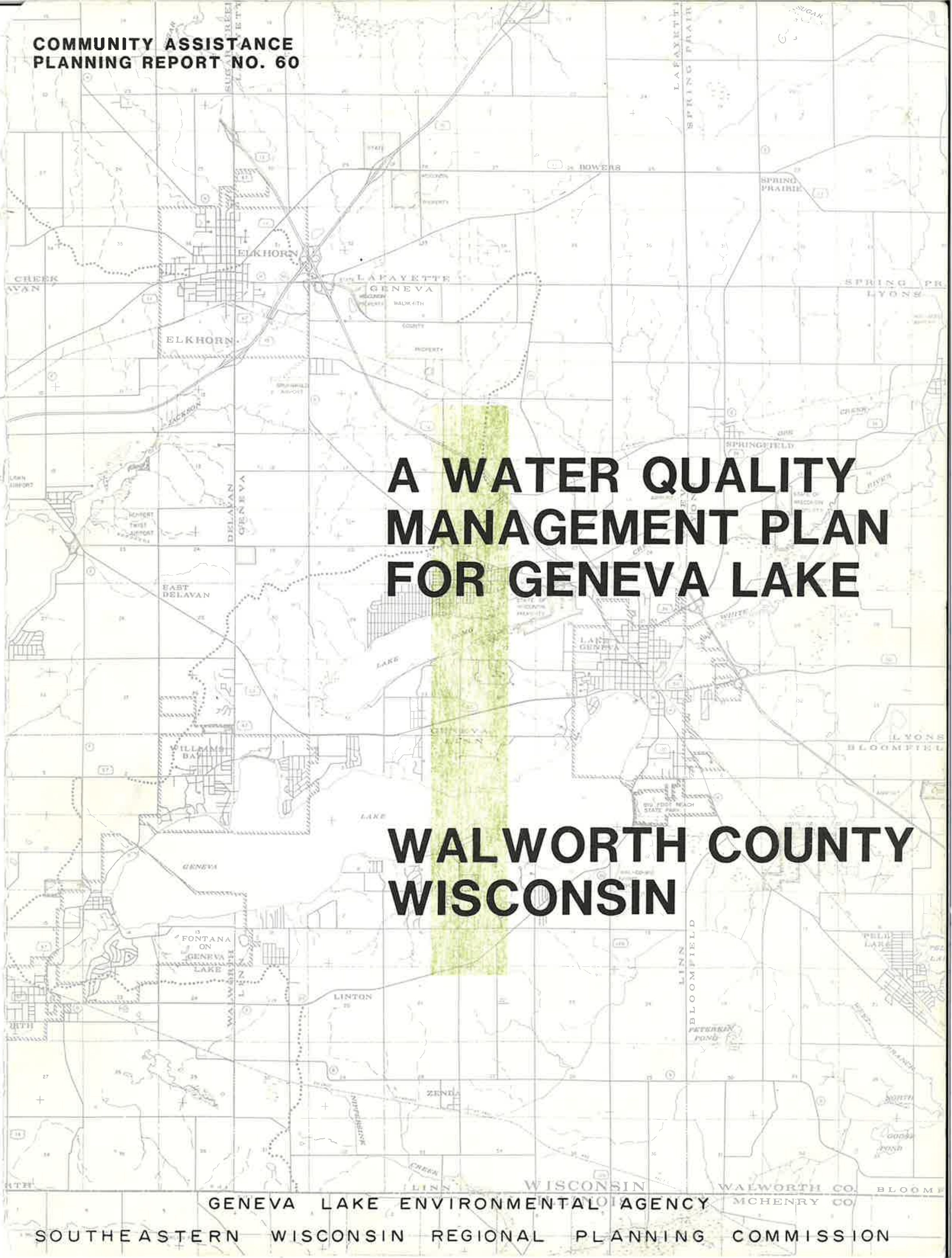
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 60

A WATER QUALITY MANAGEMENT PLAN FOR GENEVA LAKE

WALWORTH COUNTY WISCONSIN



GENEVA LAKE ENVIRONMENTAL AGENCY

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 60

A WATER QUALITY MANAGEMENT PLAN FOR GENEVA LAKE

WALWORTH COUNTY, WISCONSIN

Prepared by the
Southeastern Wisconsin Regional Planning Commission
P. O. Box 769
Old Courthouse
Waukesha, Wisconsin 53187-1607

and the
Geneva Lake Environmental Agency
P. O. Box 190
Fontana, Wisconsin 53125-0190

The preparation of this report was financed in part through a planning grant from the U. S. Environmental Protection Agency and the Wisconsin Department of Natural Resources.

October 1985

Inside Region $4.00
Outside Region $8.00

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO. EAST AVENUE • P.O. BOX 769 • WAUKESHA, WISCONSIN 53187-1607 • TELEPHONE (414) 547-6721

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

October 12, 1985

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

In 1983, the Southeastern Wisconsin Regional Planning Commission, in cooperation with the Geneva Lake Environmental Agency, undertook a study of the water quality conditions of Geneva Lake. The study was to identify existing and potential water quality problems, and proposed measures for the resolution of those problems and for the protection and enhancement of the water quality of the lake. The findings and recommendations of that study are presented in this report.

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

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

The plan presented in this report should provide a sound guide to the making of decisions concerning the wise use and management of Geneva Lake as an aesthetic and recreational asset of immeasurable value. Accordingly, careful consideration and adoption of the plan presented herein by all of the concerned water quality management agencies is respectfully urged.

The Regional Planning Commission stands ready to assist the various units and agencies of government concerned in carrying out the recommendations contained in this report.

Respectfully submitted,

Kurt W. Bauer, Executive Director
Southeastern Wisconsin Regional
Planning Commission

TABLE OF CONTENTS

Page

LIST OF APPENDICES

LIST OF TABLES

Table		Page
14	Ranking of Perennial Tributaries by Selected Pollution Parameters in the Geneva Lake Direct Tributary Drainage Area	35
15	Average Annual Concentrations/Values of Selected Water Quality Parameters for Six Intermittent Tributary Inlets to Geneva Lake: May 1976-May 1977	38
16	Effect of a Rain Event on the Water Quality of Tributary Streams and Storm Drains in the Drainage Area Directly Tributary to Geneva Lake: March 4, 1977	39
17	Effect of Snowmelt Runoff on the Water Quality of Tributary Streams and Storm Drains in the Drainage Area Directly Tributary to Geneva Lake: February 12, 1977	39
18	Mean Values of Water Quality Parameters Sampled in Six Permanent Groundwater Wells in the Drainage Area Directly Tributary to Geneva Lake: August 1976-May 1977	42
19	Atmospheric Nutrient Loading Into Geneva Lake: September 1976-May 1977	43
20	Comparison of Atmospheric Nutrient Loading Rates for Geneva Lake With Other Areas of Southern Wisconsin: 1976	43
21	Hydrologic Budget for Geneva Lake	44
22	Computed Discharge From Storm Sewers Located in the Drainage Area Directly Tributary to Geneva Lake for Dry and Normal Years	45
23	Estimated Nitrogen Loading to Geneva Lake and Nitrogen Losses Through the White River Outflow: May 1976-May 1977	47
24	Nitrogen Loading to Geneva Lake From Various Sources, and Losses Through the White River Outflow: May 1976-April 1977	48
25	Nitrogen Loading to Geneva Lake From Perennial Streams and Percent Contribution of Each Stream: May 1976-April 1977	49
26	Measured Dissolved and Total Phosphorus Loadings to Geneva Lake: 1976-1977	50
27	Phosphorus Loading to Geneva Lake From Perennial Streams and Percent Contribution of Each Stream: May 1976-April 1977	51
28	Estimated Direct Tributary Phosphorus Loads to Geneva Lake: 1975 and 2000	52
29	Sediment (Suspended Solids) Contributed to Geneva Lake by Tributaries and the Atmosphere: May 1976-April 1977	54
30	Interpretation of Fecal Coliform to Fecal Streptococci Ratio	55
31	Annual Fecal Coliform and Fecal Streptococcus Bacteria Loading Rates to Geneva Lake From Tributary Streams and Storm Sewers, and Loss Rates Through the White River: May 1976-April 1977	56
32	Average Annual Fecal Coliform and Fecal Streptococcus Concentrations in Streams in the Drainage Area Directly Tributary to Geneva Lake: May 1976-April 1977	57
33	Fecal Coliform to Fecal Streptococcus Ratio for Tributaries of Geneva Lake: 1976-1977	58

LIST OF FIGURES

LIST OF MAPS

Map		Page

Chapter I

INTRODUCTION

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

On April 28, 1976, the Southeastern Wisconsin Regional Planning Commission entered into a cooperative agreement with the Geneva Lake Environmental Agency to study Geneva Lake. The study included the design and conduct of a water quality sampling program to determine existing lake water quality conditions, and inventories and analyses of pertinent tributary watershed characteristics affecting water quality conditions, including land use and management practices, existing water uses, and sources of pollution. The lake water quality sampling program was conducted by the Geneva Lake Environmental Agency from May 1976 through May 1977. Some inventory data collected as recently as 1985, however, are incorporated into this report. This report summarizes the results of the sampling program; the physical, chemical, and biological characteristics of the lake and the direct tributary drainage area; and provides an evaluation and interpretation of the data collected and collated. From these analyses, feasible alternative actions for the maintenance and enhancement of lake water quality are proposed and evaluated, and water quality management measures are recommended.

Geneva Lake is a 5,425-acre,[1] or 8.48-square-mile, lake located within U. S. Public Land Survey Township 2 North, Range 17 East, Town of Geneva;

[1]In SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, 1969, the area of Geneva Lake was reported to be 5,262 acres, as measured from 1956 aerial photographs. Based on 1980 aerial photographs, the area of Geneva Lake was estimated to be 5,425 acres. The difference in the two estimates is well within the limitations of the accuracy of the measurement techniques involved.

