a problem in Lac La Belle. Dissolved oxygen levels at most depths were adequate for the support of fish throughout the winter, as shown in Figure 5.

Dissolved oxygen profiles during summer stratification on Lac La Belle 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, wind turbulence, atmospheric equilibrium, wave action, and plant photosynthesis maintain an adequate supply of dissolved oxygen. Gradually, if there is not enough dissolved oxygen to meet the total oxygen demand from decaying material, the dissolved oxygen concentration may be reduced to zero. This oxygen depletion was observed in Lac La Belle, as shown in Figure 5, and is a common situation in many lakes in southeastern Wisconsin. By the middle of July 1976, the dissolved oxygen concentration at the bottom fell to zero and at a depth of 20 feet it was 4.2 mg/l, which is below the level necessary to support many species of fish. By August 25,

Figure 6

**CHLOROPHYLL-a AND SECCHI DISC MEASUREMENTS IN LAC LA BELLE: 1976-1977**




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

*Source: Wisconsin Department of Natural Resources.*

1976, the dissolved oxygen at a depth of 20 feet had dropped to 1.6 mg/l and was down to 4.5 mg/l at 15 feet. These values would 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 8-inch disc lowered to a depth where it is, just, no longer visible from the water's surface. Water clarity in lakes is typically highly variable, but is usually greatest during the cold water period and least during the warm season. The lowest Secchi Disc reading during the study period in Lac La Belle occurred in late July 1976. These low readings were primarily due to algae blooms in the water column. The Secchi Disc readings ranged from a low of 4.0 feet in late July to a high of 8.2 feet in mid-April 1977, as shown in Figure 6.

Chlorophyll-a is the major photosynthetic pigment in algae. The amount of chlorophyll-a present is an indicator of the biomass of live algae in the water. Maximum chlorophyll-a concentrations occurred in mid-May and from July to August 1976, from early to mid-December 1976, and in late April 1977, as set forth in Figure 6. Vallentyne reports that chlorophyll-a levels higher than 10 milligrams per cubic meter ($mg/m^3$) may indicate algal blooms which impair recreational activities such as swimming.[1] On this basis, the chlorophyll-a concentrations measured in Lac La Belle indicated generally good water quality with moderate algal intensities during the study year.

Water samples collected from Lac La Belle during the study period were tested for pH (acidity), specific conductance (a measure of the amount of dissolved solids) chloride, suspended solids, and different forms of the plant nutrients nitrogen and phosphorus. Ranges and mean values of these parameters are set forth in Table 8. Data for additional parameters—including calcium, magnesium, sodium, potassium, iron, manganese, sulfate, alkalinity, and turbidity—were collected from 1973 to 1975 and are also included in Table 8.

Chloride concentrations ranged from 12 to 25 mg/l, with a mean concentration of 18 mg/l, which represents an increase over the chloride levels reported by Poff in 1966.[2] Chloride concentrations are known to be increasing in other southeastern Wisconsin lakes as well as in Lac La Belle, and the most important and easily recognizable source of chlorides is believed to be street deicing salt.

Conductivity ranged from 427 to 639 micromhos/cm, and pH fluctuated between 7.6 and 8.4 standard units. Conductivity is somewhat lower than the normal found in most other Waukesha County lakes.[3] The metals data collected are typical of the hard water lakes in the area. Turbidity, another

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

[2] *R. J. Poff, A Catalog of Chemical Analyses of Lake Water Samples. Wisconsin Conservation Department, Fish Management Report No. 11, 1966.*

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

## Table 8

## SEASONAL WATER QUALITY CONDITIONS IN LAC LA BELLE: 1976-1977

| Chemical Parameter[a] | Spring (mid-March - mid-June) | | Summer (mid-June - mid-September) | | Fall (mid-September - mid-December) | | Winter (mid-December - mid-March) | | Annual | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range[b] | Mean[b] | Range[b] | Mean[b] | Range[b] | Mean[b] | Range[b] | Mean[b] | Range[b] | Mean[b] |
| Nitrite+Nitrate Nitrogen | 0.122-0.561 | 0.277 | 0.012-0.268 | 0.053 | 0.032-0.530 | 0.129 | 0.105-1.336 | 0.432 | 0.012-1.336 | 0.223 |
| Ammonia Nitrogen | 0.04-0.47 | 0.07 | 0.03-1.28 | 0.17 | 0.04-0.27 | 0.13 | 0.04-0.51 | 0.17 | 0.03-1.28 | 0.13 |
| Organic Nitrogen | 0.36-1.05 | 0.60 | 0.36-1.30 | 0.75 | 0.62-1.32 | 0.83 | 0.06-0.64 | 0.39 | 0.06-1.32 | 0.64 |
| Total Nitrogen | 0.66-1.44 | 0.95 | 0.47-2.32 | 0.97 | 0.68-1.68 | 1.09 | 0.33-2.04 | 0.98 | 0.33-2.32 | 1.00 |
| Phosphate Phosphorus | 0.011-0.030 | 0.018 | 0.009-0.048 | 0.018 | 0.016-0.046 | 0.020 | 0.007-0.063 | 0.023 | 0.007-0.063 | 0.020 |
| Total Phosphorus | 0.01-0.12 | 0.04 | 0.01-0.13 | 0.03 | 0.02-0.12 | 0.04 | 0.01-0.09 | 0.04 | 0.01-0.13 | 0.04 |
| Chloride | 12-21 | 18 | 12-20 | 16 | 15-25 | 18 | 20-25 | 22 | 12-25 | 18 |
| Conductivity (micromhos/cm) | 427-492 | 471 | 427-581 | 450 | 438-545 | 475 | 458-639 | 535 | 427-639 | 483 |
| pH (standard units) | 7.7-8.4 | - - | 7.6-8.4 | - - | 7.9-8.4 | - - | 7.8-8.2 | - - | 7.6-8.4 | - - |
| Calcium | 41 | 41 | 26-65 | 44 | 36-64 | 50 | 52-117 | 74 | 27-117 | 52 |
| Magnesium | 32 | 32 | 18-44 | 32 | 36-44 | 40 | 41-56 | 47 | 18-56 | 38 |
| Sodium | 6 | 6 | 7-14 | 10 | 6-13 | 10 | 7-14 | 10 | 6-14 | 9 |
| Potassium | 1.4-2.7 | 2.0 | 1.0-6.3 | 3.7 | 2.3-8.3 | 5.5 | 2.1-5.7 | 3.6 | 1.0-8.3 | 3.7 |
| Iron | - - | - - | - - | - - | 0.09-0.13 | 0.11 | - - | - - | 0.09-0.13 | - - |
| Manganese | - - | - - | - - | - - | 0.04-0.05 | 0.04 | - - | - - | 0.04-0.05 | - - |
| Sulfate | 30-36 | 34 | 32-36 | 34 | 21-38 | 29 | 35-40 | 37 | 21-40 | 33 |
| Total Alkalinity | 198-240 | 209 | 189-202 | 197 | 180-246 | 199 | 212-264 | 234 | 180-264 | 210 |
| Turbidity (Formazin Units) | 1.65-2.60 | 2.10 | 0.60-3.00 | 1.50 | 1.60-3.50 | 2.30 | 1.40-2.30 | ~ 1.80 | 0.60-3.50 | 1.90 |

*[a] Number of samples during 1976-1977 study year for nitrogen, phosphorus, chloride, conductivity, and pH data: spring-33, 4 dates; summer-105, 7 dates; fall-24, 3 dates; winter-18, 3 dates. For remaining parameters: spring-5, 2 dates; summer-6, 2 dates; fall-9, 4 dates; winter-6, 2 dates.*

*[b] All values reported in mg/l unless otherwise specified; calcium, magnesium, sodium, potassium, iron, manganese, sulfate, total alkalinity, and turbidity collected and analyzed in 1973-1975; all other parameters collected during the study year.*

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

measure of water clarity, is low throughout the year. Total alkalinity was about average for lakes in Waukesha County.

The nutrients nitrogen and phosphorus, which are necessary for the growth of aquatic plants, including algae, have a substantial 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/or in excessive macrophyte growth. Lakes experiencing these conditions are classified as eutrophic.

Phosphorus concentrations in Lac La Belle exceeded the levels believed necessary to support periodic nuisance algae blooms. The recommended water quality standard for phosphorus, as set forth in the Regional Planning Commission's adopted area-wide water quality management plan for lakes, is 0.02 mg/l or less of total phosphorus during the 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, warm water fish, and aquatic life water use objectives. In Lac La Belle during the study year, the mean concentration of total phosphorus in the spring was 0.04 mg/l.

The ratio of total nitrogen to total phosphorus (N:P) in lake water often indicates which nutrient is the factor limiting aquatic plant growth in a lake.[4] Where the N:P ratio is greater than 14:1, the lake is thought to be phosphorus limited. If the ratio is less than 10:1, nitrogen is most likely to be the limiting nutrient. As shown in Table 9, in Lac La Belle the N:P ratio was always greater than 19:1, indicating it was consistently limited by phosphorus. Bottom sediment conditions, although not measured, also have an important effect on the condition of a lake. As the lake bottom is covered, valuable benthic habitats are covered, macrophyte prone substrates are increased, fish spawning areas are covered, and aesthetic nuisances develop. In addition, sediment particles act as a transport mechanism for other substances, such as phosphorus, nitrogen, organic substances, pesticides and heavy metals.

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[4] *M. O. Allum, R. E. Gessner, and J. H. Gokstatter, An Evaluation of the National Eutrophication Data, U. S. Environmental Protection Agency Working Paper No. 900, 1977.*

Table 9

NITROGEN-PHOSPHORUS RATIO FOR LAC LA BELLE: 1976-1977

| Sampling Date | Nitrogen (mg/l) | Phosphorus (mg/l) | Nitrogen to Phosphorus Ratio |
|---|---|---|---|
| 05-17-76 | 1.15 | 0.05 | 23.0 |
| 06-02-76 | 1.12 | 0.05 | 22.4 |
| 06-17-76 | 0.96 | 0.04 | 24.0 |
| 07-01-76 | 1.04 | 0.03 | 34.7 |
| 07-14-76 | 1.12 | 0.02 | 56.0 |
| 07-28-76 | 0.83 | 0.03 | 27.7 |
| 08-11-76 | 0.97 | 0.03 | 32.3 |
| 08-25-76 | 1.02 | 0.04 | 25.5 |
| 09-13-76 | 0.93 | 0.03 | 31.0 |
| 09-23-76 | 0.90 | 0.04 | 22.5 |
| 10-22-76 | 1.09 | 0.04 | 27.3 |
| 12-07-76 | 1.11 | 0.03 | 37.0 |
| 12-22-76 | 0.89 | 0.03 | 29.7 |
| 01-18-77 | 0.65 | 0.03 | 21.7 |
| 02-17-77 | 0.59 | 0.03 | 19.7 |
| 03-31-77 | 0.40 | 0.02 | 20.0 |
| 04-14-77 | 0.39 | 0.02 | 19.5 |

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

## EXISTING AND PROBABLE FUTURE POLLUTION SOURCES AND LOADINGS

Estimates were made of the nitrogen, phosphorus, and sediment loadings to Lac La Belle. Input and output loads from the lake were based on flow and water quality data collected at the Oconomowoc River inlet at STH 67, Rosenow Creek at Blackhawk Drive, small intermittent inlets draining the north and west drainage areas, and the Oconomowoc River lake outlet at STH 16 in Oconomowoc, as shown on Map 3. Ranges and mean values for water quality parameters measured at these sites are set forth in Table 10.

The measured concentrations during the study period were used to develop annual loading budgets for nitrogen, phosphorus, and sediment as shown in Table 11 and Figures 7, 8, and 9. The Oconomowoc River contributed 40 to 75 percent of the annual nutrient and sediment load to the lake, while other direct drainage contributed 15 to 35 percent of the annual load. Atmospheric contributions of nitrogen, phosphorus, and suspended

Table 10

WATER QUALITY CONDITIONS OF LAC LA BELLE INLET STREAMS, OUTLET, AND GROUNDWATER: 1976-1977

| Chemical Parameters[a] | L-4 (Inlet Oconomowoc River) | | L-5 (Inlet) | | L-6 (Inlet) | | L-7 (Inlet) | | L-8 (Outlet Oconomowoc River) | | Groundwater | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean[b] | Range | Mean[b] | Range | Mean[b] | Range | Mean[b] | Range | Mean[b] | Range | Mean[b] |
| Nitrite+Nitrate Nitrogen | 0.002-0.209 | 0.075(22) | 0.461-7.728 | 3.089(23) | 1.376-11.792 | 6.910(5) | 0.182-8.151 | 3.152(6) | 0.017-0.273 | 0.132(22) | - - | - - |
| Ammonia Nitrogen | 0.03-0.15 | 0.06(22) | 0.03-0.29 | 0.05(23) | 0.04-0.10 | 0.05(5) | 0.04-0.12 | 0.05(6) | 0.04-0.14 | 0.06(22) | - - | - - |
| Organic Nitrogen | 0.22-1.09 | 0.57(22) | 0.06-1.74 | 0.56(23) | 1.78-2.47 | 2.14(5) | 1.23-2.23 | 1.66(6) | 0.38-0.90 | 0.63(22) | - - | - - |
| Total Nitrogen | 0.32-1.23 | 0.703(22) | 1.58-8.07 | 3.68(23) | 3.19-14.29 | 9.10(5) | 1.48-10.42 | 4.85(6) | 0.51-1.13 | 0.18(22) | 0.053-9.250 | 2.246(16) |
| Reactive Phosphorus | 0.007-0.071 | 0.20(22) | 0.004-0.246 | 0.054(22) | 0.032-0.370 | 0.088(5) | 0.026-0.246 | 0.059(6) | 0.013-0.065 | 0.021(22) | - - | - - |
| Total Phosphorus | 0.01-0.42 | 0.06(22) | 0.01-0.41 | 0.09(22) | 0.07-0.53 | 0.16(5) | 0.02-0.44 | 0.10(6) | 0.02-0.13 | 0.04(22) | 0.01 | 0.117(16) |
| Chloride | 14-22 | 17(16) | 14-35 | 21(17) | 16-31 | 28(4) | 10-22 | 13(5) | 15-22 | 18(16) | 22-560 | 161(18) |
| Total Suspended Solids | 0-26.33 | 5.0(14) | 0.01-20.67 | 6.6(16) | 3.2-7.2 | 4.5(4) | 0.8-3.6 | 2.6(4) | 0.33-10.0 | 4.1(15) | - - | - - |
| Conductivity (micromhos/cm) | 386-533 | 425(16) | 437-708 | 632(17) | 403-837 | 715(4) | 418-669 | 559(5) | 429-555 | 471(16) | 459-2,552 | 1,166(18) |
| pH (standard units) | 7.7-8.5 | - - | 7.6-8.1 | - - | 7.5-7.6 | - - | 7.5-7.7 | - - | 7.7-8.3 | - - | 7.4-8.1 | - - |
| Calcium | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | 55-114 | 91(13) |
| Magnesium | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | 25-63 | 45(13) |
| Sodium | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | 7-153 | 55(13) |
| Potassium | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | 0.7-6.5 | 3.4(13) |
| Iron | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | 0.06-5.03 | 1.36(13) |
| Manganese | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | 0.03-0.72 | 0.34(13) |
| Sulfate | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | 10-26 | 19(3) |
| Total Alkalinity | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | 166-460 | 346(18) |

[a] *All values reported in mg/l unless otherwise specified; calcium, magnesium, sodium, potassium, iron, manganese, sulfate, and total alkalinity collected and analyzed in 1973-75.*

[b] *Number of samples in parentheses.*

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

Table 11

**ANNUAL LOADING BUDGETS TO LAC LA BELLE FOR NITROGEN, PHOSPHORUS, AND SEDIMENT BASED ON MEASURED DATA: 1976-1977**

| Source[a] | Nitrogen | | Phosphorus | | Sediment | |
|---|---|---|---|---|---|---|
| | Amount (pounds) | Total Input (percent) | Amount (pounds) | Total Input (percent) | Amount (pounds) | Total Input (percent) |
| Inputs | | | | | | |
| Oconomowoc River | 52,411 | 44.2 | 2,542 | 60.6 | 349,589 | 74.1 |
| Direct Tributary Drainage Area | | | | | | |
| Rosenow Creek | 32,798 | 27.6 | 552 | 13.1 | 61,100 | 12.9 |
| Other Direct Drainage | 12,045 | 10.2 | 170 | 4.1 | 11,645 | 2.5 |
| Atmospheric Contributions | 21,420 | 18.0 | 933 | 22.2 | 49,703 | 10.5 |
| Total | 118,674 | 100.0 | 4,197 | 100.0 | 472,037 | 100.0 |
| Outputs | | | | | | |
| Outlet | 65,805 | 55.5 | 2,454 | 58.5 | 307,636 | 65.2 |
| Net Deposition Into Bottom Sediments | 52,869 | 44.5 | 1,743 | 41.5 | 164,401 | 34.8 |
| Total | 118,674 | 100.0 | 4,197 | 100.0 | 472,037 | 100.0 |

[a] *Groundwater loads were not estimated.*

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

solids were calculated for these different constituents based on precipitation records and on literature values which were believed to be representative of the Lac La Belle region. During the year of study, it is estimated that 10 to 25 percent of the nutrients and sediments entering the lake came from atmospheric sources, which include precipitation and dry fallout on the lake.

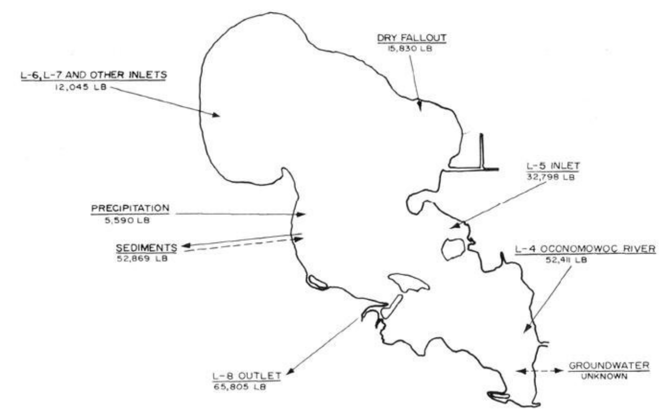
Groundwater quality and direction of movement were monitored in nine pairs of observation wells around Lac La Belle, as shown on Map 3. In the groundwater, concentrations of inorganic nitrogen (nitrite-, nitrate-, and ammonia-nitrogen) ranged from 0.053 to 9.250 mg/l with a mean value of 2.246 mg/l. Total phosphorus concentrations ranged from less than 0.01 to 0.61 mg/l, with a mean value of 0.12 mg/l. Well number 17 had extremely high phosphorus readings which is reflected in the high mean value for phosphorus. Since groundwater outflow from the lake exceeded groundwater inflow, it is very difficult to ascertain the net impact of groundwater on the lake. Accordingly, no attempt was made to include groundwater phosphorus loading estimates in the phosphorus budget for Lac La Belle, computed from measured data.

To identify and quantify specific sources of pollution in the direct tributary drainage area to Lac La Belle, existing 1975 and forecast year 2000 phosphorus loads were also calculated using SEWRPC 1975 land use inventory data, planned year 2000 land use data from the Commission adopted land use plan, and the Commission water quality simulation model.

Table 12 sets forth the estimated direct tributary phosphorus loads to Lac La Belle under 1975 conditions, and under anticipated year 2000 conditions, if no nonpoint source controls are implemented in the direct tributary area. Table 12 also presents estimated phosphorus loads to the lake if no nonpoint source controls are implemented in the upstream Oconomowoc River watershed. These estimates are based upon analyses conducted as part of the regional water quality management planning study. Under existing conditions, the inflow from the Oconomowoc River constitutes the largest phosphorus source, accounting for about 46 percent of the total phosphorus load to the lake. Under anticipated year 2000 conditions if upstream controls are implemented in the Oconomowoc River watershed, and if no nonpoint source controls are implemented in the direct

Figure 7

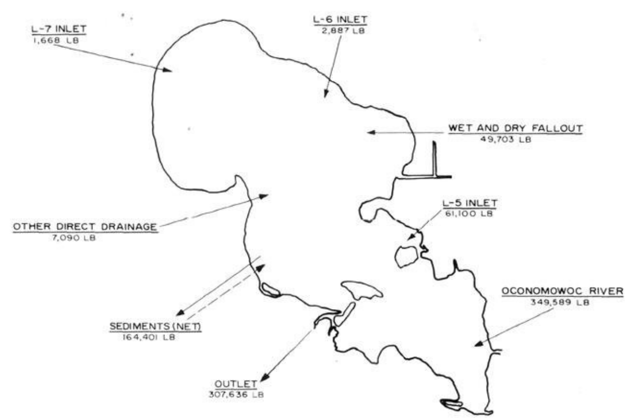
**NITROGEN BUDGET FOR LAC LA BELLE: 1976-1977**




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

Figure 9

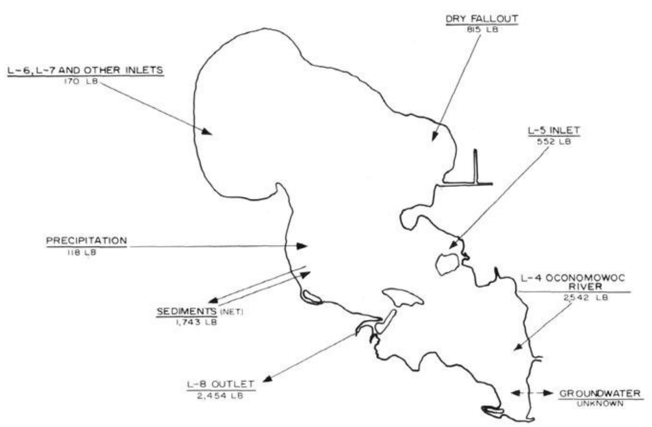
**SEDIMENT BUDGET FOR LAC LA BELLE: 1976-1977**




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

Figure 8

**PHOSPHORUS BUDGET FOR LAC LA BELLE: 1976-1977**




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

tributary area, only about 23 percent of the total load is expected to be contributed by the Oconomowoc River. This reduction in the proportion of the total phosphorus load contributed by the Oconomowoc River occurs because nonpoint source controls recommended to be implemented in the upstream drainage area are expected to reduce existing phosphorus loads to the Oconomowoc River by two-thirds. If no nonpoint source pollution control action is taken in the upstream Oconomowoc River watershed, the proportion of the total load contributed by the Oconomowoc River would be expected to increase to about 53 percent. Under both existing and anticipated year 2000 conditions, the water quality analysis results indicate that the primary direct tributary sources of phosphorus are livestock operations and construction activities. Under anticipated year 2000 conditions, septic systems become less important than under existing conditions as sanitary sewer service is provided to the watershed, and increasing urban land runoff contributes a higher proportion of the phosphorus load. Under anticipated year 2000 conditions, the total phosphorus load to the lake from direct tributary sources, as measured in pounds, is expected to decrease from existing levels if no nonpoint source controls are implemented. The existing direct tributary annual phosphorus loading estimate is about 50 percent higher than the inventory loads estimated in the detailed study, and represent an estimate of the total direct tributary phosphorus loading for years of normal weather conditions.

The phosphorus loads set forth in Table 12 are consistent with measured in-lake phosphorus concentrations. An annual loading of about 6,475 pounds of phosphorus to Lac La Belle would result in an in-lake total phosphorus concentration of

Table 12

## ESTIMATED TOTAL PHOSPHORUS LOADS TO LAC LA BELLE: 1975 AND 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | | No Action 2000[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Direct Tributary Sources | | | | | | | | | |
| Urban Land Cover (acres) | 1,608 | 296 | 4.6 | 2,107 | 365 | 8.4 | 2,107 | 365 | 5.1 |
| Land Under Development— Construction Activities (acres) | 19 | 570 | 8.8 | 19 | 570 | 13.1 | 19 | 570 | 8.0 |
| Onsite Sewage Disposal Systems[c] | 80 | 174 | 2.7 | 15 | 32 | 0.7 | 15 | 32 | 0.5 |
| Rural Land Cover (acres) | 4,980 | 337 | 5.2 | 4,481 | 295 | 6.8 | 4,481 | 295 | 4.1 |
| Livestock Operations (animal units) | 583.5 | 1,540 | 23.8 | 583.5 | 1,540 | 35.3 | 583.5 | 1,540 | 21.7 |
| Atmospheric Contribution (acres of receiving surface water) | 1,117 | 558 | 8.6 | 1,117 | 558 | 12.8 | 1,117 | 558 | 7.9 |
| Oconomowoc River | - - | 3,000 | 46.3 | - - | 1,000 | 22.9 | - - | 3,750 | 52.7 |
| Total | - - | 6,475 | 100.0 | - - | 4,360 | 100.0 | - - | 7,110 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the regional water quality management plan element and that nonpoint source controls are implemented in the upstream drainage area; assumes no nonpoint source control in the direct tributary area.*

[b] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element, but that nonpoint source controls are not implemented in the upstream drainage area or in the direct tributary area.*

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

*Source: SEWRPC.*

about 0.04 mg/l during spring turnover.[5] As set forth in Table 13, measured total phosphorus concentrations in Lac La Belle have historically approximated 0.04 mg/l during spring.

Table 13

## MEASURED TOTAL PHOSPHORUS CONCENTRATIONS IN LAC LA BELLE: 1972-1977

| Sample Date | Total Phosphorus Concentrations (mg/l) |
|---|---|
| November 9, 1972 | 0.01 |
| September 18, 1973 | 0.02 |
| February 5, 1974 | 0.03 |
| April 3, 1974 | 0.03 |
| July 10, 1974 | 0.05 |
| January 7, 1975 | 0.07 |
| February 18, 1975 | 0.02 |
| April 22, 1975 | 0.05 |
| November 5, 1975 | 0.04 |
| March 15, 1976 | 0.04 |
| Spring 1976 | 0.04 |
| Summer 1976 | 0.03 |
| Fall 1976 | 0.04 |
| Winter 1976-1977 | 0.04 |
| Mean Annual Value | 0.04 |
| Median Annual Value | 0.04 |
| Mean Spring Value | 0.04 |
| Median Spring Value | 0.04 |

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

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[5] *Based on the average in-lake phosphorus concentration calculated by the application of the 1976 Vollenweider model (R. A. Vollenweider, "Advances in Defining Critical Loading Levels for Phosphorus in Lake Eutrophication,"* Memorial Institute of Italian Idrobiologica. *Vol. 33 (1976), pp. 53-83); the 1975 Vollenweider model (R. A. Vollenweider, "Input-Output Models with Special Reference to the Phosphorus Loading Concept in Limnology," Schweiz, Z. Hydrol. Vol. 37 (1975), pp. 53-83); and the Dillon Rigler model (P. J. Dillon and F. H. Rigler, "A Test of a Simple Nutrient Budget Model Predicting the Phosphorus Concentration in Lake Water,"* Journal of the Fisheries Research Board of Canada, *Vol. 32, No. 11 (1974), pp. 1771-1778).*

## TROPHIC CONDITION RATING

Lakes are commonly classified according to the degree of their nutrient enrichment—or their 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 which has occurred. There are three terms usually used to describe the trophic status of a lake: oligotrophic, mesotrophic, and eutrophic.

Oligotrophic lakes are nutrient poor lakes. These lakes characteristically support relatively few aquatic plants and often do not contain very productive fisheries. Oligotrophic lakes provide excellent opportunities for swimming, boating, and waterskiing. Because of the naturally fertile soils and the intensive land use practices employed, 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 weeds are usually not exhibited by mesotrophic lakes. These lakes may provide opportunities for all types of recreational activities, including boating, swimming, fishing, and waterskiing. Many lakes in southeastern Wisconsin are mesotrophic.

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

The trophic status of Lac La Belle was evaluated by the application of three commonly used methods: the Lake Condition Index, the Vollenweider-Dillon model, and the Trophic State Index.

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 and/or weed growth. A measure—referred to as a Lake Condition Index—was devised in which "penalty points" were assigned to lakes for undesirable symptoms of water pollution. Thus, if a lake exhibited no undesirable symptoms of eutrophication, it received no points and had a Lake Condition Index of zero. Conversely, a lake with all the undesirable characteristics in the most severe degree had a Lake Condition Index of 23. Under the Uttormark-Wall classification system, Lac La Belle has a Lake Condition Index of 10—as set forth in Table 14—which is indicative of a slightly eutrophic lake.[6] This value for Lac La Belle is higher—that is, more eutrophic—than 17 of the 22 surveyed lakes in Waukesha County, and higher than 47 of the 65 lakes rated in the seven-county Southeastern Wisconsin Region, as shown in Table 15.

**Table 14**

**LAKE CONDITION INDEX CALCULATION OF LAC LA BELLE**

| Lake Conditions | Lake Condition Index Penalty Points |
|---|---|
| Dissolved Oxygen Concentrations at Zero During Some Periods in Portions of the Hypolimnion. . . . . . | 4 |
| Average Secchi Disc Reading 4 to 8 Feet . . . . . . . . . . . . . . . . | 2 |
| No History of Fish Winterkills. . . . . . | 0 |
| Occasional Blue-Green Algae Blooms. . | 4 |
| Total | 10 |

*Source: Wisconsin Department of Natural Resources.*

Vollenweider and Dillon developed a model for predicting critical levels of phosphorus loadings to lakes based on mean depth of the lake, hydraulic flushing time, and phosphorus loading data. Based on measured phosphorus loading data during the study year, and on the Commission water quality simulation model, the Vollenweider and Dillon model was calculated for Lac La Belle, as plotted in Figure 10.[7] The study data, which represent dry

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[6] *P. D. Uttormark and J. P. Wall, Lake Classification—A Trophic Characterization of Wisconsin Lakes, Environmental Protection Agency Report No. EPA-660/3-75-033, 1975.*

[7] *R. A. Vollenweider and P. J. Dillon, The Application of Phosphorus Loading Concept to Eutrophication Research, Natural Resource Council Technical Report 13690, 1974.*

Table 15

LAKE CONDITION INDEX OF SELECTED MAJOR LAKES IN SOUTHEASTERN WISCONSIN: 1975

| 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 . . . . . | Big Cedar | Washington | 5 | mesotrophic |
| Milwaukee . . . . . | Little Cedar | Washington | 5 | mesotrophic |
| Milwaukee . . . . . | Mud | Ozaukee | 10 | eutrophic |
| Milwaukee . . . . . | Silver | Washington | 3 | oligotrophic |

year conditions, indicate that the total phosphorus loading to Lac La Belle of 0.40 gram per square meter of lake surface per year ($g/m^2/yr.$) falls between those levels which would tend to maintain an oligotrophic (low fertility) condition and those levels which would generate accelerated eutrophic (high fertility) conditions. During a year of average precipitation, phosphorus load, as estimated by the water quality simulation model, would equal 0.65 $g/m^2/year$, which could be expected to result in eutrophic conditions.

A third measure of trophic condition can be achieved by the application of the Trophic State Index (TSI). The Trophic State Index may be computed using total phosphorus, Secchi Disc, and chlorophyll-a measurements to assign a trophic status rating to a lake.

Table 15 (continued)

| Watershed | Major Lake Name | County | Lake Condition Index[a] | Category |
|---|---|---|---|---|
| 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 | 3 | oligotrophic |
| 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 | 8 | mesotrophic |
| Rock . . . . . . . . . | Okauchee | Waukesha | 5 | mestrophic |
| Rock . . . . . . . . . | Pike | Washington | 3 | oligotrophic |
| 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.*

The equations for calculating these three TSI values are:

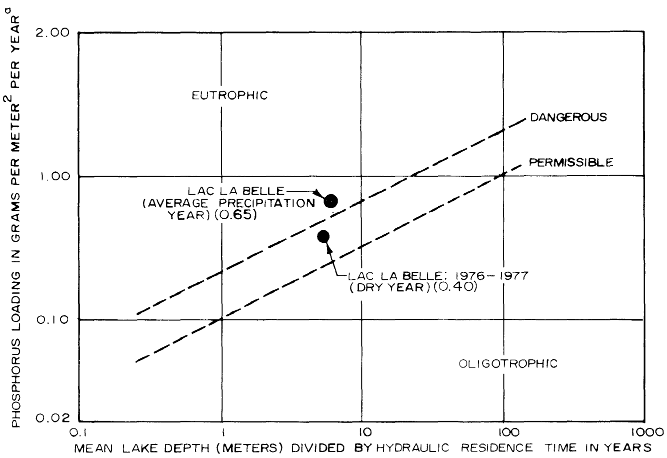
$$TSI_{\text{Total Phosphorus}} = 10\left(6 - \left[\frac{\text{Natural log of}\left(\dfrac{40.5}{\text{Total Phosphorus in } \mu g/l}\right)}{\text{Natural log of 2}}\right]\right)$$

$$TSI_{\text{Secchi Disc}} = 10\left(6 - \left[\frac{\text{Natural log of Secchi Disc in Meters}}{\text{Natural log of 2}}\right]\right)$$

$$TSI_{\text{Chlorophyll-}\underline{a}} = 10\left(6 - \left[\frac{2.04\text{-}0.68 \text{ Natural log of Chlorophyll-}\underline{a} \text{ in } \mu g/l}{\text{Natural log of 2}}\right]\right)$$

### Figure 10

### VOLLENWEIDER AND DILLON TROPHIC STATUS CALCULATION FOR LAC LA BELLE: AVERAGE PRECIPITATION YEAR AND 1976-1977

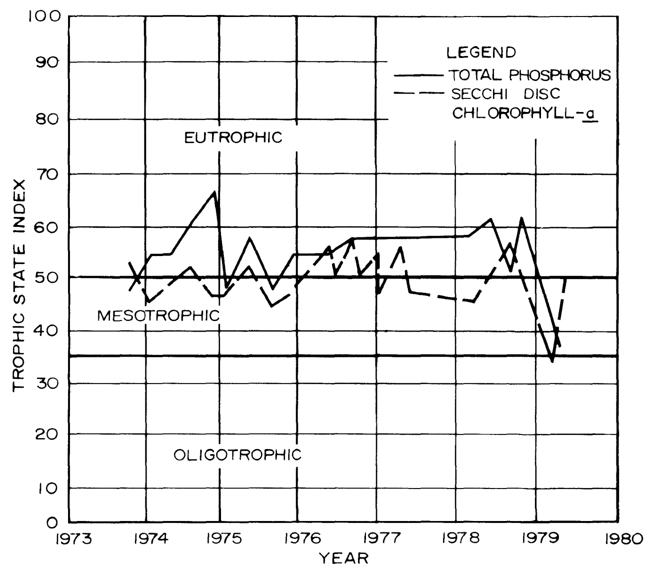



*[a]Phosphorus in lake concentrations is usually measured in milligrams per liter.*

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

### Figure 11

### TROPHIC STATE INDEX CALCULATIONS FOR LAC LA BELLE: 1973-1979




*Source: SEWRPC.*

TSI ratings of less than 35 are indicative of oligotrophic lakes; ratings of 35 to 50 signify mesotrophic lakes; and eutrophic lakes exhibit ratings higher than 50.[8] Figure 11 sets forth the TSI calculations for the period of 1973 to 1979 for Lac La Belle.

