COMMUNITY ASSISTANCE
PLANNING REPORT NO. 187

A MANAGEMENT PLAN FOR FOWLER LAKE

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Special acknowledgement is due Dr. Jeffrey A. Thornton, SEWRPC Principal Planner, and Ms. Tami J. Dake, SEWRPC Planning Analyst, for their contribution to the conduct of this study and the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 187

A MANAGEMENT PLAN FOR FOWLER LAKE, WAUKESHA COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
for
The City of Oconomowoc
and
The Fowler Lake
Management District

March 1994

Inside Region $ 6.00
Outside Region $12.00

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March 21, 1994

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

Over the past 10 years, the Regional Planning Commission and others, at the request of the Fowler Lake Management District, have been conducting lake management-related data collection and analysis efforts. These efforts have now been integrated into a lake management plan for Fowler Lake, which plan is intended to address the water quality, recreational use, and natural resource problems of the Lake. The preparation of the plan was a cooperative effort by the Southeastern Wisconsin Regional Planning Commission, the City of Oconomowoc, the Fowler Lake Management District, the U. S. Geological Survey, and the Wisconsin Department of Natural Resources.

This report documents the recommended lake management plan. The report describes the physical and biological properties of Fowler Lake and its watershed; the quality of the Lake waters and the conditions affecting that quality, including land use and management practices; the recreational use of the Lake; and the shoreline conditions around the Lake; and sets forth recommended management measures.

The plan presented in this report should provide a sound guide to the making of development decisions concerning the wise use and management of Fowler Lake as an aesthetic and recreational asset of immeasurable value. Accordingly, adoption of the plan presented herein by all the concerned water use management agencies is urged. The Regional Planning Commission stands ready to assist the various units and agencies of government concerned in adopting and carrying out over time the plan recommendations.

Respectfully submitted,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

The 101 major inland lakes within Southeastern Wisconsin constitute one of the most valuable natural resources of the Region. Concern over the deteriorating condition and increasing use of these lakes for recreational purposes led the State Legislature, in 1974, to enact legislation enabling lake residents and others to form inland lake protection and rehabilitation districts. The purpose of these special-purpose units of local government is to carry out programs that will protect and rehabilitate the valuable natural resources represented by the lakes.

Fowler Lake, consisting of a 78-acre main body and a 21-acre enlarged inlet, is one of these resources, located on the Oconomowoc River within U. S. Public Land Survey Section 33, Township 8 North, Range 17 East, City of Oconomowoc, Waukesha County. Entirely within the City of Oconomowoc, Fowler Lake is subject to the effects of continued urbanization within the watershed and to a heightened demand for water-based recreation. Realization that increased development and demands on lake use could cause problems in terms of deteriorating water quality and degradation of the overall Fowler Lake ecosystem led to the formation of the Fowler Lake Management District by the City of Oconomowoc in 1983.

Planning efforts relating to Fowler Lake have included the preparation of a regional water quality management plan[1] and a subsequent nonpoint pollution abatement plan for the Oconomowoc River watershed.[2] These plans identified surface water quality problems within the Region and the Oconomowoc River watershed, identified the major sources of pollution, and provided recommendations for abating those sources to achieve specified water use objectives and attendant water quality standards. One of the recommendations set forth in the regional plan was that there be a reduction of about 25 percent in the nonpoint source pollutant loadings to Fowler Lake in order to improve water quality conditions. The Wisconsin Department of Natural Resources nonpoint source pollution abatement priority watershed planning program was initiated in 1983 for the Oconomowoc River watershed. That program provided more specific recommendations for achieving nonpoint source pollutant loading reductions to Fowler Lake, and made State funds available to landowners and municipalities to install and maintain nonpoint source pollution abatement measures and practices in portions of the watershed, including Fowler Lake, where major nonpoint pollution sources had been identified. The project implementation period for this program will end in December of 1994. However, control of nonpoint pollution sources in the watershed is only a part of a comprehensive water quality management effort for the Lake.

Following the designation of the Oconomowoc River watershed as a priority watershed, the Fowler Lake Management District undertook a complementary program of research to evaluate water quality conditions and identify specific management measures needed to improve the water quality and recreational use potential of Fowler Lake. This program involved a cooperative effort between the U. S. Geological Survey, the City of Oconomowoc, the Wisconsin Department of Natural Resources, the Southeastern Wisconsin Regional Planning Commission, and the Fowler Lake Management District. The results of the hydrologic and water quality monitoring program, conducted by the U. S. Geological Survey from January through December 1984 to determine the existing water budget and water quality of the Lake and to quantify pollutant loadings to the Lake, were available for use in the preparation of this plan,[3] as were

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[1] *SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, September 1978; Volume Two, Alternative Plans, February 1979; Volume Three, Recommended Plan, June 1979.*

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

[3] *U. S. Geological Survey, Hydrology, Water Quality, Trophic Status, and Aquatic Plants of Fowler Lake, Wisconsin, Water Resources Investigations Report No. 91-4076, 1993.*

the findings of an aquatic plant and sediment survey conducted by a private consultant under contract to the City of Oconomowoc. This plan also incorporates pertinent data collected and recommendations made under the aforementioned Oconomowoc River priority watershed plan. In addition, this plan incorporates fishery data and recommendations provided by the Wisconsin Department of Natural Resources staff specifically for the Fowler Lake Management Plan.

The primary objectives of this plan are: 1) maintenance of a healthy fishery, 2) reduction of the severity of nuisance resulting from recurring excessive aquatic macrophyte and algal growths, and 3) improvement of the aesthetic characteristics of the Lake and enhancement of opportunities for water-based recreational activities. These objectives are intended to complement broader City objectives concerning enhancement of the economic development potential of the area and the quality of life in Oconomowoc. Particularly important in this respect is the enhancement of the central business district of the City, the setting for which is provided by Fowler Lake. This plan should serve as a practical guide over time for achieving these objectives in a technically sound manner.

Chapter II

PHYSICAL DESCRIPTION

INTRODUCTION

The physical characteristics of a lake and its watershed are primary determinants of the water quality conditions in that lake. Such characteristics as watershed topography, lake morphometry, and local hydrology ultimately influence water quality conditions and the composition of plant and fish communities within a lake. Therefore, these characteristics must be considered during the lake management planning process. Accordingly, this chapter provides pertinent information on the physical characteristics of Fowler Lake, its watershed, and the climate and hydrology of the Fowler Lake study area. Subsequent chapters deal with the chemical and biological environments of the Lake.

LAKE BASIN

Fowler Lake is a flow-through lake with extensive shallow areas and a single deep basin. Fowler Lake has a surface area of 99 acres, consisting of a main basin with a surface area of 78 acres and an expanded inlet east of N. Oakwood Avenue with a surface area of 21 acres. The Lake has been modified in both area and depth by a dam, originally constructed in 1837 and rebuilt several times since, most recently in 1974, at the outlet that raised the original water level by approximately 8.0 feet.[1] The original basin of Fowler Lake was formed as the Michigan and Green Bay Lobes of the continental glacier retreated from Southeastern Wisconsin approximately 12,500 years ago, during the late Wisconsin stage of glaciation. The Lake, like many others in the Region, lies in a depressed area of this interlobate, or "kettle moraine," area that is characterized by unconsolidated glacial sediments consisting predominantly of silty-clay till and sandy outwash deposits. These glacial sediments, ranging in thickness from 100 to 200 feet, are underlain by Silurian dolomite and are overlaid by organic deposits formed after glaciation.

The Oconomowoc River is the major inflow to the Lake and enters from the southeast, as shown on Map 1. The river exhibits continuous flow and has a resident fish population. The Lake outflow is controlled by a dam and a fixed-height overflow structure, both located at the northwest side of Fowler Lake just upstream of STH 67. The dam outlet flows westerly through a 60-foot-wide channel, while the overflow is conveyed through a concrete culvert directly into Lac La Belle, which is located immediately west of STH 67. The Oconomowoc River, which is also the outlet of Lac La Belle, ultimately discharges into the Rock River in Jefferson County, about 13 miles downstream from the Lac La Belle outlet.

Of the approximately 101 major lakes in the seven-county Southeastern Wisconsin Region, Fowler Lake ranks in the smaller third in terms of its surface area. Basic hydrographic and morphometric data on the Lake are presented in Table 1. About 33 percent of the Lake's area is less than five feet deep, 23 percent is between five and 10 feet deep, 16 percent is between 10 and 15 feet deep, and 28 percent is greater than 15 feet deep. The mean depth is 13 feet and the maximum depth is 50 feet. Fowler Lake is 0.60 mile long, southeast to northwest, and 0.35 mile wide at its widest point. The shoreline length is 1.70 miles. The shoreline development factor is 1.37, indicating that the Lake's shoreline is fairly regular and about one-third longer than a circular lake of the same area. The Lake has a volume of approximately 1,074 acre-feet, with 1,021 acre-feet in the main body of the Lake and approximately 53 acre-feet in the expanded inlet. The morphometry of the Lake is illustrated in Map 1.

Lake Bottom Substrate

Lake bottom sediment types were surveyed in 1984 by the U. S. Geological Survey and are shown on Map 2. About 43 percent of the surveyed bottom is covered by a muck/clay mixture, 23 percent by a muck/sand mixture, 15 percent by muck, and 11 percent by rubble or a muck/rubble mixture. Gravel was found over less than

[1] *The Oconomowoc Enterprise, July 22, 1971; The Oconomowoc Enterprise, August 1, 1974.*

Map 1

FOWLER LAKE HYDROLOGY AND MORPHOMETRY

LEGEND

DEPTH LESS THAN 5 FEET

DEPTH 5 - 10 FEET

DEPTH 10 - 15 FEET

DEPTH GREATER THAN 15 FEET

5 WATER DEPTH CONTOUR IN FEET

Source: Patrick Sorge and Timothy Lowry, Aquatic Plant and Sediment Survey on Fowler Lake; Wisconsin Department of Natural Resources; and SEWRPC.

6 percent of the bottom area sampled. The depths of the soft sediments ranged from none over the gravel and rubble areas to more than seven feet in some of the muck areas.

Shoreline Conditions

Erosion of shorelines results in the loss of land, damage to shoreland infrastructure, and interference with lake access and use. Such erosion is usually caused by wind-wave erosion, ice movement and/or motorized boat traffic. A survey of the Fowler Lake shoreline, conducted during the summer of 1988, identified many shoreland protection structures around the Lake. Some 38 bulkheads (vertical walls), eight revetments (sloping stone walls), and three beaches were recorded, as shown on Map 3. Most bulkheads were of concrete construction, although some appeared to have been grouted revetments given the size of the stone used. Many were in a good state of repair, although numerous problems were observed. Erosion was most common in areas where the bulkheads and revetments had been overtopped. Cracking and collapse of these structures were also common problems, especially along the northern and southern shores. The southeastern shore between E. Grove Street and St. Paul Street, in the vicinity of the N. Oakwood Avenue bridge (see Map 1), was in especially poor condition, as was the portion of the northern shore adjacent to E. Greenland Avenue near the beach. Some 40 percent of the total number of structures were subject to at least one type of failure and several others were in danger due to toe scouring, erosion at the foot of the structures. A less intensive, visual survey conducted more recently suggests that many of those failed structures have been repaired. Virtually the entire shoreland of Fowler Lake is subject to some form of shoreline protection, although most of the inlet area east of N. Oakwood Avenue is unprotected except for extensive growths of aquatic vegetation (see Chapter V).

The need for shoreland protection on Fowler Lake was noted as early as 1910, when protective structures were already in place. Fenneman[2]

Table 1

HYDROLOGY AND
MORPHOMETRY OF FOWLER LAKE

Parameter	Measurement
Size total)	99 acres
Area	
Main Body	78 acres
Enlarged Inlet East of N. Oakwood Avenue	21 acres
Total Drainage Area	49,757 acres
Direct Drainage Area	1,604 acres
Volume (total)	1,074 acre-feet
Residence Time[a] (1984 USGS study period)	6.9 days
Shape	
Maximum Length of Lake	0.6 mile
Length of Shoreline	1.7 miles
Maximum Width of Lake	0.35 mile
Shoreline Development Factor[b]	1.37
Depth	
Area of Lake	
Less than Five Feet	33 percent
Five to 10 Feet	23 percent
10 to 15 Feet	16 percent
15 to 25 Feet	13 percent
Greater than 25 Feet	15 percent
Mean Depth	13 feet
Maximum Depth	50 feet

[a]Residence time: time required for a volume equivalent to full volume replacement by inflowing waters to enter the lakes.

[b]Shoreline development factor: ratio of shoreline length to that of a circular lake of the same area.

Source: Wisconsin Department of Natural Resources and SEWRPC.

noted that "cutting would be quite general around the Lake if the artificial walls of stone and piles were removed . . . . the walls are washed vigorously in some places, while an occasional beach of gravel is beginning to build . . . ." One large beach on the north shore and two pocket beaches (depositional sites less than five feet wide) on the eastern shore attest to the ongoing nature of this beach-building process. Few erosional sites were noted.

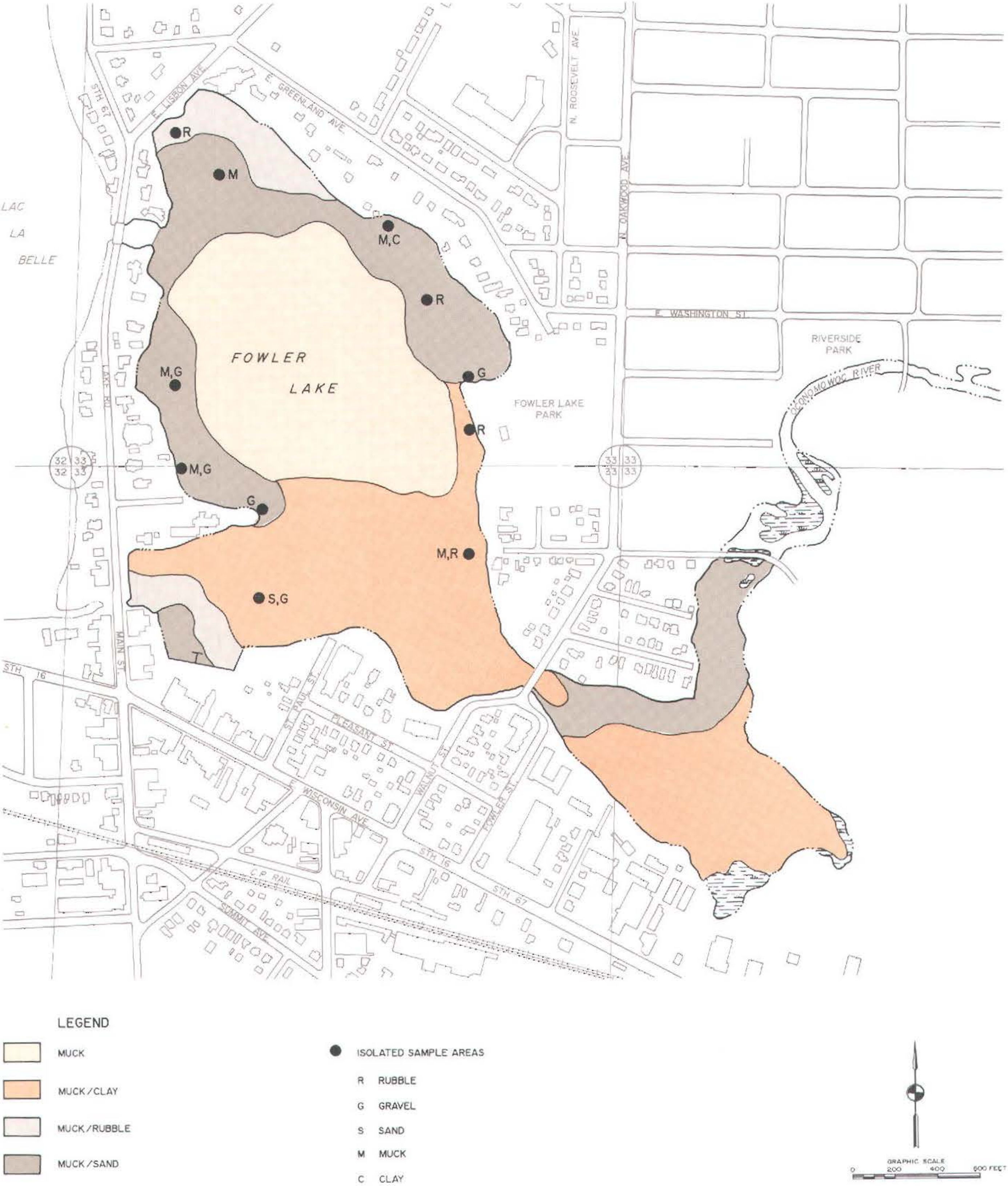
WATERSHED CHARACTERISTICS

The direct drainage area to Fowler Lake, that is, the area which drains directly to the Lake and the stream reach immediately upstream rather than draining to the Lake through the Oconomowoc River, is 1,604 acres, or 2.5 square miles. Because the Oconomowoc River is the only inflow to Fowler Lake and because of its importance to the hydrology and water quality of the Lake, the area drained by the Oconomowoc River directly upstream of Fowler Lake but below Oconomowoc Lake has been included in this area, as shown on Map 4. The total drain-

[2]*N. M., Fenneman, Lakes of Southeastern Wisconsin, Wisconsin Geological and Natural History Survey Bulletin No. VIII, Educational Series No. 2, 1910.*

Map 2

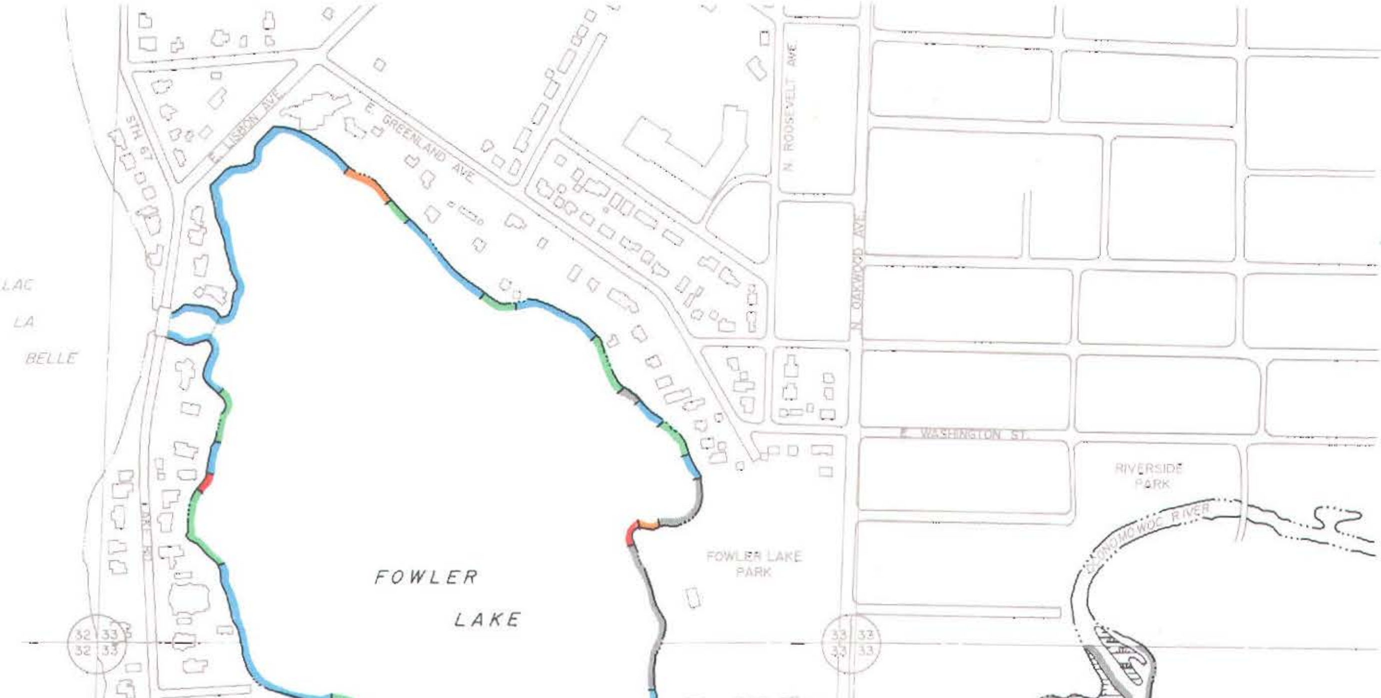
LAKE-BOTTOM SEDIMENTS IN FOWLER LAKE



Source: Patrick Sorge and Timothy Lowry, Aquatic Plant and Sediment Survey on Fowler Lake; U. S. Geological Survey; and SEWRPC.

Map 3

SHORELINE CONDITIONS ON FOWLER LAKE: 1988



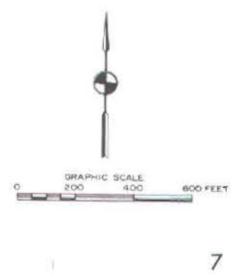
LEGEND

PROTECTED SHORELINE

- BULKHEAD
- REVETMENT
- BEACH

UNPROTECTED SHORELINE

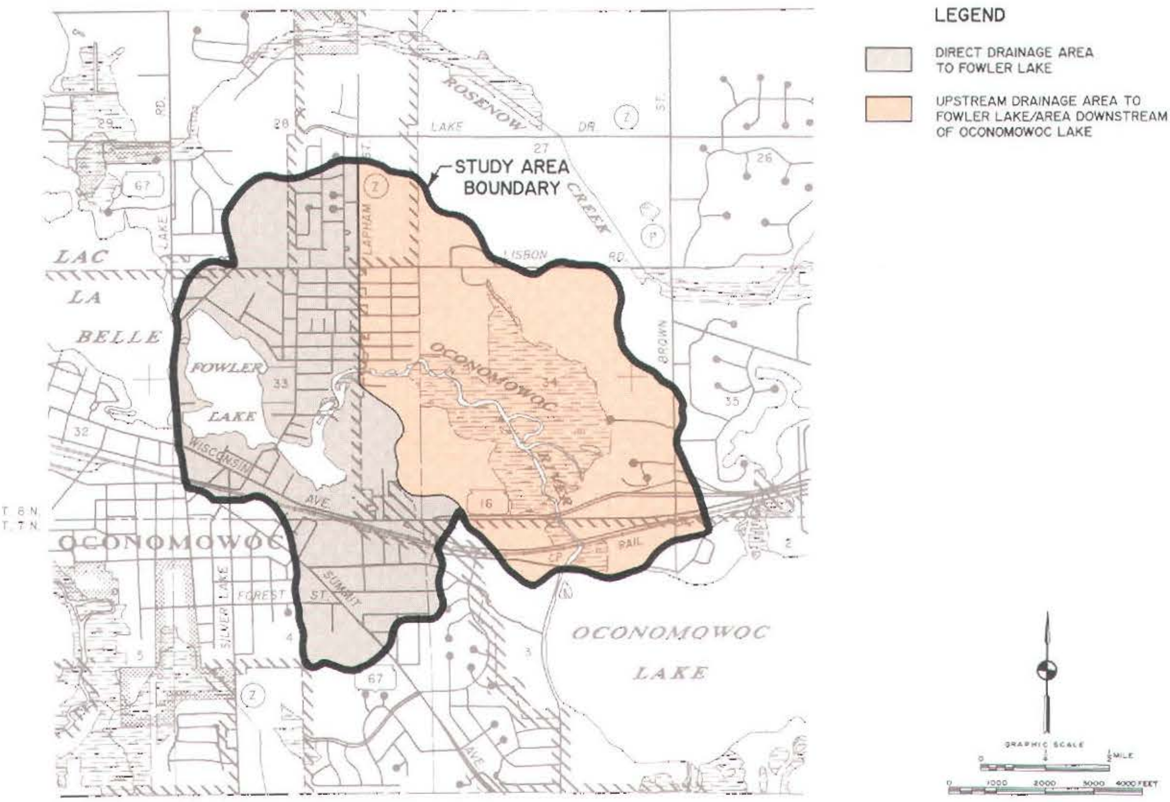
- STABLE
- UNSTABLE



Source: SEWRPC.

Map 4

FOWLER LAKE STUDY AREA



Source: SEWRPC.

age area, including the entire area upstream of Oconomowoc Lake drained by the Oconomowoc River, is 49,757 acres, or 77.7 square miles in extent, and is shown on Map 5. Fowler Lake has an areal watershed-to-lake ratio of 448:1.

The hydrology of Fowler Lake has been extensively modified by the presence of an upstream lake (Oconomowoc Lake) and a dam at the Lake's outlet to Lac La Belle. Map 6 reproduces the original 1836 plat of the U. S. Public Land Survey for the Fowler Lake area. A comparison of the present watershed of Fowler Lake, Map 4, with the 1836 map, Map 6, indicates graphically the extent to which the Lake's area has expanded since the river was dammed in 1838. According to newspaper accounts,[3] when the first settlers arrived in the area that is now the City of Oconomowoc, the Lake was surrounded on the west and south by tamarack swamp; the Oconomowoc River, which was narrower at the time, flowed north along the edge of this swamp and into Lac La Belle. Over time the water levels rose as the river was impounded, flooding the swamp and creating the Lake's boundaries as seen today.

Soil Types and Conditions

Soil type, land slope, and land use and management practices are among the more important factors determining lake water quality conditions. Soil type, land slope, and vegetative cover are also important factors affecting the rate, amount, and quality of stormwater runoff. The soil texture and the shape and stability of aggregates of soil particles, expressed as soil structure, influence the permeability, infiltration rate, and erodibility of soils. The land slope is also an important determinant of stormwater runoff rates and of susceptibility to erosion.

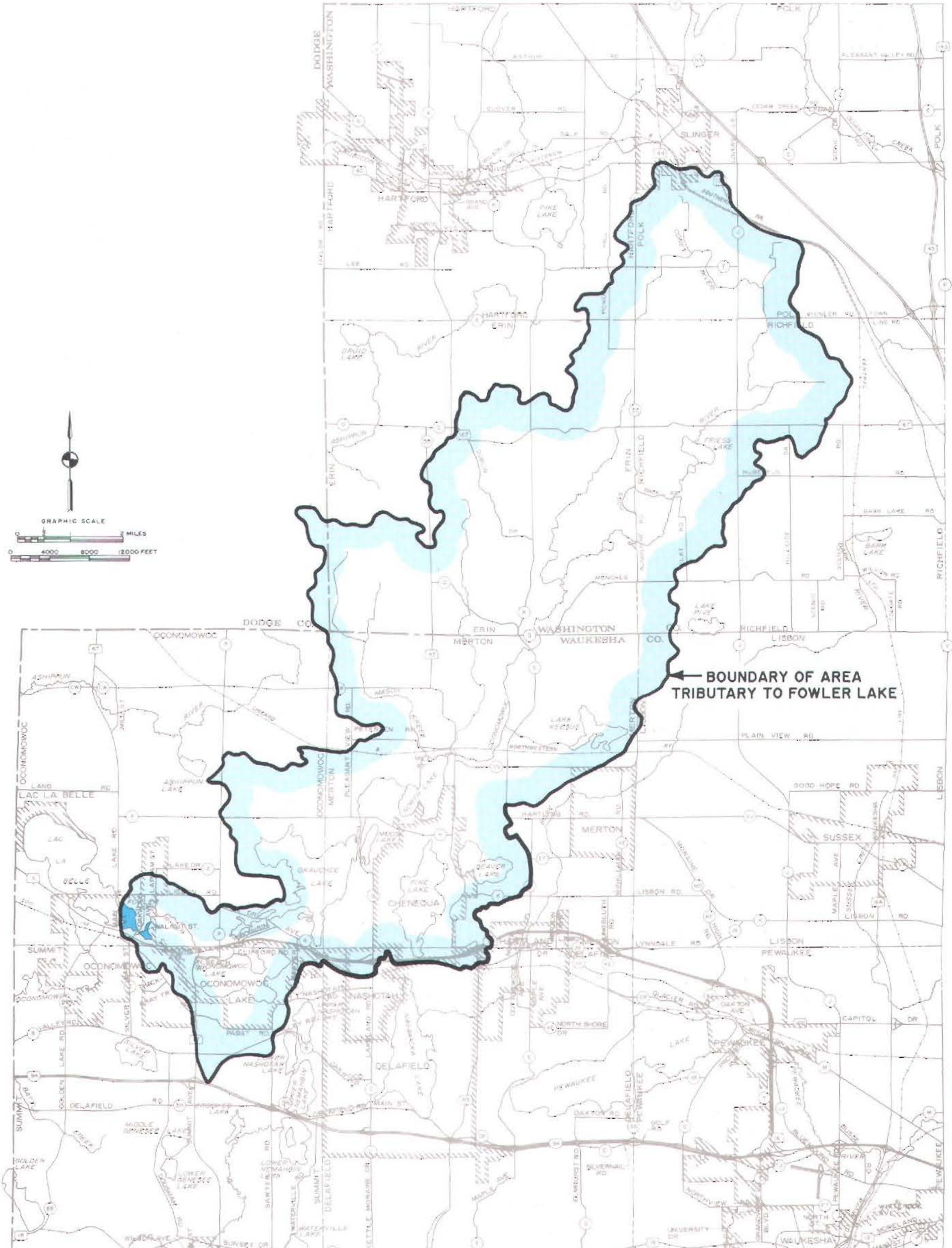
The U. S. Soil Conservation Service, under contract to the Southeastern Wisconsin Regional Planning Commission, completed a detailed soil survey of the Fowler Lake area in 1966.[4] The soil

[3] *The Oconomowoc Enterprise, July 22, 1971.*

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

Map 5

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



Source: SEWRPC.

Table 2

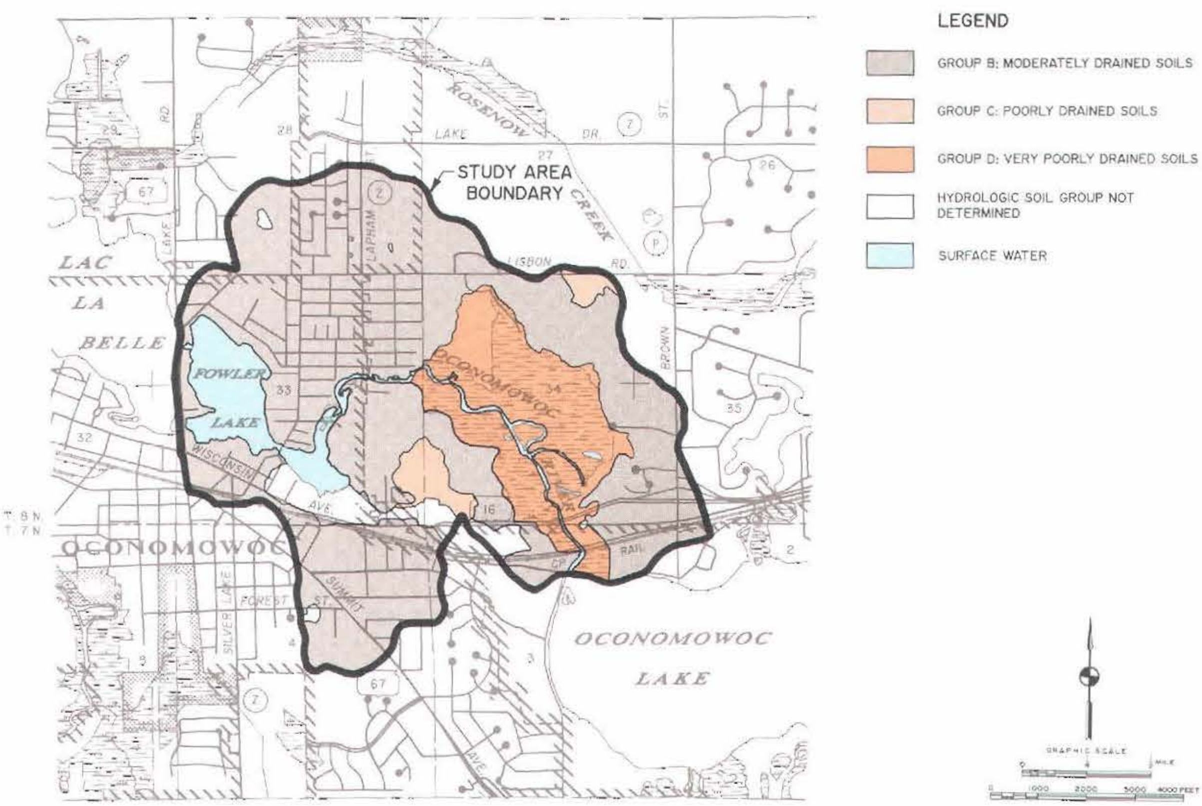
GENERAL HYDROLOGIC SOIL TYPES IN THE FOWLER LAKE STUDY AREA

Group	Soil Characteristics	Study Area Extent (acres)	Percent of Total
A	Excessively drained to somewhat excessively drained Very rapid to rapid permeability Low shrink-swell potential	0	0
B	Well drained to moderately well drained Texture intermediate between coarse and fine Moderately rapid to moderate permeability Low to moderate shrink-swell potential	1,099	68.5
C	Somewhat poorly drained to poorly drained High water table for part or most of year Mottling, suggesting poor aeration and lack of drainage, generally present in A to C horizons	51	3.2
D	Very poorly drained High water table for most of year Organic or clay soils Clay soils having high shrink-swell potential	271	16.9
Made Land	Open-pit mining areas, man-made fill areas, dumps and landfills containing widely varying soils and other materials	69	4.3
Water	- -	114	7.1
Total	- -	1,604	100.0

Source: SEWRPC.

Map 7

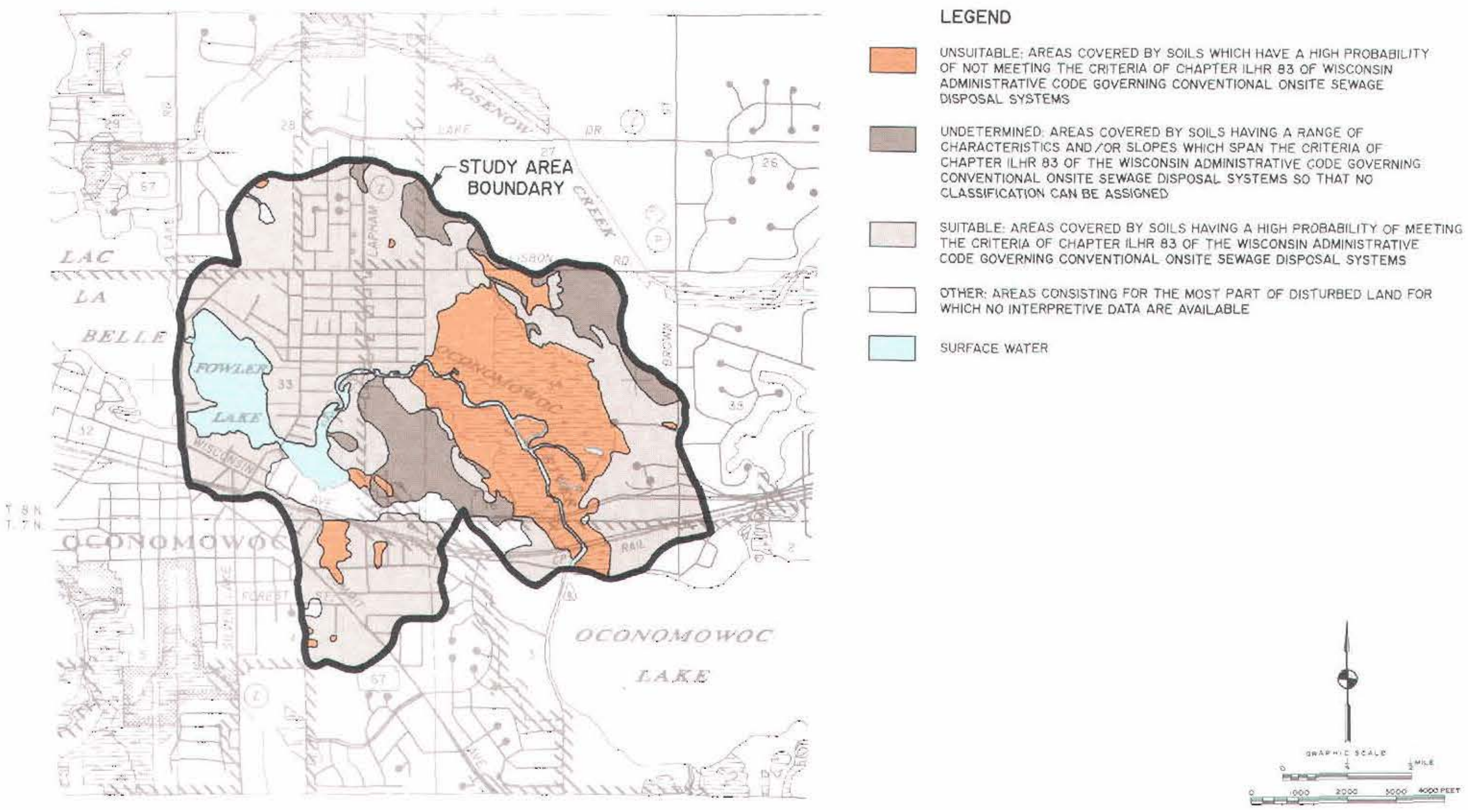
HYDROLOGIC SOIL GROUPS WITHIN THE FOWLER LAKE STUDY AREA



Source: SEWRPC.

Map 8

SUITABILITY OF SOILS WITHIN THE FOWLER LAKE STUDY AREA FOR CONVENTIONAL ONSITE SEWAGE DISPOSAL SYSTEMS UNDER CURRENT ADMINISTRATIVE RULES: FEBRUARY 1991



Source: SEWRPC.

development and about 25 percent by soils unsuitable for such development. Soil suitability could not be determined for the remaining 5 percent of the land in the drainage area. In 1985, about 35 percent of the Fowler Lake study area, approximately 558 acres, was served by sanitary sewers. The existing 1985 and the proposed year 2000 sanitary sewer service areas for the Fowler Lake study area, as embodied in the adopted regional water quality management plan, are delineated on Map 11. The regional plan calls for approximately 508 additional acres, or 32 percent of the direct drainage area, to be served by sanitary sewers by the year 2010. In all, a total of 1,066 acres, or about 67 percent of the study area, will be served by sanitary sewers by the year 2010.

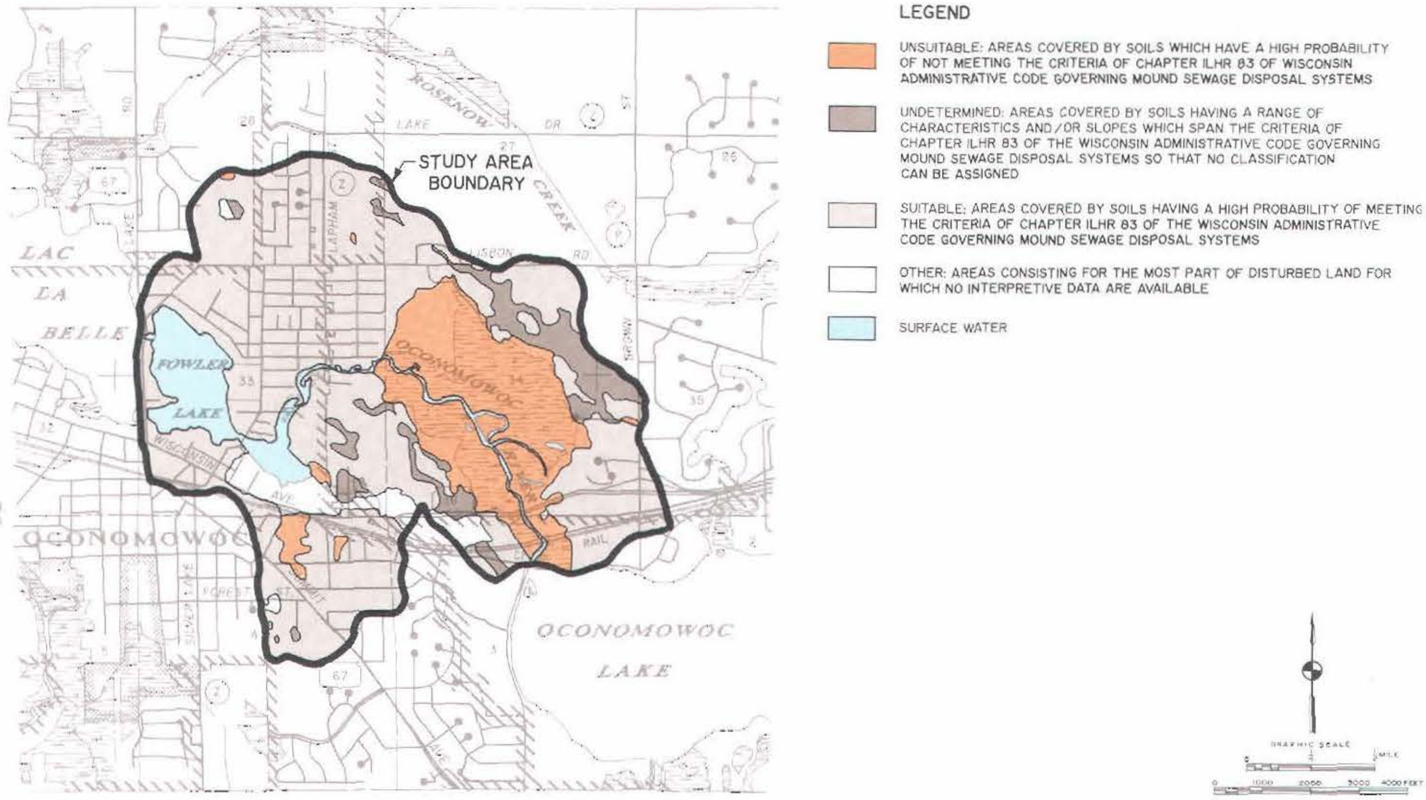
Climate and Hydrology

Climatologic and hydrologic data were collected from six monitoring sites in 1984, as shown on Map 12. Long-term average monthly air temperature and precipitation values for the Fowler Lake area are set forth in Table 3. In addition, Table 3 provides monthly air temperature and precipitation data for 1984 during the period that hydrology and water quality data were obtained for use in this report. Table 3 also provides runoff data for both periods, long-term and 1984, derived from U. S. Geological Survey flow records for the Oconomowoc River at Oconomowoc and the Rock River at Afton, Jefferson County, Wisconsin.

The mean summer and winter temperatures of 67.3°F and 24.9°F at Oconomowoc are similar to those of other recording locations in southeastern Wisconsin. Mean annual precipitation at Oconomowoc is 30.14 inches. More than half of the normal yearly precipitation falls during the growing season, from May to September. Runoff rates are generally low during this period because evapotranspiration rates are high, vegetation cover is abundant, and soils are not frozen. Normally, less than 15 percent of the summer precipitation is expressed as surface

Map 9

SUITABILITY OF SOILS WITHIN THE FOWLER LAKE STUDY AREA FOR MOUND SEWAGE DISPOSAL SYSTEMS UNDER CURRENT ADMINISTRATIVE RULES: FEBRUARY 1991



Source: SEWRPC.

runoff, but intense summer storms occasionally produce high runoff. Peak runoff usually occurs during winter and early spring when about 30 percent of the annual precipitation, in the form of snowmelt and/or rain, falls on frozen ground.

As Table 3 shows, 1984 had 8.36 inches, or 28 percent, more precipitation than the long-term average at Oconomowoc. October, the wettest month, had 7.51 inches of precipitation, or 5.25 inches more than normal. This abundant precipitation caused a 56 percent increase in the mean annual runoff at the U. S. Geological Survey streamflow gage located on the Rock River at Afton.

Groundwater levels were measured at three observation wells located just south of the expanded inlet, as shown on Map 12. The slope of the water table at these wells indicates groundwater flowed toward the Lake during the entire study period.

Using these data and the resultant inflow, outflow, and water-level data, an annual water budget for Fowler Lake was computed and is set forth in Figure 1.[6] During the 12-month period from January 1984 to December 1984, an estimated 56,640 acre-feet of water entered the Lake. The Oconomowoc River contributed 98 percent of the known inflow; 40 percent of that occurred during the months of May, June, and July. The remaining 2 percent of the known inflow came from surface runoff, direct precipitation on the Lake, and groundwater. An estimated 56,630 acre-feet of water was lost from the Lake via the outlet and evaporation from the lake surface. The net gain of water resulted in an increase to the lake level by about 0.08 feet in 1984.

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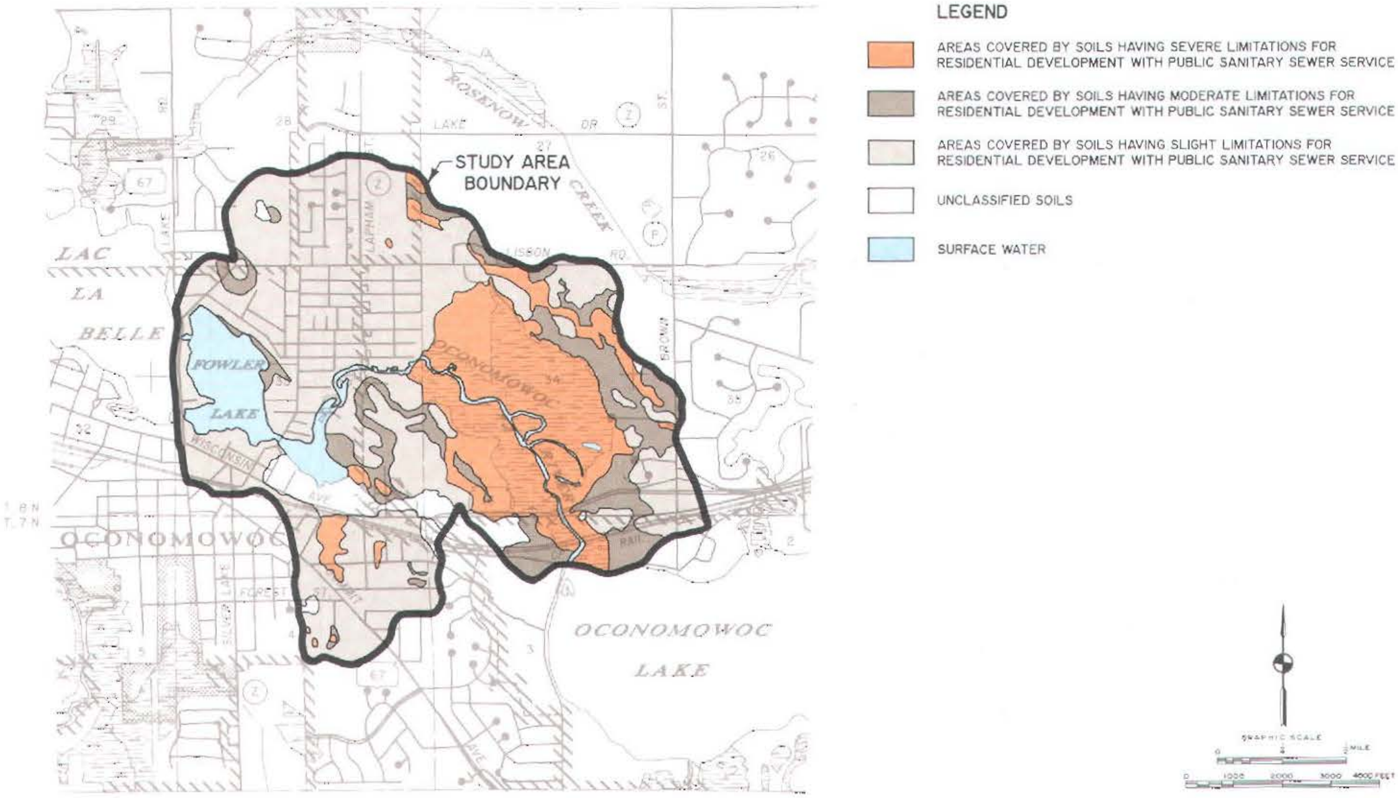
[6] *U. S. Geological Survey, Hydrology, Water Quality, Trophic Status, and Aquatic Plants of Fowler Lake, Wisconsin, Water Resources Investigations Report No. 91-4076, 1993.*

Map 10

SUITABILITY OF SOILS WITHIN THE FOWLER LAKE STUDY AREA FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER



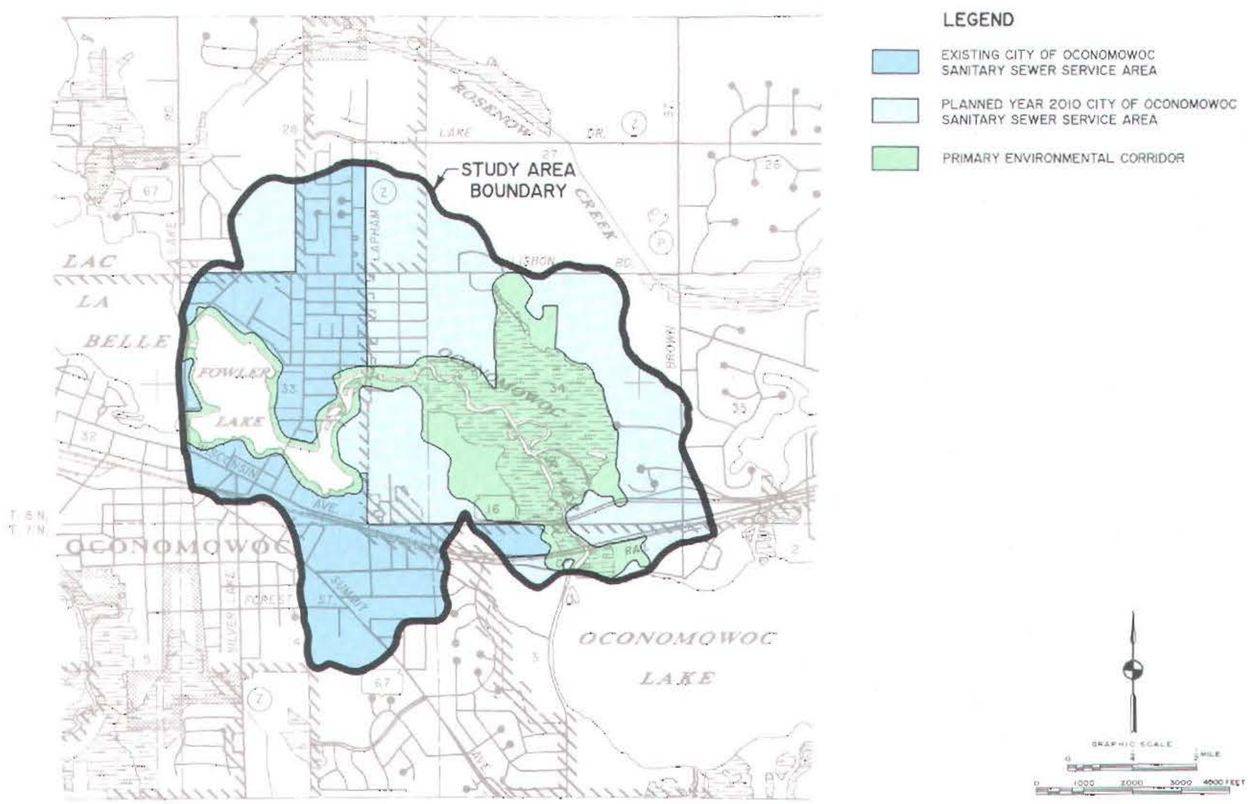
LEGEND

- AREAS COVERED BY SOILS HAVING SEVERE LIMITATIONS FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER SERVICE
- AREAS COVERED BY SOILS HAVING MODERATE LIMITATIONS FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER SERVICE
- AREAS COVERED BY SOILS HAVING SLIGHT LIMITATIONS FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER SERVICE
- UNCLASSIFIED SOILS
- SURFACE WATER

Source: SEWRPC.

Map 11

EXISTING SANITARY SEWER SERVICE AREAS WITHIN THE FOWLER LAKE STUDY AREA: 1985



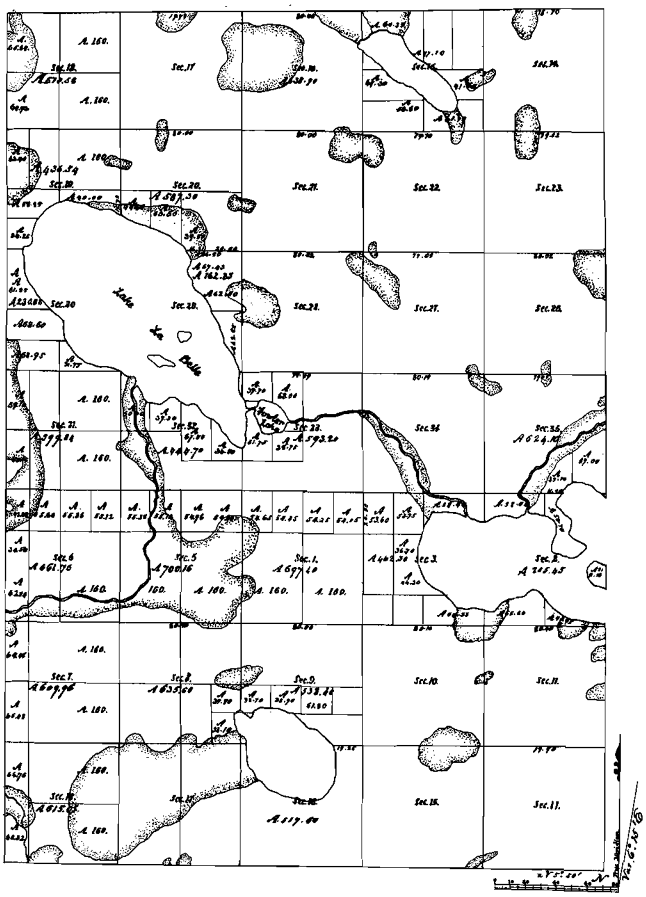
LEGEND

- EXISTING CITY OF OCONOMOWOC SANITARY SEWER SERVICE AREA
- PLANNED YEAR 2010 CITY OF OCONOMOWOC SANITARY SEWER SERVICE AREA
- PRIMARY ENVIRONMENTAL CORRIDOR

Source: SEWRPC.

Map 6

ORIGINAL U. S. PUBLIC LAND SURVEY MAP FOR THE FOWLER LAKE AREA



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

survey contained interpretations for planning and engineering applications, as well as for agricultural applications. Using the regional soil survey, an assessment was made of hydrologic characteristics of the soils in the drainage area of Fowler Lake. The suitability of the soils for urban residential development was assessed using three common development scenarios: development with conventional onsite sewage disposal systems (septic tank systems), alternative onsite sewage disposal systems, and public sanitary sewers.