Township 1 North, Range 17 East, Town of Linn; and Township 1 North, Range 16 East, Town of Walworth, all in Walworth County. Proper management of the 12,806-acre--20.01-square-mile--drainage area directly tributary to Geneva Lake will be required in order to maintain the lake as a valuable recreation resource for the residents of the County and the Region of which the County is an integral part.

This report discusses the physical, chemical, and biological characteristics of the lake together with pertinent related characteristics of the tributary drainage area, as well as the feasibility of various water quality management measures which may be applied to enhance water quality conditions in the lake. The primary management objectives for Geneva Lake include: 1) providing water quality suitable for the sustained long-term maintenance of fish and aquatic life, and 2) reducing the severity of occasional nuisance problems due to excessive algae and aquatic macrophyte growth which may constrain or preclude certain intended waters uses, and 3) improving opportunities for water-based recreational activities. The lake water quality management plan herein presented should constitute a practical guide for the management of the water quality of Geneva Lake and for the management of the land surfaces which drain directly to this lake body.

Chapter II

HISTORICAL INFORMATION AND PHYSICAL DESCRIPTION

HISTORICAL INFORMATION

The earliest occupants of the Geneva Lake area were believed to have been the Mound Builders, a tribe of Indians who constructed large symbolically shaped effigy mounds which were used for burial purposes. The Mound Builders apparently disappeared about a century before the coming of European settlers. Land use changes over the past 100 years have resulted in the loss of all but a few of the burial mounds.

The Pottawatomie, whose ancestors were believed to have been Mound Builders, were the tribe of Indians residing in the Geneva Lake area at the time of the arrival of European settlers. Three settlements, totaling approximately 500 individuals in all, are known to have existed in the area. The settlements were situated at each end of the lake and on the west shore of Williams Bay. According to the earliest explorers and travelers, the Pottowatomie Indians were less belligerent than other tribes, and more readily accepted the advance of the European civilization.[1]

Although the Pottawatomie called the lake "Kishwauketoe" meaning clear water, it later came to be known as Big Foot's Lake, in deference to Chief Big Foot, their most prominent leader. Based on the observations of early European settlers, there was an abundance of fish, game, and edible wild plants available, and the Indians apparently lived reasonably comfortable lives. A treaty between the Indians and the United States Government resulted in their relocation to Kansas in the fall of 1836.

The first recorded visit of European men to the Geneva Lake area was that of the John H. Kinzie party, which visited the west end of the lake in the spring of 1831 during a trip to Fort Winnebago, Portage County, Wisconsin. The first European settlers in what are now Fontana and Williams Bay were James Van Slyke and Israel Williams, respectively. The first European settler in what is now the City of Lake Geneva was John Brink, who was also responsible for giving the lake its present name.[2]

Two railway lines served the immediate area surrounding Geneva Lake. In 1871, the Chicago & North Western Railway Company completed a steam railway line between the City of Genoa, Illinois--near the Illinois-Wisconsin state line--and the City of Lake Geneva, permitting through train service between the east side of Geneva Lake and the City of Chicago. An extension of this railway line to the Village of Williams Bay was subsequently completed during 1888. Between 1898 and 1931, the Chicago, Harvard, & Geneva Lake Railway Company operated an

---

[1]P. B. Jenkins, The Book of Lake Geneva, the University of Chicago Press, Chicago, Illinois, 1921.

[2]Ibid.

electric interurban railway line between the City of Harvard, Illinois, and the Village of Fontana. Passengers destined for Geneva Lake's western shore from the Chicago area used the interurban railway, transferring either from the Chicago & North Western Railway at Harvard, or from the Milwaukee Road at the Village of Walworth. In addition to offering interurban passenger train service, the electric railway hauled livestock, gravel, and milk, as well as ice harvested from Geneva Lake during the winter months. The railway line between Lake Geneva and Williams Bay was abandoned by the Chicago & North Western Railway in 1965 and the remaining commuter train service between Lake Geneva and Chicago was discontinued north of the Illinois state line during 1975. As of 1985, the remainder of this railway branch line within the State of Wisconsin had been abandoned.

With the coming of the railways, Geneva Lake began to grow as a resort and recreation area. The size of Geneva Lake and the wealthy class of people who established summer homes around the lake resulted in extensive use of steamboats for travel and entertainment on the lake. The first steamboat arrived on Geneva Lake in 1858. It was a 65-foot-long, 150-passenger excursion boat with a 20-ton capacity and a 15-horsepower engine. In 1874, the first private steam yacht, called the Gertie, arrived on the lake. The original Lady of the Lake, a 90-foot-long, double-deck side wheeler excursion boat, was launched in 1873, and a similar but larger steamboat--115 feet long with a 30-foot beam--called the Lucius Newberry followed in 1875. In 1890 the Lucius Newberry, by then named the City of Lake Geneva, caught fire and sank near "The Narrows" in 60 feet of water. The Lady of the Lake, having served her purpose, was stripped and sunk off the shore of the lake in 1893.

The Geneva Lake area became relatively well known as a resort area in the upper Midwest, and attracted financial investment by Chicago investors. The world famous Yerkes Observatory, located in Williams Bay, containing the largest refracting telescope in the world, was conceived in 1892 by Professor George E. Hale of the University of Chicago.[3] A 123-acre site was selected from a survey of more than 20 suggested locations because of its freedom from smoke, dust, and disturbance. Construction started in 1895 and the observatory was opened in 1897. The main structure of the observatory is 1,046 feet above mean sea level and is situated on the north shore of Geneva Lake 190 feet above the lake.

Concerns of lake residents about water quality and lake management were reflected in early lake management decisions. The still-functioning Lake Level Corporation was created in 1894 by lake shore property owners as a nonprofit stock corporation. The Corporation engaged the services of engineers who designed and built the present day dam and sluice gates at the lake outlet on the White River. This dam replaced earlier mill dams at the lake outlet. The earlier mill dams varied in height and were subject to failure. The principle objective of installing the new dam was to control the lake level.

Early concern on the part of lakeshore property owners over maintaining the lake's water quality was reflected in the adoption of a State Statute in 1893 prohibiting the discharge of pollutants into the lake. This Statute later became part of Chapter 189 of the Wisconsin Statutes.

---

[3]P. B. Jenkins, The Book of Lake Geneva, the University of Chicago Press, Chicago, Illinois, 1921.

Other water resource-related organizations established by Geneva Lake residents include the Water Safety Patrol in 1927, the Lake Association in 1935, the Lake Law Enforcement Agency in 1971, and the Geneva Lake Environmental Agency in 1971. These agencies have been involved with different aspects of lake use and management over the past 60 years. A more complete description of the existing and potential water quality management agencies is presented in Chapter VI of this report.

LAKE BASIN AND SHORE CHARACTERISTICS

Geneva Lake is a 5,425-acre headwater lake which is fed by numerous small tributary streams and drained by the White River. The lake has a total estimated volume of 299,182 acre-feet and a direct tributary drainage area of 12,806 acres, or 20.01 square miles in areal extent. The maximum lake length--or fetch--is 7.6 miles (from the City of Lake Geneva to the Village of Walworth), and the maximum width is 2.1 miles (from Williams Bay to Southshore). The narrowest width is at "The Narrows" where the distance between the two shores is 0.5 mile. The mean depth is 57 feet and the maximum depth is 144 feet. Approximately 11 percent of the lake area is less than 10 feet deep, 45 percent has a depth between 10 and 70 feet, and about 44 percent has a depth of more than 70 feet. The lake shoreline is 20.2 miles long, with a shoreline development factor of 2.03, indicating that the lake's shoreline is about 2.03 times as long as that of a circular lake of the same area. Basic hydrographic and morphometric data for Geneva Lake are presented in Table 1. The morphometry of the lake basin and direct tributary drainage area is shown on Maps 1 and 2, respectively. Figure 1 presents an aerial photograph of the lake and surrounding shoreline.

Geneva Lake lies in the preglacial Troy Valley, which originally drained to the southwest. During the later stages of the Wisconsin Glacier, drainage to the southwest was blocked by the Darien moraine of the Delavan Glacial Lobe. This moraine created steep slopes along the south shore of the lake, while the Elkhorn moraine--a later recessive moraine--created similar steep slopes along the north shore. The Elkhorn moraine also separated Geneva Lake from Como Lake, which is located approximately one mile north of Geneva Lake. The blocking of the original drainage, plus the increased elevation of the north and south slopes, raised the surface elevation of Geneva Lake to 14 feet above the elevation of Como Lake. The presence of an outwash terrace adjacent to the White River and the present depth of Geneva Lake suggest that an iceblock broke off the receding glacier and remained in the lake basin, thus preventing it from filling to a much higher elevation, and thereby creating shallower lake depths.

Scouring of the bottom of the White River had resulted in a lowering of the lake level by approximately six feet by 1836, when the first dam was built on the White River at the lake outlet. Subsequent dam failures and reconstructions resulted in lake level fluctuations until 1894, when the Geneva Lake Level Corporation was established and the present dam and sluice gates were constructed. The spillway crest was established at an elevation of 864.42 feet National Geodetic Vertical Datum (NGVD).

Sorting by wind-driven waves has resulted in bottom sediments along the shoreline--comprising approximately 10.6 percent of the area of the lake--to be

Table 1

HYDROGRAPHY AND MORPHOMETRY OF GENEVA LAKE: 1975

Parameter	Measurement
Size	
Area of Lake	5,425 acres
Area of Direct Tributary Drainage Area	12,806 acres
Lake Volume	299,182 acre-feet
Residence Time[a]	13.9 years
Shape	
Length of Lake	7.6 miles
Length of Shoreline	20.2 miles
Maximum Width of Lake	2.1 miles
Minimum Width of Lake	0.5 mile
Shoreline Development Factor[b]	2.03
Depth	
Percent of Lake Less Than 10 Feet	11
Percent of Lake 10 to 70 Feet	45
Percent of Lake More Than 70 Feet	44
Mean Depth	57 feet
Maximum Depth	144 feet

[a]The "residence time" is estimated as the time required for the full volume of the lake to be replaced once by inflowing surface and ground waters associated with periods of normal precipitation.