The values shown in Figure 11 indicate that Lac La Belle is a mesotrophic lake. The TSI calculations based on total phosphorus are generally higher than the TSI calculations based on Secchi Disc or chlorophyll-a. About 78,000 pounds of sodium arsenite were applied during the period of 1953 to 1967 for aquatic weed control, as discussed in the aquatic plant management section of this report. Much of the applied arsenic was deposited in the bottom sediments and the arsenic may be released from the sediments to the water column during anaerobic conditions. Therefore, some arsenic may have been in the water during the sampling period shown in Figure 11. Since arsenic is colorimetrically equivalent to phosphorus, the normal measurement technique for phosphorus inadvertently also measures arsenic. Because of this interference, some of the phosphorus levels associated with Figure 11 may include some arsenic. Studies in Big Cedar Lake, Washington County, have indicated that in the 1960's and early 1970's, arsenic interference resulted in apparent "phosphorus" levels which were at least twice as high as the actual levels.[9]

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[8] *R. E. Carlson, "A Trophic State Index for Lakes," Limnology and Oceanography, Vol. 22, No. 2, 1977, pp. 361-369.*

[9] *Office of Inland Lake Renewal, Wisconsin Department of Natural Resources, Big Cedar Lake, Washington County, Management Alternatives, 1978.*

## Chapter V

# NATURAL RESOURCE BASE AND RECREATIONAL ACTIVITIES

## AQUATIC PLANTS

### Macrophytes

Aquatic macrophytes 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 an asset because they provide habitat for other forms of aquatic life and may remove nutrients from the water that otherwise may cause algae problems. However, aquatic plants become a nuisance when they reach heavy densities that interfere with swimming and boating activities. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate, wave action, and type of fish population present determine distribution and abundance of aquatic macrophytes in a lake.

To document the types and relative abundance of aquatic macrophytes in Lac La Belle, a survey was conducted on August 10, 1976. The vegetation was identified and quantified, and was separated into 10 lake areas, as depicted in Map 12. This map also shows the relative abundance of macrophyte growth based on the 1976 survey and on data provided by the Southeast District of the Wisconsin Department of Natural Resources. The macrophyte species, their frequency, and relative abundance are listed by lake area in Table 16. Illustrations of representative macrophyte species identified in Lac La Belle are set forth in Appendix B.

In general, the macrophyte growth in Lac La Belle is sparse to moderate. This is primarily a result of unsuitable sand and gravel plant substrates in many areas of the littoral zone, or that portion of the lake bottom to which sunlight penetrates. In addition, the presence of a large population of carp in the lake significantly reduces the amount of macrophyte growth. Carp removal could increase the amount of macrophytes in the lake. The dominant submerged macrophyte was Myriophyllum exalbescens (water milfoil). It was found in all lake areas and in moderate abundance. The second most frequently observed species was the European-introduced Potamogeton cripsus (curly-leaf pondweed). Several species of native Potamogetons were also present although they were not found in any significant concentrations. The most common emergent vegetation was Typha latifolia (cattail) and Juncus sp. (rush). These emergent species were found in lake areas 4, 6, and 8, in channels around Beggs Island in the northeast corner of the lake, and in the lake outlet. Several floating macrophyte species were sampled including Nelumbo lutea (American lotus), Nuphar sp. (yellow water lily), and Nymphaea sp. (white water lily). These floating species were found in the more silty substrates near Beggs Island. Zizania aquatica (wild rice), a valuable emergent aquatic grass which was historically present in Lac La Belle, was not sampled.

### Algae

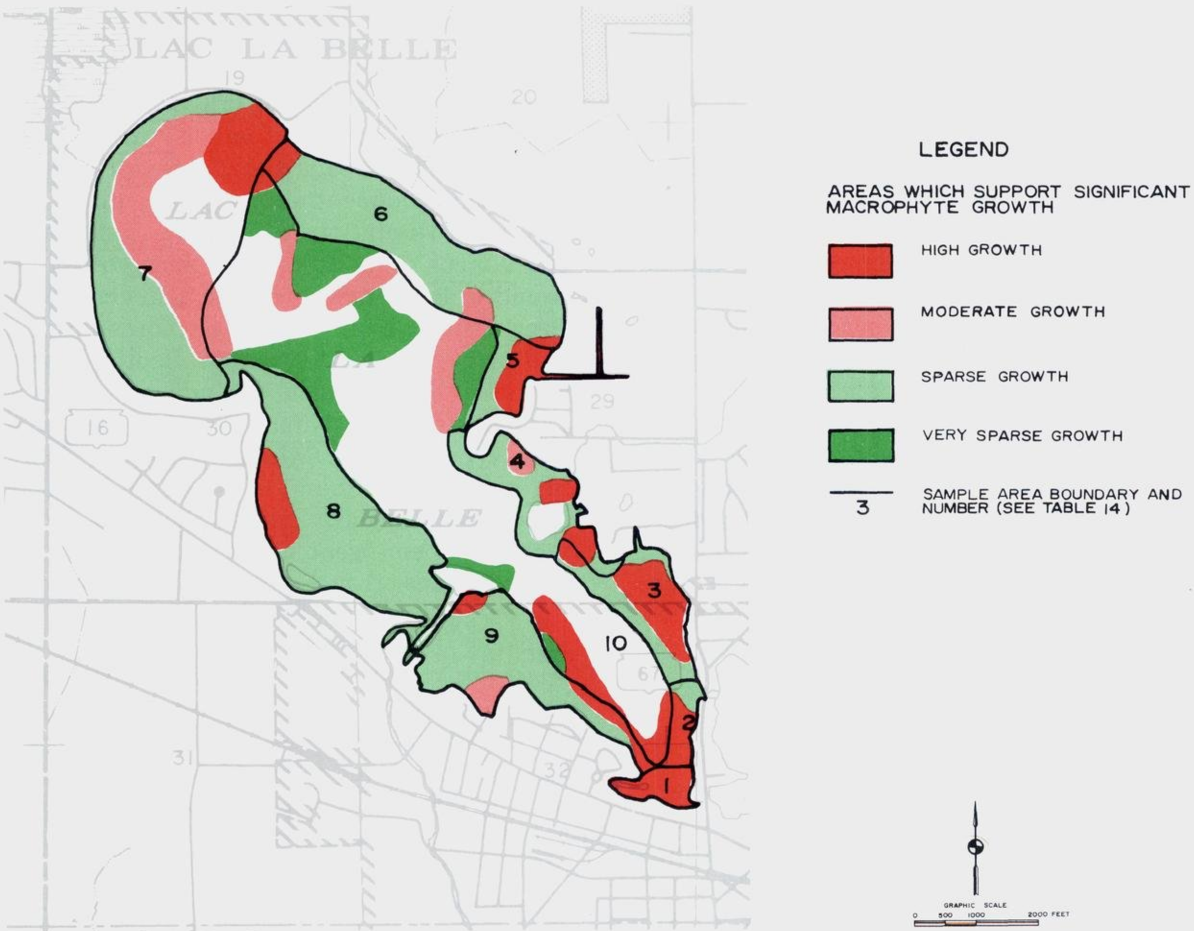
Algae are small, generally microscopic plants that are found in all lakes and streams. They occur in a wide variety of forms, in single cells or colonies, and can be either attached or free floating. Algae are primary producers that form the base of the aquatic food chain. Through photosynthesis, they 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, microscopic animals, in the lakes of southeastern Wisconsin. Blue-green algae (Cynaophyta) are not ordinarily utilized by zooplankton or fish populations, and may become over-abundant and out of balance with the organisms that feed on them. Population explosions (blooms) of blue-green algae can occur when excessive nutrient supplies are available, optimum sunlight and temperature conditions exist, and there is a lack of competition from other species.

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

Map 12

ABUNDANCE AND LOCATION OF MACROPHYTES IN LAC LA BELLE: AUGUST 1976




*Source: SEWRPC.*

conditions. The decay process consumes oxygen, sometimes depleting available supplies and resulting in fish kills. Also, certain species of decomposing blue-green algae release toxic materials into the water.

In Lac La Belle during the study year, total numbers of algae were highest during early August 1976. The lowest concentrations of algae was recorded during February 1977. On a seasonal basis, the algae populations were greatest during the summer and early autumn 1976, as set forth in Figure 12. Concentrations of algae above ninety million cells per liter (cells/liter) of lake water occurred from mid-June through mid-October 1976. During the succeeding months, algae populations declined, reaching a low of four million cells/liter by February 1977. Throughout the remainder of the winter and early spring of 1977, the algae population fluctuated around thirty million cells/liter, a level similar to the one recorded during May 1976.

The dominant group of algae found during all seasons was the blue-green algae (Cyanophyta), as set forth in Figure 13. Blue-green algae species were the most numerous present during all months except late December 1976, when Erkinia sp., a yellow-green algae, was the most abundant species. Common dominant blue-green species included Anacystis sp., Aphanocapsa delicatissima, Aphanothece sp., Aphanizomenon sp., Coelosphaerium naegelianum, Chrococcus sp., Merismopedia tenuissima and Microcystis sp. All of

Table 16

LAC LA BELLE MACROPHYTE SPECIES AND RELATIVE ABUNDANCE BY LAKE AREA: AUGUST 1976

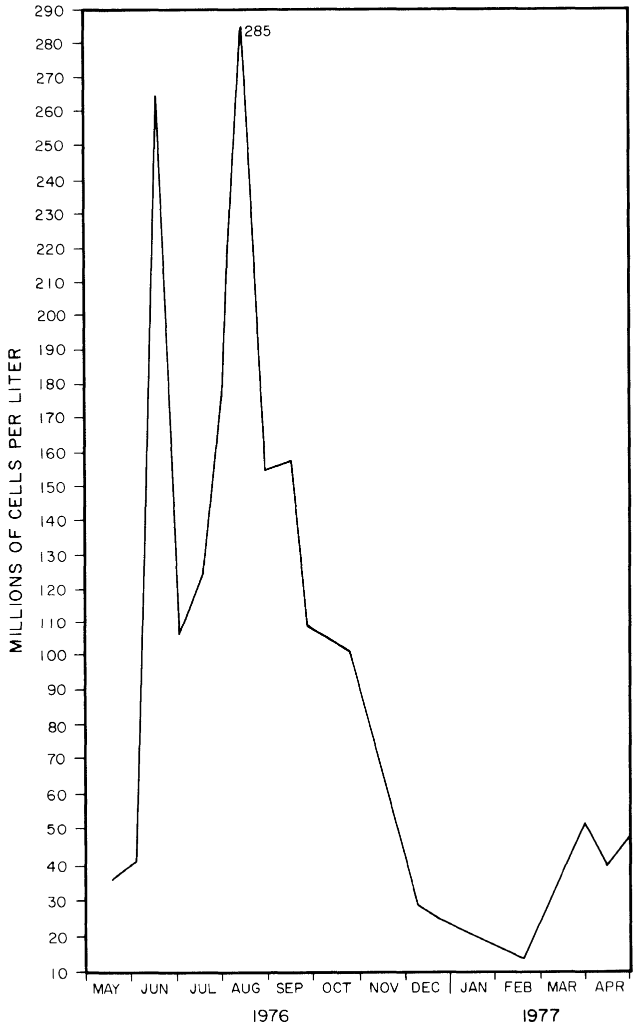
| Area | Macrophyte Species | Relative Abundance |
|---|---|---|
| 1 | Myriophyllum exalbescens. . . .<br>Potamogeton crispus . . . . . . . | Moderate<br>Sparse |
| 2 | Myriophyllum exalbescens. . . .<br>Vallisneria sp. . . . . . . . . . . .<br>Myriophyllum spicatum. . . . . | Moderate<br>Very Sparse<br>Very Sparse |
| 3 | Potamogeton crispus . . . . . . .<br>Myriophyllum exalbescens. . . .<br>Potamogeton amplifolius. . . . .<br>Myriophyllum spicatum . . . . . | Sparse<br>Moderate<br>Very Sparse<br>Sparse |
| 4 | Nymphaea sp. . . . . . . . . . . .<br>Nuphar sp. . . . . . . . . . . . .<br>Nelumbo lutea. . . . . . . . . . .<br>Myriophyllum exalbescens. . . .<br>Typha latifolia. . . . . . . . . . .<br>Potamogeton crispus . . . . . . .<br>Potamogeton amplifolius. . . . . | Very Sparse<br>Sparse<br>Sparse<br>Moderate<br>Sparse<br>Very Sparse<br>Very Sparse |
| 5 | Potamogeton pectinatus . . . . .<br>Myriophyllum sp. . . . . . . . .<br>Potomogeton amplifolius . . . .<br>Potomogeton natans . . . . . . . | Very Sparse<br>Moderate<br>Sparse<br>Sparse |
| 6 | Potomogeton crispus . . . . . . .<br>Myriophyllum exalbescens. . . .<br>Juncus sp. . . . . . . . . . . . . . | Sparse<br>Moderate<br>Very Sparse |
| 7 | Myriophyllum exalbescens. . . .<br>Potomogeton crispus . . . . . . .<br>Nuphar sp. . . . . . . . . . . . . | Sparse<br>Very Sparse<br>Very Sparse |
| 8 | Myriophyllum exalbescens. . . .<br>Potomogeton crispus . . . . . . .<br>Juncus sp. . . . . . . . . . . . . .<br>Nuphar sp. . . . . . . . . . . . . | Moderate<br>Moderate<br>Very Sparse<br>Sparse |
| 9 | Nuphar sp. . . . . . . . . . . . .<br>Potomogeton crispus . . . . . . .<br>Myriophyllum exalbescens. . . . | Sparse<br>Very Sparse<br>Sparse |
| 10 | Myriophyllum exalbescens. . . .<br>Potomogeton crispus . . . . . . . | Very Sparse<br>Very Sparse |

*Source: Wisconsin Department of Natural Resources.*

these blue-green species may occur as a floating film on the surface of the water, and because of this trait can interfere with swimming and other recreational water uses. Species other than blue-green algae which were dominant at certain times included Fragilaria crotomensis, dominant in May

Figure 12

MONTHLY ALGAE POPULATIONS FOR LAC LA BELLE: 1976-1977

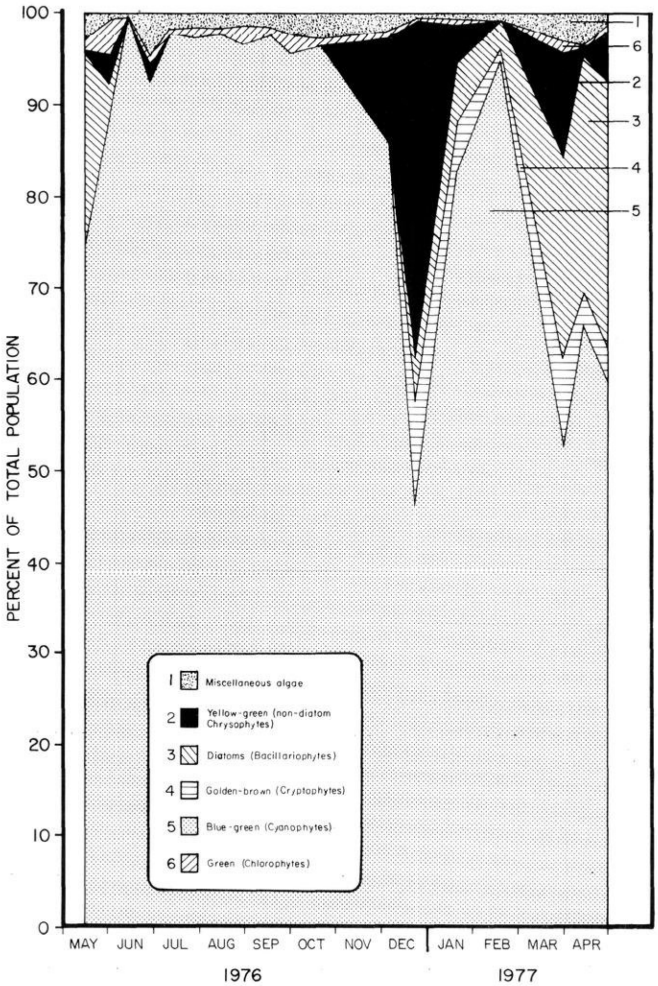



*Source: Wisconsin Department of Natural Resources.*

1976 and April 1977; Synedra radians, dominant during April 1977; and Stephanodiscus hantzii, dominant during late March 1977. These three species are diatoms and are characteristically found during periods of cool water temperature and low light intensities. An increase or bloom of diatoms occurs in the spring in many lakes in this region. During late December 1976 and January 1977, Erkinia sp., a yellow-green algae, was among the three most abundant species, as shown in Figure 13. Illustrations of representative algae species identified in Lac La Belle are presented in Appendix B.

## Figure 13

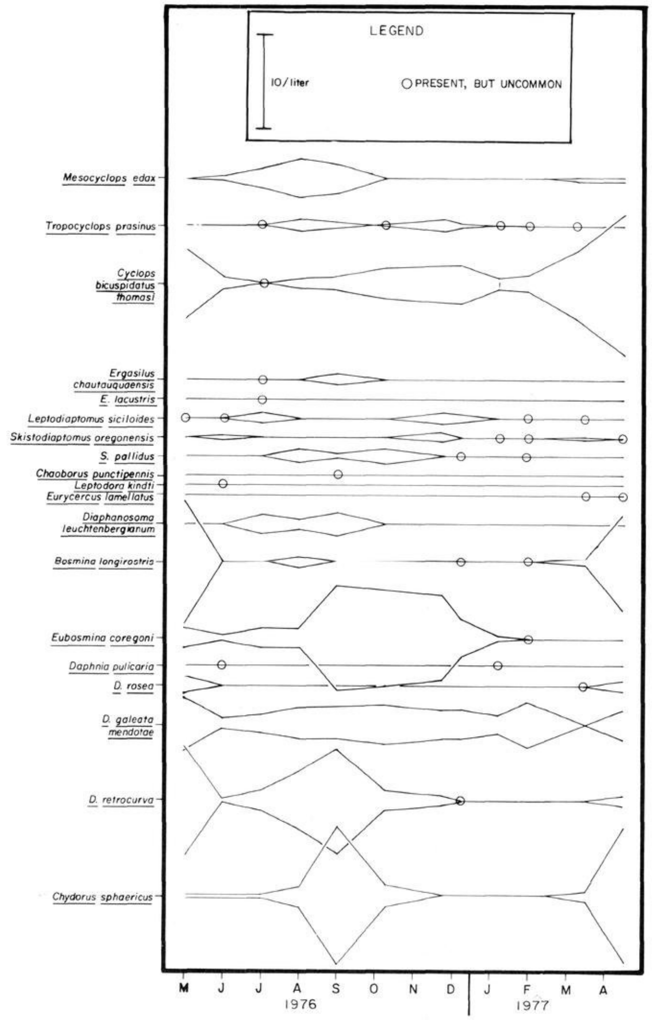
### TYPES OF ALGAE IN LAC LA BELLE: 1976-1977




*Source: Wisconsin Department of Natural Resources.*

## Figure 14

### ZOOPLANKTON SPECIES AND ABUNDANCE IN LAC LA BELLE: 1976-1977




*Source: Wisconsin Department of Natural Resources.*

Although the populations of algae reached bloom proportions in Lac La Belle in several instances during the study year, excessive accumulations along shorelines did not occur and nuisance conditions did not develop. A moderate abundance of macrophytes may have limited the growth of algae. The macrophytes and algae compete for available nutrients and sunlight, and the result of this competition is that sometimes neither the macrophytes nor the algae growth reach nuisance proportions. If the input of nutrients to the lake were to increase rapidly, however, the balance between rooted aquatics and algae could be upset in favor of the algae population. The algae can most rapidly utilize incoming nutrients, and could reproduce and increase in numbers to nuisance proportions.

## ZOOPLANKTON

Zooplankton are microscopic animals which inhabit the same environments as phytoplankton—or microscopic plants. An important link in the aquatic food chain, zooplankton feed mostly on algae and, in turn, provide a food source for fish.

During the study year of May 1976 to April 1977 20 species of zooplankton were found in Lac La Belle in varying degrees of abundance, as shown in Figure 14. The populations of most species were at their peaks in spring and early summer, although fall peaks were noted for some species. Daphnia galaeta mendotae, Daphnia retrocurva, Eubosmina coregoni, Chydorus spaericus, and Cyclops bicus-

Table 17

ZOOPLANKTON SPECIES IDENTIFIED IN LAC LA BELLE: 1974-1975 AND 1976-1977

| | | 1974-1975[a] | 1976-1977 |
|---|---|---|---|
| Class Crustacea | | | |
| Subclass: | Copepoda | | |
| Order: | Cyclopoida | | |
| | Cyclops bicupidatus thomasi | X | X |
| | Mesocyclops edax | X | X |
| | Acanthocyclops vernalis | X | -- |
| | Tropocyclops prasinus | X | X |
| | Eucyclops speratus | X | -- |
| | Ergasilis chautauquiensis | -- | X |
| Order: | Calanoida | | |
| | Skistodiaptomus oregonensis | X | X |
| | Skistodiaptomus pallidus. | X | X |
| | Leptodiaptomus siciloides | X | X |
| | Epishura lacustris | X | X |
| Subclass: | Branchiopoda | | |
| Order: | Cladocera | | |
| | Daphnia galeata mendotae | X | X |
| | Daphnia pulicaria | X | X |
| | Daphnia ambigua | X | -- |
| | Daphnia retrocurva | X | X |
| | Daphnia rosea | -- | X |
| | Bosmina longirostris | X | X |
| | Eubosmina coregoni | X | X |
| | Diaphanosoma leuchtenbergianum | X | X |
| | Leptodora kindtii | X | X |
| | Chydorus sphaericus | X | X |
| | Eurycercus lamellatus | -- | X |
| | Alona guttata | -- | X |
| Class Insecta | | | |
| Order: | Diptera | | |
| | Chaoborus punctipennis | -- | X |

[a]*Byron G. Torke, Crustacean Zooplankton Data for 190 Selected Wisconsin Inland Lakes, Wisconsin Department of Natural Resources Research Report No. 101, 1979.*

*Source: Wisconsin Department of Natural Resources.*

pidatus thomasi were the dominant animals in the zooplankton community. A list of zooplankton found are set forth in Table 17.

The cyclopoid copepod Cyclops bicuspidatus thomasi is one of the most common zooplankton throughout Wisconsin. In Lac La Belle, it was most prominent during winter and spring. Other copepods found in Lac La Belle were: Mesocyclops edax, Tropocyclops prasinus, and Ergasilis chautauquiensis. The females of the latter species are parasitic on the gills of fish and only the males and larval forms are free-swimming.

Zooplankton data are also available for 1974 and 1975. In analyzing zooplankton collections from Lac La Belle during this period, Torke found, in addition to the adove species, Acanthocyclops vernalis and Eucyclops speratus, as also set forth in Table 17. Ergasilis chautauquiensis was not noted by Torke.[1]

[1]*Byron G. Torke, Crustacean Zooplankton Data for 190 Selected Wisconsin Inland Lakes, Wisconsin Department of Natural Resources Research Report No. 101, 1979.*

The copepods Leptodiaptomus siciloides, Skistodiaptomus oregonensis, Skistodiaptamus paddidus and Epishura lacustris represented the calanoid copepods during the study period. These same species were also found by Torke. Most are typical of meso- or eutrophic conditions.

Daphnia galeatea mendotae was the most abundant daphnid, as in most lakes in Wisconsin, and is present nearly year-round at stable population numbers. D. retrocurva was the second-most abundant daphnid in Lac La Belle. Eubosmina coregoni, although a small animal, is numerically dominant throughout the fall and most of the winter. Similarly, Bosmina Longirostris is most common in the spring. The phantom midge Chaoborus punctipennis, the cladoceran Leptodora kindtii and the copepods Mesocyclops edax and Ephishura lacustris are predacious on other zooplankton. An illustration of a representative zooplankton species identified in Lac La Belle is set forth in Appendix B.

In general, fish are selective feeders and consume the largest zooplankton available. As fish food organisms, the large cladocerans found in Lac La Belle, (Daphnia pulicaria, Diaphanosoma leuchtenbergianum, and Leptodora kindtii) are of primary importance. Their large size causes them to be more common in fish diets than copepods which, because of their smaller size, as well as their ability to hang motionless and to make sudden jumps, are not as common a food item.

FISH

Lac La Belle supports a large and diverse fish community. Wisconsin Department of Natural Resources survey reports indicate that from 1946 to 1974, 29 different fish species were captured in the lake, as shown in Table 18. None of these is currently considered to be rare or endangered species. Although extensive surveys were made and several different techniques were employed in sampling the community, the species list probably is not complete; additional species are known to be present in other lakes in the Oconomowoc River chain and are probably present in Lac La Belle as well. Illustrations of representative fish species identified in Lac La Belle are set forth in Appendix B.

According to survey reports and other documents in Wisconsin Department of Natural Resources files, the fish populations and consequently the sport fishing in the lake have changed significantly over the years.[2] In 1946, Lac La Belle was best known for its panfish. Bluegills were numerous and exhibited better than average growth rates. Rock bass and white bass were also abundant. Walleyes were found to be the predominant game fish, while few northern pike or largemouth bass were caught. Good fishing was reported periodically through the 1950's, with bluegills and perch making up about 80 percent of the catch. Walleyes and northern pike were the most often caught game fish. Growth rates for all game and panfish species were average or better than average.

**Table 18**

**SPECIES OF FISH CAPTURED IN LAC LA BELLE: 1946-1974**

| Common Name | Scientific Name |
|---|---|
| Northern pike | Esox lucius |
| Walleye | Stizostedion vitreum vitreum |
| Largemouth bass | Micropterus salmoides |
| Smallmouth bass | Micropterus dolomieui |
| Bluegill | Lepomis macrochirus |
| Pumpkinseed | Lepomis gibbosus |
| Green sunfish | Lepomis cyanellus |
| Rock bass | Ambloplites rupestris |
| Yellow perch | Perca flavescens |
| Black crappie | Pomoxis nigromaculatus |
| White bass | Morone chrysops |
| White sucker | Catostomus commersoni |
| Bluntnose minnow | Pimephales notatus |
| Logperch | Percina caprodes |
| Banded killifish | Fundulus diaphanus |
| Mimic shiner | Notropis volucellus |
| Johnny darter | Etheostoma nigrum |
| Pirate perch | Aphredoderus sayanus |
| Black bullhead | Ictalurus melas |
| Brown bullhead | Ictalurus nebulosus |
| Yellow bullhead | Ictalurus natalis |
| Carp | Cyprinus carpio |
| Longnose gar | Lepisosteus osseus |
| Bowfin | Ami calva |
| Golden shiner | Notemigonus crysoleucas |
| Brook silversides | Labidesthes sicculus |
| Blackstripe topminnow | Fundulus notatus |
| Mudminnow | Umbra limi |
| Buffalo | Ictiobus bubalus or Ictiobus cyprinellus |

*Source: Wisconsin Department of Natural Resources.*

[2] *J. A. Holzer, Basic Inventory Report for Lac La Belle, Waukesha County, DNR Fish Management Report, 1975.*

The most recent fish population inventory was made during 1974, when an intensive sampling program was carried out. Table 19 presents the results of the survey and provides evidence that the fish communities have changed since 1946. As was the case in the earlier surveys, bluegills were the most abundant fish in the 1974 catch, but the size range indicates smaller bluegills than previously found. Age and growth data depicts below average growth for all year classes of bluegills and other panfish species. Fair numbers of game fish were captured, but their relative abundance was low, being below the carrying capacity of the lake. The large population of white bass evident in the lake during the 1940's was not found in 1974.

Large numbers of carp were caught in the 1974 survey, more than the total for all game fish species combined. It is not known when carp were introduced into Lac La Belle, but they were present when the earliest surveys were made. Seinings for carp and buffalo fish were conducted from the 1930's through the 1950's. Unfortunately, the actual number of seinings and the number of rough fish removed were not recorded. However, early survey reports indicate that game fish and panfish populations were healthy and not seriously affected by the carp populations. Based on the 1974 inventory, carp appear to have increased significantly over the years. In 1972, the Department of Natural Resources and the U. S. Bureau of Sport Fisheries and Wildlife prepared a plan to chemically remove a portion of the carp population in Lac La Belle.[3] However, due to a lack of funds, Lac La Belle was never chemically treated.[4] As of 1980, the Department fish manager reported that because public access fees are excessive, the Department was not surveying the fishery resources in the lake and would not undertake any management activities.[5]

**Table 19**

**SUMMARY OF 1974 FISH POPULATION SURVEY OF LAC LA BELLE**

| Species | Number | Size Range (inches) |
|---|---|---|
| Bluegills | 9,700 | 1.3-7.8 |
| Crappies | 4,500 | 5.2-13.2 |
| Carp | 2,264 | 10.9-26.7 |
| Pumpkinseed | 1,100 | 2.6-4.5 |
| Rock Bass | 1,100 | 2.5-9.4 |
| Perch | 420 | 5.2-9.5 |
| Bullheads | 150 | 9.0-9.5 |
| Largemouth bass | 82 | 2.1-18.0 |
| Walleye | 69 | 3.2-28.0 |
| Northern pike | 47 | 5.9-36.4 |
| Smallmouth bass | 35 | 2.0-11.5 |
| Green Sunfish | 22 | 1.3-4.2 |
| Buffalo | 4 | 20.0-25.0 |
| White bass | 2 | 11.5-13.2 |

*Source: Wisconsin Department of Natural Resources.*

BENTHOS

The benthic macroinvertebrate communities of lakes can be used to assess a lake's water quality and recent history. These organisms are an important part of the food web, acting as food and as processors of the organic material that accumulates on the lake bottom. Some species 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. These populations fluctuate most during the summer months. Consequently, early spring or winter sampling is most reliable. The stable population thus found will best reflect the lake's character.

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[3] *Wisconsin Department of Natural Resources and the U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Final Environmental Impact Statement for Fishery Rehabilitation of the Rock River: Dane, Dodge, Columbia, Fond du Lac, Green Lake, Jefferson, Rock, Washington, Walworth, and Waukesha Counties, Wisconsin, 1972.*

[4] *Information provided by Randy Schumacher, DNR Fish Manager, July 2, 1980.*

[5] *Ibid.*

Table 20

BENTHIC FAUNA OF LAC LA BELLE: 1976-1977

| Species | Larval Number per Square Meter and Percentages at Sites | | | | | |
|---|---|---|---|---|---|---|
| | 1976 | | | 1977 | | |
| | L-1 | L-2 | L-3 | L-1 | L-2 | L-3 |
| Class: Insecta | | | | | | |
| Order: Diptera | | | | | | |
| Family: Chaoboridae | | | | | | |
| Chaoborus punctipennis | 460 | 62 | 292 | 210 | 69 | 7 |
| (percent) | 92 | 25 | 93 | 62 | 27 | 13 |
| Family: Chironomidae | | | | | | |
| Procladius species | - - | 7 | - - | 30 | 16 | 6 |
| (percent) | - - | 3 | - - | 9 | 6 | 12 |
| Chironomus attenuatus | - - | 98 | 7 | 1 | 10 | - - |
| (percent) | - - | 39 | 2 | <1 | 4 | - - |
| Chironomus plumosus | 33 | 39 | - - | 98 | 160 | 39 |
| (percent) | 7 | 16 | - - | 29 | 63 | 75 |
| Parachironomus species | 7 | 43 | 16 | - - | - - | - - |
| (percent) | 1 | 17 | 5 | - - | - - | - - |
| Total Larvae per Square Meter | 500 | 249 | 315 | 339 | 255 | 52 |
| Number of Species | 3 | 5 | 3 | 4 | 4 | 3 |

*Source: Wisconsin Department of Natural Resources.*

Lac La Belle was sampled in the early springs of 1976 and 1977 prior to pupation and adult emergence. Samples were collected in the three deepest areas of the lake, as set forth in Map 3. The larvae were picked from the debris, counted, and classified. Larvae of the Chironomidae were not reared to adult stages and therefore species names must be considered tentative.

The benthic fauna of Lac La Belle is composed of five species, as set forth in Table 20. The predominant species are the midges Chaoborus punctipennis, Chironomus attenuatus, and Chironomus plumosus. The latter two plus the midge Parachironomus sp. comprise the omnivorous portion of the fauna and feed upon organic matter that comes into contact with their mud burrows. The carnivores are both planktonic—or free-floating—(Chaoborus punctipennis) and benthic—or bottom dwelling—(Procladius sp.). Chaoborus spends the daylight hours in or adjacent to the mud substrate and migrates vertically into the water column at night to feed upon zooplankton. Procladius is restricted to the bottom muds and actively seeks its prey, which consists of micro-crustacea and small insect larvae, predominantly the young of the benthic species present. The large number of Procladius present in 1977 could, therefore, account for the absence of the small midge Parachironomus from the sample. The population of Chaoborus varies with the population of its food supply and predation by fish and other organisms. The two years of sampling did not show any trends; the changes in observed numbers are more likely the result of normal population shifts.