Soils within the study area of Fowler Lake were categorized into four main hydrologic soil groups, as well as an "other" category, as indicated in Table 2. The areal extent of these soils and their locations within the watershed are shown on Map 7. The relative proportions of the Fowler Lake study area covered by each of the hydrologic soils groups are: Group A, excessively drained soils, 0 percent; Group B, well-drained soils, about 69 percent; Group C, poorly drained soils, 3 percent; Group D, very poorly drained soils, about 17 percent; and "other," which includes areas such as man-made fill areas and quarries, about 4 percent. Fowler Lake accounts for the remaining 7 percent of the study area.

As noted above, the soils within the Fowler Lake study area were examined for suitability for urban residential development by the U. S. Soil Conservation Service. The classification system used for onsite sewage disposal was developed under the Regional Planning Commission's most recent land use planning program[5] and was based upon soil characteristics set forth in the detailed soil surveys as well as factual field experience of County and State technicians responsible for overseeing the location and design of such systems. The classifications reflect the current soil and site specifications set forth in ILHR 83 of the Wisconsin Administrative Code. With respect to residential development utilizing conventional onsite sewage disposal systems, as shown on Map 8, about 65 percent of the Fowler Lake study area is covered by soils suitable for such development and about 24 percent by soils unsuitable for such development. The soil suitability could not be determined for 6 percent of the land in the drainage area and 5 percent could not be classified.

Using alternative onsite sewage disposal systems, such as mound systems, as shown on Map 9, yields little additional land for urban residential development: about 66 percent of the Fowler Lake study area is covered by soils suitable for such development and about 29 percent by soils unsuitable for such development. Soil suitability could not be determined for 8 percent of the land in the direct drainage area; 5 percent could not be classified.

Soil limitations for residential development utilizing sanitary sewer service are shown on Map 10. About 70 percent of the Fowler Lake study area is covered by soils suitable for such

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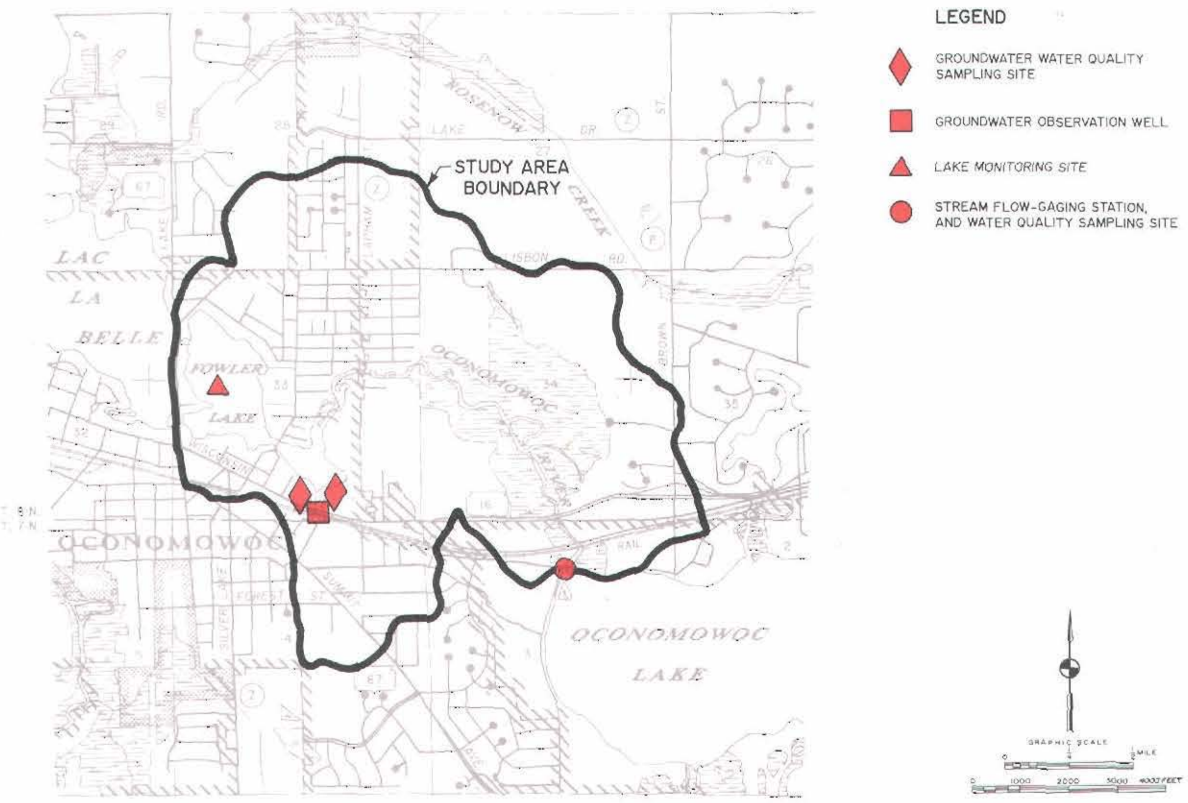
[5] *SEWRPC Planning Report No. 40, A Regional Land Use Plan for Southeastern Wisconsin: 2010, January 1992.*

Map 12

LOCATION OF MONITORING STATIONS WITHIN THE FOWLER LAKE STUDY AREA: 1984



Source: U. S. Geological Survey and SEWRPC.

The hydraulic residence time, or the time required for a volume equivalent to the full volume of the Lake to enter its basin, was approximately 6.9 days. The hydraulic residence time is important in determining the expected response time of a lake to increased or decreased nutrient and pollutant loadings. The smaller the lake volume and/or greater the rate of inflow, the shorter the hydraulic residence time will be. In comparison, the hydraulic residence time for upstream Okauchee Lake was 305 days and for downstream Lac La Belle, 145 days. The hydraulic residence time for Oconomowoc Lake was about 180 days. The short residence time for Fowler Lake implies that the water quality of the Lake will be a direct reflection of the quality of the influent Oconomowoc River (i.e., the outflow from Oconomowoc Lake).[7]

[7]*See SEWRPC Community Assistance Planning Report No. 181, A Water Quality Management Plan for Oconomowoc Lake, March 1990.*

SUMMARY

This chapter has presented an inventory of the physical characteristics of Fowler Lake and its drainage area. Proper consideration of alternative measures which affect the hydrology or water quality of Fowler Lake requires such a characterization of basin morphometry, the surface water drainage pattern, and the climate and hydrology of the drainage area.

Fowler Lake consists of a main body covering 78 acres and an enlarged inlet covering 21 acres, separated from the main basin by the N. Oakwood Avenue bridge. The Lake has a mean depth of 13 feet and a maximum depth of 50 feet. Muck/clay covers about 43 percent of the lake bottom. The Fowler Lake study area (equal to the direct drainage area) covered 1,604 acres and the total drainage area to Fowler Lake covered about 49,757 acres.

Table 3

LONG-TERM AND 1984 STUDY YEAR CLIMATOLOGICAL AND RUNOFF DATA FOR THE FOWLER LAKE AREA

Climatological Data	Long-Term Average Monthly Values												
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Mean Monthly Air Temperature (°F)[a]	16.9	21.6	32.0	46.7	58.2	67.4	72.0	70.1	62.0	51.1	36.8	23.8	46.6
Mean Monthly Precipitation (inches)[a]	1.07	0.84	1.71	2.91	2.88	3.78	4.10	3.96	3.37	2.26	1.83	1.43	30.14
Mean Monthly Runoff (inches)[a] (Rock River at Afton)	0.42	0.46	1.14	1.36	0.85	0.56	0.45	0.34	0.37	0.41	0.45	0.46	7.27

Climatological Data	1984 Study Period Average Monthly Values												
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Mean Monthly Air Temperature (°F)	14.6	30.8	27.4	45.8	54.5	68.8	69.6	72.2[b]	59.2	52.6[b]	36.0	26.3	46.5
Departure from Normal Mean Monthly Air Temperature (°F)	-2.3	9.2	-4.6	-0.9	-3.7	1.4	-2.4	2.1	-2.8	1.5	-0.8	2.5	-0.8
Total Precipitation (inches)	0.42	1.39	1.38	3.20	4.57	5.90	4.20	1.91[b]	2.47	7.51	2.28	3.27	38.50
Departure from Normal Mean Monthly Precipitation (inches)	-0.65	0.55	-0.33	0.29	1.69	2.12	0.10	-2.05	-0.90	5.25	0.45	1.84	8.36
Runoff (inches) (Rock River at Afton)[c]	0.48	0.86	1.16	0.89	1.28	1.18	1.19	0.41	0.34	0.79	1.53	0.99	11.10
Departure from Normal Mean Monthly Runoff (inches) (Rock River at Afton)	0.07	0.40	0.03	-0.45	0.44	0.63	0.75	0.07	-0.01	0.40	1.08	0.58	3.99
Runoff (inches) (Oconomowoc River at Oconomowoc)	0.48	1.04	1.09	0.74	1.27	1.63	1.61	0.62	0.54	1.14	1.75	1.26	13.17

[a]Based on data collected between 1951 and 1980.

[b]Insufficient or partial data. Values computed with from one to nine daily values missing.

[c]Based on data collected between 1914 and 1978.

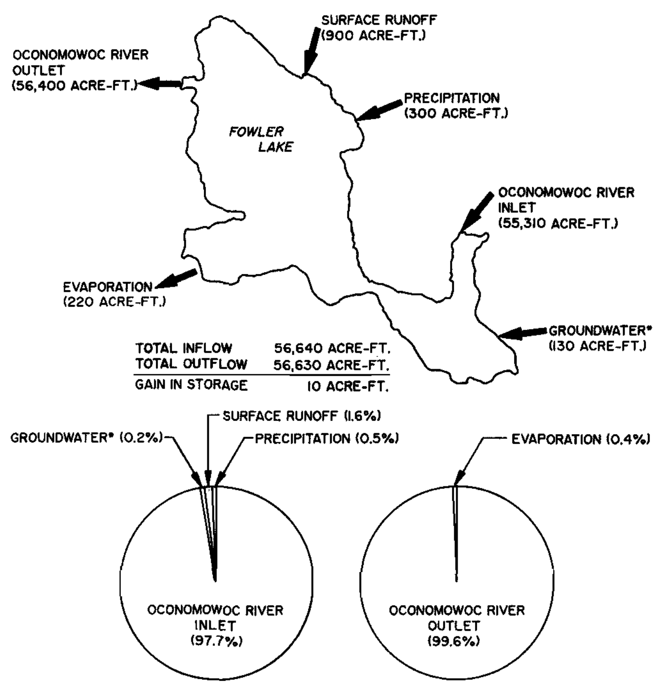
Source: U. S. Geological Survey and SEWRPC.

The climate and hydrology of Fowler Lake were observed by the U. S. Geological Survey from January 1984 through December 1984. During this period, the annual precipitation was 38.50 inches, or 8.36 inches above long-term (1951-1980) annual average for the Oconomowoc weather station. Of the total water input to Fowler Lake over this period, an estimated 56,640 acre-feet, the Oconomowoc River contributed about 98 percent. Direct precipitation, groundwater inflows, and shoreline drainage contributed the remaining 2 percent. Of the total water output from Fowler Lake, an estimated 56,630 acre-feet, most was discharged from the Fowler Lake outlet to Lac La Belle; less than 1 percent evaporated from the lake surface.

Fowler Lake has a short residence time of about 6.9 days, indicating that the water quality of the Lake will be a direct reflection of the quality of the influent Oconomowoc River exiting Oconomowoc Lake.

Figure 1

HYDROLOGIC BUDGET FOR FOWLER LAKE: 1984



* GROUNDWATER ESTIMATED FROM GAIN IN STORAGE

Source: U. S. Geological Survey and SEWRPC.

Chapter III

HISTORICAL, EXISTING, AND PLANNED LAND USE AND POPULATION

INTRODUCTION

Water pollution problems, and the ultimate solutions to these problems, are primarily a function of the human activities within the drainage area of a water body and of the ability of the underlying natural resource base to sustain those activities. This is especially true in an area directly tributary to a lake because lakes are highly susceptible to water quality degradation related to human activities in their immediate drainage area, since there are no intermediate stream segments to attenuate pollutant loads. This type of lake degradation is more likely to interfere with desired water uses and is often more difficult and costly to correct than degradation arising from clearly identifiable point sources in the watershed. Accordingly, the land uses and population levels in the direct drainage area of a lake are important considerations in lake water quality management.

Civil Divisions

The areal extent and functional responsibilities of civil divisions and special-purpose units of government are important factors which must be considered in any water quality management planning effort, since these local units of government provide the basic structure of the decision-making framework within which environmental problems must be addressed. Superimposed on the map of the Fowler Lake direct drainage area are the local civil division boundaries, as shown on Map 13. The Fowler Lake study area includes portions of the Town of Oconomowoc, the City of Oconomowoc, and the Village of Oconomowoc Lake, as well as a very small portion of the Town of Summit. Since the study area does not fall entirely within any one of these civil divisions, the area and proportion of the direct drainage area lying within each jurisdiction as of 1990, is set forth in Table 4.

Population

As indicated in Table 5, the resident population of the Fowler Lake study area has increased fairly steadily since 1970. The 1990 resident population of the drainage area, estimated at 4,800 persons, was about 2 percent higher than the estimated 1970 population. Population forecasts prepared by the Regional Planning Commission, on the basis of a normative regional land use plan, indicate, as shown in Table 5, that the population of the study area directly tributary to Fowler Lake may be expected to increase to about 5,500 persons by the year 2010. A comparison of historic, existing, and forecast population levels for the drainage area directly tributary to Fowler Lake, for Waukesha County and for the Southeastern Wisconsin Region is set forth in Figure 2. Compared to Waukesha County and the Southeastern Wisconsin Region as a whole, population growth in the Fowler Lake study area since 1970 has increased at about the same rate as the regional population but less rapidly than the population of Waukesha County. This situation reflects, in part, the generally established nature of those portions of the City of Oconomowoc bordering the lake; population growth in the County occurred primarily in peri-urban areas that had previously been agricultural. This population growth may be expected to place a continued and increasing stress on the natural resource base of the Fowler Lake drainage area. As the population of the study area, of the County, and of the Region continues to grow and change, water resource demands and use conflicts may be expected to increase.

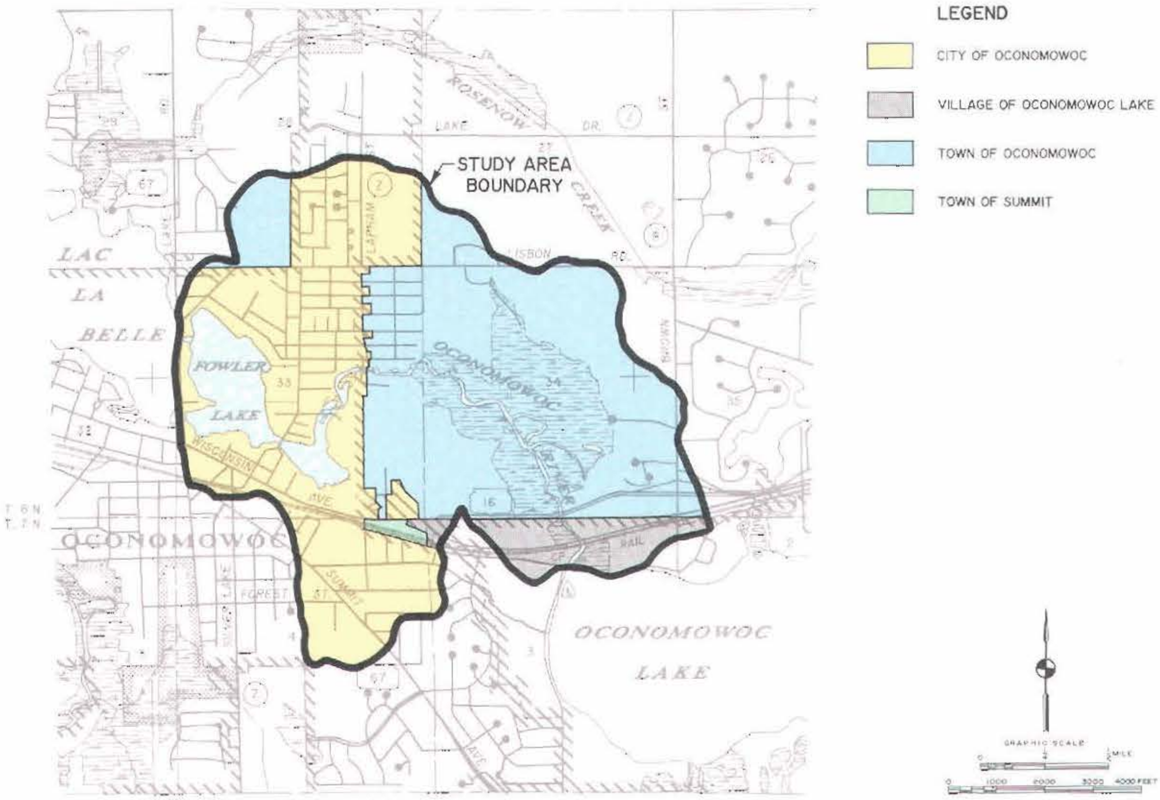
Land Use

The type, intensity, and spatial distribution of the various land uses within the Fowler Lake study area are important determinants of lake water quality. The existing land use pattern can best be understood in the context of the area's historical development. The movement of European settlers into the Southeastern Wisconsin Region began about 1830. Completion of the U. S. Public Land Survey in 1836 and the subsequent sale of public lands in Wisconsin brought a rapid influx of settlers into the area. Map 6 in Chapter II shows the original plat of the U. S. Public Land Survey for the Fowler Lake area.

Significant urban development began in the Fowler Lake area at about the time of the Civil War. Map 14 and Table 6 indicate the historical urban growth pattern in the study area since 1850. The largest increase in urban land use development, 43 percent, occurred between 1950

Map 13

CIVIL DIVISION BOUNDARIES IN THE FOWLER LAKE STUDY AREA



Source: SEWRPC.

Table 4

AREAL EXTENT OF CIVIL DIVISIONS IN THE FOWLER LAKE STUDY AREA: 1990

Civil Division	Civil Division Area within Study Area (square miles)	Percent of Study Area within Civil Division	Percent of Civil Division within Study Area
Town of Oconomowoc	1.38	55	4
City of Oconomowoc	0.95	38	17
Village of Oconomowoc Lake	0.15	6	5
Town of Summit	0.03	1	1
Total	2.51	100	- -

Source: SEWRPC.

Table 5

HISTORIC AND FORECAST RESIDENT POPULATION LEVELS IN THE FOWLER LAKE STUDY AREA: 1970-2010[a]

Year	Number of Residents	Number of Households
1970	4,720	1,450
1980	4,950	1,780
1985	4,890	1,820
1990	4,810	1,910
2010[b]	5,490	2,260

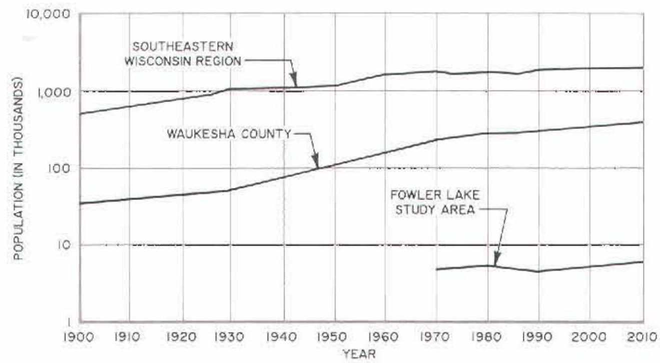
[a] *Study area approximated using whole U. S. Public Land Survey one-quarter sections.*

[b] *Year 2010 data are presented for the intermediate-growth centralized land use plan as set forth in the year 2010 regional land use plan.*

Source: SEWRPC.

Figure 2

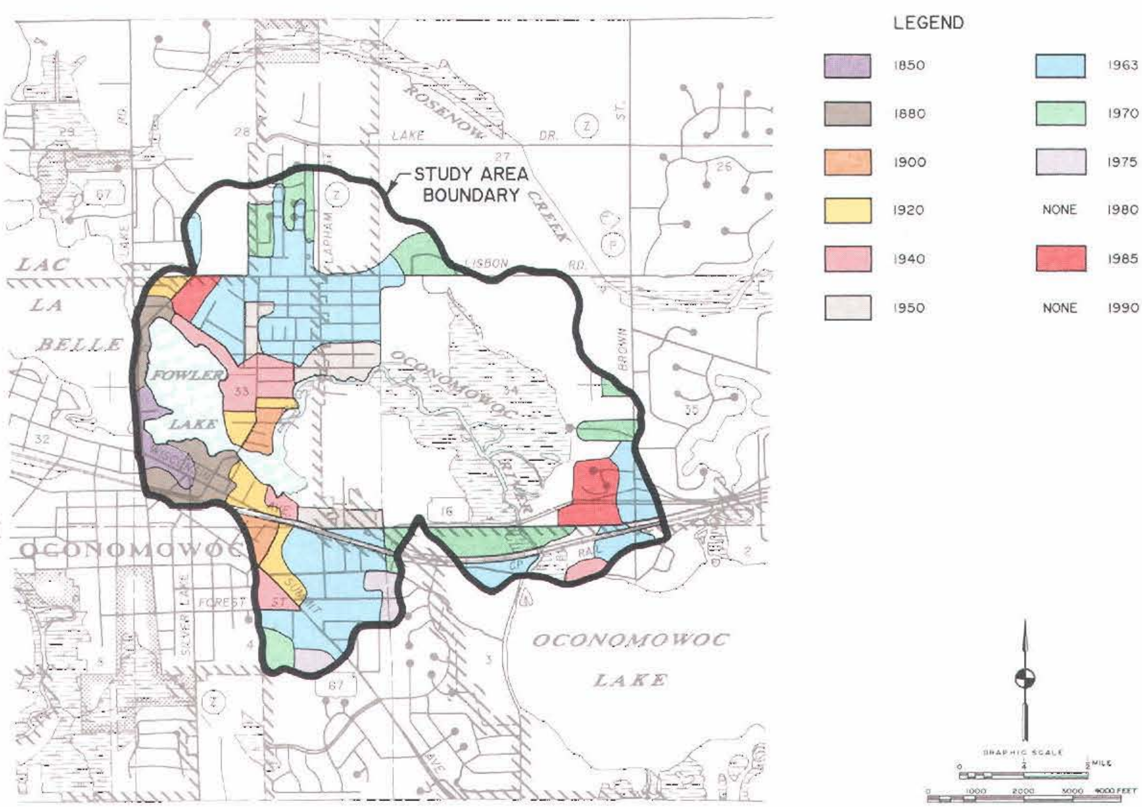
COMPARISON OF HISTORIC, EXISTING, AND FORECAST POPULATION TRENDS FOR THE FOWLER LAKE STUDY AREA, WAUKESHA COUNTY, AND THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

Map 14

HISTORIC URBAN GROWTH IN THE FOWLER LAKE STUDY AREA: 1850-1990



Source: SEWRPC.

Table 6

EXTENT OF HISTORIC URBAN GROWTH IN THE FOWLER LAKE STUDY AREA: 1850-1985

Year	Extent of Urban Development (acres)[a]
1850	26
1880	51
1900	25
1920	51
1940	59
1950	53
1963	341
1970	118
1975	18
1980	0
1985	46

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

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

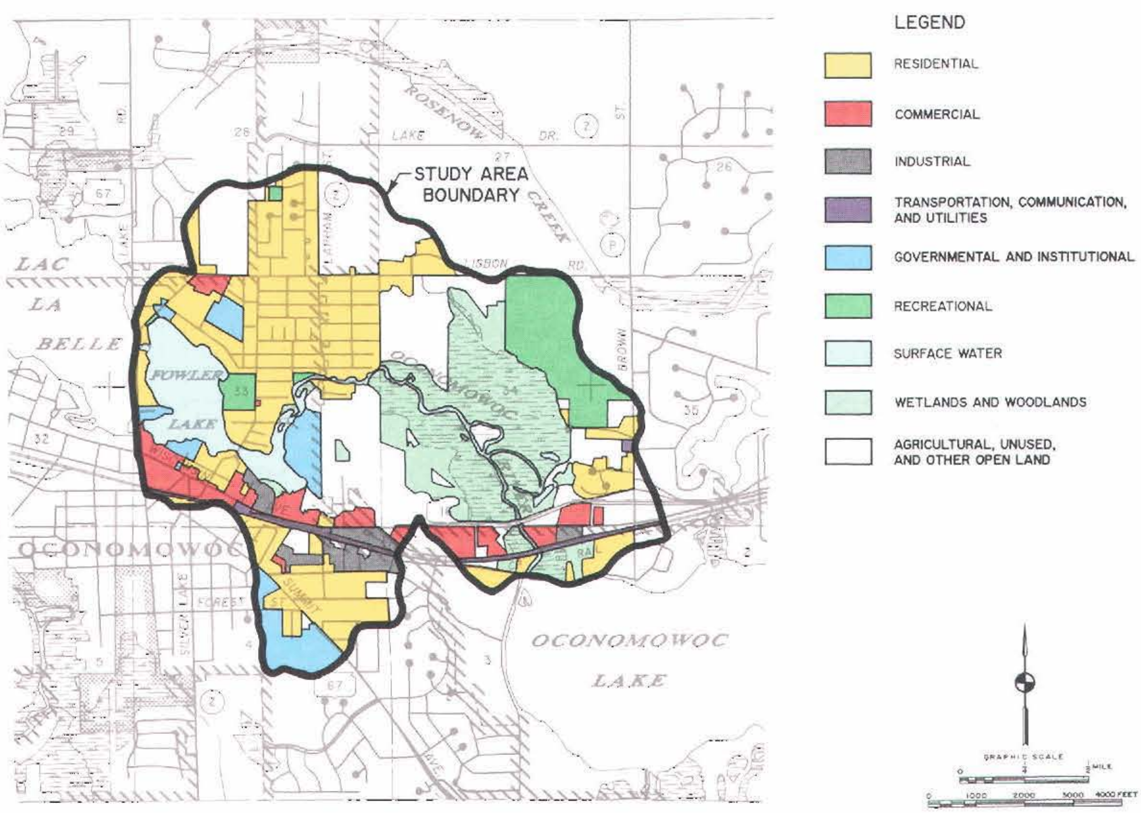
and 1963. Development after 1970 has substantially decreased in comparison to previous years; few changes have occurred in the last decade (since 1985).

The existing land use patterns in the Fowler Lake study area, as of 1990, are shown on Map 15 and quantified in Table 7. As indicated in Table 7, about 902 acres, or about 56 percent of the direct drainage area, were in urban land uses, with residential the dominant urban land use, encompassing 390 acres, or about 43 percent of the area in urban use. As of 1990, about 702 acres, or about 44 percent of the Fowler Lake study area, were still in rural land use. About 250 acres, or about 36 percent of the rural area, were in agricultural land uses. Woodlands, wetlands, and surface water, including the surface area of Fowler Lake, accounted for approximately 402 acres, or about 57 percent of the area in rural use.

The estimated 600 new residents which may be expected in the study area between 1985 and 2010 will require an increase in the land area

Map 15

EXISTING LAND USE WITHIN THE FOWLER LAKE STUDY AREA: 1990



Source: SEWRPC.

devoted to urban use. The year 2010 land use plan adopted by the Regional Planning Commission, as set forth on Map 16 and quantified in Table 8, recommends that most new residential development in the Fowler Lake study area occur at medium densities. Compared to existing land use, an 8 percent increase in urban land uses and a 7 percent increase in residential land uses are envisioned by the design year of the plan. Lands encompassing 151 acres, or just under 10 percent of the study area, are designated as primary environmental corridor and are recommended to be kept in essentially natural, open uses. About 1 percent, or 15 acres of the study area, is designated as prime agricultural land, to be preserved in agricultural use.

On a larger scale, existing and planned land uses within the Fowler Lake watershed, the Oconomowoc River basin upstream of the Fowler Lake outlet into Lac La Belle, are shown on Maps 17 and 18 and quantified in Tables 9 and 10. Generally, the anticipated changes in land use within this watershed are less pronounced than, but parallel to, the expected changes in the Fowler Lake study area.

Qualitatively, the greatest changes in land use in the Fowler Lake study area and watershed are in the amounts of land allocated for residential and agricultural use. Residential lands are expected to increase substantially in extent, primarily at the expense of agricultural lands. Interestingly, woodlands and wetlands are expected to be little affected by the continued growth of the residential areas, provided the recommendations to protect the environmental corridors are fully implemented. Significant growth is also expected in the transportation sector, primarily in support of the expanding residential land use sector. Planning and controlling this urban growth in the Fowler Lake study area and watershed presents a major challenge in protecting the water quality of the Fowler Lake-Lac La Belle system.

EXISTING ZONING REGULATIONS

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

Table 7

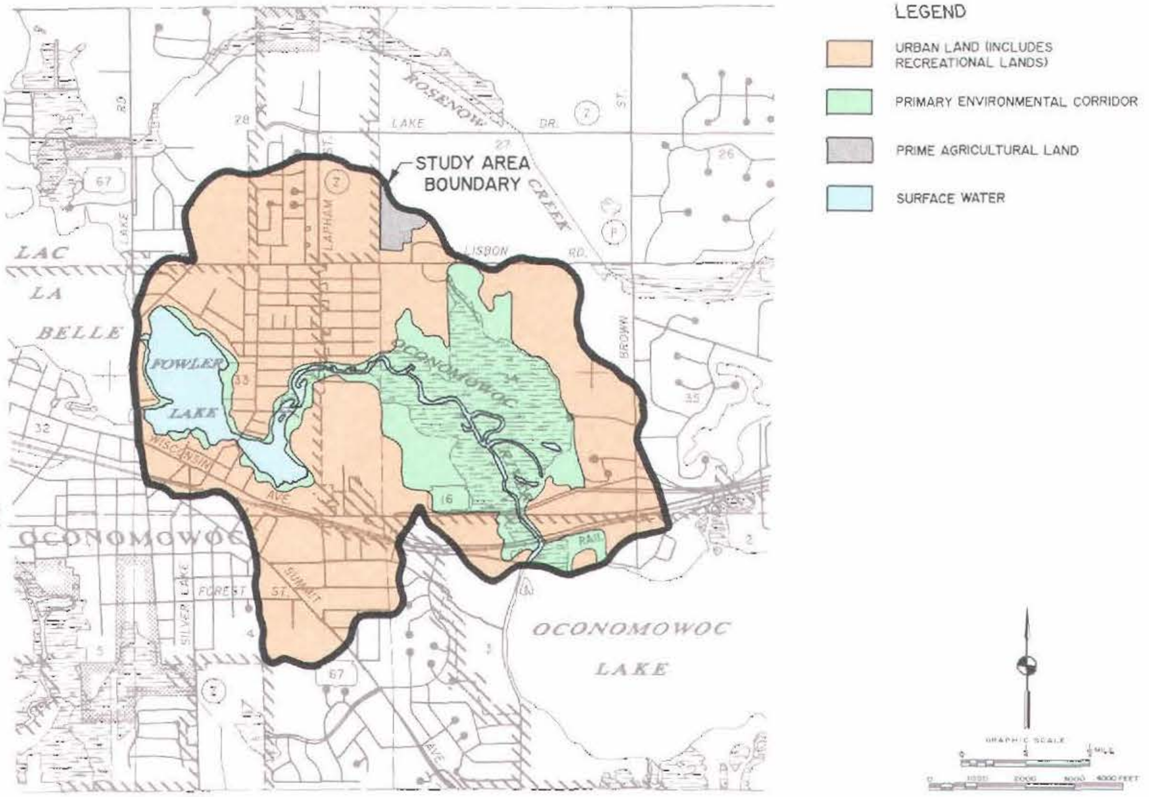
EXISTING LAND USE WITHIN THE FOWLER LAKE STUDY AREA: 1990

Land Use Categories	Acres	Percent of Major Category	Percent of Study Area
Urban			
Residential	390	43.2	24.3
Commercial	59	6.5	3.7
Industrial	35	3.9	2.2
Government and Institutional	75	8.3	4.7
Transportation, Commercial, and Utilities	167	18.5	10.4
Recreation	154	17.1	9.6
Land under Construction	22	2.5	1.4
Subtotal	902	100.0	56.3
Rural			
Agricultural	250	35.6	15.6
Woodlands	62	8.8	3.9
Wetlands	226	32.2	14.1
Water	114	16.2	7.1
Other	50	7.2	3.0
Subtotal	702	100.0	43.7
Total	1,604	- -	100.0

Source: SEWRPC.

Map 16

YEAR 2010 LAND USE PLAN FOR THE FOWLER LAKE STUDY AREA



Source: SEWRPC.

Table 8

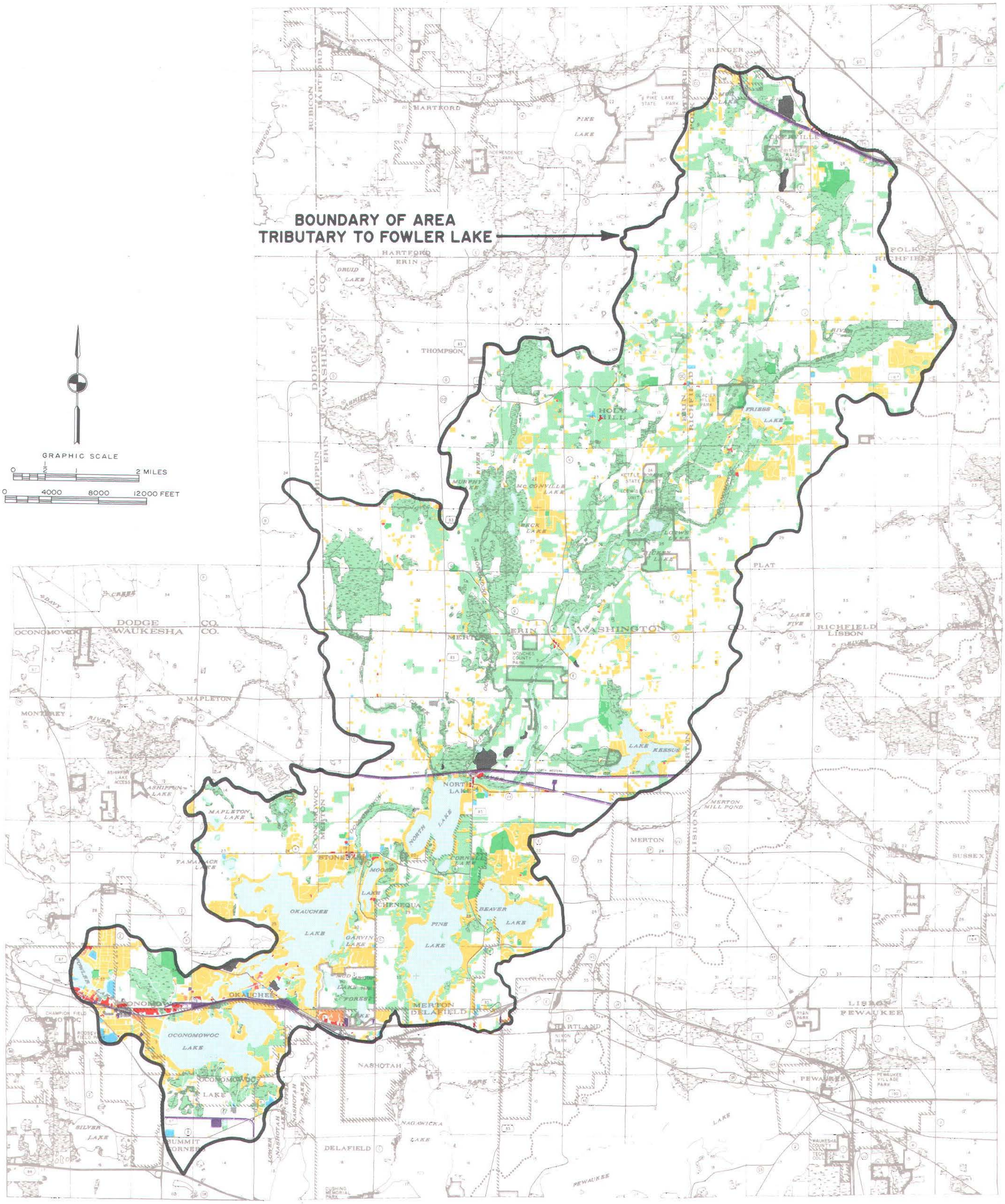
PLANNED 2010 LAND USE WITHIN THE FOWLER LAKE STUDY AREA

Land Use Categories	Acres	Percent of Major Category	Percent of Study Area
Urban			
Residential	500	48.3	31.2
Commercial	45	4.3	2.8
Industrial	28	2.7	1.8
Government and Institutional	66	6.4	4.1
Transportation, Commercial, and Utilities	227	21.9	14.2
Recreation	157	15.2	9.8
Land under Construction	13	1.2	0.8
Subtotal	1,036	100.0	64.7
Rural			
Agricultural	133	23.4	8.3
Woodlands	56	9.9	3.5
Wetlands	226	39.8	14.0
Water	114	20.0	7.1
Other	39	6.9	2.4
Subtotal	568	100.0	35.3
Total	1,604	- -	100.0

Source: SEWRPC.

Map 17

EXISTING LAND USES WITHIN THE AREA TRIBUTARY TO FOWLER LAKE: 1990



LEGEND

PRIMARY LAND USES

- SINGLE-FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- RETAIL AND SERVICE
- MANUFACTURING, WHOLESALE, AND STORAGE
- LANDFILL AND EXTRACTIVE
- TRANSPORTATION, COMMUNICATION, AND UTILITIES (EXCEPT HIGHWAYS, RAILWAYS, AND TRANSMISSION LINES)
- WATER
- GOVERNMENTAL AND INSTITUTIONAL
- WOODLAND AND WETLAND
- RECREATIONAL
- AGRICULTURAL AND OTHER OPEN LANDS

Source: SEWRPC.

Table 9

EXISTING LAND USE IN THE TOTAL TRIBUTARY DRAINAGE AREA TO FOWLER LAKE: 1990

Land Use Categories	Acres	Percent of Major Category	Percent of Study Area
Urban			
Residential	4,461	60.8	8.9
Commercial	189	2.6	0.4
Industrial	54	0.7	0.1
Government and Institutional	142	2.0	0.3
Transportation, Commercial, and Utilities	1,967	26.8	3.9
Recreation	471	6.4	1.0
Unused Land and Land under Construction	49	0.7	0.1
Subtotal	7,333	100.0	14.7
Rural			
Agricultural	23,938	56.4	48.1
Woodlands	6,447	15.2	13.0
Wetlands	6,166	14.5	12.4
Water	3,453	8.2	6.9
Other	2,420	5.7	4.9
Subtotal	42,424	100.0	85.3
Total	49,757	- -	100.0

Source: SEWRPC.

Table 10

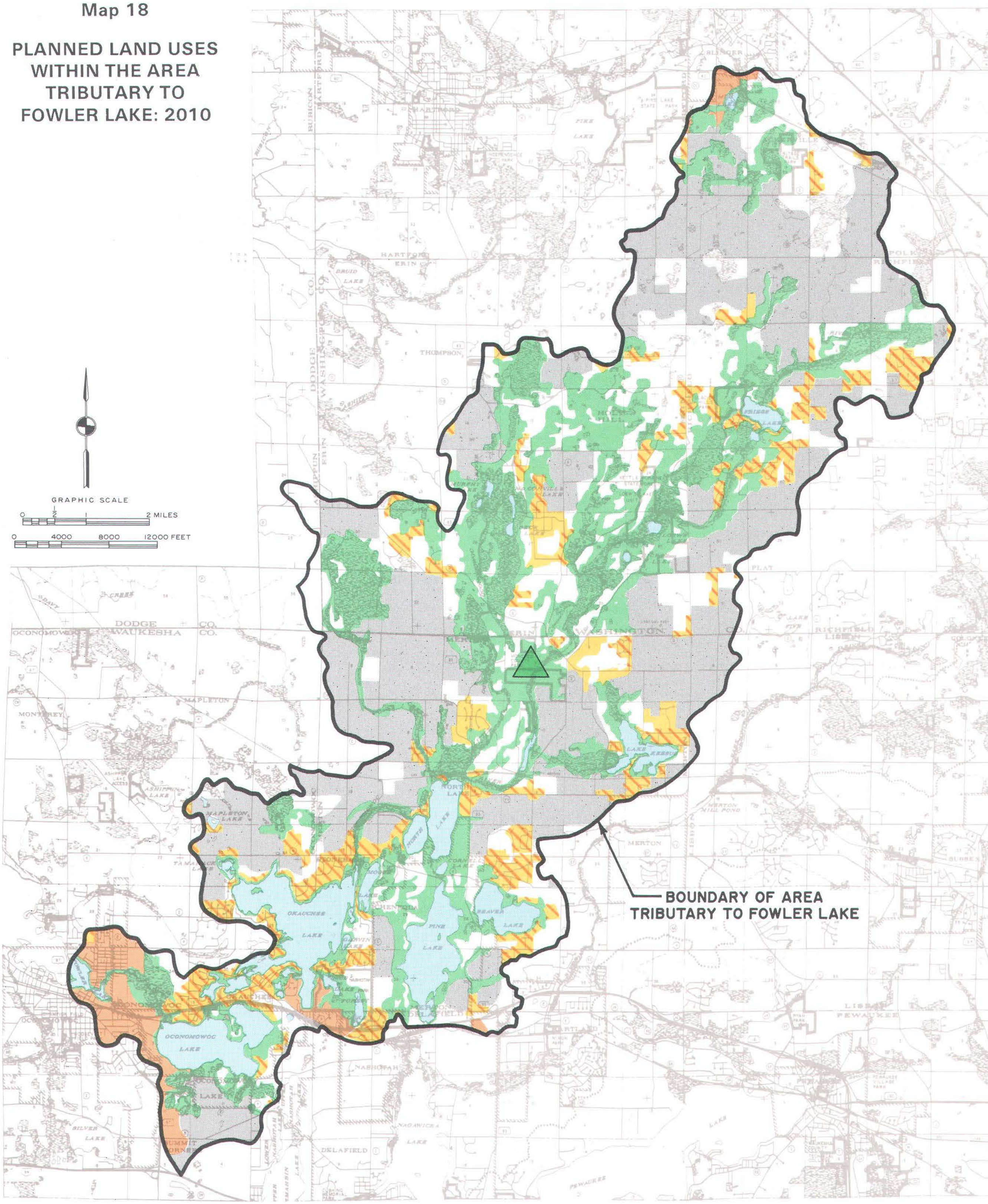
RECOMMENDED 2010 LAND USE IN THE TOTAL TRIBUTARY DRAINAGE AREA TO FOWLER LAKE

Land Use Categories	Acres	Percent of Major Category	Percent of Total Tributary Drainage Area
Urban			
Residential	4,443	58.0	8.9
Commercial	188	2.4	0.4
Industrial	67	0.9	0.1
Government and Institutional	147	1.9	0.3
Transportation, Commercial, and Utilities	1,958	25.5	3.9
Recreation	725	9.5	1.5
Unused Land and Land under Construction	138	1.8	0.3
Subtotal	7,666	100.0	15.4
Rural			
Agricultural	24,244	57.6	48.7
Woodlands	6,447	15.3	13.0
Wetlands	6,166	14.7	12.4
Water	3,453	8.2	6.9
Other	1,781	4.2	3.6
Subtotal	42,091	100.0	84.6
Total	49,757	- -	100.0

Source: SEWRPC.

Map 18

PLANNED LAND USES WITHIN THE AREA TRIBUTARY TO FOWLER LAKE: 2010



LEGEND

PRIMARY LAND USES

- SUBURBAN RESIDENTIAL (0.2-0.6 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- LOW DENSITY RESIDENTIAL (0.7-2.2 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MEDIUM DENSITY RESIDENTIAL (2.3-6.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MAJOR PUBLIC MULTI-USE SITE OUTDOOR RECREATION CENTER
- WATER
- PRIMARY ENVIRONMENTAL CORRIDOR
- PRIME AGRICULTURAL LAND
- OTHER AGRICULTURAL AND RURAL LAND

Source: SEWRPC.

jurisdiction. The Fowler Lake study area includes portions of the City of Oconomowoc, the Village of Oconomowoc Lake, and the Town of Oconomowoc. The City of Oconomowoc and the Village of Oconomowoc Lake each administer their own zoning regulations, while zoning in the Town of Oconomowoc is under the jurisdiction of Waukesha County and its zoning ordinance. A summary of the zoning districts available for use in the three civil divisions listed above and the extent of the land placed in each of the three zoning districts is shown on Map 19.

While the existing zoning ordinances have proven generally effective in protecting the wetlands, woodlands, and water resources of the Fowler Lake study area, concerns have been expressed over the need to protect the lakeshore from over-intensive land use. These concerns have arisen in light of infilling and densification, the process of replacing low-density residential development with high-density, condominium-type development, such as has taken place on neighboring Lac La Belle. Such redevelopment of the lakefront is undesirable both from the point of view of water quality protection and of shoreland aesthetics and historic preservation.[1] Densification generally results in a greater area of impervious surface, increased runoff, and increased pollutant loading as described in Chapter IV. Control of shoreland redevelopment is not specifically addressed in the existing zoning codes. The City of Oconomowoc and the Village of Oconomowoc Lake should review this issue and amend their ordinances accordingly if the ambience and environmental quality of the natural resources is to be preserved. Amendment of the Waukesha County ordinance affecting the Town of Oconomowoc may also be desirable in this respect.

In addition to the three general zoning ordinances administered in the Fowler Lake study area, the Waukesha County Board of Supervisors adopted a Shoreland and Floodland Protection Zoning Ordinance in 1970. This ordinance, prepared pursuant to the requirements of the Wisconsin Water Resources Act of 1965 (Chapter 30, Wisconsin Statutes), imposes special land use regulations on all unincorporated lands located within 1,000 feet of the shoreline of any navigable lake, pond, or flowage, and within 300 feet of the shoreline of any navigable river or stream, or to the landward side of the floodplain, whichever is greater. The Shoreland and Floodland Protection Zoning Ordinance is similar in content to the Waukesha County Zoning Ordinance but includes additional regulations intended to protect waterways and the attendant shorelines.

Other pertinent regulations include wetland and shoreland protection ordinances. Chapters 23 and 330 of the Wisconsin Statutes require that counties regulate the use of all wetlands five acres or larger located in shoreland areas of the unincorporated areas within 300 feet of a stream and 1,000 feet of a lake, or to the landward side of the floodplain, whichever is greater. Preliminary wetland maps for Waukesha County were prepared for the Wisconsin Department of Natural Resources (DNR) by the Regional Planning Commission in 1981. In accordance with Chapter NR 115 of the Wisconsin Administrative Code, Waukesha County has updated its shoreland zoning regulations and attendant maps to preclude further loss of wetlands in the shoreland areas. These zoning modifications were adopted in 1986. In accordance with Chapter NR 117 of the Wisconsin Administrative Code, cities and villages are also required to protect shoreland-wetland areas following the receipt of final wetland inventory maps from the DNR. Both the City of Oconomowoc and Village of Oconomowoc Lake received final wetland inventory maps in 1987. The City of Oconomowoc adopted shoreland zoning regulations on October 20, 1987, and the Village of Oconomowoc Lake adopted shoreland zoning regulations on November 21, 1988.

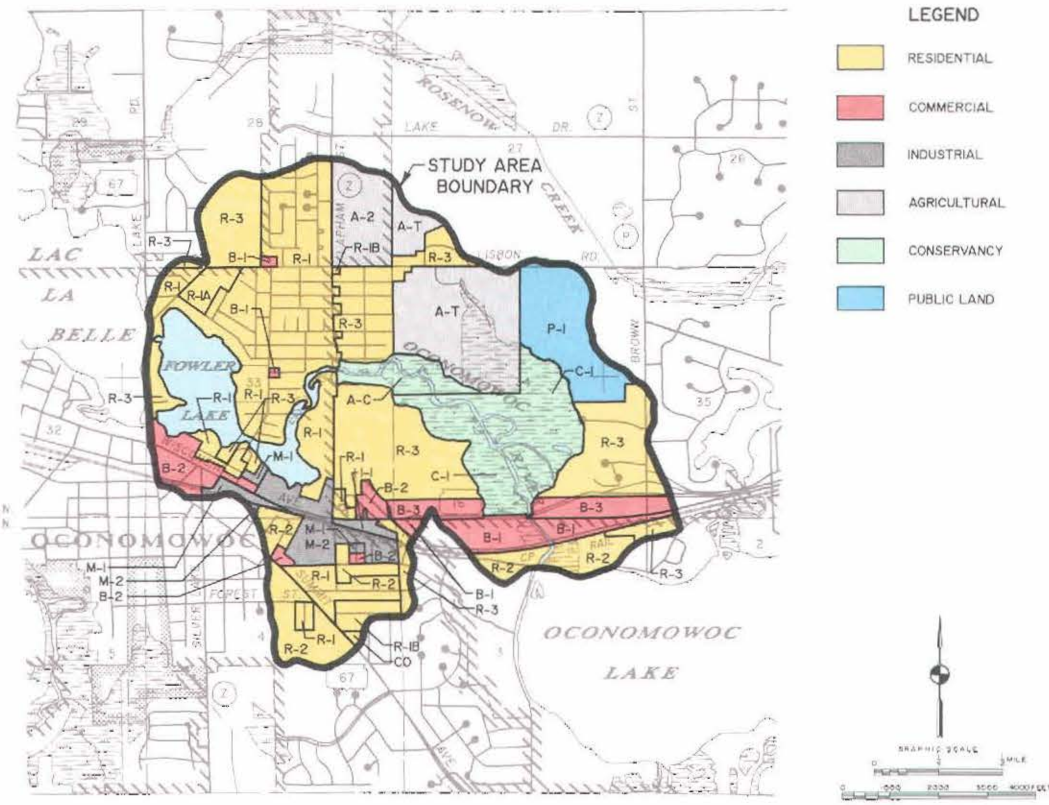
SUMMARY

Current population growth forecasts suggest that the number of people within the Fowler Lake study area will continue to increase, as it has over the last 150 years. Initially, the urban growth was centered along Main Street, Oconomowoc, with relatively little areal expansion until the suburban growth in the post-World War II period (see Table 6). This growth is expected to continue, but at a slower rate, into the foreseeable future. Residential land use, sup-

[1]*The Greater Oconomowoc Area Chamber of Commerce, <u>Oconomowoc: Historic Walking Tour Around Fowler Lake</u>, 1990.*

Map 19

EXISTING ZONING DISTRICTS IN THE FOWLER LAKE STUDY AREA: 1990



ZONING DISTRICTS

CITY OF OCONOMOWOC

R-1	ONE FAMILY RESIDENCE 66FT LOT FRONTAGE
R-1A	ONE FAMILY RESIDENCE 80FT LOT FRONTAGE
R-1B	ONE FAMILY RESIDENCE 100FT LOT FRONTAGE
R-2	ONE AND TWO FAMILY RESIDENCE
R-3	MULTI-FAMILY RESIDENCE
A-2	AGRICULTURAL - MINIMUM 5 ACRES
C-O	COMMERCIAL OVERLAY
B-1	NEIGHBORHOOD BUSINESS
B-2	DOWNTOWN BUSINESS
M-1	LIGHT MANUFACTURING
M-2	GENERAL MANUFACTURING

VILLAGE OF OCONOMOWOC LAKE

R-2	SINGLE FAMILY RESIDENTIAL
R-3	SINGLE FAMILY RESIDENTIAL
B-1	BUSINESS
I-1	RESTRICTED INDUSTRIAL

TOWN OF OCONOMOWOC

R-2	RESIDENTIAL
R-3	RESIDENTIAL
A-T	AGRICULTURAL LAND PRESERVATION TRANSITION
A-C	AGRICULTURAL LAND PRESERVATION CONSERVANCY
C-1	CONSERVANCY
B-3	GENERAL BUSINESS
P-1	PUBLIC

TOWN OF SUMMIT

I-1	RESTRICTED INDUSTRIAL

Source: SEWRPC.

ported by commercial developments, is anticipated to increase from about 449 to about 545 acres in extent by the year 2010 in the Fowler Lake study area and remain relatively stable at about 4,650 acres in the watershed. Agricultural land use is expected to decrease from about 250 acres to about 133 acres in the study area and increase slightly from about 23,938 acres to about 24,244 acres in the watershed during this period. Woodlands and wetlands are expected to remain relatively stable at about 60 acres and 226 acres, respectively, in the study area, and about 6,447 acres and 6,166 acres, respectively, in the watershed. The situation of those wetlands and woodlands, and water bodies in the environmental corridors delineated by the Regional Planning Commission would appear to underlie this apparent stability.[2] (See Table 8 and 10). The adoption of shoreland zoning regulations, in association with good urban planning principles, should continue to guide this development along the lines of minimal environmental impact (see Chapter VII).

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[2] *SEWRPC Planning Report No. 27, A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000, November 1977; B. P. Rubin and G. H. Emmerich, Jr., "Refining the Delineation of Environmental Corridors in Southeastern Wisconsin," SEWRPC Technical Record, Vol. 4, No. 2, 1981.*

Chapter IV

WATER QUALITY

HISTORICAL BACKGROUND

Some data on the water quality of Fowler Lake before the 1984 U. S. Geological Survey (USGS) study exist and were collated for this study. Most of the data, however, are relatively recent. The earliest, although limited, definitive information on water quality conditions in Fowler Lake was collected by R. J. Poff and C. W. Threinen in the early 1960s.[1] Other sources of information on the historical water quality conditions in Fowler Lake included the results of a 1973 to 1975 monitoring study conducted by the Wisconsin Department of Natural Resources (DNR). Selected historical water quality data for Fowler Lake are set forth in Table 11 and Figure 3. These data indicate that Fowler Lake had good water quality at the times of those studies and that there was little evidence of pollution or excessive fertilization.

More recently, however, residents of Fowler Lake have expressed concerns about trends in water quality conditions, and, in 1983, the Fowler Lake Management District decided that a water quality study was necessary to provide background information on the Lake. A comprehensive water quality monitoring program was developed, designed to provide data for the development of a lake management plan.

The U. S. Geological Survey, in cooperation with the Fowler Lake Management District, conducted an intensive water quality monitoring program for Fowler Lake from January to December 1984. This study involved the determination of physical and chemical characteristics of the Lake's water, including dissolved oxygen and water temperature profiles, pH, specific conductance, water clarity, and nutrient and chlorophyll-a concentrations. In addition to these data, the USGS collected information on streamflow and chemical loads entering and leaving the Lake, on the basic hydrology of the Lake, and on groundwater flow and contamination. In-lake water quality monitoring was reinstated in February 1987 and is being continued through 1993 under the Chapter NR 119, Wisconsin Administrative Code, Lake Planning Grant Program.