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

Source: Geneva Lake Environmental Agency and SEWRPC.

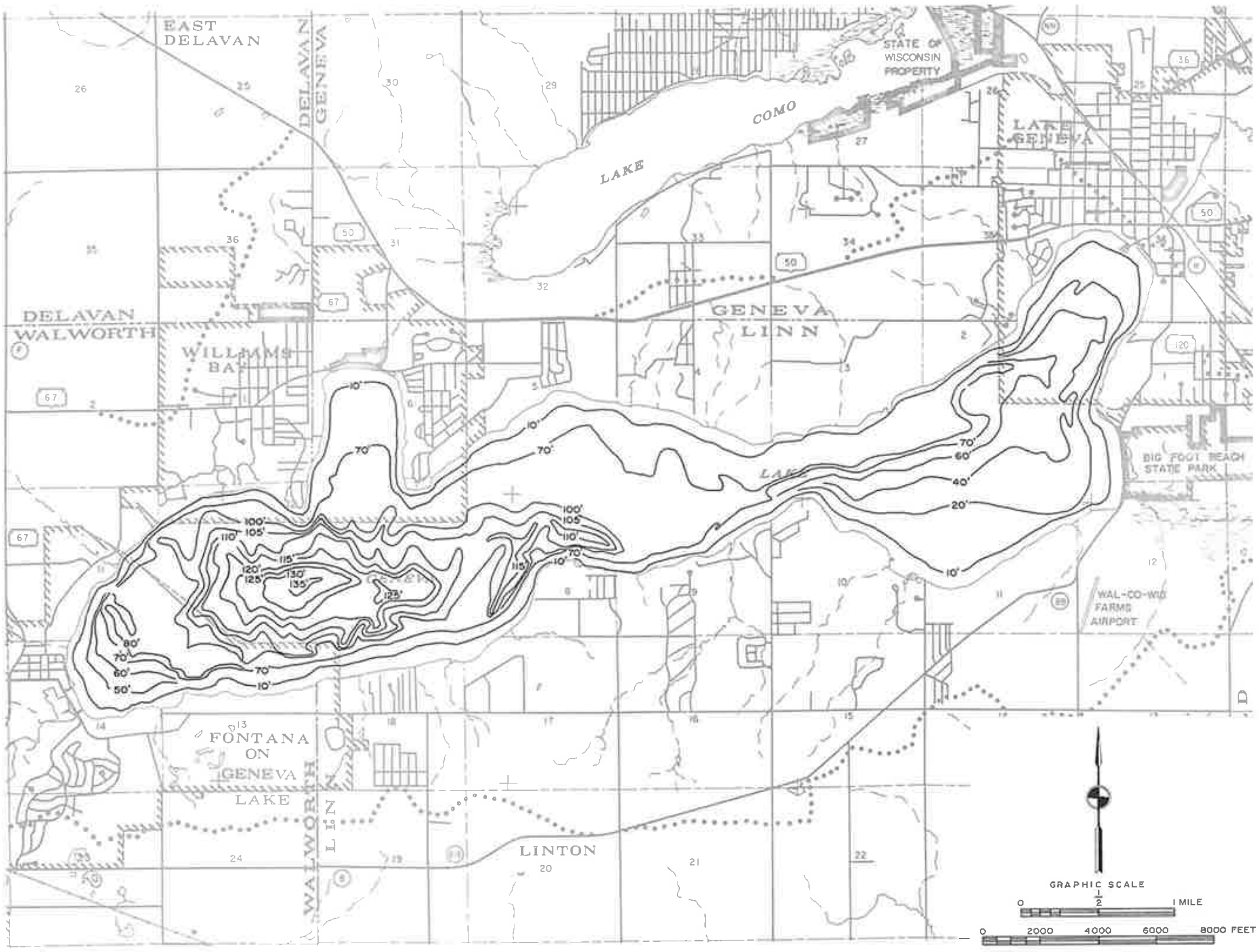
composed predominately of sand, 38.9 percent; rubble, 32.5 percent; gravel, 27.9 percent; and muck, 1.5 percent. Lake bottom sediment types are shown on Map 2. The remainder of the lake basin bottom sediment--89.4 percent--is composed of silt and muck. During periods of high winds in spring and fall, observers have reported waves in excess of four feet in height on the lake. Predominant southwesterly winds--and the resulting waves--have caused active shoreline erosion, particularly along the north shore. Although portions of the shoreline have been stabilized with seawalls and stone riprap, wave action produced by power boats has accelerated erosion along unprotected portions of the shore. Changes in land use in the direct tributary drainage area have also brought about changes in the composition of both shoreline and bottom material. This is most evident along the southwestern shores where the volume of muck and silt has increased in recent years.

DIRECT TRIBUTARY DRAINAGE AREA CHARACTERISTICS

With a direct tributary drainage area of 12,806 acres and a surface area of 5,425 acres, Geneva Lake has a low watershed-to-lake area ratio of 2.4:1. Water enters the lake by direct precipitation, terrestrial springs, artesian wells, underwater springs, seepage, and numerous small perennial and intermittent streams. Although the tributary streams carry surface runoff, their primary water source is groundwater discharge. A shallow water table and hydrostatic pressure create numerous springs and artesian wells in the

Map 1

HYDROGRAPHIC AND MORPHOMETRIC MAP OF GENEVA LAKE



Source: Wisconsin Department of Natural Resources and SEWRPC.

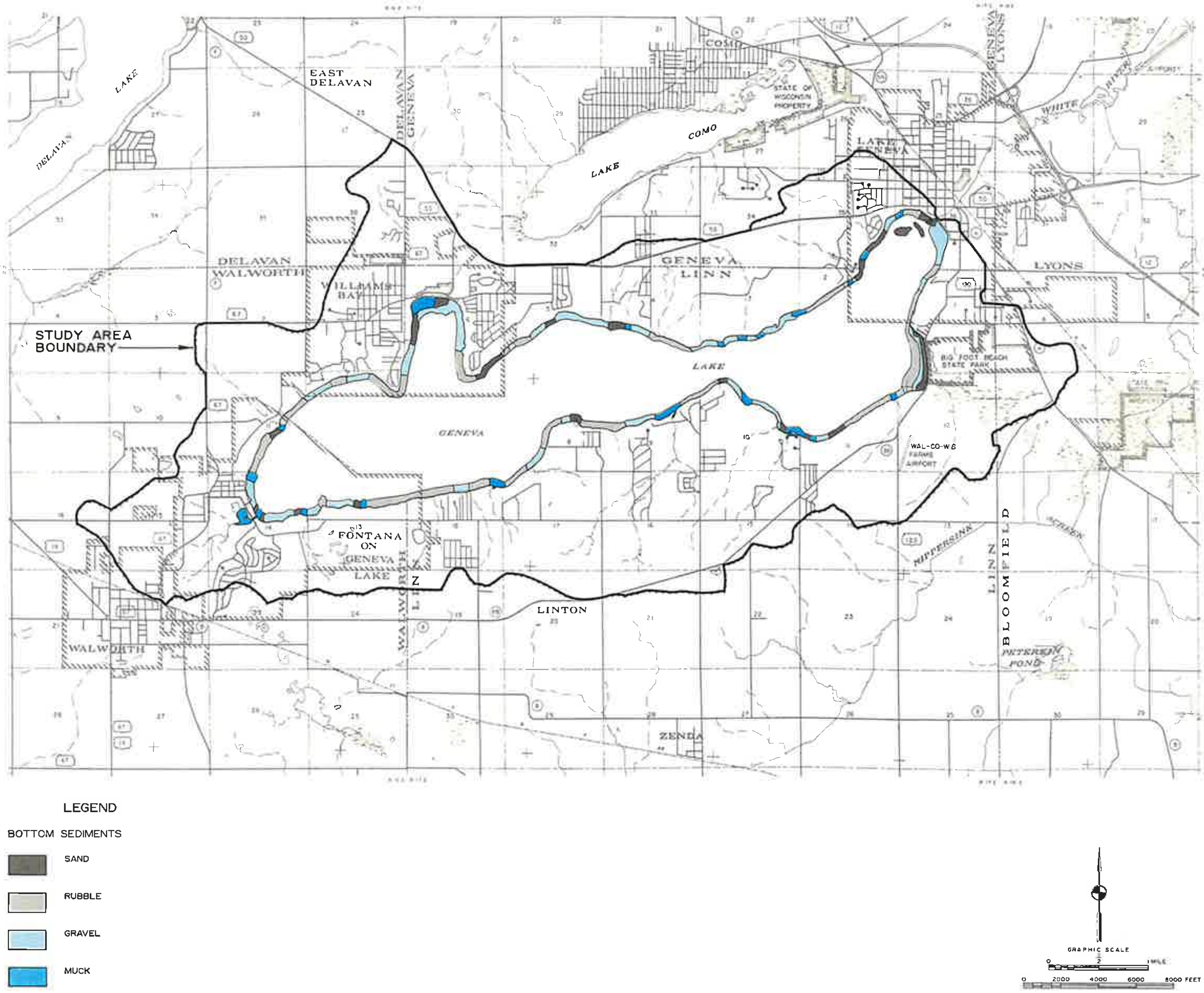
moraines surrounding the lake, particularly along the south and west shores. Many springs are located within 100 feet of the lake, as well as within the lake itself. The lake outlet is the White River, which flows approximately 20 miles in a northeasterly direction before joining the Fox River, a tributary of the Illinois River, at Burlington, Wisconsin.