The fauna present is typical of profundal areas that experience short anoxic conditions during the summer and winter stagnation periods. The presence of the two midges Chironomus attenuatus and Chironomus plumosus indicates that this lake is in an early eutrophic state. Chironomus plumosus is generally associated with lakes of eutrophic and extreme eutrophic status, while Chironomus attenuatus is associated with mesotrophic lakes. A shift in status to a more eutrophic condition would favor a larger population of Chironomus plumosis and a reduced population of Chironomus attenuatus, Parachironomus, and Procladius. The loss of these species would reduce available fish food and indicate a reduced area of fishery habitat. A representative benthic invertebrate identified in many southeastern Wisconsin lakes is illustrated in Appendix B.

## WILDLIFE

Wildlife habitat areas were initially inventoried by the Regional Planning Commission in 1963 and this initial inventory was updated in 1970 for the Commission by the Wisconsin Department of Natural Resources, Bureau of Research. The wildlife habitat areas were classified by the Commission as deer, pheasant, waterfowl, muskrat-mink, songbird, squirrel, 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 also provide squirrel and songbird habitat as well.

The five major criteria used to determine the value of these wildlife habitats are as follows:

1. Diversity—An area must maintain a high but balanced diversity of species for a temperate climate; balanced in that the proper predator-prey (consumer-food) relationships can occur. Also, 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 only occur 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 close 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 habitats in the Lac La Belle 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, and are generally located in proximity to other wildlife habitat areas.

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 close proximity to other medium- and/or high-value wildlife 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 13, Lac La Belle has little waterfowl or wildlife habitat located along its shores, but it does have several outlying low-value deer wildlife habitat areas within its watershed. Other wildlife habitat areas within the Lac La Belle drainage basin include medium-value waterfowl habitat and low-value pheasant and squirrel wildlife habitat. There is no information available at this time concerning the hunting and trapping pressure in the Lac La Belle drainage basin.

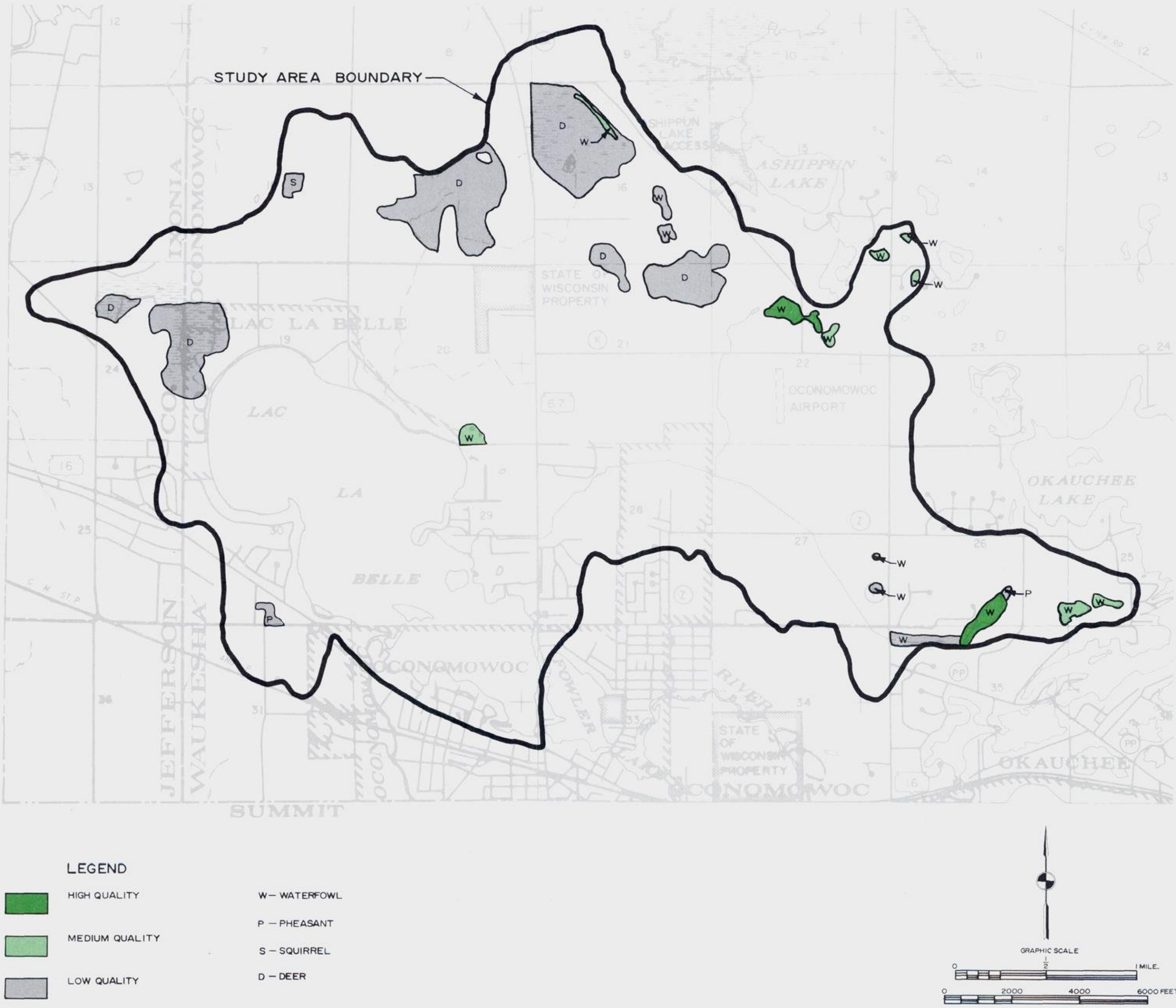
## WOODLANDS

Woodlands in southeastern Wisconsin are defined as those areas which contain 17 or more trees per acre which have a four inch diameter at breast height. In addition, the native woodlands are classified as dry, dry-mesic, mesic, wet-mesic, wet hardwood, and conifer swamp forests. The drainage area directly tributary to Lac La Belle contains five of the six native woodland classifications.

Specifically, woodland in the Lac La Belle drainage basin includes conifer, or tamarack swamps, and southern wet to southern wet-mesic hardwood forests which are characterized by black willow, (Salix nigra), cottonwood (Populus deltoides), green ash (Fraxinus pennsylvanica), silver maple (Acer saccharinum), and American elm (Ulmus americana); southern mesic hardwood forests

Map 13

**WILDLIFE HABITAT IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE**



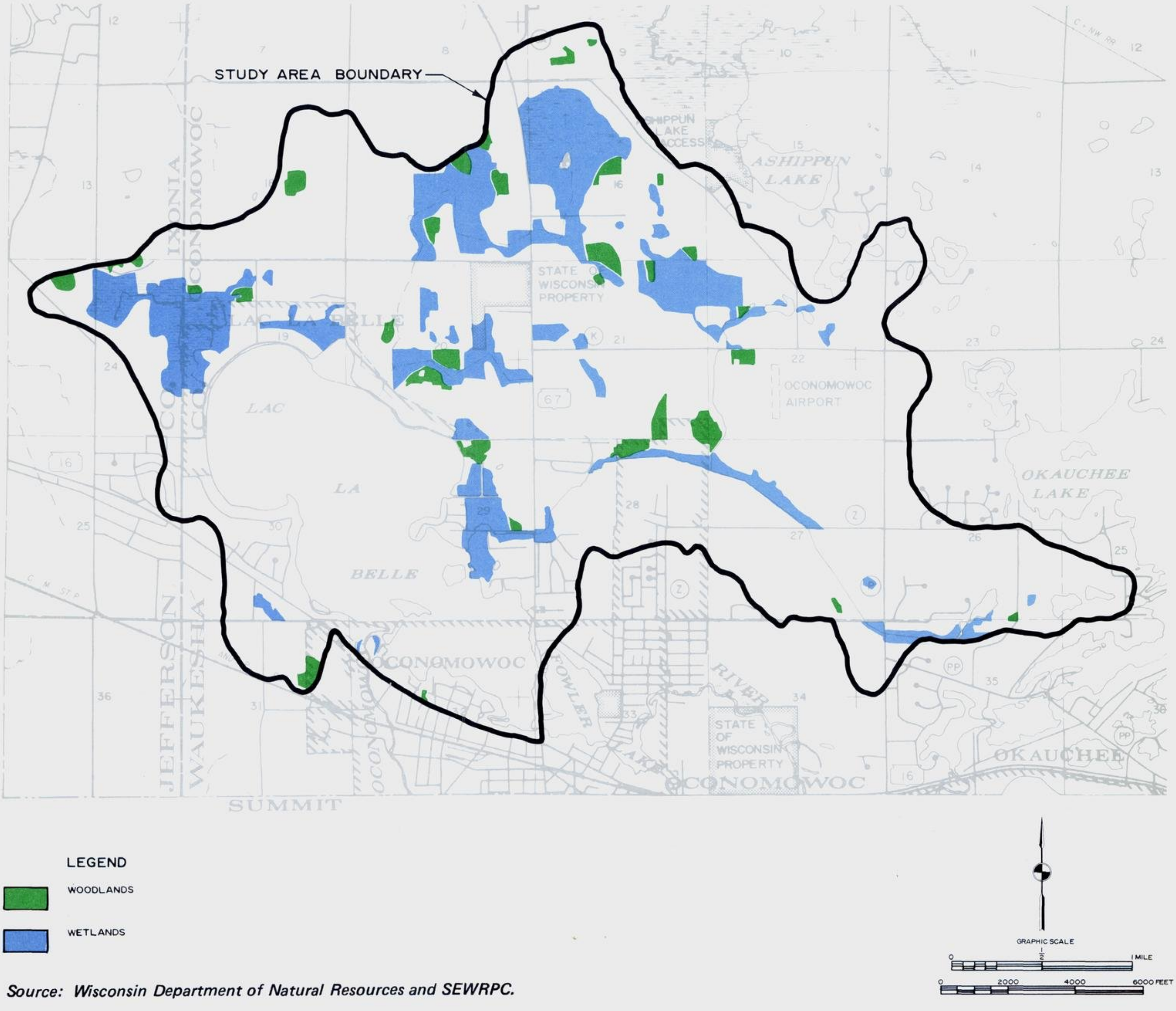

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

which are characterized by sugar maple (Acer saccharum), and basswood (Tilia americana); and southern dry-mesic hardwood forests which are characterized by northern red oak (Quercus borealis) and shagbark hickory (Carya ovata). Woodlands in the direct drainage area are shown on Map 14.

Within the Lac La Belle drainage basin, woodlands are scattered in relatively small stands and are generally associated with wetland complexes in the northern portion of the drainage basin. Isolated stands of good quality tamarack (Larix laricina) swamps are located in Sections 16, 17, 19, and 21, Town 8 North, Range 17 East.

Map 14

WOODLANDS AND WETLANDS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1975




Source: Wisconsin Department of Natural Resources and SEWRPC.

WETLANDS

In addition to the lowland forests described above, wetlands in southeastern Wisconsin are classified as shrub carr, fresh (wet) meadow, southern sedge meadow, low prairie, fens, bogs, shallow marsh, and deep marsh. The major wetland communities located in the drainage area directly tributary to Lac La Belle, shown on Map 14, include sedge meadows, fresh (wet) meadow, shrub carr, bog, and shallow marsh.

Sedge meadows are considered to be stable wetland plant communities that tend to perpetuate themselves if dredging activities and water level changes are prevented from occurring. Sedge meadows in southeastern Wisconsin are characterized by the Tussock sedge (Carex stricta) and to a lesser extent, by Canada 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, contained an abundance of willows (Salix sp.) and red osier dogwood (Cornus stolonifera). In extremely disturbed shrub carrs, the willows, red osier dogwoods, and sedges are replaced by such exotic plants as honeysuckle (Lonicera sp.), buckthorn (Rhamnus sp.), and the very aggressive reed canary grass (Phalaris arundinacea). The highest quality southern sedge meadow in the drainage basin is in a wetland complex located on the northwest side of the lake in Section 19, Town 8 North, Range 17 East. This 3.7-acre southern sedge meadow is considered to be a natural area of county or regional significance.

Fresh (wet) meadows are essentially lowland grass meadows which are dominated by Canada bluejoint grass and forbes such as Marsh (Aster simplex), red-stem (Aster puniceus) and New England (Aster Novae-angliae) asters, and giant goldenrod (Solidago gigantea). Several disturbed fresh (wet) meadows are located throughout the Lac La Belle drainage basin and are largely associated with southern sedge meadows and shrub carr. Many of these wetlands have been subject to grazing and plowing and are subsequently dominated by reed canary grass, rather than Canada bluejoint grass.

Several small shallow marshes are scattered throughout the northern portion of the direct tributary drainage area. The larger shallow marshes are predominantly located in the northeast portion of the watershed. The shallow marshes are dominated by the broad leaf and narrow leaf cattail (Typha spp.) and their hybrids, as well as lake sedge (Carex lacustris) and bullrush (Scirpus sp.).

A large bog—the Raasch tamarack bog—is located in Section 16, Town 8 North, Range 17 East. This 100-acre bog is dominated by tamarack, leather leaf (Chamaedaphne calyculata), and sphagnum moss (Sphagnum sp.). However, ditching, dredging, and some selective cutting of the tamarack have degraded the bog and allowed the European buckthorn (Rhamnus frangula) to invade this wetland. The Raasch tamarack bog has been identified as a natural area of local significance.

RECREATIONAL USE

Lac La Belle—which has a large water surface area generally free of shallow areas, free of excessive algae growth, and free of underwater hazards—provides opportunities for a variety of water-based outdoor recreational activities, including boating, fishing, swimming, and nature study. Boating is the most popular summer outdoor recreation activity on Lac La Belle. Aerial surveys of boating activity on Lac La Belle on two weekends during August 1976, indicated that the lake is heavily used, particularly on weekends, and that pleasure boating, as well as sailing and waterskiing, comprise the major portion of boating activity.

Fishing is also an important but less popular summer outdoor recreation activity on Lac La Belle. As discussed above, Lac La Belle provides a high quality habitat for smallmouth and largemouth bass, northern pike, walleye, and panfish; and a proposed fish management program seeks to improve the Lac La Belle fishery.

Swimming at beaches is also a popular outdoor recreation activity. Lac La Belle—which has many fine, natural sand and gravel beaches and suitable water quality—provides an excellent swimming resource. There is, however, only one major public swimming beach on Lac La Belle. This beach is approximately 200 feet long and is owned by the City of Oconomowoc. An additional shoreline area owned by the City of Oconomowoc and located adjacent to STH 67 is also used for swimming activities by the public.

Nature study opportunities are provided by the small marsh areas on the eastern and northern shores of Lac La Belle. Deer, muskrat, pheasant, and limited numbers of ducks use these areas on a year-round basis, and a small number of diving ducks and large numbers of coot use the lake as a rest stop during the spring and autumn migrations. In addition, spawning northern pike and walleye congregate near the Fowler Lake dam located on the eastern side of the lake and the carp barrier located at the outlet of Lac La Belle in the southwestern side of the lake.

Public boat access sites provide an opportunity for the general public to participate in water-based outdoor recreation activities. Such sites consist of a boat launch area which permits the launching

Table 21

PUBLIC ACCESS SITES ON LAC LA BELLE: APRIL 1976

| Location | Owner | Type | Area (acres) | Lake Frontage (feet) | Available Spaces: Car/ Trailers | Available Spaces: Cars |
|---|---|---|---|---|---|---|
| Town 8 North, Range 17 East, | | | | | | |
| Section 20 | Town | Walk-in-trail roadside | 0.50 | 1,000 | 0 | 0 |
| 29 | Town | Walk-in-trail roadside | 0.10 | 20 | 0 | 0 |
| 29 | Town | Walk-in-trail | 0.10 | 40 | 0 | 0 |
| 30 | Town | Walk-in-trail roadside | 0.25 | 1,000 | 0 | 0 |
| 32 | City | Ramp | 0.25 | 170 | 25 | 20 |
| 32 | City | Walk-in-trail | 0.10 | 40 | 0 | 0 |
| 32 | City | Walk-in-trail | 0.10 | 40 | 0 | 0 |
| 32 | City | Walk-in-trail ramp | 0.50 | 40 | 0 | 4 |
| 32 | Private | Livery | 0.25 | 100 | 0 | 8 |

*Source: Wisconsin Department of Natural Resources, Southeast District Office.*

and beaching of boats, and often includes an area for the parking of automobiles and trailers. The Wisconsin Department of Natural Resources, under guidelines established in the Wisconsin Administrative Code, Chapters NR 1.90 and NR 1.92, and SEWRPC, under the adopted regional park and open space plan, recommend that at least one such boat access site open to the general public be provided on all large inland lakes. On Lac La Belle, this recommendation is met by the publicly owned—City of Oconomowoc—boat access site which provides a boat launch ramp and 20-car parking spaces and 25-car/trailer parking spaces. In addition to this boat access site, there are seven publicly owned sites and one nonpublicly owned site which provide access to the lake shoreline. As indicated in Table 21, six of these sites do not provide associated parking opportunities. It is important to note that virtually the entire shoreline surrounding Lac La Belle has been developed for intensive urban-type residential use, thereby providing a large number of private landowners with ready access to Lac La Belle.

In general, Lac La Belle provides opportunities for a variety of outdoor recreation activities in a high-quality setting. As of the study year, only a few problems, such as summer weekend boating congestion, occasional nuisance algae blooms, and a major carp problem, were considered limitations on the resource value of the lake for water-based outdoor recreation. An outdoor recreational rating technique was developed to summarize the outdoor recreational value of inland lakes. As shown on Table 22, Lac La Belle scored 58 points out of a possible 72 points, placing it among those lakes in southeastern Wisconsin providing diverse, high quality outdoor recreation opportunities. In order to assure that Lac La Belle will continue to provide such recreation opportunities, the resource values of the lake must be protected and preserved.

Table 22

**RECREATIONAL RATING OF LAC LA BELLE: 1976**

| | | | | | |
|---|---|---|---|---|---|
| Boating: | | | | | |
| X | 6 Adequate depths (>75 percent of basin 5 feet) | | 4 Adequate depths (50-75 percent of basin 5' deep) | | 2 Adequate depths (< 50 percent of basin) |
| X | 6 Adequate size for extended boating (>1,000 acres) | | 4 Adequate size for some boating (200-1,000 acres) | | 2 Limit of boating challenge and space (< 200 acres) |
| | 6 Good water quality | X | 4 Some inhibiting factors such as weedy bays, algae blooms, etc. | | 2 Overwhelming inhibiting factors such as weed beds throughout |
| Subtotal: 16 | | | | | |
| Fishing: | | | | | |
| | 9 High production | X | 6 Medium production | | 3 Low production |
| | 9 No problems | X | 6 Modest problems such as infrequent winterkill, small rough fish problems | | 3 Frequent and overbearing problems such as winter-kill, carp, excessive fertility |
| Subtotal: 12 | | | | | |
| Swimming: | | | | | |
| X | 6 Sand or gravel (75 percent or more) | | 4 Sand or gravel (25-75 percent) | | 2 Sand or gravel (< 25 percent) |
| X | 6 Clean water | | 4 Moderately clean | | 2 Turbid or darkly stained |
| | 6 No algae or weed | X | 4 Moderate algae or weed problems | | 2 Frequent algae or weed problems |
| Subtotal: 16 | | | | | |
| Aesthetics: | | | | | |
| | 6 Existence of 25 percent or more wild shore | X | 4 Less than 25 percent wild shore | | 2 No wild shore |
| X | 6 Varied landscape | | 4 Moderately varied landscape | | 2 Unvaried landscape |
| | 6 Few nuisances such as excessive algae, carp, dumps, etc. | X | 4 Moderate nuisance conditions | | 2 High nuisance conditions |
| Subtotal: 14 | | | | | |
| Total Quality Rating: 58 out of a possible 72 | | | | | |

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

# Chapter VI

# EXISTING MANAGEMENT AND LEGAL CONSIDERATIONS AFFECTING WATER QUALITY

## SEWAGE DISPOSAL

### Onsite Sewage Disposal Systems

As of 1975, the sanitary and household wastewaters from an estimated 2,561 persons, or about 78 percent of the total resident population of the drainage area directly tributary to Lac La Belle, were treated and disposed of through the use of onsite systems. The location and extent of urban development which relied on such onsite sewage disposal systems as of 1975 is shown on Map 15. An onsite sewage disposal system may be a conventional septic tank system, a mound system, or a holding tank. As of 1975, there were 722 septic tank systems, no known holding tanks, and one mound system known to exist in the direct tributary drainage area.[1]

The septic tank system consists of two components: a septic tank 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 basin intended to separate floating and settleable solids from the liquid fraction of domestic sewage and to discharge liquid, together with its burden of dissolved particulate solids, into the biologically active zone of the soil mantle to a subsurface percolation system. The discharge system may be a tile field, a seepage bed, or an earth-covered sand filter. The liquid passes through the active soil zone and percolates downward until it strikes an impervious layer or groundwater. Thus, the purpose of the percolation system is to dispose of sewage effluents by utilizing the same processes which lead to the accumulation of groundwater.

[1] *As of October 1979, there were three holding tanks and six mound systems known to exist in the direct tributary drainage area.*

Providing that the system is located, installed, used, and maintained properly, and that there is an adequate depth—at least four to five feet—of moderately permeable unsaturated soil below the drainage field, the system should operate with few problems for periods of up to 20 years. However, as previously noted, not all residential development within the drainage area directly tributary to Lac La Belle is located in areas covered by soils suitable for septic tank 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 such a system's use, from improper design or installation of the system, or from inadequate maintenance of the system. 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 tank problems requires a sanitary survey. Such a survey has not been conducted in the lake watershed by the Waukesha County Board of Health.

### Sanitary Sewer Service

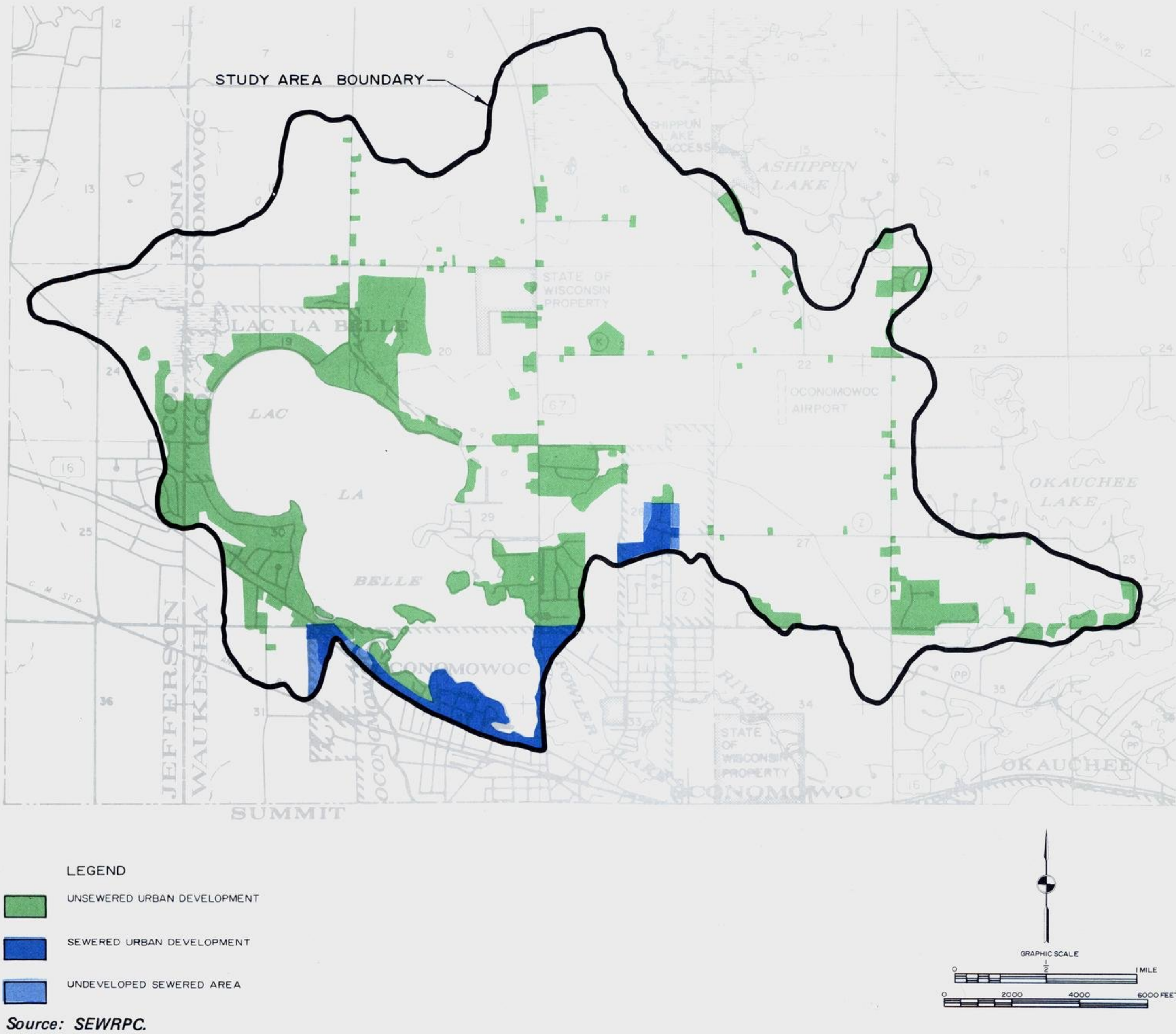
About 739 persons, or about 22 percent of the resident population of the Lac La Belle direct tributary drainage area, receive sanitary sewer service from the City of Oconomowoc. The existing sanitary sewer service area is also shown on Map 15, and includes about 154 acres, or about 9 percent, of the urban development in the direct tributary 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

Map 15

## EXISTING LOCATION AND EXTENT OF SEWERED AND UNSEWERED URBAN DEVELOPMENT IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1975




*Source: SEWRPC.*

proper use of lands within their area of jurisdiction. The drainage area directly tributary to Lac La Belle includes all of the Village of Lac La Belle, portions of the City of Oconomowoc, and the Town of Oconomowoc, all in Waukesha County, and the Town of Ixonia, located in Jefferson County. Consequently, four zoning ordinances are administered within the Lac La Belle drainage area. The zoning ordinance currently in effect within the Town of Oconomowoc is administered jointly by the Town and Waukesha County. The ordinance was initially approved and adopted by Waukesha County in February 1959, ratified by the Town in April 1959, and was most recently amended in September

1979. The City of Oconomowoc zoning ordinance was initially approved and adopted by the City in July 1952, and was most recently amended in February 1980. The Village of Lac La Belle zoning ordinance was initially approved and adopted by the Village in July 1931, and was most recently amended in October 1969. The zoning ordinance for the Town of Ixonia is administered jointly by the Town and Jefferson County. The ordinance was initially approved and adopted by Jefferson County in December 1975, and was most recently amended in December 1977, A summary of the zoning districts currently available for use in the four civil divisions is presented in Table 23. The areas of land placed in each of the districts are shown graphically on Map 16 and are quantified in Table 23.

In addition to the general Waukesha County Zoning Ordinance, administered in the Town of Oconomowoc, 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 within 300 feet of the landward side of the floodplain, whichever is greater. The shoreline and floodplain zoning map applicable to the portion of the Town of Oconomowoc located within the Lac La Belle direct drainage area was prepared and adopted in 1970 and amended in February 1980, as shown on Map 17.

The availability of 78 percent of the total Lac La Belle direct drainage area for essentially urban and suburban land uses under the existing zoning ordinances encourages the diffusion of urban-type development throughout the drainage area in a manner that conflicts with the recommendations contained in the adopted regional land use and water quality management plans. In order to prevent undesirable urban development in the lake watershed, it will be necessary for the appropriate persons in the four civil divisions to critically review the individual zoning ordinances and accompanying zoning district maps for the Lac La Belle direct drainage area and amend the ordinances and district maps so as to preserve and enhance the existing natural resource base of the drainage area directly tributary to Lac La Belle.

## AQUATIC PLANT MANAGEMENT

Efforts to manage the aquatic plants in Lac La Belle have been made yearly for over 30 years. Records of aquatic plant management were not maintained prior to 1950. Aquatic plant management for Lac La Belle can be categorized as macrophyte harvesting, chemical macrophyte control, and chemical algae control.

### Macrophyte Harvesting

The Town and City of Oconomowoc have historically conducted an aquatic macrophyte harvesting program on Lac La Belle, Okauchee Lake, Fowler Lake, and Upper Oconomowoc Lake, beginning in the 1960's. The Town no longer harvests aquatic weeds, but the City has a continuing harvesting program on Lac La Belle. Approximately 2,000 acres of weeds have been harvested from these lakes each year and disposed of at a sanitary landfill site or used as mulch. Although the macrophyte harvesting in Lac La Belle is primarily conducted to provide open water areas and thereby improve the aesthetic quality and usability of the lake, some beneficial nutrient removal from the lake may also occur since macrophytes are able to utilize nutrients from the bottom sediments as well as from the water column.

### 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, and no other chemicals were applied in significant amounts to control macrophytes. The first recorded application of sodium arsenite to Lac La Belle was in 1953. As set forth in Table 24, sodium arsenite was applied to Lac La Belle each year from 1953 through 1967. In all, since 1953, 77,858 pounds of sodium arsenite have been applied to the lake. As shown in Table 25, Lac La Belle has received the seventh largest amount of sodium arsenite in the State.