EXISTING WATER QUALITY CONDITIONS

The data collected during the 1984 and 1987 through 1990 study periods were used to determine water quality conditions in the Lake and to characterize the suitability of the Lake for recreational use and the support of fish and aquatic life. Water quality samples were taken from the main basin of the Lake every two weeks from April through November 1984, monthly during the rest of 1984, and once per season during the 1987 through 1990 monitoring period. The findings are summarized in Tables 12 and 13 and are discussed below. The primary sampling station was located at the deepest point in the Lake, as shown on Map 20. Comparable data collected in 1984 by the U. S. Geological Survey for Lac La Belle, Okauchee Lake, and the Oconomowoc River are listed in Table 14 and indicate that the water quality of Fowler Lake is similar to all of these other sampling sites. More detailed information on these water quality data, including locations and procedures, may be found in reports published by the U. S. Geological Survey.[2]

Thermal Stratification

Thermal and dissolved oxygen profiles for Fowler Lake are shown in Figure 3. Water temperature ranged from 36.5°F during the winter to 81°F during the summer. Complete mixing of the Lake was restricted by thermal stratification in the summer and by ice cover in

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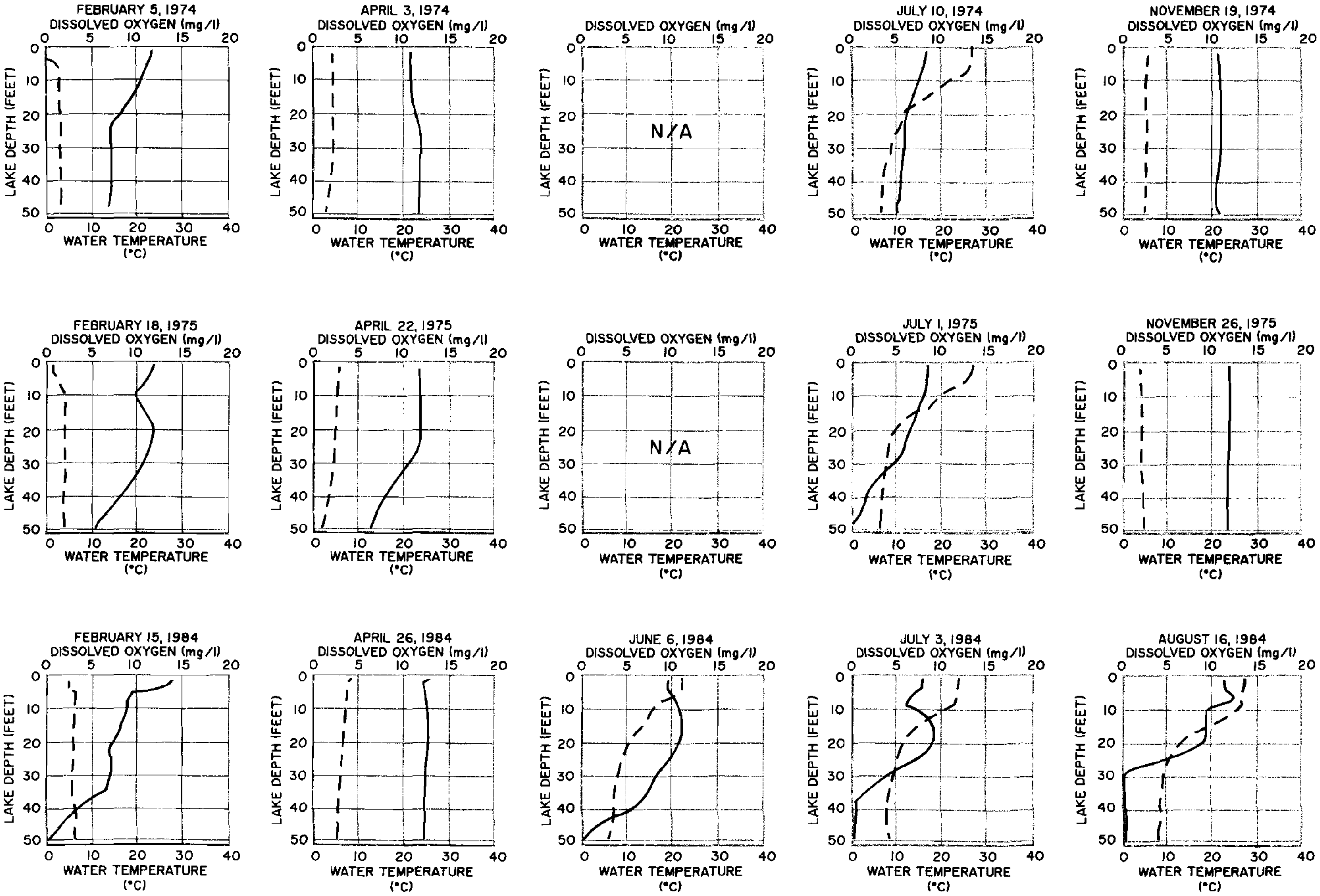
[1] *R. J. Poff and C. W. Threinen, Surface Water Resources of Waukesha County, Wisconsin Conservation Department, 1963.*

[2] *U. S. Geological Survey, Hydrology, Water Quality, Trophic Status, and Aquatic Plants of Fowler Lake, Wisconsin, Water Resources Investigations Report No. 91-4076, 1993 and U. S. Geological Survey, Water Resources Data Wisconsin, Water Year 1990, Water Data Reports, 1987 through 1991.*

Figure 3

TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR FOWLER LAKE: 1974-1975, 1984, 1987-1990



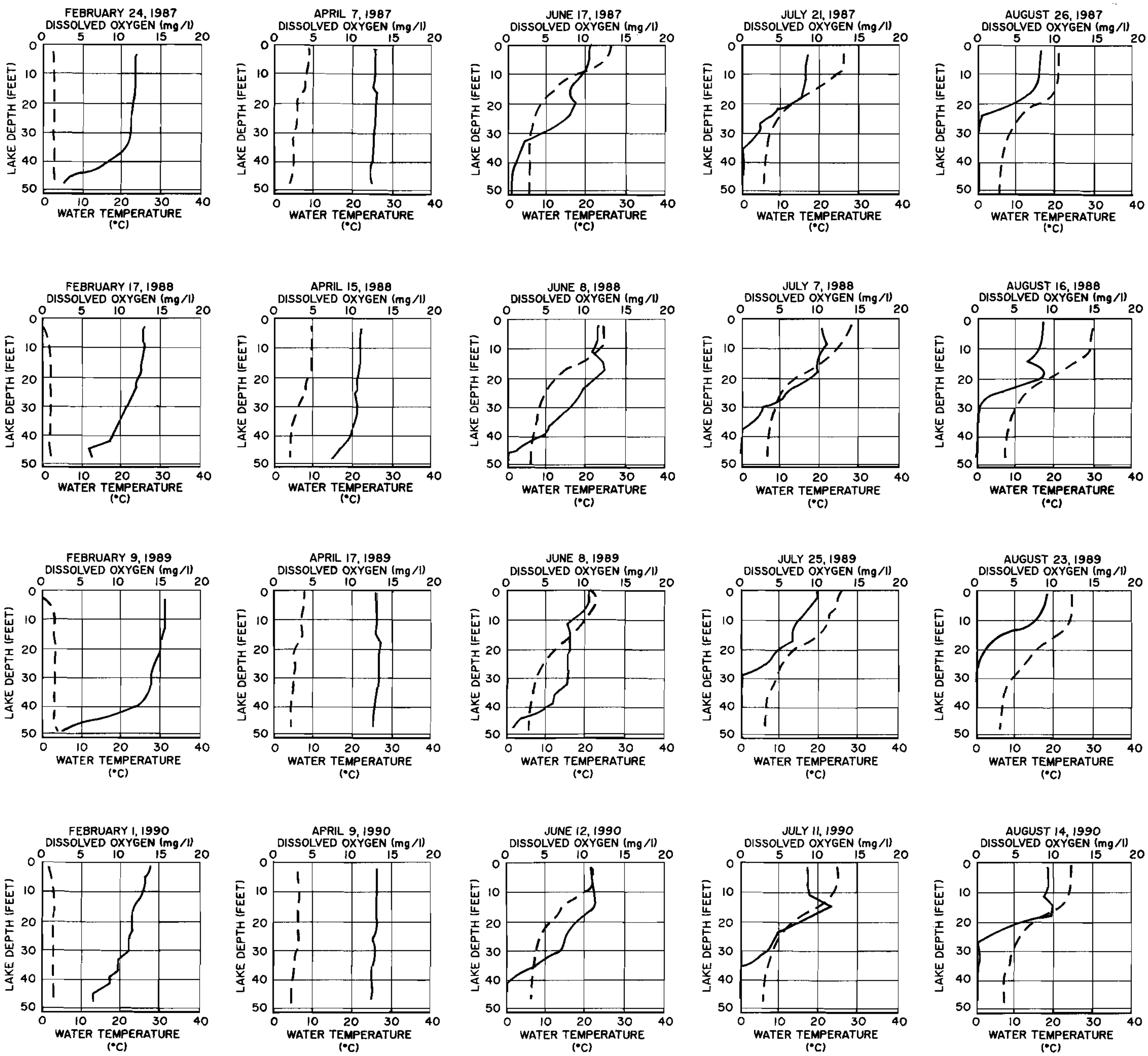
LEGEND

——— DISSOLVED OXYGEN (mg/l)

- — - WATER TEMPERATURE (°C)

the winter. Thermal stratification is the result of differential heating of lake water and the resulting water temperature-density relationships. Water is unique among liquids because it reaches its maximum density, weight per unit of volume, at about 39.2°F. As summer begins, a lake absorbs solar energy at the surface. Wind action and, to some extent, internal heat-transfer mechanisms, transmit this energy to the underlying portions of the water body. As the upper layer of water is heated by solar energy, a physical barrier begins to form between the warmer surface water and the lower, heavier, colder water (see June, July and August profiles in Figure 3). This "barrier" is marked by a sharp temperature gradient known as the thermocline and is characterized by a 1°C drop in temperature per meter of depth that separates the warmer, lighter, upper layer of water (called the epilimnion), from the cooler, heavier, lower layer (called the hypolimnion). Although this barrier is readily crossed by fish, provided sufficient oxygen exists, it essentially prohibits the exchange of water between the two layers. This condition, which is discussed further in this report, has a great impact on both chemical and biological activity in a lake, which are also commonly stratified as a result. The develop-

Figure 3 (continued)



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

ment of the thermocline begins in early summer, reaches its maximum in late summer, and disappears in the fall, as illustrated in Figure 3. This autumnal mixing period occurs when air temperatures cool the surface water and wind action results in the erosion of the thermocline: as the surface water cools, it becomes heavier, sinking and displacing the warmer water below. The colder water sinks and mixes under wind action until the entire column of water is of uniform temperature. This process is known as "fall turnover."

Table 11

SEASONAL WATER QUALITY DATA FOR FOWLER LAKE: 1973-1975

Water Quality Parameter	Fall (mid-September to mid-December)		Winter (mid-December to mid-March)		Spring (mid-March to mid-June)		Summer (mid-June to mid-September)	
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
Water Temperature (°F)								
Range	38.3-42.5	39.2-41.5	31.0-32.5	36.0-39.0	40.5-42.0	38.5-40.5	62.0-81.5	43.5-54.0
Mean	40.6 (3)	40.4 (3)	31.8 (2)	37.3 (4)	41.3 (2)	39.3 (3)	74.7 (3)	48.1 (6)
Dissolved Oxygen (mg/l)								
Range	11.3-11.7	11.0-11.7	12.0-12.1	5.5-10.9	10.9-11.5	5.6-12.2	6.9-8.4	0.0-7.1
Mean	11.5 (3)	11.4 (3)	12.1 (2)	7.6 (4)	11.2 (2)	9.9 (3)	7.9 (3)	3.2 (6)
Specific Conductivity (μmhos/cm at 25°C)								
Range	439-470	440-472	485-499	468-508	448-464	464-472	380-426	421-480
Mean	456 (3)	455 (3)	492 (2)	494 (4)	456 (2)	468 (3)	402 (3)	450 (6)
Alkalinity, as $CaCO_3$ (mg/l)								
Range	186-204	196-212	207-210	206-226	196-210	202-206	166-182	184-222
Mean	196 (3)	202 (3)	209 (2)	213 (4)	203 (2)	205 (3)	176 (3)	200 (6)
pH (standard units)								
Range	8.1-8.3	8.0-8.3	--	7.8-8.6	8.1-8.2	8.0-8.2	8.1-8.5	7.7-8.3
Mean	8.2 (3)	8.2 (3)	8.2 (2)	8.0 (4)	8.2 (2)	8.1 (3)	8.3 (3)	8.0 (6)
Secchi Disk (feet)								
Range	13.3-15.5	--	9.5-11.1	--	7.1-8.6	--	11.8-17.0	--
Mean	14.3 (3)	--	10.3 (2)	--	7.9 (2)	--	13.9 (3)	--
Turbidity (Nephelometric turbidity units)								
Range	1.4-1.9	1.2-1.5	1.2-1.9	1.0-1.8	1.0-1.8	1.2-2.0	0.6-1.6	0.6-2.7
Mean	1.6 (3)	1.4 (3)	1.6 (2)	1.3 (4)	1.4 (2)	1.5 (3)	1.0 (3)	1.5 (6)
Nitrite Nitrogen (mg/l)								
Range	.005-.056	.007-.052	.002-.006	.002-.007	.007-.009	.005-.008	.002-.013	.002-.015
Mean	.025 (3)	.023 (3)	.004 (2)	.005 (4)	.016 (2)	.006 (3)	.007 (3)	.008 (6)
Nitrate Nitrogen (mg/l)								
Range	0.09-0.11	0.10-0.13	0.14-0.23	0.07-0.18	0.27-0.34	0.35-0.37	0.10-0.14	0.13-0.27
Mean	0.1 (3)	0.12 (3)	0.19 (2)	0.14 (4)	0.30 (2)	0.36 (3)	0.12 (3)	0.18 (3)
Total Ammonia (mg/l)								
Range	0.07-0.16	0.06-0.16	<0.03-0.05	<0.03-0.37	--	<0.03-0.1	<0.03-0.15	<0.03-0.79
Mean	0.11 (3)	0.11 (3)	0.03 (2)	0.13 (4)	<0.03 (2)	0.04 (3)	0.06 (3)	0.34 (6)
Organic Nitrogen (mg/l)								
Range	0.44-0.70	0.45-0.66	<0.03-0.47	0.15-0.46	0.43-0.54	0.38-0.49	0.47-0.78	0.39-1.07
Mean	0.6 (3)	0.58 (3)	0.24 (2)	0.32 (4)	0.49 (2)	0.44 (3)	0.59 (3)	0.65 (6)
Total Nitrogen, as N (mg/l)								
Range	0.63-0.95	0.62-0.95	0.14-0.76	0.34-0.91	0.71-0.88	0.63-0.95	0.60-1.05	0.66-1.99
Mean	0.84 (3)	0.84 (3)	0.45 (2)	0.59 (4)	0.80 (2)	0.76 (3)	0.77 (3)	1.17 (6)
Total Phosphorus, as P (mg/l)								
Range	0.02-0.04	0.02-0.04	<0.01-0.03	<0.01-0.07	0.02-0.03	0.02-0.05	0.01-0.03	0.02-0.12
Mean	0.03 (3)	0.03 (3)	0.02 (2)	0.03 (4)	0.03 (2)	0.03 (3)	0.02 (3)	0.06 (6)
Orthophosphorus, as PO_4P (mg/l)								
Range	<0.005-0.130	0.120-0.140	0.010-0.016	0.012-0.085	0.007-0.030	0.005-0.054	<0.005-0.024	<0.005-0.10
Mean	0.009 (3)	0.040 (3)	0.013 (2)	0.035 (4)	0.019 (2)	0.024 (3)	0.016 (3)	0.050 (6)
Calcium, as Ca (mg/l)								
Range	37.0-73.0	37.0-95.0	43.0-57.0	40.0-63.0	47.0-60.0	47.0-76.0	43.6-53.0	39.0-70.0
Mean	51.3 (3)	59.2 (3)	50.0 (2)	50.3 (4)	53.5 (2)	61.0 (3)	46.9 (3)	48.8 (6)
Magnesium, as Mg (mg/l)								
Range	27.6-44.0	37.1-44.0	30.0-42.0	27.0-45.0	33.0-39.0	34.0-36.0	20.0-44.0	20.0-41.3
Mean	36.9 (3)	40.0 (3)	36.0 (2)	37.0 (3)	36.0 (2)	35.0 (3)	32.6 (3)	33.9 (6)
Sodium, as Na (mg/l)								
Range	7.0-10.0	9.0-11.0	7.0-8.0	7.0-11.0	--	8.0-10.0	4.4-9.0	2.9-12.0
Mean	8.7 (3)	9.8 (3)	7.5 (2)	9.0 (3)	8.0 (2)	9.0 (3)	7.5 (3)	7.1 (6)
Potassium, as K (mg/l)								
Range	1.2-3.7	2.2-5.0	0.5-1.7	0.7-2.1	<0.5-3.4	1.1-3.0	1.2-6.0	1.3-6.3
Mean	2.6 (3)	3.2 (3)	1.1 (2)	1.3 (3)	1.8 (2)	1.8 (3)	3.2 (3)	3.2 (6)
Sulfate, as SO_4 (mg/l)								
Range	30.0-34.0	29.0-38.0	38.0-40.0	36.0-40.0	31.0-38.0	34.0-37.0	31.0-37.0	20.0-37.0
Mean	32.7 (3)	32.7 (3)	39.0 (2)	38.3 (4)	34.5 (2)	36.0 (3)	33.3 (3)	30.7 (6)
Chloride (mg/l)								
Range	13.0-14.0	13.0-19.0	--	16.0-20.0	--	14.0-20.0	13.0-16.0	12.0-20.0
Mean	13.3 (3)	15.3 (3)	15.0 (2)	17.8 (4)	15.0 (2)	16.3 (3)	14.3 (3)	15.0 (6)
Iron, as Fe (μg/l)								
Range	--	--	--	--	--	--	--	--
Mean	0.09 (1)	<0.09 (1)	--	--	--	--	0.39 (1)	0.39 (1)

NOTE: Number in parentheses represents number of samples.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 12

SEASONAL WATER QUALITY CONDITIONS IN FOWLER LAKE: 1984

Parameter[a]	Winter (January to March) Shallow[b]	Winter Deep[c]	Spring (April to mid-June) Shallow[b]	Spring Deep[c]	Summer (mid-June to mid-September) Shallow[b]	Summer Deep[c]	Fall (mid-September to December) Shallow[b]	Fall Deep[c]
Temperature (°F)								
Range	36.5-37.0	38.5-39.0	43.5-72.0	41.5-46.0	70.5-81.0	45.0-47.0	44.5-63.5	44.5-45.5
Mean[d]	36.9 (4)	38.6 (4)	56.4 (5)	44.3 (5)	75.9 (7)	45.6 (7)	56.0 (4)	45.0 (4)
Dissolved Oxygen								
Range	9.7-12.8	0.1-1.0	9.2-12.3	1.8-12.2	7.2-12.7	0.0-0.8	9.6-10.2	0.0-10.1
Mean[d]	11.2 (4)	0.6 (4)	10.8 (5)	7.4 (5)	9.6 (7)	0.3 (7)	10.1 (4)	3.3 (7)
Conductivity (μS/cm)								
Range	482-533	495-595	487-520	493-520	446-507	505-551	441-489	477-551
Mean[d]	508 (3)	543 (3)	505 (5)	505 (5)	478 (7)	525 (7)	471 (4)	519 (4)
pH (standard units)								
Range	8.1-8.8	7.5-8.1	8.5-8.7	8.0-8.6	8.2-8.8	7.3-7.9	8.2-9.1	7.3-8.2
Mean[d]	8.4 (4)	7.9 (4)	8.6 (5)	8.2 (5)	8.5 (7)	7.6 (7)	8.8 (4)	7.6 (4)
Secchi Disk (feet)								
Range	--	--	9.0-13.0	--	10.0-12.0	--	13.0-14.0	--
Mean[d]	--	--	11.6 (5)	--	11.4 (5)	--	13.3 (3)	--
Total Phosphorus								
Range	<0.01-0.04	<0.01-0.04	<0.01-0.02	<0.01-0.01	<0.01-0.02	<0.01-0.05	<0.01-0.01	<0.01-0.05
Mean[d]	<0.023 (3)	<0.023 (3)	<0.012 (5)	<0.010 (5)	<0.011 (7)	<0.029 (7)	<0.010 (4)	<0.035 (4)
Orthophosphorus								
Range	<0.01-0.05	<0.01-0.04	<0.01-0.01	<0.01-0.01	<0.01-0.01	<0.01-0.06	<0.01-0.02	<0.01-0.06
Mean[d]	<0.027 (3)	<0.023 (3)	<0.010 (5)	<0.010 (5)	<0.010 (7)	<0.020 (7)	<0.013 (3)	<0.028 (4)

NOTE: Number in parentheses represents number of samples.

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

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

[c]*Depth of sample greater than 45 feet.*

[d]*Number of samples in parentheses.*

Source: U. S. Geological Survey and SEWRPC.

When the water temperature drops below 39.2°F, the original surface waters again become lighter and "float" to the surface. Eventually, the surface of the water is cooled until, at 32°F, ice forms and covers the surface of the lake, isolating it from the atmosphere for a period of up to four months (see February profiles in Figure 3). During the study period, ice cover existed from the time the first sample was taken on January 25, 1984, through April 1, 1984. This winter stratification occurs as the colder, lighter water and ice remain at the surface, now separated from the relatively warmer, heavier water near the bottom of the lake.

Spring brings a reversal of this 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, deeper water until the entire water column reaches the same temperature. This is referred to as "spring turnover" and usually occurs within weeks after the ice goes out (see April profiles in Figure 3). After spring turnover, the water at the surface again warms and becomes lighter, causing it to float above the colder, deeper water. Wind and resulting waves carry some of the energy of the warmer, lighter water to lower depths, but only to a limited extent. Thus begins the formation of the thermocline and another period of summer thermal stratification.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake's ecosystem. As shown in Figure 3, dissolved oxygen levels were generally higher at the surface of Fowler Lake, where there was an interchange between the water and the atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels were lowest on the bottom of the Lake, where decomposer organisms and chemical oxidation processes utilized oxygen in the decay process.

When any lake becomes thermally stratified, as described above, the surface supply of dissolved oxygen to the hypolimnion is cut off. Gradually, if there is not enough dissolved oxygen to meet

Table 13

FOWLER LAKE SPRING OVERTURN WATER QUALITY DATA: 1984, 1987-1990

Water Quality Parameter	April 10, 1984		April 7, 1987		April 15, 1988		April 17, 1989		April 9, 1990	
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
Depth of Sample (feet)	1	48	3	49.5	1.5	47.5	1.5	48	1.5	48
Specific Conductance	504	510	498	495	524	523	514	510	508	509
pH	8.5	8.4	8.3	8.3	8.2	7.8	8.2	8.2	8.4	8.4
Water Temperature (°F)	43.5	43.0	48.2	40.8	50	40.1	47.3	42.8	43.5	40.5
Color (platinum-cobalt scale)	20	30	7	10	9	8	10	10	10	10
Turbidity (Nephelometric turbidity units)	0.6	0.7	1	2	4.2	0.4	0.8	0.5	0.7	0.8
Secchi Disk (feet)	- -	- -	12.5	- -	7.9	- -	12.1	- -	11.8	- -
Dissolved Oxygen	11.5	10.5	12.7	12.3	10.9	7.8	13.1	12.9	13.1	12.5
Hardness, as $CaCO_3$	240	240	270	270	250	250	250	250	260	260
Calcium	45	45	55	54	47	47	44	44	44	45
Magnesium	32	32	33	33	32	32	34	34	36	36
Sodium	9.6	9.6	10	10	11	11	12	12	12	12
Potassium	1.9	1.9	2.2	2.2	2.1	2.1	2	2.1	2	2.1
Alkalinity, as $CaCO_3$	208	208	234	230	223	219	213	215	216	217
Sulfate	33	33	29	29	29	27	27	26	25.7	25.6
Chloride	22	22	23	23	23	24	26	26	26	26
Silica	3.6	3.8	5.1	5.4	32	4.7	3	3.9	2.9	2.9
Dissolved Solids	293	273	300	296	289	290	306	306	296	294
Nitrate Nitrogen	0.19	0.27	0.39	0.39	0.2	0.2	<0.02	<0.02	0.15	0.14
Nitrite Nitrogen	0.01	0.03	<0.01	<0.01	<0.01	<0.01	- -	- -	- -	- -
Ammonia Nitrogen	0.06	0.11	0.04	0.04	0.02	0.08	<0.02	<0.02	0.05	0.06
Organic Nitrogen	0.34	0.49	1.1	0.96	0.38	0.42	- -	- -	0.45	0.44
Total Nitrogen	0.6	0.9	1.5	1.4	0.6	0.7	0.4	0.4	0.65	0.64
Total Phosphorus	0.01	0.01	0.035	0.031	0.003	0.003	- -	- -	0.01	0.009
Orthophosphorus	<0.010	<0.01	0.002	<001	<0.001	<0.001	0.002	0.002	0.002	0.002
Iron (μg/l)	5	5	7	5	<3	<3	<50	<50	<50	<50
Manganese (μg/l)	2	2	2	<1	<1	7	<40	<40	<40	<40
Chlorophyll-a (μg/l)	2.6	- -	2	- -	4	- -	2	- -	3	- -

Source: U. S. Geological Survey and SEWRPC.

the total demands from the decaying material, the dissolved oxygen levels in the bottom waters may be reduced, even to zero, a condition known as anoxia or anaerobiasis.

The hypolimnion of Fowler Lake becomes anoxic during summer stratification. During the 1984 and 1987 to 1990 study periods, dissolved oxygen concentrations at the bottom of the Lake fell to zero by the middle of July. Even at a depth of approximately 25 feet, it was only five milligrams per liter (mg/l), the minimum level necessary to support many species of fish. By September, the dissolved oxygen concentration was zero from this depth to the bottom of the Lake. The depleted oxygen levels in the hypolimnion caused many fish species to move upward, nearer to the surface of the Lake, where higher dissolved oxygen concentrations exist. Fall turnover restores the supply of oxygen to the bottom waters.

Hypolimnetic anoxia is common in many of the lakes in Southeastern Wisconsin during summer stratification. In some lakes in the Region, anoxia also occurs during winter stratification; thick ice and deep snow cover may prevent adequate photosynthetic aeration of the water column. This condition may result in fish winterkills if the supply of dissolved oxygen in the water is not sufficient to meet the total winter demand. In Fowler Lake, however, dissolved oxygen levels at depths of less than 40 feet were found to be adequate for the support of fish throughout the winter.

A further implication of hypolimnetic anoxia lies in the release of nutrients, especially phosphorus, and some salts, notably iron and manganese, into the water column from the sediments, primarily because of a change in the chemical state of the metals. This "internal loading" can affect water quality significantly if these nut-

Map 20

SAMPLING LOCATIONS FOR PHOSPHORUS, IRON, AND MANGANESE

LEGEND

- ● L1 — LAKE-WATER SAMPLING SITE DEEPEST POINT BOTTOM SEDIMENT SAMPLING SITE
- ● L2 — BOTTOM SEDIMENT SAMPLING SITE
- ● L3 — BOTTOM SEDIMENT SAMPLING SITE
- ~5~ — WATER DEPTH CONTOUR IN FEET

GRAPHIC SCALE 0 200 400 600 FEET

Source: U. S. Geological Survey and SEWRPC.

Table 14

WATER QUALITY CONDITIONS AT SPRING TURNOVER FOR FOWLER LAKE, LAC LA BELLE, OKAUCHEE LAKE, AND THE OCONOMOWOC RIVER INLET: APRIL 1984

Parameter[a]	Oconomowoc River April 10, 1984	At One-Foot Depth Fowler Lake April 10, 1984	At 48-Foot Depth Fowler Lake April 10, 1984	At Three Foot Depth Lac La Belle Center Site April 11, 1984	At 44-Foot Depth Lac La Belle Center Site April 11, 1984	At Three-Foot Depth Okauchee Lake Center Site April 19, 1984	At 89-Foot Depth Okauchee Lake Center Site April 19, 1984
Water Temperature (°F)	49.1	43.7	42.8	44.5	42.8	41.8	41.9
Dissolved Oxygen	12.5	11.5	10.5	12.4	12.2	12.6	12.3
Specific Conductance (μS/cm)	507	504	510	505	517	464	517
Dissolved Solids	287	293	277	296	274	332	329
Alkalinity, as $CaCO_3$	202	208	208	206	206	223	223
Hardness, as $CaCO_3$	240	240	240	240	240	260	260
pH	8.8	8.5	8.4	8.9	8.7	8.5	8.5
Secchi Disk (feet)	--	13.0	--	11.5	--	13.8	--
Color (platinum-cobalt scale)	25	20	30	20	20	20	--
Turbidity (Nephelometric turbidity units)	1.0	0.6	0.7	1.5	1.4	<1.0	--
Chlorophyll-a (μg/l)	--	2.60	--	1.8	--	4.1	--
Nitrate Nitrogen	0.19	0.19	0.27	0.68	0.68	0.39	0.47
Nitrite Nitrogen	0.01	0.01	0.03	0.02	0.02	<0.01	0.03
Nitrate/Nitrite	0.20	0.20	0.30	0.70	0.70	0.40	0.50
Ammonia Nitrogen	0.11	0.06	0.11	0.10	0.12	0.04	0.05
Organic Nitrogen	0.39	0.28	0.49	0.60	0.78	0.76	0.55
Total Nitrogen	0.70	0.54	0.90	1.50	1.60	1.20	1.10
Dissolved Phosphorus	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Phosphorus	0.03	0.01	0.01	<0.01	<0.01	0.01	<0.01
Calcium (Ca)	45	45	45	45	45	51	51
Magnesium (Mg)	31	32	32	32	32	32	32
Sodium (Na)	8.5	9.6	9.4	11.0	11.0	7.8	7.7
Potassium (K)	1.8	1.9	1.9	2.1	2.0	2.0	2.0
Sulfate (SO_4)	32	33	33	35	33	32	32
Chloride (Cl)	20	22	22	27	25	19	19
Silica (SiO_2)	2.9	3.6	3.8	3.7	3.7	4.3	4.3
Iron (μg/l)	14	5	5	<4	<3	11	8
Manganese (μg/l)	2	2	3	<1	<1	1	<1

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

Source: U. S. Geological Survey.

rients and salts are mixed into the epilimnion as the result of an intense storm, especially during spring, when these nutrients can become available for algal or plant growth. This phenomenon is further discussed below.

Specific Conductance

Specific conductance is an indicator of the concentration of dissolved solids in the water; as the amount of dissolved solids increases, the specific conductance increases. During winter and summer thermal stratification, specific conductance increases at the lake bottom due to an accumulation of dissolved materials in the hypolimnion, referred to as "internal loading." As shown in Table 13, the specific conductance of Fowler Lake during spring turnover of 1984 and 1987 to 1989 ranged from 495 to 524 μS/cm (microSiemens per centimeter at 25°C), which is within the normal range for lakes in Southeastern Wisconsin.[3]

Chloride

Chloride concentrations ranged from 22 to 26 mg/l during the spring turnover of 1984, and of 1987 to 1990. As shown in Table 14, these values are similar to those found in other area lakes. The most important anthropogenic source of chlorides is believed to be street-deicing salts.

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

Alkalinity and Hardness

Alkalinity is an index of the buffering capacity of a lake, or the capacity of a lake to absorb and neutralize acids. The alkalinity of a lake depends on the levels of bicarbonate, carbonate, and hydroxide ions present in the water. Lakes in Southeastern Wisconsin typically have a high alkalinity because of the types of soil covering, and the bedrock underlying, the watersheds. In contrast, water hardness is a measure of the multivalent metallic ions, such as calcium and magnesium, present in the lake. Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$). Applying these measures to the study lake, Fowler Lake is a hard-water alkaline lake. During the spring turnovers of 1984 and 1987 to 1990, alkalinity averaged 218 mg/l, while hardness averaged 279 mg/l, as listed in Table 13. These values are within the normal range of lakes in Southeastern Wisconsin.[4]

Hydrogen Ion Concentration (pH)

The pH is a logarithmic measure of hydrogen ion concentration on a scale of 0 to 14 standard units, with 7 indicating neutrality. A pH above 7 indicates basic (or alkaline) water, a pH below 7 indicates acidic water. In Fowler Lake, the pH was found to range between 7.3 and 9.1 standard units, as shown in Table 12. Since Fowler Lake has a high alkalinity, or buffering capacity, the pH does not fluctuate below 7 and the Lake is not susceptible to the harmful effects of acidic precipitation.

Water Clarity

Water clarity, or transparency, gives an indication of overall water quality; clarity may decrease because of high concentrations of suspended materials, such as algae and zooplankton, and of turbidity, or due to high concentrations of dissolved organic substance such as water color. Water clarity is measured with a Secchi disk, a black-and-white, eight-inch-diameter disk, which is lowered into the water until a depth is reached at which the disk is no longer visible. This depth is known as the "Secchi-disk reading." These readings form an integral part of the DNR Self-Help Monitoring Program; enrollment of a citizen volunteer monitor in this program is recommended as part of a local water quality monitoring effort (see Chapter VIII).

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in weather conditions and nutrient loadings. These same factors make Secchi-disk readings vary from year to year as well. Secchi-disk readings for Fowler Lake were always greater than nine feet; during much of the study period they were between 12 and 13 feet. As shown in Figure 4, these values indicate very good water quality compared to other lakes in Southeastern Wisconsin.[5]

Chlorophyll-a

Chlorophyll-a is the major photosynthetic ("green") pigment in algae. The amount of chlorophyll-a present in the water is an indication of biomass or amount of algae in the water. Chlorophyll-a concentrations in Fowler Lake ranged from a low of less than 1.0 micrograms per liter (μg/l) in July 1984, to a high of 6.0 μg/l in August 1989. These values are within the range of chlorophyll-a concentrations recorded in other lakes in the Region[6] and indicate good water quality, as illustrated in Figure 4.

Nutrient Characteristics

Aquatic plants and algae require such nutrients as phosphorus, nitrogen, carbon, calcium, chloride, iron, magnesium, sulfur, and silica for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations which exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, plant growth is limited by the amount of that nutrient available. Two of the most important nutrients, in this respect, are phosphorus and nitrogen.

The ratio of total nitrogen to total phosphorus in lake water, or the N:P ratio, can indicate which nutrient is likely to be limiting plant growth. Where the nitrogen-to-phosphorus ratio is greater than 14:1, a lake is probably phosphorus-limited, while a ratio of less than

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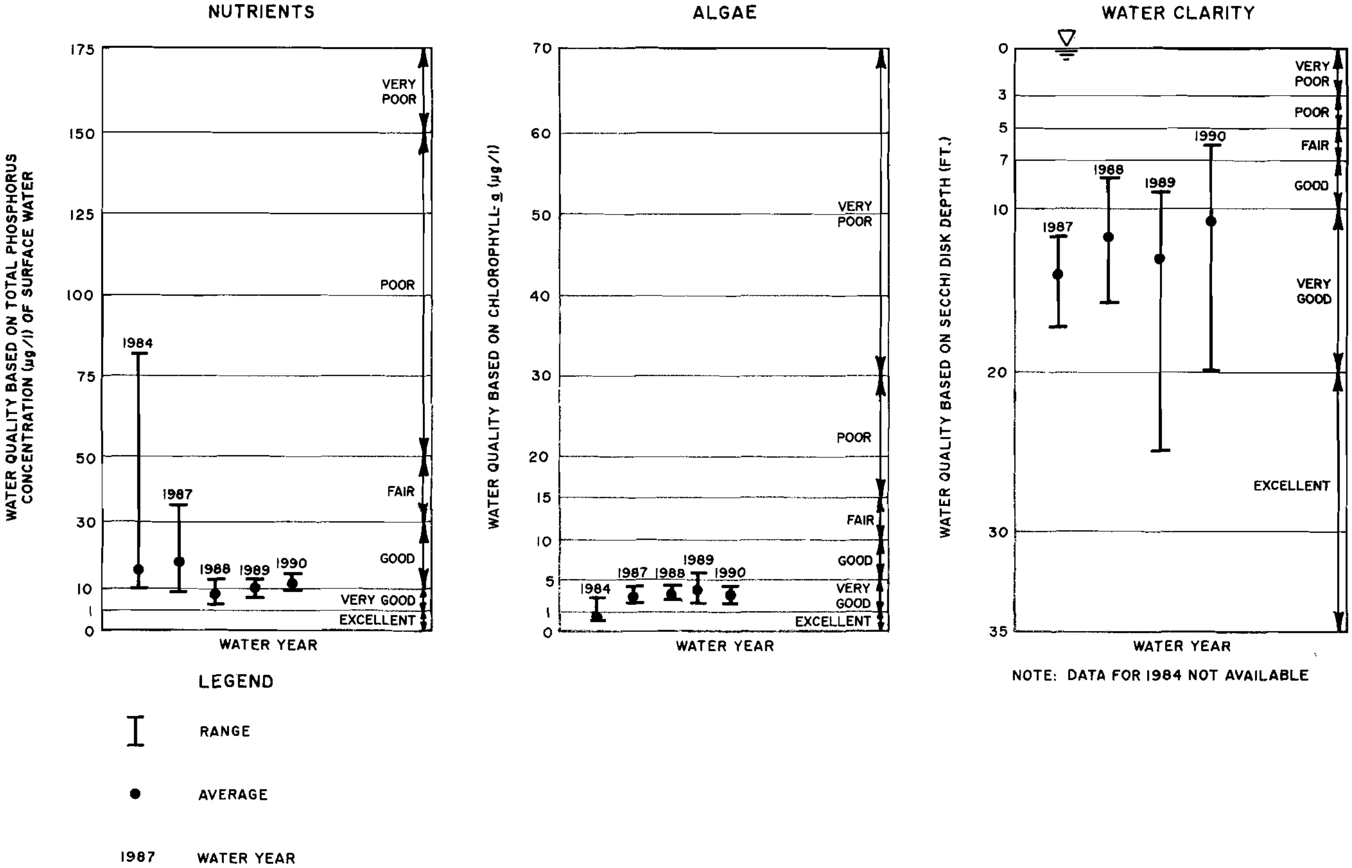
[4] *Ibid.*

[5] *Ibid.*

[6] *Ibid.*

Figure 4

FOWLER LAKE PRIMARY WATER QUALITY INDICATORS: 1984, 1987-1990



Source: U. S. Geological Survey and SEWRPC.

10:1 indicates that nitrogen is probably the limiting nutrient.[7] As shown in Table 15, the nitrogen-to-phosphorus ratios in samples collected from Fowler Lake in 1984 were always greater than 50. This indicates that plant production was most likely consistently limited by phosphorus. Other factors, such as light and turbulence, through flow, may also limit plant growth; these are further discussed below.

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

The Southeastern Wisconsin Regional Planning Commission recommends that total phosphorus concentrations in lakes not exceed 0.020 mg/l during spring turnover. This is the level considered necessary to prevent nuisance algal and macrophyte growths. During the study years, the total phosphorus concentrations at spring turnover in Fowler Lake were generally less than 0.010 mg/l, as shown in Table 13. On only

[7]*M. O. Alum, 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 15

NITROGEN-PHOSPHORUS RATIOS FOR FOWLER LAKE: 1984

Date	Nutrient Levels		
	Nitrogen (mg/l)	Phosphorus (mg/l)	N:P Ratio (mg/l)
April 10, 1984	0.54	0.01	54.0
April 26, 1984	0.87	0.01	87.0
May 10, 1984	2.70	0.01	270.0
May 24, 1984	1.08	0.02	54.0
June 6, 1984	1.06	0.01	106.0
June 20, 1984	1.00	0.02	50.0
July 3, 1984	0.50	0.01	50.0
July 19, 1984	1.00	0.01	100.0
August 2, 1984	0.90	0.01	90.0
August 16, 1984	0.90	0.01	90.0
August 30, 1984	0.60	0.01	60.0
September 13, 1984	0.60	0.01	60.0
September 26, 1984	0.70	0.01	70.0
October 11, 1984	1.00	0.01	101.0
October 24, 1984	1.80	0.01	180.0

Source: U. S. Geological Survey.

one occasion during the study, during the 1987 spring turnover, did the total phosphorus concentrations exceed the recommended threshold. At that time, total phosphorus concentration in the surface water reached 0.035 mg/l (see Table 13). While this reading did extend the range of concentrations observed during that year into a slightly poorer water quality zone (Figure 4), the range of values observed throughout that year was not significantly different from that observed during the previous year for which data were available, 1984. Throughout the 1984 and 1987 to 1990 study periods, total phosphorus in the surface waters of Fowler Lake averaged 0.012 mg/l, indicating good water quality, as illustrated in Figure 4.

In the hypolimnion, or bottom waters, of Fowler Lake, total phosphorus concentrations were higher, ranging from 0.010 to 0.050 mg/l, as shown in Tables 12 and 13. The average bottom-water total phosphorus concentration in Fowler Lake during the study period was 0.025 mg/l. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed. Phosphorus from these organisms is stored in the bottom sediments or re-released into the water column. Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates, predominantly in the lake sediments. However, when the bottom waters become depleted of oxygen during stratification, certain chemical changes occur, especially the change in the oxidation state of iron from the insoluble Fe^{3+} state to the more soluble Fe^{2+} state. The effect of these chemical changes is that phosphorus becomes soluble and is more readily released from the sediments. This process also occurs under aerobic conditions, but generally at a slower rate. As the water begins to mix again, during spring and fall turnover, this phosphorus can be mixed throughout the lake and may be available for algal growth. If the turnover event is slow, over several weeks, this hypolimnetic phosphorus may be re-adsorbed by the iron and precipitate back to the sediment. If the process is more rapid, hours to days, some of this phosphorus is circulated into the upper waters of the lake, generally in a bio-available form, where it can be taken up very rapidly by algae. Nevertheless, the 1984 and 1987 through 1990 data indicated that there was little internal loading of phosphorus from the bottom sediments of Fowler Lake. While such releases did occur (the dissolved phosphorus concentrations in the bottom waters ranged from 0.006 to 0.150 mg/l for samples collected during the summer anoxic periods, as shown in Table 12),

Table 16

PHOSPHORUS, IRON, AND MANGANESE LEVELS AT IN INCREASING SEDIMENT DEPTHS IN FOWLER LAKE: 1984

Parameter	Core Depth (cm)	Site Number and Water Depth		
		L1 (15.2m)	L2 (2.4m)	L3 (2.4m)
Phosphorus (mg/kg)	0-10 10-40	490 500	410 460	1,500 260
Iron (mg/kg)	0-10 10-40	8,500 8,500	6,400 7,500	8,000 5,700
Manganese (mg/kg)	0-10 10-40	350 180	220 240	2,000 180

Source: U. S. Geological Survey.

the limited volume of the hypolimnion, 20 percent of the Lake is deeper than 20 feet, and the short water residence time combined to make this contribution of phosphorus from the anoxic area of Fowler Lake negligible in terms of the total phosphorus load.

CHARACTERISTICS OF BOTTOM SEDIMENT

Analyses of sediment cores from three locations within the Lake were conducted to determine the levels of phosphorus, iron, and manganese at increasing sediment depths. Map 20 shows the sampling locations and Table 16 lists the concentrations at the referenced locations.

According to a U. S. Environmental Protection Agency (EPA) classification system for sediments, phosphorus concentrations greater than 650 milligrams per kilogram (mg/kg), manganese concentrations greater than 500 mg/kg, and iron concentrations greater than 25,000 mg/kg are indicative of "heavily polluted"[8] lakes. In Fowler Lake, most of these indicators were present at less than their threshold values. Sediment phosphorus concentrations varied, but were highest near the eastern shoreline. Elsewhere, the sediment phosphorus concentrations were in the 400 to 500 mg/kg range, with little vertical variation observed within the cores; the eastern shore, Site L3, again, was an exception. Given the average sedimentation rates in the Region, this lack of vertical variation within the core may imply a relatively stable post-contact phosphorus loading or a relatively small urban impact on the natural state of the Lake; the former is the more likely situation. Similarly, manganese concentrations varied, with the highest concentration again recorded in the shallow sediments near the eastern shoreline. At Site L3, the sediments were "heavily polluted" in terms of the aforementioned classification. Again, except for Site L3, there was relatively little vertical variation within the core sample. Iron followed the same general pattern, except that Site L3 was not as different from the remainder of the sediments, as previously noted. Given that all three indicators at Site L3 exceeded the EPA threshold values only in the surficial sediments, it is probable that these values reflect the impacts of recent (1970 to 1975) subdivision construction and stormwater drainage into this part of the Lake (i.e., via the Fowler Park outfall).[9] Considering the relatively large lawned areas in this portion of the study area, the higher nutrient levels observed at Site L3 are consistent with this hypothesis.

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[8] *U. S. Environmental Protection Agency, Guidelines for the Pollutional Classification of Great Lakes Harbor Sediment, 1977.*

[9] *Donohue & Associates, Inc., Stormwater Management Feasibility Study for the City of Oconomowoc, 1989.*

Table 17

ANNUAL LOADING BUDGETS, BASED ON MEASURED DATA, TO FOWLER LAKE FOR NITROGEN, PHOSPHORUS, SEDIMENT, AND LEAD: 1984

Source	Nitrogen		Phosphorus		Sediment		Lead	
	Amount (pounds)	Total Input (percent)	Amount (pounds)	Total Input (percent)	Amount (pounds)	Total Input (percent)	Amount (pounds)	Total Input (percent)
Inputs								
Oconomowoc River	176,000	97.3	2,300	87.5	1,888,700	91.7	60	17.1
Agricultural and Wetland Drainage	1,390	0.8	20	0.8	18,100	1.0	40	11.4
Urban Area	1,670	0.9	280	10.6	130,000	6.3	200	57.2
Atmospheric	1,900	1.0	30	1.1	18,800	1.0	50	14.3
Total	181,000	100.0	2,630	100.0	2,060,000	100.0	350	100.0
Outputs								
Outlet	140,000	77.6	2,000	75.5	Not determined		90	25.7
Net Deposition into Bottom Sediments	40,000	22.2	600	22.6	Not determined		260	74.3
Plant Harvesting	320	0.2	50	1.9	- -		- -	- -
Total	180,320	100.0	2,650	100.0	- -		350	100.0

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

POLLUTION LOADINGS AND SOURCES

Currently, there are no known point source discharges of pollutants to Fowler Lake or to the surface waters tributary to Fowler Lake. Nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, industrial, transportation, construction, and recreational activities, and rural sources, such as runoff from cropland, pasture, and woodland. In order to estimate the amount of pollution contributed by these sources to Fowler Lake, and eventually to downstream Lac La Belle, annual loading budgets for nitrogen, phosphorus, sediment, and lead were developed, as shown in Table 17. Input and output loads were based on flow and water quality data collected at the streamflow gage on the Oconomowoc River and on water quality data collected for Fowler Lake during the study period. To develop the input loads from the City of Oconomowoc, the Wisconsin Urban Runoff Model (WURM)[10] was used by the Commission. Data for 1984 were also used to generate watershed specific, unit area loads which were used to forecast similar loading estimates for 2010, using land use data presented in Table 8.

[10]*Wisconsin Department of Natural Resources, Evaluation of Urban Nonpoint Source Pollution Management In Milwaukee County, Wisconsin, Volume 2, Feasibility and Application of Urban Nonpoint Source Water Pollution Abatement Measures, 1983.*

Nitrogen Loads

The total nitrogen load calculated to have entered the Lake during 1984 was 181,000 pounds. About 97 percent of the load came from the Oconomowoc River and the remaining 3 percent was contributed by agricultural and wetland drainage, the City of Oconomowoc, and atmospheric deposition. No significant changes in this load are forecast as a result of new development in the Lake's direct drainage area. Approximately 22 percent, or 40,000 pounds of the nitrogen, was lost to the sediments, denitrified and lost to the atmosphere, or used by the biomass within the Lake.

Phosphorus Loads

A total of 2,630 pounds of phosphorus was calculated to have entered Fowler Lake during 1984. The Oconomowoc River was the major source of phosphorus, contributing 88 percent of the load, followed by runoff from the City of Oconomowoc (10 percent), agricultural and wetland runoff (1 percent), and atmospheric deposition on the Lake's surface (1 percent). Little change in this load is forecast as a result of new development in the direct drainage area of Fowler Lake. Approximately 23 percent of the total phosphorus load, or 600 pounds, was used by the biomass within the Lake or deposited in the sediments, resulting in a net transport of phosphorus to Lac La Belle of 2,650 pounds, or 76 percent of the total phosphorus load to Fowler Lake. The City of Oconomowoc weed harvesting program removed 792 cubic yards of weeds during 1984. This amount of plant material, approximately 63 tons of dried plant tissue, would result in about 350 pounds of phosphorus being removed from the Lake.[11]

Sediment Loads

Bottom sediment conditions have an important effect on the condition of a lake. As the sediment is deposited, valuable benthic habitats are buried, macrophyte-prone substrates are increased, fish spawning areas are covered, and aesthetic nuisances develop. Sediment particles also act as transport mechanisms for other substances, such as phosphorus, nitrogen, organic materials, pesticides, and heavy metals.

The 1984 sediment load to Fowler Lake was calculated to have been 2,060,600 pounds (see Table 17). About 92 percent of the sediment load came from the Oconomowoc River and approximately 6 percent was contributed by runoff from the City. Again, little change in these loads is forecast as a result of new development in the Fowler Lake direct drainage area. Sediment loads transported out of Fowler Lake were not calculated because no measured data were obtained at the Lake outlet.

Lead Loads

In contrast to the foregoing, the lead loading to Fowler Lake was dominated by runoff from the urban areas. Of the 350 pounds calculated to have entered Fowler Lake during 1984, 57 percent was contributed through urban runoff, 14 percent from the atmosphere, 11 percent from agriculture, and 17 percent from the Oconomowoc River. Lead was the only element that was forecast to show a significant change as a result of land use changes within the Fowler Lake direct drainage area. Most of this lead, 74 percent, is retained in the Lake's sediments.

Lead was used in this analysis as an indicator of metals and other pollutants contributed primarily from urban sources. It should be noted that lead loadings will probably decline in the future as the use of leaded engine fuels decline and is discontinued and as the use of lead in solder for domestic water supply piping and in paint products is also discontinued. Thus, future lead loadings presented in this section may overestimate the actual loadings of that metal. However, the loadings of other metals from urban sources will not be affected by these changes and it is likely that loads of total metals to Fowler Lake may be expected to increase by about 10 percent as a result of the increasing urbanization in the study area.

Urban Areas

A more complex analysis of pollutant loadings was conducted for urban areas using the Wisconsin Urban Runoff Model. WURM generated loadings for suspended solids, phosphorus, nitrogen, and lead during spring, summer, and fall. Input data to the model included land use, soil, traffic, atmospheric, and meteorological data. Output generated by the model included event flows and pollutant concentrations, pollutant loadings, and unit area loads. In its application in the Oconomowoc River watershed, WURM was used to simulate pollutant loads from storm sewers within the City of Oconomowoc and adjacent to Fowler Lake and Lac La Belle. This storm sewered area was divided into 47 subbasins, and pollutant loadings were simulated for each subbasin by land use type. Of these 47 subbasins, 25 drain into Fowler Lake. Simulated loadings of suspended solids, nitrogen, and phosphorus are given for each subbasin in Table 18.

The 25 subbasins were then ranked to determine major pollution loading areas. In general, the simulation modeling results indicated that the highest pollutant loadings were contributed by the downtown commercial areas of the City of Oconomowoc and that the outlying urban areas had a relatively low pollutant impact, with the exception of areas under development and major transportation routes.

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[11] *T. M. Burton, D. L. King, and J. L. Ervin, "Aquatic Plant Harvesting As A Lake Restoration Technique," Proceedings of the U. S. Environmental Protection Agency National Lake Restoration Conference, EPA 440/5-79-OD1, 1979.*

Eight important urban subbasins were identified on the basis of unit area loadings and the percentage of industrial and commercial land uses in each subbasin. These eight subbasins, A, B, J, M, N, P, Q, and R, and the locations of their storm-sewer outfalls are shown on Map 21. Subbasins J, M, N, P, Q, and R are located entirely within the City of Oconomowoc. Most of subbasins A and B are also located in the City, with small portions located in the Town of Oconomowoc. The inclusion of subbasins A and B in this group is consistent with the sediment data (Table 16) discussed above. Table 19 provides a more detailed analysis of the land use and pollutant loading characteristics of these eight urban subbasins.

Onsite Sewage Disposal

Onsite sewage disposal systems are designed to remove phosphorus by adsorption to soil in the drainfield. Removal capacity decreases with increasing soil particle size and all soils have a fixed absorptive capacity that could eventually become exhausted.

As of 1985, the sanitary and household wastewaters from approximately 625 persons, or 15 percent of the population in the study area of Fowler Lake, were treated and disposed of through the use of onsite systems. An onsite sewage disposal system may be a conventional septic tank system, a holding tank, or a mound system. Holding tanks store wastewater temporarily until it is pumped and conveyed by tanker truck to a sewage treatment plant, storage lagoon, or land disposal site. Approximately 200 septic tank systems, mound systems, and holding tanks were known to exist in the direct drainage area of Fowler Lake in 1985.

The septic tank system consists of two components: a septic tank proper, used to provide partial treatment of the raw wastes by skimming, settling, and anaerobically decomposing the waste, and a 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 watertight tank intended to separate floating and settleable solids from the liquid fraction of domestic sewage and to discharge the liquid and its burden of dissolved particulate solids into the biologically active zone of the soil mantle through a subsurface percolation system. The discharge system may be a tile field, a seepage bed, or an earth-covered sand filter. Liquid passing through the active soil zone percolates downward until it strikes an impervious layer or the groundwater. Thus, the purpose of the percolation system is to dispose of sewage effluent by utilizing the same natural phenomena which lead to the accumulation of groundwater.

Provided that a septic tank system is located, installed, used, and maintained properly, and that there is an adequate depth, four to five feet, of moderately permeable, unsaturated soil below the drainage field and above the groundwater level, or any layer of impervious soil or bedrock, the system should operate with few problems for periods of up to 20 years. However, not all residential areas within the Fowler Lake direct drainage area served by septic tanks are located in areas covered by soils suitable for septic tank use. Further, it has been estimated that, as of 1985, 10 septic tank systems, or about 5 percent of the existing systems, are located on soils with limitations for such use.

Failure of a septic tank system occurs when the soil surrounding the seepage area will no longer accept or properly stabilize the septic tank effluent, such as when the groundwater rises to levels which will no longer allow infiltration of liquid effluent into the soils or when age or lack of proper maintenance cause the system to malfunction. Hence, septic system failure may result from improper location, poor installation, or inadequate maintenance. In many older systems, the septic tank effluent may not receive the benefit of soil infiltration, but rather may be discharged directly from the septic tank through a drain tile or culvert. Such discharges can constitute a health hazard and add excessive nutrients to surface and groundwaters. While many older systems met Wisconsin Administrative Code requirements when installed, these requirements have changed over the years, with the effect that many older systems no longer conform to present practices. Also, many installations, designed for vacation use are now in use year-round and are subject to overloading. The precise identification of potential septic tank problems will require a sanitary survey.