CLIMATE

Average monthly air temperature and precipitation values for the drainage area directly tributary to Geneva Lake, as computed from official National Oceanic and Atmospheric Administration (NOAA) records for the weather recording station at Lake Geneva, Wisconsin, are set forth in Table 2. Table 2 also sets forth runoff values derived from the U. S. Geological Survey (USGS) flow records for the Fox River at Waukesha, Wisconsin. Measured pan-evaporation rates collected at Rockford, Illinois, were also utilized in the hydrologic analyses.

Map 2

DRAINAGE AREA DIRECTLY TRIBUTARY TO, AND LAKE BOTTOM SEDIMENTS IN, GENEVA LAKE

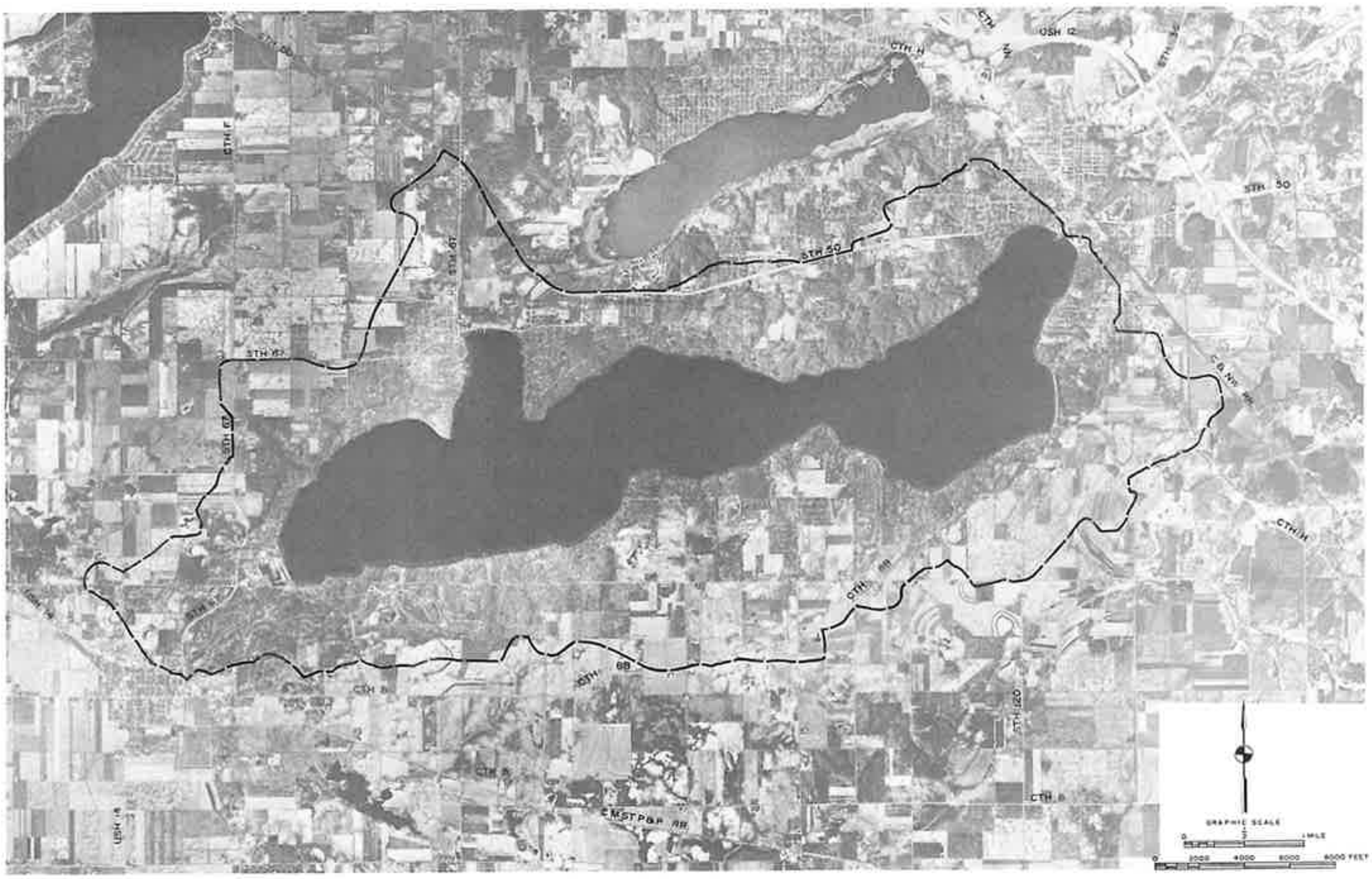


Source: SEWRPC.

The 12-month period over which the field study was carried out--May 1976 through April 1977--was a period of variable temperatures and extreme drought in southeastern Wisconsin. Precipitation at Lake Geneva--24.72 inches--was 8.38 inches, or over 25 percent, below the average annual precipitation of 33.10 inches. Approximately 1.2 inches, or 5 percent of the precipitation during the study year, fell as rain from May through September. About 7.3 inches, or 29 percent of the annual precipitation, fell as snow or rain from December through March. The remaining 16.22 inches, or 65 percent, fell as rain scattered throughout the rest of the study year. Normally, less than

Figure 1

AERIAL PHOTOGRAPH OF GENEVA LAKE
AND SURROUNDING SHORELINE: 1980



Source: SEWRPC.

15 percent of the summer precipitation is expressed as surface runoff. About 30 percent of the annual precipitation occurs during the winter or early spring when the ground is frozen, normally resulting in high surface runoff during those seasons.

SOIL TYPE AND CONDITIONS

Soils can have a positive or detrimental effect upon stream and lake water quality, depending on three variables. These variables are the physical composition of the soil, its slope, and its usage. Data on the specific soil types in the drainage area directly tributary to Geneva Lake were collated from the detailed operational soil surveys conducted by the U. S. Soil Conservation Service under contract to the SEWRPC, and analyzed in terms of the associated hydrologic characteristics. Assessments were made of soil erodibility, soil suitability for use of onsite septic tank sewage disposal systems, and soil suitability for the application of wastewater sludges.

Table 2

CLIMATOLOGICAL DATA FOR THE GENEVA LAKE AREA: MAY 1976-APRIL 1977

	May[a]	June	July	August	September	October	November	December	January	February	March	April	Year
Mean Monthly Temperature	63.7	68.5	70.2	70.4	60.1	46.5	30.3	15.1	7.1	24.6	41.1	53.3	45.9
Mean Monthly Precipitation	2.72	2.45	2.09	3.33	1.45	2.26	0.67	0.97	1.11	0.86	4.37	2.44	24.72
Days with Precipitation[b]	13	7	8	7	5	9	5	15	17	8	14	12	120
Lake Evaporation in Inches[c]	2.05	3.91	5.41	5.13	5.10	2.76	1.73	0.47	0.36	0.37	1.08	1.84	30.21
Ratio of Runoff to Rainfall, Fox River, Waukesha, Wisconsin	0.21	0.16	0.12	0.11	0.09	0.19	0.22	0.28	0.35	0.38	0.66	0.43	0.27

[a]Average of May 1976 and May 1977--except for evaporation data.

[b]Precipitation of 0.01 inches or more.

[c]Evaporation data from Rockford, Illinois.

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

Soil composition and vegetative cover are important factors affecting the rate, amount, and quality of runoff. The shape and stability of aggregates of soil particles, expressed as soil structure, influences, to some degree, the permeability, infiltration rate, and erodibility of soils. In general, soils with structural arrangements with horizontal cleavage and aggregates that fit closely together are less permeable than those with granular structure and spheroidal aggregates. Generally, soils with adequate vegetative cover and stable granular or subangular blocky structure are less erosive than soils with other kinds of structure. In addition to soil structure and vegetative cover, slope also affects the amount and rate of runoff from soils. Thus, slope is important in predicting susceptibility to erosion, whereas soil position is the principal controlling factor in drainage. Soils located in depressions in the landscape are generally poorly or very poorly drained because of the presence of high water tables and/or slow surface drainage. Hillside, ridgetop, high bench, or terrace soils are generally well drained.

The various soil types within the Geneva Lake watershed can be categorized into the following four main hydrologic groups. Group A includes soils with high infiltration rates consisting mainly of well and excessively well-drained sandy or gravelly soils. These soils have a high rate of water transmission and a low runoff potential. Group B includes soils with moderate infiltration rates consisting mainly of moderately well-drained soils with moderately fine to moderately coarse textures and a moderate rate of water transmission. Group C includes the moderately fine or fine-textured soils with slow infiltration rates or soils with layers that impede the downward movement of water. These soils have a slow rate of water transmission. Group D includes the soils with very slow infiltration rates and consists mainly of a) clay soils with a high shrink-swell potential; b) soils with a high permanent water table; c) soils with a clay pan or clay layer at or near the surface; and d) shallow soils over nearly impervious substrates. These factors cause the members of this soil group to have a very slow rate of water transmission. The fifth category, called "made land," consists of open pit mining areas, man-made fill areas, dumps and landfills. The relative proportion of the total direct tributary drainage area covered by each of these hydrologic soil groups is: Group A, well drained soils, 3.5 percent; Group B, moderately drained soils, 79.3 percent; Group C, poorly drained soils, 5.6 percent; Group D, very poorly drained soils, 10.4 percent; and "made land," 1.2 percent. The areal extent of these soils and their locations within the watershed are presented in Table 3 and shown on Map 3.