The sodium arsenite was usually sprayed—see Figure 15—within 200 feet of the shoreline. Treatment typically occurred only once per year, in

# Table 23

## SUMMARY OF EXISTING GENERAL ZONING DISTRICTS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1980

| Zoning District | Permitted Uses | | Conditional/Special Uses | Area Regulations: Minimum Lot Size | | Civil Division Area Zoned Within Direct Drainage Area (acres) | Percent of Direct Drainage Area |
|---|---|---|---|---|---|---|---|
| | Principal | Accessory | | Area | Width | | |
| TOWN OF OCONOMOWOC ZONING ORDINANCE | | | | | | | |
| C-1 Conservancy District | Open space uses | - - | Outdoor recreation facilities, quarrying, refuge disposal sites, fish hatcheries | No minimum required | No minimum required | 1,020.3 | 15.4 |
| A-E Exclusive Agricultural District | Open space uses, agricultural uses | - - | Outdoor recreation facilities, quarrying, refuse disposal sites, fish hatcheries | No minimum required | No minimum required | - - | - - |
| A-1 Agricultural District | Single-family residence, agricultural uses | Garages, barns, home occupations | Airports, gift shops, kennels, churches, cemeteries, fish hatcheries, special agricultural uses, laboratories, mobile home parks, motels and hotels, outdoor theater, planned unit development, outdoor recreation facilities, public buildings, quarrying, refuse disposal sites, restaurants and taverns | 3 acres | 200 feet | 1,802.3 | 27.3 |
| A-la Agricultural District | Single-family residence, agricultural uses | Garages, barns, home occupations | 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 | - | - - |
| A-2 Rural Home District | Single-family residence, agricultural uses | Garages, barns, home occupations | 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 District | Single-family residence, agricultural uses | Garages, barns, home occupations | 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 District | Single-family residence | - - | Gift shops, churches, cemeteries, fish hatcheries, motels and hotels, planned unit development, outdoor recreational facilities, public buildings, restaurants and taverns | 1 acre | 150 feet | 149.7 | 2.3 |
| R-la Residential District | Single-family residence | - - | Gift shops, churches, cemeteries, fish hatcheries, motels and hotels, planned unit development, outdoor recreational facilities, public buildings, restaurants and taverns | 1 acre | 150 feet | - - | - - |
| R-2 Residential District | Single-family residence | - - | Gift shops, churches, cemeteries, fish hatcheries, motels and hotels, planned unit development, outdoor recreational facilities, public buildings, restaurants and taverns | 30,000 square feet | 120 feet | 1,547.1 | 23.4 |
| R-3 Residential District | Single-family residence | - - | Gift shops, churches, cemeteries, fish hatcheries, motels and hotels, multiple-family dwellings, planned unit development, outdoor recreational facilities, public buildings, restaurants and taverns | 20,000 square feet | 120 feet | 787.4 | 11.9 |

## Table 23 (continued)

| Zoning District | Permitted Uses: Principal | Permitted Uses: Accessory | Conditional/Special Uses | Area Regulations, Minimum Lot Size: Area | Area Regulations, Minimum Lot Size: Width | Civil Division Area Zoned Within Direct Drainage Area (acres) | Percent of Direct Drainage Area |
|---|---|---|---|---|---|---|---|
| TOWN OF OCONOMOWOC ZONING ORDINANCE (continued) | | | | | | | |
| P-1 Public District | Recreation, governmental, institutional | - - | Churches, cemeteries, fish hatcheries, laboratories, motels and hotels, planned unit development, outdoor recreational facilities, public buildings, quarrying, refuse disposal sites | No minimum required | No minimum required | 166.4 | 2.5 |
| B-1 Restricted District | Single-family, multiple-family, limited retail and service | - - | Churches, cemeteries, fish hatcheries, mobile home parks, planned unit development, outdoor recreational facilities, public buildings, refuse disposal sites, restaurants, and taverns | 20,000 square feet | 120 feet | - - | - - |
| B-2 Local Business District | Retail and service, single-family, multiple-family | - - | Service stations, kennels, churches, cemeteries, fish hatcheries, drive-in foods, mobile home parks, motels and hotels, multiple-family dwellings, outdoor theater, planned unit development, recreational facilities, public buildings, quarrying, refuse disposal sites | 20,000 square feet | 120 feet | - - | - - |
| B-3 General Business District | Commercial uses | Single-family residence | Service stations, kennels, churches, cemeteries, fish hatcheries, drive-in foods, mobile home parks, motels and hotels, multiple-family dwellings, outdoor theater, planned unit development, outdoor recreational facilities, public buildings, quarrying, refuse disposal sites | 20,000 square feet | 120 feet | 38.8 | 0.6 |
| Q-1 Quarrying District | Quarrying, open space, agricultural, single-family residence | - - | Churches, cemeteries, fish hatcheries, mobile home parks, motels and hotels, planned unit development, outdoor recreational facilities, public buildings, quarrying, refuse disposal sites | 3 acres | 200 feet | - - | - - |
| M-1 Limited Industrial District | Commercial, limited industrial (low impact on surrounding residential uses) | Single-family residence | 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 recreational facilities, public buildings, quarrying, refuse disposal sites | 1 acre | 150 feet | 33.3 | 0.5 |
| M-2 General Industrial District | Quarrying, industrial, commercial | Single-family residence | 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 recreational facilities, public buildings, quarrying, refuse disposal sites | 1 acre | 150 feet | - - | - - |
| Subtotal | - - | - - | - - | - - | - - | 5,545.3 | 83.9 |

## Table 23 (continued)

| Zoning District | Permitted Uses | | Conditional/Special Uses | Area Regulations | | Civil Division Area Zoned Within Direct Drainage Area (acres) | Percent of Direct Drainage Area |
|---|---|---|---|---|---|---|---|
| | | | | Minimum Lot Size | | | |
| | Principal | Accessory | | Area | Width | | |
| CITY OF OCONOMOWOC ZONING ORDINANCE | | | | | | | |
| C-1 Conservancy District | Management of forestry, wildlife and fish, harvesting of wild crops, dams, power stations, gravel or sand pits, and quarries | - - | Water pumping or storage facilities, amusement parks, golf courses and driving ranges | No minimum required | No minimum required | - - | - - |
| A-1 Agricultural District | Single-family residences | - - | Farm labor housing, housing for seasonal or migratory farm workers, land restoration, parks and playgrounds | 35 acres | 100 feet | - - | - - |
| A-2 Agricultural District | Single-family residences, plant nurseries | - - | Schools, churches, governmental and cultural uses, community centers, libraries, public emergency shelters, parks, playgrounds, and museums | 5 acres | 100 feet | - - | - - |
| R-1 One-Family Residence | Single family residences, two-family residences, churches, schools, colleges, universities, and municipal buildings | Gardening, antenna systems, summer houses, parking facilities, professional offices, home occupation | Churches, public schools, parochial schools, colleges, universities, public libraries, museums having their inception origination or incorporation after December 1, 1957, private noncommercial recreation areas, hospitals | Dwellings: 8,000 square feet Other permitted uses: 16,000 square feet | Varies with the number of stories per dwelling unit | 189.9 | 2.9 |
| R1-A One-Family Residence District | Single-family detached dwelling | - - | Same as R-1 One-Family Residence District | 9,600 square feet | Varies with the number of stories per dwelling unit | - - | - - |
| R1-B One-Family Residence District | Single-family detached dwelling | - - | Same as R-1 One-Family Residence District | 12,000 square feet | Varies with the number of stories per dwelling unit | 261.4 | 4.0 |
| R1-C One-Family Residence District | Single-family detached dwelling | - - | Same as R-1 One-Family Residence District | 15,000 square feet | Varies with the number of stories per dwelling unit | - - | - - |
| R-2 Residence District | Single-Family dwellings, two-family dwellings and hospitals | - - | Three- and four-family dwellings | 8,000 square feet (single- and two-family dwellings) 12,000 square feet (four-family and dwelling groups) | Varies with the number of stories per dwelling unit | - - | - - |
| R-3 Residence District | Multifamily dwellings, apartments, hotels, boarding houses | Tourist homes | Motels and motor hotels, private clubs, fraternities, lodges, clinics, homes for the aged | 8,000 square feet (single- and two-family dwellings) 12,000 square feet (four-family dwellings) | Varies with the number of stories per dwelling unit | 28.8 | 0.4 |
| B-1 Business District | Local retail business or service establishments | Essential services | Drive-in establishments, automotive services, building and related trade shops, animal hospitals, commercial recreation, eating and drinking establishments, and billboards | 8,000 square feet | Varies with the number of stories per building unit | - - | - - |

## Table 23 (continued)

| Zoning District | Permitted Uses | | Conditional/Special Uses | Area Regulations | | Civil Division Area Zoned Within Direct Drainage Area (acres) | Percent of Direct Drainage Area |
|---|---|---|---|---|---|---|---|
| | Principal | Accessory | | Minimum Lot Size | | | |
| | | | | Area | Width | | |
| B-2 Business District | Retail and services, banks, commercial art studios, publishing, hotels, funeral homes | Essential services | Same as B-1 Business District | Nonresidence: No minimum required Residence: varies with number of stories per dwelling unit | - - | 13.7 | 0.2 |
| M-1 Manufacturing District | Manufacturing plants, warehouses, laboratories | Essential services | Same as B-1 Business District | No minimum required | No minimum required | 20.8 | 0.3 |
| M-2 General Manufacturing District | Automobile assembly, coal yards, grain mills, sewage disposal plant, steam power plants | - - | Same as B-1 Business District | No minimum required | No minimum required | - - | - - |
| Subtotal | - - | - - | - - | - - | - - | 514.6 | 7.8 |
| TOWN OF IXONIA ZONING ORDINANCE | | | | | | | |
| A-1 Agricultural District | Single-family residences, general farming, poultry, livestock horticulture, etc. | Essential services, household occupations | Residential units for farm help, fish hatcheries, fur farm, private agrorelated airstrips | 40 acres | 200 feet | 199.4 | 3.0 |
| A-2 Agricultural District | All uses within the A-2 Agricultural District are conditional uses | - - | Canneries, milk processing plants, meat packing plants, livestock sales facilities, farm machinery, sales outlets, kennels, animal hospitals, campgrounds, golf courses, grain mills | No minimum required | No minimum required | - - | - - |
| A-3 Rural Residential District | Single-family residences | - - | None | 1 acre | 150 feet | - - | - - |
| R-1 Residential District | Single-family residences | Essential services, household occupations, professional home office, parking, garages or parking areas | Two-family and multi-family dwellings, mobile homes, rest and nursing homes, public and semi-public uses | 8,000 square feet (10,000 square feet in shoreland area) | 80 feet | - - | - - |
| R-2 Residential District | Single-family residences | Essential services, household occupations, professional home office, parking, garages or parking areas | Two-family units, mobile home parks, public and semi-public uses | Varies with soil percolation rate | 100 feet | 85.4 | 1.3 |
| C-1 Community District | One- and two-family residences | Essential services, household occupations, professional home office, parking, garages or parking areas | Two-family units, mobile home financial, professional or office building, retail outlet, eating, drinking, or entertainment, service station, motel, hotel, feed mill, recreational equipment sales and service, repair shop | 8,000 square feet | 80 feet (sewered lot) 100 feet (unsewered lot) | - - | - - |
| B-1 Business District | Professional offices, retail stores, government offices, financial institutions, clubs, gas stations | Essential services, household occupation, parking garage, or parking area | Drive-in theater, funeral home | 8,000 square feet (10,000 square feet in shoreland area) | 80 feet | - - | - - |

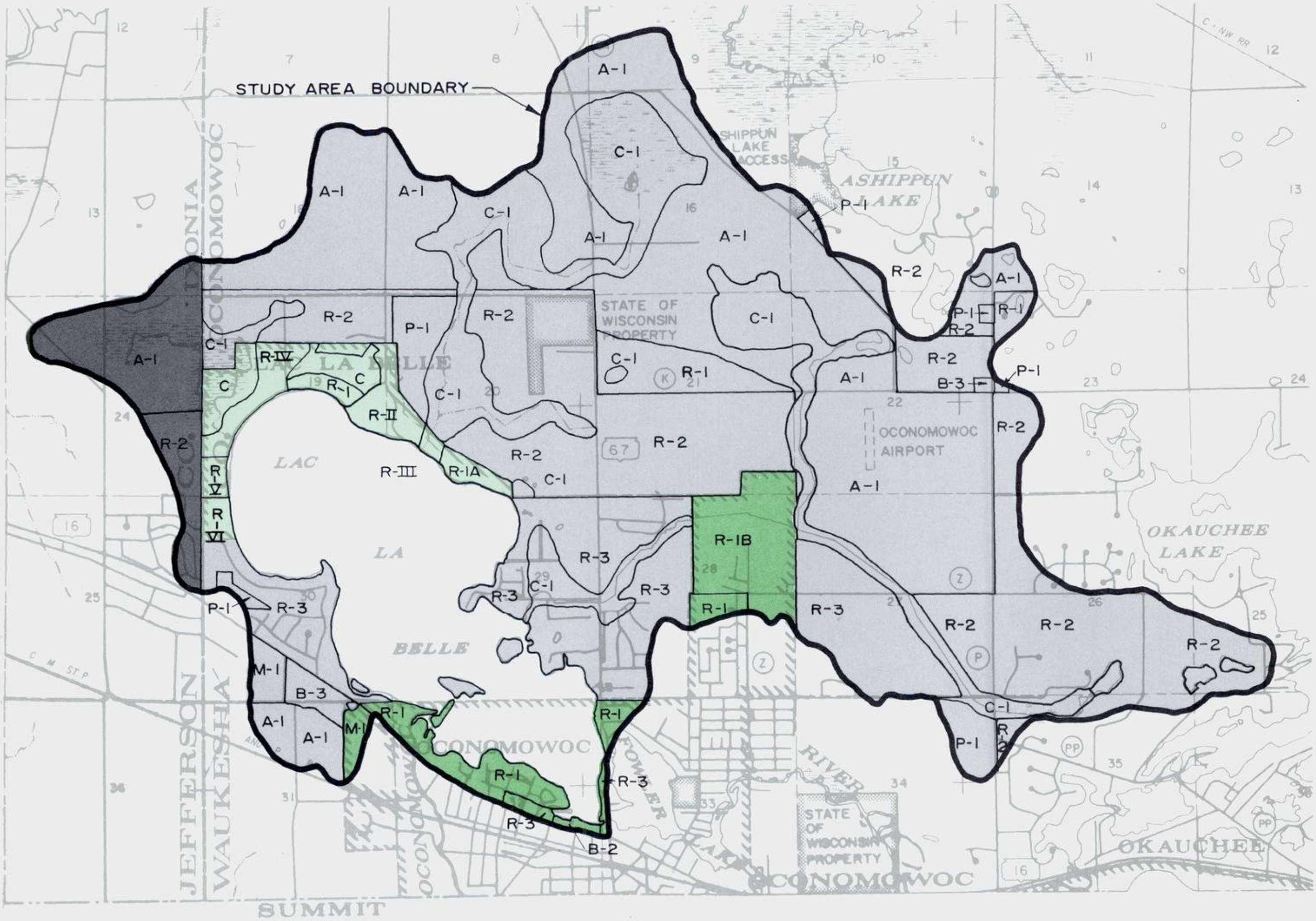
## Table 23 (continued)

| Zoning District | Permitted Uses: Principal | Permitted Uses: Accessory | Conditional/Special Uses | Area Regulations, Minimum Lot Size: Area | Area Regulations, Minimum Lot Size: Width | Civil Division Area Zoned Within Direct Drainage Area (acres) | Percent of Direct Drainage Area |
|---|---|---|---|---|---|---|---|
| I-1 Industrial District | Warehouse or wholesale product establishments | Essential services | Manufacturing, processing, refining, storage or repairing facilities, veterinarian offices, animal hospitals, kennels, food processing facilities, mineral extraction, and processing plants | 8,000 square feet (sewered) | 80 feet | -- | -- |
| W Waterfront District | Single-family residences | Essential services | Two-family dwellings, boathouses, bait, tackle, and gift shops, taverns, restaurants, grocery store, marinas | 12,000 square feet (sewered) | 150 feet | -- | -- |
| S Shoreland (Overlay) District | Any principle use allowed in the underlying district | Essential services | Any conditional use allowed in the underlying district | No minimum required | No minimum required | -- | -- |
| N Natural Resource District | Parks and recreation lands | Essential services | Agricultural practices, watercourse relocation, filling, draining, dredging, boathouses, docks, piers, dams, hydroelectric plants | 2 acres | 100 feet | -- | -- |
| Subtotal | -- | -- | -- | -- | -- | 284.8 | 4.3 |
| VILLAGE OF LAC LA BELLE ZONING ORDINANCE | | | | | | | |
| C-1 Conservancy District | Grazing, harvesting of wild crops, dams and hydroelectric power stations | -- | None | No minimum required | No minimum required | 67.4 | 1.1 |
| R-1 Residential District | Single-family residences, home occupations, professional offices | -- | None | 20,000 square feet | 75 feet | 19.9 | 0.3 |
| R-1A Residential District | Single-family residences, home occupations, professional offices | -- | General farming and truck farming, temporary structures for sale of farm products | 20,000 square feet | 75 feet | 23.1 | 0.4 |
| R-11 Residential District | Single-family residences, home occupations, professional offices | -- | None | 20,000 square feet | 75 feet | 54.6 | 0.8 |
| R-III Residential District | Single-family residences, home occupations, professional offices | -- | Picnic grounds, boat launchings, boat rentals, taverns, restaurants, ballroom and catering facilities, parking | 20,000 square feet | 75 feet | 9.2 | 0.1 |
| R-IV Residential District | Single-family residences, home occupations, professional offices | -- | Golf courses and clubhouses, two-family dwellings, cemeteries, grade and high schools, churches, public libraries, and municipal buildings | 30,000 square feet | 100 feet | 55.3 | 0.8 |
| R-V Residential District | Single-family residences, home occupations, professional offices | -- | None | 30,000 square feet | 100 feet | 14.4 | 0.2 |
| R-VI Residential District | Single-family residences, home occupations, professional offices | -- | None | 30,000 square feet | 100 feet | 18.4 | 0.3 |
| Subtotal | -- | -- | -- | -- | -- | 262.3 | 4.0 |
| Total | -- | -- | -- | -- | -- | 6,607.0 | 100.0 |

*Source: City of Oconomowoc, Town of Ixonia, Village of Lac La Belle, Waukesha County Park and Planning Commission, and SEWRPC.*

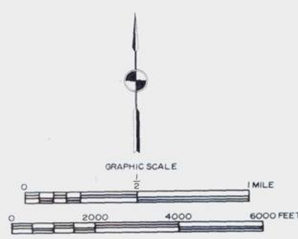
## Map 16

## EXISTING ZONING DISTRICTS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1980




LEGEND

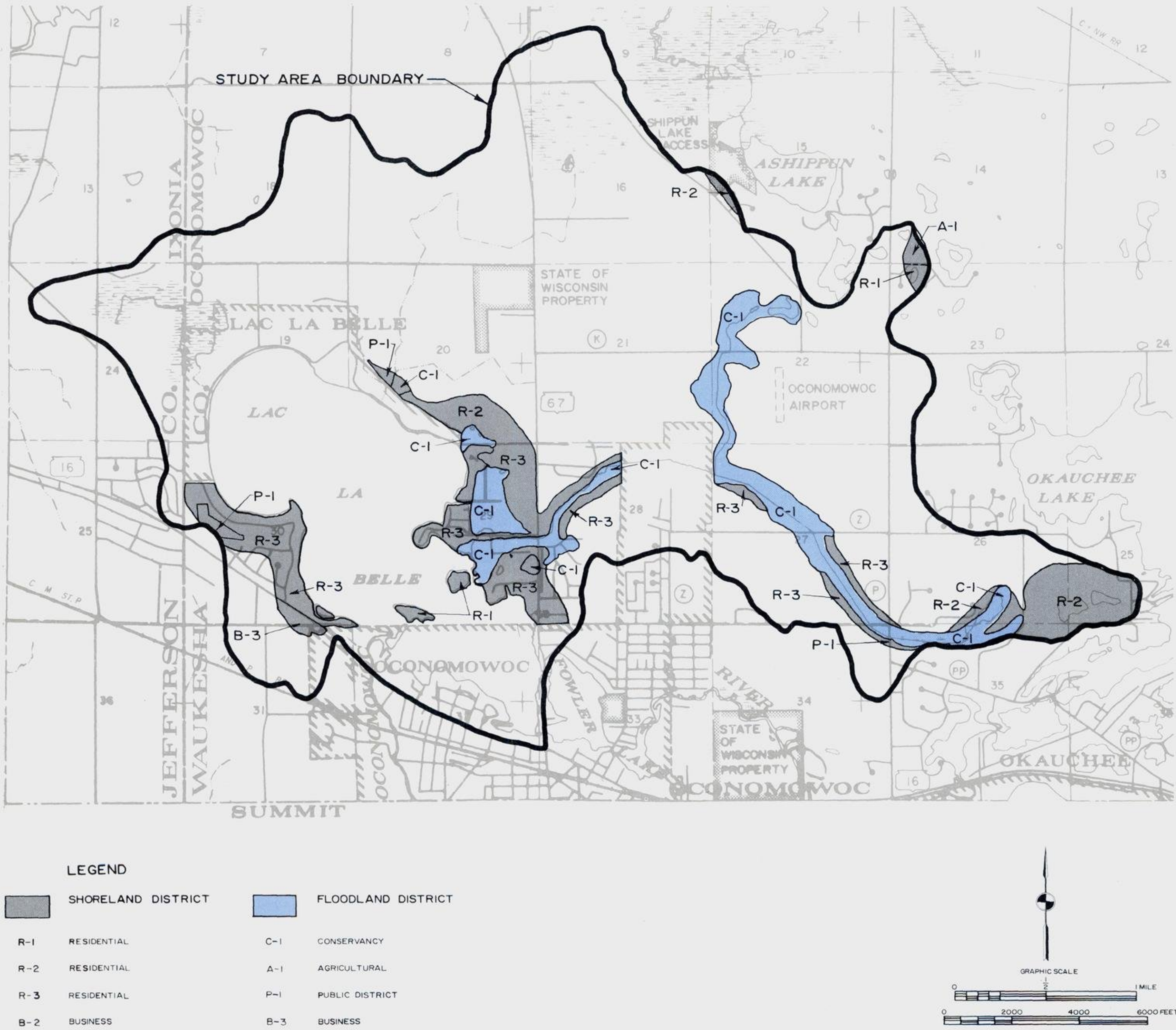
| | | | | | |
|---|---|---|---|---|---|
| | CITY OF OCONOMOWOC, WAUKESHA COUNTY | R-IA | RESIDENTIAL DISTRICT | R-2 | RESIDENTIAL DISTRICT |
| R-I | RESIDENTIAL DISTRICT | R-II | RESIDENTIAL DISTRICT | R-3 | RESIDENTIAL DISTRICT |
| R-IB | RESIDENTIAL DISTRICT | R-III | RESIDENTIAL DISTRICT | P-I | PUBLIC DISTRICT |
| R-3 | RESIDENTIAL DISTRICT | R-IV | RESIDENTIAL DISTRICT | B-3 | GENERAL BUSINESS DISTRICT |
| B-2 | BUSINESS DISTRICT | R-V | RESIDENTIAL DISTRICT | M-I | LIMITED INDUSTRIAL DISTRICT |
| M-I | LIGHT MANUFACTURING, PARK AND WAREHOUSE DISTRICT | R-VI | RESIDENTIAL DISTRICT | | TOWN OF IXONIA, JEFFERSON COUNTY |
| | VILLAGE OF LAC LA BELLE, WAUKESHA COUNTY | | TOWN OF OCONOMOWOC, WAUKESHA COUNTY | R-2 | RESIDENTIAL DISTRICT |
| C-I | CONSERVANCY DISTRICT | C-I | CONSERVANCY DISTRICT | A-I | AGRICULTURAL DISTRICT |
| R-I | RESIDENTIAL DISTRICT | A-I | AGRICULTURAL DISTRICT | | |
| | | R-I | RESIDENTIAL DISTRICT | | |




*Source: SEWRPC.*

## Map 17

### SHORELAND AND FLOODLAND ZONING IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE: 1980




*Source: Waukesha County Park and Planning Commission and SEWRPC.*

June to 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. The arsenic residue was naturally 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 (μg/g) dry weight. However, biomagnification of arsenic through the food chain

Table 24

CHEMICAL CONTROL OF AQUATIC PLANTS IN LAC LA BELLE: 1950-1978

| Year | Acres Treated | Algae Control | | Macrophyte Control | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Copper Sulfate | Cutrine | Sodium Arsenite | 2, 4-D | Diquat | Endothal | Aquathol |
| 1950 | - - | - - | - - | - - | - - | - - | - - | - - |
| 1951 | - - | - - | - - | - - | - - | - - | - - | - - |
| 1952 | - - | - - | - - | - - | - - | - - | - - | - - |
| 1953 | - - | - - | - - | 400 pounds | - - | - - | - - | - - |
| 1954 | - - | - - | - - | 1,508 pounds | - - | - - | - - | - - |
| 1955 | - - | - - | - - | 2,520 pounds | - - | - - | - - | - - |
| 1956 | - - | - - | - - | 8,640 pounds | - - | - - | - - | - - |
| 1957 | - - | - - | - - | 16,536 pounds | - - | - - | - - | - - |
| 1958 | 77.8 | 200 pounds | - - | 10,220 pounds | - - | - - | - - | - - |
| 1959 | 46.0 | - - | - - | 7,740 pounds | - - | - - | - - | - - |
| 1960 | 40.5 | 475 pounds | - - | 4,860 pounds | - - | - - | - - | - - |
| 1961 | 42.5 | 700 pounds | - - | 12,240 pounds | - - | - - | - - | - - |
| 1962 | 22.0 | 120 pounds | - - | 3,366 pounds | - - | - - | - - | - - |
| 1963 | 33.0 | 175 pounds | - - | 4,800 pounds | - - | - - | - - | - - |
| 1964 | 10.5 | - - | - - | 1,260 pounds | - - | - - | - - | - - |
| 1965 | 5.0 | - - | - - | 1,260 pounds | - - | - - | - - | - - |
| 1966 | 8.0 | - - | - - | 1,248 pounds | - - | - - | - - | - - |
| 1967 | 8.0 | - - | - - | 1,260 pounds | - - | - - | - - | - - |
| 1968 | 8.0 | - - | - - | - - | 45 gallons | - - | - - | - - |
| 1969 | 45.0 | - - | - - | - - | 123 gallons<br>150 pounds | 20.5 gallons | - - | - - |
| 1970 | 18.7 | - - | - - | - - | 15 gallons<br>240 pounds | - - | 20 gallons | 25 pounds |
| 1971 | 28.0 | - - | - - | - - | 4 gallons<br>30 pounds | 14 gallons | - - | 50 gallons |
| 1972 | 47.4 | - - | - - | - - | 3 gallons | 14 gallons | - - | 110 gallons<br>350 pounds |
| 1973 | 48.8 | - - | - - | - - | - - | 15 gallons | - - | 103 gallons<br>100 pounds |
| 1974 | 68.5 | - - | - - | - - | 18 gallons | 76 gallons | 16 gallons | - - |
| 1975 | 34.6 | 45.3 pounds | 15 gallons | - - | 21 gallons | 25 gallons | 10 gallons | - - |
| 1976 | 11.6 | - - | - - | - - | 20 gallons | 3.5 gallons | 3 gallons | - - |
| 1977 | 17.0 | - - | - - | - - | 24 gallons | - - | - - | - - |
| 1978 | 24.6 | - - | 15.5 gallons | - - | 51 gallons | 8 gallons | 15.5 gallons | - - |
| Total | 645.5 | 1,715.3 pounds | 30.5 gallons | 77,858 pounds | 324 gallons<br>420 pounds | 176 gallons | 64.5 gallons | 263 gallons<br>475 pounds |

*Source: Wisconsin Department of Natural Resources.*

Table 25

LAKES RECEIVING THE 10 LARGEST AMOUNTS OF SODIUM ARSENITE IN WISCONSIN FOR AQUATIC MACROPHYTE CONTROL: 1950-1969

| Lake | County | Amount of Sodium Arsenite (pounds) |
|---|---|---|
| Pewaukee | Waukesha | 334,232 |
| Okauchee | Waukesha | 181,580 |
| Big Cedar | Washington | 179,164 |
| Pine | Waukesha | 129,337 |
| Fowler Lake[a] | Waukesha | 87,456 |
| Nagawicka | Waukesha | 87,214 |
| La Belle | Waukesha | 77,858 |
| Onalaska | La Crosse | 64,676 |
| Shangrila (Benet) | Kenosha | 59,020 |
| Browns | Racine | 56,600 |
| Total | -- | 1,257,137[b] |

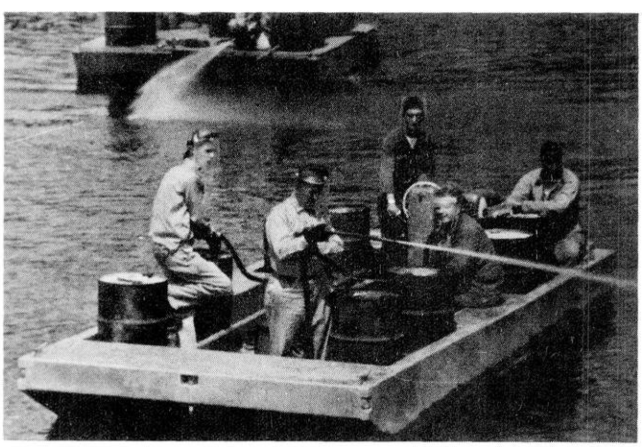
[a] *Includes application of sodium arsenite to the Oconomowoc River near Fowler Lake.*

[b] *The 1,257,137 pounds of sodium arsenite applied to these lakes constitutes 57 percent of the total amount of sodium arsenite applied to a total of 167 lakes and streams in Wisconsin during the period 1950 to 1969.*

*Source: Wisconsin Department of Natural Resources.*

Figure 15

APPLICATION OF SODIUM ARSENITE TO SHORELINE OF AN INLAND LAKE



*Source: SEWRPC.*

has not been known to occur. Analyses of fish tissue from some treated lakes by the Wisconsin Department of Natural Resources indicated no excessive levels of arsenic.

When it became apparent that arsenic was accumulating in the sediments of treated lakes, the use of sodium arsenite was discontinued, in Lac La Belle in 1967, and in the entire State in 1969. The application and accumulation of arsenic presented potential health hazards to humans and to aquatic life. In drinking water supplies, arsenic is a suspected 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). Table 26 sets forth measured arsenic levels in Lac La Belle for selected years from 1961 through 1978.

During anaerobic conditions, arsenic may be released from the sediments to the water. In this way, some arsenic continues to be "flushed out" of Lac La Belle 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 continue to decrease.

As shown in Table 24, 2,4-D, Diquat, Endothall, and Aquathol also have been applied to Lac La Belle to control aquatic macrophytes. All of these chemicals were applied after 1967, when the use of sodium arsenite was discontinued. All aquatic plant control chemicals used must be approved by the U. S. Environmental Protection Agency and the Wisconsin Department of Natural Resources. The Federal Insecticide, Fungicide, and Rodenticide Act as amended in 1972 designates that all pesticides be approved and registered.

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

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.

Table 26

MEASURED ARSENIC LEVELS IN LAC LA BELLE FOR SELECTED YEARS 1961-1978

| Sampling Date | Arsenic Concentration (mg/l) |
|---|---|
| May 1961 . . . . . . . | 0.11 |
| May 1962 . . . . . . . | 0.06 |
| June 1962 . . . . . . . | 0.12 |
| April 1962. . . . . . . | 0.06 |
| February 1963 . . . . | 0.09 |
| May 1966 . . . . . . . | 0.07 |
| February 1967 . . . . | 0.10 |
| May 1968 . . . . . . . | 0.06 |
| May 1969 . . . . . . . | 0.04 |
| April 1970. . . . . . . | 0.01 |
| April 1971. . . . . . . | 0.01 |
| June 1978 . . . . . . . | 0.01 |

*Source: Wisconsin Department of Natural Resources.*

2. The elimination of macrophytes reduces competition for light and nutrients with algae, and increased algae blooms may develop.

3. Since the plant bodies are not removed from the lake upon decomposition, nutrients will be released to the water. Decomposition of the plant bodies also increases dissolved oxygen consumption and increases the potential for fish kills.

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

5. Diquat has been shown to kill the zooplankton Daphnia (water fleas) and Hyalella (scuds) at the level applied for marcophyte control. Both Daphnia and Hyalella are important fish foods, and Daphnia is a primary food for the young of nearly all fish species.

Chemical Algae Control

Table 24 indicates that copper sulfate and Cutrine have been occasionally applied for algae control. The less frequent use of algae control chemicals, compared to chemicals for macrophyte control, indicates that algae growths are probably perceived to be a lesser problem than macrophyte growths. Many of the disadvantages of chemical macrophyte control discussed above apply to chemical algae control as well. In addition, copper, the active ingredient in algicides, may accumulate in the bottom sediments. Excessive levels of copper are toxic to fish and benthic animals.

## FISH MANAGEMENT

Prior to 1960, the City of Oconomowoc maintained a mechanical carp barrier on the outlet dam of Lac La Belle to prevent carp from migrating into the lake from the Oconomowoc River. The City removed the barrier in 1960 after receiving complaints that the barrier was hampering navigation. Since 1960, poor fishing and large numbers of carp in the lake have been reported.

Many species of fish were stocked in Lac La Belle prior to 1946, including bluegills, bullheads, largemouth bass, smallmouth bass, walleyes, crappies, and white bass. After 1946, only walleye—as fingerlings in 1952, 1956, 1957, and 1960 and as fry from 1960 through 1966—were stocked. A study by the Bureau of Research, Wisconsin Department of Natural Resources, concluded that in Lac La Belle walleye fry survival was related to zooplankton densities at the time of the stocking.[2] During periods when a plentiful food source was present, walleye fry stocking was successful.

Since the comprehensive fishery survey of Lac La Belle in 1974, several management activities have been initiated for the purpose of reducing the carp population, increasing the abundance of game fish, and promoting better growth of panfish. The following activities have been undertaken:

1. A carp barrier has been installed on the dam at the outlet of Lac La Belle to prevent migration of adult carp over the dam.

2. The Oconomowoc River was chemically treated to reduce the carp population.

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[2] *G. R. Priegel, "Walleye Fry—Zooplankton Relationships in Southeastern Wisconsin Lakes," Unpublished Research Report, 1971.*

3. Chemical vegetation control in the lake was substantially reduced, in order to promote aquatic plant growth and increase fish food production.

4. Walleye and northern pike fry were stocked in 1976.

## GOVERNMENTAL AGENCIES WITH WATER QUALITY MANAGEMENT RESPONSIBILITIES

There are several local, state, and federal agencies which may become involved in the implementation of a water quality management plan for Lac La Belle. These agencies include an inland lake protection and rehabilitation district, sanitary districts, towns, cities, and villages, counties, soil and water conservation districts, 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, but a more detailed discussion is presented in Chapter VI, Volume One, SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000.

### Inland Lake Protection and Rehabilitation Districts

Inland lake protection and rehabilitation districts are special purpose units of government created pursuant to Chapter 33 of the Wisconsin Statutes. In its initial 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, select appropriate boundaries encompassing the riparian property and as much of the lake watershed as deemed necessary. Once the boundary is 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 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 make contracts, own property, disburse money, bond, borrow, and make special assessments. Its specific lake management powers include:

1. Study of existing water quality conditions and determine the causes of existing or expected future water quality problems.

2. Control of aquatic macrophytes, algae, and swimmer's itch.

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 district does 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:

1. Three property owners from within the district, elected by all property owners within the district.

2. A county board member who is also a Soil and Water Conservation District Supervisor

who has been nominated by the Supervisors of the Soil and Water Conservation District and appointed by the County Board, and

3. A representative of the town, village or city having the highest assessed evaluation within the district who is appointed by that governing body.

Sanitary Districts

Sanitary districts may be created under Section 66.30 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 with respect to 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, particularly including sanitary sewer and storm water management services. Towns may also undertake stream and lake improvements and watershed protection projects.

Cities and Villages

Cities and villages possess authority to implement both the point and urban nonpoint source pollution abatement plans. Cities and villages possess general home rule authority and have specific authority to construct, operate, and maintain a sanitary sewerage system. In addition, cities and villages have authority to convey and treat storm waters, including construction, operation, and maintenance of urban storm water conveyance, storage, and treatment facilities. Cities and villages can undertake nonpoint source pollution abatement activities in conjunction with traditional public works activities, including litter and leaf control, animal waste control, and street sweeping and cleaning. Thus, cities and villages are granted all of the powers required to implement the point and nonpoint source pollution abatement elements of the plan in urban areas. Those powers may be exercised in the promulgation of construction erosion control ordinances, the construction and operation of storm water management systems, the development and enforcement of urban sanitation and refuse control ordinances, and the construction, operation, and maintenance of sanitary sewerage systems and attendant sewage treatment works.

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. Counties are also important to the functioning of the soil and water conservation districts. Not only are such districts fiscally dependent upon county boards, but in effect the districts are governed by a county board committee. In implementation of the areawide water quality management plan, therefore, it would be necessary for county boards and the soil and water conservation districts to work cooperatively.

Soil and Water Conservation Districts

Soil and water conservation districts, as authorized under Section 92.05 of the Wisconsin Statutes, have the authority to develop plans for the conservation of soil and water resources and for the prevention of soil erosion. In addition, the districts have authority to request the County Board of Supervisors to adopt special land use regulations that would implement such plans in unincorporated areas. Such adoption, however, requires a referendum in which a simple majority of the eligible electors who voted and were residents of the area affected approve the proposed regulations. Soil and water conservation districts have the authority to acquire through eminent domain proceedings any property or rights therein for watershed protection, soil and water conservation, flood prevention works, and fish and wildlife conservation and recreational works.

Regional Planning Commissions

In its role as a coordinating agency for water pollution control activities within southeastern Wisconsin, the Regional Planning Commission utilizes the 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 areawide 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 plan implementation responsibilities of the other management agencies, through whose direct actions the plans are converted to reality.