Mound systems are above ground septic systems using a pump to circulate the septic tank effluent through one-inch-diameter perforated distribu-

Table 18

SIMULATED LOADINGS FOR STORM-SEWERED AREAS

Subbasin	Area (acres)	Suspended Solids (pounds)	Nitrogen (pounds)	Phosphorus (pounds)	Lead (pounds)
A	42.5	8,310.6	93.4	20.4	11.7
B	30.7	6,865.7	76.6	15.9	10.3
C	8.0	1,383.4	14.4	3.5	1.9
D	44.7	4,972.1	64.9	18.6	4.0
E	31.0	6,050.5	66.0	14.9	7.9
F	19.0	6,811.6	74.7	13.5	5.5
G	1.0	779.9	7.6	1.7	1.1
H	5.3	633.9	14.7	1.0	0.2
I	4.7	1,954.3	24.4	3.8	4.3
J	9.3	3,915.3	59.9	7.1	8.4
K	0.8	1,145.1	7.7	2.1	3.3
L	6.0	2,152.1	25.5	2.4	2.6
M	12.0	9,415.0	77.6	18.4	22.4
N	9.0	6,866.0	58.6	13.8	14.9
O	4.0	1,249.4	13.1	3.1	1.8
P	12.0	10,081.9	85.3	18.7	26.4
Q	23.5	2,959.2	71.2	6.4	5.0
R	219.9	38,769.8	634.0	75.6	60.7
T	1.3	319.1	4.5	0.7	0.6
U	3.7	1,178.7	10.4	3.5	2.6
V	6.0	1,911.4	6.4	1.1	1.4
W	2.0	554.1	5.3	1.4	0.8
X	6.6	594.8	9.8	1.4	0.7
Y	15.7	795.5	17.4	1.5	0.5
Z	57.8	4,195.4	67.2	11.1	4.4
Total	358.9	87,183.5	1,156.6	176.3	159.8

Source: SEWRPC.

tion pipes placed in fill over the natural soil. When in place, this fill takes on the appearance of a mound. A typical installation, designed to accommodate wastes from a four-bedroom, single-family house, might have a mound 64 feet wide by 84 feet long, or 5,376 square feet in areal extent, and would represent about 12 percent of the total area of a one-acre lot. At its highest point, the mound would be approximately five feet in height.

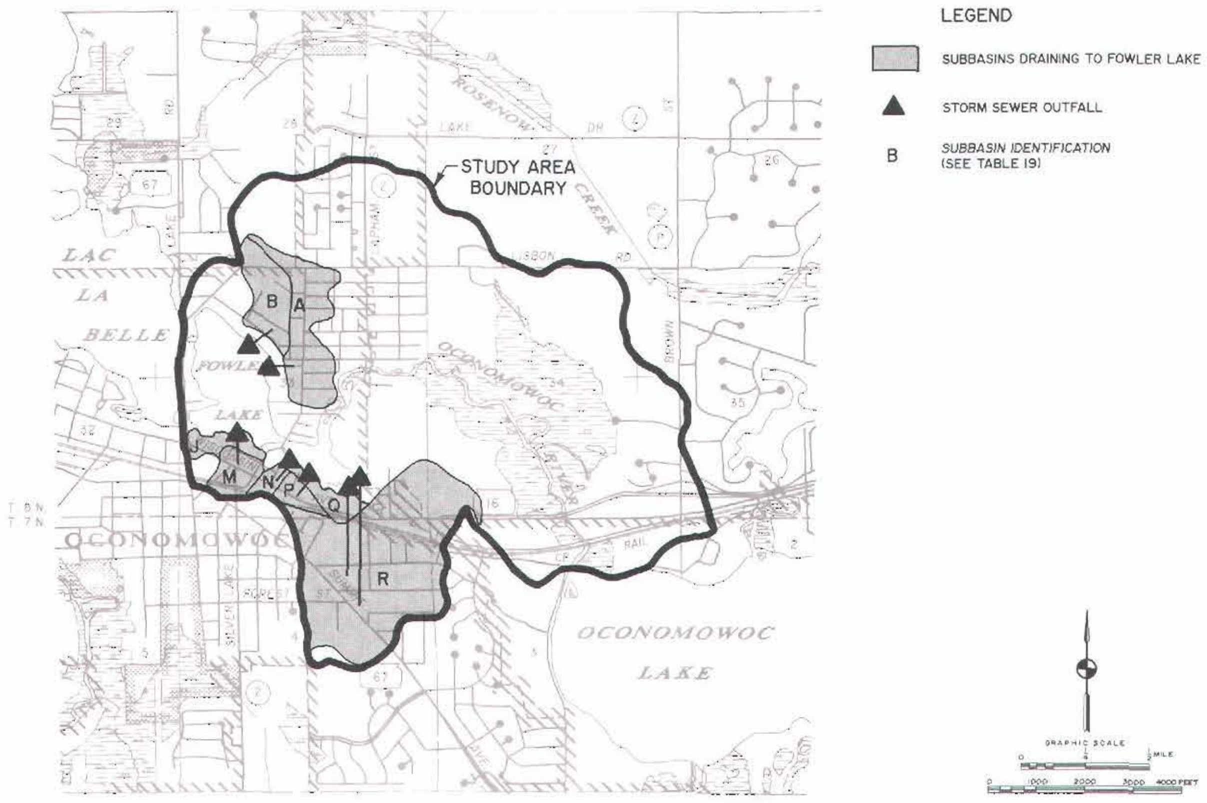
As noted, installation of sanitary sewers serving 508 additional acres, or about 67 percent of the Fowler Lake study area, by the year 2000 may be expected to reduce the number of existing onsite sewage disposal systems to approximately five. These will remain on soils limited for such use and will need to be properly maintained so as to minimize potential adverse environmental impacts on surface and groundwater quality in the direct drainage area.

Groundwater Monitoring Program

Three groundwater observation wells were installed by the U. S. Geological Survey as part of their monitoring program (see Map 12). Groundwater quality and levels were monitored at two wells placed near the southeast edge of the expanded inlet to the Lake. A third well, located approximately 400 feet from the Lake, was used only for groundwater level measurements. The wells were installed in an area formerly used as an open-burning dump which had been filled and leveled more than 10 years before. Water samples from these wells were analyzed to determine the likelihood of leachates from the dump flowing

Map 21

CRITICAL URBAN SUBBASINS DRAINING TO FOWLER LAKE



Source: SEWRPC.

Table 19

LAND USE AND ESTIMATED POLLUTANT LOADING CHARACTERISTICS OF IMPORTANT URBAN SUBBASINS IN THE FOWLER LAKE SUBWATERSHED

Urban Subbasin	Percent of Urban Pollutant Load from Subbasin			Percent of Study Area Land Use in Subbasin	
	Lead	Phosphorus	Sediment	Industrial	Commercial
R	22	26	30	84	42
P	12	7	8	- -[a]	10
M	10	7	7	- -	7
N	7	5	5	- -[a]	5
A	5	8	6	- -	- -[a]
B	5	6	5	- -	5
J	- -[a]	- -[a]	- -[a]	- -	7
Q	- -[a]	- -[a]	- -[a]	12	8
Total	73	65	68	100	93

[a] *Values represent less than 5 percent of the total for the subwatershed.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 20

COMPARISON OF GROUNDWATER QUALITY IN VICINITY OF DISPOSAL AREA NEAR FOWLER LAKE: 1984

Well Number	Date	Calcium (mg/l)	Chloride (mg/l)	Sulfate (mg/l)	Total Phosphorus (mg/l)	pH (standard units)	Specific Conductance (µs/cm)
1	June 20	110	- -	- -	<0.01	- -	- -
2	June 20	170	- -	- -	<0.01	- -	- -
1	September 26	- -	350	7.1	- -	7.3	2,120
2	September 26	- -	370	6.3	- -	7.3	2,190

Comparable Groundwater Quality Data in Waukesha County			
Location	Calcium (mg/l)	Chloride (mg/l)	Sulfate (mg/l)
Sand and Gravel Aquifers			
Range	51-111	5.0-170	16-115
Mean Concentration	77	29	47
Number of Wells	15	15	15

Source: U. S. Geological Survey, 1981; P. A. Kammerer, Ground-Water Quality Atlas of Wisconsin.

into the Lake. Table 20 shows the data for chloride, calcium, and sulfate found in the samples and also lists comparative data for the Waukesha County sand and gravel aquifer.

High concentrations of chloride were detected in the samples, ranging from 350 to 370 mg/l. These high chloride concentrations might be indicative of leachate from the former disposal area polluting the groundwater. It is also possible that the sand used to pack the wells after drilling could have been contaminated with road-deicing salt ($CaCl_2$), although efforts were made to avoid this type of contamination. The sand was obtained from the Oconomowoc maintenance yard and taken from inside the storage pile to reduce the possibility of contamination by windblown salt. In addition, the wells were installed in May 1984 and given four months to equilibrate. It was estimated that the groundwater flow should have leached any salts from the sand pack if this type of contamination was present. Although Table 20 shows elevated concentrations of both calcium and chloride, consistent with contamination by calcite deicers, additional sampling would be needed to determine the actual source of the chloride in the wells.

Similarly, additional samples would be needed to draw any conclusions regarding the lack of contamination of the groundwater with phosphorus and acidic substances, as may be suggested by the data in Table 20. It should be noted, however, that the results obtained during the groundwater sampling program did differ markedly from the results obtained elsewhere in this Region, and that the data did fall within the ranges of results that might be expected in landfill leachates.[12] Notwithstanding these issues, the low volume of groundwater in the Fowler Lake water budget, shown in Figure 3, would suggest that any nutrient and contaminant loading from this source would be effectively masked by the much larger loads carried by the Oconomowoc River.

RATING OF TROPHIC CONDITION

Lakes are commonly classified according to their degree of nutrient enrichment or trophic status. The ability of a lake to support a variety of recreational activities and healthy fish and aquatic life communities is often correlated to the degree of nutrient enrichment that has occurred. There are three terms usually used to describe the trophic status of a lake: oligotro-

[12]*F. van der Leeden, F. L. Troise, and D. K. Todd, The Water Encyclopedia, 2nd Edition, Lewis Publishers, 1990.*

phic, mesotrophic, and eutrophic. Oligotrophic lakes are nutrient-poor lakes. These lakes characteristically support relatively few aquatic plants and often do not contain productive fisheries. Because of the naturally fertile soils and the intensive land use practices employed in the State, there are relatively few oligotrophic lakes in Southeastern Wisconsin. Mesotrophic lakes are moderately fertile lakes that support abundant aquatic plant growths and may support productive fisheries. Nuisance growths of algae and weeds are usually not exhibited by mesotrophic lakes. Many of the cleaner lakes in Southeastern Wisconsin are classified as mesotrophic. Eutrophic lakes are defined as nutrient-rich lakes. These lakes are often characterized by excessive growths of aquatic weeds and/or experience frequent algal blooms. Many eutrophic lakes support very productive fisheries. In shallow eutrophic lakes, fish winterkills may also be common. Many of the more polluted lakes in Southeastern Wisconsin are classified as eutrophic.

Several numerical "scales," based on one or more water quality parameters, have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numerical scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale(s) used are appropriate for the lake to which it(they) is(are) applied. In this case, three indices, specific to Wisconsin lakes, have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[13] the Uttormark and Wall Lake Condition Index,[14] and the Carlson Trophic State Index (TSI).[15]

Vollenweider-OECD
Trophic Classification System

The European Organization for Economic Cooperation Development (OECD) investigated numerous lakes and reservoirs from around the world (although the vast majority of their approximately 750 lakes were in Europe and North America) and developed a number of empirical relationships between chlorophyll-a, Secchi-disk transparency, phosphorus, nitrogen, primary productivity, and trophic state. The result was both a set of predictive models and a set of trophic boundary descriptors. Applying the latter to the Fowler Lake data given in Table 14 results in the Lake being classified as having a 10 percent probability of being ultra-oligotrophic, a 25 percent probability of being mesotrophic, and a 65 percent probability of being oligotrophic, based on the total phosphorus concentration, as shown in Figure 5. Similarly, using chlorophyll-a concentration, the Lake has a 50 percent probability of being oligotrophic, a 40 percent probability of being mesotrophic, an 8 percent probability of being ultra-oligotrophic, and a 2 percent probability of being eutrophic. The Secchi-disk-based classification yields a similar result: a 50 percent probability of being mesotrophic, a 30 percent probability of being eutrophic, a 15 percent probability of being oligotrophic, and a 5 percent probability of being hypertrophic, also as shown in Figure 5. Thus, Fowler Lake should be classified as a meso-oligotrophic lake, or a lake with acceptable water quality for most uses.

Lake Condition Index

Uttomark and Wall developed a lake classification method based on four indicators of enrichment (eutrophication): dissolved oxygen levels, water clarity (transparency), the occurrence of fish winterkills, and recreational use impairment due to algal blooms and/or weed growth. A measure, referred to as the Lake Condition Index, was devised in which "penalty points" were assigned to lakes for undesirable symptoms of

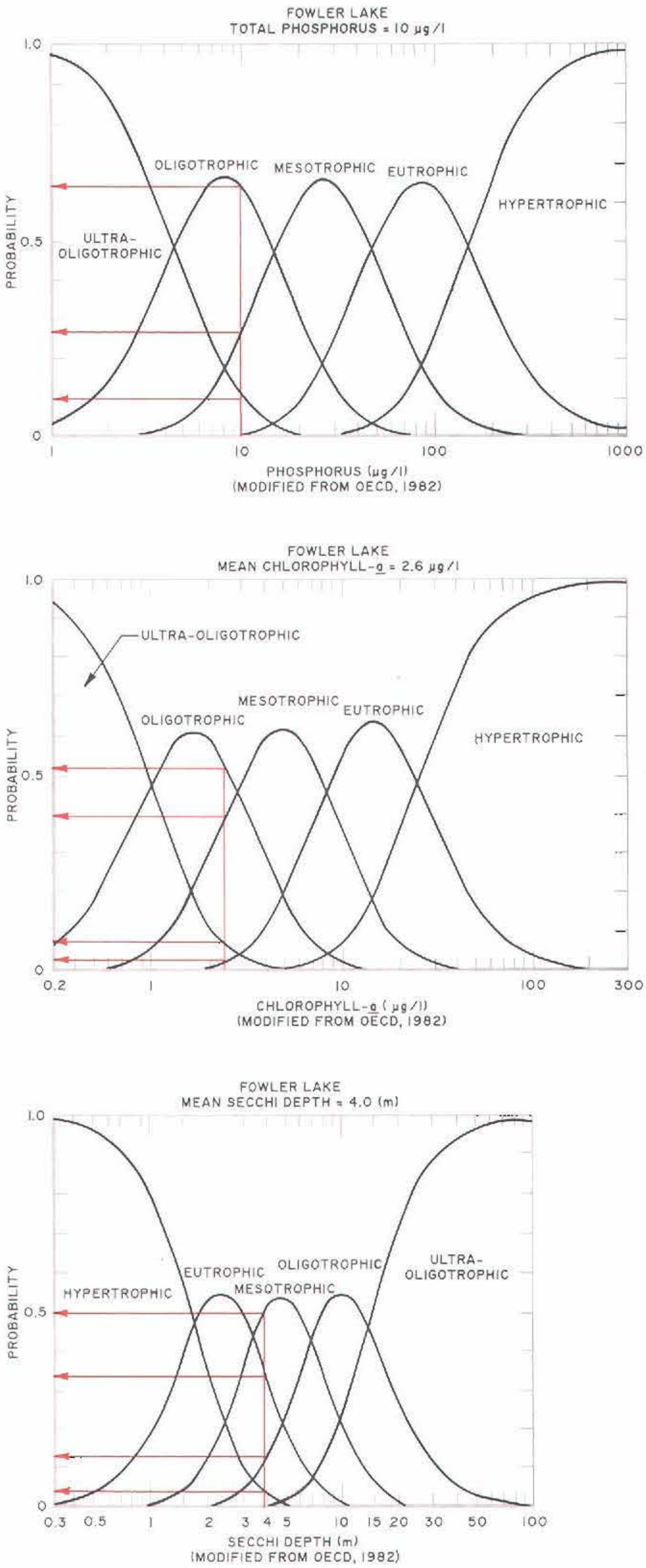
[13]*Organization for Economic Cooperation and Development (OECD), Eutrophication of Waters: Monitoring, Assessment and Control, Paris, 1982; S.-O. Ryding and W. Rast, The Control of Eutrophication in Lakes and Reservoirs, UNESCO/MAB Series 1, Parthenon Press, 1989; and H. Olem and G. Flock, The Lake and Reservoir Restoration Guidance Manual, 2nd Edition, USEPA Report EPA-440/4-90-006, Office of Water (WH-553), Washington, D. C., 1990.*

[14]*P. D. Uttormark and J. P. Wall, Lake Classification—A Trophic Characterization of Wisconsin Lakes, U. S. EPA Report No. EPA-660/3-75-633, 1975.*

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

Figure 5

TROPHIC STATE CLASSIFICATION OF FOWLER LAKE BASED ON THE VOLLENWEIDER MODEL



Source: S. Ryding and W. Rast, The Control of Eutrophication of Lakes and Reservoirs, Vol. 1, 1989, and SEWRPC.

Table 21

UTTORMARK AND WALL "LAKE CONDITION INDEX" CALCULATION FOR FOWLER LAKE: 1984

Lake Conditions	Lake Condition Index Penalty Points
Dissolved Oxygen Concentrations at 0.0 mg/l during Some Periods in Portions of the Hypolimnion	4
Average Secchi Disk Reading of Nine to 13 Feet	1
No History of Fish Winterkills	0
Heavy Weed Growth in Littoral Zone	3
Total	8

Source: SEWRPC.

water pollution. Thus, if a lake exhibited no undesirable symptoms, it would receive no points and would have a Lake Condition Index of zero. Conversely, a lake with all of the undesirable characteristics in the most severe degree would have a Lake Condition Index of 23. Under the Uttormark-Wall classification system, Fowler Lake has a Lake Condition Index of eight, as shown in Table 21, which is indicative of a mesotrophic lake. This has remained unchanged during the subsequent sampling periods (1987 through 1990).

Trophic State Index

The Trophic State Index (TSI) assigns a numerical trophic condition rating based on Secchi-disk transparency and total phosphorus and chlorophyll-a concentrations. The original Trophic State Index developed by Carlson has been modified for Wisconsin lakes by the Wisconsin Department of Natural Resources using data on 184 lakes throughout the State.[16] The Trophic State Index ratings for Fowler Lake are shown in Figures 6 and 7 as a function of sampling data. Based on these Trophic State Index ratings, Fowler Lake may also be classified as mesotrophic under this system.

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[16] *R. A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes," Research Management Findings, No. 35, Wisconsin Department of Natural Resources Publication PUBL-RS-73S 93, 1993.*

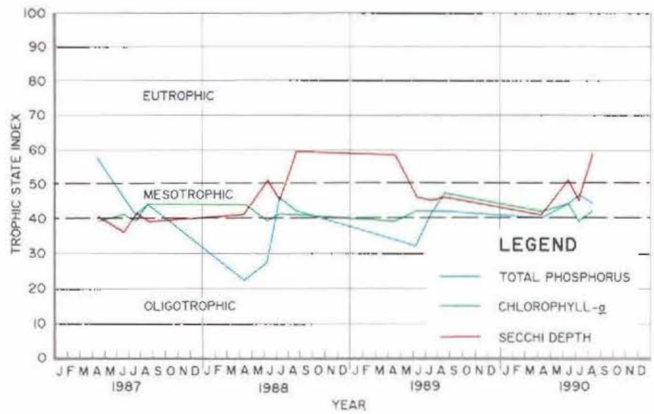
Figure 6

TROPHIC STATE INDICES
FOR FOWLER LAKE: 1984

Source: U. S. Geological Survey and SEWRPC.

Figure 7

TROPHIC STATE INDICES
FOR FOWLER LAKE: 1987-1990



Source: U. S. Geological Survey and SEWRPC.

SUMMARY

Fowler Lake represents a typical hard-water, alkaline lake that has not been subjected to high levels of pollution. Physical and chemical parameters measured during the study period indicated that the water quality is within the "good to very good" range, compared to other regional lakes. Total phosphorus levels were found to be below the level considered to cause nuisance algal and macrophytic growths. During summer stratification, the water below a depth of 25 feet was found to be devoid of oxygen, while the upper waters remained well oxygenated and supported a healthy fish population (see Chapter V). Winterkill was not a problem in Fowler Lake because dissolved oxygen levels were found to be adequate for the support of fish throughout the winter at depths above 40 feet. Internal releases of phosphorus from the bottom sediments were not a problem in Fowler Lake.

There were no known point sources of pollutants in the Fowler Lake watershed. Nonpoint sources of pollution included stormwater runoff from urban and agricultural areas. Suspended solids, phosphorus, nitrogen, and lead loadings from the urban areas in the watershed were estimated using the Wisconsin Urban Runoff Model and were found to be highest in the downtown commercial areas and new residential areas bordering the Lake. Unit area loadings data indicate that agricultural and residential runoff was the largest external source of sediment and phosphorus; commercial and transportation-related runoff was the largest external source of lead. Lead, in particular, was included in the modeling study as a surrogate value for total metals of urban origin. Thus, while the actual concentrations of lead may actually decrease in the future as environmental use of the element is phased out, the total metal loads can be expected to increase as modeled.

In 1984, the total phosphorus load to Fowler Lake was 2,510 pounds. The Oconomowoc River contributed the largest amount of phosphorus, 81 percent of the load. Based on the Vollenweider phosphorus loading model, the Lake Condition Index, and the Trophic State Index ratings calculated from Fowler Lake data (1984 through 1990), Fowler Lake may be classified as an oligotrophic to slightly mesotrophic lake.

In general, the water quality data and the classification systems used indicate that Fowler Lake has relatively good water quality. Important water quality considerations to be considered further in subsequent sections of this report are the potential impacts of the Oconomowoc River and of shoreline drainage on water quality conditions and alternatives for protecting Fowler Lake from problems that may arise from these sources. In addition, lake management actions that will maintain or reduce other pollution sources are also to be considered.

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Chapter V

AQUATIC BIOTA, ECOLOGICALLY VALUABLE AREAS, AND RECREATIONAL ACTIVITIES

INTRODUCTION

Fowler Lake is an important natural resource for the City of Oconomowoc. The Lake, its biota, and the adjacent park and residential lands combine to contribute to the quality of life in the City of Oconomowoc and its environs. The Lake also directly impacts the economy of the City, since it is an important feature of the central business district, which has recently undergone major renovations to improve its attractiveness to business.

Natural resource features such as wetlands and lakes, when located in urban settings, are typically subject to great stresses. Point and nonpoint source pollution discharges, common forms of stress to aquatic systems, may result in the deterioration of this natural resource feature. The formulation of sound management strategies must be based on a thorough knowledge of the pertinent characteristics of the individual resource feature. Accordingly, this chapter provides information concerning the natural resource features of the Fowler Lake watershed, including data on primary environmental corridors, wetlands, aquatic macrophytes, fish and wildlife. In addition, recreational activities relating to the use of these natural resource features are described.

AQUATIC PLANTS

Aquatic plants include larger plants, or macrophytes, and microscopic algae, or phytoplankton. These are the primary producers of a lake and form an integral part of the aquatic food web. They convert inorganic nutrients in the water and sediments into organic compounds which are directly available as food for other aquatic organisms. In this process, known as photosynthesis, plants utilize energy from sunlight and release the oxygen required by other aquatic life forms.

Aquatic Macrophytes

Aquatic macrophytes play an important role in the ecology of Southeastern Wisconsin lakes. They can be either beneficial or a nuisance, depending on their distribution and abundance and the activities taking place on the water body. Macrophytes are usually an asset because they provide food and habitat for fish and other aquatic life, produce oxygen, and may remove nutrients and pollutants from the water that could otherwise cause algal blooms or other problems. Aquatic plants become a nuisance when their presence reaches densities that interfere with swimming and boating and the normal functioning of a lake's ecosystem. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate, wave action, and type of fish populations present, determine the distribution and abundance of aquatic macrophytes in a lake. Some nonnative plant species, lacking natural controls, may be especially favored by the habitats available in this Region and can exhibit explosive growths to the detriment not only of lake users but also of indigenous aquatic life and native plant species.

To document the types and relative abundances of aquatic macrophytes in Fowler Lake, aquatic plant surveys were conducted by consultants under contract to the City of Oconomowoc on June 9 through 11 and on August 25, 1984.[1] The aquatic plant survey was designed to determine: 1) species distribution, 2) species relative abundance, 3) species percent occurrence, and 4) maximum depth of growth.

Fifteen species of aquatic macrophytes were identified and are listed in Table 22 along with the percentage of occurrence and a rating of density for each species. On a scale of zero to five, five is the most dense. Map 22 shows the distribution of common species during the June survey and Figure 8 illustrates the relative abundance of the more common species at each depth interval.

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[1] *Patrick Sorge and Timothy Lowry, Aquatic Plant and Sediment Survey on Fowler Lake, 1984.*

Table 22

FOWLER LAKE AQUATIC MACROPHYTE SURVEY RESULTS: JUNE 1984

Species	Percent Occurrence (maximum equals 100.0)	Mean Density (maximum equals 5.0)
Chara sp. (muskgrass)	64.2	3.8
Myriophyllum sp. (milfoil)	50.5	2.7
Ceratophyllum demersum (coontail)	34.7	2.4
Vallisneria americana (wild celery)	24.2	1.9
Potamogeton pectinatus (sago pondweed)	20.0	1.4
P. illinoensis (Illinois pondweed)	14.7	2.4
Nymphaea tuberosa (white water lily)	13.7	2.6
Utricularia vulgaris (bladderwort)	11.6	1.5
Nitella sp. (stonewort)	6.3	2.5
P. crispus (curly-leaf pondweed)	5.2	1.8
P. richardsonii (clasping-leaf pondweed)	4.2	1.0
Nuphar sp. (yellow water lily)	3.2	2.7
Najas marina (bushy pondweed sp.)	2.0	1.0
N. flexilis[a] (bushy pondweed)	- -	- -
Ranunculus sp.[a] (buttercup)	- -	- -

[a]*Species found during the surveys but did not occur at any sample points.*

Source: Patrick Sorge and Timothy Lowry, Aquatic Plant and Sediment Survey on Fowler Lake, and SEWRPC.

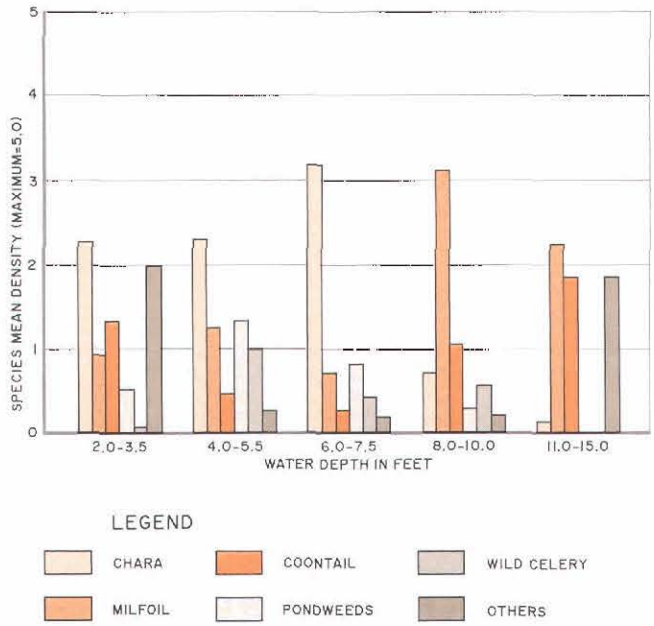
The June survey indicated that aquatic macrophytes occurred throughout Fowler Lake to a depth of 22 feet. However, plant growth was most abundant at depths of less than 15 feet. Aquatic macrophytes were found at 93 of the 95 sample points. The most abundant growths occurred in the southwest bay and in the inlet upstream of the N. Oakwood Avenue bridge.

Chara was the most abundant species, occurring at about 64 percent of the sample points with a mean density rating of 3.8. It dominated the macrophyte community in water depths of less than eight feet. Milfoil (Myriophyllum sp.) was also abundant, occurring at about 51 percent of the sample points with a mean density rating of 2.7. It was the dominant species in water depths of 8 to 15 feet. Coontail (Ceratophyllum demersum) was common at all depths and occurred at about 35 percent of the sample points with a mean density rating of 2.4. It was most abundant in the southeastern end of the expanded inlet.

Wild celery (Vallisneria americana) and several species of pondweeds (Potamogeton spp.) were also common in Fowler Lake. They occurred

Figure 8

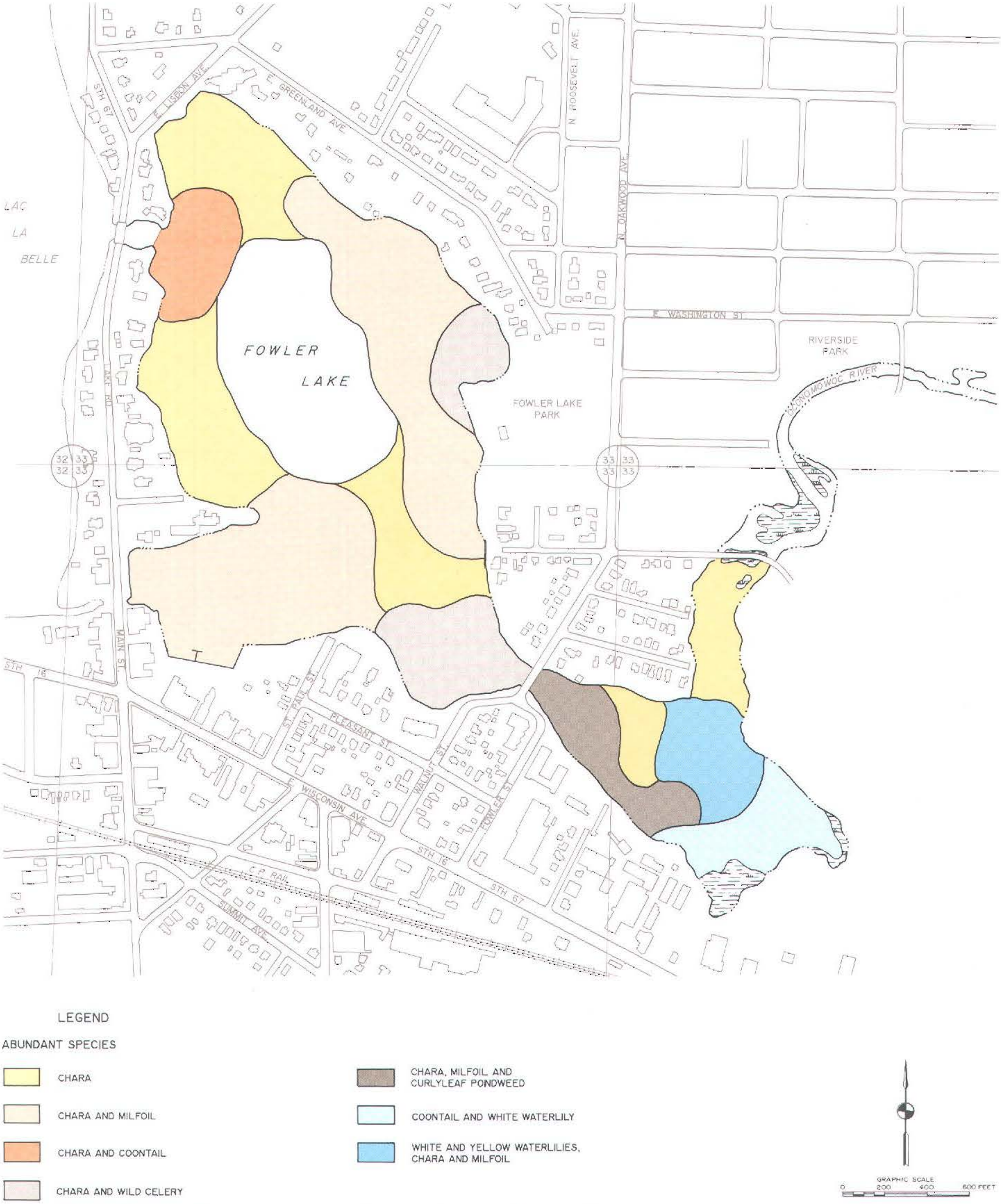
ABUNDANCE OF AQUATIC MACROPHYTES IN FOWLER LAKE: JUNE 1984



Source: Patrick Sorge and Timothy Lowry, Aquatic Plant and Sediment Survey on Fowler Lake, and SEWRPC.

Map 22

MACROPHYTE DISTRIBUTION IN FOWLER LAKE: JUNE 1984



Source: Patrick Sorge and Timothy Lowry, Aquatic Plant and Sediment Survey on Fowler Lake.

throughout the Lake and were most abundant in water depths of less than eight feet. White and yellow water lilies were common in the shallow water of the expanded inlet. Nitella sp. was the only species found to occur in water depths of greater than 15 feet; it was consistently found at depths of 18 to 22 feet.

The results of the August survey indicated that seasonal changes occurred in species abundance and distribution. The most significant change was that Najas marina became very abundant throughout the Lake. In June, N. marina occurred at only 2 percent of the sample points, but by August it was abundant and widely distributed over the entire main basin of the Lake. This late-season growth is typical of this species in Wisconsin. Wild celery became more abundant in August but its distribution did not expand, while milfoil abundance appeared to have decreased although its distribution may have increased slightly. Chara increased in abundance but its distribution remained constant.

In general, Fowler Lake supported a healthy and diverse aquatic macrophyte community. Species such as milfoil and coontail had a tendency to form dense mats that may interfere with boat traffic, but harvesting appeared to keep their growths under control. Harvesting may explain the apparent decline in milfoil abundance between June and August. The maximum depth of vegetative growth was greater than in most southeastern Wisconsin lakes and indicated good water clarity and the lack of algal blooms.

Phytoplankton

Phytoplankton, or algae, are small, generally microscopic plants that are found in all lakes and streams. They occur in a wide variety of forms, in single cells or colonies, and can be either attached or free floating. Phytoplankton abundance varies seasonally with fluctuations in solar irradiance, turbulence due to prevailing winds, and nutrient availability. In lakes with high nutrient levels, heavy growths of phytoplankton, or algal blooms, may occur.

Algal blooms have not been a problem in Fowler Lake and, therefore, identification and quantification of those algae present within the Lake were not included as part of the consultant study.

Aquatic Plant Management

Records of aquatic plant management efforts on Wisconsin lakes were not maintained by the Wisconsin Department of Natural Resources (DNR) prior to 1950. Therefore, while previous interventions were likely, the first recorded efforts to manage the aquatic plants in Fowler Lake took place in 1950. Aquatic plant management activities in Fowler Lake can be categorized as macrophyte harvesting, chemical macrophyte control, and chemical algal control.

Perceived excessive macrophyte growth on Fowler Lake has historically resulted in a control program that used both harvesting and chemicals. Under the existing macrophyte control program, the City of Oconomowoc harvests macrophytes with an Aquamarine H5-200 harvester. Since chemical herbicides are applied to Fowler Lake in early summer, harvesting is initiated only after the macrophytes become reestablished, usually in mid- to-late July. Typically, only the macrophytes growing along the shoreline of the Lake are cut, although excessive macrophyte growths occur in other shallow portions of the Lake away from the shoreline. These are occasionally cut to improve navigation and enhance swimming opportunities. It was estimated that approximately 700 cubic yards of macrophytes were harvested from Fowler Lake in 1986, at a cost to the City of Oconomowoc of approximately $17,000. No permit is currently required to cut vegetation in lakes mechanically, although the harvested plant material must be removed from the water.

Since 1941, the use of chemicals to control aquatic plants has been regulated in Wisconsin. Before this, chemicals used to control aquatic plant growth in lakes and streams were not regulated. In 1926, sodium arsenite, an agricultural herbicide, was first applied to lakes in the Madison area, and, by the 1930s, sodium arsenite was widely used throughout the State for aquatic plant control. No other chemicals were applied in significant amounts to control macrophytes until recent years, when a number of organic chemical herbicides have come into general use. The amounts of sodium arsenite applied to the 10 lakes receiving the largest amounts of sodium arsenite in Southeastern Wisconsin, including Fowler Lake, are shown on Table 23.

Sodium arsenite was usually sprayed onto the lake surface within an area of up to 200 feet from the shoreline. Treatment typically occurred between mid-June and mid-July. The amount of sodium arsenite used was calculated to result in a concentration of about 10 milligrams per liter (mg/l) sodium arsenite (about five mg/l arsenic) in the treated lake water. The sodium arsenite typically remained in the water column for less than 120 days. Although the arsenic residue was naturally converted from a highly toxic form to a less toxic and less biologically active form, much of the arsenic residue was deposited in the lake sediments.

When it became apparent that arsenic was accumulating in the sediments of treated lakes, the use of sodium arsenite was discontinued in the State of Wisconsin in 1969. The applications and accumulations of arsenic were found to present potential health hazards to both humans and aquatic life. In drinking water supplies, arsenic was suspected of being carcinogenic and, under certain conditions, arsenic has leached into and contaminated groundwaters, especially in sandy soils that serve as a source of drinking water in some communities. The U. S. Environmental Protection Agency-recommended drinking water standard for arsenic is a maximum level of 0.05 mg/l.

During anaerobic conditions, arsenic may be released from the bottom sediments to the water column above. In this way, some arsenic probably continues to be "flushed out" of Fowler Lake and enter Lac La Belle through the outlet. However, the arsenic-laden sediments are continually being covered by new sediments; thus, the level of arsenic in the water and in the surface sediments may be expected to decrease with passage of time. There is some evidence that the arsenic-laden sediments in Fowler Lake have been covered by additional debris which has entered the Lake and do not appear to be releasing arsenic into the water column.

As shown in Table 24, the aquatic herbicides Diquat, Aquathol, Hydrothol, and 2,4-D have also been applied to Fowler Lake to control aquatic macrophyte growth since 1980. Diquat, Aquathol, and Hydrothol are contact herbicides and kill plant parts exposed to the active ingredient. Diquat use is restricted to the control of duckweed (Lemna), milfoil (Myriophyllum), and waterweed (Elodea). However, this herbicide is nonselective and will actually kill many other aquatic plans such as pondweeds, bladderwort, and naiads. Aquathol and Hydrothol kill primarily pondweeds but do not control such nuisance species as Eurasian water milfoil. The herbicide 2,4-D is a systemic herbicide which is absorbed by the leaves and translocated to other parts of the plant; it is more selective than the other herbicides listed above and is generally used to control Eurasian water milfoil. However, it will also kill more valuable species, such as water lilies. The present restrictions for use of these herbicides are given in Table 25.

At present, the City of Oconomowoc holds the State permits for chemical treatment of aquatic plants required under Chapter NR 107, Wisconsin Administrative Code. Chemicals are applied annually on a contractual basis by a local applicator. As previously noted, herbicide application usually takes place in late spring or early summer with, occasionally, a second treatment of a smaller area, if necessary, in late July or early August. Map 23 shows the areal extent of that portion of Fowler Lake to which chemicals were applied between 1988 and 1991. All chemicals for aquatic plant control used today are approved by the U. S. Environmental Protection

Table 23

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[a]	Waukesha	87,456
Nagawicka	Waukesha	87,214
Lac 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 constitute 57 percent of the total amount of sodium arsenite applied to a total of 167 lakes and streams in Wisconsin from 1950 to 1969.*

Source: Wisconsin Department of Natural Resources.

Table 24

CHEMICAL CONTROL OF AQUATIC PLANTS IN FOWLER LAKE: 1980-1991

Year	Macrophyte Control					Algae Control
	Diquat (gallons)	Aquathol-K (gallons)	2,4-D (gallons)	Hydrothol (gallons)	Hydrothol (pounds)	Cutrine Plus (gallons)
1980	22	0.0	0.0	0.0	- -	0.00
1981	25	33.0	0.0	0.0	- -	0.00
1982	14	23.0	0.0	0.0	- -	0.00
1983	7	5.0	52.0	2.0	- -	12.00
1984	0	9.0	34.5	2.5	- -	6.00
1985	0	38.0	0.0	- -	160	0.00
1986	0	11.0	23.0	- -	450	5.50
1987	0	3.5	47.0	0.0	- -	4.75
1988	0	15.0	84.0	0.0	- -	12.00
1989	0	0.0	45.0	0.0	- -	0.00
1990	0	0.0	64.5	0.0	- -	0.00
1991	- -	- -	- -	- -	- -	- -
Total	68	137.5	350.0	4.5	610	40.25

Source: Wisconsin Department of Natural Resources.

Agency and the Wisconsin DNR and are registered in terms of the Federal Insecticide, Fungicide, and Rodenticide Act as amended in 1972.

In addition to the chemical herbicides used to control large aquatic plants, algicides have also been applied to Fowler Lake. As shown in Table 24, Cutrine Plus has been applied to Fowler Lake, on occasion, since 1980, primarily to control the macroscopic alga, Chara. Like arsenic, copper, the active ingredient in many algicides including Cutrine Plus, may accumulate in the bottom sediments. Excessive levels of copper have been found to be toxic to fish and benthic organisms but are not generally harmful to humans. Restrictions on the use of Cutrine Plus are also given in Table 25.

Table 25

PRESENT RESTRICTIONS ON USE OF THE MAJOR AQUATIC HERBICIDES[a]

Use	Days after Application		
	Cutrine Plus	Diquat	Hydrothal and Aquathol
Drinking	0	14	7-14
Fishing	0	14	3
Swimming . . .	0	1	- -
Irrigation	0	14	7-14

[a]*EPA believes if these restrictions are observed, pesticide residues in water, irrigated crops, or fish will not pose an unacceptable risk to humans and other organisms using or living in the treatment zone.*

Source: Wisconsin Department of Natural Resources.

AQUATIC ANIMALS

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

Zooplankton

Zooplankton are minute, free-floating animals inhabiting the same environment as phytoplankton. Zooplankton are primary consumers in the aquatic food chain, feeding to a large extent on such phytoplankton as green algae and diatoms. The zooplankton, in turn, are preyed upon by fish, particularly the larvae and fry of bluegills, pumpkinseeds, sunfish, and largemouth bass. While the zooplankton population is an indicator of the trophic status of a lake and of the diversity of aquatic habitat, zooplankton were not sampled during the 1984 U. S. Geological Survey inventory; no information on the species composition

Map 23

CHEMICALLY TREATED AREAS OF FOWLER LAKE: 1990

LEGEND

AREAS TREATED WITH 2,4-D TO CONTROL EURASIAN WATER MILFOIL

GRAPHIC SCALE 0 200 400 800 FEET

Source: Wisconsin Department of Natural Resources.

Table 26

SPECIES OF FISH IDENTIFIED DURING FOWLER LAKE FISH SURVEY: 1969

Angling Type	Common Name	Family Name	Scientific Name
Sport Fish	Walleyed Pike	Percidae	Stizostedion vitreum
	Largemouth Bass	Centrarchidae	Micropterus salmoides
Panfish	Yellow Perch	Percidae	Perca flavescens
	Bluegill	Centrarchidae	Lepomis macrochirus
	Pumpkinseed	Centrarchidae	Lepomis gibbosus
	Green Sunfish	Centrarchidae	Lepomis cyanellus
	Rock Bass	Centrarchidae	Ambloplites rupestris
	Black Crappie	Centrarchidae	Poxomis nigromaculatus
	White Bass	Serranidae	Morone chrysops
	Bullhead	Ictaluridae	Ictalurus sp.
Rough Fish	Carp	Cyprinidae	Cyprinus carpio

Source: Wisconsin Department of Natural Resources.

or relative abundance is available for Fowler Lake. However, given the composition and condition of the fish community in Fowler Lake, it may be assumed that the zooplankton population is sufficiently robust and diverse to support a relatively healthy fishery.

Fish of Fowler Lake

Fowler Lake supports a moderately diverse, but relatively unstudied, fish community. A Wisconsin DNR fish survey conducted in 1969 recorded the presence of 11 species of fish representing five families, as shown in Table 26.

The top predator fishes in Fowler Lake include northern pike, walleyed pike, and largemouth bass. These species are carnivorous, feeding primarily on other fish, crayfish, and frogs. These species are among the largest and most prized game fish sought by Fowler Lake anglers. As shown in Table 27, the Wisconsin DNR currently stocks the Lake to supplement the natural fishery.

"Panfish" is a common term applied to a broad group of smaller fish; their short and usually broad shape makes them a perfect size for the frying pan. Panfish species present in Fowler Lake include bluegills, pumpkinseeds, green sunfish, rock bass, black crappies, white bass, yellow perch, and bullheads. The habitats of panfish vary widely among the different species, but their cropping of the plentiful supply of insects and plants, coupled with prolific breeding rates, leads to large populations with a rapid

Table 27

FOWLER LAKE FISH STOCKING RECORD

Year	Walleyed Pike	Brown Trout	Rainbow Trout
1985	4,000	0	0
1986	4,000	0	0
1989	7,350	3,000	3,000
1990	6,000	6,500	0
1991	4,000	6,000	0

Source: Wisconsin Department of Natural Resources.

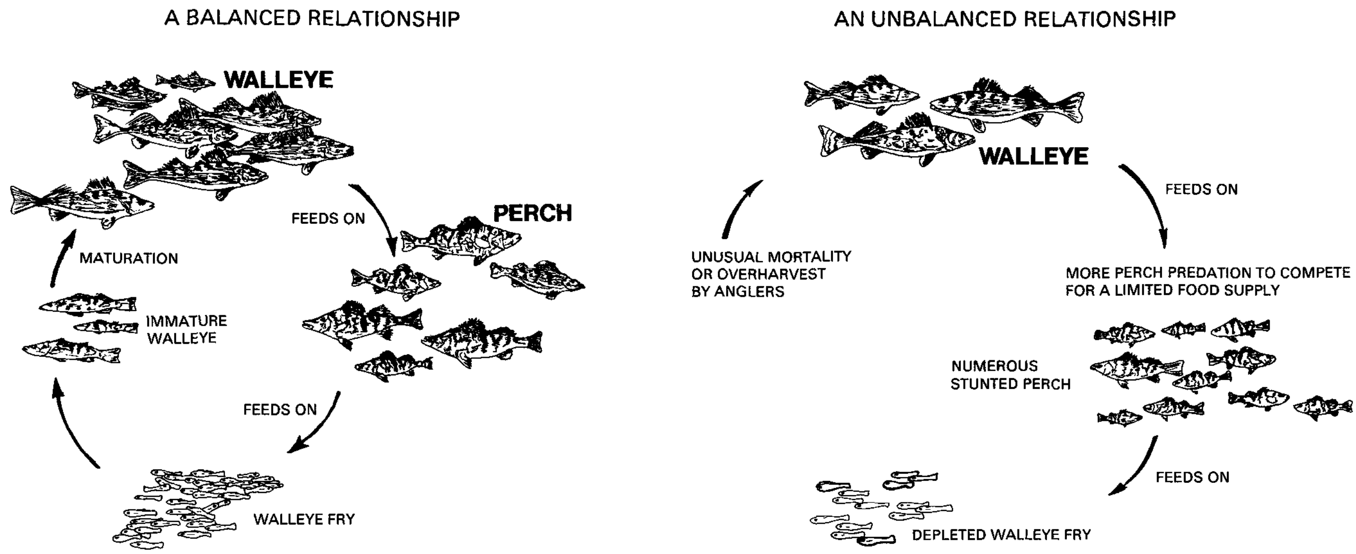
turnover. Many regional lakes have stunted, or slow-growing, panfish populations because their numbers are not controlled by predator fishes.[2] Panfish frequently feed on the fry of predator fish and, if the panfish population is overabundant, they may quickly deplete the predator fry population. Figure 9 illustrates the importance of a balanced predator-prey relationship, using walleyed pike and perch as an example.

Rough fish is a broad term applied to species such as carp that do not readily bite on hook and line, but feed on game fish, destroy habitat needed by more desirable species, and have a poor eating quality because of numerous bones

[2]*Personal communication, Dr. Ron Crunkilton, University of Wisconsin-Stevens Point College of Natural Resources, 1992.*

Figure 9

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources.

or off flavors. An experimental rough fish removal project was carried out on Fowler Lake in 1981. Approximately 90 carp were removed from the Lake. Because of the large average size of the carp taken during the experimental removal, and because of a low catch per unit effort, Fowler Lake does not appear to have had a serious carp problem. Buffalo fish, though present in downstream Lac La Belle, were not present in Fowler Lake and, likewise, do not constitute a problem in Fowler Lake.

It is estimated that the Fowler Lake fish composition has changed little since 1969.[3] The Wisconsin DNR does not plan any fish management surveys for Fowler Lake in the near future. Because it is small, located in an urban area, and heavily fished, basic trends observed in other, similar lakes are believed to apply to Fowler Lake.

The Lake is currently managed for the production of bluegills, largemouth bass, and northern pike. It is assumed that an over-harvest of largemouth bass, northern pike, and larger bluegills may have contributed to an unbalanced, slow-growing panfish population because of a lack of predation. In order to enhance and maintain sport fishing opportunities for anglers using Fowler Lake, the Wisconsin DNR has stocked the Lake with walleyed pike, brown trout, and rainbow trout, as shown in Table 27. The Department plans to continue to stock Fowler Lake with walleyed pike at least every third year and with trout every year, depending on their availability from the Department's fish hatcheries.

Other Aquatic Wildlife

Although a field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the Fowler Lake study, it is possible, by polling naturalists and wildlife managers familiar with the area, to complete a list of amphibians, reptiles, birds, and mammals which may be expected to be found in the area under existing conditions. The technique used in compiling the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to exist, or have existed, in the two counties in which the Fowler Lake drainage area lies; associating these lists with the historic and remaining habitat areas as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the Fowler Lake area. The net result of the application of this technique is an appreciation of those species which were once present in the drainage area, those species which are still expected to be

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[3]*Personal communication, Edward R. Schumacher, Fish Manager, Wisconsin Department of Natural Resources, 1990.*

Table 28

AMPHIBIANS AND REPTILES LIKELY TO OCCUR IN THE FOWLER LAKE AREA

Scientific (family) and Common Name	Species Reduced or Dispersed with Full Area Urbanization	Species Lost with Full Area Urbanization
Amphibians		
Necturides		
Mudpuppy	X	- -
Ambystomatidae		
Blue-Spotted Salamander	- -	X
Eastern Tiger Salamander	X	- -
Salamandridae		
Central Newt	X	- -
Bufonidae		
American Toad	X	- -
Hylidae		
Northern Spring Peeper	- -	X
Eastern Gray Tree Frog	- -	X
Western Chorus Frog	X	- -
Ranidae		
Bull Frog	- -	X
Green Frog	X	- -
Northern Leopard Frog	- -	X
Reptiles		
Chelydridae		
Common Snapping Turtle	X	- -
Kinosternidae		
Musk Turtle (Stinkpot)	X	- -
Emydidae		
Painted Turtle	X	- -
Blanding's Turtle[a]	- -	X
Colubridae		
Northern Water Snake	X	- -
Northern Brown Snake	X	- -
Red-Bellied Snake	X	- -
Eastern Garter Snake	X	- -
Butler's Garter Snake	X	- -
Eastern Milk Snake	- -	X

[a]*Identified as threatened in Wisconsin.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

present under currently prevailing conditions, and those species which could be expected to be lost or gained as a result of urbanization within the area.

Amphibians and Reptiles: Although often unseen and unheard, amphibians and reptiles are vital components of the ecosystem in an environmental unit like the Fowler Lake drainage area. Examples of amphibians native to the area include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the Fowler Lake area. Table 28 presents a summary of the 14 amphibian and 16 reptile species normally expected to be present in the Fowler Lake area under present conditions and identifies those species most sensitive to urbanization.

Most amphibians and reptiles have definite habitat requirements which are adversely affected by advancing urban development as well as by certain agricultural land management practices. One of the major detrimental factors affecting the maintenance of amphibians in a changing environment is the destruction of breeding ponds. Frogs and salamanders often return to the same breeding site each year, continuing this behavior even if the breeding pond is not there and they cannot breed. If an area is being filled and developed, some ponds must be selectively retained if the amphibian populations are to be maintained. Toads are something of an exception among amphibians in this respect, in that they better adapt to the changes in environment which normally accompany urbanization.

Another major consideration in the preservation of both amphibians and reptiles is the maintenance of migration routes. Many species annually traverse distances of a mile or more from wintering sites to breeding sites to summer foraging grounds. The same pathways are used each year, and, if these species are to be maintained in an area, these pathways must be preserved. Protection of the environmental corridors can assist materially in this respect.

Certain amphibians and reptiles are particularly susceptible to changes in food sources brought about by urbanization. The eastern milk snake, for example, is very likely to be lost from the area over time because of a reduction in the number of rodents, their normal prey.

Birds: A large number of birds, ranging in size from large game birds to small songbirds, are found in the Fowler Lake area. Table 29 lists those birds that normally occur in the drainage area. Each bird is classified as to whether it breeds within the area, visits the area only during the annual migration periods, or visits the area only on rare occasions.

Game birds which are found in the Fowler Lake drainage area include the pheasants, woodcocks, snipe, rails, dabbling ducks, diving ducks, coots, and geese. Pheasants are upland game birds and provide some opportunities for hunting. Although the drainage area lies within the Mississippi flyway, opportunities for waterfowl hunting are now limited because of habitat deterioration and urbanization. The fall pheasant population within the drainage area is irregularly distributed, but fair populations live in the larger habitat areas. In areas adjacent to the direct drainage area that are actively hunted, harvests may reach 20 or more cocks per square mile. Wintering flocks may reach 50 to 100 birds. Flocks of that size require good cover interspersed with fields containing waste grain, such as corn, from farming operations. Supplemental feeding of such flocks will greatly aid in their survival during severe winters.

The Fowler Lake drainage area supports a significant population of waterfowl, including mallards and teals. Larger numbers move through the drainage area during migrations when most of the regional species may also be present. Other species of water-based birds within the area include herons, sandpipers, gulls, plovers, and terns. Most of the waterfowl, shorebirds, and wading birds may be expected to appear in, and adjacent to, Fowler Lake.

Because of the mixture of lowland and upland woodlots, wetlands, and agricultural lands still present in the area, along with the favorable summer climate, the area supports many other species of birds. Hawks and owls function as major rodent predators within the ecosystem. Swallows, whippoorwills, woodpeckers, nuthatches, and flycatchers, as well as several other species, serve as major insect predators. In addition to their ecological roles, birds such as robins, red-winged blackbirds, orioles, cardinals, kingfishers, and mourning doves serve as subjects for bird watchers and photographers.

Not all birds are viewed as an asset from an ecological, economic, or social point of view. With the advance of urbanization and, therefore, the loss of natural habitat, conditions have become less compatible for the more desirable bird species. English sparrows, starlings, grackles, and pigeons have replaced more desirable birds in certain areas because of their greater tolerance for urban conditions. The red-winged blackbird, in particular, is beginning to feel the impacts of urbanization as wetland areas, particularly cattail marshes, are drained or filled.