Table 3

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

Group	Soil Characteristics	Extent (acres)	Percent of Total
A	High infiltration rates Well-drained and excessively drained sandy or gravelly soils High rate of water transmission and low runoff potential	448	3.5
B	Moderate infiltration rates Moderately well drained Moderately coarse textures Moderate rate of water transmission	10,154	79.3
C	Slow infiltration rates Moderately fine or fine-textured or layers that impede downward movement of water Slow rate of water transmission	717	5.6
D	Very low infiltration rates Clay soils with high shrink-swell potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; shallow soils over nearly impervious substrate Very slow rate of water transmission	1,333	10.4
Made Land	Open pit mining areas, man-made fill areas, dumps and landfills, containing widely varying soils and other materials	154	1.2
Total	--	12,806	100.0

Source: SEWRPC.

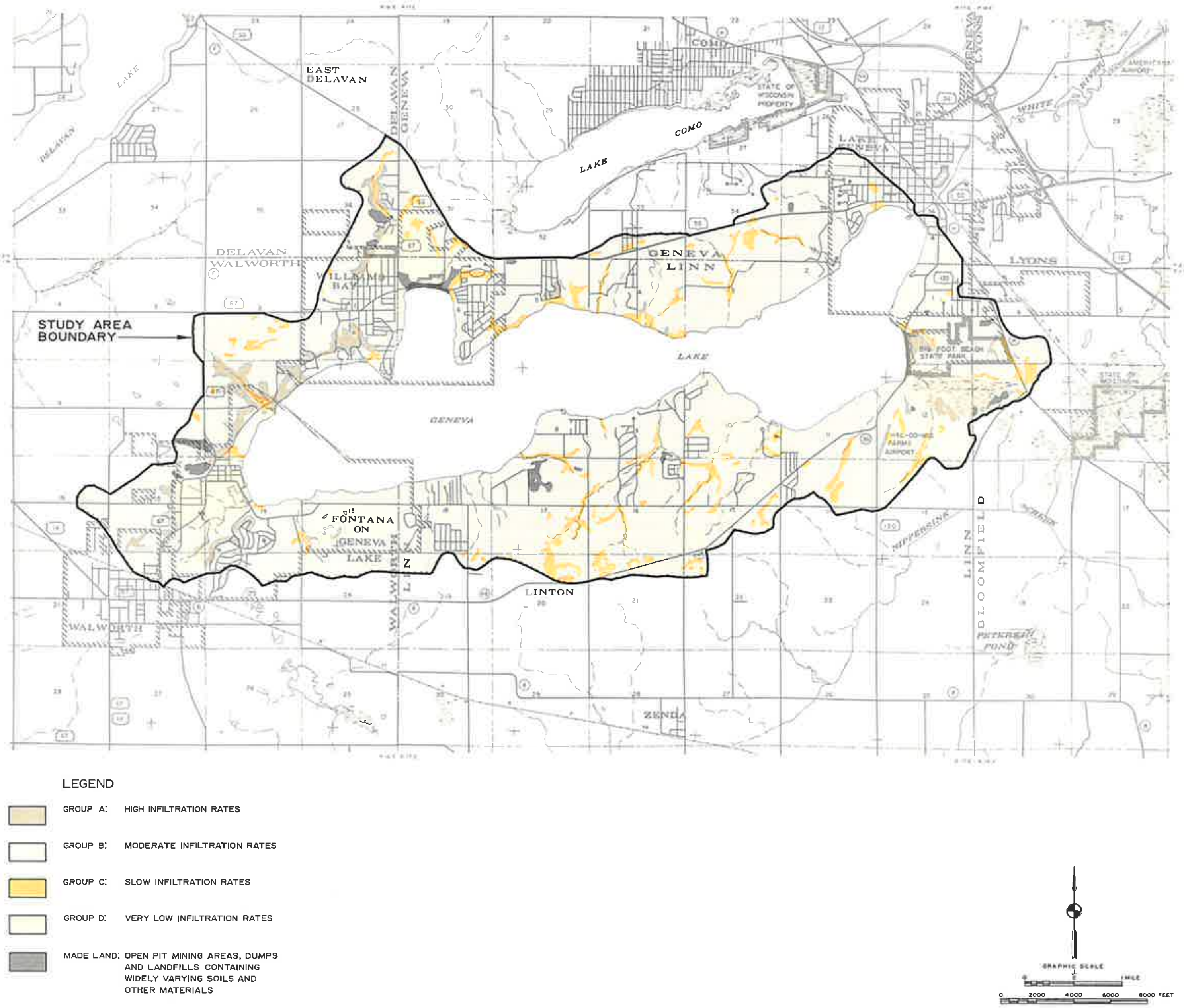
The major specific soil types present within the Geneva Lake direct drainage area are: Casco silt loam, Calamus silt loam, Clyman silt loam, Dodge silt loam, Fox silt loam, Ehler silt loam, McHenry silt loam, Miami silt loam, Pistakee silt loam, Lapeer loam, Miami loam, and Houghton muck.

Soils within the direct tributary area were also examined for their suitability for septic tank use. The suitability of soils for such systems is indicated on Map 4 according to three major groupings: slightly limited, severely limited, and very severely limited for septic systems on residential lots one acre or less in area. These soil categories cover 66.2, 16.4, and 16.2 percent of the total direct drainage area, respectively. Approximately 1.2 percent of the land in the directly tributory drainage area of Geneva Lake was not able to be rated for septic tank suitability due to the disturbed nature of the soils. As of 1984, there were an estimated 1,673 privately owned septic tank systems in the direct drainage area of Geneva Lake. About 667, or 40 percent of these systems, were located in areas covered by soils having severe or very severe limitations for the use of onsite sewage disposal systems.

Another consideration of interest for watershed management is the suitability of the soils for land application of residual wastewater treatment sludges. The Commission inventory of sewage sludge management practices within the

Map 3

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

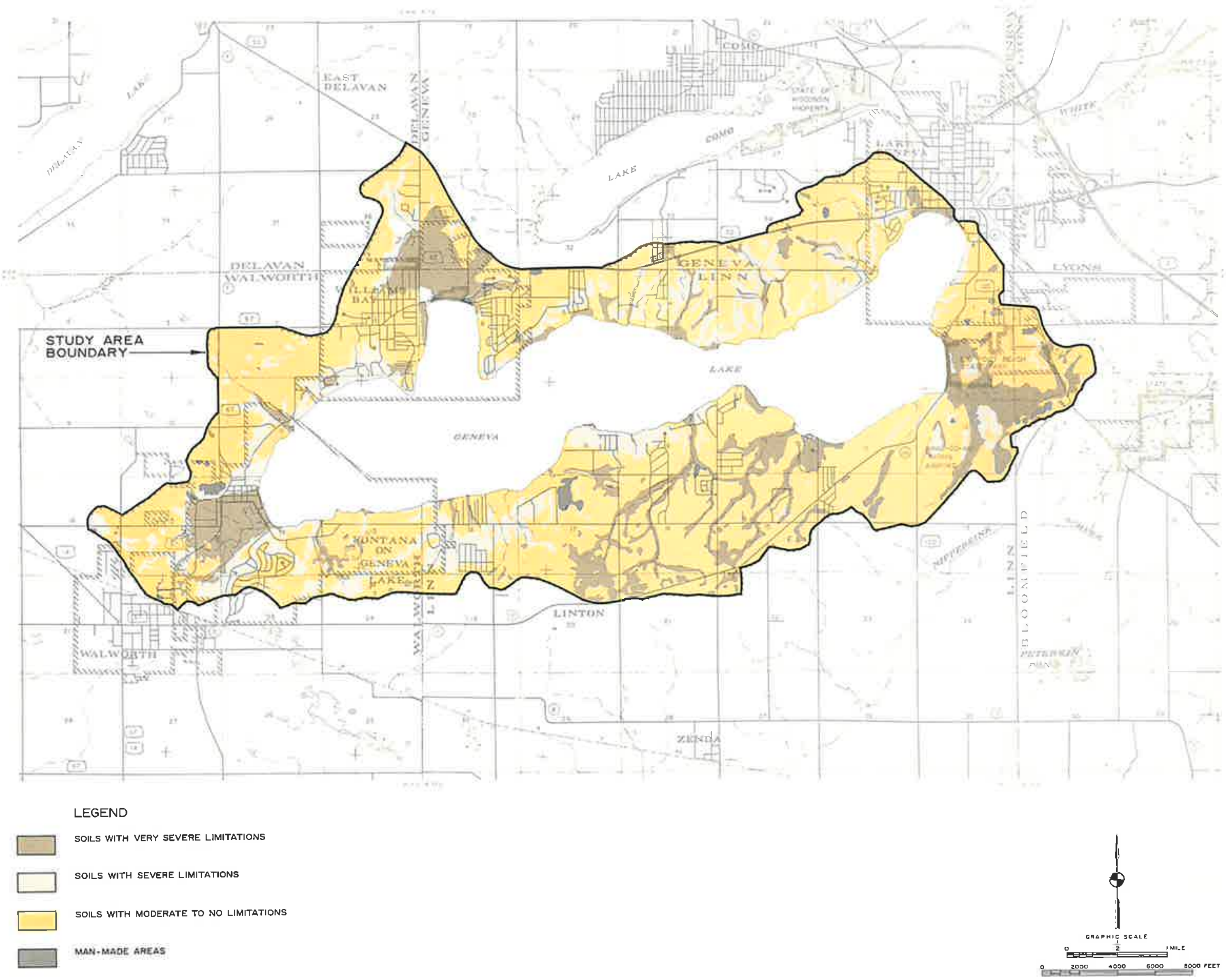


Source: SEWRPC.