Wisconsin Department of Natural Resources

The responsibility for water pollution control in Wisconsin is centered in the 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; 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 any 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 soil and water conservation districts, 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 208(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 POLLUTION CONTROL

The foregoing discussion deals exclusively with water quality management by units and agencies of government. Direct action may also be taken, however, by private individuals or organizations to effectively abate water pollution. As shown later in the "Alternative Water Quality Management Measures" section, 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 previously 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 Regional Planning Commission adopted areawide water quality management plan, 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 both Lac La Belle and the Oconomowoc River are full recreational use and support of a healthy warmwater fishery and aquatic life. The water quality standards which support these objectives are set forth in Table 27. Standards were established for temperature, pH, dissolved oxygen, fecal coliform, residual chlorine, un-ionized ammonia nitrogen, and total phosphorus.

The total phosphorus standard of 0.02 milligram per liter (mg/l) applies to lakes during spring turnover, when the lake is not stratified and maximum vertical mixing is occurring. The achievement of this recommended standard is expected to prevent excessive macrophyte and algae growths in most lakes, although lake rehabilitation techniques may also be required. Excessive total phosphorus levels stimulate large growths of algae and possibly of aquatic macrophytes, which interfere with recreational use. Also, as these plant masses die and decompose, dissolved oxygen depletions may result which 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 the amount of plant material generated from one pound of phosphorus may 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 via stream inlets, direct tributary runoff, and atmospheric sources, although some recycling of phosphorus from the lake bottom sediments may also occur. Figure 16 shows the phosphorus concentrations expected to occur during spring turn-

Table 27

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

| Parameter | Standard |
|---|---|
| Maximum Temperature | $89^{o}F$[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 5°F for streams and 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 monthly geometric mean of 400 per 100 ml in more than 10 percent of all samples during any month.*

[d] *The values presented for lakes are the critical total phosphorus concentrations which apply only during spring when maximum mixing is underway.*

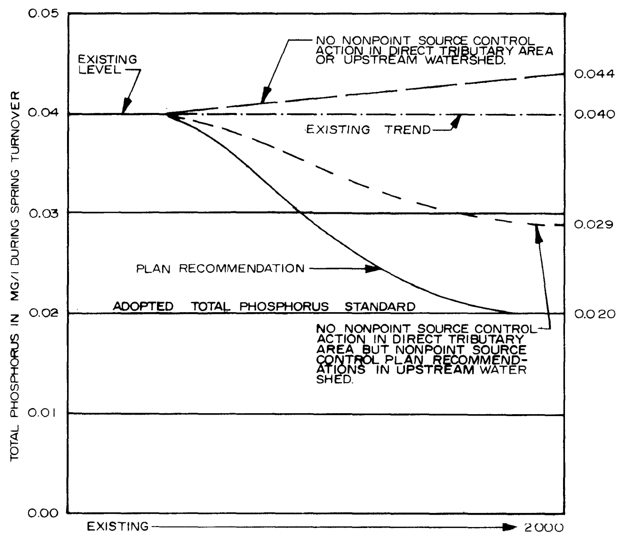
[e] *All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating 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. The determination of the toxicity of a substance shall be based upon the available scientific data base. References to be used in determining the toxicity of a substance shall include, but not be limited to, Quality Criteria for Water, EPA-440/9-76-003, U. S. Environmental Protection Agency, Washington, D. C., 1976, and Water Quality Criteria 1972. EPA R3-73-003, National Academy of Engineering, U. S. Government Printing Office, Washington, D. C., 1974. Questions concerning the permissible levels, or changes in the same, of a substance, or combination of substances, or undefined toxicity to fish and other biota shall be resolved in accordance with the methods specified in Water Quality Criteria 1972 and Standard Methods for the Examination of Water and Wastewater, 14th Edition. American Public Health Association, New York, 1975, or other methods approved by the Department of Natural Resources.*

*Source. SEWRPC.*

## Figure 16

### EFFECT OF ALTERNATIVE ACTIONS ON TOTAL PHOSPHORUS LEVELS IN LAC LA BELLE




NOTE: THE PHOSPHORUS CONCENTRATIONS ARE ESTIMATED WITH THE USE OF THE S.E.W.R.P.C. WATER QUALITY SIMULATION MODEL.

*Source: SEWRPC.*

over under alternative water quality management actions in the lake watershed, as estimated with the Regional Planning Commission's water quality simulation model. Failure to implement any management measures in the entire lake watershed will result in an accelerated increase in phosphorus levels, and a resulting decrease in water quality and water use potential. Complete implementation of the plan recommendations, including watershed management measures and in-lake management techniques, is expected to result in the achievement of the phosphorus standard of 0.02 mg/l and subsequently provide water quality suitable for a full range of recreational use opportunities and for support of a healthy community of warmwater fish and aquatic life.

# Chapter VIII

# ALTERNATIVE WATER QUALITY MANAGEMENT MEASURES

## INTRODUCTION

Potential measures for water quality management of Lac La Belle include point source control measures, nonpoint source control measures, and lake rehabilitation techniques. Point source controls, primarily by the provision of sanitary sewer service, would eliminate pollutant loads to the lake from malfunctioning septic systems. Nonpoint source controls include the improved management of both urban and rural land uses, and serve to reduce pollutants discharged to the lake by direct overload drainage, by drainage through natural channels, by drainage through engineered storm sewer systems, and by groundwater inflow. Lake rehabilitation techniques either directly treat the symptoms of lake eutrophication, such as macrophyte harvesting, or alter the characteristics of the lake basin which may be interfering with the achievement of water use objectives, such as dredging of bottom sediments.

In developing alternative water quality management measures, it was assumed that the adopted areawide water quality management plan recommendations for the Oconomowoc River drainage area upstream of Lac La Belle would be implemented. Therefore, recommendations in this report deal primarily with water quality management measures in the drainage area directly tributary to the lake, or within the lake basin itself.

## 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 and expanded 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 million gallons per day (mgd). It is anticipated that 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 will require an average hydraulic capacity of 3.1 mgd in 1985. Final extension of sanitary sewer service to urban development around Okauchee Lake, Pine Lake, Beaver Lake, North Lake, and Silver Lake will require an average hydraulic design capacity at the City of Oconomowoc sewage treatment plant of 6.5 mgd by the year 2000. Based on this plan, additional capacity will be required at the Oconomowoc facility before the year 2000. Early in 1980 the Village of Lac La Belle, acting in conjunction with the Town of Oconomowoc and the Town of Ixonia Sanitary District No. 1, initiated a facility plan to study public sewerage system needs for urban development in the areas around Lac La Belle. This study will evaluate existing onsite waste disposal problems and establish the detailed local planning for a public sanitary sewer system to be connected to the City of Oconomowoc system in those areas where public sewers are the most practical solution for wastewater disposal. The proposed sewer service area and trunk sewer system are shown on Map 18. As of 1975, there were no known industrial point sources of wastewater tributary to Lac La Belle or to streams tributary to the lake which required elimination or treatment.

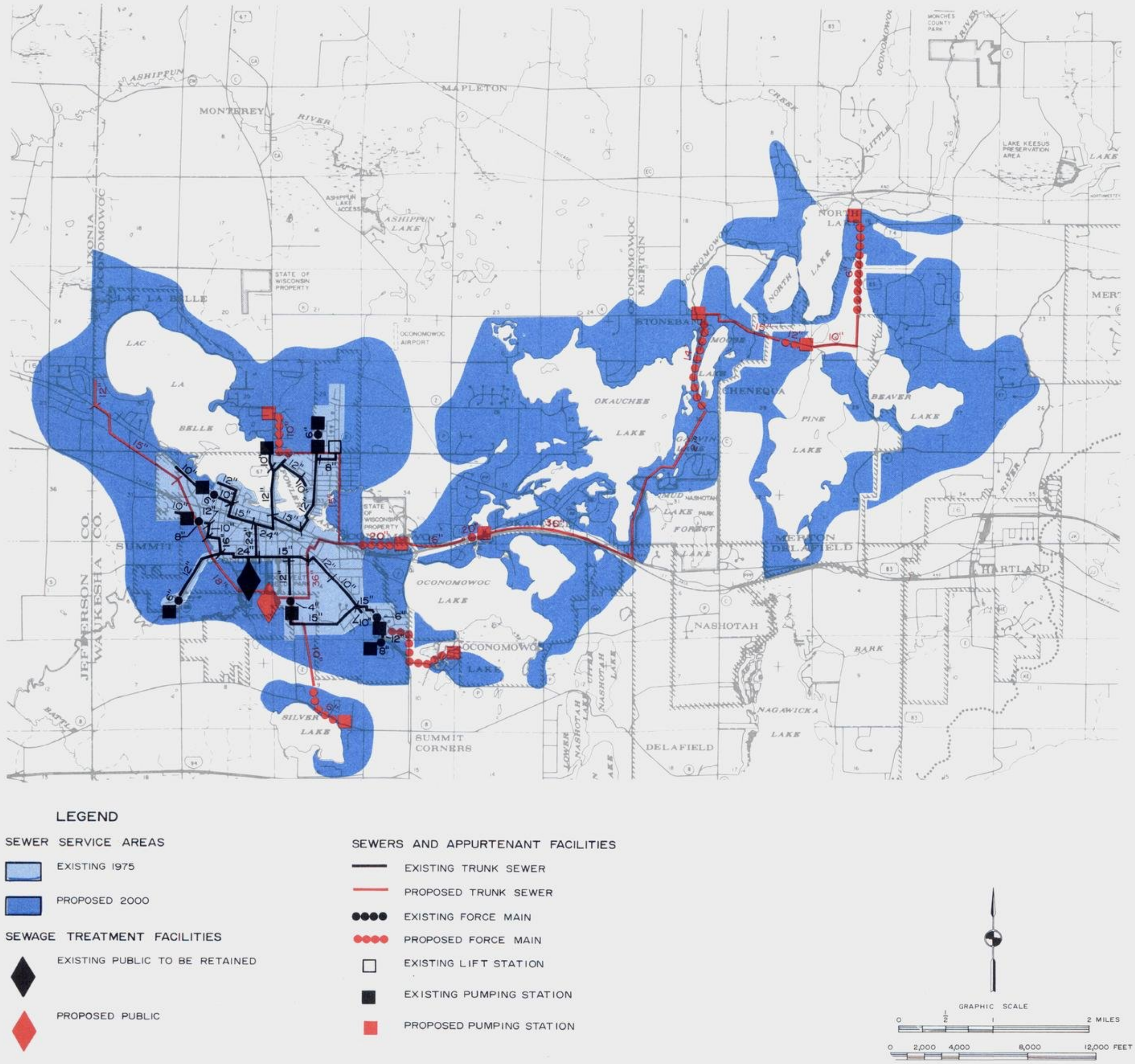
## NONPOINT SOURCE POLLUTION CONTROL

Nonpoint sources of water pollution include urban sources—such as runoff from residential, commercial, industrial, transportation, and recreational land uses; construction activities; and septic tank systems—and rural sources—such as runoff from cropland, pasture, and woodland; livestock wastes; and atmospheric contributions.

The water quality analyses presented previously in this report indicated that a reduction in nutrient loads from nonpoint sources in the direct tributary

Map 18

RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE OCONOMOWOC-LAC LA BELLE, OCONOMOWOC LAKE, OKAUCHEE, NORTH LAKE, BEAVER LAKE, AND SILVER LAKE SEWER SERVICE AREAS—MIDDLE ROCK RIVER SUBREGIONAL AREA: 2000




*Source: SEWRPC.*

area would be needed to satisfy the established water use objectives. Alternative nonpoint source control measures are set forth in Table 28. About a 30 percent reduction in nonpoint source loads from the direct tributary area is needed to meet the recommended water use objectives and supporting standards.

## LAKE REHABILITATION TECHNIQUES

Although preventing further deterioration in lake water quality conditions, the reduction of nutrient inputs to Lac La Belle alone may not result in the elimination of existing water quality problems. In mesotrophic lakes, such as Lac La Belle, especially

## Table 28

## GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF NONPOINT SOURCE WATER POLLUTION ABATEMENT

| 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 ordinance | 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 existing 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 the operation and maintenance of a sweeper is about $10 per curb/mile swept. |
| | Increased leaf and clippings collection and disposal | Increase the frequency and efficiency of leaf collection procedures in fall; use vacuum cleaners to collect leaves; implement ordinances for leaves, clippings, and other organic debris to be mulched, composted, or bagged for pickup | 2-5 | 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 |

Table 28 (continued)

| Applicable Land Use | Control Measures[a] | Summary Description[b] | Approximate Percent Reduction of Released Pollutants[c] | Assumptions for Costing Purposes |
|---|---|---|---|---|
| Urban (continued) | 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 area 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 storm water 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 storm water 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 storm water 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 28 (continued)

| Applicable Land Use | Control Measures[a] | Summary Description[b] | Approximate Percent Reduction of Released Pollutants[c] | Assumptions for Costing Purposes |
|---|---|---|---|---|
| Urban (continued) | Storm water storage—urban | Store storm water 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 of 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 storm water storage would range from $1,000-$10,000 per acre of tributary drainage area, with an annual operation and maintenance cost of about $20-$40 per acre |
| | Storm water 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 storm water following storage | 10-50 | To be applied only in combination with storm water 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. Storm water treatment has an estimated capital cost of from $900-$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-$14 per acres of rural land, with an average annual operation and maintenance cost of from $2-$4 per rural acre |

## Table 28 (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 is $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 about $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 28 (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 to 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 is $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 streambank protection measures cost about $37,000 per stream mile |
| | Pesticide and fertilizer application restrictions | Match application rate to need; eliminate excessive applications and applications near or into surface water drainageways | 0-3 | 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 for Southeastern Wisconsin, Volume Three, Urban Storm Water Runoff, and Volume Four, Rural Storm Water Runoff.*

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

*Source: SEWRPC.*

in the presence of anaerobic conditions in the hypolimnion, significant amounts of phosphorus may be released from the sediments to the overlying water column. Furthermore, macrophytes may continue to proliferate rooting in the nutrient-rich bottom sediments, regardless of the nutrient content of the overlying water. 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 to implementing lake rehabilitation techniques is recommended. Certain lake rehabilitation techniques should be applied only to lakes in which: 1) nutrient inputs to the lake have been reduced to below the critical level; 2) there is a high probability of success; and 3) the possibility of adverse environmental impacts is minimal.

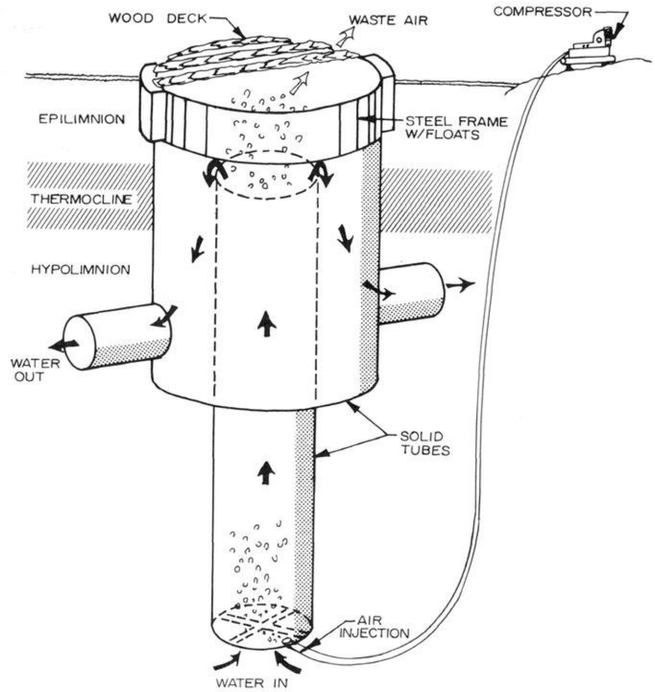
Alternative lake rehabilitation techniques discussed below include hypolimnetic aeration, dredging, sediment covering, drawdown, nutrient inactivation, dilution/flushing, selective discharge, diversion, improvement of the internal lake circulation patterns by reducing flow restrictions under the access road to Islandale, macrophyte harvesting, algae harvesting, chemical controls, and fish management. All cost figures related to the measures discussed are presented in January 1980 dollars.

Hypolimnetic Aeration

The purpose of hypolimnetic aeration is to provide oxygen to the hypolimnion of a stratified lake without disrupting the stratification. Typically, the bottom water is airlifted up a vertical tube, with oxygenated water returned to the hypolimnion, as shown in Figure 17 and on Map 19. Aeration of the hypolimnion increases the oxidation and decomposition of organic matter, and promotes sorption of phosphorus by the hydrous oxides of iron and manganese present in the lake bottom sediments. The result is that the concentration of phosphorus in the bottom waters is substantially reduced, and the improved oxygen levels result in increased habitat for fish and aquatic life. Hypolimnetic aeration also provides additional habitat for zooplankton, which can seek refuge from feeding fish during the day in the dark bottom waters, and migrate toward the surface at night to graze on algae. Increased zooplankton populations can effectively reduce certain species of algae. Hypolimnetic aeration in Lac La Belle would involve a capital cost of about $125,000, with an annual operation and maintenance cost of about $6,200. It is unlikely that point and nonpoint source pollution control measures would—at least for many years—substantially improve dissolved oxygen conditions in the hypolimnion. Therefore, hypolimnetic aeration could be implemented even prior to the control of point and nonpoint pollution sources in order to provide additional and immediate water quality improvement.

**Figure 17**

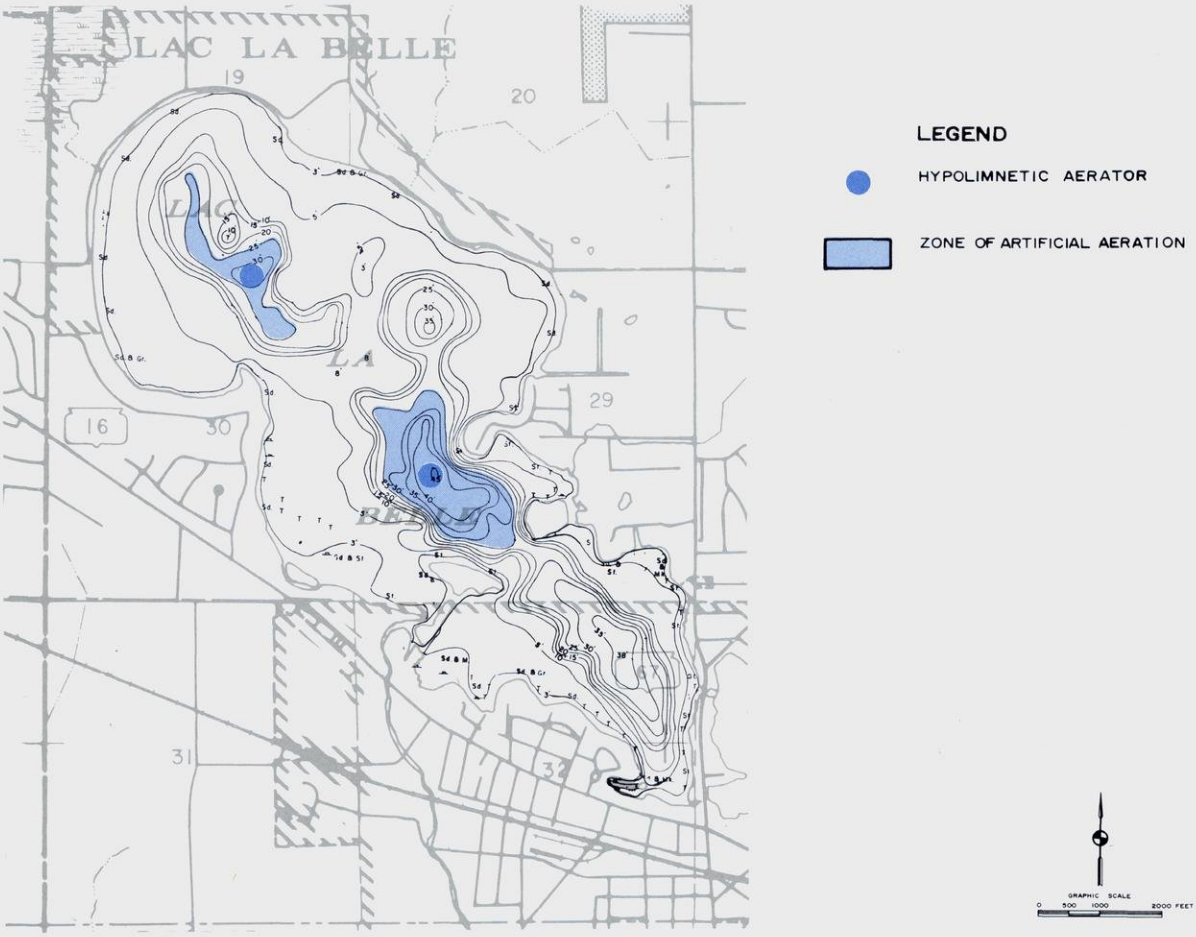
**TYPICAL HYPOLIMNETIC AERATION SYSTEM FOR AN INLAND LAKE**




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

Map 19

PLAN ALTERNATIVE FOR PLACEMENT OF HYPOLIMNETIC AERATION SYSTEMS IN LAC LA BELLE AND ZONES OF ARTIFICIAL AERATION




*Source: SEWRPC.*

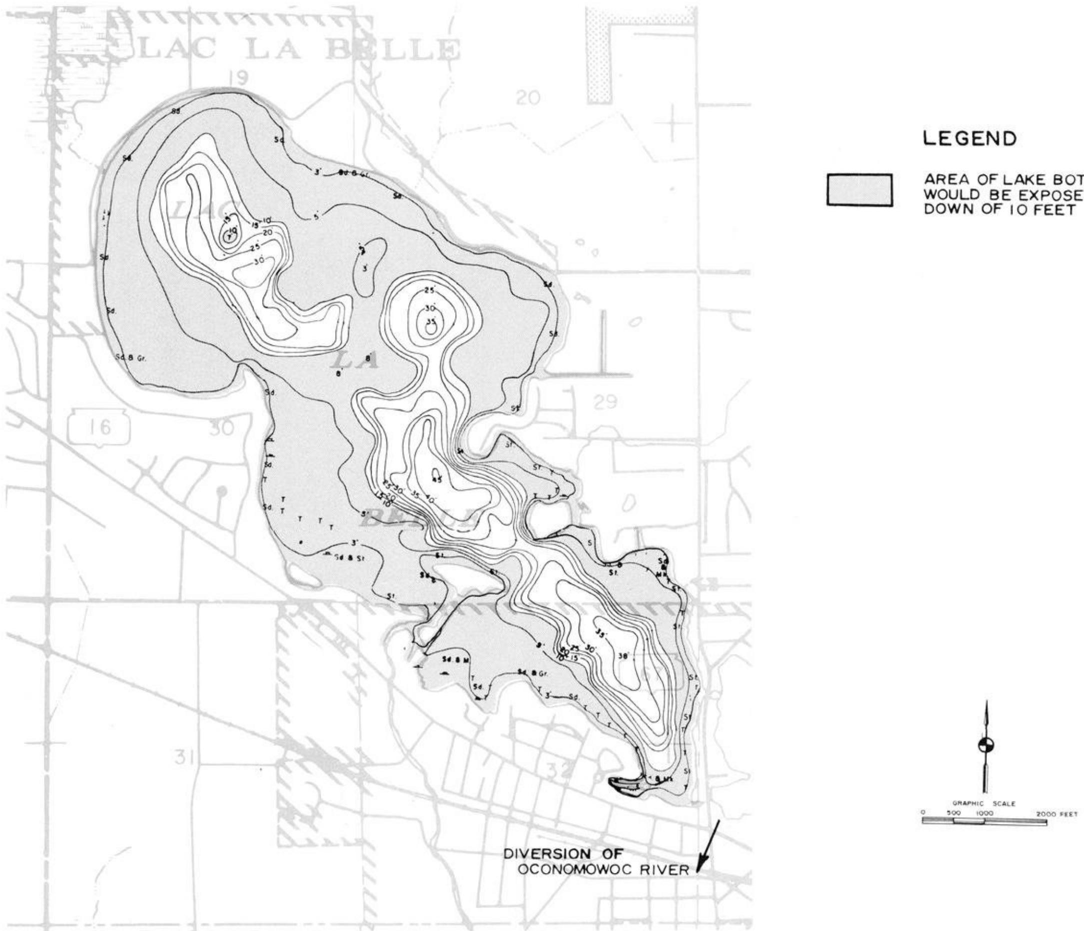
Measures for Controlling Sediment Effects on Water Column and Macrophyte Growth

Dredging, sediment covering, and drawdown for sediment consolidation serve to either deepen the lake or provide bottom sediments which are less likely to release nutrients to the water column or support excessive macrophyte growth. These measures may become more desirable in the future if the carp populations are reduced and macrophyte growths subsequently increase. Because of the relatively high cost of these practices, and the temporary disruption to the lake community which occurs when these techniques are implemented on a large scale, they are probably only warranted on a limited-scale basis for Lac La Belle.

If incoming nutrient load reductions are not fully effective in reducing the in-lake nutrient concentration, then additional sediment controls could be considered. Drawdown of the lake level by 10 feet would expose about 800 acres, or 72 percent of the area of the lake, as shown on Map 20. The pumpage of the necessary 3,800 acre-feet of water in one month from Lac La Belle at a rate of 39 million gallons per day through a 2,600-foot pipeline 36 inches in diameter would involve a capital cost of about $500,000, with an operation and maintenance cost of about $3,000 for each year of pumpage. The drawdown would probably increase the depth of the shallow areas by up to one foot and the consolidated sediments

**Map 20**

**PLAN ALTERNATIVE FOR A 10-FOOT DRAWDOWN AND SEDIMENT CONSOLIDATION FOR LAC LA BELLE**



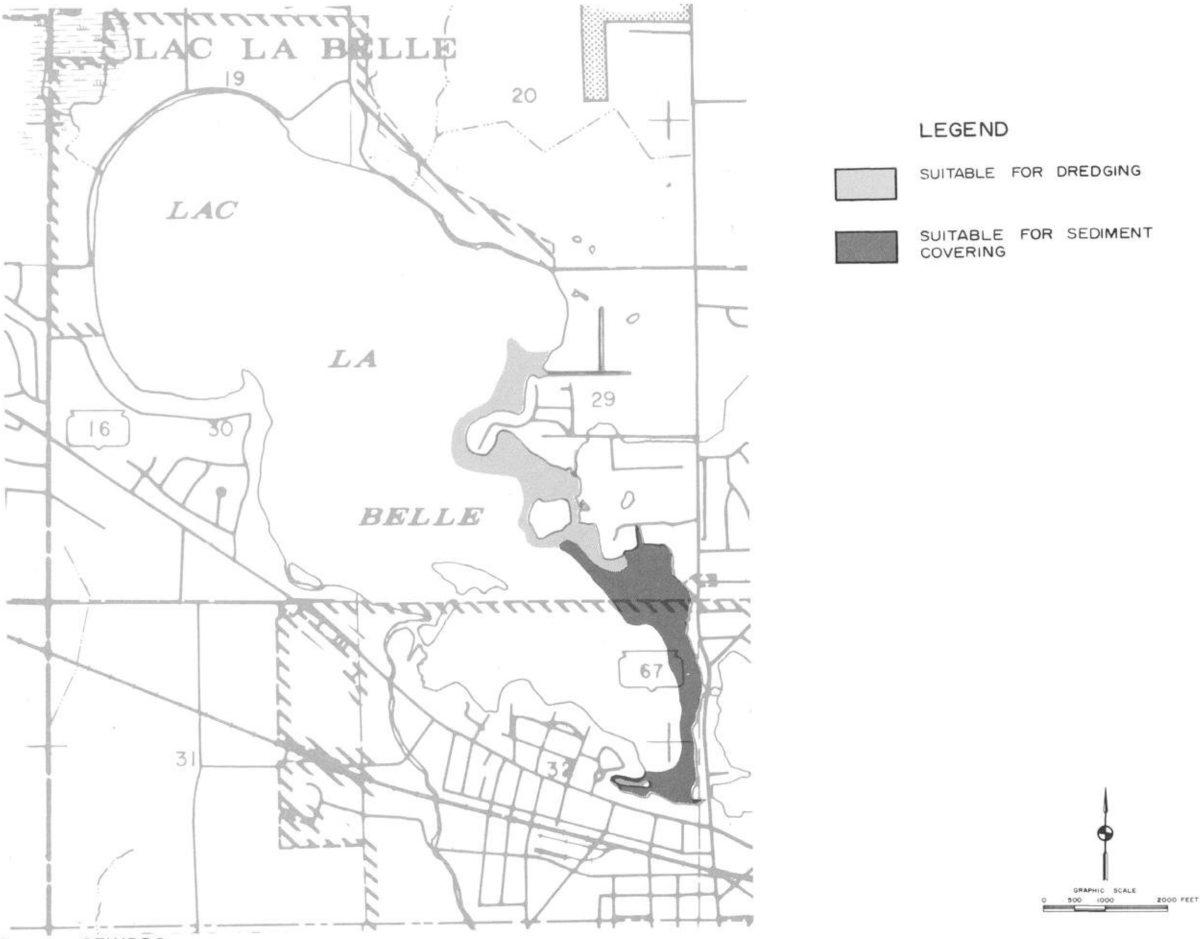

*Source: SEWRPC.*

could be expected to reduce macrophyte growths. Drawdown of Lac La Belle could potentially result in land settling, reducing the stability of building foundations and structures. The effect of drawdown on buildings and other structures would need to be investigated prior to implementation of this technique. The drawdown would occur over the winter and may need to be periodically repeated. Successful drawdown would also require that the Oconomowoc River be temporarily or permanently diverted around Lac La Belle which, as discussed below, would itself have adverse effects on the water quality of the lake, as well as numerous other disadvantages. Following a drawdown of 10 feet, it would take approximately one and one-half months for the lake to refill to normal levels.

Dredging and covering the bottom sediment with sand and/or plastic lining could be useful on a limited scale to eliminate excessive macrophyte growths in localized areas, such as swimming areas or boat access sites, as shown on Map 21. Dredging with an hydraulic dredge would cost about $3,200 per acre-foot of bottom sediment removed, or about $120,000 to dredge to an average depth of 12 feet in areas totaling 10 acres. Prior to actual dredging, it would need to be determined what

Map 21

PLAN ALTERNATIVE FOR LIMITED DREDGING AND SEDIMENT COVERING IN LAC LA BELLE




*Source: SEWRPC.*

effect the arsenic residue from sodium arsenite applications would have on groundwater quality at the disposal sites. In addition, sediment covering would cost about $2,000 per acre, or about $75,000 for the area totaling 37 acres, as shown on Map 21.

Diversion

Diversion would include rerouting the Oconomowoc River around Lac La Belle, as shown on Map 22. Diversion of the Oconomowoc River around Lac La Belle is technically possible by the construction of a new channel 4,500 feet in length through a portion of the City of Oconomowoc. The channel could be constructed about nine feet in depth with grass-lined slopes, a bottom width of 25 feet, and a top width of 44 feet. The cost would exceed $5 million, and the water quality of Lac La Belle would decline, not improve. While the existing phosphorus loading would be reduced by about 40 percent, the hydraulic residence time of the lake would be increased by a factor of five, and the resulting nutrient levels would be more than double the existing levels. Thus, the water use objectives would not be achieved. In addition, diversion of the Oconomowoc River would disrupt the natural fish migration routes into and out of the lake from the river. The construction of a diver-

## Map 22

## PLAN ALTERNATIVE FOR DIVERSION OF THE OCONOMOWOC RIVER AROUND LAC LA BELLE


*Source: SEWRPC.*

sion channel through the City of Oconomowoc would also cause several problems relating to existing land uses, with purchase and removal of about 40 homes, construction of five new bridges, and changes in the local floodplain regulations. As an alternative, diversion of the Oconomowoc River could be accomplished by intercepting the Oconomowoc River flow at the lake inlet and discharging, via a pipeline placed on the lake bottom, at the lake outlet. An environmental impact statement would probably be required to obtain approval of necessary permits from the Wisconsin Department of Natural Resources (DNR).

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-penetrating) zone; and/or 3) prevent release or recycling of potentially available nutrients from the lake sediments. Nutrient inactivation of phosphorus, which is usually accomplished by application of aluminum or other metallic salt, can be conducted for the entire lake, if nutrients from the epilimnion as well as the hypolimnion are to be removed, or for just the hypolimnion if only nutrients from the hypolimnion are to be removed. Nutrient inactivation is most applicable to lakes which have long hydraulic residence times or in which recycling of phosphorus from the bottom sediments is significant. The hydraulic residence time of Lac La Belle is relatively short, and there is no indication that the amounts of phosphorus being released from the bottom sediments are having significant water quality effects. Therefore, this measure alone would likely not achieve the water use objectives. The application of nutrient inactivation to the entire lake would cost about $300,000; application to the hypolimnion would only cost about $140,000. The treatment could need to be repeated periodically.

Dilution/Flushing

Dilution/flushing has primarily been attempted to alleviate excessive algal growths and associated problems. The reduction of nutrient levels within a lake is accomplished by replacing nutrient-rich waters with nutrient-poor waters and thus washing out the phytoplankton and the nutrients contained in the nutrient-rich waters. Lake restoration projects have attempted nutrient dilution by two procedures: 1) pumping water out of the lake, thus permitting the increased inflow of nutrient-poor groundwater; and 2) routing additional quantities of nutrient-poor surface waters into the lake. Since 80 percent of the water input to Lac La Belle is contributed by the Oconomowoc River, any reductions achieved by flushing nutrients from Lac La Belle would be rapidly restored by inflow from the upstream watershed. Therefore, this measure could not achieve the water use objectives.