Table 29

BIRDS LIKELY TO OCCUR IN THE FOWLER LAKE AREA

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Podicipedidae			
Pied-Billed Grebe	--	--	X
Ardeidae			
American Bittern	--	--	X
Least Bittern	--	--	X
Great Blue Heron	--	--	X
Green-Backed Heron[a]	X?	--	X
Black-Crowned Night Heron	--	--	R
Yellow-Crowned Night Heron	--	--	R
Anatidae			
Tundra Swan	--	--	R
Canada Goose	--	--	X
Wood Duck[a]	X	--	X
Green-Winged Teal	--	--	X
American Black Duck	--	X	X
Gadwall	--	--	X
Mallard[b]	X	X	X
Northern Pintail	--	--	X
Blue-Winged Teal[a]	X	--	X
Northern Shoveler	--	--	X
American Widgeon	--	--	X
Redhead	--	--	X
Ring-Necked Duck	--	--	X
Canvasback	--	--	X
Lesser Scaup	--	--	X
Common Goldeneye	--	--	X
Bufflehead	--	--	X
Hooded Merganser	--	--	X
Common Merganser	--	--	X
Cathartidae			
Turkey Vulture	--	--	X
Accipitridae			
Osprey	--	--	R(E)
Bald Eagle	--	--	R(E)
Northern Harrier	--	--	R
Sharp-Shinned Hawk	--	--	X
Cooper's Hawk	--	--	X(T)
Northern Goshawk	--	--	R
Red-Shouldered Hawk	--	--	R(T)
Broad-Winged Hawk	--	--	X
Red-Tailed Hawk[a]	X	X	X
Rough-Legged Hawk	--	X	X
Falconidae			
American Kestrel[b]	X	X	X
Merlin	--	--	R
Peregrine Falcon	--	--	R(E)
Phasianidae			
Ring-Necked Pheasant[b] (introduced)	X	X	NA
Rallidae			
Virginia Rail[a]	R	--	X
Sora[a]	R	--	X
Common Moorhen	--	--	X
American Coot	R	--	X
Gruidae			
Sandhill Crane	--	--	R

Table 29 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Charadriidae			
Semipalmated Plover	--	--	X
Killdeer[b]	X	--	X
Scolopacidae			
Greater Yellowlegs	--	--	X
Lesser Yellowlegs	--	--	X
Solitary Sandpiper	--	--	X
Spotted Sandpiper[b]	X	--	X
Semipalmated Sandpiper	--	--	X
Pectoral Sandpiper	--	--	X
Dunlin	--	--	X
Common Snipe	R	R	X
American Woodcock[a]	X	--	X
Wilson's Phalarope	--	--	X
Laridae			
Ring-Billed Gull	--	X	X
Herring Gull	--	X	X
Caspian Tern	--	--	R
Common Tern	--	--	R(E)
Forster's Tern	--	--	R(E)
Black Tern	--	--	R
Columbidae			
Rock Dove	X	X	NA
Mourning Dove	X	X	X
Cuculidae			
Black-Billed Cuckoo[a]	X	--	X
Yellow-Billed Cuckoo[a]	--	--	X
Stirigidae			
Eastern Screech Owl[b]	X	X	NA
Great Horned Owl[a]	X	X	NA
Snowy Owl	--	R	R
Long-Eared Owl	--	R	R
Short-Eared Owl	--	--	R
Northern Saw-Whet Owl	--	--	X
Common Barn Owl	--	--	R(E)
Caprimulgidae			
Common Nighthawk	X	--	X
Whippoorwill	--	--	X
Apodidae			
Chimney Swift	X	--	X
Trochilidae			
Ruby-Throated Hummingbird	X	--	X
Alcedinidae			
Belted Kingfisher[b]	X	--	X
Picidae			
Red-Headed Woodpecker[b]	X	R	X
Red-Bellied Woodpecker[b]	R	X	NA
Yellow-Bellied Sapsucker	--	R	X
Downy Woodpecker[b]	X	X	NA
Hairy Woodpecker[b]	X	X	NA
Northern Flicker[b]	X	R	X
Tyrannidae			
Olive-Sided Flycatcher	--	--	X
Eastern Wood-Ewee[b]	R?	--	X
Yellow-Bellied Flycatcher	--	--	X
Acadian Flycatcher	--	--	X
Alder Flycatcher	--	--	X

Table 29 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Tyrannidae (continued)			
Willow Flycatcher[a]	X	- -	X
Least Flycatcher	- -	- -	X
Eastern Phoebe[a]	X	- -	X
Great Crested Flycatcher[b]	X	- -	X
Eastern Kingbird[b]	X	- -	X
Alaudidae			
Horned Lark[a]	- -	X	X
Hirundinidae			
Purple Martin[b]	X	- -	X
Tree Swallow[b]	X	- -	X
Northern Rough-Winged Swallow	R?	- -	X
Bank Swallow[a]	R?	- -	X
Cliff Swallow[a]	X	- -	X
Barn Swallow[a]	X	- -	X
Corvidae			
Blue Jay	X	X	X
American Crow	X	X	X
Paridae			
Black-Capped Chickadee[b]	X	X	X
Tufted Titmouse	R?	R	NA
Sittidae			
Red-Breasted Nuthatch	- -	R	X
White-Breasted Nuthatch	R	X	NA
Certhiidae			
Brown Creeper	- -	X	X
Troglodytidae			
Carolina Wren	- -	- -	R
House Wren	X	- -	X
Winter Wren	- -	- -	X
Sedge Wren[a]	R	- -	X
Marsh Wren[a]	R	- -	X
Musicapidae			
Golden-Crowned Kinglet	- -	X?	X
Ruby-Crowned Kinglet	- -	- -	X
Blue-Gray Gnatcatcher[a]	R	- -	X
Eastern Bluebird[a]	R	- -	X
Veery[a]	R?	- -	X
Gray-Cheeked Thrush	- -	- -	X
Swainson's Thrush	- -	- -	X
Hermit Thrush	- -	- -	X
Wood Thrush[b]	R?	- -	X
American Robin	X	X	X
Mimidae			
Gray Catbird	X	- -	X
Northern Mockingbird	- -	R	R
Brown Thrasher[b]	X	- -	X
Motacillidae			
Water Pipit	- -	- -	X
Bombycillidae			
Bohemian Waxwing	- -	R	- -
Cedar Waxwing	X	X	X
Laniidae			
Northern Shrike	- -	R	X
Sturnidae			
European Starling	X	X	X

Table 29 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Vireonidae			
White-Eyed Vireo	--	--	R?
Solitary Vireo	--	--	X
Yellow-Throated Vireo[a]	--	--	X
Warbling Vireo	X	--	X
Philadelphia Vireo	--	--	X
Red-Eyed Vireo[b]	R?	--	X
Emberizidae			
Blue-Winged Warbler[a]	R	--	X
Golden-Winged Warbler	--	--	X
Tennessee Warbler	--	--	X
Orange-Crowned Warbler	--	--	X
Nashville Warbler	--	--	X
Northern Parula	--	--	X
Yellow Warbler[b]	X	--	X
Chestnut-Sided Warbler[a]	R?	--	X
Magnolia Warbler	--	--	X
Cape May Warbler	--	--	X
Black-Throated Blue Warbler	--	--	X
Yellow-Rumped Warbler	--	--	X
Black-Throated Green Warbler	--	--	X
Blackburnian Warbler	--	--	X
Pine Warbler	--	--	X
Palm Warbler	--	--	X
Bay-Breasted Warbler	--	--	X
Blackpoll Warbler	--	--	X
Cerulean Warbler	--	--	X
Black-and-White Warbler[a]	R?	--	X
American Redstart[a]	R?	--	X
Prothonotary Warbler	--	--	R
Ovenbird[a]	R	--	X
Northern Water Thrush	--	--	X
Louisiana Water Thrush	--	--	R
Kentucky Warbler	--	--	R
Connecticut Warbler	--	--	X
Mourning Warbler[a]	R	--	X
Common Yellowthroat[b]	X	--	X
Hooded Warbler	--	--	X
Wilson's Warbler	--	--	X
Canada Warbler[a]	R?	--	X
Yellow-Breasted Chat	--	--	R
Scarlet Tanager[a]	--	--	X
Northern Cardinal	X	X	NA
Rose-Breasted Grosbeak[b]	X	--	X
Indigo Bunting[b]	X	--	X
Dickcissel	--	--	R
Rufous-Sided Towhee[a]	X?	--	X
American Tree Sparrow	--	X	X
Chipping Sparrow	X	--	X
Clay-Colored Sparrow	--	--	X
Field Sparrow[a]	X	--	X
Vesper Sparrow[a]	--	--	X
Savannah Sparrow[a]	X	--	X
Grasshopper Sparrow	--	--	X
Henslow's Sparrow[a]	X?	--	X
LeConte's Sparrow	--	--	R
Fox Sparrow	--	R	X

Table 29 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Emberizidae (continued)			
Song Sparrow[b]	X	R	X
Lincoln's Sparrow	- -	- -	X
Swamp Sparrow[a]	X	R	X
White-Throated Sparrow	- -	R	X
White-Crowned Sparrow	- -	- -	X
Harris' Sparrow	- -	- -	R
Dark-Eyed Junco	- -	X	X
Lapland Longspur	- -	R?	X
Snow Bunting	- -	R?	X
Bobolink[a]	R?	- -	X
Red-Winged Blackbird[b]	X	X	X
Eastern Meadowlark[a]	X	R	X
Western Meadowlark[a]	R?	- -	X
Yellow-Headed Blackbird	- -	- -	X
Rusty Blackbird	- -	R	X
Brewer's Blackbird	- -	- -	X
Common Grackle	X	X	X
Brown-Headed Cowbird[b]	X	X	X
Orchard Oriole	R	- -	R
Northern Oriole	X	- -	X
Fringillidae			
Pine Grosbeak	- -	R	- -
Purple Finch	- -	X	X
Red Crossbill	- -	R?	R
White-Winged Crossbill	- -	R	R
Common Redpoll	- -	X	X
Pine Siskin	- -	X	X
American Goldfinch	X	X	X
Evening Grosbeak	- -	R	X
Ploceidae			
House Sparrow	X	X	NA

NOTE: Breeding—Nesting species (nonnesting species present in summer are not included)
Wintering—Present January-February
Migrant—Transient spring and/or fall

X - present, not rare
R - rare
V - vagrant (not regularly occurring in Southeastern Wisconsin)
NA - not applicable
(T) - threatened species in Wisconsin
(E) - endangered species in Wisconsin (bald eagle also U. S. threatened, peregrine falcon also U. S. endangered)
? - seasonal status uncertain

[a]*Species lost as breeding birds with full watershed urbanization.*

[b]*Species reduced in numbers as breeding birds with full watershed urbanization.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Mammals: A variety of mammals, ranging in size from large animals like the northern white-tailed deer to small animals like the cinereous shrew, is found in the Fowler Lake area. Table 30 lists 38 mammals whose ranges are known to extend into the area.

The larger mammals that are still fairly common in the less densely populated areas of the drainage area include the white-tailed deer, cottontail rabbits, gray squirrels, muskrats, minks, weasels, raccoons, red foxes, skunks, and opossums. The first three are often considered game mammals, while the rest are classified as fur-bearing mammals. White-tailed deer are generally restricted to the larger wooded areas, the open meadows and croplands adjacent to the woodlots, and the shrub swamps. Human and deer populations living in close proximity are incompatible. When deer wander, or are forced, into residential, commercial, or industrial areas, they typically exhibit extreme panic, running wildly and presenting a threat to people, property, and themselves. Foraging deer sometimes cause damage to gardens or ornamental trees, croplands, and orchards. Deer-automobile collisions often occur on the fringes of urban areas, while hunters stalking the animals in urbanizing areas create yet another hazard in such fringe areas.

Cottontail rabbits are abundant throughout the drainage area, even in urbanized areas. Rabbit hunting may be possible in some areas, although many people enjoy simply observing the activities of this mammal. Gray squirrels abound in the area. The gray squirrel is found primarily in woodlots and wooded residential areas. Gray squirrels require trees of some maturity because natural cavities in such trees are needed both for the rearing of young and for winter protection.

Muskrats may be attracted to any significant water area, including Fowler Lake, wetlands, small ponds, creeks, and drainage ditches, all of which may provide suitable habitat. The familiar muskrat house contributes a certain amount of interest to the landscape and is often used by other wildlife. Waterfowl may make use of the houses for nesting and minks and raccoons occasionally use muskrat houses as dens. Preservation and improvement of muskrat habitat could, therefore, benefit waterfowl, minks, and raccoons. The Fowler Lake area may still provide the potential for trapping on a limited basis in that a 40-acre marsh can provide a yield of over 100 muskrats in a year; on the other

Table 30

MAMMALS OF THE FOWLER LAKE AREA

Didelphidae
Common Opossum
Soricidae
Cinereous Shrew
Short-Tailed Shrew
Vespertilionidae
Little Brown Bat
Eastern Long-Earred Bat
Silver-Haired Bat
Georgian Bat
Big Brown Bat
Red Bat
Hoary Bat
Leporidae
Mearns's Cottontail Rabbit
Sciuridae
Woodchuck
Striped Ground Squirrel
Eastern Chipmunk
Gray Squirrel
Castoridae
Beaver
Cricetidae
Woodland Deer Mouse
Prairie Deer Mouse
Northern White-Footed Mouse
Meadow Vole
Muskrat
Muridae
Norway Rat
House Mouse
Zapodidae
Hudsonian Meadow Jumping Mouse
Canidae
Coyote
Red Fox
Procyonidae
Raccoon
Mustelidae
Long-Tailed Weasel
Mink
Northern Plains Skunk
Otter (occasional visitor)
Cervidae
White-Tailed Deer

Source: H. T. Jackson, Mammals of Wisconsin, 1961, and SEWRPC.

hand, wildlife traps particularly in urbanized areas, such as the Fowler Lake area, can present a danger to domestic pets and children. Muskrats and cottontail rabbits are probably the most abundant and widely distributed fur-bearing mammals in and near the area.

The raccoon is associated with the woodland areas. Much of the raccoon's food, however, is water-based, so it makes considerable, if transient, use of wetland areas. Scavenging raccoons can become pests in the wooded residential environments of the urban fringe.

The red fox is more characteristic of mixed habitat and farmland areas. Most people are tolerant of the fox because of its aesthetic appeal while others, less well-informed, consider it a threat to other wildlife.

Skunks and opossums are common furbearers in this area. Both of these mammals inhabit woodland areas bordering farmlands and urban fringes and venture into wetlands in search of food. Skunks and opossums tend to become inactive in cold weather, although neither is a true hibernator.

Small mammals fairly common in the area include the short-tailed shrew, striped ground squirrel or gopher, meadow vole, white-footed mouse, and little brown bat. These small mammals, with the exception of the bats, are commonly associated with meadows, fencerows, and utility and transportation rights-of-way. People view their importance differently depending on whether they consider these mammals to be insect predators and food sources for larger mammals and such raptors as hawks and owls, or pests in croplands, gardens, and lawns.

Bats, despite their appearance and nocturnal habits, have a very positive impact on the urban environment in that they are major insect predators, often consuming one-third of their weight in insects in one night. With the destruction of woodland and wetland habitats through urban development, the more adaptable species of these flying mammals may relocate within the areas of urban development where they are either viewed as a boon or a pest.

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

WILDLIFE HABITAT AND RESOURCES

Wildlife habitat areas remaining in the Region were inventoried by the Wisconsin DNR and the Southeastern Wisconsin Regional Planning Commission in 1985. The five major criteria used to determine the value of these wildlife habitat areas are listed below:

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

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

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

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

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

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

As shown on Map 24, approximately 355 acres, or 22 percent, of the direct drainage area to Fowler Lake, were identified as wildlife habitat. About 151 acres, or 10 percent, of the direct drainage area were classified as Class I habitat; 156 acres, or 10 percent, of the direct drainage area, were classified as Class II habitat; and 47.5 acres, or 3 percent, of the direct drainage area, were classified as Class III habitat.

WETLANDS

Definition and Occurrence

Wetlands are defined by the U. S. Army Corps of Engineers as areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. This definition is also used by the Regional Planning Commission. The Wisconsin DNR defines wetlands as areas where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which have soils indicative of wet conditions. Wetlands in Southeastern Wisconsin are classified predominantly as deep marsh, shallow marsh, southern sedge meadow, fresh (wet) meadow, shrub carr, alder thickets, low prairie, fens, bogs, southern wet- and wet-mesic hardwood forest, and conifer swamp.

Wetlands form an important part of the landscape in and adjacent to Fowler Lake in that they perform an important set of natural functions that make them ecologically and environmentally invaluable resources. These functions may be summarized as follows:

1. Wetlands affect the quality of water. The aquatic plants which grow in wetlands change inorganic nutrients, such as phosphorus and nitrogen, into organic material, storing it in their leaves and in peat (the plant remains). In addition, the stems, leaves, and roots of these plants slow the flow of water through the wetlands, allowing silt and other sediments, with their attached nutrients and other water pollutants, to settle out, helping to protect downstream or offshore resources from siltation and pollution.

2. Wetlands influence the quantity of water. Wetlands provide water during periods of drought and hold it back during periods of wet weather, thereby stabilizing streamflows and controlling downstream flooding. At a depth of 12 inches, one acre of marsh is capable of holding more than 300,000 gallons of water, helping to protect downstream areas from flooding.

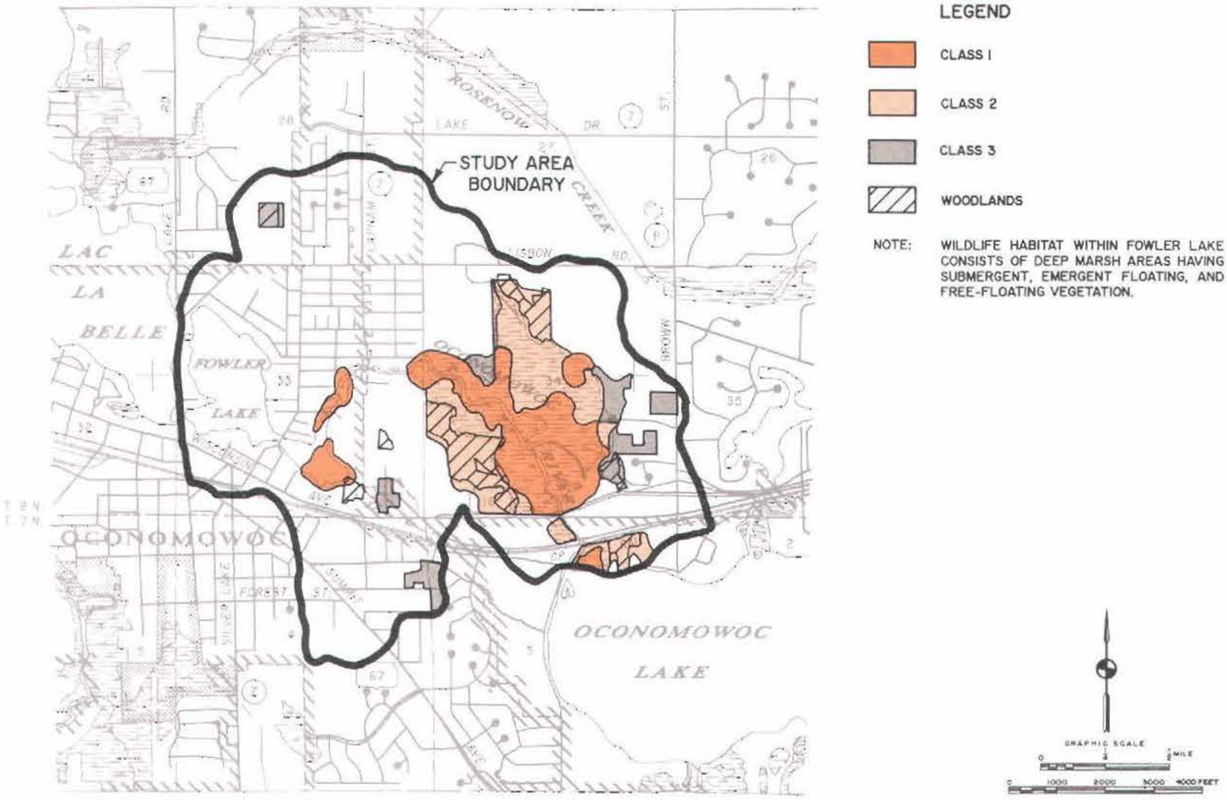
3. Wetlands located along the shorelines of lakes and streams help protect those shorelines from erosion.

4. Wetlands may serve as groundwater discharge and recharge areas.

5. Wetlands are important resources for overall ecological health and diversity, providing essential breeding and feeding

Map 24

WILDLIFE HABITAT AREAS WITHIN THE FOWLER LAKE STUDY AREA: 1990



Source: SEWRPC.

grounds, shelter, and escape cover for many forms of fish and wildlife. The water present in a wetland is attractive to upland birds and other animals, giving wetlands economic, recreational, research, and educational values. Wetlands support activities such as hunting, trapping, and fishing and add aesthetic value to the community.

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

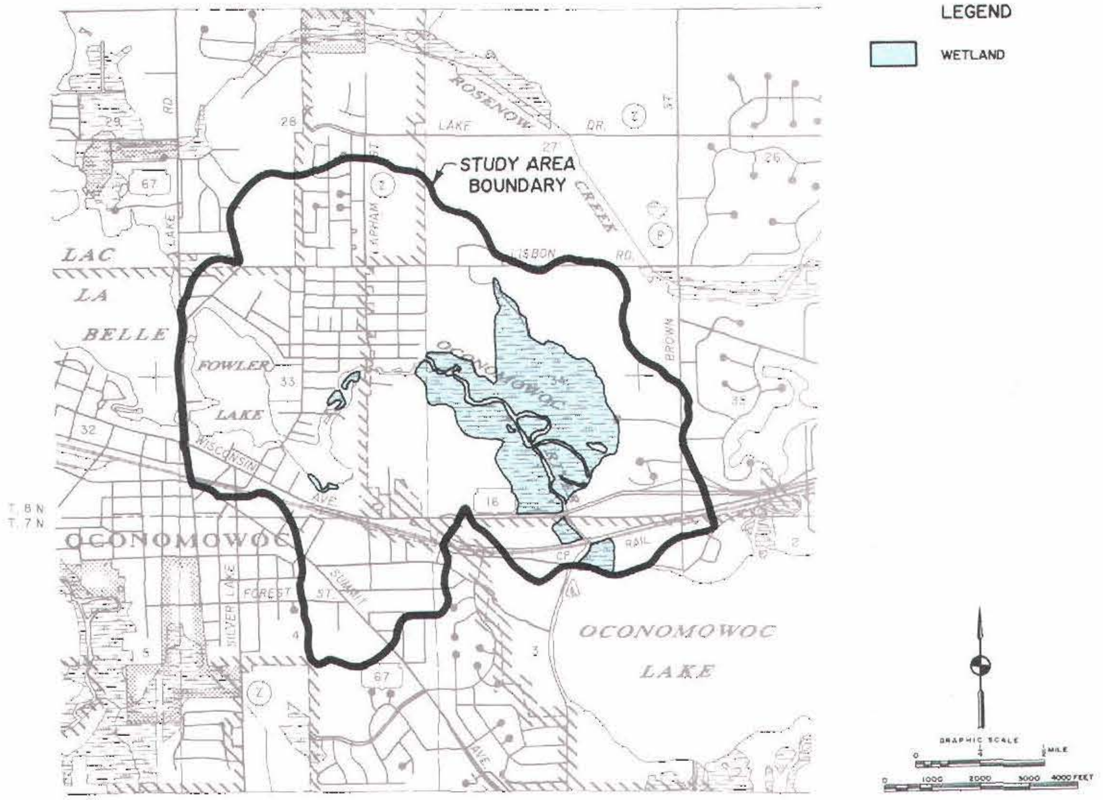
From 1985 to 1990, the wetlands within the Fowler Lake watershed were inventoried and mapped by the Southeastern Wisconsin Regional Planning Commission under contract to the Wisconsin DNR, with the results shown on Map 25. In 1985, wetlands covered about 226 acres, or 14 percent, of the Fowler Lake direct drainage area. This distribution should remain relatively constant, as shown in Tables 5 and 6, if regional plan recommendations are followed.

Purple Loosestrife

Purple loosestrife, Lythrum salicaria, L. virgatum, and their hybrids, are nonnative plant species which invade wetland areas, often displacing native vegetation and forming monotypic stands that diminish vegetative diversity and degrade wetland habitats. A visit to the Fowler Lake site in August 1991 found purple

Map 25

EXISTING WETLANDS IN THE FOWLER LAKE STUDY AREA



Source: SEWRPC.

loosestrife growing profusely along part of the shoreline, particularly along the shoreline in the southeastern bay, as shown on Map 26.

Purple loosestrife is a declared noxious weed in the State of Wisconsin and the sale, distribution, planting, and cultivation of the plant is prohibited under S.66.955, Wisconsin Statutes. Many of the counties in the Region are heavily infested with the plant and stands are expanding faster than control programs can eradicate them. Recommended control techniques are discussed in Chapter VII of this report; manual or chemical controls are the only methods found to be effective in controlling this plant.

WOODLANDS

Woodlands are defined by the Regional Planning Commission as those areas containing a minimum of 17 trees per acre with a diameter of at least four inches at breast height (4.5 feet above the ground).[4] The woodlands are classified as dry, dry-mesic, mesic, wet-mesic, wet hardwood, and conifer swamp forests. The last three are also considered wetlands and as such have been discussed above. In the Fowler Lake direct drainage area, shown on Map 24, the major tree species include the black willow (Salix nigra), cottonwood (Populus deltoides), green ash (Fraxinus pennsylvanica), silver maple (Acer saccharinum), American elm (Ulmus americana), basswood (Tilia americana), northern red oak (Quercus borealis), and shagbark hickory (Carya ovata). Other upland species such as the white oak (Quercus alba), burr oak (Quercus macrocarpa), and black cherry (Prunus serotina), occur in the direct drainage area as well.

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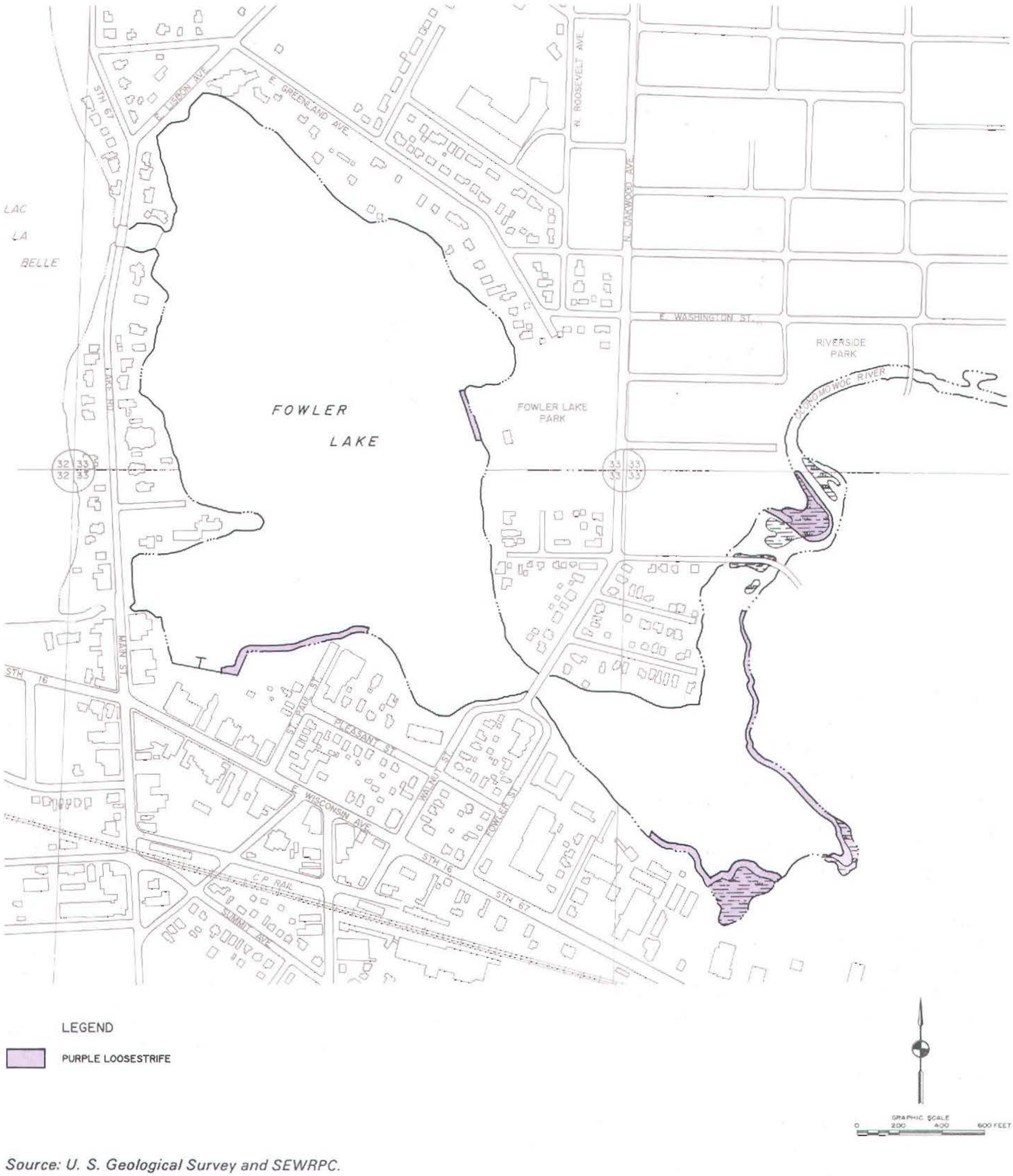
[4]*SEWRPC Technical Record, Vol. 4, No. 2, March 1981.*

Map 26

GENERAL DISTRIBUTION OF PURPLE LOOSESTRIFE IN FOWLER LAKE: AUGUST 1991



Source: U. S. Geological Survey and SEWRPC.

Woodland acreage should remain stable in the Fowler Lake direct drainage area for the foreseeable future if the recommendations regional plan are followed.

ENVIRONMENTAL CORRIDORS

The Environmental Corridor Concept

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

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

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

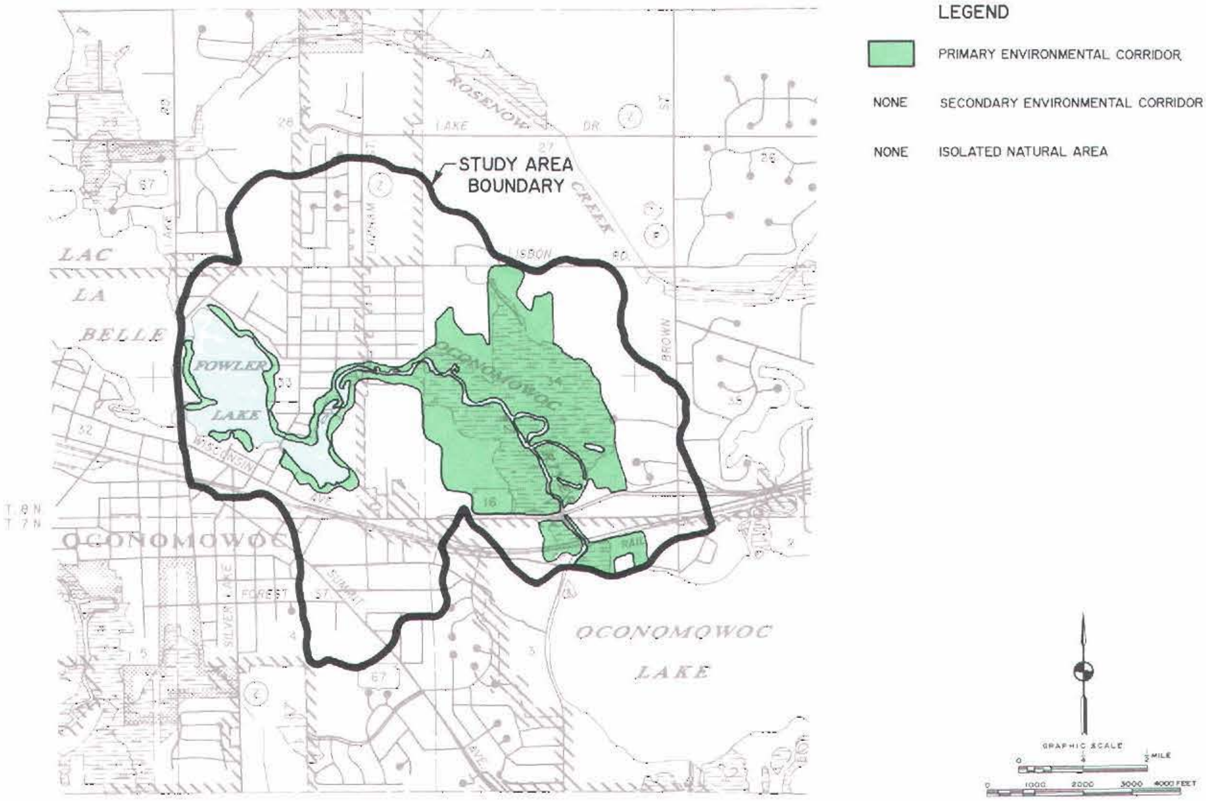
Primary environmental corridors were first identified within the Region in 1963 as part of the original regional land use planning effort of the Commission and were subsequently refined under the Commission watershed studies and regional park and open space planning programs. The primary environmental corridors in Southeastern Wisconsin generally lie along major stream valleys and around major Lakes and contain almost all the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all the major bodies of surface water and related undeveloped floodlands and shorelands.

Primary Environmental Corridors

Primary environmental corridors in the Fowler Lake study area are shown on Map 27. About 350 acres, or 22 percent, of the study area are identified as primary environmental corridor. These areas consist of Fowler Lake itself, the

Map 27

ENVIRONMENTALLY VALUABLE AREAS IN THE FOWLER LAKE STUDY AREA



Source: Wisconsin Department of Natural Resources and SEWRPC.

large wetland complex located east of the Lake, the Oconomowoc River, and the undeveloped floodlands and shorelands.

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

In the Fowler Lake area, the undeveloped river banks and lakeshores are immediate candidates for protection as environmental corridors. Many of these areas are already in public ownership, including the six public parks on the lakeshore. Of the areas not already publicly owned, the inlet area east of N. Oakwood Avenue has been identified by the Commission and Wisconsin DNR as perhaps the most sensitive area, in need of greatest protection. It is essentially a large wetland filter at the headwaters of the Lake. It is also the area where the invasive purple loosestrife is most prevalent and where habitat restoration (loosestrife control, bird-nesting facilities, litter cleanup and removal) would be most effective. The area could also be brought into the existing park system by providing a boardwalk around the wetland, similar to the existing structure on the western shore of the main basin, and some form of interpretive center or overlook.

RECREATIONAL USE

Existing Public Parks and Recreational Facilities

Fowler Lake, lying in the center of an urban area, provides an ideal setting for the provision of parks and open space sites and facilities. There are six publicly owned parks along the Fowler Lake shoreline, including the Boardwalk and Gazebo, Fowler Lake Park, Lisbon Road Park, Midway Area, Oakwood Avenue Terrace, and the St. Paul Street Access. These sites, shown on Map 28, occupy approximately 2,200 linear feet, or 15 percent, of the shoreline of Fowler Lake. Existing recreational facilities in the Fowler Lake vicinity are also shown on Map 28.

Fowler Lake Park is a popular 10-acre neighborhood park on the eastern shore of Fowler Lake in the north-central portion of the City of Oconomowoc. Existing facilities include a basketball court, horseshoe pits, tennis courts, picnic area, playground, and a shoreline fishing area. The St. Paul Street Access is a one-acre lake-access site on the south shore of Fowler Lake in the central portion of the City, providing a boat-launching area and service area for the Lake District's aquatic plant harvester. In addition, the surfaced walkways surrounding, and, at times, bordering, Fowler Lake and the Boardwalk and Gazebo located on the southwest shore of the Lake provide opportunities for recreational walking, jogging, and viewing the Lake. These areas were crowded during the August 1992 site visit. The Gazebo is popular with persons of all ages. The N. Lake Drive and Lisbon Road parks are popular angling venues.

Water-based outdoor recreational activities on Fowler Lake include boating, fishing, swimming, and other active and passive recreational pursuits. Because of its relatively small size, Fowler Lake receives little powerboat and sailboat use, although a few of these craft were moored along the shore. It does, however, receive considerable small fishing boat and canoe use. A boat survey conducted on October 8, 1986, indicated that 42 boats were either moored in the water or stored on land. Of this total, 18 were small fishing boats or rowboats, 15 were canoes, and nine were classified as other types of boats. Importantly, eight of the boats observed, or about 20 percent, were made available their use to residents of the two condominium complexes on the Lake. Similar numbers of craft were subsequently observed, during two further site visits in August 1991 and 1992. During these latter surveys, fewer small boats were recorded; the most popular types of vessel were powerboats and pontoons. It is estimated that about one boat per riparian property owner is available for use on the Lake. Canoeists paddling down the Oconomowoc River are also known to use Fowler Lake.

Seasonal community and private events and activities take advantage of the aesthetic qualities of the Lake, including the annual City of Oconomowoc Festival of the Arts, a special boating event called "Venetian Night," and numerous weddings and celebrations which use the Lake, Boardwalk, and Gazebo site as a focal point for picture taking. Ice fishing is a particularly popular pastime on Fowler Lake. A large number of special events, including five ice fishing jamborees, are held during the winter. In addition, a winter carnival is held annually, using the Lake for speed skating, snowmobiling, and a variety of other recreational activities.

It is important to note that the provision of park and open space sites in the Fowler Lake study area should be guided, to a large extent, by the recommendations contained in SEWRPC Community Assistance Planning Report No. 72, A Park and Open Space Plan for the City of Oconomowoc, November 1987. The purpose of that plan is to guide the preservation, acquisition, and development of land for park, outdoor recreation, and related open space purposes and to protect and enhance the underlying and sustaining natural resource base of the City. With respect to the Fowler Lake direct drainage area, including the lands along the Oconomowoc River and the shoreline of Fowler Lake, the plan recommends the maintenance of existing park and open space sites in the area, the acquisition of the undeveloped land in the primary environmental corridor along the main stem of the Oconomowoc River as part of the proposed Oconomowoc River Parkway, and the acquisition and development of one proposed new neighborhood park along the main stem of the Oconomowoc River. In addition, the plan recommends that, as additional lands along the shore of Fowler Lake become available, the City should consider the acquisition of such lands in order to provide additional lake-access and outdoor recreational opportunities. Implementa-

Map 28

PUBLICLY OWNED PARKS AND RECREATIONAL FACILITIES IN THE FOWLER LAKE STUDY AREA: 1990

Source: SEWRPC.

Table 31

RECREATIONAL RATING OF FOWLER LAKE: 1991

Space: Total Area—99 acres	Total Shore Length—1.7 miles	
Ratio of Total Area to Total Shore Length: 1.37		
Quality (18 maximum points for each item)		
Fish:		
___ 9 High production	X 6 Medium production	___ 3 Low production
___ 9 No problems	X 6 Modest problems such as infrequent winterkill, small rough fish problems	___ 3 Frequent and overbearing problems such as winterkill, carp, excessive fertility
Swimming:		
___ 6 Extensive sand or gravel substrate (75 percent or more)	___ 4 Moderate sand or gravel substrate (25 to 50 percent)	X 2 Minor sand or gravel substrate (less than 25 percent)
X 6 Clean water	___ 4 Moderately clean water	___ 2 Turbid or darkly stained water
___ 6 No algae or weed problems	___ 4 Moderate algae or weed problems	X 2 Frequent or severe algae or weed problems
Boating:		
___ 6 Adequate water depths (75 percent of basin more than five feet deep)	X 4 Marginally adequate water depths (50 to 75 percent of basin more than five feet deep)	___ 2 Inadequate depths (less than 50 percent of basin more than five feet deep)
___ 6 Adequate size for extended boating (more than 1,000 acres)	___ 4 Adequate size for some boating (200 to 1,000 acres)	X 2 Limit of boating challenge and space (less than 200 acres)
___ 6 Good water quality	X 4 Some inhibiting factors such as weedy bays, algae blooms, etc.	___ 2 Overwhelming inhibiting factors such as weed beds throughout
Aesthetics:		
___ 6 Existence of 25 percent or more wild shore	X 4 Less than 25 percent wild shore	___ 2 No wild shore
___ 6 Varied landscape	X 4 Moderately varied	___ 2 Unvaried landscape
X 6 Few nuisances such as excessive algae carp, etc.	___ 4 Moderate nuisance conditions	___ 2 High nuisance condition
Total Quality Rating: 46 out of a possible 72		

Source: Wisconsin Department of Natural Resources and SEWRPC.

tion of the recommendations set forth in aforementioned park and open space plan will help to achieve one of the previously discussed objectives of this study, the improvement of the aesthetic characteristics of Fowler Lake and enhancement of opportunities for water-based recreational activities.

Wisconsin Department of Natural Resources Recreational Rating

A recreational rating technique has been developed by the Wisconsin DNR to characterize the recreational value of inland lakes. As shown in Table 31, Fowler Lake received 46 out of the possible 72 points, indicating that moderately diverse recreational opportunities are provided by the Lake. Favorable features include good quality water and a healthy fishery. Boating is limited by the size of the Lake and aquatic macrophyte growth. In general, Fowler Lake provides good opportunities for a variety of outdoor recreational activities, particularly fishing, swimming, and aesthetic enjoyment. The natural resource features associated with Fowler Lake provide an aesthetically pleasing setting for an attractive urban environment which encourages public participation in outdoor recreation activities. In order to assure that Fowler Lake will continue to provide such recreational opportunities, the resource values of the Lake must be protected.

SUMMARY

Fowler Lake is an urban lake situated in the downtown area of the City of Oconomowoc. While the Lake has many of the features of a typical urban lake, hardened shorelines, encircling development, heavy recreational use pressures, it has avoided many of the more severe water quality and environmental impacts characteristic of this type of water body and still presents a relatively unblemished vista for the downtown observer. It is this setting that makes the continued maintenance of the environmental quality of the Lake particularly important.

Despite the high quality of its waters, the Lake does suffer from an excessive abundance of aquatic plants, predominantly the nuisance species Chara, Myriophyllum (milfoil), and Ceratophyllum (coontail). Because of the relative clarity of the lake water, plant growth extends outward from the shore to the 22-foot depth contour, impacting almost 85 percent of the water's surface (Table 1). These aquatic plant growths have historically been managed using a combination of chemical and mechanical control. Chemical controls, previously effected with sodium arsenite and more recently with Cutrine Plus and various synthetic organic herbicides (Diquat, Aquathol, Hydrothol, and 2,4-D) (see Table 24), are applied in late spring, with a possible follow-up treatment in late summer. Mechanical controls are effected with an Aquamarine H5-200 harvester.

The Lake supports a vigorous, well-balanced, fish community, including sport fish, panfish, and rough fish that are heavily sought by anglers. Walleyed pike and trout are stocked Wisconsin DNR.

Other aquatic life and wildlife in the direct drainage area of the Lake include amphibians and reptiles (frogs, toads, turtles, and snakes), birds (including migratory waterfowl, raptors, and songbirds), and small and large mammals (mice, rabbits, squirrels, fox, skunks, and deer). While many of the wetland habitats frequented by many of these animals are expected to remain intact, the predominantly hardwood forest woodlands that house much of the terrestrial fauna are prime areas for further urban residential and recreational development (Tables 6 and 7). Indeed, the wetlands themselves are being heavily encroached upon in places by invasive purple loosestrife and will require timely intervention to preserve their structure and function from this threat. Nevertheless, the Fowler Lake direct drainage area provides an adequate refuge for a healthy and diverse fauna.

The incorporation of much of the shorelands into the Oconomowoc River environmental corridor and the adoption of a park and open space plan by the City of Oconomowoc has done much to preserve and maintain the relatively high quality environment at Fowler Lake. The existing zoning protection applied to the environmental corridor lands should be retained and the existing public lands in the Oconomowoc park system should be expanded to extend this protection into the inlet area east of N. Oakwood Avenue. Given the present use of the Fowler Lake Park and other City amenities surrounding Fowler Lake, any additions to the public open space system are likely to be well used, especially for such more passive pursuits as picnicking, playing, walking, and scenic viewing. Fishing is also a popular pastime at Fowler Lake, reinforcing the relatively high score which the Lake received during a recent Wisconsin DNR recreational rating exercise (Table 31).

Chapter VI

CURRENT WATER USES AND WATER USE OBJECTIVES

INTRODUCTION

Effective lake management programs must integrate institutional concerns, as expressed by the public, resource administrators, and elected decision makers, with the uses to which the resource is put, balancing the whole against mandated and achievable standards and public requirements. Generally, it is the latter issues, reconciling public demands against what is achievable within the limits of technology and finance, that generate most debate. Nearly all major lakes in this Region serve multiple purposes, ranging from recreation to stormwater management. Recreational uses range from noncontact, passive recreation such as picnicking and walking, to full-contact, active recreation such as swimming and water skiing. Stormwater management tends to make use of surface water bodies as discharge areas. Water use objectives and supporting water quality standards have been adopted by the Southeastern Wisconsin Regional Planning Commission as set forth in the adopted regional water quality management plan[1] for all major lakes and streams in the Region. The current water uses as well as the water use objectives and supporting water quality standards for Fowler Lake are discussed in this chapter.

WATER USES

Chapter V of this report presented information on the uses of Fowler Lake. Boating, swimming, and fishing figure strongly in these uses, as shown in Table 32. While few boats were observed using Fowler Lake during the user surveys, numerous craft were either moored or trailered on the shore. Over 40 such vessels were observed, most of which were either powerboats or pontoons. Curiously, during the 1992 field inspection, it appeared that Lac La Belle was used primarily for pleasure boating while Fowler Lake was used primarily for fishing. This allocation may be attributed, at least in part, to Lac La Belle's greater surface area which is more conducive to boat traffic. Nonetheless, the scope of uses engaged in on Fowler Lake is sufficiently broad to warrant the recommended use objectives of full recreational use and the support of a healthy warmwater fishery.[2]

WATER QUALITY STANDARDS

The water quality standards supporting the warmwater fishery and full recreation use objectives are set forth in Table 33. Standards are recommended for temperature, pH, dissolved oxygen, fecal coliforms, residual chlorine, un-ionized ammonia nitrogen, and total phosphorus. These standards apply to the epilimnion of the lakes and to streams. The total phosphorus standard applies to spring turnover concentrations measured in the surface waters. Such contaminants as oil, debris, scum; or odor, taste, and color-producing substances; and toxins are not permitted in concentrations harmful to the public or to aquatic life as set forth in Chapter NR 103 of the Wisconsin Administrative Code.

The adoption of these standards was intended to specify conditions in the waterways concerned that mitigated against excessive macrophyte and algal growths and promoted all forms of recreational use, including angling, in these waters. Failure to implement management measures in the direct drainage area and in the Oconomowoc River watershed upstream of Fowler Lake may be expected to result in continued excessive nutrient and pollutant loadings and to a continued decline in water quality and lake use potential. Implementation of remedial measures in the Oconomowoc River watershed upstream of Fowler Lake is especially important, given the short water residence time in Fowler Lake (Figure 1) and the major role of the river water in determining the nutrient and pollutant loading on the Lake (Table 17).

Complete implementation of the plan recommendations, including the watershed management

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[1]*SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, September 1978; Volume Two, Alternative Plans, February 1979; Volume Three, Recommended Plan, June 1979.*

[2]*Op. cit. Volume Two, Map 1, p. 14.*

Table 32

RECREATIONAL USE SURVEY OF FOWLER LAKE: 1991, 1992

Boating Activity	Participants					
	Weekday		Weekend		Weekday	
	August 13, 1991		August 31, 1991		August 6, 1992	
	2:00 p.m.-2:15 p.m.	3:30 p.m.-3:45 p.m.	2:30 p.m.-2:45 p.m.	3:45 p.m.-4:00 p.m.	2:00 p.m.-2:15 p.m.	3:30 p.m.-3:45 p.m.
Fishing	0	0	0	3	3	1
Pleasure	1	0	1	2	0	0
Skiing	0	0	0	0	0	0
Sailing	0	0	1	0	0	0
Jet Skiing	0	0	0	0	0	0
Windsurfing	0	0	2	0	0	0
Total	1	0	4	5	3	1

Nonboating Activity	Participants					
	Weekday		Weekend		Weekday	
	August 13, 1991		August 31, 1991		August 6, 1992	
	2:00 p.m.-2:15 p.m.	3:30 p.m.-3:45 p.m.	2:30 p.m.-2:45 p.m.	3:45 p.m.-4:00 p.m.	2:00 p.m.-2:15 p.m.	3:30 p.m.-3:45 p.m.
Picnicking, Walking, Other . . .	- -	- -	- -	- -	27	34
Swimming	0	4	9	0	6	6
Fishing from Shore	7	4	3	6	9	1
Total	7	8	12	6	42	41

Source: SEWRPC.

and in-lake management techniques set forth in this report, may be expected to result in the achievement of the recreational and warmwater fishery objectives set for the Lake.

SUMMARY

Fowler Lake is a multiple-purpose lake serving many recreational and aesthetic users. Over 40 boats of all descriptions are kept on or around the Lake and the Lake is a popular angling venue. During summer site inspections, many people were observed using the Lake for swimming and wading. As a result, recommended standards for full recreational use and support of a warmwater fishery should clearly apply to Fowler Lake. The achievement of these objectives will form the basis for the management plan herein recommended.

Table 33

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

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

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

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

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

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

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

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

Source: SEWRPC.

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Chapter VII

ALTERNATIVE WATER QUALITY MANAGEMENT MEASURES

INTRODUCTION

Potential measures for the management of the water quality of Fowler Lake include zoning ordinance modifications, point source pollution control measures, nonpoint source pollution control measures, and lake rehabilitation techniques. Zoning ordinance modifications would serve to promote land use development in an environmentally sound manner. Point source pollution control measures would serve to promote the design, construction, and operation of sanitary sewerage and industrial wastewater systems so as to avoid pollution of the Lake. Nonpoint source pollution control measures would serve to reduce pollutants discharged to the Lake by direct overland drainage, by drainage through natural or man-made channels, and by groundwater inflow. Lake rehabilitation techniques would seek to treat directly the symptoms of eutrophication.

It should be noted, as has been emphasized throughout this report, that Fowler Lake is dominated, in terms of its water quality, by the inflow from the Oconomowoc River. Given the prominent role of this river in both the water and nutrient budgets of Fowler Lake, as shown in Figure 1 and Table 17, actions taken in the Fowler Lake direct drainage area can have only a minimal effect on the water quality of the Lake. That is not to say that any actions taken in the direct drainage area would be meaningless, because any remedial measures will moderate the actual and anticipated impacts of enrichment on the Lake. In addition to undertaking a program of lake protection in the direct drainage area, it is recommended that the local authorities and Lake District participate in remedial efforts recommended in the adopted regional water quality management plan and the Oconomowoc River nonpoint source priority watershed program for the tributary drainage basin.

It should also be noted that any pollution abatement practices adopted in the Fowler Lake study area will also benefit Lac La Belle and the downstream lakes, in addition to providing direct benefit to Fowler Lake.

LAND USE AND ZONING REGULATION ALTERNATIVES

A basic element of any water quality management effort for Fowler Lake is the promotion of sound land use development and management in the tributary watershed. The type and location of future urban and rural land uses in the watershed will determine, to a large degree, the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, various forms of land management; and, to a limited degree, the water quality of the Lake. Existing 1990 and planned year 2010 land use patterns in the direct drainage area and existing zoning regulations are described in Chapter III.

The major land use changes, as noted in Chapter III, are expected to be in the form of residential and recreational developments, with an attendant decline in agricultural lands. The potential increase in impervious surface will increase runoff into the Lake and will increase some pollutant loadings unless mitigative measures are taken. Additional urban development or redevelopment in the direct drainage area can also potentially increase recreational-use pressures on the Lake.

Given the expected increase in urban residential lands, land use development or redevelopment proposals around the shoreline of Fowler Lake must be carefully evaluated for potential impacts on the Lake. At present, the existing residential development, unlike the commercial development on the Lake, appears to be well buffered through the judicious use of greenery along the lakefront. Such an observation is supported in part by the fact that the nutrient concentrations in the lake sediments approached "polluted" levels only in the vicinity of the Fowler Lake Park outfall, which conveys stormwater from a residential area directly to the Lake without flowing overland across a vegetative buffer area along the Lake, as shown in Table 16 and Map 1. Stormwater runoff routed to bypass fringing "green belts" may be expected to introduce additional loadings of phosphorus directly into the Lake. Elimination of these green belts could lead to the same effect along the developed shoreline.

It is anticipated that all expected new development in the Fowler Lake study area will be served by municipal sanitary sewerage systems. In addition, many of the existing onsite sewage disposal systems in the study area may be expected to be replaced by public sanitary sewerage systems.

The existing land use zoning within the study area is generally consistent with the recommended future land use pattern within the Fowler Lake study area. It is, however, recommended that the zoning be maintained and applied in such a manner as to maintain the existing green space surrounding much of the lakeshore.

Wetland protection can be accomplished through regulation, acquisition, and, to lesser degree, by public education programs. These programs are measures that should be considered for inclusion in the recommended Fowler Lake management plan.

Wetlands in the Fowler Lake study area are currently protected to a degree under the U. S. Army Corps of Engineers 404 Permit Program, the Wisconsin Shoreland Zoning Program, and local zoning ordinances. The wetlands protected under these regulatory programs are shown on Map 25. Nearly all wetland areas in the Fowler Lake direct drainage area are protected under one or more of the Federal, State, County, and local regulations.

POINT SOURCE POLLUTION CONTROL

The adopted regional water quality management plan recommends that the City of Oconomowoc sewage treatment plant serve as an areawide facility, providing secondary sewage treatment plus advanced treatment for phosphorus removal and nitrification for the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake sanitary sewer service areas. This plant discharges treated effluent to the Oconomowoc River downstream of Fowler Lake. The existing and proposed sanitary sewer service areas in the Fowler Lake study area are shown on Map 11.

As of 1990, there were no other public or private sewage treatment plants in operation within the Fowler Lake study area, nor any known significant industrial point sources of wastewater which would require treatment or elimination. Furthermore, there are no public or private sewage treatment plants discharging to the surface waters in the Oconomowoc River watershed upstream of Fowler Lake.