Region indicated that in 1976 such sludges were not being applied in the drainage area directly tributary to the lake. Such sludges were made available to the residents of the Villages of Fontana and Williams Bay for application on lawns and gardens. No data were available on the prevalence of such application, however. About 37 percent of the total area of the direct drainage area to Geneva Lake is covered by soils rated as having only slight limitations for wastewater sludge application, as shown on Map 5. About 28

Map 4

SUITABILITY OF SOILS FOR CONVENTIONAL PRIVATELY OWNED ONSITE SEWAGE DISPOSAL SYSTEMS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE

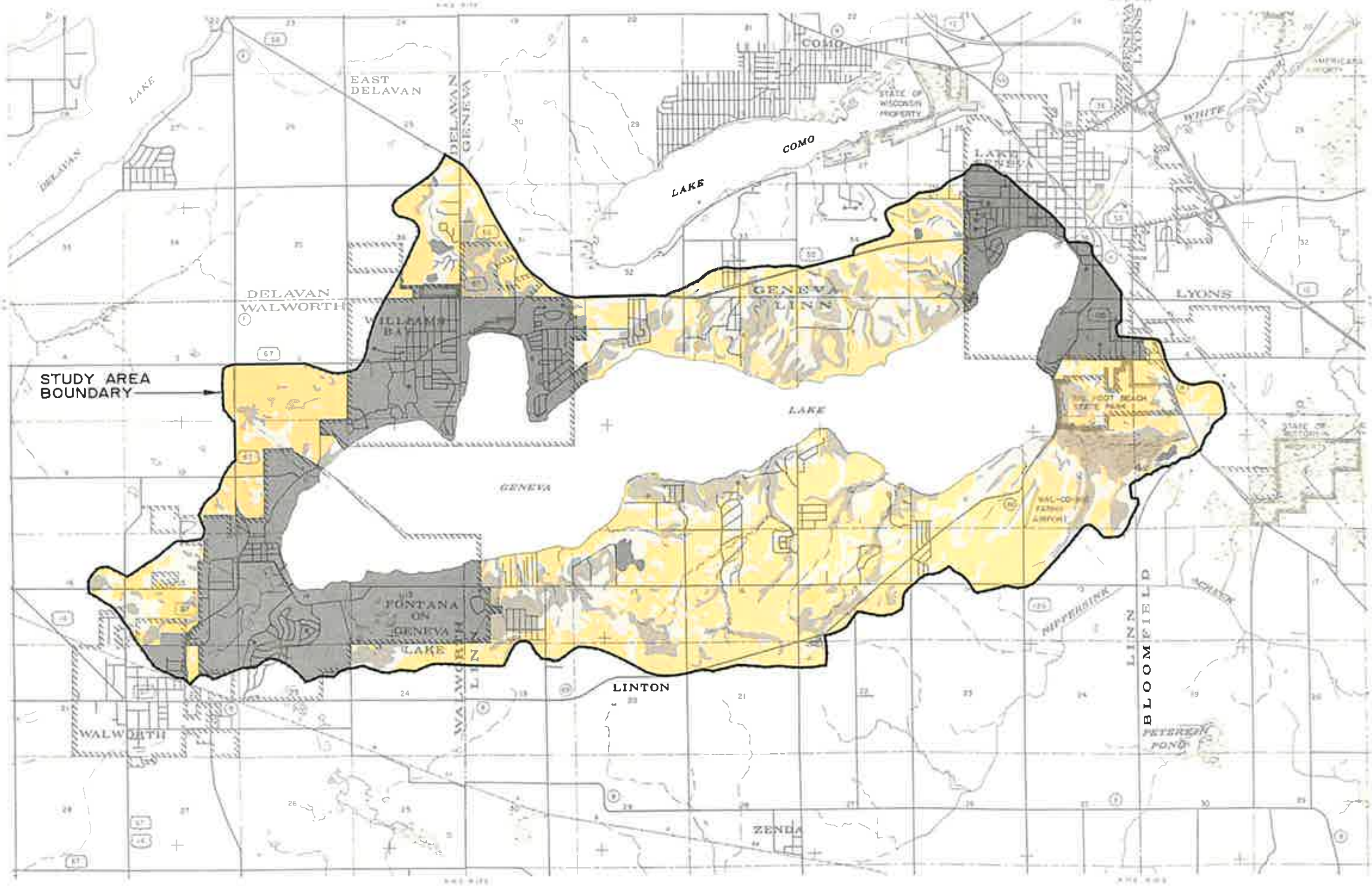


Source: SEWRPC.

percent of the soils were in generalized urban land uses which would be incompatible with wastewater sludge application on land, or, due to their disturbed nature, were otherwise unable to be rated for soil suitability for sewage sludge application. The remaining 35 percent of the area is covered by soils which have severe or very severe limitations for sludge application; and any such application in these areas could potentially be detrimental to lake water quality.

Map 5

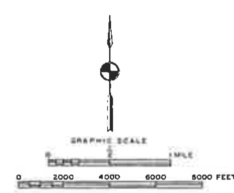
SUITABILITY OF SOILS FOR SLUDGE APPLICATION IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE



LEGEND

- SEVERE LIMITATIONS
- MODERATE LIMITATIONS
- SLIGHT LIMITATIONS
- MAN-MADE OR URBAN

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



Source: SEWRPC.

Chapter III

HISTORIC, EXISTING, AND FORECAST LAND USE AND POPULATION

INTRODUCTION

Water pollution problems, and ultimate solutions to those problems, are primarily a function of the human activities within the drainage area of a water body and of the ability of the underlying natural resource base to sustain those activities. This is especially true in an area directly tributary to a lake, because lakes are highly susceptible to water quality degradation, and such degradation is more likely to interfere with desired water uses. This chapter describes the extent and organization of human activities within the lake drainage area, and includes data concerning civil divisions, population, and land use of the study area.

CIVIL DIVISIONS

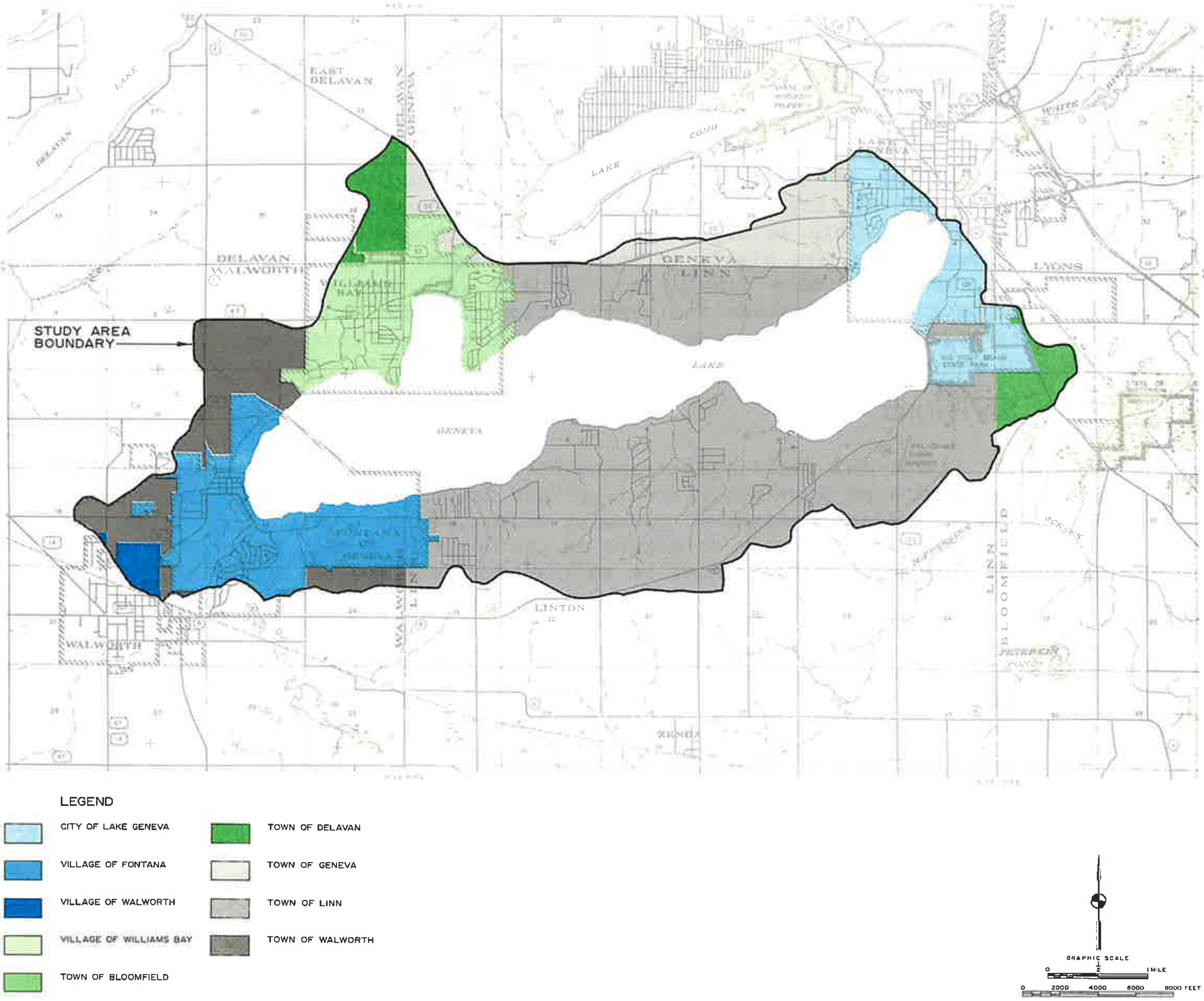
The areal extent and functional responsibilities of general and special purpose local units of government are important factors which must be considered in any water quality management planning effort, since these local units of government provide the basic structure of the decision-making framework within which environmental problems must be addressed. Superimposed on the irregular drainage area directly tributary to Geneva Lake is a generally rectilinear pattern of local civil division boundaries, as shown on Map 6. The drainage area directly tributary to Geneva Lake includes portions of the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth; the Villages of Fontana on Geneva Lake, Walworth, and Williams Bay; and the City of Lake Geneva, all of which are located in Walworth County. However, none of these civil divisions lies entirely within the direct drainage area to the lake. The area and proportion of the direct drainage area lying within the jurisdiction of each civil division, as of January 1, 1985, are set forth in Table 4.