Selective Discharge

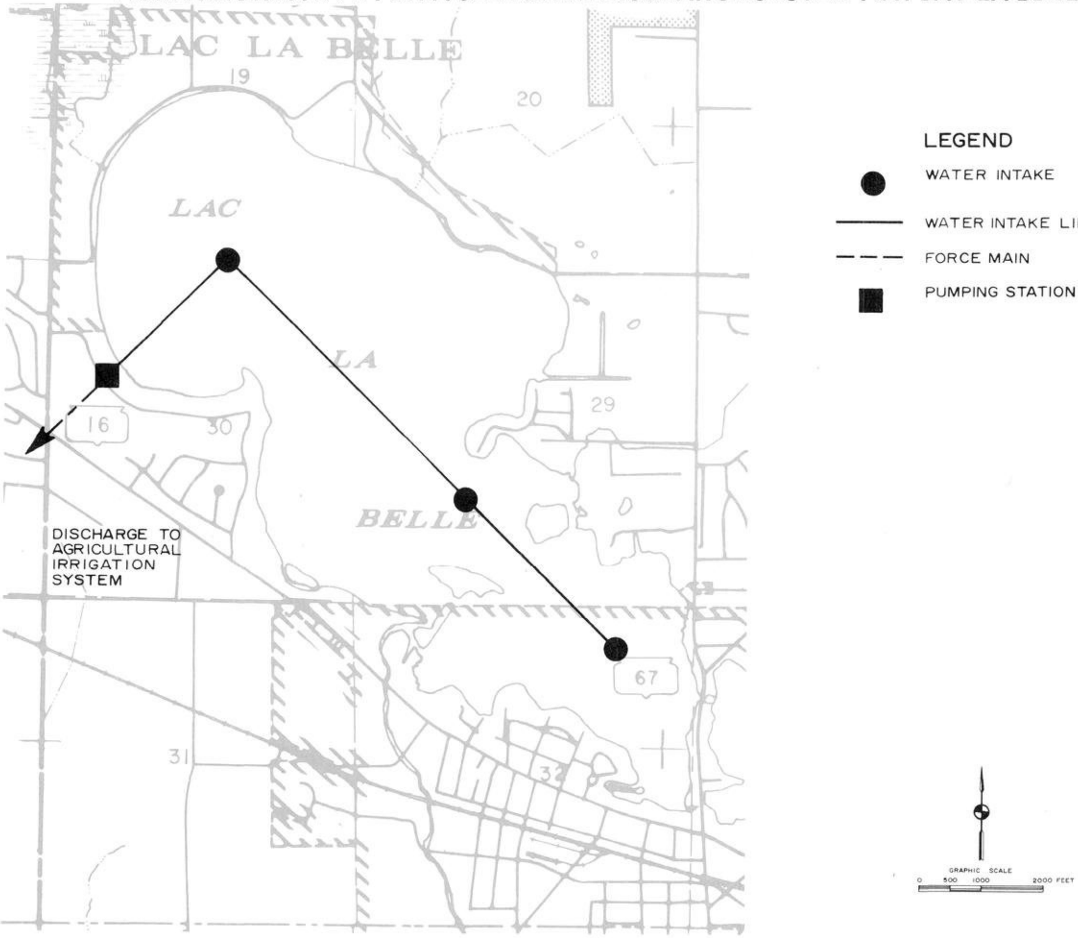
Selective discharge has been employed to substantially improve the dissolved oxygen levels near the bottom and/or to increase the nutrient output from a lake by up to 25 percent. This technique is implemented by releasing anaerobic, nutrient-rich water from the hypolimnion during summer stratification. Typically, the technique is readily employed in lakes with suitable outlet controls, but water may also be pumped from the hypolimnion and discharged downstream. The pumping from three sites in the hypolimnion, at the equivalent of two times the volume of the hypolimnion of Lac La Belle each summer, would require a capital cost of about $5.6 million and an average annual operation and maintenance cost of about $90,000. The water quality impacts could be favorable. In order to avoid causing the adverse effects associated with discharging nutrient-rich, oxygen-poor water into the Oconomowoc River, the cost assumes discharge to an existing suitable nearby agricultural irrigation system for surface discharge of the water, as depicted on Map 23. Since an existing irrigation system is used for cost purposes, the cost does not include the construction of a new irrigation system. As an alternative, new irrigation systems could be constructed at nearby sites, probably to irrigate agricultural land and the golf course, located north of Lac La Belle. Prior to discharge via the irrigation system, it would need to be determined whether or not arsenic residues from historical applications of sodium arsenite for macrophyte control are being released to the lake water during anaerobic conditions, and what effect this arsenic, if present, would have on the irrigated vegetation and underlying groundwater quality.

Improve Internal Circulation Patterns by Reducing Flow Restrictions Under Access Road to Islandale

On the northwest side of the City of Ocnomowoc exists a private road which provides access to Islandale, a small eight-acre island located just north of the City of Oconomowoc jurisdictional boundary, as shown on Map 24. Culverts located beneath the drive allow a limited quantity of flow to be transported directly to the lake outlet. However, the culverts restrict the flow under the road severely, compared to the probable lake current patterns

Map 23

PLAN ALTERNATIVE FOR A SELECTIVE DISCHARGE SYSTEM FOR LAC LA BELLE




*Source: SEWRPC.*

prior to road construction. The diversion of lake water around Islandale results in a greater mixing of lake water with Oconomowoc River water than would naturally occur. The effect of this hydraulic phenomenon is that a greater amount of pollutants are contributed to the main lake basin, with an increased opportunity for the accumulation of pollutants, and the manifestation of water quality problems, such as increased algae blooms. Lake flow currents and the effect of the private road on lake water mixing could be assessed with a dye analysis with appropriate fluorimeter apparatus, at a cost of about $2,000. The construction of new, larger culverts under the private road to Islandale would involve a capital cost of about $125,000. A decrease in the water retention, or hydraulic residence time, could be beneficial to the lake water quality, but would not alone meet the water use objectives.

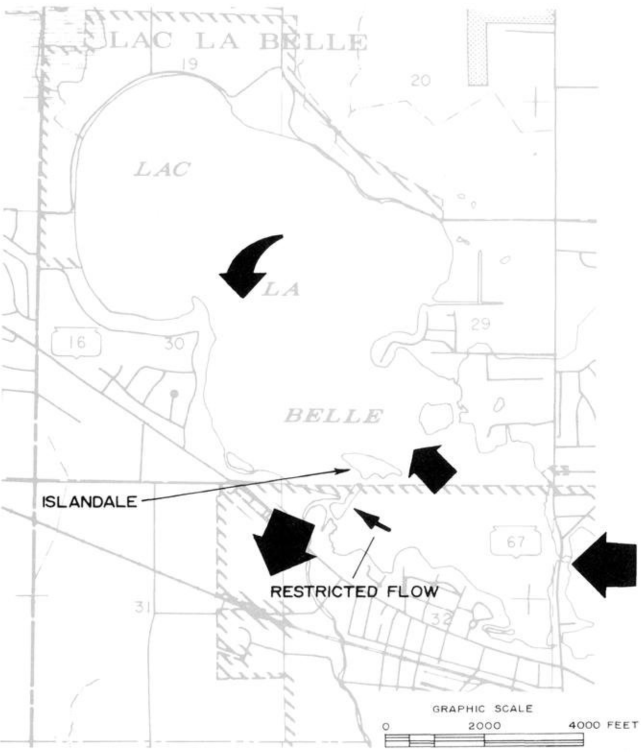
Aquatic Plant Harvesting

The existing macrophyte harvesting practices being conducted on Lac La Belle could be continued or expanded to provide desired open water areas. Upon implementation of the point and nonpoint source controls in the watershed, macrophyte growths can be expected to remain stable or perhaps even decrease. However, removal of a portion of the carp population in the lake could substantially increase the existing macrophyte levels. The carp graze on macrophytes, uproot the plants, and create turbid conditions whereby ade-

## Map 24

### PLAN ALTERNATIVE FOR IMPROVING INTERNAL LAKE CIRCULATION PATTERNS BY REDUCING FLOW CONSTRICTIONS UNDER ACCESS ROAD TO ISLANDALE IN LAC LA BELLE

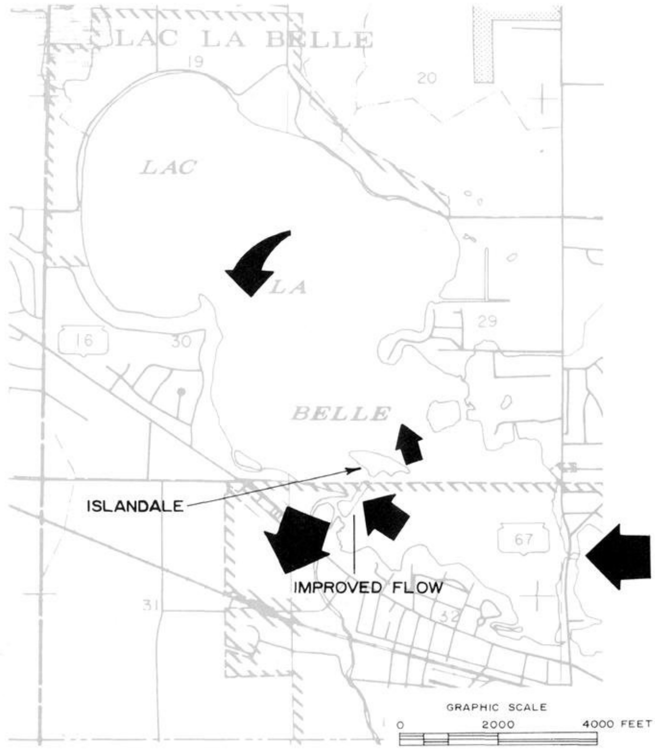
Existing Restricted Flow Conditions Beneath Access Drive




Restricted flow beneath the private drive providing access to Islandale could result in a greater mixing of lake water with Oconomowoc River water than would occur naturally. The increased mixing provides an increased opportunity for the accumulation of pollutants, and the manifestation of water quality problems, such as algae blooms. The hydraulic effects of restricted flow beneath the drive should be assessed by a dye analysis, at a cost of about $2,000.

*Source: SEWRPC.*

Improved Flow Conditions Beneath Access Drive




Increased transport of water beneath the private drive would allow the Oconomowoc River water to flush through the lake faster, thereby providing less opportunity for the development of water quality problems. Improvement of the flow conditions beneath the access drive would cost about $125,000.

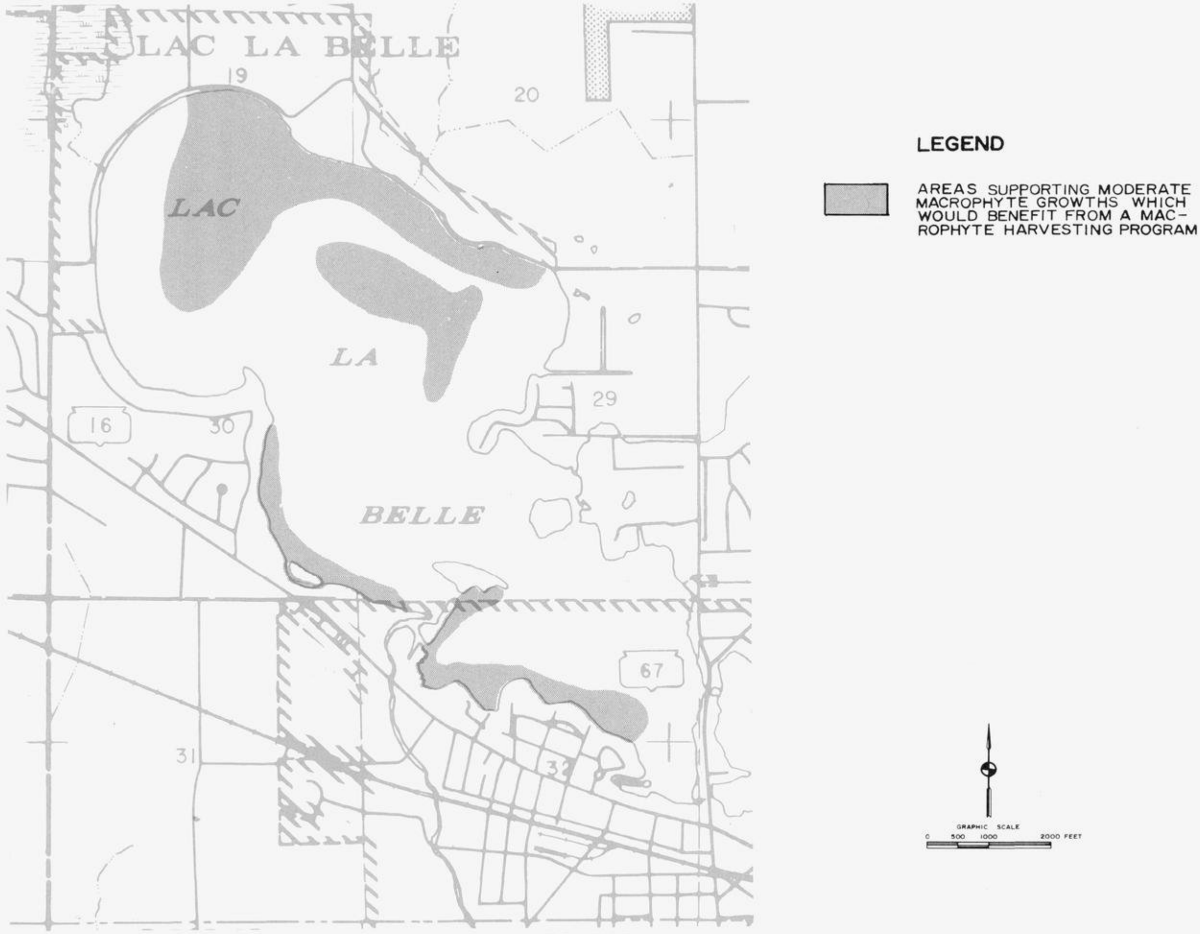
*Source: SEWRPC.*

quate sunlight is not available for plant growth. A new harvester suitable for Lac La Belle would cost about $75,000. The annual operation and maintenance cost of a continuing macrophyte harvesting program would be about $13,000. Harvesting about 300 tons of macrophytes per year from the areas totaling about 350 acres shown on Map 25 would remove about 200 pounds of phosphorus from the lake. If the areas needed to be harvested more than once per year, additional harvesters would be needed. Because macrophytes utilize nutrients from the bottom sediments, it is doubtful that all of this phosphorus would contribute to water quality problems other than the growth of macrophytes themselves. It is possible, however, that a continuing macrophyte harvesting program would eventually result in a decrease in the nutrient and organic content of the bottom sediments.

Algae harvesting has seldom been used for large-scale in-lake applications. The only practical system developed involves filtration of the lake water through a screen system such as a microstrainer. A pump and microstrainer system designed to treat about one-fourth of the lake water each summer

Map 25

PLAN ALTERNATIVE FOR MACROPHYTE HARVESTING FOR LAC LA BELLE




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

would require a capital cost of about $1.75 million, with an annual operation and maintenance cost of about $100,000. In addition to providing aesthetic improvements, harvesting of the algae could remove about 250 pounds of phosphorus from the lake annually.

Chemical Control of Algae and Macrophytes

Chemical control of algae and macrophytes is currently practiced in Lac La Belle. Because of the numerous disadvantages of chemical control of aquatic plant growth, as discussed in Chapter VI, chemical control is not recommended unless other practices—such as harvesting, sediment covering, dredging, 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 over one acre in size requires supervision by DNR staff. Chemical control of both algae and macrophytes at the existing application levels involves a cost of about $4,000 per year.

Fish Management

Removal of the carp barrier at the Lac La Belle outlet in 1960 resulted in an increase in carp populations in the lake, with a corresponding decline in game and panfish catches. This barrier was re-installed in 1976 and the Oconomowoc River downstream of Lac La Belle was chemically treated for the eradication of carp, which formerly migrated into Lac La Belle during the spawning runs. Walleye and northern pike fry were stocked in 1976. Since public lake access opportunities were unacceptable to the DNR, fish management and surveillance activities were severely curtailed. As of November 1979, the success of the 1976 fish management activities had not been ascertained. The DNR, upon the provision of adequate public access, could assess the effectiveness of the 1976 management measures and develop a continuing program of periodic fish surveillance and management.

Removal of carp from the lake could be accomplished by mechanical means (sein netting) or by the use of fish toxicants. Sein netting for carp removal is usually conducted by private individuals under contract to the DNR. It was reported that these private individuals involved in carp removal are generally not willing to undertake a removal project for Lac La Belle because the carp are relatively small in size, and therefore the financial success of the project would be questionable.[1] Fish toxicant treatment would probably involve the use of Rotenone or Antimycin chemicals. Either a partial or total kill of the fish populations could be accomplished. Under a chemical treatment program, because many species of fish—not just carp—are killed, subsequent stocking of game fish species would be necessary to establish a balanced productive fishery in the lake. Chemical fish removal is conducted by the DNR.

Possible benefits of carp removal include the removal from the lake of nutrients and organic matter contained in the fish bodies, increased primary productivity (algae), increased populations of fish food organisms (zooplankton and benthic invertebrates), increased rooted macrophytes providing food and cover for game fish-reduced nutrient recycling from the bottom sediments, and improved water clarity. The primary disadvantage would be the possible development of excessive macrophyte and algae levels if adequate supplies of nutrients are available, if the water clarity improves enough to allow greater sunlight penetration, and if the bottom substrates are suitable to support heavy growths of macrophytes. In addition, chemical treatment could have adverse effects on nontarget organisms and on the ecological balance of the lake.

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[1] *Information provided by Randy Schumacher, DNR Fish Manager, July 2, 1980.*

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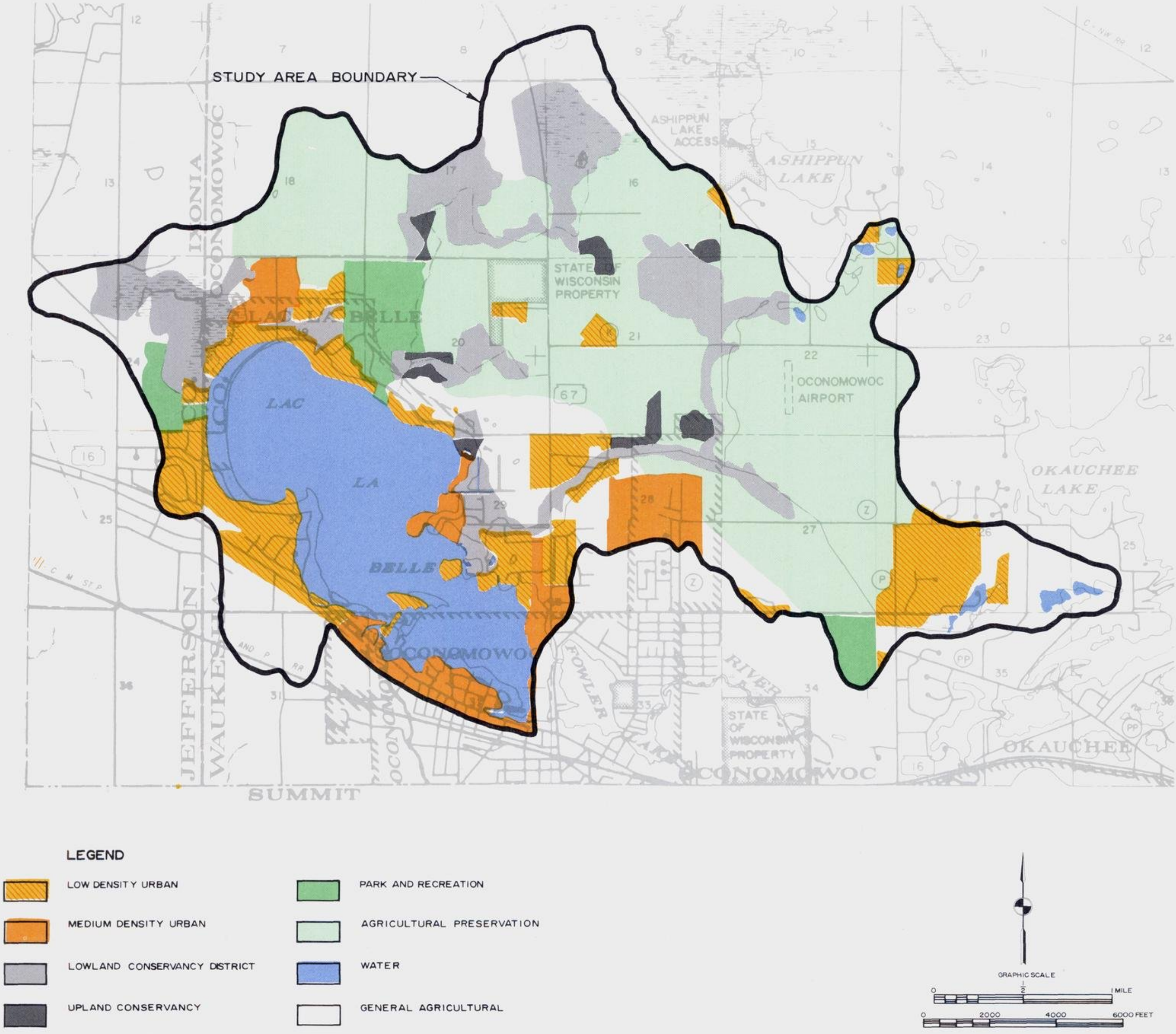
due to a printing error

Map 26

PROPOSED ZONING DISTRICTS FOR THE DRAINAGE AREA DIRECTLY TRIBUTARY TO LAC LA BELLE




*Source: SEWRPC.*

It is proposed that 968 acres, or about 14.6 percent of the direct drainage area, be included in a Lowland Conservancy District. The 968 acres are located in portions of all of the civil divisions within the Lac La Belle direct drainage area. Under the existing zoning ordinances administered within the direct drainage area approximately 41 acres are currently included in residential districts, 115 acres are included in agricultural districts, and 812 acres are in conservancy districts. The existing C-1 Conservancy Districts applied in the Town and City of Oconomowoc and the Village of Lac La

Belle are adequate and can be used. However, the lowland conservancy district would be included in the Town of Ixonia zoning ordinance as a new zoning district.

Upland Conservancy District

This district could be used to conserve and enhance the significant woodlands, related scenic areas, and marginal farmlands while at the same time allowing for rural estate residential development that maintains the rural character of the Lac La Belle area. It is proposed that 157 acres, or about 2.4 percent of the direct drainage area, be included in an Upland Conservancy District. The 157 acres are located in the Town and City of Oconomowoc and the Village of Lac La Belle, Waukesha County. This district would be included in the Town and City of Oconomowoc and Village of Lac La Belle zoning ordinances as a new zoning district. Under the existing zoning ordinances administered within the direct drainage area approximately 53 acres are currently included in residential districts, 35 acres are included in agricultural districts, and 69 acres are included in conservation districts.

Agricultural Preservation District

This district could be used to preserve and enhance lands historically used for agricultural purposes. The district provides for a minimum parcel size of 35 acres in order to preserve workable farm units, and prohibits further intrusion of urban land uses. A conditional agricultural or agricultural-related industrial use such as a cheese factory, food processing plant, or agricultural supply center would be permitted in this district.

It is proposed that 2,802 acres, or about 42.4 percent of the direct drainage area, be included in this district. The 2,802 acres are located in the Town and City of Oconomowoc, Waukesha County. Under the existing zoning ordinances administered within the direct drainage area approximately 768 acres are currently included in residential districts and 2,034 acres are in agricultural districts. This district would be included in the Town and City of Oconomowoc zoning ordinances as a new zoning district.

General Agricultural District

This district could be used to preserve and protect open space lands in areas of the Town having marginal farmland value, while at the same time allowing for estate-type residential development that maintains the rural character of the countryside. The district provides for a minimum lot size of 10 acres and would permit a mixture of farm sites and estate-type residences.

It is proposed that 1,149 acres, or about 17.4 percent of the direct drainage area, be included in this district. The 1,149 acres are located in portions of all of the civil divisions within the Lac La Belle direct drainage area. Under the existing zoning ordinances administered within the direct drainage area approximately 639 acres are currently included in residential districts, 28 acres are in business districts, 54 acres are in industrial districts, and 428 acres are in agricultural districts. The General Agricultural District would be included in the Towns of Ixonia and Oconomowoc, the City of Oconomowoc, and the Village of Lac La Belle zoning ordinances as a new zoning district.

Low-Density Residential and Medium-Density Residential Districts

These districts are used to preserve and protect residential areas within a physical environment that is healthy, safe, convenient, and attractive. It is proposed that 836 acres, or about 12.7 percent of the direct drainage area, be included within a Low Density Residential District. It is proposed that 426 acres, or 6.4 percent of the direct drainage area, be included within Medium-Density Residential Districts. Under the existing zoning ordinances administered within the direct drainage area approximately 3,245 acres are currently included in residential districts. As noted in Chapter II of Volume Two of SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, the Commission defines low-density residential land use as approximately 0.7-2.2 dwelling units per net residential acre, and medium-density residential land use as approximately 2.3-6.9 dwelling units per net residential acre. It should be noted that medium-density residential districts may also include commercial and industrial land uses, and that these land uses would be permitted only within a Medium-Density Residential District.

Park and Recreation District

This district could be used to properly zone existing recreation land uses in the direct drainage area and to protect them from possible encroachment by other less desirable or incompatible land uses. This category would prohibit the conversion of a private recreational site to urban or other incompatible uses without approval of the appropriate civil division. It is proposed that 269 acres, or about 4.1 percent of the direct drainage area, be included in this district. Under the existing zoning ordinances administered within the direct drainage area approximately 53 acres are currently included in residential districts, 50 acres are included in conservancy districts, and 166 acres are included in public districts. The Park and Recreation District would be included in the Town of Ixonia and the Village of Lac La Belle zoning ordinances as a new zoning district, and would necessitate the modification of the P-1 Public District presently included in the Town of Oconomowoc zoning ordinance. Thus, only existing and proposed public and private park and outdoor recreation sites would be placed in the Park and Recreation District, while governmental and institutional land uses in the Town would be retained in the existing P-1 Public Districts.

## POINT SOURCE POLLUTION CONTROL

The provision of sanitary sewer service to the drainage area directly tributary to Lac La Belle, as described in the preceding chapter, is recommended to eliminate malfunctioning septic tank systems and to provide an appropriate means of sewage treatment for planned future urban development. Sewage treatment would be provided by the City of Oconomowoc sewage treatment facility.

## NONPOINT SOURCE POLLUTION CONTROL AND LAKE MANAGEMENT

The water quality management plan for Lac La Belle must address methods for reducing the nutrient loading to the lake from nonpoint sources, and techniques for lake rehabilitation. As described below, the implementation of nonpoint source controls and in-lake management measures requires new institutional frameworks, improved public works activities, pollutant runoff controls by private industry and commercial establishments, improved urban "housekeeping" practices and agricultural management, increased regulation of some land management activities, and technical and financial assistance from state and federal units of government.

### Inland Lake Protection and Rehabilitation District

It is recommended that an Inland Lake Protection and Rehabilitation District be formed for Lac La Belle under the provisions of Chapter 33 of the Wisconsin Statutes in order to utilize further technical and financial assistance under state and federal lake protection and renewal programs. The Office of Inland Lake Renewal, Department of Natural Resources, coordinates these lake protection and renewal technical and financial aid programs in Wisconsin. Such an action will assure a viable organization to conduct lake protection and management programs. To seek state financial assistance for lake management techniques, it is necessary for lake districts to conduct a feasibility study to evaluate the lake's problems and consider alternative abatement measures or rehabilitation techniques. The Wisconsin Department of Natural Resources has indicated in interagency meetings with SEWRPC that this water quality management report can serve as the feasibility study for Lac La Belle. It is recommended that the proposed lake district conduct a continuing in-lake water quality sampling program to assess the effects of implemented lake management measures. This sampling program would consist at least of measurements of soluble and total phosphorus; nitrate-, nitrite-organic-, and ammonia-nitrogen; chlorophyll-a; and water clarity; and the development of temperature and dissolved oxygen profiles at least twice each summer and once each spring turnover. These data should be obtained at the deepest point in the lake. Such a data collection program would have an estimated cost of $1,000 per year. Surveys of fish, macrophytes, and algae should periodically be conducted, by, or with technical assistance of, the Wisconsin Department of Natural Resources.

### Urban Nonpoint Source Pollution Controls

The implementation of nonpoint source controls is urban areas requires the efforts of Waukesha County, the Waukesha County Board of Health, the Waukesha County Soil and Water Conservation District, the proposed Lac La Belle Protection and Rehabilitation District, the City of Oconomowoc, and the Village of Lac La Belle. The recommended responsibilities of each of these governmental agencies—consistent with their legal authorities under existing state and federal laws—are summarized in Table 29.

Septic Tank System Management Program: The basic objective of a septic tank system management program is to ensure the proper installation, operation, and maintenance of existing septic tank and other onsite waste disposal systems, and of any such new systems that may be required to serve existing urban development in those portions of the Lac La Belle drainage area where centralized sanitary sewer service is not recommended to be provided.

A septic tank system management program should consist of at least the following actions:

Table 29

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

| Urban Nonpoint Source Management Agency | Local Land Use Planning and Zoning | Undertake Septic System Management Program | Undertake Construction Erosion Control Program | Develop and Implement Detailed Plan for Urban Practices | Conduct Educational and Informational Program | Provide Technical Assistance | Provide Fiscal Support to Soil and Water Conservation District |
|---|---|---|---|---|---|---|---|
| Waukesha County | X | -- | X | -- | X | -- | X |
| Waukesha County Board of Health | -- | X | -- | -- | X | -- | -- |
| Waukesha County Soil and Water Conservation District | -- | -- | -- | -- | -- | X | -- |
| New District (Inland Lake Protection and Rehabilitation District for Lac La Belle) | -- | -- | -- | X | X | -- | -- |
| City of Oconomowoc | -- | -- | X | X | X | -- | -- |
| Village of Lac La Belle | -- | -- | X | X | X | -- | -- |

*Source: SEWRPC.*

1. The revision of the Waukesha County sanitary ordinance to include regulation of the operation and maintenance of onsite sewage disposal systems, including septic tanks, holding tanks, and "mound" systems or other systems approved by the applicable state regulations.

2. The establishment through such a sanitary ordinance of a regular program of inspection of onsite sewage disposal systems by the Waukesha County Board of Health. Such a program would include the visual inspection by trained individuals in the field of each onsite sewage disposal system. The purpose of the inspection would be to identify any malfunctioning sewage disposal systems. Such an inspection program could extend to the testing of individual systems through the injection of dye, or the use of septic leachate detector systems, particularly in those cases where onsite systems are suspected of discharging directly to the lake. Each system should be inspected once every five years, and accordingly, one-fifth of all such systems should be inspected annually. The inspection program would result, as necessary, in the issuance of orders to abate improper practices and take appropriate corrective measures.

3. The conduct of an educational program whereby homeowners would be advised of the rules and regulations governing onsite sewage disposal systems and be encouraged to undertake preventive maintenance measures.

Construction Erosion Control Program: It is recommended that Waukesha County, the City of Oconomowoc, and the Village of Lac La Belle take appropriate steps to ensure the reduction of water pollution—particularly phosphorus—caused by soil erosion from land under construction, particularly including land being converted from rural to urban use and land laid bare for transportation facility construction.

These designated units of goverment should review their subdivision regulations, zoning ordinances, and building codes, and revise such regulations, ordinances, and codes to assure that, when taken together, they encompass administrative procedures, erosion control performance standards, and enforcement provisions. It is recommended that the ordinances require the submittal of an erosion control plan by land developers and that the erosion control plan be reviewed and approved by the county Soil and Water Conservation District. It is recommended that each designated agency adopt the appropriate ordinances; require the submittal of erosion control plans for all construction projects; review such plans with the technical assistance of the Soil and Water Conservation District in conjunction with local municipal engineers; and provide for the proper enforcement through inspection of the erosion control measures to be implemented. The review and evaluation of the plans and control measures implemented should be based on criteria set forth in the U. S. Soil Conservation Service Soil and Water Technical Guide. Enforcement of the ordinances would be through the land subdivision, zoning, and building code approval authority of the designated management agency. The Southeastern Wisconsin Regional Planning Commission can assist in the development of the ordinance.

Development and Implementation of a Detailed Plan for Application of Urban Land Management Practices

The design of urban nonpoint source pollution abatement practices should be a highly localized, detailed, and individualized effort, requiring, as it does, highly specific knowledge of the physical, managerial, social, and fiscal considerations that affect the local public officials and landowners concerned. Accordingly, it is recommended that the proposed Lac La Belle Protection and Rehabilitation District, the City of Oconomowoc, and the Village of Lac La Belle develop detailed plans for a 25 percent reduction in nonpoint source pollution from developed urban land areas.

It is recommended that the proposed Lake Rehabilitation District, in cooperation with the City of Oconomowoc and the Village of Lac La Belle, identify the specific sources of nonpoint source pollution within the urban areas of the lake's direct drainage area and develop programs to implement measures to control these specific sources. Specifically, it is recommended that these designated agencies inventory and assess the existing land management practices, determine the extent and location of the problem areas, define and recommend applicable pollution control measures, estimate the effectiveness and costs of these control measures, and develop a program for implementing and financing the recommended control measures.

It is recommended that urban nonpoint source control measures implemented in the drainage area tributary to Lac La Belle include a public education program to provide information on the relationship of land management practices to water quality; improved street cleaning and maintenance; the proper collection and disposal of leaves, grass clippings, and other vegetative debris; the proper use of fertilizers, pesticides, and other lawn care measures; improved refuse collection and disposal; the proper vegetative management of near-shore areas; the adequate maintenance of storm water drainage ditches and storm sewer systems, including discharge sites; the proper disposal of litter and pet wastes, and other measures as locally identified. It is recommended that a fact sheet identifying 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 detailed practices from the Waukesha County Soil and Water Conservation District, and seek assistance in the form of public educational 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 controls in rural areas requires the efforts of Waukesha County, the Waukesha County Soil and Water Conservation District, and the proposed Lac La Belle Protection and Rehabilitation District. The recommended responsibilities of each governmental agency are set forth in Table 30.