WATERSHED LAND MANAGEMENT ALTERNATIVE MEASURES FOR NONPOINT SOURCE POLLUTION CONTROL

Watershed management measures may be used to reduce nonpoint source pollutant loadings from such urban sources as runoff from residential, commercial, industrial, transportation, and recreational land uses; from construction activities; from onsite sewage disposal systems; and from such rural sources as runoff from cropland and pastureland and from livestock wastes. The alternative nonpoint source pollution control measures considered in this report are presented in the regional water quality management plan,[1] the Oconomowoc River priority watershed plan,[2] and the Waukesha County soil erosion control plan.[3]

An inventory and analysis of nonpoint pollution sources in the urban and rural areas of the study area are presented in Chapter IV. That inventory identified sources of urban and rural nonpoint pollution and determined the relative contribution of each source under the then current 1984 and future year 2010 land use conditions so that control measures could be

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[1] *SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, Volume One, Inventory Findings, 1978; Volume Two, Alternative Plans, 1979; and Volume Three, Recommended Plan, 1979.*

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

[3] *SEWRPC Community Assistance Planning Report No. 159, Waukesha County Agricultural Soil Erosion Control Plan, June 1988.*

developed. A total of 1,306 acres were inventoried. Of these 1,306 acres, 794 acres were located in urban areas and 512 acres in rural areas.

Pollution sources identified within the Fowler Lake study area included upland agricultural field and open land erosion, streambank and lakeshore erosion, urban runoff, and construction site erosion.

Rural Nonpoint Source Control

Upland erosion from agricultural and other rural lands is a major contributor of sediment to streams and lakes in the Oconomowoc River watershed and in the Fowler Lake watershed. Sediment erosion rates were quantified for all croplands, woodlots, pastures, and grasslands in the Fowler Lake study area. The Universal Soil Loss Equation was used to estimate the average annual unit area soil loss for each parcel inventoried. Parcels were delineated on the basis of homogeneity of the land characteristics, land ownership, and subwatershed configuration. These data were utilized in determining the percentage pollutant load reduction that could be achieved in the Fowler Lake study area, the types of practices needed, and the extent of the areas to which the practices were to be applied. On the basis of 1984 land use conditions, which appeared to be consistent with the 1986 inventory used in the County soil erosion control plan, the Fowler Lake study area experienced about 1,660 tons per annum of sediment erosion from rural lands. Approximately 16 percent of this erosion came from lands with annual soil losses of up to three tons per acre, 4 percent from lands losing three to five tons per acre, 62 percent from lands losing five to 10 tons per acre, and 18 percent from lands losing over 10 tons per acre. The distribution of the soil losses in the different erosion categories reflected the large portion of soil losses from lands to which limited conservation practices were applied, indicating that a high degree of erosion control could be achieved through the application of good conservation practices. Applicable conservation practices to control rural soil erosion include conservation tillage, changes in crop rotations, contouring, contour strip-cropping, terraces, grassed waterways, cover crops, and permanent vegetative cover. These practices are described in the Waukesha County agricultural soil erosion control plan.

A target level of agricultural land sediment control of three tons per acre per year, based upon review of the Waukesha County agricultural soil erosion control plan and the priority watershed plan, was established for the Fowler Lake study area. Application of conservation practices providing this level of control would result in about a 60 percent decrease in soil loss from agricultural lands in the Fowler Lake study area. This reduction in soil loss of about 1,000 tons per year could be achieved by installing basic conservation tillage, pasture management, and other selected land management practices on 180 acres of land. This reduction in soil loss may be expected to result in a reduction of about 40 percent of the phosphorus loading from the rural lands. Thus, if fully implemented, the percentage of reduction expected to be achieved by the application of good agricultural land management practices would exceed somewhat the 25 percent reduction level recommended in the regional water quality management plan for the study area.

As recommended in the County agricultural soil erosion control plan, detailed farm conservation plans will be required to adapt and refine those recommendations for individual farm units. Conservation plans are detailed plans, generally prepared with the assistance of the U. S. Soil Conservation Service or County Land Conservation Department staffs, intended to guide agricultural activity in a manner which conserves soil and water resources. The conservation plan indicates desirable tillage practices, cropping patterns, and rotation cycles, considering the specific topography, hydrology, and soil characteristics of the farm, together with the specific resources of the farm operator and the operator's objectives as owner or manager of the land.

Urban Nonpoint Source Control

Urban nonpoint source pollution can vary directly with the degree of land disturbance. Developing areas can generate significantly higher pollutant loadings than similar established areas. Developing areas include a wide array of situations, including urban renewal projects, individual site development within the existing urban area, or new land subdivision development. Established urban areas include existing residential, commercial, industrial, transportation, and open space land uses.

Developing Areas: Between 1985 and 1990, development was occurring on about three acres of land per year in the Fowler Lake study area. As discussed in Chapter III, development may be expected to continue to occur at about this same rate in the Fowler Lake study area.

As indicated in Chapter IV, construction sites can be expected to produce suspended solids and phosphorus at rates several times higher than established urban land uses. Construction erosion control measures are required under the provisions of existing construction erosion control ordinances. The City of Oconomowoc and Waukesha County have such ordinances, based on the model ordinance developed by the Wisconsin League of Municipalities and the Wisconsin Department of Natural Resources (DNR), as set forth in Wisconsin Construction Site Best Management Practices Handbook, 1989. These ordinances define the land disturbance activities subject to control, set forth standards and criteria for erosion control, describe permit application and administrative procedures, and identify enforcement and appeal procedures. The Town of Oconomowoc also has a construction erosion control ordinance developed independently of the model ordinance.

Construction site erosion control measures are temporary measures designed to reduce pollutant loadings during stormwater runoff events. These measures include such revegetation practices as temporary seeding, mulching, and sodding and such runoff control measures as filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins. Construction erosion control measures may be expected to reduce pollutant loadings from construction sites by about 75 percent. These practices are expected to reduce phosphorus loadings to Fowler Lake by about 30 pounds per year, given the amount of land that may be expected to be under development or redevelopment each year in the Fowler Lake study area, and would reduce the total loading to Fowler Lake by about 1 percent. Such controls are important pollution control measures in order to prevent localized short-term loadings of phosphorus and sediment from the study area and the upstream tributary area. Although the capital costs of erosion control measures are highly variable, depending on site conditions, such costs will typically range from about $1,500 per acre for the simpler nonstructural control methods, to about $3,000 to $4,000 per acre if sedimentation basins are provided. Annual operation and maintenance costs average 5 percent of the capital costs, or about $75 to $200 per acre per year. Assuming that sedimentation basins are not required, construction site erosion control over the 20-year planning period may be expected to entail a capital cost of about $4,500 and an annual operation and maintenance cost of about $300.

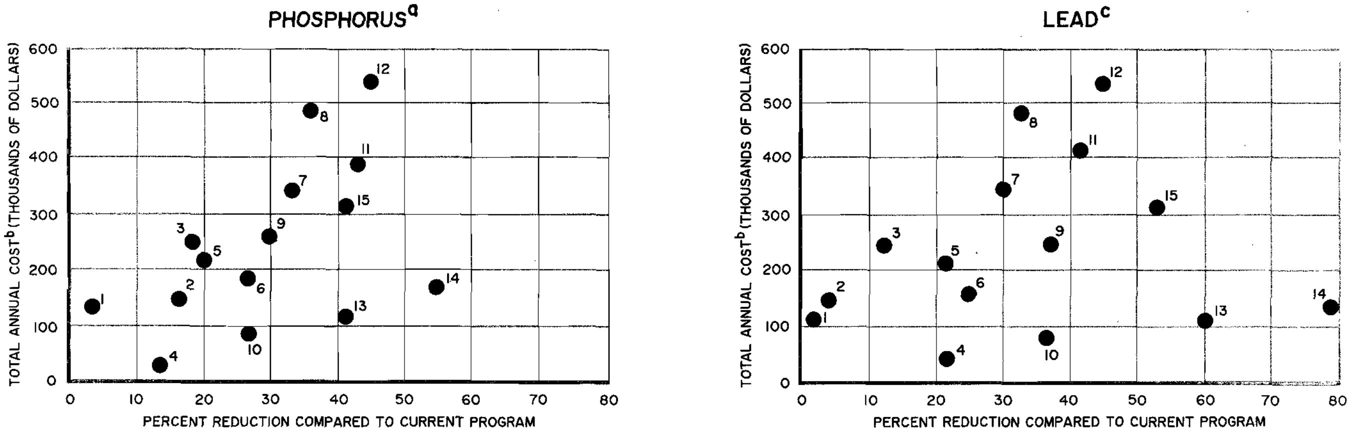
Established Urban Areas: Urban lands comprise about 900 acres, or about 56 percent of the study area. Most of the land within the study area lies within the City of Oconomowoc. Table 17 shows that about 65 tons of suspended solids, or about 6 percent of the total suspended solids loading to Fowler Lake, are delivered by urban lands within the study area. Additionally, 280 pounds of phosphorus, or 11 percent of the total loading, and 200 pounds of lead, or 57 percent of the total lead, are contributed by urban areas. Lead was used in this analysis as an indicator of toxic metals and other pollutants contributed primarily by urban sources. It should be noted that lead loadings have declined and are expected to continue to decline in the future, as the effect of the discontinuation of the use of leaded gasoline is manifested. However, loadings of other metals from urban sources will not be affected by this change in motor fuel; in the analyses, lead serves as a surrogate for these other toxic metals.

The City of Oconomowoc is currently carrying out management practices which serve to reduce the urban pollutant loading to Fowler Lake. The City conducts a street sweeping program which is heavily concentrated in the downtown areas and includes outlying residential areas less frequently. The sweeping program includes an intensive spring cleanup throughout the City. The City recently purchased a vacuum style sweeper, replacing an older, less efficient brush-style machine. The City also collects leaves during the fall. In addition to the street sweeping and leaf pickup program, the City recently constructed a grass filter strip between Fowler Lake and a portion of a large downtown parking lot located in Urban Subbasin J, as shown in Map 21.

There are several places in the City where urban runoff has a chance to infiltrate. For example, there are still some residential areas in the City served by grass drainage swales. When properly constructed and maintained, grass swales serve to increase the infiltration of runoff waters,

Figure 10

POLLUTANT REMOVAL FOR CONTROL PROGRAMS



PROGRAM DESCRIPTIONS

1. CATCH BASIN CLEANING
2. STREET CLEANING
3. STREET CLEANING AND CATCH BASIN CLEANING
4. WET DETENTION BASINS FOR 25 PERCENT OF THE LAND AREA
5. INFILTRATION OF 50 PERCENT OF THE COMMERCIAL AND INDUSTRIAL ROOFTOPS AND PARKING LOTS
6. STREET CLEANING AND 25 PERCENT WET DETENTION
7. STREET CLEANING AND INFILTRATION
8. STREET CLEANING, CATCH BASIN CLEANING, AND INFILTRATION
9. INFILTRATION AND 25 PERCENT WET DETENTION
10. WET DETENTION BASINS FOR 50 PERCENT OF THE LAND AREA
11. STREET CLEANING, INFILTRATION, AND 25 PERCENT WET DETENTION
12. STREET CLEANING, INFILTRATION, CATCH BASIN, AND 25 PERCENT WET DETENTION
13. WET DETENTION BASINS FOR 75 PERCENT OF THE LAND AREA
14. WET DETENTION BASINS FOR 100 PERCENT OF THE LAND AREA
15. INFILTRATION AND 50 PERCENT WET DETENTION

[a]Zinc and COD behave similarly, except programs 2 and 6 are less cost-effective than for phosphorus.

[b]Includes capital cost amortized at 9 percent over 20 years, labor and maintenance. Does not include land costs. Costs in 1992 dollars.

[c]Copper and suspended solids behave similarly.

Source: Donohue & Associates, Inc., 1989.

thereby reducing the pollutant loading from adjacent land uses to the surface water system. However, where the design of the grassed swales is not adequate to serve as an infiltration device, the swales may become drainage and maintenance problems, a situation that occurs along some of the City's grassed swales. In addition to these swales, some of the rooftops in the downtown commercial area discharge to cisterns which provide infiltration and may be expected to filter pollutants from the percolating waters.

The urban pollution control practices that could be either initiated or enhanced in the urban area draining to Fowler Lake include street sweeping, cleaning catch basins, infiltration of runoff from urban areas and parking areas, renovation of grassed swales, and stormwater detention. Not all these practices are equally cost-effective, however, since they remove pollutants to varying degrees and vary widely in cost. The regional water quality management plan recommends a reduction in nonpoint source loadings from urban areas in the study area of about 25 percent.

In order to determine which practices to evaluate in greater detail for application in the Fowler Lake study area, a review was made of a stormwater management study prepared for the City of Oconomowoc by Donohue & Associates, Inc., which includes a cost-benefit and feasibility analysis of stormwater management options.[4] The analysis evaluated more than 20 site-specific alternatives that were formulated as different combinations of the applicable practices. Fifteen of these alternatives were evaluated for cost effectiveness in reducing pollutant loads. Figure 10 presents the results of this analysis.

In Figure 10, the desirable alternatives are presented to the lower right of the chart, since those programs represent high pollution abatement at relatively low cost. For lead, the most cost-effective urban pollution control programs totaling between $100,000 and $150,000 per year

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[4]*Donohue & Associates, Inc., Stormwater Management Feasibility Study for the City of Oconomowoc, April 1989.*

to implement and operate, included detention or infiltration or a combination of these practices. For the control of phosphorus, the conclusions were similar. The City of Oconomowoc stormwater management study recommended adoption of construction erosion control measures and preparation of stormwater management plans at the commencement of development projects in order to consider the alternatives further.

Additional actions recommended in the City of Oconomowoc stormwater management study included the installation of detention ponds at two sites adjacent to Fowler Lake, at Armour Road and Fowler Lake Park. The Armour Road site would receive stormwater from industrial and residential lands which currently drain directly to the Lake. The Fowler Lake Park site would receive stormwater from the storm sewer draining to the outfall near which the lake sediments were considered to be "polluted." The combination of these two basins and the infiltration system previously installed in the parking lot in subbasin J are expected to result in pollutant reductions of about 40 percent for sediment, 35 percent for phosphorus, and 60 percent for lead from urban areas within the Fowler Lake study area. Thus, if all of the practices recommended in the City's stormwater management study are implemented, the pollutant loading reductions expected would exceed the 25 percent level of reduction determined to be needed in the regional water quality management plan. However, the total pollutant loading to Fowler Lake after use of pollutant reduction measures both within the study area and from upstream sources is expected to be about 21 to 30 percent, depending upon whether or not loadings from onsite sewage disposal systems are eliminated. Thus, the levels of control which are expected for the urban areas of the study area, based upon the City's stormwater management study, are considered reasonable and in the same range as recommended in the adopted regional water quality management plan.

The capital cost for installation of the two detention ponds is estimated at $340,000; the operation and maintenance costs are estimated at $13,000 per year.

IN-LAKE MANAGEMENT

The reduction of external nutrient loadings to Fowler Lake by the measures described above should help to prevent deterioration of its water quality conditions, but may not eliminate existing water quality and lake-use problems. In mesotrophic and eutrophic lakes, particularly in the presence of such anaerobic conditions in the hypolimnion as occur in Fowler Lake during the summer, significant amounts of phosphorus can be released from the existing sediments to the overlying water column. Consequently, the water quality improvements expected from a reduced nutrient input may be inhibited or prevented by this condition. Because of this and because of other characteristics of the Lake, such as abundant macrophyte growth, which can result in restricted water use potential, the application of in-lake rehabilitation techniques should be considered.

The applicability of specific in-lake rehabilitation techniques is highly dependent on lake characteristics. The success of any lake rehabilitation technique can seldom be guaranteed since the technology is still in the early stages of development. Because of the relatively high cost of applying most techniques, a cautious approach to implementing in-lake rehabilitation techniques is generally recommended. Certain in-lake rehabilitation techniques should be applied only to lakes in which: 1) nutrient inputs have been reduced below the critical level, 2) there is a high probability of success in applications of the particular technology to lakes of similar size, shape, and quality, and 3) the possibility of adverse environmental impacts is minimal. Finally, it should be noted that some in-lake rehabilitation techniques require the issuance of permits from appropriate State and Federal agencies prior to implementation.

Alternative lake rehabilitation and in-lake management measures include lake destratification, hypolimnetic aeration, and nutrient inactivation to improve water quality; lake drawdown; dredging; aquatic plant control; and fish management. Each of these management measures, together with the attendant costs, are described below. All cost figures related to the measures discussed herein are presented in 1992 dollars.

Lake Destratification

To prevent the depletion of dissolved oxygen in the bottom waters of stratified lakes, mechanically induced circulation, or destratification, may be used.[5] Destratification of a lake eliminates the density differences in the water layers, thereby allowing for complete mixing of the well-oxygenated surface water with the oxygen-poor lower layers. In addition, whole lake mixing may reduce the release of phosphorus from the sediments, while at the same time controlling algal blooms by circulating the algae out of the zone of light penetration.

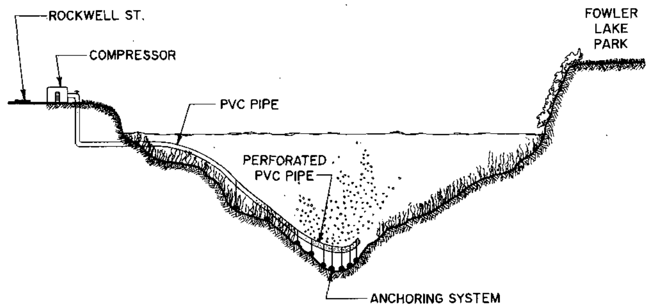
In addition to the decreased algal biomass resulting from mixing-induced light limitation, destratification elevates epilimnetic carbon dioxide levels and may cause a sufficient drop in pH to shift dominance in the algal community from the nuisance blue-greens to a mixed assemblage of green algae and diatoms. This more edible plant resource, combined with an expansion of habitat, leads to a more abundant zooplankton population consisting, in part, of large-bodied daphniids. Habitat expansion and shifts in community structure of benthic macroinvertebrates can also potentially increase the abundance and diversity of fish-food organisms. Surface water temperatures, which may be reduced by lake mixing, can allow for increased fish stocking.

Lake destratification is typically accomplished with a forced air system consisting of a blower and distribution system. The system works by circulating water from the bottom of the lake to the surface, using air bubbles as the lifting mechanism. A system to meet the needs of Fowler Lake would consist of 50- to 100-cubic-foot-per-minute blower rated at 25 to 30 pounds per square inch. A blower is usually used instead of an air compressor to reduce electric power costs. The blower or compressor is connected to an air distribution system as illustrated in Figure 11. Polyvinyl chloride or galvanized steel pipe, 0.5 inch in diameter, runs from the air blower to the lake. This pipe is best placed underground, below the frost line, to prevent ice damage and vandalism. A manifold pipe with three outlets for 0.5-inch piping is attached to the lake end of the transmission section. A gate or globe valve, vented to the atmosphere, should be

[5]*Robert Pastorok, "Review of Aeration/Circulation for Lake Management," in U. S. Environmental Protection Agency, Restoration of Lakes and Inland Waters, EPA 440/5-81-010, 1981.*

Figure 11

TYPICAL DESTRATIFICATION SYSTEM FOR FOWLER LAKE



Source: U. S. Environmental Protection Agency and SEWRPC.

installed in the line so that air pressure in the diffuser can be gradually increased or decreased.

The pipes laid in the lake are commonly rated at 80 pounds per square inch of pressure, using 1.5-inch polyvinyl chloride pipe. Pipes are placed in the deepest part of the lake. Each pipe usually has two 0.125-inch-diameter holes that have been deburred for air release. To ensure even air flow, it is critical that all these holes be placed along the lake bottom so that the water depth above all the holes is approximately equal, that the end of the pipe be plugged and the air release holes spaced appropriately, and that the pipe is anchored to the bottom.

The installation of a blower destratification system in Fowler Lake would cost approximately $18,000. If operated from May through October, the annual cost of operation would be approximately $2,400 for electric power and maintenance. The total cost of operation over a 20-year period would be approximately $66,000.

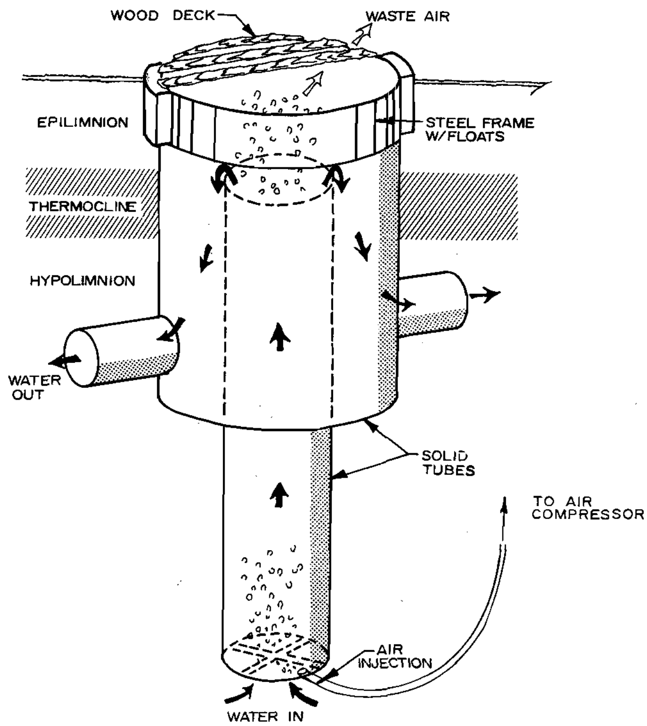
The available water quality data indicate that phosphorus levels in the Lake are not high enough to cause nuisance algal growths and that there is no evidence of phosphorus being released from the sediments in significant amounts. The temporary anoxic conditions that occur do not result in fish kills because there is an adequate volume of oxygenated water above the hypolimnion. Therefore, under these circumstances, lake destratification is not recommended.

Hypolimnetic Aeration

An alternative to complete lake destratification would be hypolimnetic aeration, whereby oxygen is provided to the hypolimnion of a stratified lake without disrupting the stratification. The hypolimnion of Fowler Lake underlies about 11 acres, or about 13 percent of the lake surface area. During part of the summer, this entire volume has been found to be devoid of dissolved oxygen. To provide hypolimnetic aeration, bottom water is typically air-lifted up a vertical tube, with the oxygenated water returned to the hypolimnion, as shown in Figure 12. Aeration of the hypolimnion increases the decomposition of organic matter and promotes sorption of phosphorus by the hydrous oxides of iron and manganese present in the lake bottom sediments. The result is that the concentration of phosphorus in the bottom waters may be substantially reduced and the oxygen levels and the habitat for fish and other aquatic life improved. Specifically, hypolimnetic aeration provides additional habitat for zooplankton, which can seek refuge from feeding fish during the day. These microcrustaceans then migrate towards the surface at night to graze on algae. Increased zooplankton grazing pressures can effectively reduce the numbers of certain species of algae. Hypolimnetic aeration in Fowler Lake, to aerate the zone depicted on Map 29 at depths greater than 20 feet below the surface, would entail a capital cost of about $60,000, with an annual operation and maintenance cost of about $2,400. Installation of a hypolimnetic aerator would require a permit from the Wisconsin DNR under Section 33.12 of the Wisconsin Statutes.

Figure 12

TYPICAL HYPOLIMNETIC AERATION SYSTEM FOR AN INLAND LAKE



Source: Adapted by SEWRPC from A. W. Fast, "The Effects of Artificial Aeration on Lake Ecology," U. S. Environmental Protection Agency Water Pollution Control Research Series 16010EXE, 1975.

It is unlikely that the effects of nonpoint source pollution control measures in the drainage area directly tributary to Fowler Lake and the Oconomowoc River watershed would, for some years, if ever, substantially improve dissolved oxygen conditions in the hypolimnion. On the other hand, conditions are unlikely to deteriorate further. Thus, hypolimnetic aeration could be implemented, even before the control of nonpoint pollution sources, in order to provide additional and more immediate improvement in the dissolved oxygen conditions in the bottom waters of the Lake. Hypolimnetic aeration, however, is not recommended for Fowler Lake since the release of phosphorus from the sediments and temporary anoxic conditions are not considered significant problems.

Nutrient Inactivation

The use of aluminum sulfate (alum) to remove phosphorus from nutrient-rich lake waters is an extension of common water supply and wastewater treatment processes. Alum is typically applied to a lake surface in the deeper parts of the lake in a liquid form, resulting in the formation of a precipitate of aluminum hydroxide. Aluminum hydroxide has a high capacity to absorb phosphorus and make it unavailable to plants and algae. In addition, the use of aluminum salts is relatively inexpensive and any free aluminum that might result has a relatively low toxicity to most forms of aquatic life.

The objective of most alum treatments is to remove available phosphorus rapidly from the water column and, at the same time, prevent the release of phosphorus from the lake sediments, thus limiting the availability of the nutrient for the growth of planktonic plants. The floc absorbs phosphorus in the water column and

Map 29

AREA OF FOWLER LAKE CONSIDERED FOR HYPOLIMNETIC AERATION AND NUTRIENT INACTIVATION

Source: SEWRPC.

forms a chemical and physical layer which retards the transfer of the nutrient from the sediments. When it is successful, results appear relatively quickly, and, if external sources of nutrients and in-lake turbulence are low, the effects are generally long-lasting.

The rate of alum application will depend on the phosphorus concentration and buffering capacity of the lake. It is important that aluminum not be added in higher concentrations than the absorptive ability of the water to prevent toxicity to aquatic organisms. Bench scale testing is necessary before alum is used. The application of alum to the hypolimnion of Fowler Lake, as shown on Map 29, would cost about $48,000, assuming an alum application rate of 15 milligrams per liter of water. The labor and equipment cost of the application is estimated at $12,000, resulting in a total cost for sediment alum application of about $60,000.

However, as stated in Chapter IV, the water quality of Fowler Lake is currently in the mesotrophic range, with good water clarity and no nuisance algal problems. Therefore, nutrient inactivation is not recommended for Fowler Lake.

Lake Drawdown

Sediment exposure and desiccation by means of lake drawdown has been used as a means of stabilizing bottom sediments, retarding nutrient release, reducing macrophyte growth, and reducing the volume of bottom sediments. The effects of lake drawdown are illustrated in Map 30. During the period of drawdown, the exposed sediments are allowed to oxidize and consolidate. It is believed that by reducing the sediment oxygen demand and increasing the oxidation state of the surface layer of the sediments, drawdown may retard the subsequent movement of phosphorus from the sediments. Sediment exposure may also curb sediment nutrient release by physically stabilizing the upper flocculent (sediment-water interface) zone of the sediments which plays an important role in the exchange reaction and mixing of the sediments with the overlying water.

Drawdown also deepens the lake by dewatering and compacting the bottom sediments. The amount of compaction depends upon the organic content of the sediment, the thickness of sediment exposed above the water table, and the timing and duration of the drawdown. Based on sediment types in Fowler Lake, it is estimated that a 30 to 50 percent reduction in volume of exposed sediments may be feasible.

Lake drawdown is an effective technique for the control of several nuisance macrophyte species. The objective is to retard macrophyte growth by destroying seeds and vegetative reproductive structures through exposure to drying and/or freezing conditions and by altering their substrate by dewatering and consolidating of sediments. Table 34 lists several species controlled by lake drawdown. This control generally lasts from one to two years. While drawdown can control the regrowth of several plants, it can also stimulate the growth of others, such as Bushy pondweed (Najas flexils), Flatstem pondweed (Potamogeton zosteriformis), and several sedges and shoreline species.

Possible improvements resulting from a lake drawdown include reduced turbidity from wind action, improved game fishing, an opportunity to collect fish more effectively in fish removal programs, an opportunity to improve docks and dams, and an opportunity to clean and repair shorelines and deepen areas using conventional earth-moving equipment. Depending on the timing and duration of the drawdown, drawbacks include loss of fish breeding habitat, loss of benthic food organisms, and disruption of waterfowl feeding and roosting patterns. Increased turbidity and unpleasant odors from rotting organic matter may occur during the period of the drawdown.

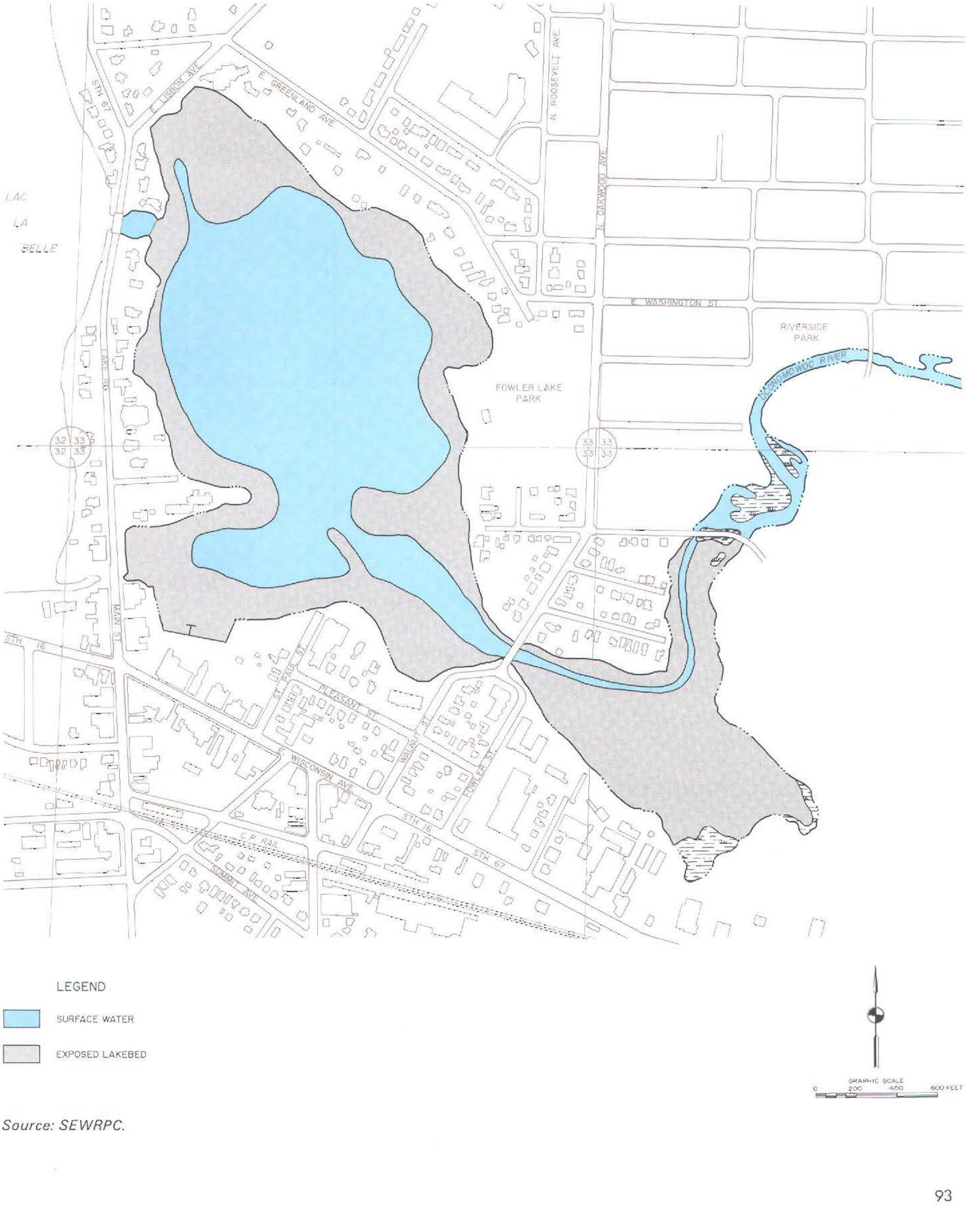
Other adverse impacts of lake drawdown include algal blooms after reflooding, loss of use of the lake during the drawdown, changes in species composition, and a reduction in the density of benthic organisms following drawdown and reflooding.

In some drawdown projects, it has been found that several years after reflooding, flocculent sediments began to reappear because of algae and macrophyte sedimentation. In Fowler Lake, with the type of organic sediments existing, sedimentation of this type may take place. Therefore, to maintain the benefits of a drawdown project, the Lake may have to be drawn down every five to 10 years to recompact any new sediment.

The timing of a drawdown project is an important factor affecting the success of the project. Winter drawdowns have been employed success-

Map 30

AREA OF FOWLER LAKE AFFECTED BY A SEVEN-FOOT DRAWDOWN



Source: SEWRPC.

Table 34

AQUATIC PLANTS
CONTROLLED BY LAKE DRAWDOWN

Common Name	Scientific Name
Water Shield	Brasenia schreberi
Coontail	Ceratophyllum demersum
Stonewort	Chara sp.
Elodea	Elodea sp.
Milfoil	Myriophyllum sp.
American Lotus	Nelumbo lutea
Yellow Water Lily	Nuphar sp.
White Water Lily	Nymphaea odorata
White Water Lily	Nymphaea tuberosa
Clasping-Leaf Pondweed	Potamogeton robbinsii
Large-Leaf Pondweed	Potamogeton amplifolius
Swamp Fivefinger	Potentilla palustris
Arrowhead	Sagittaria heterophylla
Bladderwort	Utricularia vulgaris
Wild Celery	Vallisneria americana

Source: Based on G. Dennis Cooke, et al., Restoration and Management of Lakes and Reservoirs, 2nd Edition, Lewis Publishers, 1993.

fully in several projects in Wisconsin. The advantages of a winter drawdown are: 1) it would not interfere with summer boating, fishing, recreation, and irrigation activities, 2) the freezing and thawing of the sediments would facilitate dewatering, 3) the frozen sediment would provide a surface for access of earth-moving equipment, and 4) the freezing of the sediment would provide increased macrophyte mortality. The longer the sediments are exposed, the greater the benefit of the drawdown. Fowler Lake could be drained after Labor Day and left drained until March of the following year, allowing seven months of sediment exposure. With water from the spring snowmelt and spring rainstorms, the Lake would quickly refill. A disadvantage of the over-winter drawdown is the increased potential for a fish winterkill due either to an oxygen deficit or to a whole lake freeze.

There are two water-control structures on Fowler Lake: a fixed-sill dam with a seven-foot head in the northwest corner of the Lake and a flume on the west bank linking the Lake with Lac La Belle. City officials have indicated that a drawdown of only between two and three feet could be obtained by opening the gates on the flume, which would not be enough to have an appreciable effect on reducing macrophyte growth. A total breaching of the dam would allow a drawdown of approximately seven feet, exposing about 50 percent of the lake bottom. Even this level of drawdown would not produce the amount of control that is desired. Added to this is the unpredictability of the results, the impairment of recreational uses, and the temporary nature of the beneficial effects of a drawdown. Thus, drawdown is not recommended for Fowler Lake.

Dredging

Dredging is the only restoration technique that directly removes the accumulated products of degradation and sediment from a lake system and can return a lake to a younger "age." If carried to the extreme, dredging can be used to construct a new lake on the present site with a size and depth to suit the management objectives. Dredging has been used to increase water depth; remove toxic materials; decrease sediment oxygen demand, preventing fish winterkills and nutrient recycling; and decrease macrophyte growth. Because Fowler Lake is now 50 feet deep and does not experience winter dissolved oxygen problems, the main objective of a dredging program at Fowler Lake would be to reduce the size of the littoral zone, thereby reducing the areal extent of macrophyte growth. The maximum depth of macrophyte growth in Fowler Lake, under present conditions of water clarity, is 22 feet. To reduce the extent of macrophyte growth, sections of the bottom would have to be deepened to 25 feet or more by dredging.

Map 31 illustrates areas for possible dredging in Fowler Lake and the depth contours which would result in the greatest reduction in macrophyte growth. A slope of four on one or less should be maintained to prevent slumping of the organic sediments and to ensure the safety of recreational users.

Dredging may have serious, though generally short-term, adverse effects on the Lake. These adverse effects could include increased turbidity caused by sediment resuspension, oxygen depletion as organic sediments mix with the overlying water, water temperature alterations, and

Map 31

PROPOSED DREDGING PLAN FOR FOWLER LAKE

Source: SEWRPC.

destruction of benthic habitats. There may also be impacts at upland disposal sites, such as odor problems, restricted use of the site, and disturbances associated with heavy truck traffic.

Dredging of lake bed material from navigable waters of the State would require a Wisconsin DNR Chapter 30.20 permit and a U. S. Army Corps of Engineers Chapter 404 permit. In addition, current solid waste disposal regulations define dredge material as a solid waste. Chapter NR 180.13 of the Wisconsin Administrative Code requires that any dredging project of over 3,000 cubic yards submit preliminary disposal plans to the DNR for review and potential solid waste licensing of the disposal site. Because of the large amounts of sodium arsenite that were applied to Fowler Lake in the 1950s and 1960s, as discussed in Chapter V, sediment samples may need to be analyzed to determine the extent and severity of any residual arsenic contamination.

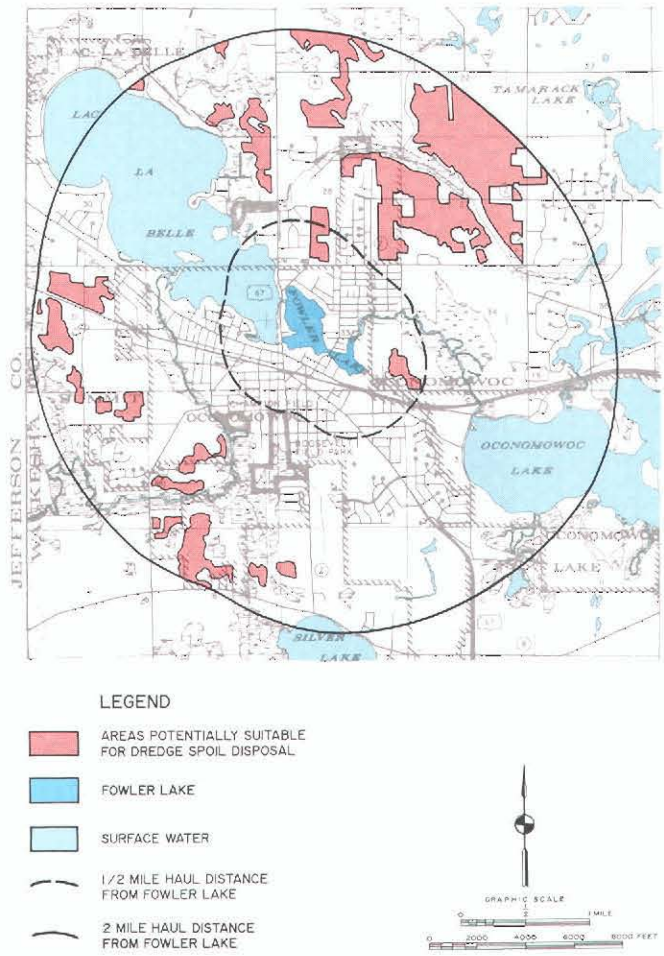
Dredging Fowler Lake could be accomplished with several different types of equipment, including a hydraulic cutterhead dredge mounted on a floating barge; or bulldozer and backhoe equipment if part of the Lake were drained; or a clamshell, or bucket, dragline dredge from the shoreline.

Hydraulic cutterhead dredging is the most commonly employed method in the United States. The dredge is typically a rotating auger or cutterhead on the end of a ladder that is lowered to the sediment-water interface. Sediment excavated by the cutterhead is pumped in a slurry of 10 to 20 percent solids by a centrifugal pump to the disposal site. This pumping usually limits the distance between the lake and disposal site to less than a mile, even using intermediate booster pumps. Because of the large volume of slurry produced, a large disposal site would be required. Potential disposal sites are illustrated on Map 32. Water returned from the disposal site, whether returned to the lake or a stream, would have to meet effluent water quality standards of the State and would be subject to State permitting.

Draining the lake and removing sediment with conventional earth-moving equipment has some advantages over hydraulic dredging since it would not require a large disposal or dewatering site in the immediate area. Draining is also more advantageous than dragline dredging because it

Map 32

POSSIBLE DREDGE SPOIL DISPOSAL SITES IN THE VICINITY OF FOWLER LAKE



Source: SEWRPC.

would not require the removal of a large number of trees and would probably involve less disturbance of the shoreline to provide access for trucks and equipment.

Shoreline dredging of Fowler Lake to remove and dispose of about 1,500,000 cubic yards of sediment would cost approximately $7.5 million. Because of the potential negative environmental effects of dredging and the high cost associated with dredge spoil disposal, this alternative is not recommended for Fowler Lake.

Shoreline Erosion Control

Shoreline erosion is evident at scattered locations around Fowler Lake, as shown on Map 3 in Chapter II, although only the Fowler Lake Park site was considered as having a serious problem. Such erosion has been reported to be occurring since the turn of the century, as described in Chapter II, and has been a notable feature of the Fowler Lake shoreline for many years. This phenomenon resulted in the armoring of the shore with stone before 1910 and is the basis for the almost completely armored shoreline of today. Shoreline erosion not only interferes with such activities as swimming, but also results in the retreat of the land by sloughing into the Lake, as much as one foot per year in some areas, and in the deposition of sediment and nutrients into the Lake itself, which contributes to the formation of bottom sediments suitable for supporting excessive aquatic plant growth. It is estimated that, in an average year, 10 to 40 pounds of phosphorus, or between 5 and 15 percent of the total urban load from the study area, are contributed to Fowler Lake from shoreline erosion. This erosion may be attributed to the following factors:

1. Maintenance of lawns to the lake edge can increase the rate of shoreline erosion. The shallow root system of lawn grass fails to bind the soil in place sufficiently and allows undercutting and the filtering of sediment particles through the unstable shore slopes into the water. The lack of vegetation at the waterline serves as an indicator of active erosion.

2. Wave action is the primary direct cause of shoreline erosion when a lake is not ice-covered. Shoreline erosion by wave action is most evident along the eastern shoreline of lakes within Southeastern Wisconsin because of prevailing westerly winds. The waves undercut the exposed shoreline slopes, resulting in sloughing of the shore into the lake.

3. High lake levels may increase the shoreline erosion by exposing higher areas to direct wave action and by saturating normally unsaturated shoreline soils, thereby reducing the adhesiveness of the soil particles.

4. Ice action may be the single most important cause of shoreline erosion on Fowler Lake. Fowler Lake is normally covered by ice from about early December to late March. During this time, thermal expansion of the ice may force a layer of ice up onto the shore, while during spring breakup, windblown floating ice blocks and fragments can be forced onto the shore. Under high lake level conditions, freeze-thaw phenomena may also weaken submerged shore slopes. Together these ice-related activities physically scour the shoreline and prevent the establishment of a stable vegetative cover.

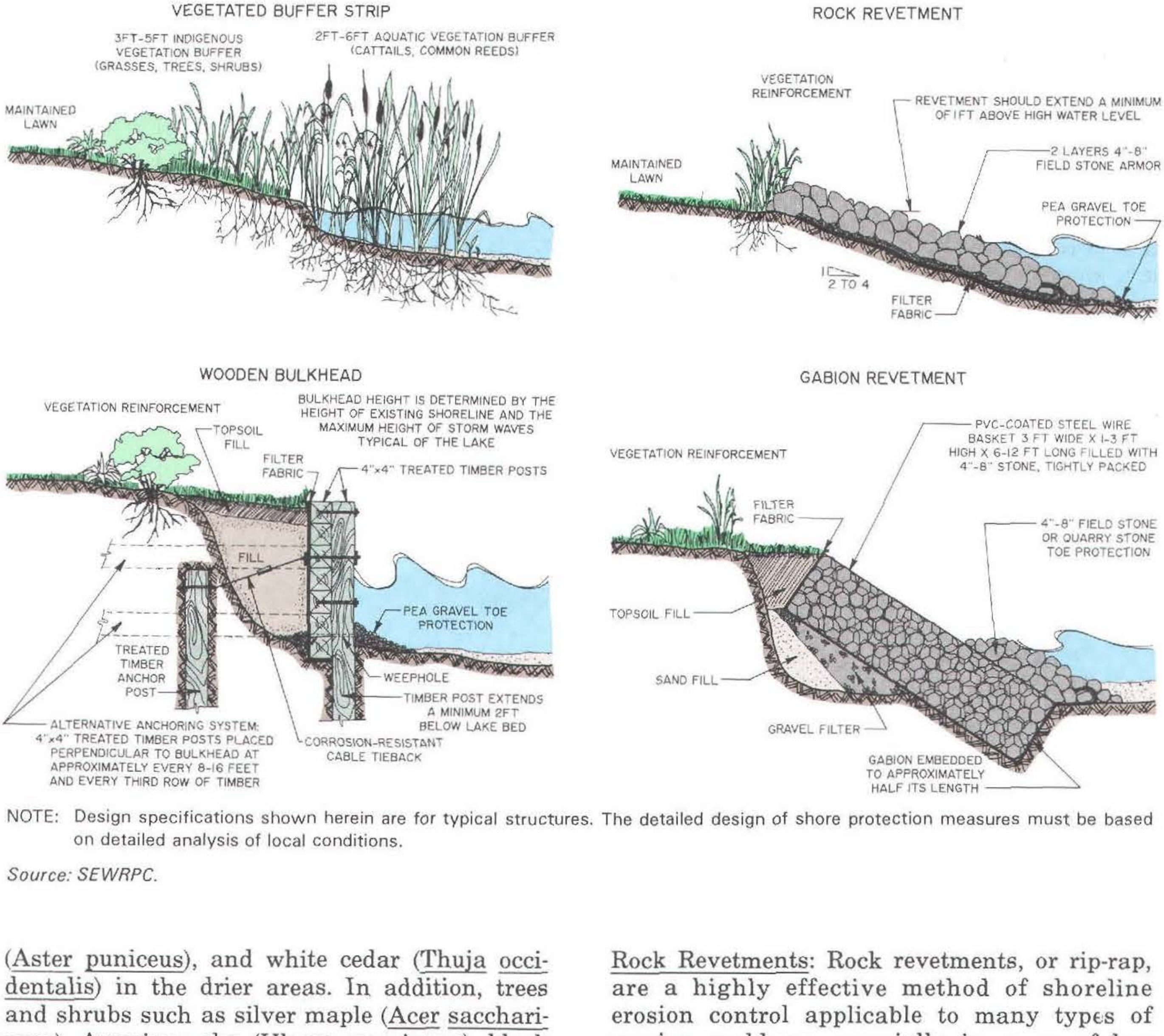
Four alternative shoreline erosion control techniques were considered: vegetative buffer strips, rock revetments, wooden bulkheads, and gabions. These alternatives considered were selected because they can be constructed, at least partially, by local residents; because most of the construction materials involved are readily available; because the technique would, in most cases, enable the continued use of the immediate shoreline; and because the measures are visually "natural" or "semi-natural" and should not significantly affect the aesthetic qualities of the lake shoreline. The cost estimates presented below are for the control of the roughly 300 feet of unstable shoreline identified in Chapter II.

<u>Vegetative Buffer Strips</u>: The simplest, cheapest, and most natural method of reducing shoreline erosion is the provision of a vegetative buffer strip immediately adjacent to the lake (Figure 13). This technique employs natural vegetation, rather than maintained lawns, within five to 10 feet of the lake-shore or the establishment of emergent aquatic vegetation from two to six feet lakeward of the eroding shoreline. Aquatic species, such as cattails (<u>Typha</u> spp.) and common reed (<u>Phragmites communis</u>), may be suitable in the littoral areas along the eroding shores. Taller grasses invaded initially by weeds, and later by other species of grasses, forbs, and shrubs, should be encouraged on the shoreline. Some transplanting or seeding with carefully chosen indigenous plant types can decrease the time of this succession of plant species.

Desired plant species which may be expected and encouraged to invade the buffer strip, or which could be planted, include arrowhead (<u>Sagittaria latifolia</u>), cattail (<u>Typha</u> spp.), common reed (<u>Phragmites communis</u>), water plantain (<u>Alisma plantago-aquatica</u>), bur-reed (<u>Sparganium eurycarpum</u>), and blue flag (<u>Iris versicolor</u>) in the wetter areas; and jewelweed (<u>Impatiens biflora</u>), elderberry (<u>Sambucus canadensis</u>), giant goldenrod (<u>Solidago gigantea</u>), marsh aster (<u>Aster simplex</u>), red-stem aster

Figure 13

PLAN ALTERNATIVES FOR SHORELINE EROSION CONTROL



NOTE: Design specifications shown herein are for typical structures. The detailed design of shore protection measures must be based on detailed analysis of local conditions.

Source: SEWRPC.

(Aster puniceus), and white cedar (Thuja occidentalis) in the drier areas. In addition, trees and shrubs such as silver maple (Acer saccharinum), American elm (Ulmus americana), black willow (Salix nigra), and red-osier dogwood (Cornus stolonifera) could become established. These plants will develop a more extensive root system than the lawn grass and the aboveground portion of the plants will protect the soil against the erosive forces of rainfall and wave action. A narrow path to the lake could still be maintained as lake access for boating, swimming, fishing, and other activities. A vegetative buffer strip would also serve to trap nutrients and sediments washing into the lake via direct overland flow. This alternative would involve only minimal cost.

Rock Revetments: Rock revetments, or rip-rap, are a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water. Some of these structures are already in place at Fowler Lake (see Map 3). The technique, as shown in Figure 13, involves the shaping of the shoreline slope, the placement of a porous filter material, such as sand, gravel, or pebbles, on the slope and the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of a rock revetment are that the structure is highly flexible and not readily weakened by movements caused by settling or ice expansion, it can be constructed in stages, and it requires little or no maintenance. The disadvantages of a rock revetment are that it limits the use of the immediate shoreline in that the rough, irregular rock surfaces are unsuitable for walking; a relatively large amount of filter material and rocks needs to be transported to the lakeshore; and excavation and shaping of the shore slope may cause temporary disruptions and contribute sediment to the lake. Even if improperly constructed, the revetment may fail because of washout of the filter material. A rock revetment constructed along the entire 300 feet of unstable shoreline by a private contractor would involve a total capital cost of about $7,500, or about $25 per linear foot. By providing labor and some materials, Fowler Lake residents could reduce this cost by up to 50 percent.

Wooden Bulkheads: Wooden bulkheads, as shown in Figure 13, prevent the sliding of land or slope failure and provide protection against wave action and, to a lesser extent, ice action. A series of horizontal boards are bolted to a series of vertical posts sunk into the soil at the waterline. Alternatively, a close-set series of vertical poles three to six inches in diameter can be erected. A stone toe is usually provided on the lakeward side to protect against undercutting. A sunken cable tieback to an anchored "deadman" may be used to prevent the bulkhead from slipping towards the lake. Advantages of a wooden bulkhead are that it provides substantial protection and maintains the shoreline in a fixed position and that the materials are readily available. Bulkheads, depending on their type, may be considered less visually appealing than rock revetments; are less flexible and more susceptible to ice damage; and are considerably more difficult and expensive to repair than a rock revetment. A wooden bulkhead for the entire unstable shoreline installed by a private contractor would involve a total capital cost of about $2,200, or about $7.50 per linear foot. As with rock revetments, the provision of labor and some materials by local residents could substantially reduce this cost.

Gabions: A gabion is simply a steel wire-mesh basket filled with rock. Gabions are commercially available in a variety of sizes and are constructed and filled with rocks at the site of placement. A single gabion three feet high and three feet wide, sunk into the soil to about one-half its height, as shown in Figure 13, may be expected to protect the shoreline of Fowler Lake adequately. An underlying filter cloth prevents the erosion of finer particles below and behind the gabion, which could cause excessive movement and settling of the gabion. A rock toe may also be provided to prevent undercutting. The advantages of gabions are that they are flexible and easily repaired, relatively easy to construct, and are effective against ice movement. Gabions often become covered with vegetation, which adds to their visual appeal. The disadvantages of gabions are their relatively high cost, the potential for damage and breakage of the wire mesh basket, and the considerable excavation needed to implant them. Gabions installed by a private contractor along the entire 300 feet of unstable shoreline would cost about $10,800, or about $36 per linear foot. If labor and some materials could be provided by local residents, this cost could be substantially reduced.

Because of the extensive system of shoreline armor already in place at Fowler Lake, armoring the additional unprotected shoreline in the main basin of the Lake would appear to be a viable option. If additional shore protection is installed, it is recommended that consideration be given to the visual aesthetics of blending various types of construction along the shore. This will not only enhance the visual appeal of the shoreline but minimize the edge effects that can occur as the result of two dissimilar abutting styles of construction. These boundaries can become points of weakness, susceptible to undercutting, overtopping or back erosion, which could undermine both sets of abutting structures. A further consideration along the Fowler Lake Park shore may be the desire to maintain as natural an aspect as possible in this area to foster the park "atmosphere." Vegetative buffer strips may be highly desirable in this area, and some work has been done to thus stabilize the shore in this area since the original shoreline inspection in 1988.

Aquatic Plant Management

Although macrophytes and phytoplankton are important to the overall health of a lake, excessive or unwanted aquatic plant growth can disrupt the natural ecosystem, detract from the aesthetic quality of a lake, and interfere with such recreational lake uses as boating and swimming. Techniques available to control nuisance aquatic plants include chemical herbicides, mechanical harvesting, and lake bottom covers.

Aquatic Herbicides: Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. Chemicals are applied to the growing plants in either liquid or granular form.

The advantages of using chemical herbicides to control aquatic macrophyte growth are the relatively low cost and the ease, speed, and convenience of application. However, the disadvantages associated with chemical control include the following:

1. Although the short-term, lethal effects of chemicals are relatively well known, potential long-term, sublethal effects, especially on fish, fish-food organisms, and humans, are relatively unknown.

2. The elimination of macrophytes eliminates their competition with algae for light and nutrients. Algal blooms may then develop unless steps are taken simultaneously to control the sources of nutrient input.

3. Since much of the dead plant materials is left to decay in the lake, nutrients contained in them are rapidly released into the water and fuel the growth of algae. The decomposition of the dead plant material also consumes dissolved oxygen and increases the potential for fish kills. Accretion of additional organic matter in the sediments as a result of decomposition also increases the organic content of the soils and predisposes the sediments toward reintroduction of other (or the same) nuisance plant species.

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

5. Adverse impacts on other aquatic organisms may be expected. At the concentrations used for macrophyte control, Diquat has been known to kill the zooplankton Daphnia and Hyalella, both important fish foods. Daphnia is the primary food for the young of nearly all fish species found in the Region's lakes.[6]

6. Areas must be treated again in the following season and weed beds may need to be treated more than once in a summer.

7. Many of the chemicals available are nonselective, often affecting nontarget, desirable species as well as the "weeds."

The advantages and disadvantages of chemical macrophyte control also apply to the chemical control of algae. Copper, the active ingredient in algicides, may accumulate in the bottom sediments, where excessive amounts are toxic to fish and benthic animals. Fortunately, copper is rapidly eliminated from human systems and few cases of copper sensitivity among humans are known.[7]

Costs of chemical treatments vary widely. Large, organized treatments are more efficient and tend to decrease unit costs for commercial applications compared to individual treatments. Other factors, such as the type of chemical used and the number of treatments needed, are also important. Estimated costs for lakes in Southeastern Wisconsin range from $240 to $480 per acre. Current treatment costs on Fowler Lake are approximately $3,500 per year. Chemical treatments must be permitted by the State under Chapter NR 107 of the Wisconsin Administrative Code. Because the demonstrated need to control aquatic plants in selected areas of Fowler Lake and the relatively low cost of chemical treatment and because current management decisions have indicated a need for some chemical treatment, chemical treatment is considered to be a viable management option to be considered further for Fowler Lake.