POPULATION

As indicated in Table 5, the resident population of the drainage area directly tributary to Geneva Lake has increased steadily since 1950. In 1980, the resident population of the drainage area was estimated at 8,011 persons, or more than double the estimated 1950 population of 2,980. 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 resident population of the drainage area directly tributary to Geneva Lake may be expected to increase to about 10,100 persons by the year 2000. A comparison of historic, existing, and forecast population levels for the drainage area directly tributary to Geneva Lake, for Walworth County, and for the Southeastern Wisconsin Region is set forth in Figure 2. Compared to Walworth County and the Southeastern Wisconsin Region as a whole, population growth in the Geneva Lake drainage area since 1950 has increased at a higher rate than that for the Region and Walworth County. This population growth may be expected to place a continued and increasing stress on the natural resource base of the Geneva

Map 6

CIVIL DIVISION BOUNDARIES IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: 1985



Source: SEWRPC.

Table 4

AREAL EXTENT OF CIVIL DIVISIONS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: JANUARY 1, 1985

Civil Division	Civil Division Area Within Direct Drainage Area (square miles)	Percent of Direct Drainage Area Within Civil Division	Percent of Civil Division Within Direct Drainage Area
Walworth County			
City			
Lake Geneva.....	2.38	8.4	49.5
Villages			
Fontana on Geneva Lake....	3.58	12.6	91.3
Walworth........	0.21	0.7	16.1
Williams Bay....	2.66	9.3	91.7
Towns			
Bloomfield......	0.44	1.5	1.3
Delavan.........	0.49	1.7	1.5
Geneva..........	1.68	5.9	5.2
Linn............	14.61	51.3	43.4
Walworth........	2.44	8.6	8.1
Total	28.49[a]	100.0	--

[a]Includes the surface water area of 8.48 square miles of Geneva Lake.

Source: SEWRPC.

Lake drainage area, and, as the populations of the lake's direct drainage area, the County, and the Region continue to grow and change, water resource demands and use conflicts may be expected to increase.

LAND USE

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

The movement of European settlers into the Southeastern Wisconsin Region began about 1830. Completion of the U. S. Public Land Survey in southeastern Wisconsin in 1836 and the subsequent sale of public lands brought a rapid influx of settlers into the area. Map 7 shows the original plat of the U. S. Public Land Survey for the Geneva Lake area. Map 8 and Table 6 indicate the recent historic urban growth pattern in the drainage area directly tributary to Geneva Lake. The largest increases in urban development occurred between 1950 and 1963.

The existing land use patterns in the drainage area directly tributary to Geneva Lake as of 1980 are shown on Map 9 and quantified in Table 7. As indicated in Table 7, about 4,778 acres, or 37 percent of the total direct drainage area, were in urban land uses, with the dominant urban land use being residential, encompassing 2,786 acres, or about 58 percent of the area in urban use. The remainder of the urban land uses constituted 1,992 acres, or

Table 5

HISTORIC AND FORECAST RESIDENT POPULATION LEVELS OF THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE

Year	Population
1950	2,980
1960	4,920
1970	6,560
1975	7,630
1980	8,011
2000	10,100

Source: SEWRPC.

Table 6

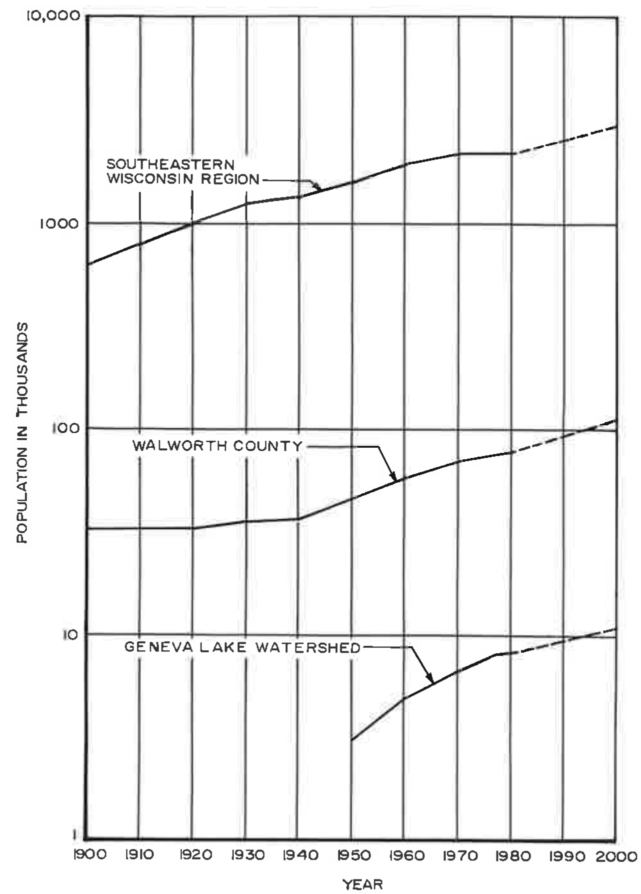
EXTENT OF HISTORIC URBAN GROWTH IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: 1950-1980

Year	Extent of Urban Development (acres)
1950	1,899
1963	2,980
1970	3,189
1975	3,448
1980	3,702

Source: SEWRPC.

Figure 2

COMPARISON OF HISTORICAL, EXISTING, AND FORECAST POPULATION TRENDS FOR THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE, WALWORTH COUNTY, AND THE REGION

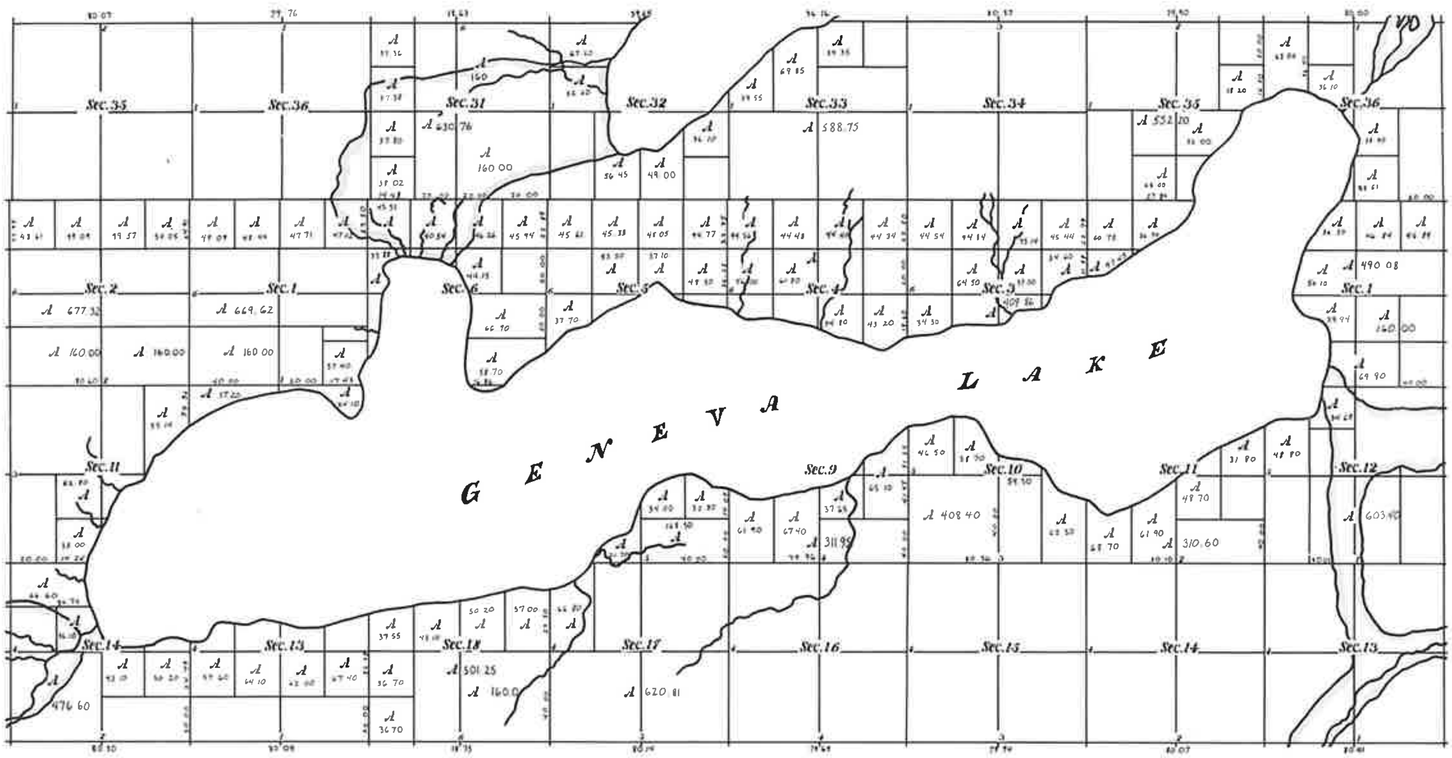


Source: SEWRPC.

42 percent of the area in urban use. As of 1980, about 8,028 acres, or 63 percent of the total direct drainage area, were still in rural land uses, with approximately 4,043 acres, or 50 percent of the area in rural uses, being in agricultural use. Open lands and woodlands comprised about 3,466 acres, or 44 percent of the area in rural use. Wetlands and surface water, excluding the surface area of Geneva Lake, accounted for about 519 acres, or 6 percent of the area in rural use.

Map 7

ORIGINAL PLAT OF THE U. S. PUBLIC LAND SURVEY FOR THE GENEVA LAKE AREA: 1836



Source: U. S. Public Land Survey.