Like the design of urban nonpoint source pollution abatement practices, the design of rural nonpoint source pollution abatement practices should be a highly localized, detailed, and individualized effort, requiring, as it does, highly specific knowledge of the physical, managerial, social, and fiscal considerations that particularly affect the farmers and rural landowners concerned.

Accordingly, it is recommended that the Waukesha County Soil and Water Conservation District, in cooperation with the proposed Lac La Belle Protection and Rehabilitation District, undertake the design of detailed rural soil and water conservation practices on each farm in the watershed. It is recommended that the proposed lake district be the lead agency in the preparation of such practices, and, as such, formally request that the Soil and Water Conservation District conduct a detailed assessment of the potential for agricultural nonpoint source pollution in the lake watershed, including estimates of soil loss, and recommend specific abatement measures for each identified source. It is also recommended that an estimate of

Table 30

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

| Rural Nonpoint Source Management Agency | Local Land Use Planning and Zoning | Develop Livestock Waste Control Program | Develop and Implement Detailed Plan for Rural Practices | Conduct Educational and Informational Program | Provide Technical Assistance | Provide Fiscal Support to Soil and Water Conservation District |
|---|---|---|---|---|---|---|
| Waukesha County | X | X | - - | X | - - | X |
| Waukesha County Soil and Water Conservation District | - - | X | X | - - | X | - - |
| New District (Inland Lake Protection and Rehabilitation District for Lac La Belle) | - - | - - | X | X | - - | - - |

*Source: SEWRPC.*

the cost and effectivenss of each practice be made. Agricultural nonpoint source abatement measures which may be appropriate for use in the Lac La Belle watershed include crop rotation, conservation tillage, grassed waterways, diversions, terraces, contour strip-cropping, and livestock waste control. Some agricultural areas in the lake watershed with relatively steep slopes and in proximity to the lake are particularly susceptible to erosion, which can significantly harm the lake environment, and should receive priority for planning and implementation efforts. It is envisioned that the proposed lake protection and rehabilitation district will—through an intergovernmental memorandum of understanding—cooperate with the Waukesha County Soil and Water Conservation District in the necessary detailed planning.

Following the preparation of a detailed local plan for the abatement of nonpoint source pollution in rural areas, it is recommended that the management agencies take appropriate steps to implement the detailed plan. This could include the establishment of public educational programs, the installation of soil conservation practices, and the undertaking of improvements to protect critical areas from erosion. It is further recommended that the county Soil and Water Conservation District provide all necessary technical assistance in carrying out the detailed plans. Finally, it is recommended that the county office of the University of Wisconsin-Extension Service establish appropriate education and information programs in support of the plan implementation efforts.

## LAKE REHABILITATION TECHNIQUES

The selection of lake rehabilitation techniques must consider local circumstances and lake management objectives. The implementation of lake rehabilitation techniques is best carried out by the proposed Lac La Belle Protection and Rehabilitation District. Additional technical assistance from the Wisconsin Department of Natural Resources, Office of Inland Lake Renewal, will be required prior to actual implementation of a rehabilitation technique.

It is recommended that limited dredging, limited sediment covering, macrophyte harvesting, and fish management activities be implemented in Lac La Belle in order to provide a lake environment most suitable for a full range of recreational activities and for the support of warmwater fish and other aquatic life. Hypolimnetic aeration is also recommended to increase dissolved oxygen levels in the hypolimnion, thereby increasing the habitat for fish in the summer and reducing the release of nutrients from the bottom sediments. Hypolimnetic aeration will also provide additional refuge for zooplankton; increased zooplankton populations can effectively reduce certain species of algae. It should be noted that the choice between dredging and sediment covering depends upon many factors, including the evolution of these techniques in the coming years, the sediment characteristics in the specific areas chosen, the availability of personnel and equipment at the time of project construction, the availability of safe dredge spoil disposal areas, the availability of bottom covering materials, and the configuration of the final lake bottom design.

A dye study of the lake is recommended to assess the effects of lake flow currents and mixing with the Oconomowoc River water in the central basin. Improvement of the hydraulic transport efficiency of the culverts located beneath the private road providing access to Islandale should be considered if the dye analysis indicates that the natural flow-through of the lake is being restricted significantly. The current practice of chemical control of algae and macrophytes should be carefully reviewed on a continuing basis, in light of the numerous adverse effects of this activity. Given the high cost and uncertain effects of the remaining lake rehabilitation techniques, they are not warranted at this time. The recommended water quality sampling program should continue to monitor the effects of implemented in-lake management measures.

## COST ANALYSES

Cost estimates—expressed in 1980 dollars—for recommended nonpoint source controls in the Lac La Belle watershed and in-lake management techniques are set forth in Table 31. The total capital cost of the recommended plan is $1,943,100 over a 20-year plan implementation period, with an average annual operation and maintenance cost of $53,500, resulting in a total annual average cost of $147,300. Of these totals, $351,100, or 18 percent, of the capital cost; $19,300, or 36 percent, of the annual operation and maintenance cost; and $36,500, or 25 percent, of the total annual cost would be borne by the local units of government. The remaining costs would be borne by individual property owners or by state or federal cost-sharing programs. About $1,436,000, or 95 percent, of the total capital cost of the recommended watershed management measures is associated with control of erosion from construction activities, with 90 percent of the erosion control cost being borne by the private sector. The in-lake management costs include a total average annual cost of $1,000 for an in-lake water quality sampling program, $12,400 for hypolimnetic aeration, $16,800 for macrophyte harvesting, $3,800 for limited sediment covering, $100 for a lake flow analysis with dye, and $6,000 for limited dredging. Table 32 sets forth the estimated costs of implementing the recommended plan that could be expected to be provided by state or federal cost-sharing funds. Based on the expected 1985 population of the lake drainage area, the total average annual cost for each lake watershed resident would be about $30, or $94 per household. The average annual local public sector cost for each lake drainage area resident would be about $7, or $23 per household.

Table 31

## ESTIMATED COST OF RECOMMENDED WATER QUALITY AND LAKE MANAGEMENT MEASURES FOR LAC LA BELLE: 1980-2000

| Water Quality or Lake Management Measure[b] | Capital[a] | | Average Annual Operation and Maintenance[a] | | Total Average Annual[a] | |
|---|---|---|---|---|---|---|
| | Total | Local Public Sector | Total | Local Public Sector | Total | Local Public Sector |
| Sanitary Sewer Service[c] | $ -- | $ -- | $ -- | $ -- | $ -- | $ -- |
| Septic Tank System Management[d] | -- | -- | -- | -- | -- | -- |
| Rural Land Management | 1,100 | -- | 9,800 | -- | 9,900 | -- |
| Livestock Waste Control | 81,900 | -- | 6,800 | -- | 10,900 | -- |
| Urban Land Management | 100 | 100 | 4,000 | 4,000 | 4,000 | 4,000 |
| Construction Erosion Control[e] | 1,463,000 | 146,000 | 12,700 | 1,300 | 82,400 | 8,200 |
| Watershed Management Subtotal | $1,546,100 | $146,100 | $33,300 | $ 5,300 | $107,200 | $12,200 |
| Hypolimnetic Aeration[f] | $ 125,000 | $ 50,000 | $ 6,200 | $ -- | $ 12,400 | $ 2,500 |
| Limited Dredging[f] | 120,000 | 48,000 | -- | -- | 6,000 | 2,400 |
| Limited Sediment Covering[f] | 75,000 | 30,000 | -- | -- | 3,800 | 1,500 |
| Macrophyte Harvesting | 75,000 | 75,000 | 13,000 | 13,000 | 16,800 | 16,800 |
| Fish Management[g] | -- | -- | -- | -- | -- | -- |
| Lake Flow Analysis with Dye Tests | 2,000 | 2,000 | -- | -- | 100 | 100 |
| Water Quality Sampling Program | -- | -- | 1,000 | 1,000 | 1,000 | 1,000 |
| In-Lake Management Subtotal | $ 397,000 | $205,000 | $ 20,200 | $14,000 | $ 40,100 | 24,300 |
| Total | $1,943,100 | $351,100 | $53,500 | $19,300 | $147,300 | $36,500 |

[a] *All costs expressed in January 1980 dollars.*

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

[c] *Nearly all urban development in the drainage area directly tributary to Lac La Belle 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 total estimated capital 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, is $9.0 million, plus an annual operation and maintenance cost of about $168,000.*

[d] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lac La Belle. However, because septic tank systems 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 total estimated capital expenditure for septic system management in the Lac La Belle drainage basin over the period of 1980-2000 is $55,000, plus an average annual operation and maintenance cost of $6,500.*

[e] *It was estimated that about 10 percent of the total construction erosion control cost would be needed to control erosion from the construction of public land uses, such as highways, schools, etc.*

[f] *It was assumed that 60 percent of the capital costs for hypolimnetic aeration, dredging, and sediment covering would be provided by state and federal funds under the Wisconsin inland lake protection and rehabilitation program.*

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

*Source: SEWRPC.*

Table 32

## AVAILABLE STATE AND FEDERAL COST-SHARING FOR IMPLEMENTATION OF THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN

| Water Quality or Lake Management Measure | Estimated Total Cost 1980-2000 | | Anticipated Percent State or Federal Cost Share | State or Federal Cost-Share Program |
|---|---|---|---|---|
| | Capital | Annual Operation and Maintenance | | |
| Rural Land Management Practices and Livestock Waste Control[a] | $ 83,000 | $16,600 | 50-75 percent of capital cost, none for operation and maintenance | Federal Agricultural Conservation Program (ACP) administered by the USDA Agricultural Stabilization and Conservation Service (ASCS) and the Soil Conservation Service (SCS) |
| Urban Land Management Practices[a] | 100 | 4,000 | None | - - |
| Construction Erosion Control[a] | 1,463,000 | 12,700 | None | - - |
| Aquatic Macrophyte Harvesting | 75,000 | 13,000 | None | - - |
| Hypolimnetic Aeration | 125,000 | 6,200 | 60 percent of capital cost, none for operation and maintenance | Department of Natural Resources, Inland Lake Rehabilitation Program |
| Limited Dredging | 120,000 | - - | | |
| Limited Sediment Covering | 75,000 | - - | | |
| Fish Management | - - | - - | - - | Cost for fish management will be borne by the Wisconsin Department of Natural Resources |
| Low Flow Analysis with Dye | 2,000 | - - | None | - - |
| Water Quality Sampling Program | - - | 1,000 | None | - - |

[a] *Cost-sharing and technical assistance for nonpoint source controls could also be applied for as a local priority project under the Wisconsin Fund Nonpoint Source Pollution Abatement Program administered by the Wisconsin Department of Natural Resources.*

*Source: SEWRPC.*

## Chapter X

## SUMMARY

The preparation of the water quality management plan for Lac La Belle as presented herein was a cooperative effort of the Southeastern Wisconsin Regional Planning Commission and the Wisconsin Department of Natural Resources. The lake study included the design and conduct of a water quality sampling program—with field sampling conducted from May 1976 through April 1977—and the inventory and analysis of land use, watershed characteristics, natural resource base, recreation use, and existing management practices. The objectives of the plan were to provide a level of water quality in Lac La Belle suitable for the maintenance of a healthy warmwater fishery, to reduce the severity of occasional nuisance conditions caused by excessive algae growth, and to improve opportunities for water-based recreational activities.

Lac La Belle is located entirely within U. S. Public Land Survey Township 8 North, Range 17 East, Town of Oconomowoc in Waukesha County. The lake has a surface area of 1,117 acres, a maximum depth of 45 feet, and a mean depth of 9 feet. The lake has a direct tributary drainage area of 6,607 acres, or 10.32 square miles, and a total watershed area of 55,349 acres, or 86.48 square miles.

The drainage area of Lac La Belle includes all of the Village of Lac La Belle (0.48 square mile, or about 4.0 percent) and portions of the City of Oconomowoc (0.94 square mile, or about 7.8 percent), the Town of Oconomowoc (10.13 square miles, or 83.9 percent), all of which are located in Waukesha County, and the Town of Ixonia (0.52 square mile, or 4.3 percent), located in Jefferson County. As of 1975, the resident population of the direct tributary drainage area to the lake was estimated by the Commission to be 3,300 persons.

The type, intensity, and spatial distribution of land uses are important factors determining resource demand in the direct tributary drainage area. As of 1975, approximately 1,627 acres, or 25 percent of the 6,607-acre direct tributary drainage area, were in urban land use, with the dominant urban land use—878 acres, or 54 percent—in residential use. The remaining urban land uses—commercial, industrial, governmental and institutional, transportation, communication, utilities, and recreation—constituted about 749 acres, or 11 percent of the Lac La Belle direct drainage area. Approximately 4,980 acres, or 75 percent of the direct tributary drainage area, were in rural land use, with the dominant rural land use—3,664 acres, or 74 percent—in agricultural use. Woodlands and open lands comprised about 342 acres, or 7 percent of the rural land area. Wetlands and surface water, excluding the surface area of Lac La Belle, accounted for 974 acres, or 20 percent of the rural land area.

As of 1975, the sanitary and household wastewaters from an estimated 2,561 persons, or about 78 percent of the total resident population of the drainage area directly tributary to Lac La Belle, were treated and disposed of through the use of onsite disposal systems. As of 1975, there were approximately 722 septic tank systems in the direct tributary drainage area—80 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems. As of 1979, six mound systems and three holding tanks were known to exist in the direct tributary drainage area.

In the year of study, it is estimated that approximately 31,959 acre-feet of water entered the lake. Of this total, about 25,724 acre-feet, or 80 percent, was contributed by inflow from the Oconomowoc River; about 3,406 acre-feet, or 11 percent, was contributed by inflow from Rosenow Creek; direct precipitation contributed about 1,887 acre-feet, or 6 percent; and about 942 acre-feet, or about 3 percent, was contributed by surface runoff from elsewhere in the direct tributary drainage area. Of the total water output from Lac La Belle, about 85 percent was discharged via the Oconomowoc River and 7 percent was evaporated from the surface of the lake. In addition, groundwater was estimated to have a net output from the lake of 2,520 acre-feet, or 8 percent.

Monthly temperature and dissolved oxygen profiles indicate that complete mixing of Lac La Belle is restricted during the summer by thermal stratification and during the winter by ice cover. The data indicate that Lac La Belle, 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, where higher dissolved oxygen concentrations exist. Water clarity, as measured by a Secchi Disc, ranged from about 4.0 feet to 8.2 feet.

Lac La Belle supports a relatively large and diverse fish community. Survey reports of the Wisconsin Department of Natural Resources indicated that from 1946 through 1974, 29 different fish species were surveyed in the lake. No threatened or endangered fish species were found in the lake.

The Regional Planning Commission-recommended water quality standard for recreational use and warmwater fish and aquatic life indicates that nuisance aquatic 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 Lac La Belle, the mean concentration of total phosphorus in the spring was about 0.04 mg/l, which indicates that the potential for nuisance aquatic plant growths exists in the lake.

In general, the aquatic weed growth in Lac La Belle was sparse to moderate and diverse. Populations of blue-green algae in the lake reached "bloom" proportions in several instances during the study year.

It is estimated that under the existing, 1975, conditions, the total phosphorus load to Lac La Belle during an average year would be 6,475 pounds. Of this total, about 3,000 pounds, or 46 percent, was estimated to be contributed by the Oconomowoc River. In addition, livestock operations were estimated to contribute about 1,540 pounds, or 24 percent of the total. Construction activities contributed approximately 570 pounds, or 9 percent of the total phosphorus load to the lake. The remaining sources of phosphorus in the Lac La Belle direct drainage area—urban land use, rural land use, onsite sewage disposal systems, and direct atmospheric fallout—contributed an estimated 1,365 pounds, or 21 percent of the phosphorus load to the lake.

Based on the study data, Lac La Belle was classified as mesotrophic, a term describing moderately fertile lakes which may support abundant aquatic plant growths and may support productive fisheries. Nuisance growths of algae and weeds may occasionally be exhibited by mesotrophic lakes.

According to the land use plan adopted by the Commission, the population of the Lac La Belle direct tributary drainage area is expected to increase by 107 percent, or approximately 3,540 residents, by the year 2000. The year 2000 land use plan recommends that most new residential development in the direct tributary drainage area occur at medium densities. Under the year 2000 land use plan, approximately 2,126 acres, or 32 percent of the 6,607-acre direct tributary drainage area, would be in urban land use, with the dominant urban land use being residential, encompassing 1,191 acres, or about 56 percent of the urban land area. The remaining 935 acres, or 44 percent of the urban land, would be in a mixture of commercial, industrial, governmental, institutional, transportation, communication, utility, and recreation land uses. Compared with 1975 land use, this represents a 31 percent increase in urban land uses and, specifically, a 36 percent increase in residential land in the direct tributary drainage area. Most of the planned development would occur on land presently in agricultural use. According to the land use plan, the remaining 4,481 acres, or 68 percent of the direct drainage area, would be occupied by a mixture of rural land uses, including agricultural, water, wetlands, woodlands, and other open land uses.

The Commission also estimated that under year 2000 conditions, the total phosphorus load to the lake would be approximately 4,360 pounds per year, or about 33 percent less than the estimated 1975 loadings. Of this total, approximately 1,000 pounds, or 23 percent, would be contributed by the Oconomowoc River. The anticipated decrease of about 2,000 pounds in phosphorus loading from the Oconomowoc River would occur following implementation of the upstream water pollution control measures recommended in the regional water quality management plan. Further, there would also be a decrease of approximately 142 pounds of phosphorus—from about 174 pounds per year in 1975 to approximately 32 pounds per year, or 1 percent of the load in the year 2000—entering the lake from malfunctioning septic tank systems following the provision of sanitary sewer service to residents of Lac La Belle, also as recommended in the regional water quality management plan. The other sources of phosphorus, under anticipated year 2000 conditions, would be livestock operations, representing about 1,540 pounds, or 35 percent; direct atmospheric contributions, representing 558 pounds, or 13 percent; construction activities, representing about 570 pounds, or 13 percent; urban land, representing about 365 pounds, or 8 percent; and rural land, representing 295 pounds, or about 7 percent.

Management measures required to meet the water use objectives for Lac La Belle must address the nonpoint source pollution controls needed. Commission estimates indicate that there will need to be a reduction of 30 percent in nonpoint source phosphorus loads from the direct tributary drainage area in order for the recommended water use objectives and supporting standards to be met. As noted, the provision of sanitary sewer service to the drainage area directly tributary to Lac La Belle is recommended as a point source control measure in the adopted regional water quality management plan. This would abate a nonpoint source by eliminating all but approximately 15 of the septic tank systems with severe or very severe limitations. Sewage treatment would be provided by the City of Oconomowoc sewage treatment facility. Other nonpoint source control measures, as discussed in Chapter IX, consist of improved management of both urban and rural land uses to reduce pollutant discharges to the lake by direct overland drainage, by drainage from natural or man-made channels, and by groundwater inflow. These actions would be designed to reduce the in-lake concentration of total phosphorus in Lac La Belle during the spring turnover to the Commission-recommended standard of 0.02 mg/l.

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 and flushing, selective discharge, diversion, improvement of the internal lake circulation patterns, macrophyte harvesting, algae harvesting, chemical controls, fish management, and initiation of a water quality monitoring program. As a result of these analyses, the Commission recommends that the City of Oconomowoc continue and expand the current macrophyte harvesting program. To further control excessive macrophyte growths, particularly on the eastern shore, it is recommended that limited dredging and sediment covering be employed. The dredging and sediment covering would provide a long-term reduction in macrophyte growth of the treated areas, thus improving the recreational potential of these areas. Dredging, sediment covering, and macrophyte harvesting will also reduce the need for chemicals to control macrophytes. The Commission also recommends the use of hypolimnetic aeration to reduce phosphorus concentrations in the lake. Hypolimnetic aeration could be implemented prior to control of point and nonpoint pollution sources to provide additional and immediate water quality improvements. A dye study of the lake is also recommended to assess the effects of lake flow, currents, and mixing.

The Department of Natural Resources, upon the provision of adequate public access, should assess the effectiveness of the 1976 management measures and develop a continuing program of periodic fish surveillance and management. It is recommended that the Department assess the methods available to eradicate the carp population, and the subsequent effect on nontarget organisms and the ecological balance of the lake.

In summary, the water quality management recommendations for Lac La Belle were developed within the framework of the adopted regional water quality management plan for the upstream tributary areas draining to the Oconomowoc River, and include:

1. The modification of local zoning ordinances to more effectively implement the adopted regional land use plan.

2. The provision of sanitary sewer service to portions of the drainage area directly tributary to the lake to provide for collection and conveyance of sanitary wastewaters for treatment and discharge at the City of Oconomowoc sewage treatment plant.

3. The establishment of a new Inland Lake Protection and Rehabilitation District for Lac La Belle.

4. The implementation of nonpoint source controls in both urban and rural areas, including a public education program, improved agricultural management, and technical and financial assistance from state and federal units of government.

5. The revision of the Waukesha County sanitary ordinance to address the operation, maintenance, and inspection of the privately owned onsite sewage disposal systems which would not be eliminated by the proposed centralized sanitary sewerage system.

6. The implementation of construction erosion control ordinances by Waukesha County, the City of Oconomowoc, the Towns of Oconomowoc and Ixonia, and the Village of Lac La Belle.

7. The design and implementation of aeration, limited dredging, and sediment covering operations, and continued weed harvesting.

8. The implementation of a continuing in-lake water quality and fishery resource monitoring program by the Wisconsin Department of Natural Resources.

Implementation of the recommended nonpoint source controls in the drainage area directly tributary to Lac La Belle and in-lake management would entail a total capital cost of about $1.9 million, with an average annual operation and maintenance cost of about $53,500, and a total average annual cost of about $147,300 over the 20-year plan period. About 95 percent of the capital cost of watershed management is associated with the control of erosion from construction activities, with 90 percent of this construction erosion control being borne by the private sector. The in-lake management costs include a total average annual cost of $40,100, ranging from a low of $100 for a lake flow dye analysis to a high of $16,800 for macrophyte harvesting. Based on the expected 1985 population of the drainage area directly tributary to the lake, the total average annual cost for each household in the lake watershed would be about $94, or about $30 per resident. The average annual local public sector cost of the recommended plan is about $36,500, or about $23 for each household in the lake watershed and about $7 per resident.

Lac La Belle 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 direct tributary drainage area of the lake. Projected increases in population, urbanization, income, leisure time, and individual mobility forecast for the Region will 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 Lac La Belle, based upon comprehensive water quality management and related land use plans, the water quality protection needed to maintain conditions suitable for recreational use and for maintenance of fish and other aquatic life in Lac La Belle will not be provided.

# APPENDICES

## Appendix A

## ACKNOWLEDGMENT OF ASSISTANCE IN PREPARATION OF THE LAC LA BELLE STUDY

Local citizens who provided review and comment on the draft plan

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Mr. Robert Q. Conley
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Mrs. Jacquelin A. Morgan
Mr. Louis J. Morgan
Mr. Todd Rathkamp
Mr. William A. Swendson, Jr.
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Mr. Thomas Wierdsma

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Mr. Craig F. Walters
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Mr. Gerald Wegner

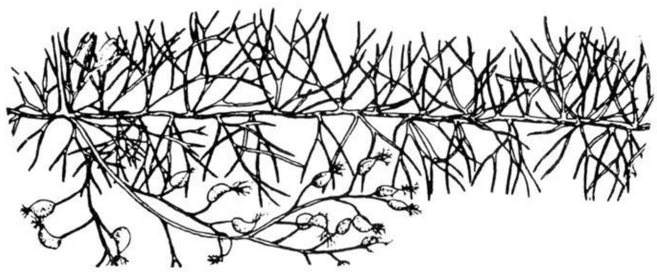
# Appendix B

## ILLUSTRATIONS OF REPRESENTATIVE BIOTA IN LAC LA BELLE

# Appendix B-1

## REPRESENTATIVE MACROPHYTES FOUND IN SOUTHEASTERN WISCONSIN LAKES

### BLADDERWORT (Utricularia sp.)

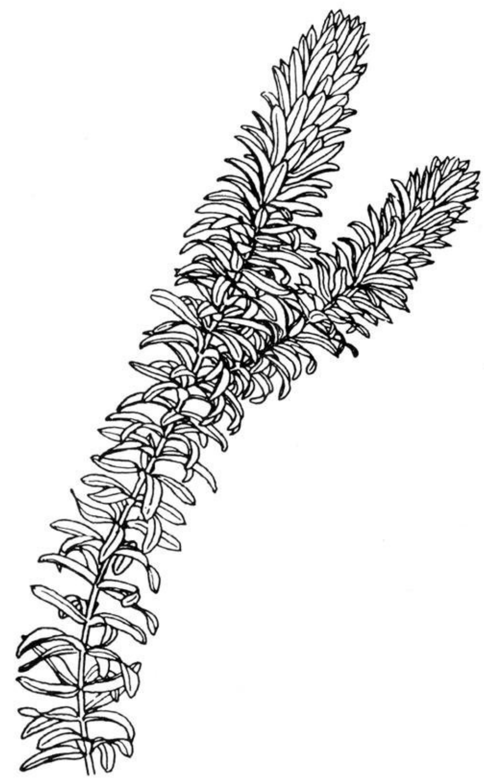


Bladderwort is a carnivorous plant which occurs in shallow ponds and lakes or on wet soils. The small bladders are traps which catch tiny animal life, particularly crustaceans. Bladderwort provides some food and cover for fish. It is never abundant enough to become a nuisance.

### 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.

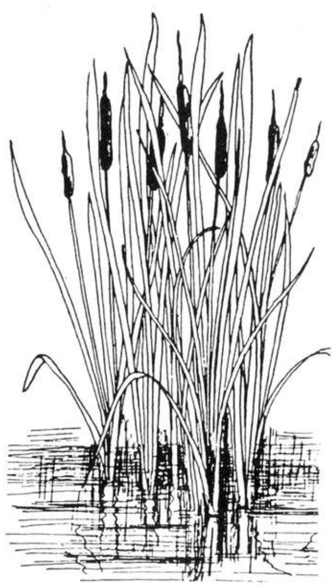
## FLOATING LEAF PONDWEED (Potamogeton natans)

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)

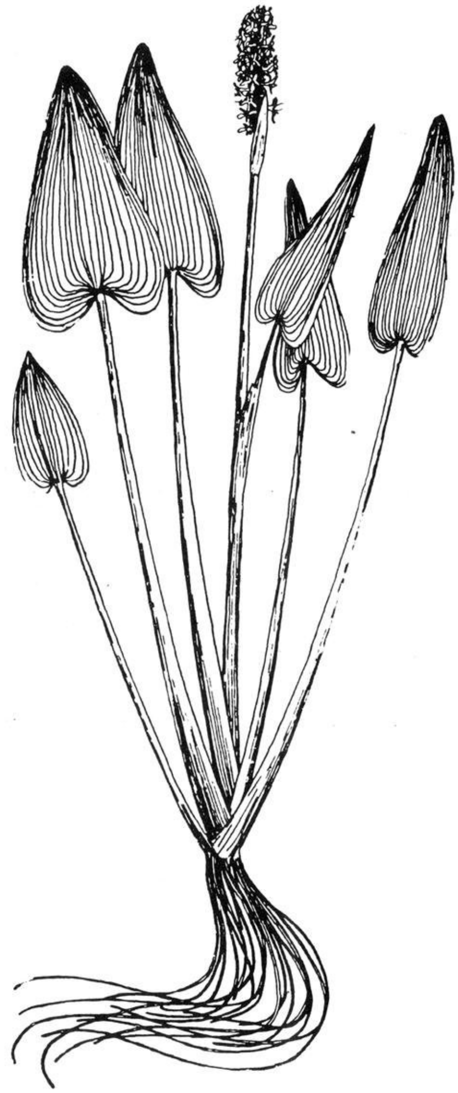
Large leaf pondweed is usually found in relatively hard water. Submersed, it supports insects and provides a good food supply for fish.

## NARROW-LEAVED CATTAIL (Typha angustifolia)



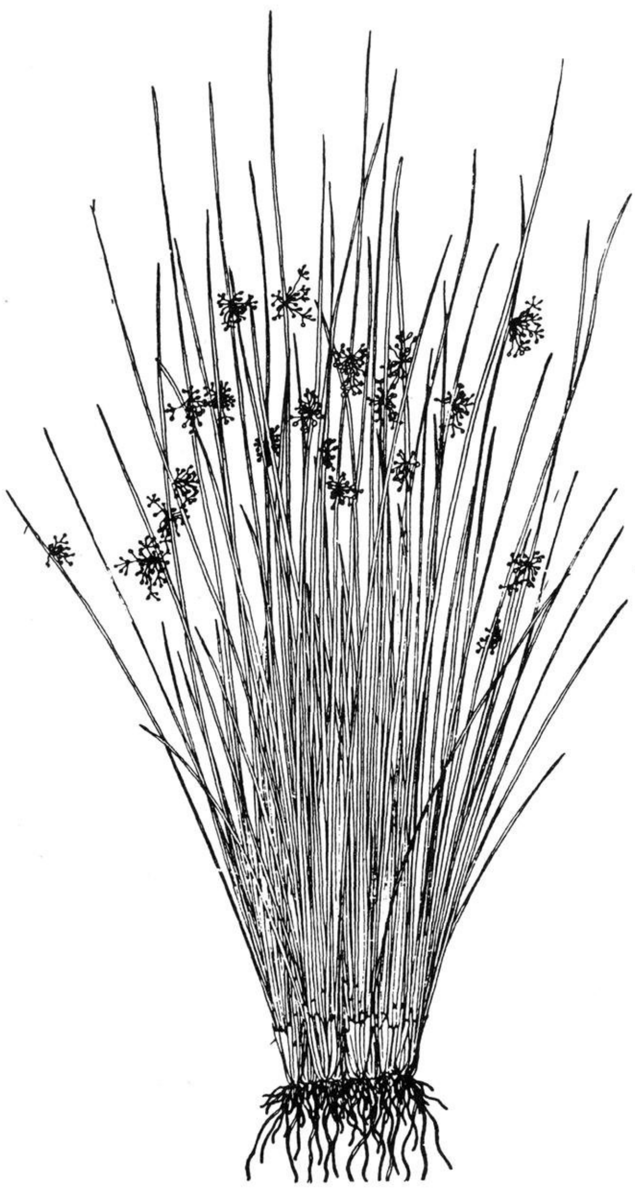
Narrow-leaved cattail may appear in almost any wet place. It is used as a spawning area for sunfish and shelter for various species of young fish, as well as a variety of other forms of wildlife. Cattails often occur in dense stands and therefore may become a nuisance.

## PICKEREL WEED (Pontedera 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.)

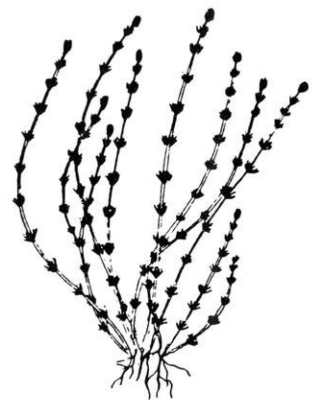


Rushes are an emergent aquatic plant with a widespread habitat which ranges from wet meadows and lakeshores to shallow pools. Thick growths of rushes often form spawning grounds for rock bass, bluegills, and other sunfish.

SAGO PONDWEED (*Potamogeton pectinatus*)

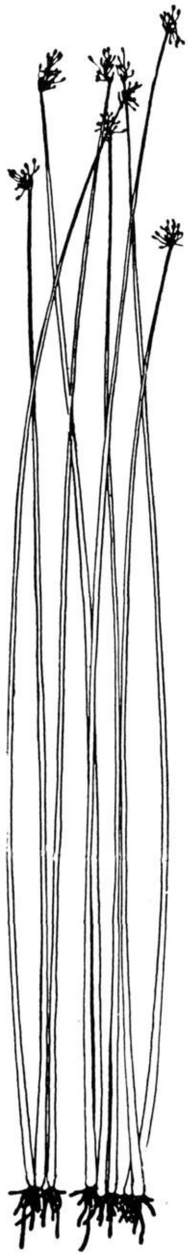
Sago pondweed is found in hard or brackish water of lakes and slow-flowing streams. Sago pondweed provides food and shelter for young trout and other fish.

## STONEWORT (Chara aspera)



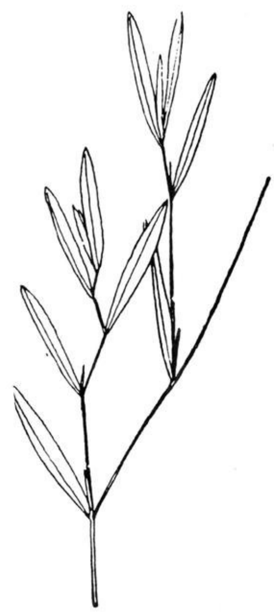
Stonewort is a type of algae which usually occurs in hard water. It provides fair cover for fish and produces excellent food for young trout, large and small mouth bass, and black bass.