Aquatic Plant Harvesting: Aquatic macrophytes are mechanically harvested with specialized equipment consisting of a cutting apparatus which cuts up to five feet below the water surface and a conveyor system which picks up the cut plants and hauls them to shore. Advantages of macrophyte harvesting include the following:

1. Harvesting removes the plants from the lake. The removal of this plant biomass

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

[7] *J. A. Thornton, and W. Rast, "The Use of Copper and Copper Compounds as an Algicide," Copper Compounds Applications Handbook, H. W. Richardson, ed., Dekker, New York, in press.*

decreases the rate of accumulation of organic sediment. A typical harvest of submerged macrophytes from eutrophic lakes in Southeastern Wisconsin can yield between 140 and 1,100 pounds of biomass per acre per year.[8]

2. Harvesting removes plant nutrients, including nitrogen and phosphorus, which would otherwise "refertilize" the lake as the plants decay. A typical harvest of submerged macrophytes from eutrophic lakes in Southeastern Wisconsin can remove between four and 34 pounds of nitrogen and 0.4 to 3.4 pounds of phosphorus per acre per year. In addition to the physical removal of nutrients, plant harvesting may reduce internal nutrient recycling. Several investigators have shown that aquatic macrophytes can act as nutrient pumps, recycling nutrients from the bottom sediments into the water column. Ecosystem modeling results, produced by Loucks and Weiler, have indicated that a harvest of 50 percent of the macrophytes in Lake Wingra, Wisconsin, could reduce instantaneous phosphorus availability by about 30 percent, with a maximum reduction of 40 to 60 percent, depending on the season.[9]

3. Repeated macrophyte harvesting may reduce the regrowth of certain aquatic macrophytes. The regrowth of milfoil has been reported to have decreased as harvesting frequency was increased.[10]

4. Where dense growths of filamentous algae are closely associated with macrophyte stands, they may be harvested simultaneously.

5. The macrophyte stalks remaining after harvesting provide cover for fish and fish-food organisms, and stabilize the bottom sediment against wind erosion.

6. Selective macrophyte harvesting may reduce stunted populations of panfish in lakes where excessive cover has adversely influenced predator-prey relationships. By allowing an increase in predation on young panfish, both gamefish and the remaining panfish may show increased growth.[11]

7. The cut plant material can be used as mulch.

The disadvantages of macrophyte harvesting include the following:

1. Harvesting is most effective in water depths greater than two feet. Large harvesters cannot operate in shallow water or around docks and buoys.

2. The reduction in aquatic macrophytes by harvesting reduces their competition with algae for light and nutrients. Thus, algal blooms may develop.

3. Fish, especially young-of-the-year bluegills and largemouth bass, as well as fish-food

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[8]*James E. Breck, Richard T. Prentki, and Orie L. Loucks, editors, Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting, Proceedings of Conference at Madison, Wisconsin, February 14-16, 1979.*

[9]*E. B. Welch, M. A. Perkins, K. Lynch, and P. Hufschmidt, "Internal Phosphorus Related to Rooted Macrophytes in a Shallow Lake," in James E. Breck et al., editors pp. 81-99; G. B. Lie, "The Influence of Aquatic Macrophytes on the Chemical Cycles of the Littoral," op. cit., pp. 101-106; K. H. Landers, "Nutrient Release from Senescing Milfoil and Phytoplankton Response," 1979, op cit., pp. 127-143; J. W. Barko and R. M. Smart, "The Role of Myriophyllum spicatum in the Mobilization of Sediment Phosphorus," op cit., pp. 177-190; Orie L. Loucks and P. R. Weiler, "The Effects of Harvest Removal of Phosphorus on Remineralized P Sources in a Shallow Lake," op. cit., pp. 191-210.*

[10]*S. Nichols and G. Cottam, "Harvesting As A Control for Aquatic Plants," Water Resources Bulletin, Vol. 8, No. 6, December 1972, pp. 1,205-1,210; J. K. Neel, S. A. Peterson, and W. L. Smith, "Weed Harvest and Lake Nutrient Dynamics," EPA-660/3-73-001, 1973.*

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

organisms, are frequently caught in the harvester. As much as 5 percent of the juvenile fish population can be removed by harvesting. A Wisconsin DNR study found that four pounds of fish were removed per ton of plants harvested.[12]

4. The reduction in aquatic macrophyte biomass by harvesting or chemical control can reduce the diversity and productivity of macroinvertebrate fish-food organisms feeding on the epibiota.[13] Bluegills generally move into the shoreline area after sunset, where they consume these macroinvertebrates. After sunrise they migrate to open water, where they graze, primarily on zooplankton.[14] If harvesting or chemical control shifts the dominance of the littoral macroinvertebrate fauna to sediment dwellers, the macroinvertebrate component of the bluegill diet could be restricted. This would increase predation pressure on zooplankton and reduce the growth rate of the panfish; it could eventually lead to undesirable ramifications throughout the food web in a lake.

5. Launching harvesting equipment in shallow water can be a problem. Most commercially available equipment requires two to four feet of water to float the harvester off its trailer. If water depth is not adequate, a crane may be required to place the harvester in the water. This restriction does not apply for Fowler Lake, where the harvester operates from the St. Paul Street ramp.

6. Macrophyte harvesting may influence the community structure of macrophytes by favoring such plants as milfoil (Myriophyllum sp.) that propagate from cut fractions. This may allow these plants to spread into new areas through the rerooting of the cut fractions.

7. The efficiency of macrophyte harvesting is greatly reduced around piers, rafts, and buoys because of the difficulty in maneuvering the harvesting equipment in those restricted areas. Manual methods have to be used in these areas.

8. High capital and labor costs are associated with harvesting programs. Macrophyte harvesting on Fowler Lake could be continued by the City of Oconomowoc staff or be contracted to a private company. Based upon the number of acres cut in 1986, the estimated annual cost of harvesting by the City staff would be $12,000. These monies are largely staff costs and operating costs such as fuel, oil, and maintenance. The cost of a new harvesting equipment, when needed, would be about $70,000.

A harvesting program should be designed to provide optimal benefits and minimal adverse impacts. Small fish are common in dense macrophyte beds, but larger fish, such as largemouth bass, do not utilize these dense beds.[15] Narrow channels may be harvested to provide navigational access and "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. "Shared access" lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. Because of the demonstrated need for control of aquatic plants in Fowler Lake and because the current lake management decisions have indicated a need for aquatic plant harvesting, harvesting is considered a viable management option to be considered further.

Lake Bottom Covering: Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. They have been used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboating.

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

[13] *Breck et al., op. cit.*

[14] *Breck et al., op. cit.*

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

Sand and gravel are usually readily available and relatively inexpensive to use as cover materials, but plants readily recolonize areas so covered in about a year. Synthetic material, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years. The screens are flexible and can be anchored to the lake bed in spring or draped over plants in summer.

The advantages of bottom covers and screens are that control can be confined to specific areas, the covers and screens are usually unobtrusive and create no disturbance on shore, and the covers are relatively easy to install over small areas. The disadvantages of bottom covers and screens are that they do not reduce eutrophication of the lake, they are expensive, they are difficult to spread and anchor over large areas or obstructions, they can slip on steep grades or float to the surface after trapping gases beneath them, and they may be difficult to remove or relocate.

Screens and covers should not be used in areas of strong surfs, heavy angling, or shallow waters where motorboating occurs. They should also not be used where aquatic vegetation is desired for fish and wildlife habitat. To minimize interference with fish spawning, screens should be placed before or after spawning. A permit from the Wisconsin DNR is required for use of sediment covers and light screens. Permits require inspection by the Department staff during the first two years, with subsequent permits issued for three-year periods.

The estimated cost of lake bottom covers that would control plant growth along a typical shoreline property, an area of about 700 square feet, ranges from $40 for burlap to $220 for aquascreen. Because of the limitations involved, lake bottom covers as a method to control aquatic plant growth are not recommended for Fowler Lake.

Aquatic Macrophyte Survey: To monitor changes in the diversity and abundance of the Fowler Lake aquatic macrophyte community, a periodic survey should be developed that includes, at a minimum, a study of species present, their relative abundance, and a permanent collection of species observed. The survey should result in a species distribution map that can be used to update the aquatic plant management plan given in Appendix A of this report.

The survey should follow the Wisconsin DNR methodology which is a modification of the Jesson and Lound approach.[16] The lake should be surveyed in late June or early July, with a follow-up survey at the end of the summer. Such a survey can be important in monitoring the spread of such exotic species as Eurasian water milfoil. Changes in the aquatic macrophyte community diversity and abundance often indicate changes in the water quality of a lake. The survey should be repeated about every three to five years to detect such changes. The estimated cost of one survey would be $4,000, or about $20,000 for five surveys conducted between 1993 and 2010.

Public Education: Aquatic plant management usually centers on the eradication of nuisance aquatic plants for the improvement of recreational lake use. The majority of the public view all aquatic plants as "weeds" and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impacts. Thus, public education is an important component of an aquatic plant management program and should include information and education on:

1. The types of aquatic plants in Fowler Lake and their value to water quality, fish, and wildlife.

2. The preservation of existing stands of desirable plant species.

3. The identification of nuisance species and the methods of preventing their spread.

4. Alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method.

An organized aquatic plant identification/education day is one method of providing hands-on education to lake residents. Other sources of information and technical assistance include the DNR and the UW-Extension Service (UWEX). The aquatic plant species list provided in Chapter V may serve as a checklist for individuals interested in identifying the plants near

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[16] *Robert Jesson and Richard Lound, An Evaluation of a Survey Technique for Submerged Aquatic Plants, Minnesota Department of Conservation, St. Paul, 1962.*

their residences. Residents can observe and record changes in the abundance and types of plants in their part of a lake on an annual basis.

Of the 23 submerged floating and free-floating aquatic plant species found in Fowler Lake during surveys conducted in 1967, 1986, and 1990, Eurasian water milfoil is one of the few species likely to cause lake-use problems. As discussed in Chapter V, milfoil, like most aquatic plants, can reproduce from fragments and often forms dense beds. Residents should also be encouraged to collect fragments that wash ashore after storms, from weekend boat traffic, and after harvesting. The plant fragments can be used as mulch on flower gardens or ornamental planting areas.

Milfoil and other aquatic plants can be transported between lakes as fragments on boats and boat trailers. To prevent unwanted introductions of plants into lakes, boaters should remove all plant fragments from their boats and trailers when exiting the lake. Providing the opportunity for the removal of plant fragments at the boat landing on Fowler Lake will remind boaters of this practice. Posters and pamphlets are available from the DNR and UWEX that provide information and illustrations of milfoil, discuss the importance of removing plant fragments from boats, and remind boaters of their duty in this regard.

Fish Management

Fowler Lake provides a high quality habitat for a healthy, warmwater fishery. Good water quality, adequate dissolved oxygen levels, sand/gravel shorelines, and a moderate and diverse plant community contribute to the maintenance of a fish population that is dominated by desirable sport fish. Winterkills and the presence of rough fish are not problems.

Table 35 presents a summary of the general habit and habitat of Fowler Lake fish species, potential problems that are perceived by Fowler Lake anglers or that are known to occur in lakes similar to Fowler Lake, and management alternatives to these problems. Specific management alternatives are discussed below.

Fish Surveillance Program: The fish population of Fowler Lake has not been thoroughly studied since 1969. The existing conditions are, therefore, not well understood. As the first step in a fish management program, a periodic fish surveillance program should be developed for Fowler Lake by the Wisconsin DNR or a private consulting firm retained for this purpose. Such a program should include a study of the species present, the predominant age groups present, the growth rates of important species, their condition factors and the ratio of forage fish to predacious fish. This comprehensive survey, including boom shocking, seine netting, and watershed habitat investigations would take approximately two weeks and cost about $16,000.

Habitat Protection: Loss of habitat should be a primary concern of any fish management program. The environmentally valuable areas identified in Chapter V are the most important areas to be protected. Limiting or restricting power boats in these areas will prevent significant disturbance of fish nests and aquatic plant beds. Aquatic plant control should be avoided in these areas. Dredging, filling, and the construction of piers and docks should be discouraged in these areas.

Water level fluctuations can also alter fish habitat. The potential effects of any proposed perturbations in water levels on the fishery should be well-studied before considering implementation. Finally, the importance of maintaining good water quality cannot be overemphasized as a fish habitat protection measure. Because all of these alternatives are preventive in nature, no cost is associated with them.

Habitat Creation: In lakes where vegetation is lacking or where plant species diversity is low, artificial habitat may need to be developed. Northern pike artificial spawning habitat can be created by impounding small streams entering the lake.[17] Such impoundments usually have extensive shallows and marshy habitats that are prime northern pike habitat. Artificial walleyed pike spawning beds have been constructed from rocks and boulders, but the success has varied among lakes. In lakes that lack a healthy and diverse native aquatic plant community, transplant experiments have also been attempted to

[17] *G. C. Becker, Fishes of Wisconsin, The University of Wisconsin Press, Madison, Wisconsin, 1983.*

Table 35

FOWLER LAKE FISH MANAGEMENT

Species	Primary Adult Food Source	Habitat	Potential Problems in Fowler Lake[a]	Management Alternatives
Predator Fish				
Northern Pike	Bullhead, sunfish, perch, sucker, minnow, smaller northern pike, other vertebrates, leeches	Spawn in wetlands adjacent to lake; vegetation utilized as refuge for young and for hunting cover for all ages; optimal midsummer plant cover of 30 to 75 percent of shallow water area	Loss of habitat	Protect natural habitat Develop artificial spawning marshes
			Poor growth rates	Increase spawning habitat of existing forage species Stock to supplement natural reproduction
			Overharvest	Enforce bag limits Encourage catch and release program
Walleyed Pike	Perch, bullhead, darter, minnow, crayfish, insects, worms	Spawn on windswept rocky shores, sandbars, and gravelly shoals; live near or on lake bottom; travel through open water, feeding primarily at night	Lack of habitat	Improve/create spawning habitat
			Poor natural reproduction	Stock to maintain population
			Overharvest	Enforce bag limits Encourage catch and release program
Largemouth Bass	Bluegills, bullhead, perch, largemouth bass, minnow, crayfish, frogs, large insects	Spawn on sand/gravel nests in shallows, adults prefer shallow areas, less than 20 feet deep, with 40 to 60 percent plant cover	Heavy predation on young/competition with panfish	Habitat protection
			Overharvest	Enforce bag limits Encourage catch and release program
Smallmouth Bass	Perch, sunfish, small sucker, young bass, minnow, crayfish	Spawn over sand/gravel bottoms where there is a current; prefer deeper water than largemouth bass, except when feeding	Lack of habitat	Protect existing habitat
			Overharvest	Enforce bag limits Encourage catch and release program
Panfish[b]	Macrophytes, zooplankton, insect larvae, insects, minnow, and juvenile fish	Habitat varies with species: most spawn along sand and gravel shores, although perch prefer vegetation; many forage in beds of aquatic plants or just beyond the plant bed margin; crappies prefer open water rather than the shelter of plant beds; bullheads are primarily bottom feeders	Stunting (slow growth due to overpopulation and limited food source)	Balance predator/prey relationship through stocking and/or panfish removal Encourage panfish harvest by anglers
Rough Fish[c]	Aquatic plants, forage and game fish	Bottom dwelling species; tolerant of low dissolved oxygen levels	Feeding and spawning activities destroy habitat of desirable species, and increase turbidity	Maintain good water quality to reduce potential increase of rough fish Chemical eradication of large populations

[a] These problems are known to occur in other regional lakes and/or are perceived as problems by Fowler Lake anglers surveyed in 1990. The Fowler Lake fish population requires further study to determine the existing problems.

[b] Panfish species include bluegill, pumkinseed, green sunfish, crappie, rock bass, warmouth bass, yellow perch, bullhead.

[c] Rough fish species include carp, white sucker, long-nose gar, bowfin, redhorse, lake chubsucker.

Sources: Wisconsin Department of Natural Resources, Fish and Wildlife Comprehensive Plan, 1979; G. C. Becker, Fishes of Wisconsin, The University of Wisconsin Press, 1983; S. Eddy and J. C. Underhill, Northern Fishes, The University of Minnesota Press, 1974; and SEWRPC.

increase the available fish habitat.[18] As discussed in Chapter V, the results of the aquatic plant surveys of Fowler Lake indicate that there is sufficient habitat for a healthy fish community. The aquatic plant community does not appear to have changed greatly since the 1969 plant survey. Therefore, no habitat creation programs are recommended at this time.

Stocking: Fish stocking is a management method used to supplement naturally reproducing species or to maintain populations of species with poor natural reproduction. Stocking of sport fish encourages angler use of a lake and can be used to maintain a balanced predator-prey relationship. Proper stocking of fish requires a thorough understanding of the existing fish population. Predator fish should not normally be stocked to control a panfish population that is already stunted. Once panfish become so abundant that the population is stunted, the number of predators required to control them is probably higher than the capacity of the lake in question for predators.[19] Overstocking or stocking when native predators are already present in adequate numbers may result in one or more of the following problems: 1) competition of stocked fish and native fish may force stocked fish out of a lake and into adjacent water bodies where their presence may be undesirable, 2) overcrowded fish populations may be more susceptible to bacterial, viral, and parasitic infections, and 3) overstocking may have an unfavorable effect on angling success.[20]

In Fowler Lake, stocking of walleyed pike and/or trout by the Wisconsin DNR is recommended to supplement the existing game fish populations. This may help prevent a stunted panfish population. Largemouth and smallmouth bass stocking is not normally needed where habitat conditions are favorable and is seldom successful where they are not.[21] The estimated annual cost of walleyed pike stocking is $1,000, and for trout is $5,000, based on current stocking programs.

Regulations and Public Education: To reduce the risk of overharvest, the DNR has placed restrictions on the number and size of certain fish species caught by anglers. The open season, size limits, and bag limits for the fish species of Fowler Lake are given in Table 36. Enforcement of these regulations is critical to the success of any sound fish management program.

Chemical Eradication and Lake Drawdown: In lakes with an unbalanced fishery, dominated by carp and other rough fish, chemical eradication has been used to manage the fishery. The fish toxicant Rotenone is used to eradicate the existing fish population with the desired predator fish and panfish reintroduced. Lake drawdown is often used along with the chemical treatment. Drawdown will expose spawning areas and eggs and concentrate fish in shallow pools, thereby increasing their availability to anglers, commercial harvesters, or chemical eradication treatments. The newly created habitat will also benefit desired gamefish populations. Chemical eradication is a drastic, costly measure and the end result may be highly unpredictable. The estimated cost of a Rotenone treatment of Fowler Lake is $35,000; most of this cost is for the chemical itself. Because the rough fish are not currently abundant, this management alternative is not recommended.

Recreational Use Management

In the final analysis, there is the option to adapt recreational uses of a system to its quality and constraints. Sometimes recreational use management can alter public expectations of a system and lead to increased satisfaction among users. Chapter VI noted the informal segregation of uses observed between Fowler Lake, angling and passive recreation, and Lac La Belle, boating, during a recent site visit. Subsequent conversations with City of Oconomowoc staff suggest

[18] *D. H. Les, G. Guntherspergen, J. Keough, and F. Stearns, "Feasibility of Increasing Native Aquatic Macrophytes in Lac La Belle and Okauchee Lakes, Wisconsin: Final Report on 1987 Field Study," unpublished report to the Wisconsin Department of Natural Resources, January 1988.*

[19] *H. Snow, "Effects of Stocking Northern Pike in Murphy Flowage, Wisconsin," Wisconsin Department of Natural Resources Technical Bulletin No. 50, 1974, 25 pp.*

[20] *G. C. Becker, Fishes of Wisconsin, The University of Wisconsin Press, Madison, Wisconsin, 1983.*

[21] *Wisconsin Department of Natural Resources, Fish and Wildlife Comprehensive Plan, 1979.*

Table 36

1992 OPEN SEASON, SIZE LIMITS, AND BAG LIMITS FOR FISH SPECIES IN FOWLER LAKE[a]

Species	Open Season	Daily Limit	Minimum Size
Northern Pike	May 2 to March 1	5	None
Walleyed Pike	May 2 to March 1	5	15 inches
Largemouth and Smallmouth Bass	May 2 to March 1	5 of each	14 inches
Rock Bass	Open all year	None	None
Bluegill, Pumpkinseed (sunfish), Crappie, and Perch	Open all year	50 in total	None
Bullhead	Open all year	None	None
Rough Fish	Open all year	None	None
Trout	May 2 to September 3 Regulated by pamphlet	3	9 inches

[a] *The limits and sizes set forth in this table are for Fowler Lake. Daily limits and minimum sizes vary between lakes.*

Source: Wisconsin Department of Natural Resources, Guide to Wisconsin Hook and Line Fishing Regulations, 1991.

that this is "normal." Formalization of these arrangements, through restrictive boating ordinances that limit the time and area of use and the velocity of the boating traffic, has proven successful in some communities as a way of reconciling use conflicts. It could be applied to Fowler Lake to protect sensitive fish breeding areas. Protection of fish breeding areas has been discussed above. Protection of wetland areas, especially the Class I wildlife areas in the eastern inlet area, could also be accomplished by placing no-wake and boat channel restrictions east of the N. Oakwood Avenue bridge. Similar no-wake restrictions in the vicinity of Fowler Lake Park could also assist the vegetative cover to thrive and resist wind and wave erosion. Jet skiing and water skiing should be restricted to the northern portions of the main basin of Fowler Lake as part of zoning recreational use.

While Fowler Lake has relatively good water quality, primarily because of the quality of the inflow and rapid flushing rate; while the direct drainage areas contribute little in the way of deleterious nutrient or pollutant loads to the system, increased enforcement may be a necessary consequence of placing recreational use and land use restrictions on lakeside residents and lake users. This enforcement could be no more than the placement of notices and advisories at strategic points around the Lake. This is, to a certain extent, already being done with fish advisories; it could be done with milfoil alert notices and other materials. Additional educational and informational brochures and pamphlets, of interest to homeowners, are available from UWEX and the DNR nonpoint pollution control section. These latter cover topics such as beneficial lawn care practices, household chemical use guidelines, and rainwater use guidelines. These brochures could be provided to homeowners through local media, direct distribution or targeted library/civic center displays. The annual Oconomowoc Festival, for example, could include a nature or environmental component similar to the historic Oconomowoc walking tours offered during previous events. Such interventions could also rekindle public interest in the activities of the Fowler Lake Management District.

Many of the foregoing ideas can be integrated into ongoing, larger-scale municipal activities, such as lakeside litter collections, which can reinforce anti-littering. The boardwalk area in the enlarged inlet area could be used as an outdoor classroom by the local schools.

Finally, enrollment of Fowler Lake in the DNR volunteer "Self-Help Monitoring" program, which involves citizens in taking Secchi disk transparency readings in the Lake at regular intervals, could also spur public interest in the Lake, especially if these data were publicized at the annual meeting of the Lake District and the citizen-monitors given some recognition for their

Table 37

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR FOWLER LAKE

Alternative Measure	Description	Estimated Cost: Capital	Estimated Cost: Operation and Maintenance	Considered Viable for Inclusion in Recommended Plan for Fowler Lake	Estimated Percent Reduction in Phosphorus Loading from Source	Estimated Percent Reduction in Phosphorus Loading to Fowler Lake
Rural Nonpoint Source Pollutant Control	Buffer strips, conservation tillage, contour cropping, improved fertilizer and pesticide management, critical area sections	- -[a]	- -	Yes	40	3
Construction Erosion Control	Adoption and enforcement of construction and erosion control ordinance	$ 4,500	$ 300	Yes	75	1
Urban Nonpoint Source Pollutant Control	Two detention ponds and urban housekeeping practices	340,000[b]	13,000[b]	Yes	35	4
Sanitary Sewer Service	Provision of public sanitary sewerage system	- -	- -	Yes	- -	- -
Lake Destratification	Circulation of water column	18,000	2,400	No	N/A	N/A
Aeration	Hypolimnetic aeration	60,000	2,400	No	N/A	N/A
Nutrient Inactivation	Alum treatment	60,000	- -	No	N/A	N/A
Lake Drawdown	Variety of benefits	- -[c]	- -	No	N/A	N/A
Dredging	Sediment removal	7,500,000	- -	No	N/A	N/A
Shoreline Erosion Control	Buffer strips or revetments/ bulkheads	- -	2,200-10,800	Yes	N/A	N/A
Aquatic Plant Management	Plant survey	- -	20,000[d]	Yes	N/A	N/A
Aquatic Plant Control	Chemical treatment	- -	3,500[e]	Yes[f]	N/A	N/A
	Weed harvesting	70,000	12,000	Yes	N/A	N/A
	Lake bottom covering	- -[g]	- -	No	N/A	N/A
Fish Management	Stocking, fish survey, creel census, and public education activities	16,000[h]	5,000[h]	Yes	N/A	N/A
Recreational-Use Zoning	Space and time zoning to restrict fast boating and jet skiing	- -[i]	- -[i]	Yes	N/A	N/A
Education Measures	Variety of measures to educate public on water quality and recreational-use issues	- -[i]	- -[i]	Yes	N/A	N/A

[a] *Implementation of these measures may require new farm machinery or modification of existing machinery but can result in lowered input costs overall.*

[b] *Detention basin sizing based upon 1989 City of Oconomowoc stormwater management study. Costs estimated by SEWRPC.*

[c] *Costs not developed because of limitations of the existing outlet structures to draw down the lake levels adequately.*

[d] *Cost includes five surveys at $4,000 each. Survey to be repeated every three to five years, depending upon the perceived degree of changes in the aquatic plant communities.*

[e] *Treatment area and cost may be reduced by maximizing harvesting.*

[f] *To be combined with mechanical harvesting program. Chemical treatment limited to control of Eurasian water milfoil.*

[g] *Costs range from $40 to $220 per property, assuming about 700 square feet of covering.*

[h] *Costs are about $5,000 for each year stocking occurs and about $16,000 for a comprehensive two-week survey.*

[i] *Costs variable.*

Source: SEWRPC.

work. The Lake Coordinator of the DNR Southeast District could assist in enlisting one or more volunteers in this program. The information gained at first hand by a member of the public during participation in this program could increase the credibility of the proposed changes in the nature and intensity of use to which the Lake is subjected.

SUMMARY

This chapter has described 17 options that could be employed in managing the types of problems recorded as occurring in Fowler Lake and which could, singly or in combination, assist in achieving and maintaining the water quality objectives set forth in Chapter VI. Selected characteristics of these measures are summarized in Table 37.

An evaluation of the potential management techniques was carried out on the basis of the effectiveness of the method for improving the Fowler Lake water quality by dealing with pollutant loadings at their source and on the basis of cost and technical feasibility of the measure. Those alternative measures eliminated from further consideration were: destratification, nutrient inactivation, aeration, drawdown, dredging, and bottom covering. The remaining measures are considered further for incorporation in the recommended plan described in Chapter VIII.

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Chapter VIII

RECOMMENDED MANAGEMENT PLAN FOR FOWLER LAKE

INTRODUCTION

This chapter presents the recommended management plan, including attendant costs, for Fowler Lake. The plan is based upon the land use, land and water management, and physical, biological, and water quality inventory findings; the pollution source and loading analyses; the land use and population forecasts; and the alternative lake management plan evaluations described in Chapter VII of this report. The plan sets forth the recommended means for: 1) providing water quality conditions suitable for full-body contact recreational use and the maintenance of healthy communities of warmwater fish and other aquatic life, 2) reducing the severity of existing nuisance problems due to excessive macrophyte growth, which constrains or precludes desired water uses, 3) improving opportunities for water-based recreational activities, and 4) minimizing shore erosion. The recommended plan was selected from among the alternatives considered and described in Chapter VII considering the degree to which the desired water use objective and the related biological and recreational use objectives could be expected to be met by the alternative and also considering costs and feasibility of implementation.

Analyses of water quality and biological conditions indicate that the general condition of the water in Fowler Lake is good, but that water-based recreation is limited by nuisance growths of aquatic macrophytes. In addition to recommended in-lake management measures, this section of the report also sets forth recommendations for related land use control, land management, and shore protection measures.

As discussed in Chapter VII, major in-lake water quality-related projects are not deemed necessary to meet the water use, recreational, aquatic resource protection, or shore erosion control objectives. Rather, a program to reduce pollutant loadings and to protect land resources deemed important to lake water quality is recommended.

The recommended Fowler Lake management measures are graphically summarized on Map 33 and are listed in Table 38. It is recommended that the Fowler Lake Management District take the lead in implementing the plan. The recommended plan measures are described in the following paragraphs.

LAND USE AND ZONING MEASURES

A fundamental element of a sound management plan and program for Fowler Lake is the proper development of the lands lying in the drainage area tributary to the Lake. The type and location of urban and rural land uses in the drainage area determines the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, various methods of land management measures; and, ultimately, the water quality of the lake.

The recommended land use plan for the drainage area tributary to Fowler Lake has a 2010 design year and is described in Chapter III. The content and framework for the plan is the regional land use plan as prepared and adopted by the Regional Planning Commission. The recommended land use plan is shown in graphic summary form on Map 16 and recommends that additional urban land use development occur at medium and low densities in the Fowler Lake study area. Such urban uses should be permitted to occur, however, only in areas which can be readily served by centralized sanitary sewage facilities; which are covered by soils suitable for the intended use; which are not subject to special hazards such as flooding; and which are not environmentally sensitive, that is, are not encompassed within the Regional Planning Commission-delineated environmental corridors described in Chapter V. By the year 2010, urban development in the Fowler Lake study area and in the total drainage area tributary to the Lake may be expected to increase from 902 to 1,036 acres, or by about 15 percent over the 1990 level of urban development.

A land use issue which has potential to affect Fowler Lake is the redevelopment of existing lakefront properties, replacing low-density, single-family dwellings with higher-density, multi-family dwellings with increased roof areas, parking areas, and other impervious surface areas. This has occurred at other lakes in Waukesha County. Replacement of a pervious

Table 38

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR FOWLER LAKE

Plan Element	Subelement	Location	Management Measures
Land Use Management	Development control	Entire watershed	Observe the guidelines set forth in regional land use plan
	Shoreland protection	City	Add a shore setback provision to ordinances
	Conservancy zoning	City	Place inlet area environmentally sensitive land into conservancy district
Watershed Land Management Measures	Construction site erosion control	Entire watershed	Continue enforcement of existing ordinances
	Urban nonpoint control	City	Construct Fowler Lake Park and Armour Road detention basins as proposed by Donohue & Associates; maintain existing infiltration strip at the Wisconsin Avenue parking lot
	Rural nonpoint control	County	Continue implementation of Oconomowoc River Priority Watershed Plan
	Environmentally sensitive land protection	City	Establish adequate protection of inlet and upstream wetlands as appropriate
Water Quality Management	Water quality monitoring	Entire Lake Fowler Lake Park beach	Enroll in Department of Natural Resources Self-Help Monitoring Program, health monitoring
Aquatic Plant Management	Comprehensive plan revision	Entire Lake	Periodically update aquatic plant management plan
	Major channel harvesting	Zone A Zone O Zone R	Harvest aquatic plants as required
	Minor channel harvesting	Zone B Zone F	Provide access to active recreational zones by harvesting fish lanes and boat-access lanes
	Chemical treatment	Zone B Zone F Zone R	Limited to control of nuisance milfoil growth around docks
Fish Management	Comprehensive survey	Entire Lake	Conduct fish survey to determine stocking needs; conduct creel surveys periodically to update data base
	Fish stocking	Entire Lake	Stock fish as required
Habitat Protection and Lake Use	Restrict boating	Zone A Zone F Zone H	Establish "Slow-No-Wake" zones as shown on Map 33
	Restrict harvesting	Zone H	Restrict harvesting to access channel (Zone A) only
	Restrict chemical treatments	Zone A Zone B Zone F Zone H Zone O Zone R	Prohibit chemical treatments, harvest plants only Limited to control of nuisance growths around docks Limited to control of nuisance growths around docks Prohibit chemical treatments, restrict harvesting to Zone A Prohibit chemical treatments Limited to control of nuisance growths around docks
Shore Protection	Maintain existing structures	Entire Lake	Maintain structures
	Install shore erosion measures	Fowler Lake Park	Install erosion control measures
Information and Education Program	Develop comprehensive program	Entire Lake	Public information and education program

Source: SEWRPC.

land surface with an impervious surface increases the rate at which stormwater enters a lake and increases the pollutant loading to the system. While these effects can be moderated to some extent through structural stormwater management measures, there is likely to be some residual adverse impact in any lake from redevelopment into higher densities. Added to this potential water quality impact is the loss of ambiance associated with the historic homes along the Fowler Lake shoreline and the potential negative impact on the City of Oconomowoc central business district, for which the historic district surrounding the Lake provides the context. For these reasons, maintenance of the historic low- and medium-density shoreline homes on Fowler Lake to the extent practical is recommended. In addition, it is recommended that a green space be maintained around the Lake through the ordinance provision set forth below.

As discussed in Chapter III, the applicable existing City and existing joint Waukesha County-Town of Oconomowoc zoning ordinances are generally consistent with the recommended future land use pattern within the Fowler Lake study area and serve to implement the recommended land use plan. However, current zoning would accommodate redevelopment of portions of the shoreline to multi-family or high-density development along N. Lake Drive. In addition, current zoning provides for multi-family or high-density residential uses and for light and general manufacturing along the southeastern shore of the Lake and inlet area. In order to maintain and expand suitable buffering green space between these land uses and Fowler Lake, including the inlet area, it is recommended that the City zoning ordinance be modified to provide, in all zoning districts, for a minimum shoreline setback of 75 feet from the Fowler Lake and inlet surface water and from other major surface waters. These setback requirements should be designed to prevent construction of principle structures and most impervious surfaces in the shore yard areas. Such provisions could allow for such secondary structures as boathouses and related facilities and could be designed to minimize the creation of nonconforming existing structures or related problems. Adoption of conservancy zoning for the environmentally sensitive lands surrounding the inlet area of Fowler Lake, including wetland areas as shown on Map 33, is also recommended.

WATERSHED LAND MANAGEMENT MEASURES

The recommended watershed land management measures are specifically aimed at reducing the water quality impacts arising from nonpoint sources of pollution within the Fowler Lake watershed. On the basis of a review of the sources of phosphorus loadings to Fowler Lake, as described in Chapters IV and VII, the only significant sources of phosphorus to the Lake in the study area subject to control are rural and urban nonpoint sources. Appropriate nonpoint source pollution control measures include modified agricultural land management practices, construction site erosion control practices, and urban nonpoint source control and stormwater management practices. Technical and financial assistance from the State is available to help implement such practices. For example, funding is available for the institution and maintenance of best management practices under the Chapter NR 120 Wisconsin Nonpoint Source Pollution Abatement Program-Oconomowoc River Priority Watershed Project; the review and amendment of lake-related ordinances is an eligible cost-share expense under the Chapter NR 191 Lake Protection Grant Program. Both programs are administered by the Wisconsin Department of Natural Resources (DNR).

The Regional Planning Commission-adopted regional water quality management plan included recommendations for meeting water use objectives and supporting standards for all major lakes in the Region. The regional plan identified the need for second-level studies to refine the adopted regional plan by identifying locally the particular nonpoint source control practices which are appropriate for specific areas. As discussed in Chapter VII, this management plan, the Oconomowoc River nonpoint source control plan, and the 1989 City of Oconomowoc stormwater management study represent such plan refinement efforts. In addition, recommendations relating to soil erosion control for rural areas are identified in the Waukesha County soil erosion control plan.

As noted in Chapter VII, nonpoint source control measures should be considered for the areas directly tributary to Fowler Lake and the Oconomowoc River downstream of Oconomowoc Lake, as well as in the upstream tributary watershed area. The regional water quality management plan recommended that a reduction of about

25 percent in both rural and urban nonpoint sources be achieved in the study area and in the upstream watershed. Nonpoint source pollution abatement controls in the study area are recommended to be achieved through a combination of rural agricultural controls affecting about 180 acres of land and urban runoff management provided by one infiltration system already constructed, two proposed detention ponds, and construction erosion controls, as well as continued street sweeping in the manner currently carried out by the City.

Implementation of these practices may be expected to result in a reduction of phosphorus loading of about 35 to 40 percent in the study area. Total phosphorus loadings to Fowler Lake may be expected to be reduced by about 30 percent if these recommended measures and the recommendations of the regional water quality management plan and the Oconomowoc River priority watershed plan are carried out in the total drainage area tributary to the Lake, including the provision of public sanitary sewer systems for lakeshore development around North Lake, Okauchee Lake, and Oconomowoc Lake. The phosphorus loading reductions may be expected to be reduced by about 21 percent if the recommended nonpoint source controls, except the elimination of onsite sewerage system impacts, are implemented. There is a continued reliance on onsite sewage disposal systems in the upstream drainage area.

Rural Nonpoint Source Pollution Control

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of the Fowler Lake Management District, Waukesha County, and the Waukesha County Land Conservation Committee. Additional technical assistance can be provided by the U. S. Department of Agriculture Soil Conservation Service; the Wisconsin Department of Agriculture, Trade and Consumer Protection; and the University of Wisconsin-Extension (UWEX).

Highly localized, detailed, and site-specific measures are required to reduce soil loss and contaminant inputs to waters in rural areas effectively. These measures are best defined and implemented at the local level through the preparation of detailed farm conservation plans. It is recommended that such plans be prepared for about 180 acres, as documented in the Oconomowoc River priority watershed plan and the County soil erosion control plan as having estimated soil losses of greater than three tons per acre. Practices which are considered most applicable include conservation tillage and pasture management. In addition, it is recommended consideration be given to cropping patterns and crop rotation cycles, with attention to the specific topography, hydrology, and soil characteristics for each farm. Implementation of these measures will reduce soil loss from agricultural lands by about 60 percent and phosphorus loads by about 30 to 40 percent. This loading reduction in the study area results in a total loading reduction to Fowler Lake of about 3 percent. The cost of these measures varies and depends upon completion of detailed farm conservation plans. These costs may be expected to be incurred for purposes of agricultural land erosion control in any case.

Construction Site Erosion Control

It is recommended that the City and Town of Oconomowoc continue their efforts to control soil erosion from construction activities. As noted in Chapter VII, both the City of Oconomowoc and Town of Oconomowoc have adopted construction erosion control ordinances. The City ordinance is based on the model ordinance promulgated by the Wisconsin League of Municipalities and Wisconsin Department of Natural Resources in Wisconsin Construction Site Best Management Practices Handbook, published by the DNR in 1989. Such controls may include the use of silt fences, sedimentation basins, rapid revegetation of disturbed areas; the control of "tracking" from the site; and careful planning of the construction sequence to minimize the areas disturbed. Construction site erosion controls are particularly important in minimizing the more severe localized short-term nutrient and sediment loadings to Fowler Lake that can result from uncontrolled construction sites. Construction site erosion control measures over the 20-year planning period may be expected to entail a capital cost of about $4,500 per year and an annual operation and maintenance cost of about $300.

Urban Nonpoint Source Control

The development of urban nonpoint source pollution abatement measures should be the joint responsibility of the City of Oconomowoc, the Fowler Lake District, and private property owners. Accordingly, it is recommended that the Fowler Lake Management District work with property owners to promote the needed urban land management and good urban housekeeping practices, such as limiting use of fertilizers and pesticides, controlling litter and pet waste, and managing leaf and yard waste. In this regard, it is recommended that the Fowler Lake Management District obtain and distribute fact sheets for residents specifying specific residential land management practices that would be beneficial to the water quality of Fowler Lake. Several appropriate brochures are available from the Wisconsin DNR and the University of Wisconsin-Extension.

In addition, it is recommended that the City of Oconomowoc continue to provide street sweeping at the current level and maintain the existing infiltration system located in the downtown parking lot adjacent to the Lake. It is further recommended that the City and the Fowler Lake District construct two new detention ponds, one at the Fowler Lake Park and one at the Armour Road site, to reduce urban nonpoint sources of pollution as described in Chapter VII. It is estimated that implementation of these measures would provide a 35 percent reduction in urban nonpoint source pollution runoff. Application of these measures would reduce the total phosphorus load to Fowler Lake by about 4 percent. The capital cost of these structural facilities is about $340,000, with an annual operation and maintenance cost of about $13,000.

Environmentally Sensitive
Land Protection Measures

Given the dominating influence of the Oconomowoc River on the water quality of Fowler Lake, the protection and preservation of the extensive environmental corridor-wetland area at the Lake inlet is important to the protection of the water quality of Fowler Lake. As noted previously, it is recommended that the inlet area wetlands located to the shoreward of the Ordinary High Water Mark be placed under conservancy zoning, not only to provide wildlife habitat and breeding areas, but also to protect the beneficial water quality effects generated by the passage of the influent River through this natural area during high-flow periods. Similar recommendations apply to the area below the Ordinary High Water Mark; these are set forth herein as in-lake management measures. Public acquisition of conservation easements over such lands, or public acquisition of the lands, would provide for the long-term protection of the water quality, aesthetic, and habitat preservation benefits accruing from these wetlands. In this regard, implementation of the recommendations of SEWRPC Community Assistance Planning Report No. 72, A Park and Open Space Plan for the City of Oconomowoc, would provide for the acquisition of some of these environmentally sensitive lands in the vicinity of the Fowler Lake inlet for park and open space purposes. Acquisition of environmentally sensitive lands, wetland restoration, and ordinance development can be subvented under the Stewardship Program, set out in Chapters NR 50 and NR 51, Wisconsin Administrative Code, or the Wisconsin Lake Protection Grant Program, established under S. 144.254, Wisconsin Statutes, the administrative rules recently published in Chapter NR 191, Wisconsin Administrative Code. Purchasing riparian lands or conservation easements along the southern shore of the inlet, east of N. Oakwood Avenue, may be an eligible cost-sharing project under the latter program. The City of Oconomowoc should contact the Wisconsin DNR to pre-qualify as an eligible project sponsor under the program and to include these lands and the proposed Oconomowoc River Parkway lands in a preliminary application for cost-share funding.

IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for Fowler Lake are summarized in Table 38 and are graphically summarized on Map 33. The major plan elements include water quality monitoring, aquatic plant management, fish management, habitat protection, shoreline protection, and recreational-use zoning.

Water Quality Monitoring

Continued water quality monitoring of Fowler Lake is recommended. Enrollment of one or more Lake Management District residents as Wisconsin DNR Self-help Monitoring Program volunteers is recommended. This may be done through the Southeast District Office of the Department at no cost to the Lake Management District, although a time commitment will be asked of the volunteers. In addition, participation in the expanded self-help monitoring program, measuring nutrients, chlorophyll-a, dissolved oxygen, pH, and temperature, is recommended. Such monitoring should be conducted in at least three locations and at least four times per year. The City of Oconomowoc, in conjunction with its public health maintenance responsibilities, should continue to monitor water clarity and bacterial levels at regular intervals to ensure compliance with full-contact recreational standards.

Aquatic Plant Management

An aquatic macrophyte control plan consistent with Chapters NR 103 and NR 107 of the Wisconsin Administrative Code is included as Appendix A of this report. The plan recommends that continued aquatic macrophyte surveys be conducted at three-to five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of:

1. Major areas of nuisance plant growth;
2. Areas harvested and/or chemically treated;
3. Species harvested and amounts of plant material removed from lake; and
4. Species and approximate numbers of fish caught in the harvest.

A daily harvester log, containing this information, should be maintained as set out in the attached aquatic plant management plan. This information, in conjunction with the formal aquatic macrophyte surveys, will allow evaluation of the effectiveness of the aquatic plant control program and allow adjustments to be made to maximize its benefit.

Modifications of the existing aquatic plant management program are recommended to enhance the use of the Lake while maintaining the quality and diversity of the biological communities. The following guidelines are recommended:

1. Mechanical harvesting is recommended as the primary management method.
2. Shared-access lanes should be harvested, rather than clear-cut, to minimize the potential detrimental effects on the fish and invertebrate communities. Directing boat traffic through these common lanes should delay the regrowth of vegetation in these areas.
3. Chemical herbicide use should be limited to controlling nuisance growth of nonindigenous species, such as Eurasian water milfoil. Only herbicides that selectively control milfoil, such as 2,4-D, should be used.
4. Chemical use should be restricted to those areas of nuisance aquatic macrophyte growth in shallow water near docks and other areas where harvesting is not feasible.
5. Chemical application, if required, should occur shortly after harvesting to maximize its effectiveness. The harvested plants will thus be chemical-free and suitable for use as mulch or other uses.
6. Algicides, such as Cutrine Plus, are not recommended because there are no filamentous or planktonic algae problems in the Lake. Valuable macroscopic algae, such as Chara and Nitella, are killed by this chemical.

Fowler Lake has been partitioned into zones, with aquatic plant controls in each zone designed to optimize desired recreational opportunities and to protect the aquatic resources. The recommended aquatic plant control zones are shown on Map 33 and the controls recommended for each zone are described below.

1. Zone A, Access: A narrow channel, approximately 10 to 15 feet wide, would be harvested along a portion of the eastern bay and the Oconomowoc River inlet to provide boating access to the main body of Fowler Lake. The total area harvested is approximately 0.5 acre. No chemicals should be used.
2. Zone F, Fishing: Zone F, along the northern parkway and along the western access sites, would accommodate fishing from the shore. In this zone, approximately 10- to 15-foot-wide channels would be harvested perpendicular to the shore at about 100-foot intervals. The total area harvested would be approximately 0.5 acre. Chemical use, if required, would be restricted to nuisance milfoil control near the public access.

3. Zone B, Boating: Zone B, along the western shore, is an important largemouth bass spawning area on a hard substrate. Harvesting would be limited to 10- to 15-foot-wide channels extending perpendicular to the shore to allow boat access to the central portion of the lake. The total area harvested would be approximately one acre. Chemical use, if required, would be restricted to pier and dock areas and would not extend more than 50 feet from the shore.

4. Zone R, Recreational: Zone R, along the eastern and southern end of the lake, above the bridge, contains the most heavily used areas of shoreline. Nuisance aquatic macrophyte growth within 150 feet of shoreline would be harvested to provide maximum opportunities for boating, fishing, and limited swimming. Two additional 30-foot-wide shared-access channels would extend to the center of the lake. The maximum total area harvested would be approximately five acres. Although 4,500 feet of shoreline are included in this zone, the entire area may not require intensive management. Harvesting should be concentrated in areas of abundant macrophyte growth. Patterns of harvesting will vary yearly dependent on macrophyte abundance. Chemical use, if required, would be restricted to pier and dock areas and would not extend more than 50 feet from shore.

5. Zone O, Open Water: Harvesting would be conducted in selected areas of deeper water to provide a larger shared space for boating and fishing. Navigational channels, 30 feet in width, would be harvested. This zone would supplement those areas with a water depth greater than 20 feet which do not have excessive macrophyte growth. The total area harvested would be approximately two acres. No chemicals should be used.

6. Zone H, Habitat: Most of the eastern bay of the Fowler Lake and the Oconomowoc River inlet would be preserved as a high-quality habitat area. This zone and adjacent lands would be managed for wildlife, with the possible construction of waterfowl nesting facilities such as wood duck boxes and nesting poles. No harvesting or in-lake chemical application would be conducted, although some herbicide application may be required in the wetlands for control of purple loosestrife. Debris and litter cleanup would be needed in some adjacent areas; the immediate shoreline would be preserved in natural, open use.

Summary of Recommended Aquatic Plant Management Program: Under the recommended aquatic plant control program, about 8.0 to 10.0 acres of Lake surface area would be harvested. Some of these areas would be harvested more than once per year. Chemical applications would be restricted to the control of milfoil and purple loosestrife and use at the public boat launch and around docks and piers. The recommended program should not require an increase in the City's equipment or labor cost for aquatic plant control, although the eventual replacement of the harvester and other machinery may be required. Cost-share programs administered by the Wisconsin Waterways Commission may be available to offset up to 50 percent of the capital cost of new or used harvesting equipment purchased by State-approved organizations with aquatic plant management plans consistent with the requirements of Chapters NR 103 and NR 107 of the Wisconsin Administrative Code. The present cost of an aquatic plant harvester and ancillary equipment is approximately $70,000 as set forth in Appendix A, with annual operating costs of about $12,000. In addition, it is recommended that an aquatic plant survey be conducted once every three to five years to determine changes in the aquatic plant community. Such surveys are estimated to cost $4,000, or about $20,000 over the 20-year planning period.

Fish Management

The aquatic plant management strategy set forth above recognizes the importance of angling as a recreational use of Fowler Lake. Integral to the aquatic plant management strategy is the protection and preservation of fish breeding habitat, especially in the area of the enlarged inlet/headwater marsh (Zone H) and along the western shore of the lake (Zones B and F on Map 33). Any interventions in the inlet should be confined to the navigation access channel on the northern shore, shown as Zone A on Map 33.

Two specific actions are recommended in respect of fisheries management: conducting a fish survey and assessing angling pressures. The fish survey would have several objectives:

1. To identify any changes in fish species composition that may have taken place in the Lake since the previous survey, in 1969;

2. To relate any changes in fish populations, species composition and condition factors to such known interventions as stocking programs, water pollution control activities, and/or aquatic plant management programs;

3. To refine and update information on fish breeding areas, breeding success and survival rates.

Additional information, such as obtaining confirmation of the lack of disturbance by rough fish populations, could also be obtained through such a survey.

The second action in terms of the fish management program is the assessment of angling pressures on the Lake. This program would:

1. Provide information on the survival of walleyed pike and trout currently stocked into Fowler Lake (Table 27);

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

3. Provide data to assess the implications of a possible over-harvest of largemouth bass from the lake.

This last action is recommended to be carried out by the Wisconsin Department of Natural Resources. Given the fishing pressures on the Lake, it would be useful to conduct a one-time analysis of fish tissues for metal and toxic contamination. This task could be included in the fish survey, when it would be possible to obtain representative samples from among the fish species collected during the survey. The cost of such a comprehensive fish survey is estimated to be $16,000. Stocking costs are dependent on the availability and types of fish stocked but can be expected to average $5,000 annually.

Habitat Protection

Habitat protection measures recommended for Fowler Lake are, in part, provided for by the recommended aquatic plant management program activities. The aquatic plant management plan is designed to provide for such habitat protection measures, as being aware of fish breeding areas and avoiding disturbances in these areas during spring and autumn; reducing the use of herbicides in these areas; and maintaining stands of native plants especially in the inlet area. In addition, it is recommended that environmentally sensitive lands including wetlands along the lakeshore and influent River be preserved as set forth above.

Recreational Use Zoning

The principle actions required in terms of this task would include the imposition of "Slow-No-Wake" restrictions on those portions of the Lake bordering sensitive areas such as Zone A, and where boating activities could be expected to come into conflict with other uses such as angling in Zone F, swimming in Zone R, and habitat areas in Zone H. Adoption of a boating regulation ordinance by the City may be necessary to carry out this action. Delegation of Lake safety patrol functions to the Lake District pursuant to Section 33.22 of the Wisconsin Statutes could be considered. A Fowler Lake safety patrol operation may be eligible for partial State cost-share funds under Section 30.77 of the Wisconsin Statutes. Such a patrol could function part-time on Fowler Lake and part-time on Lac La Belle.

Shoreline Protection

Most of the Fowler Lake shoreline is protected; however, an area of erosion has been identified along the Fowler Lake Park shoreline which requires protection. Various possible protection options have been outlined in Chapter VII to be considered to repair or replace existing protection structures. Adoption of the vegetated buffer strip method is recommended along Fowler Park shoreline in order to maintain the natural ambience of the park-like setting. Continued maintenance of existing revetments and bulkheads is also recommended. The cost of shoreline erosion control measures in Fowler Park is estimated to be $2,500.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the City of Oconomowoc and the Fowler Lake Management District. The recommended plan introduces few new elements, although some of the plan recommendations

Table 39

LOCAL GOVERNMENTAL MANAGEMENT AGENCY RESPONSIBILITIES FOR PLAN IMPLEMENTATION

Plan Element	Agency				
	Waukesha County	Fowler Lake Management District	City of Oconomowoc	Town of Oconomowoc	Department of Natural Resources
Land Use Management					
Development Control	X	--	X	--	--
Shoreland Setback Protection	--	--	X	--	--
Inlet Area Zoning	--	--	X	--	--
Watershed Land Management					
Construction Site Erosion Control	X	--	X	X	--
Urban Nonpoint Source Control	--	--	X	--	--
Rural Nonpoint Source Control	X	--	--	--	--
Environmentally Sensitive Land Protection	--	X	X	--	--
Water Quality Management					
Self-Help Monitoring	--	X	--	--	X
Health Monitoring	--	--	X[a]	--	--
Aquatic Plant Management					
Comprehensive Plan Revision	--	X	X	--	X[b]
Major Channel Harvesting	--	X	X	--	--
Minor Channel Harvesting	--	X	X	--	--
Chemical Treatment	--	X	X	--	X[c]
Fish Management					
Comprehensive Survey	--	X	X	--	X
Fish Stocking	--	X	X	--	X
Habitat Protection and Lake Use					
Restrict Boating	--	--	X	--	X[b]
Restrict Harvesting	--	X	X	--	--
Restrict Chemical Treatment	--	X	X	--	X[c]
Shore Protection					
Maintain Existing Structures	--	X[d]	--	--	--
Install Protection In Fowler Lake Park	--	X	X	--	X[c]
Information/Education	X[e]	X	X	X	X

[a] *The City of Oconomowoc should continue to conduct biological and fecal coliform bacterial sampling; in addition, the City may wish to continue with the more comprehensive U. S. Geological Survey sampling program.*

[b] *The Wisconsin Department of Natural Resources reviews aquatic plant management plans, revisions thereof, and boating ordinances for compliance with State rules.*

[c] *This activity requires a Wisconsin Department of Natural Resources permit.*

[d] *Resident responsibility.*

[e] *County assistance is provided through the Land Conservation Committee and University of Wisconsin-Extension.*

Source: SEWRPC.

represent refinements of current operations. This is especially true in the case of the fisheries and aquatic plant management programs, where the field surveys recommended in this plan will permit more efficient management of these resources.

Generally, fisheries and aquatic plant management practices such as stocking, harvesting, and public awareness campaigns currently implemented by the City of Oconomowoc are recommended to continue with refinements set forth herein and further refinements to be considered at some later time. Some aspects of these programs lend themselves to citizen involvement through volunteer-based creel surveys, participation in the DNR Self-Help Monitoring Program, and identification with environmentally sound household land management. It is recommended that the City take the lead in these actions, with a view toward building community commitment and involvement. Assistance is generally available from agencies such as the Wisconsin DNR, the County UWEX office, and the Southeastern Wisconsin Regional Planning Commission. Thus, much of the proposed lake management program is based on a continuation of existing expenditures, voluntary programs, and occasional surveys that involve little additional expense to the City of Oconomowoc or the Fowler Lake Management District.