## SOFTSTEM BULRUSH (Scirpus validus)



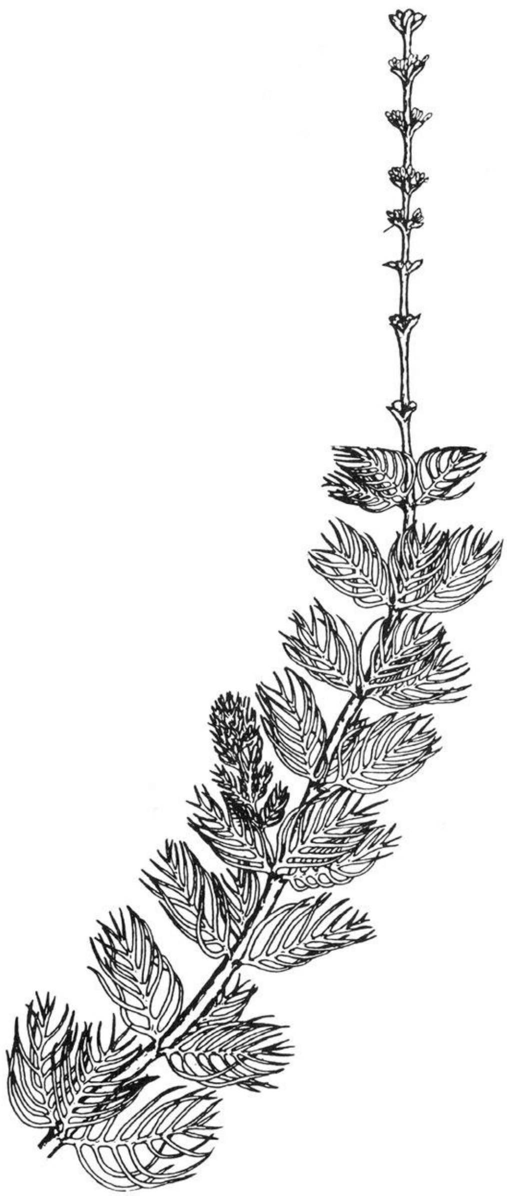
Softstem bulrush is an emergent aquatic species. It supports insects and provides food for young fish and many species of waterfowl.

## 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.

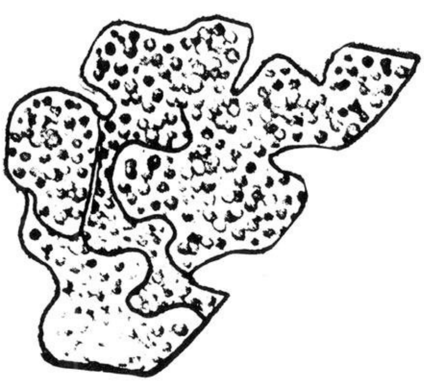
## Appendix B-2

# REPRESENTATIVE PHYTOPLANKTON FOUND IN SOUTHEASTERN WISCONSIN LAKES

### Anabaena

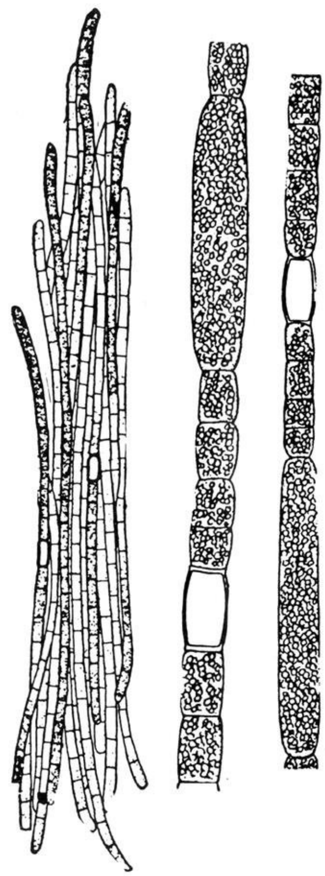
There are many individual species of the bluegreen algae, Anabaena. Some species are solitary while others form aggregated masses of indefinite shape. Anabaena seldom cause disagreeable conditions in lakes and reservoirs when they bloom, as they remain suspended throughout the water column and do not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

### Anacystis



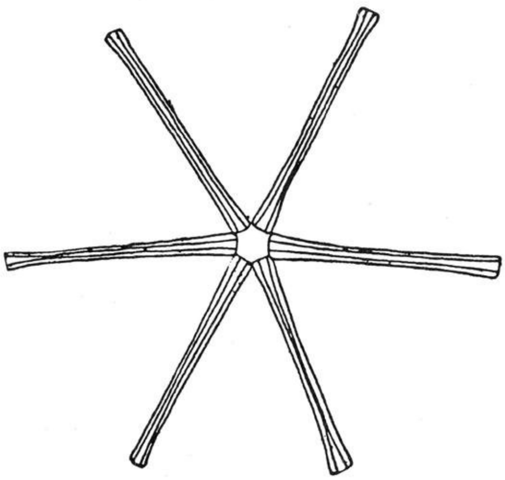
Anacystis is a loose colony of small spherical bluegreen algae cells contained in a gelatinous mass. The colony floats in the water column and is visible to the naked eye. Like Anabaena, Anacystis have been known to cause toxic water supplies.

### Aphanizomenon



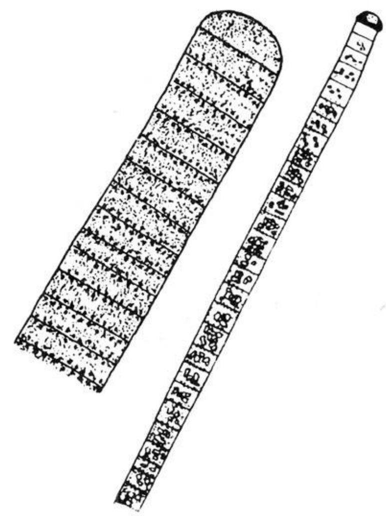
Individual cells of Aphanizomenon form strands which lie parallel in bundles and often occur so abundantly that the water appears to be filled with bits of chopped grass. The individual cells contain air spaces which give the plants great bouyancy. This accounts for the abundant growths of this bluegreen 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



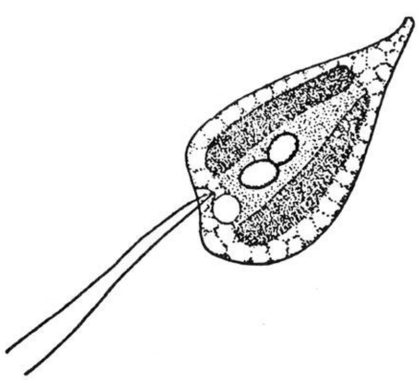
The diatom, Asterionella, usually occurs as a member of lake plankton. It prefers hard-water lakes and is readily identified by the spoke-like arrangement of the rectangular arms about a common center. Asterionella may be so abundant that lake water used for domestic water supplies may have a fishy taste.

## Oscillatoria



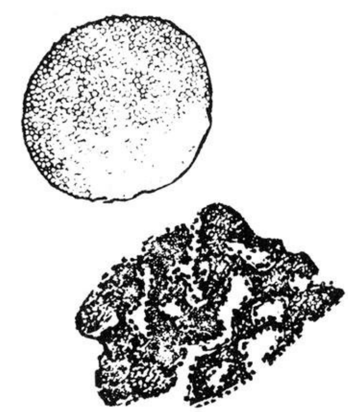
Oscillatoria is a filamentous bluegreen algae that grows in dense darkly colored clumps or mats. A characteristic of this bluegreen algae is the active oscillating movement for which it is named.

## Dinobryon



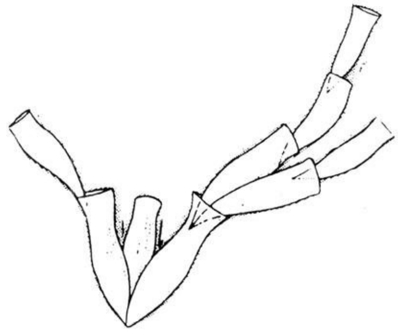
Dinobryon typically inhabit hard water lakes and, under certain conditions, may bloom. Dinobryon may produce disagreeable odors and tastes in domestic water supplies.

## 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)

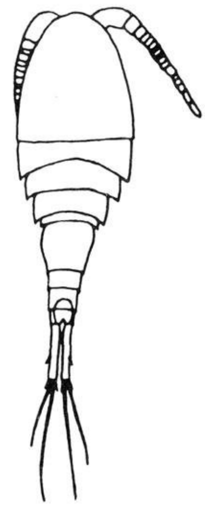


Many freshwater Chrysophyta are restricted to cold brooks, especially mountain streams, springs, and lakes duirng cool seasons. Most thrive in water relatively free of pollution.

## Appendix B-3

# A FORM OF ZOOPLANKTON FOUND IN SOUTHEASTERN WISCONSIN LAKES

### COPEPODS (Diacyclops thomasi)



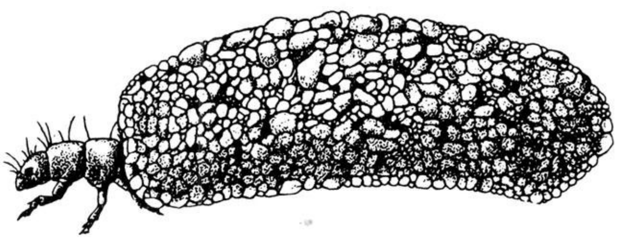
A common example of copepods found in permanent bodies of water of all types from shallow ponds and marshes to lakes is Diacyclops thomasi. The adults are predaceous on other zooplankton and can injure fish fry.

## Appendix B-4

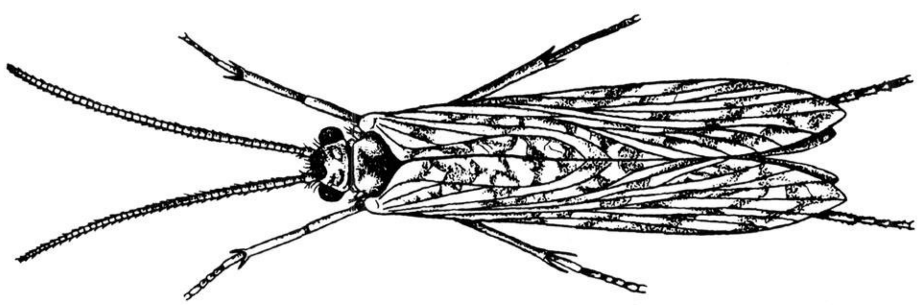
## A FORM OF BENTHIC OR BOTTOM DWELLING ORGANISM FOUND IN SOUTHEASTERN WISCONSIN LAKES

### CADDISFLIES (Trichoptera)

Caddisfly Larvae and Case



Adult Caddisfly

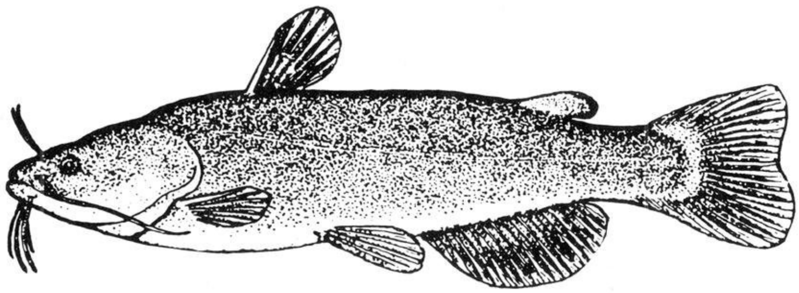


Caddisflies are found in most types of freshwater habitat, including streams, spring seepages, rivers, lakes, marshes, and temporary pools. Their tolerance to organic pollution varies widely, with some species being quite tolerant. Caddisflies are a food source for many species of fish.

Appendix B-5

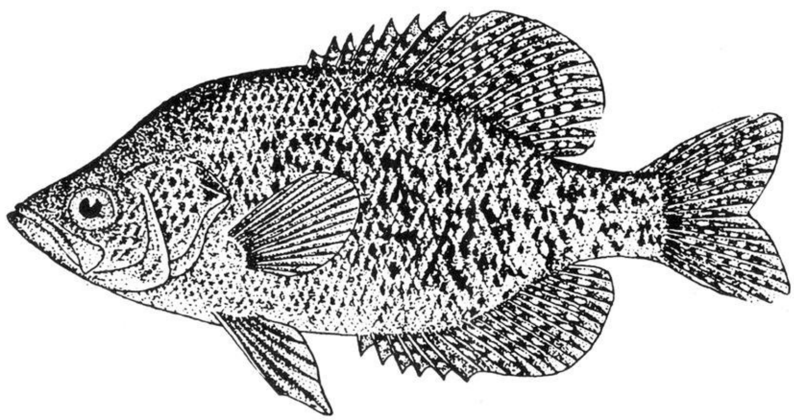
## REPRESENTATIVE FISH SPECIES FOUND IN SOUTHEASTERN WISCONSIN LAKES

### BLACK BULLHEAD (Ictalurus melas)



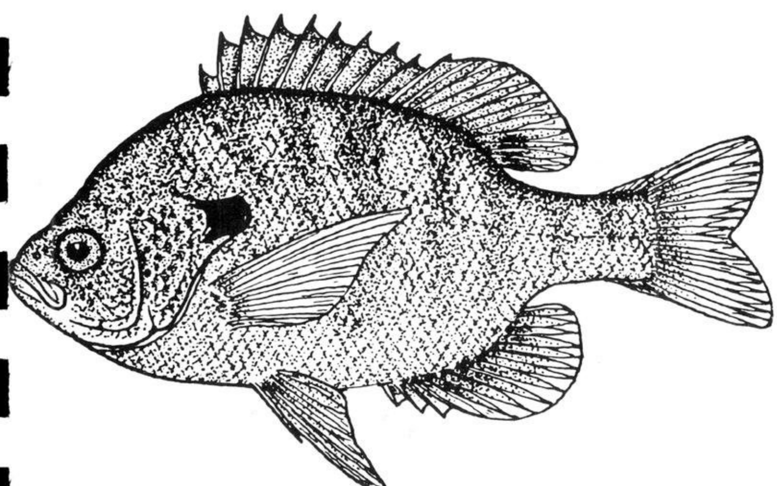
The black bullhead is common in shallow lakes and muddy streams. It nests in shallow water on either a sand or mud bottom. Bullheads are scavengers and will eat whatever food is available, such as minnows, leeches, crayfish, and amphipods.

### BLACK CRAPPIE (Pomoxis nigromaculatus)



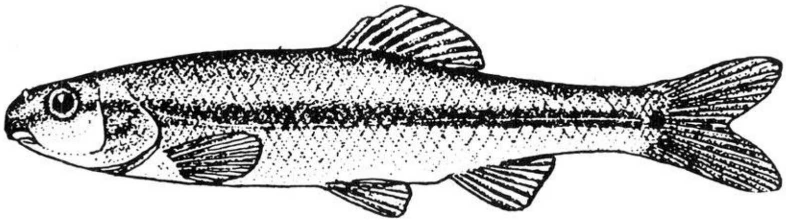
The black crappie prefers large streams and medium-sized lakes. It nests in water between three and six feet deep with a somewhat muddy bottom. Crappies feed on aquatic insects, small crustaceans, minnows, and other small fish.

### BLUEGILL (Lepomis macrochirus)



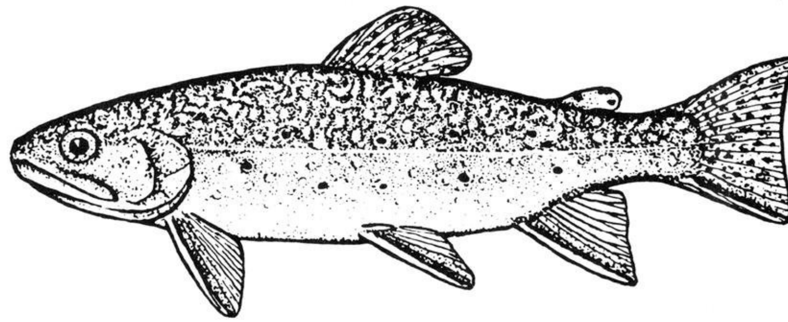
The bluegill is found in nearly all clear water lakes and streams. It nests in shallow areas with sandy bottoms; nests are often crowded together. Bluegills feed on small aquatic insects, worms, snails, and amphipods.

## BLUNTNOSE MINNOW (*Pimephales notatus*)



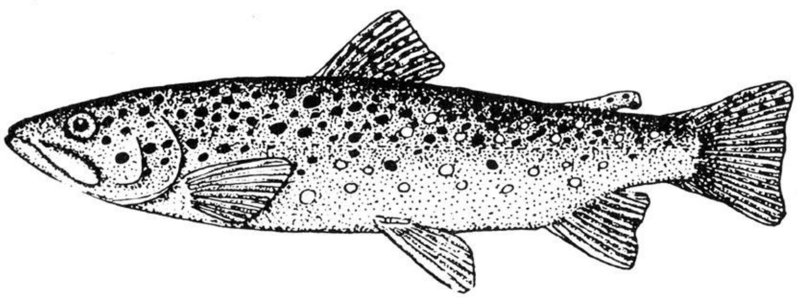
The bluntnose minnow is common in lakes and streams, but not in large rivers. The nest is built under an object, such as a rock or log. Bluntnose minnows feed mainly on algae.

## BROOK TROUT (*Salvelinus fontinalis*)



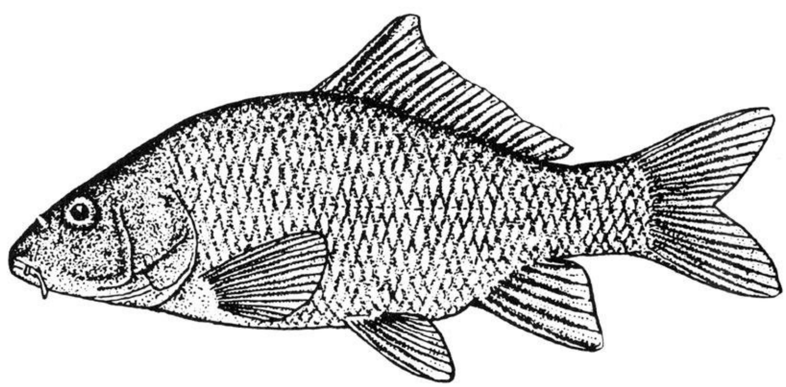
The brook trout, a native species in southeastern Wisconsin, prefers clear brooks and rivers in which the mean annual temperature rarely exceeds 50°F. The nest or redd is built on gravel bottoms in shallow riffle areas. Brook trout feed on adult aquatic insects and their larvae.

## BROWN TROUT (*Salmo trutta*)



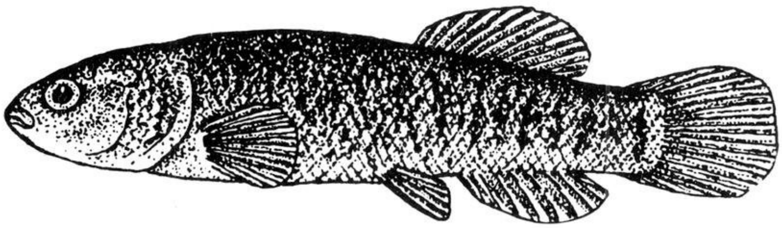
The brown trout is an introduced trout species which has become common in cold water streams. Nests or redds are built on sand and gravel bars at the mouths of tributaries. Young brown trout feed on small crustaceans and aquatic insects. Adults eat small fish, snails, crayfish, and terrestrial insects.

## CARP (*Cyprinus carpio*)



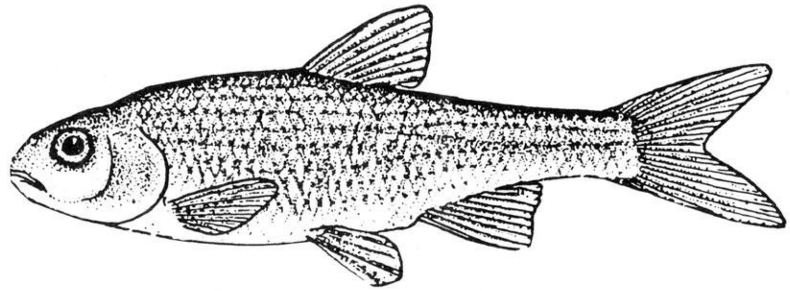
The carp is an introduced species which is tolerant of low dissolved oxygen conditions and prefers warm waters, with shallow mud-bottom lakes. Carp eat a wide variety of food. The uprooting of vegetation during feeding results in suspension of bottom sediments into the water column and a loss of aquatic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

## CENTRAL MUDMINNOW (Umbra limi)



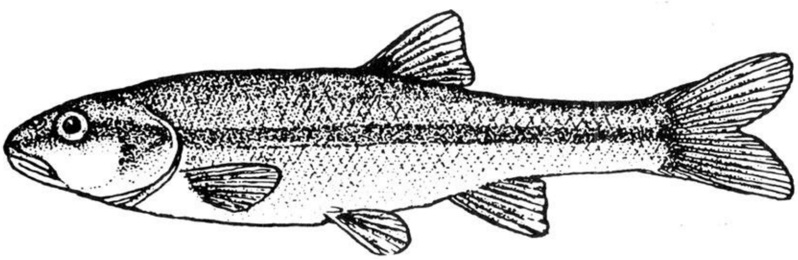
The central mudminnow prefers bog habitats, ditches, and streams with mud bottoms supporting dense aquatic vegetation. Spawning occurs in late spring and early summer. Mudminnows feed on insects, small crustaceans, and worms.

## COMMON SHINER (Notropis cornutus)



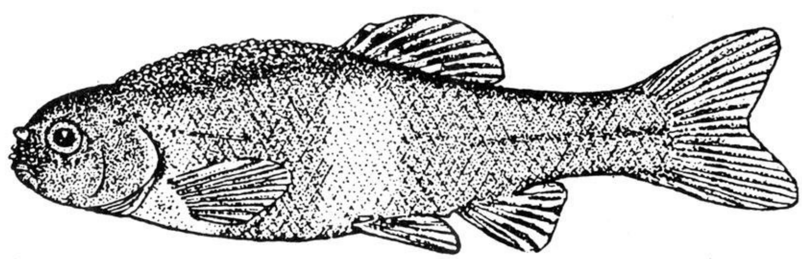
The common shiner occurs in habitats ranging from intermittent streams to large rivers and lakes. Common shiners are a forage fish that have value as a food source for game species. Shiners feed on small insects, crustaceans, and some algae.

## CREEK CHUB (Semotilus atromaculatus)



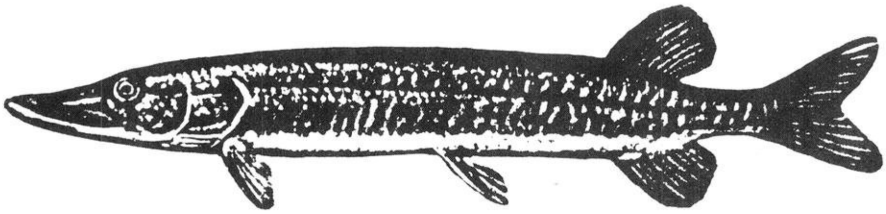
The creek chub prefers small streams and rivers but occasionally is found in lakes and large rivers. Creek chubs are quite common in beaver dam pools and may compete with trout for food. Chubs feed on all types of insects, amphipods, vegetation, and other, smaller fish.

## FATHEAD MINNOW (Pimehales promelas)



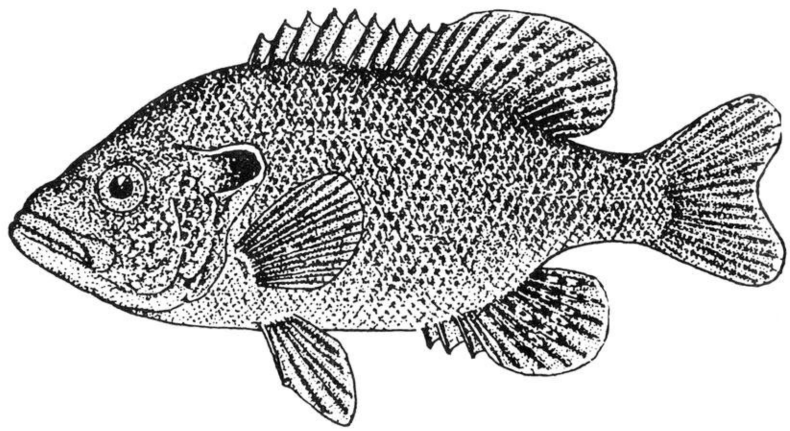
The fathead minnow prefers shallow lakes, ponds, and ditches. Nests are built on the underside of sticks, boards, and rocks in water between 3 and 12 inches deep. The fathead minnow can withstand very low oxygen conditions and, therefore, are very tolerant to pollution. Young fathead minnows feed on 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)**



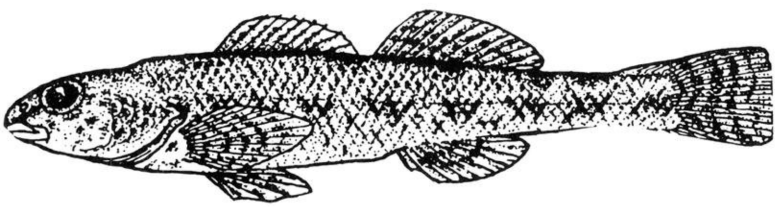
The grass pickerel is common in weedy portions of lakes and rivers. Pickerels are predators and as such feed almost exclusively on other fish. Grass pickerel are too small to have much value as a game fish.

**GREEN SUNFISH (Lepomis cyanellus)**



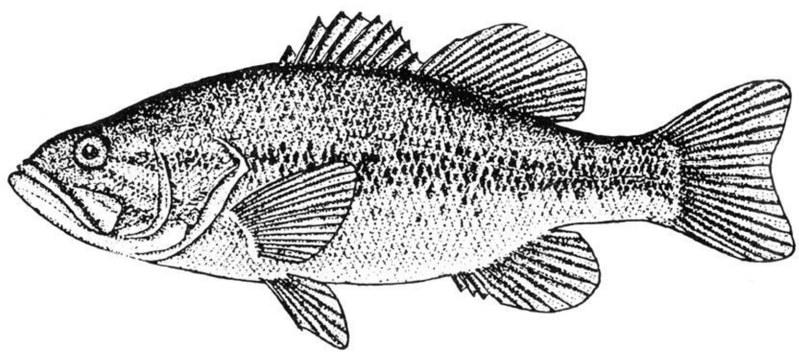
The green sunfish prefers small, shallow lakes and is common in creeks. Green sunfish feed on aquatic insects and any flying insects that happen to fall into the water. Large numbers of stunted adults may occur in some lakes and as such may decrease the viability of the existing fishery.

**JOHNNY DARTER (Etheostoma nigrum)**



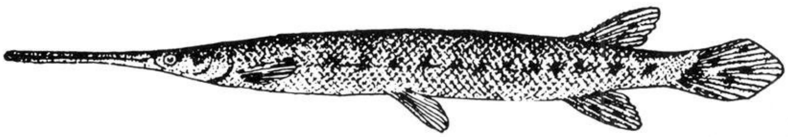
The johnny darter occurs in relatively clean lakes and streams. Nests are built under sticks and stones. The johnny darter feeds on algae and small, immature insects.

**LARGEMOUTH BASS (Micropterus salmoides)**



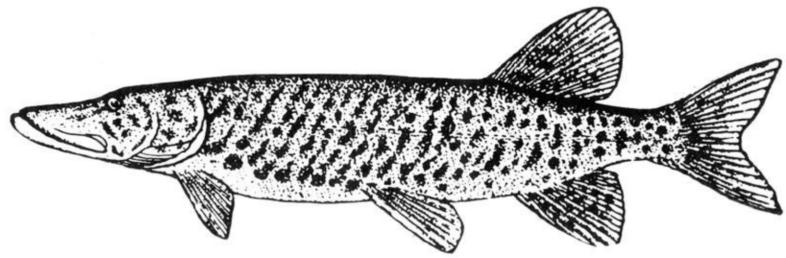
The largemouth bass prefers small- to medium-sized hardwater lakes with clear water, sandy shores, and marginal weed beds. The largemouth bass is carnivorous and as an adult feeds on perch, minnows, and small sunfish.

## LONGNOSE GAR (Lepisosteus osseus)



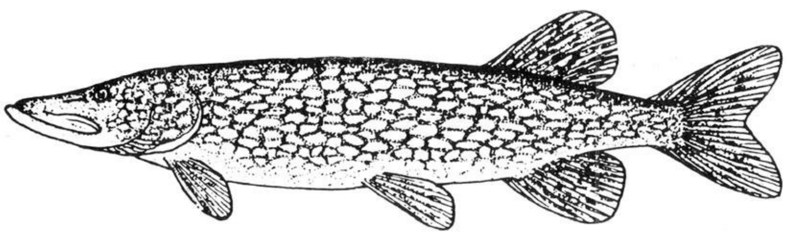
The longnose gar is a warmwater fish that often can tolerate surface waters which are too polluted for other species. Gars feed on game and forage fish and in some instances may alter fish populations enough to damage a fishery resource.

## MUSKELLUNGE (Esox masquinongy)



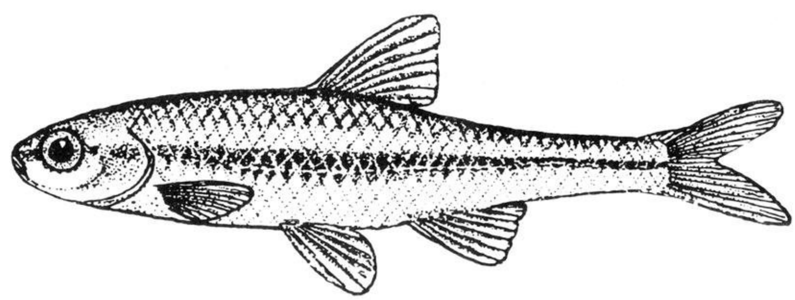
The muskellunge is common in lakes but is seldom abundant because it requires a large area of water to supply enough food for its voracious appetite. Spawning occurs in early May in tributary streams and shallow lake channels. Muskellunge are strictly carnivorous, feeding primarily on perch and suckers.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

## NORTHERN PIKE (Esox lucius)



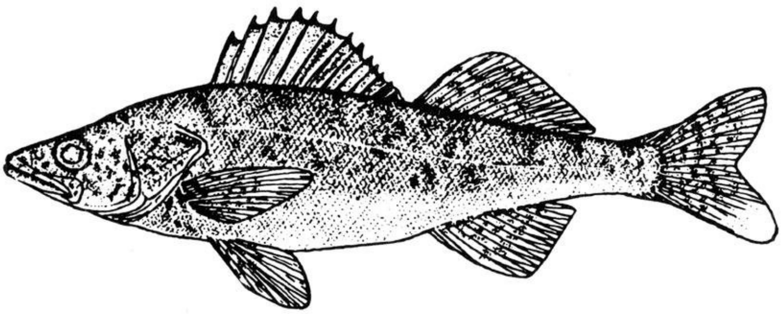
The northern pike is common in southeastern Wisconsin lakes. It feeds on a variety of fish, including perch, small suckers, sunfish, and even smaller northern pike. Spawning occurs immediately after the ice melts in April or early May in wetlands adjacent to lakes and streams.

## PUGNOSE SHINER (Notropis anogenus)



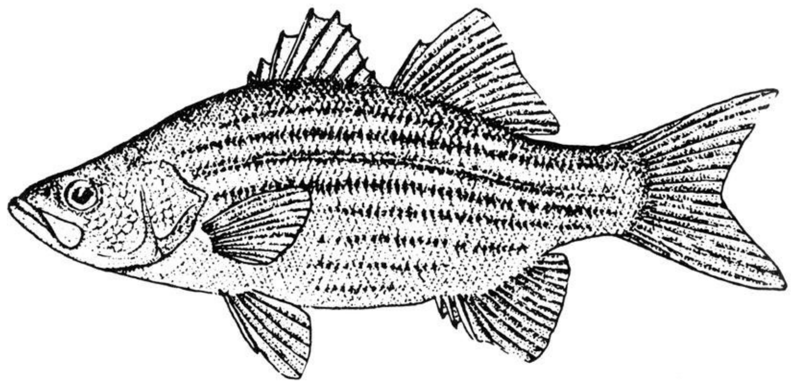
The pugnose shiner is threatened in Wisconsin. This small fish—up to two inches in length—prefers weedy waters in streams and lakes. Little is known about its life history as it is one of the rarest shiners. Changes by man in streams, rivers, and lakes have been responsible for its disappearance and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

## WALLEYE (Stizostedion vitreum vitreum)



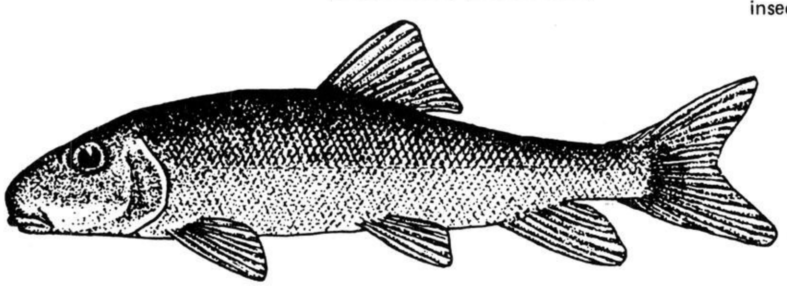
The walleye prefers clean and moderately warm to cold lakes and rivers. Spawning occurs in early spring on sand bars and shoals. Walleye feed on small minnows, small bullheads, and leeches. Walleye are a very desirable game fish.

## WHITE BASS (Morone chrysops)



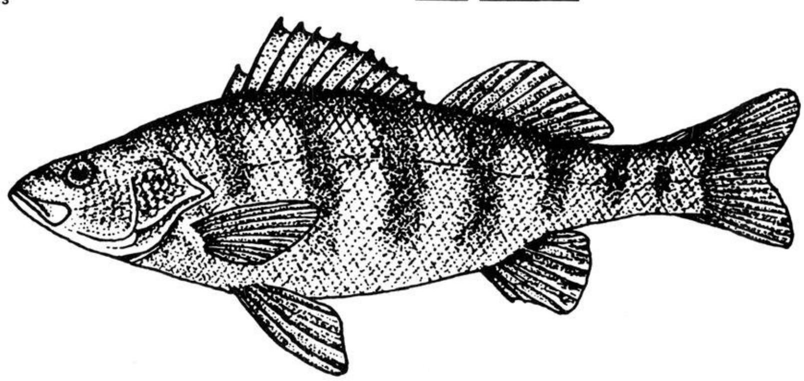
The white bass occurs in large rivers and connected lakes. White bass usually travel in large schools near the surface. Eggs are scattered randomly on shallow bars and gravelly reefs. White bass feed on insects and small fish.

## 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.