New work elements recommended in the plan include the periodic surveys indicated above. Some of the recommendations form part of ongoing operations or have been anticipated. For example, review and assessment of zoning ordinances and boating ordinances are ongoing activities. The conduct of fish and aquatic plant surveys, recommended in the plan, are designed to provide necessary information for the continued sound management of the Lake, while citizen-based volunteer monitoring programs will involve the public in a meaningful and constructive way in lake management.

The major cost item relating to new elements contained in this plan relates to the conduct of nonpoint source pollution abatement structural measures and to the purchase of lands and/or easements associated with the environmentally sensitive area protection. Inclusion of the environmentally sensitive areas in the vicinity of Fowler Lake inlet area in some type of protection program is recommended. State cost-share opportunities may be available to obviate the funding burden associated with at least some of these expenditures.

The suggested lead agency or agencies for initiating program-related activities, by plan element, are set forth in Table 39 and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in Table 40.

Table 40

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR FOWLER LAKE: 1993-2010

Plan Element	Estimated Cost 1993-2010[a] Capital	Estimated Cost 1993-2010[a] Annual Average Operation and Maintenance	Potential Funding Sources
Land Use Management			
Development Control	- -[b]	- -[b]	Department of Natural Resources, Waukesha County, City and Town of Oconomowoc
Shoreland Protection	- -	- -	City of Oconomowoc
Shoreland Zoning	- -[b]	$ 1,000[b]	Department of Natural Resources, Waukesha County, City and Town of Oconomowoc
Watershed Land Management Measures			
Construction Site Erosion Control	$ 4,500	$ 300	Private firms, individuals
Urban Nonpoint Source Control	340,000[c]	13,000[c]	City of Oconomowoc
Rural Nonpoint Source Control	- -[c,d]	- -[c,d]	Department of Natural Resources, Waukesha County
Environmentally Sensitive Land Protection	- -[c]	- -[c]	Department of Natural Resources, City of Oconomowoc
Water Quality Management			
Self-Help Monitoring	- -	$ 100[e]	Fowler Lake District, Department of Natural Resources
Health Monitoring	- -	5,000[f]	City of Oconomowoc, U. S. Geological Survey, Department of Natural Resources, Fowler Lake District, residents
Aquatic Plant Management			
Comprehensive Plan Revision and Plant Surveys	$ 20,000	- -	Fowler Lake District, City of Oconomowoc
Major/Minor Channel Harvesting	70,000[g]	$12,000	City of Oconomowoc, Fowler Lake District, Department of Natural Resources, Wisconsin Waterways Commission
Chemical Treatment	- -	3,000	City of Oconomowoc, Fowler Lake District, Department of Natural Resources
Fish Management			
Comprehensive Survey	$ 16,000	- -	Department of Natural Resources, Fowler Lake District, City of Oconomowoc
Fish Stocking	- -	$ 5,000	Department of Natural Resources, Fowler Lake District, City of Oconomowoc
Habitat Protection and Lake Use			
Restrict Boating	- -	- -	Department of Natural Resources, City of Oconomowoc
Restrict Harvesting	- -	- -	City of Oconomowoc
Restrict Chemical Treatment	- -	- -	Department of Natural Resources, City of Oconomowoc

Table 40 (continued)

Plan Element	Estimated Cost 1993-2010[a] Capital	Estimated Cost 1993-2010[a] Annual Average Operation and Maintenance	Potential Funding Sources
Shore Protection			
Maintain Existing Structures	- -	- -	Residents
Install Protection In Fowler Lake Park . . .	$ 2,500	- -	Fowler Lake District, City of Oconomowoc
Information/Education	- -	$ 1,000	Fowler Lake District, City of Oconomowoc, University of Wisconsin-Extension, Department of Natural Resources

[a]*All costs expressed in January 1993 dollars.*

[b]*Cost-share assistance may be available for ordinance review, revision, and writing under the NR 191 Lake Protection Grant Program.*

[c]*Cost-share assistance may be available for watershed-based best management practice repair or replacement under the NR 120 Wisconsin Nonpoint Source Pollution Abatement Program.*

[d]*Costs vary and will depend upon preparation of individual farm plans.*

[e]*Enrollment in the Self-Help Monitoring Program is without cost but does entail a time commitment from the volunteer.*

[f]*Cost-share assistance may be available from the NR 119 Lake Management Planning Grant Program.*

[g]*It is assumed that the existing harvester and ancillary equipment will be replaced during the planning period; cost-share assistance for harvester purchase may be available from the Wisconsin Waterways Commission Recreational Boating Grant Program.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

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Chapter IX

SUMMARY

This management plan for Fowler Lake was cooperatively prepared by the Southeastern Wisconsin Regional Planning Commission, the Fowler Lake Management District, the City of Oconomowoc, the Wisconsin Department of Natural Resources (DNR), and the U. S. Geological Survey (USGS). The planning effort included the design and conduct of a water quality sampling program encompassing sampling for the quality not only of the Lake itself but also of the surface water inflows and outflows and of the groundwater entering and leaving the Lake. Inventories and analyses were conducted of the existing and recommended future land use patterns within the watershed of the Lake, the physiography and natural resource base of the watershed, the recreational uses of the Lake, and the management practices employed both on the Lake and in its watershed. Field studies associated with these activities were conducted during 1984, 1988, 1991, and 1992.

The objectives of this lake management plan are to provide for the protection and maintenance of good water quality conditions, for the enhancement of recreational opportunities, and for the maintenance of a healthy fishery and other aquatic resources. These objectives are intended to complement broader City objectives concerning the enhancement of the economic development potential of the area and quality of life in the Oconomowoc area. Fowler Lake is situated immediately adjacent to the City of Oconomowoc central business district, and, for this reason, is of particular concern to the City, its citizens, and visitors. An inland lake protection and rehabilitation district was established for the Lake in 1983, and both the District and the City have played active roles on the Lake since that time.

The analyses indicate that the Lake is a dimictic, oligomesotrophic water body with excellent water clarity and rapid through-flow of water. These characteristics help to maintain healthy and diverse aquatic plant and fish communities. However, the abundant growths of aquatic plants within the Fowler Lake basin exert constraints on its recreational uses, including angling, boating and swimming, while continued urban development and agricultural activity within the watershed threaten its ecological integrity through the transport of eroded materials and contaminants into the Lake by stormwater. Nevertheless, despite its urban location, Fowler Lake is remarkably free from the pollution problems experienced by many similarly situated water bodies.

Fowler Lake is a 99-acre impoundment of the Oconomowoc River downstream of Oconomowoc Lake and directly upstream of Lac La Belle. The Lake lies entirely within U. S. Public Land Survey Section 33, Township 8 North, Range 17 East, City of Oconomowoc, Waukesha County. It was created on the site of an existing water body in about 1837 when construction of a dam on the Oconomowoc River increased the water level of the Lake by about eight feet. The Lake has a maximum depth of 50 feet and a mean depth of 13 feet. Its direct drainage area, including the area draining to the wetland complex and the Oconomowoc River between Fowler Lake and Oconomowoc Lake, totals about 1,604 acres, or 2.5 square miles, while its total tributary drainage area, or watershed, encompasses about 47,757 acres, or 77.7 square miles.

INVENTORY FINDINGS

Population

In 1990, the resident population of the Fowler Lake direct drainage area was estimated by the Regional Planning Commission at 4,800 persons. By the year 2010, the resident population of the direct drainage area may be expected to reach about 5,500 persons.

Land Use

As of 1990, approximately 885 acres, or 55 percent of the 1,604-acre direct drainage area, was in urban land uses, as shown on Map 15, with residential land uses the dominant urban use. Approximately 719 acres, or 45 percent of the drainage area, were in rural land uses, with agriculture the dominant nonurban land use.

Water Quality

Measurements of the primary water quality indicators, total phosphorus and chlorophyll-a concentrations and Secchi disk transparency, indicate that Fowler Lake continues to have good water quality, as shown in Figure 4.

Water Budget
The Oconomowoc River provides almost 98 percent of the total water inflow to Fowler Lake, as shown in Figure 1; nearly 100 percent of the outflow from the Lake is via the same River.

Sediment Yields
Approximately 92 percent of the more than two million pounds of sediment entering Fowler Lake annually are delivered from the total watershed of the Lake via the Oconomowoc River; only about 6 percent of this load is contributed by runoff from the City of Oconomowoc.

Nutrient Loading
As of 1990, phosphorus was delivered to the Lake primarily by the Oconomowoc River, which transports about 88 percent of the 2,630 pounds of phosphorus entering the Lake annually; about 10 percent of the load is contributed by runoff from the City of Oconomowoc. Some 76 percent of the load leaves the Lake by way of the outlet, while about 24 percent of the load is retained in the Lake through sedimentation. About 97 percent of the 181,000 pound total nitrogen load to Fowler Lake is delivered by the Oconomowoc River. Approximately 78 percent of this load leaves the Lake via the outlet, while 22 percent is retained in the Lake through sedimentation or lost to the atmosphere by denitrification.

Natural Resources Base 1990
As of 1990, wetlands, as shown on Map 25, covered about 226 acres, or 14 percent of the direct drainage area of the Lake. Woodlands covered a further 56 acres, or 3.5 percent of the direct drainage area of the Lake. Approximately 355 acres, or 22 percent of the direct drainage area, were identified as wildlife habitat; about 151 acres, or 10 percent of the drainage area, as Class I habitat; 156 acres, or 10 percent, as Class II habitat; and about 47.5 acres, or 2 percent, as Class III habitat, as shown on Map 24. Environmentally valuable areas within the Fowler Lake basin included the extensive wetland area which forms the inlet to the Lake.

Recreational Use
A total of more than 40 vessels was observed docked or moored in and around the Lake during field surveys conducted for the planning effort. The number of watercraft in active use on Fowler Lake during the 1991 and 1992 surveys ranged from none to five, as indicated in Table 32. The number of participants engaged in nonboating activities on and around Fowler Lake during the 1991 and 1992 surveys ranged from six to 42, with the greatest number walking or picnicking in the various public areas surrounding the Lake. Angling was the next most popular pastime.

Shoreline Protection
Virtually all of the Fowler Lake shoreline is protected by some form of shoreline protection structure, as shown on Map 3. These structures, based upon surveys conducted in 1988 and in 1992, consisted of 38 bulkheads, eight revetments, and three beaches. Most of the inlet was unprotected, except for extensive growths of rooted aquatic plants. Of the existing shoreline protective structures, about 40 percent were judged to be subject to some type of failure during the 1988 survey; most had been repaired at the time of the 1992 survey.

Public Access
In 1990, there were six public access sites on Fowler Lake, all located within the City of Oconomowoc, as shown on Map 28. Provision of park and open space sites in the Fowler Lake study area should be guided by the recommendations set forth in SEWRPC Community Assistance Planning Report No. 72, A Park and Open Space Plan for the City of Oconomowoc, published in November 1987 and developed in connection with the proposed Oconomowoc River Parkway.

ALTERNATIVE LAKE MANAGEMENT MEASURES

Seventeen lake management measures were evaluated as part of the planning process. The alternative measures considered include: amendment of the land use and zoning regulations to provide additional water quality protection for Fowler Lake; refinement of sanitary sewer service areas serving the Fowler Lake drainage area; adoption of additional rural nonpoint source controls, relating especially to agricultural soil loss; adoption of urban nonpoint source controls, relating especially to construction site erosion control and stormwater management in the City of Oconomowoc; destratification; hypolimnetic aeration; nutrient inactivation; drawdown to control aquatic plants; dredging; institution of further shoreline erosion controls, including both vegetative and structural approaches; use of aquatic herbicides to control aquatic plant growth; use of aquatic plant harvesting techniques; bottom covering; fish stocking; drawdown to control rough fish; protection and/or creation of fish habitat; chemical eradication of rough fish; and use of regulatory measures to control angling pressure. In addition, the contribution of public information and education to lake management programs, including participation in the Wisconsin DNR Self-Help Monitoring Program, was mooted.

THE RECOMMENDED PLAN

Because Fowler Lake enjoys relatively good water quality and management of surrounding land use, the management plan for this water body has focussed largely on maintaining good water quality and protecting the Lake from future abuse. Maintenance of the aesthetic appeal and recreational utility of the Lake is recommended to be attained through ongoing aquatic plant and fishery management practices, such as harvesting and stocking. Adoption of a lake use zoning system, set forth on Map 33, should ensure that all users have ample opportunity to engage in their activities with minimal interference from other users. Incorporation of habitat and conservation considerations into this use zoning system will ensure the ecological stability of the Lake, which underlies many of its recreational uses, including aesthetic enjoyment and angling. As the Oconomowoc area may be expected to continue to experience growing urban development in the foreseeable future, incorporation of additional parklands and/or conservancy areas into the lake protection scheme is recommended. Not only will these areas provide additional recreational facilities for the expanding population, but they will also protect the aesthetic appeal of the Lake and its direct drainage area, especially in the vicinity of the headwaters of the Lake. The principle plan elements include:

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

1. Maintenance and expansion of vegetated, "green" space, buffers between the shore of the Lake and the shoreline development across all zoning districts by modifying the City zoning ordinance to provide for a 75-foot setback to prevent the construction of principal structures and impervious surfaces within this zone. Such provisions could allow for secondary structures such as boathouses and related facilities designed to minimize the creation of nonconforming existing structures. This modification should also provide for the adoption of conservancy zoning for the environmentally valuable lands surrounding the Fowler Lake Inlet not already included in such a zoning district, as shown on Map 33.

2. Continued implementation of the nonpoint source controls recommended in the regional water quality management plan and the Oconomowoc River priority watershed plan to achieve an overall 25 percent reduction in nonpoint source contamination through the application of rural agricultural controls on about 180 acres of land in the direct drainage area, the construction of two proposed urban stormwater detention basins, continuation of such actions as maintenance of the Pleasant Street parking area infiltration system and street sweeping, householder information campaigns aimed at fostering good urban housekeeping practices, and enforcement by the City of Oconomowoc of the construction site erosion control ordinance.

3. Enrolment of one or more Lake District electors in the Wisconsin DNR Self-Help Monitoring Program and participation in the expanded program. The City of Oconomowoc should also maintain the City's bacteriological monitoring program for the Lake.

For the enhancement of recreational opportunities through the reduction in severity of nuisances arising from recurring excessive algal and aquatic plant growths:

1. Adoption and maintenance of the modified aquatic plant management plan provided as Appendix A of this plan and maintenance of the daily harvester logs, as recommended therein. Adoption of this plan would entail modification of the existing aquatic plant management practices by specifying mechanical harvesting as the primary management method, limiting the use of herbicides to the control of nonnative plants such as Eurasian water

milfoil and purple loosestrife, restricting herbicide use to shallow water areas near docks and areas where harvesting is not feasible, modifying herbicide application times to coincide with recent harvesting to maximize herbicide effectiveness, eliminating the use of algicides, and creating shared-access lanes to enhance fisheries and deep-water access while retaining native aquatic plant beds for fish habitat and breeding purposes.

2. Adoption of lake use zoning as set forth on Map 33 to provide for multiple-purpose recreational use of Fowler Lake. Zoning is recommended to provide for boating access from the northern shore of the inlet to the main lake basin, Zone A; boating access to and from the public launch sites and primary residential areas, Zone B; shore-based fishing from the northern parkway and western shores, Zone F; water-based recreation, including swimming, fishing, and boating along the eastern and southern shores, Zone R; deep-water recreational activities in the central portions of the Lake, Zone O; and habitat preservation within the eastern embayment and Inlet, Zone H.

For the protection and enhancement of fish stocks and other aquatic resources, including wildlife habitat, woodlands, and wetlands:

1. Obtaining lands by purchase or conservation easement along the southern shore of the Fowler Lake Inlet and maintenance of the integrity of the environmental corridors upstream of, and in the vicinity of, Fowler Lake, including modification of the City zoning ordinance to provide for conservancy zoning of the inlet wetlands, as previously noted.

2. Conducting a fish survey to assess changes in species composition within Fowler Lake since the previous fisheries survey undertaken in 1969 and changes in angling-related pressures on the fish populations. This will provide information needed to manage better the ongoing fish stocking program for the Lake.

3. Through recreational use zoning and related activities for the protection of fish breeding areas and habitat including promulgation of modifications to the City zoning code, set forth above, minimizing disturbances to lacustrine fish breeding areas during spring and autumn. Applying "slow-no-wake" restrictions applicable to Zone A and in those areas immediately adjacent to use zones where boating activities could be expected to interfere with other uses, such as adjacent to Zones F, R, and H, where boating could be expected to affect fishing, swimming, and habitat protection uses, would be useful.

4. Continuing proper maintenance of the shoreline protection structures, including the repair and/or replacement of failed structures and the erection of suitable structures along eroding shorelines, as shown on Map 3, is encouraged. Use of vegetative buffers along the Fowler Lake Park shoreline is especially recommended.

The recommended plan is based largely on existing and ongoing lake management measures being employed by the City of Oconomowoc and the Fowler Lake Management District. These two public entities would retain primary responsibility for implementing this plan. Implementation of the plan would entail a capital expenditure of about $453,000 and an annual operations and maintenance expenditure of about $40,400, as shown in Table 40, including existing expenditures.

Fowler Lake is a valuable natural resources in the Southeastern Wisconsin Region and a particularly valuable asset to the City of Oconomowoc central business district. The delicate, complex relationship between water quality conditions in Fowler Lake and the land uses within its tributary drainage area is likely to be subject to continuing pressures as demands for water-based recreation in the Lake and for urban development within its watershed, resulting from increases in population, income, leisure, and individual mobility for the Region, increase in the foreseeable future. To provide the water quality protection needed to maintain in Fowler Lake conditions conducive to meeting such pressures, it will be necessary to adopt and administer an effective program of lake management based upon comprehensive water quality management and related plans. This plan comprises an important element of such a program and is consistent with previously adopted comprehensive land use, water quality, recreation and open space, soil erosion control, and sanitary sewer service area plans for the Southeastern Wisconsin Region.[1]

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[1] *SEWRPC Planning Report No. 40, A Regional Land Use Plan for Southeastern Wisconsin—2010, January 1992; SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin, Volume 3, Recommended Plan, June 1979; DNR Publication No. WR-194-86, A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed, March 1986; SEWRPC Community Assistance Planning Report No. 72, A Park and Open Space Plan for the City of Oconomowoc, November 1987; SEWRPC Community Assistance Planning Report No. 159, Waukesha County Agricultural Soil Erosion Plan, June 1988; SEWRPC Community Assistance Planning Report No. 172, Sanitary Sewer Service Area for the City of Oconomowoc and Environs, Waukesha County, Wisconsin, February 1989.*

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APPENDIX

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Appendix A

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

INTRODUCTION

This aquatic plant management plan is an integral part of the Fowler Lake Management Plan and represents an important element of the ongoing commitment of the City of Oconomowoc and Fowler Lake Management District to sound environmental management of the Lake. The aquatic plant management portion of the management plan, prepared between 1992 through 1993 by the Regional Planning Commission, is based on field surveys conducted during 1991. This plan follows the format adopted by the Wisconsin Department of Natural Resources (DNR) for aquatic plant management plans pursuant to Chapters NR 103 and NR 107 of the Wisconsin Administrative Code. Its scope is limited to those management measures which can be effective in the control of aquatic plant growth in Fowler Lake; those measures which can be readily undertaken by the City and Lake Management District in concert with the riparian residents; and those measures which will directly affect the use of Fowler Lake.

This report is comprised of seven main sections: 1) a statement of planning goals and objectives, 2) a brief description of the Lake and its watershed, 3) a statement of the current use restrictions and the need for aquatic plant management in Fowler Lake, 4) an evaluation of alternative means of aquatic plant management and a selected plan, 5) a description of the recommended plan, 6) a description of the equipment needs for the selected plan, and 7) the recommended means of monitoring and evaluating the effectiveness of the plan and equipment.

STATEMENT OF AQUATIC PLANT MANAGEMENT GOALS AND OBJECTIVES

The goals and objectives of the Fowler Lake Management District were developed in consultation with the City of Oconomowoc. The goals and objectives are to:

- control effectively the quantity and density of aquatic plant growths in portions of the Fowler Lake basin to improve the water-related recreation opportunities, to improve the aesthetic value of the resource to the community, and to enhance the resource value of the water body;

- manage the impoundment in an environmentally sound manner, pursuant to the standards and requirements set forth in the Wisconsin Administrative Codes NR 103, "Water Quality Standards for Wetlands," and NR 107, "Aquatic Plant Management," to preserve and enhance its water quality and biotic communities, their habitats, and essential structure and function in the water body and adjacent areas, as determined by the overall Lake management plan set forth in SEWRPC Community Assistance Planning Report No. 187, A Water Quality Management Plan for Fowler Lake;

- protect and maintain public health and to promote public comfort, convenience, and welfare in concert with the natural resource through the environmentally sound management of native vegetation, fishes, and wildlife in and around Fowler Lake; and

- promote a quality water-based experience for residents and visitors to Fowler Lake consistent with the policies and objectives of the Wisconsin Department of Natural Resources, as set forth in the regional water quality management plan, SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, adopted by the Regional Planning Commission on July 12, 1979.

FOWLER LAKE AND ITS WATERSHED CHARACTERISTICS

Fowler Lake is located immediately north of the City of Oconomowoc in Waukesha County, as shown on Map 1. The Lake is situated on the Oconomowoc River, immediately upstream of Lac La Belle and slightly downstream of Oconomowoc Lake. Fowler Lake is fifth in the chain of six lakes formed along the river. The Oconomowoc River forms the principal inflow and outflow of Fowler Lake. The Lake is a 99-acre impoundment with two distinct basins: the larger, 78-acre main basin, roughly circular in shape, and a smaller basin, a shallow, elongated, dendritic, 21-acre water body with a marsh-like character.

The total drainage area of Fowler Lake is about 69 square miles. Portions of the watershed extend into Washington County. Friess, North, Okauchee, and Oconomowoc Lakes are included within this watershed. The study area of the Lake, that area which drains to Fowler Lake minus the area that drains through any of the other major lakes, is about 2.5 square miles, situated wholly within Waukesha County.

Several surveys of aquatic plant communities in Fowler Lake have been conducted, the most comprehensive is that of Sorge and Lowry, conducted in 1984.[1] A species list, compiled from the results of this aquatic plant survey, is set forth in Table 1. This survey identified some 15 species of plants, many of which were common to abundant. Many of the species identified as abundant in Table 1 can interfere with the recreational and aesthetic use of the Lake.

Plant growth occurred in water up to 22 feet deep, but was concentrated in those areas of less than 15 feet deep. Chara sp. was the dominant species, occurring in depths of less than eight feet in both the main basin and the inlet. Myriophyllum sp. was found with Chara sp. in many areas of the main basin and inlet and was especially abundant in the main basin at depths of between eight and 15 feet. Ceratophyllum demersum was common at all depths, but was especially abundant in the vicinity of the Lake's outflow to Lac La Belle. Vallisneria americana, Nitella sp. and Najas marina were common to abundant in the vicinity of the N. Oakwood Avenue bridge dividing the two Lake basins. The distribution of these plant communities is shown on Map 2.

Given the wetland-like character of the inlet area, control programs will not extend into this area or the upper reaches of the impoundment except for a narrow, 10-foot-wide navigation channel which will provide access from the Oconomowoc River to the main basin of Fowler Lake. Infestations of Lythrum salicaria and L. virgatum, the purple loosestrife, observed in this area along the Lake's southeastern shoreline, will also be controlled, since these plant species are considered noxious weeds.

USE RESTRICTIONS IMPOSED BY AQUATIC PLANTS

Heavy plant growth in all but the middle of the main Fowler Lake basin, up to 75 percent of the water surface area, restricts boating traffic in all but a small area of open water at the center of the water body. These conditions are partially mitigated by an ongoing harvesting and chemical treatment program conducted by the City of Oconomowoc. In particular, excessive plant growth in the riparian zone makes access to the open water difficult. Dense growths also severely restrict shoreline angling and swimming. Plant growth recorded by Sorge and Lowry[2] in Fowler Lake exceeded a moderate density rating at most sites sampled on the water body and approached a high density rating in several areas, particularly those with infestations of Myriophyllum sp., Potamogeton pectinatus, and Ceratophyllum demersum.

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[1] *Patrick Sorge and Timothy Lowry, Aquatic Plant and Sediment Survey on Fowler Lake, 1984.*

[2] *Ibid.*

Map 33

RECOMMENDED MANAGEMENT PLAN FOR FOWLER LAKE

LEGEND

LAKE USE ZONES

- A: ACCESS
- B: BOATING
- F: FISHING
- H: HABITAT
- O: OPEN WATER
- R: RECREATIONAL

- PUBLIC ACCESS SITE
- PROPOSED STORMWATER DETENTION BASIN

AQUATIC PLANT MANAGEMENT

- HARVESTING: HIGH PRIORITY CHEMICALS: LIMITED
- HARVESTING: MODERATE PRIORITY CHEMICALS: LIMITED
- HARVESTING: LOW PRIORITY CHEMICALS: NONE
- HARVESTING: NONE CHEMICALS: NONE
- ENVIRONMENTALLY VALUABLE AREAS RECOMMENDED FOR PROTECTION

MONITORING PROGRAM

- CONDUCT FISH SURVEY
- CONDUCT AQUATIC PLANT SURVEY
- CONTINUE WATER QUALITY MONITORING

WATERSHED MANAGEMENT

- CONTINUE IMPLEMENTATION OF PRIORITY WATERSHED PLAN

LAND USE MANAGEMENT

- PROTECT ENVIRONMENTALLY VALUABLE AREAS:
  - -NO BOAT ACCESS
  - -NO PLANT HARVESTING
  - -NO HERBICIDE USE
- INCLUDE SHOREYARD PROVISIONS IN ZONING ORDINANCE

SHORELINE PROTECTION

- MAINTAIN AND REPAIR EXISTING STRUCTURES
- PROTECT UNSTABLE AREAS
- REPAIR ERODED AREAS USING VEGETATION

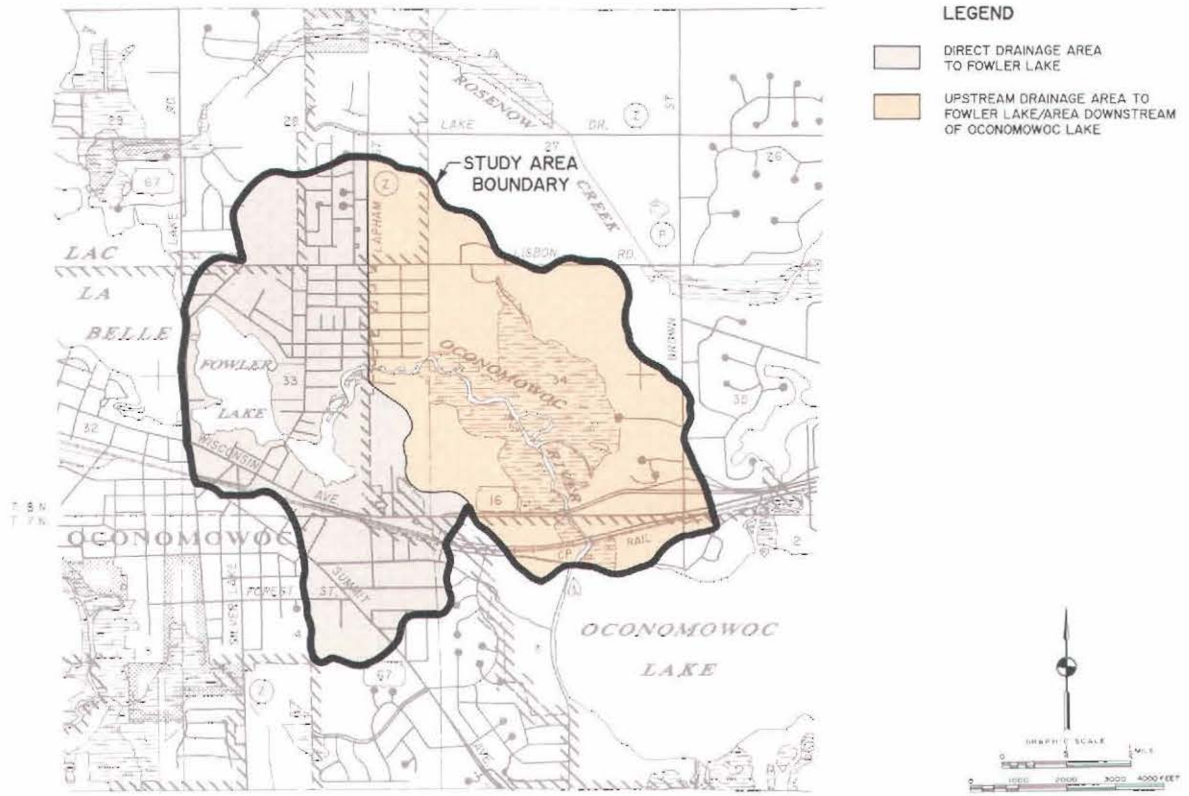
FISH MANAGEMENT

- CONTINUE STOCKING AS REQUIRED

Source: SEWRPC.

Map 1

FOWLER LAKE STUDY AREA



Source: SEWRPC.

The high abundance of aquatic plants in the main Lake basin, situated adjacent to the downtown Oconomowoc area, adversely affects riparian property values and the aesthetic enjoyment of the residents and can have significant impact in terms of tourism and the aesthetic enjoyment of visitors to the City. Recent shoreland improvements to revitalize the Oconomowoc downtown business district, which include the City's boardwalk and gazebo on the southwestern shore of the Lake, could be jeopardized by uncontrolled aquatic plant growth along the shoreline.

PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

A DNR-approved aquatic plant control program has been undertaken on Fowler Lake since the 1950s, when records of such control programs began to be kept by the DNR. However, aquatic plant control programs on Fowler Lake probably predate the DNR record-keeping system by several decades. This program initially involved the chemical treatment of aquatic plant growths with sodium arsenite. Fowler Lake was one of the ten most heavily dosed water bodies in Wisconsin, receiving more than 40 tons of sodium arsenite during the 20-year period from 1950 to 1969. Applications of sodium arsenite were discontinued in 1969 after arsenic accumulations were found in lacustrine sediments and concerns were expressed over possible human health impacts. No health impacts, however, have been recorded. More recently, chemical treatments have consisted of systemic herbicides such as 2,4-D, as set forth in Table 2. All chemical treatments to Fowler Lake are applied by State-licensed applicators and conform to the requirements of the DNR Chapter NR 107, "Aquatic Plant Management," permit held by the City of Oconomowoc. Chemical applications are normally made in late spring/early summer as the plants begin to grow, with occasional follow-up treatments being applied in midsummer.

Table 1

AQUATIC PLANT SPECIES PRESENT IN FOWLER LAKE

Aquatic Plant	Relative Abundance
Myriophyllum sp. (milfoil)	Abundant
Chara sp. (muskgrass)	Abundant
Nymphaea tuberosa (white water lily)	Abundant
Ceratophyllum demersum (coontail)	Abundant
Nitella sp. (stonewort)	Abundant
Potamogeton illinoensis (Illinois pondweed)	Abundant
Nuphar sp. (yellow water lily)	Abundant
Valisneria americana (wild celery)	Common
Potamogeton crispus (curly leaf pondweed)	Common
Potamogeton pectinatus (Sago pondweed)	Common
Utricularia sp. (bladderwort)	Common
Potamogeton richardsoni (clasping leaf pondweed)	Present
Najas marina (bushy pondweed)	Present
Najas flexilis (bushy pondweed)	Isolated stands
Ranunculus sp. (buttercup)	Isolated stands

Source: U. S. Geological Survey and SEWRPC.

Copper-based algicides, such as Cutrine-Plus, have also been applied to Fowler Lake to control the growth of the macroscopic alga Chara sp. and are set forth in Table 2.

Since the mid-1980s, harvesting has been used in concert with an annual herbicide treatment to control aquatic plant growth in Fowler Lake. The City of Oconomowoc has purchased and operates an Aquamarine H5-200 harvester on the Lake, removing about 700 cubic yards of plant material annually.

This dual control program has been viewed favorably by the public, although some concerns continue to be expressed on both sides of the issue. These concerns notwithstanding, the control program has reversed the opinion, widely held since the 1960s, that Fowler Lake was "gross."[3] The Lake is now viewed as an asset to the community and is a well-used recreational resource. Nevertheless, it is a goal of the Management Plan for Fowler Lake that aquatic herbicide use be minimized, synchronized with the aquatic plant harvesting operation to maximize its impact, and applied primarily in the nearshore areas to control nuisance plants such as milfoil and purple loosestrife.

ALTERNATIVE METHODS FOR AQUATIC PLANT CONTROL

Background

Various aquatic plant management techniques, manual, mechanical, physical and chemical, are potentially viable on Fowler Lake.[4] Consideration has been given to each of these techniques. A number of these methods have been employed with varying success on Fowler Lake in the past.

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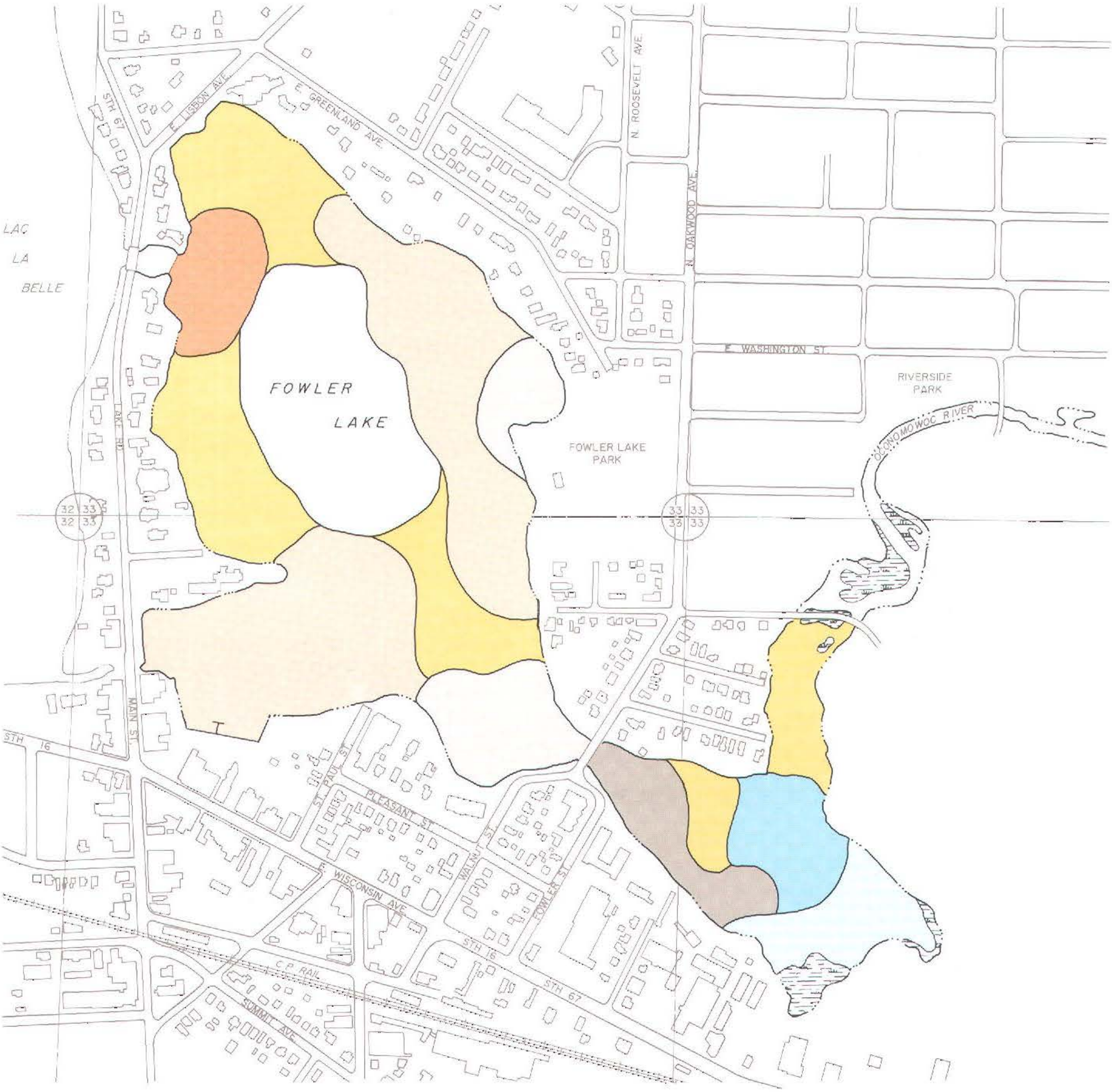
[3] *Oconomowoc Enterprise, June 2, 1983.*

[4] *The various methods referred to in the text are described in more detail in U. S. Environmental Protection Agency Report No. EPA-440/4-90-006, The Lake and Reservoir Restoration Guidance Manual, August 1990.*

Map 2

MACROPHYTE DISTRIBUTION IN FOWLER LAKE: JUNE 1984



LEGEND

ABUNDANT SPECIES

- CHARA
- CHARA AND MILFOIL
- CHARA AND COONTAIL
- CHARA AND WILD CELERY
- CHARA, MILFOIL AND CURLYLEAF PONDWEED
- COONTAIL AND WHITE WATERLILY
- WHITE AND YELLOW WATERLILIES, CHARA AND MILFOIL

GRAPHIC SCALE 0 200 400 600 FEET

Source: Patrick Sorge and Timothy Lowry, Aquatic Plant and Sediment Survey on Fowler Lake, 1984, and SEWRPC.

Table 2

HERBICIDE USE ON FOWLER LAKE BETWEEN 1950 AND 1992

	Macrophyte Control						Algal Control
				Hydrothol			
Year	Sodium Arsenite (pounds)	Diquat (gallons)	Aquathol K (gallons)	(gallons)	(pounds)	2,4-D (gallons)	Cutrine-Plus (gallons)
1950-1969	87,456	- -	- -	- -	- -	- -	- -
1980	0	22	0	0	- -	0	0
1981	0	25	33	0	- -	0	0
1982	0	14	23	0	- -	0	0
1983	0	7	5	2	- -	52	12
1984	0	0	9	2.5	- -	34.5	6
1985	0	0	38	- -	160	0	0
1986	0	0	11	- -	450	23	5.5
1987	0	0	3.5	0	- -	47	4.75
1988	0	0	15	0	- -	84	12
1989	0	0	0	0	- -	45	0
1990	0	0	0	0	- -	64.5	0
1991	- -	- -	- -	- -	- -	- -	- -
1992	- -	- -	- -	- -	- -	- -	- -
Total	87,456	68	137.5	4.5	610	350.0	40.25

Source: Wisconsin Department of Natural Resources and SEWRPC.

Physical Controls

Physical methods, such as drawdown, are not feasible because of the heavy recreational demands placed on the Lake throughout the year. Although an eight-foot drawdown could be achieved by removal of the dam at the Lake outlet to Lac La Belle, the impact upon recreation and the uncertainty surrounding its effects, combined with the limited duration of such effectiveness, necessitating frequent repeat treatments, makes this type of control expensive and problematical, and, hence, not feasible for use on Fowler Lake. Drawdown can also encourage the growth of some plant species. For these reasons, drawdown is not a recommended technique for Fowler Lake at this time.

Other physical controls, such as the placement of bottom barriers and use of shoreline protection structures such as riprap, may be more practicable for Fowler Lake. There are extensive shoreline protection structures in place around Fowler Lake, as shown on Map 3. These structures have been installed primarily to control erosion of the shoreline but have been successful in limiting the growth of rooted aquatic plants in the shoreland zone of the main basin. Little scope currently exists for installing additional areas of riprap. The use of such techniques in the inflow arm of the Lake is not recommended since the macrophyte growth in this embayment forms an ecologically valuable biological filter for the Lake.

Chemical Controls

Chemical controls are viewed by the community as having uncertain long-term environmental impacts as well as possible consequences for human health. While all the herbicides used on Fowler Lake have met applicable U. S. Environmental Protection Agency standards and are applied by registered applicators, the use of chemical control techniques can contribute to an ongoing aquatic plant problem by augmenting the natural rates of accumulation of decaying organic matter in the Lake, contributing to the oxygen demand which may cause anoxia. The use of herbicides can also potentially damage or destroy non-target plant species that provide needed habitat for fish and other aquatic life. As a result, less-desirable, invasive, introduced plant species may out-compete the more beneficial, native species. Hence this option is not feasible on the scale required to control the infestations of aquatic plants in Fowler Lake.

Map 3

SHORELAND PROTECTION STRUCTURES AT FOWLER LAKE

Source: SEWRPC.

However, chemical control is the recommended technique for the control of the relatively small-scale infestations of milfoil and purple loosestrife found in the Lake. Chemical applications should be conducted in accordance with current DNR administrative rules, under the authority of the appropriate permit, by a licensed applicator working under the supervision of DNR staff.

Manual Controls

Manual methods, such as raking or hand-pulling, are difficult to employ on a large scale. Although very effective for small-scale application, for example, in and around docks and piers, manual techniques are generally the least efficient of the aquatic plant control methods. While manual means will be needed to control nearshore plant growths and collect floating plant material from mechanical harvesting operations, this method is too inefficient and time-consuming to employ on the scale need to manage aquatic plant problems over the entire basin of Fowler Lake.

Mechanical Controls

On the basis of previous use of mechanical harvester technologies on Fowler Lake, mechanical harvesting of aquatic plants appears to be a practicable and efficient means of controlling plant growth in an environmentally sensitive manner. Harvesting removes the plant biomass and nutrients from the Lake. While mechanical harvesting can potentially impact fish and other aquatic life, disturb loosely consolidated lake bottom sediments, and result in the fragmentation and spread of some aquatic plants, it has been shown to be of benefit in ultimately reducing the regrowth of other plants. Harvesting also removes attached, epiphytic algal growths with the harvested plant material, and leaves sufficient plant material in the Lake to provide forage and shelter for fish and other aquatic life and to stabilize sediments. Mechanical harvesting is the recommended method for control of aquatic plants in Fowler Lake.

Information and Education

In addition to these in-Lake rehabilitation methods, an ongoing campaign of community information will support the aquatic plant management program by encouraging the use of shoreland buffer strips, responsible use of household and garden chemicals, and environment-friendly household and garden practices to minimize the input of nutrients from these riparian areas. This information program will also remind riparian residents of the value of the lacustrine habitat and other benefits, such as shoreline stabilization, provided by the aquatic flora of the Lake, and will promote the preservation of an healthy aquatic flora in the Lake.

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

Harvesting Plan

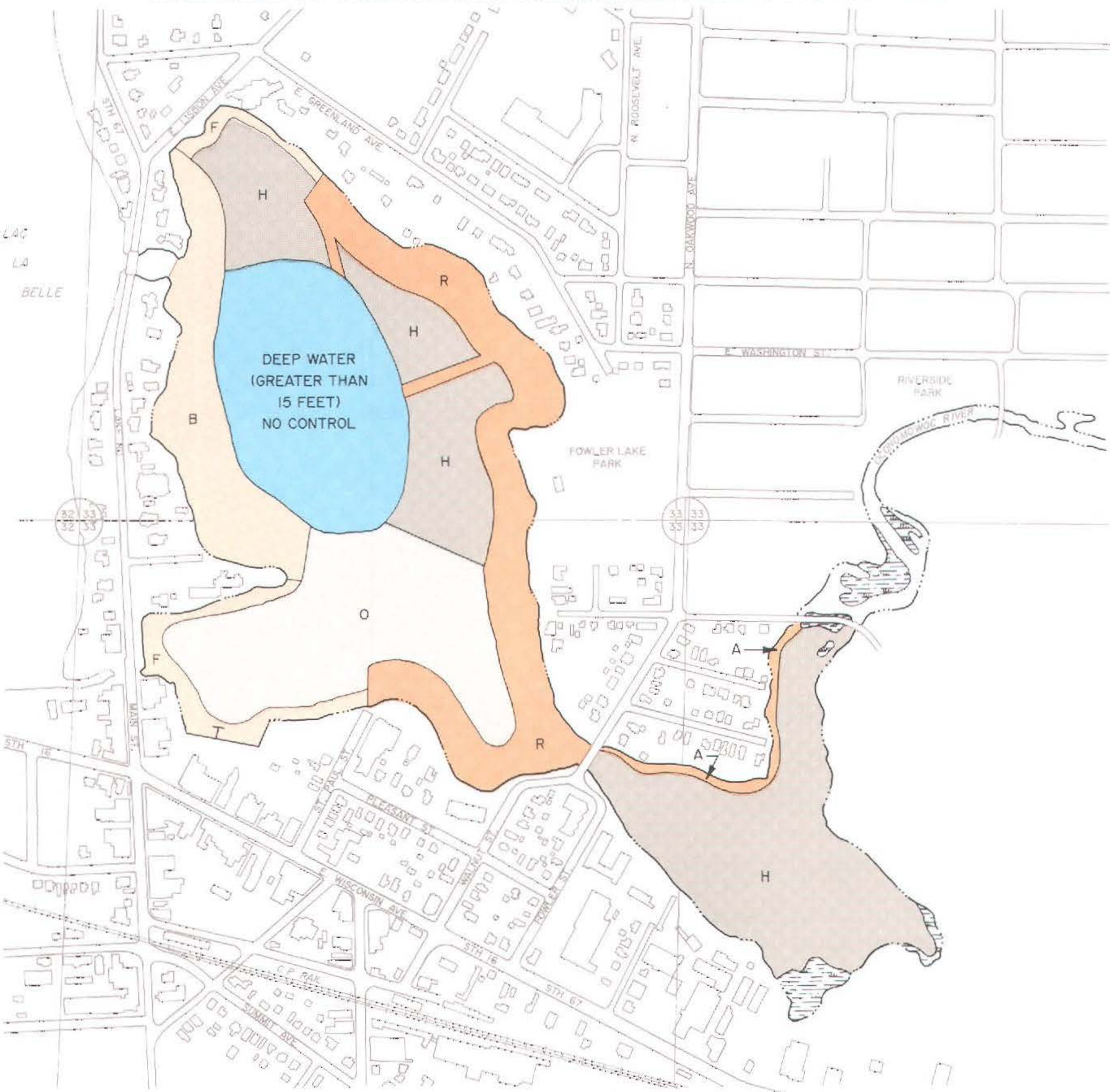
The recommended aquatic plant management plan for Fowler Lake is set forth in Map 4. As indicated, it is proposed that aquatic plant management activities be restricted in certain ecologically valuable areas of the Lake. For this reason, aquatic plant management activities will be confined to zones A, B, F, O and R of the Lake. Further, aquatic plant management operations will be concentrated in the main basin of the Lake and in Zones B and F, especially near the boating access ramps and in the principal boating and fishing areas. There are no identified environmentally sensitive areas in zones B, F, or R.

In contrast, the upper reaches of the impoundment above the N. Oakwood Avenue bridge have more of a wetland character and will be excluded from aquatic plant management operations, except for provision of an access channel along the northern shore and for operations associated with the eradication of purple loosestrife in this area. In addition, harvesting will not take place in waters less than three feet deep to avoid the disturbance of fish spawning and nursery areas and beds of native aquatic plants. Special efforts will be made to avoid disturbing major spawning and habitat areas of sport fish in Fowler Lake during the spring spawning season, May 1 to June 30.

As noted above, the goal of the management program is to accommodate recreational uses of the impoundment as much as possible and to enhance the public perception of the impoundment as the "centerpiece" of the City of Oconomowoc, without inflicting irreparable damage on the ecosystem of

Map 4

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR FOWLER LAKE



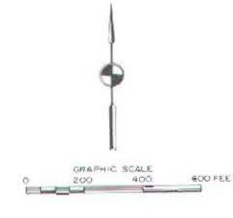
LEGEND

LAKE USE ZONES

A:	ACCESS	H:	HABITAT
B:	BOATING	O:	OPEN WATER
F:	FISHING	R:	RECREATIONAL

AQUATIC PLANT MANAGEMENT

- HARVESTING: HIGH PRIORITY; CHEMICALS: LIMITED
- HARVESTING: MODERATE PRIORITY; CHEMICALS: LIMITED
- HARVESTING: LOW PRIORITY; CHEMICALS: NONE
- HARVESTING: NONE; CHEMICALS: NONE



Source: SEWRPC.

the Lake, its structure and functioning. To accomplish this goal, specific control measures will be applied in the various Lake zones identified on Map 4. The aquatic plant management treatments that will be applied in each of the six Lake zones are as follows:

- Zone A (access): Narrow channels, approximately 10 feet wide, will be harvested along a portion of the eastern bay and inlet area to provide boating access to the main body of the Lake; no chemicals will be used in this 0.3-acre area.

- Zone B (boating): Narrow channels, approximately 10 feet wide, will be harvested along the western shore of the Lake and will be extended perpendicular to the shore into the area of open water; chemical use will be restricted to pier and dock areas within 50 feet of the shore in this one-acre area.

- Zone F (fishing): Narrow channels, approximately 10 feet wide, will be harvested perpendicular to the shore along the northern and western shores of the main basin at 100-foot intervals; chemical use would be limited to milfoil and purple loosestrife control at public access sites in this 0.3-acre area.

- Zone H (habitat): Areas of the Lake having a predominantly wetland-like character will be preserved from any intervention except where necessary to control purple loosestrife infestations; additional litter collection efforts will probably be required in these areas to maintain their aesthetic appeal.

- Zone O (open water): Deep-water areas of the Lake would be linked to boating access areas by approximately 30-foot-wide channels in this two-acre, largely plant-free area; no chemicals will be used in this area.

- Zone R (recreation): Broad bands of macrophytes within 150 feet of the shore will be harvested in the heavily used recreational areas of the Lake, which will be connected to the open water areas by approximately 30-foot-wide shared-access channels; chemical use will be restricted to pier and dock areas within 50 feet of the shore in this five-acre area.

Depth of Harvesting and Treatment of Fragments

The Aquamarine H5-200 Aquatic Plant Harvester has a maximum cutting depth of five feet. While this exceeds the actual water depth of fully one-third of the impoundment, it is not the intention of the owners or operators of the equipment to denude the impoundment of aquatic plants given the heavy angling use of the water body, its morphology, which is not conducive to extensive motorized boat traffic, and the program goals. All plant cuttings and fragments will be collected by the harvester on the site. Those fragments accumulating along the shore will be collected by the City or the riparian homeowners. Fragments can be used by the homeowners as garden mulch.

Buoys

Temporary marker buoys may be used to direct harvesting operations in the Lake basin by marking the areas to be cut. However, the size of the Lake generally precludes the need for such buoys except as they are required for the control of boating traffic on the Lake. The harvester operators will be provided with a laminated copy of the harvesting plan and made familiar with the plan and local landmarks to the degree necessary to carry out the plan without the use of buoys. Harvesting operations are regularly supervised by City staff.

Harvested Plant Material Transfer Site(s)

Off-loading of harvested plant material will take place at the boating access site at St. Paul Street, as shown on Map 4. Plant material will be removed from the harvester on a transporter and conveyed to the off-loading area, where it will be transferred to a dump truck using a conveyor and transported to disposal sites identified by the City of Oconomowoc. Plant material will be collected and disposed of daily to avoid leaching of nutrients back into the impoundment and to minimize the visual degradation of the environment near the boat launching site. The operators will stringently police the off-loading site to ensure minimal disruption of boating and of the activities of people using the riparian areas of the Lake.

Disposal of Harvested Plant Material
Harvested plant material will be combined with the City's grass clippings and land-spread on area farms.

Precautions to Protect Wildlife, Fisheries, and Ecologically Valuable Areas
Operators will be provided with a laminated copy of the approved harvesting plan map as set forth on Map 4, showing the limits of harvesting operations. A copy of this map will be kept on the harvester at all times. Operations will be forbidden in the upper reaches of the Lake, except for the navigation channel described above, to prevent disturbance of the wetland areas, and in those areas of three feet or less in depth to protect sport fish habitat and spawning areas. Harvesting operations in the areas identified as suitable for sport fish spawning will be restricted until July to permit undisturbed spawning.

Public Information
It is the policy of the City of Oconomowoc to maintain an active dialogue with the community. This dialogue is carried out through the medium of the public press and through various City Committees, public meetings, and other scheduled hearings. In addition, the Fowler Lake Management District holds regular public meetings. Where necessary, personal contacts with homeowners will be made.

Harvesting Schedule
The harvesting season will begin no earlier than May 15 and will end no later than September 15 of each year. Harvesting will average 30-35 hours per week over a five-day week, depending on weather conditions and plant growth, to minimize recreational conflicts. In addition, harvesting will be confined to daylight hours to minimize public disturbances resulting from harvester and plant removal operations. As described above, harvesting operations will also be modified to protect fish spawning areas and other ecologically valuable areas of the Lake as set forth on Map 4.

EQUIPMENT NEEDS AND OPERATION

Equipment Needs and Total Costs
Harvester: Aquamarine model H5-200 or equivalent
Manufacturer: Aquamarine Division, Erectoweld, Inc., Waukesha, Wisconsin

Costs:	(1) H5-200 Aquatic Plant Harvester or equivalent	$45,950
	(1) TC-200 Trailer and Shore Conveyor or equivalent	17,900
	Total	$63,850

Maintenance Schedule, Storage, and Related Costs
Routine maintenance will be performed by the City of Oconomowoc in accordance with the manufacturer's recommended maintenance schedule. Maintenance costs will be borne by the City of Oconomowoc.

Winter storage of the harvesting equipment will be the responsibility of the City of Oconomowoc. The harvester will be stored at the municipal garage.

Insurance Coverage
Insurance coverage on the harvester will be incorporated into the policy held by the City of Oconomowoc on all capital equipment. Liability insurance for the operation of the harvester will also be borne by the City. The relevant certificates of insurance will be held by the City of Oconomowoc.

Operators, Training and Supervision
The harvester will be owned and operated by the City of Oconomowoc, which will be responsible for day-to-day operations of the equipment. The City will provide operator training as required. City staff have extensive experience in the operation of this type of machinery. Initial training will be provided by Aquamarine on delivery of the machinery.

Day-to-day supervision will be by the City staff, with oversight by the Director of Public Works and the City Engineer.

EVALUATION AND MONITORING

Daily Record-Keeping Relating to the Harvesting Operation

A record of daily harvesting activities will be recorded by the operator in a harvester operations log. An annual summary of the harvesting program will be submitted to the City of Oconomowoc Common Council, or a designated Committee thereof, and made available to the public at that time. The summary will also be published at the annual meeting of the Fowler Lake Management District.

It is the intention of the City of Oconomowoc to undertake a periodic, formal review of the harvesting program as set forth in the Management Plan for Fowler Lake, a copy of which has been lodged with the Wisconsin Department of Natural Resources Southeast District Office.

Daily Record-Keeping Relating to the Harvester

Daily maintenance and service records showing engine hours, fuel consumed and oil used, will be recorded in a harvester operations log.