Table 7

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

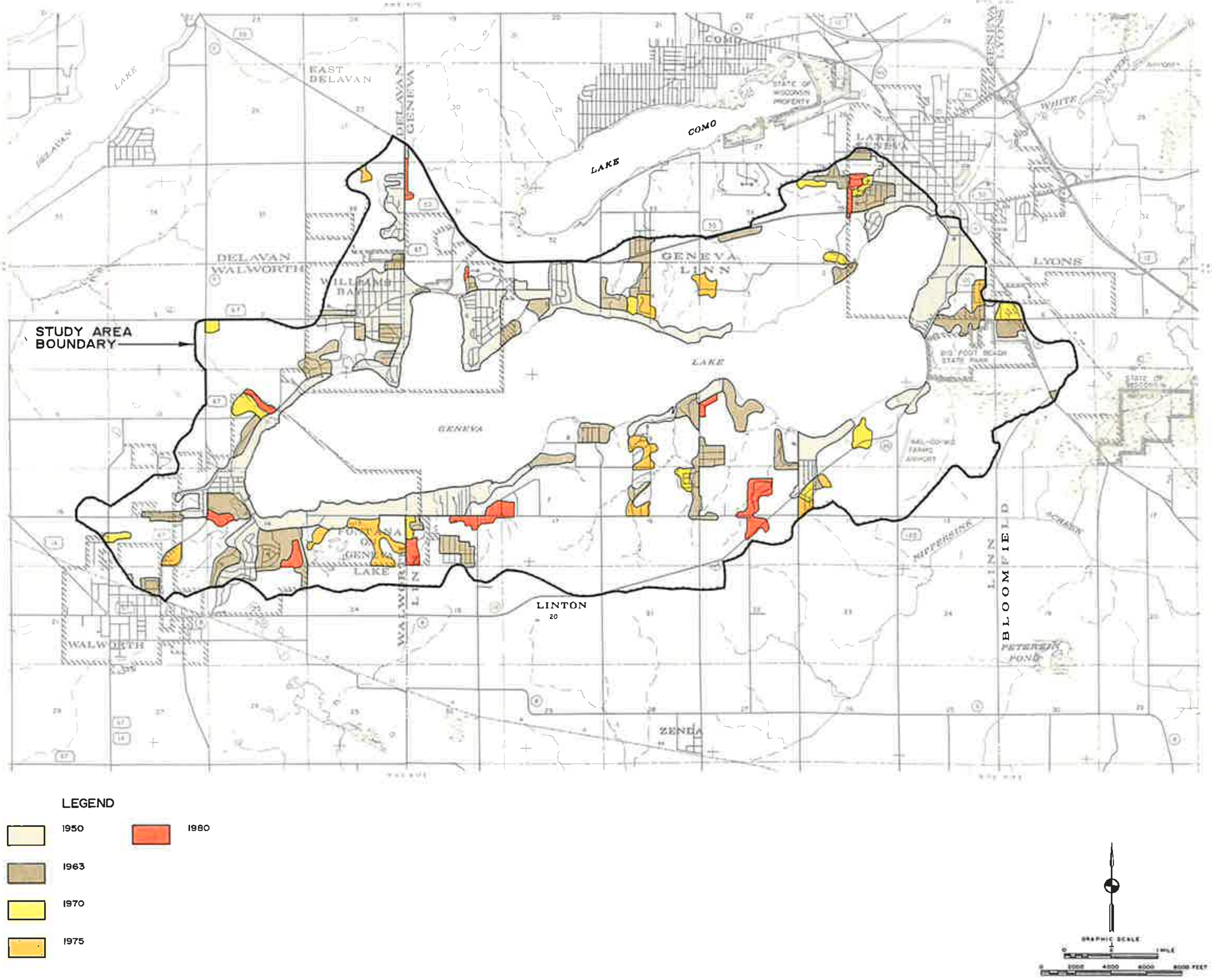
Land Use Categories	Existing 1980		
	Acres	Percent of Major Category	Percent of Study Area
Residential	2,786	58.3	21.8
Commercial	121	2.5	0.9
Industrial	21	0.4	0.2
Governmental and Institutional	198	4.2	1.5
Transportation, Communication, and Utilities	936	19.4	7.3
Recreation	716	15.0	5.6
Urban Land Use Subtotal	4,778	100.0	37.3
Prime Agriculture	2,417	30.1	18.9
Other Agriculture	1,626	20.3	12.7
Water[a]	27	0.3	0.2
Wetlands	492	6.1	3.9
Woodlands	2,515	31.3	19.6
Other Open Lands	951	11.9	7.4
Rural Land Use Subtotal	8,028	100.0	62.7
Study Area Total	12,806	--	100.0

[a] Excludes the surface area of 5,425 acres of Geneva Lake.

Source: SEWRPC.

Map 8

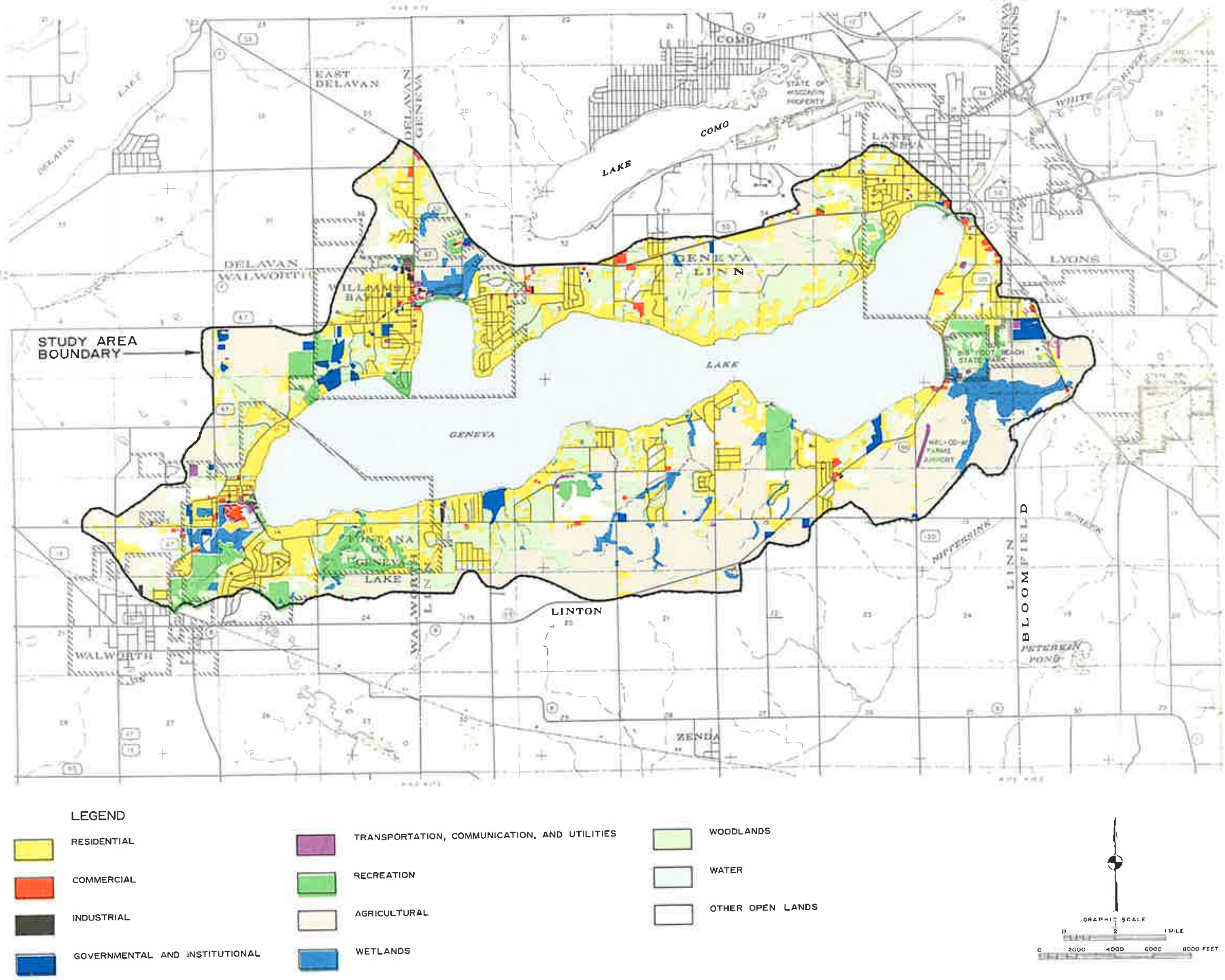
HISTORIC URBAN GROWTH IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: 1950-1980



Source: SEWRPC.

Map 9

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



Source: SEWRPC.

Chapter IV

WATER QUALITY

SAMPLING PROGRAM

The water quality sampling program for Geneva Lake included the collection of water samples from the lake itself, from streams and watercourses and storm drains directly tributary to the lake, from the groundwater reservoir, and from precipitation, and the analyses of the samples to ascertain certain physical, chemical, and biological characteristics. The locations of the monitoring stations are shown on Map 10. The frequency of sampling and the parameters measured varied with the specific type of water sampled--lake, tributary stream, groundwater, precipitation--and, in a few cases, the sampling regime was modified because of climatic conditions or work load. The sampling was initiated in May 1976 and terminated in May 1977.

As shown on Map 10, lake water samples were collected for chemical analyses at three sites in Geneva Lake: Fontana Bay (G-22), Williams Bay (G-23), and Geneva Bay (G-24). Stratified samples were taken at each station. Six depths were sampled at Fontana Bay, the deepest sample location, and three depths were sampled at the other two locations. Samples were collected monthly from May 1976 through May 1977 with the exception of March 1977, when unsafe ice conditions prohibited sample collection. The sampling depths varied slightly during the year to correspond to temperature and/or oxygen variations at different depths, as determined by temperature and/or oxygen profiles. During summer stratification, sampling depths corresponded to the epilimnion, thermocline, and hypolimnion strata of the lake.

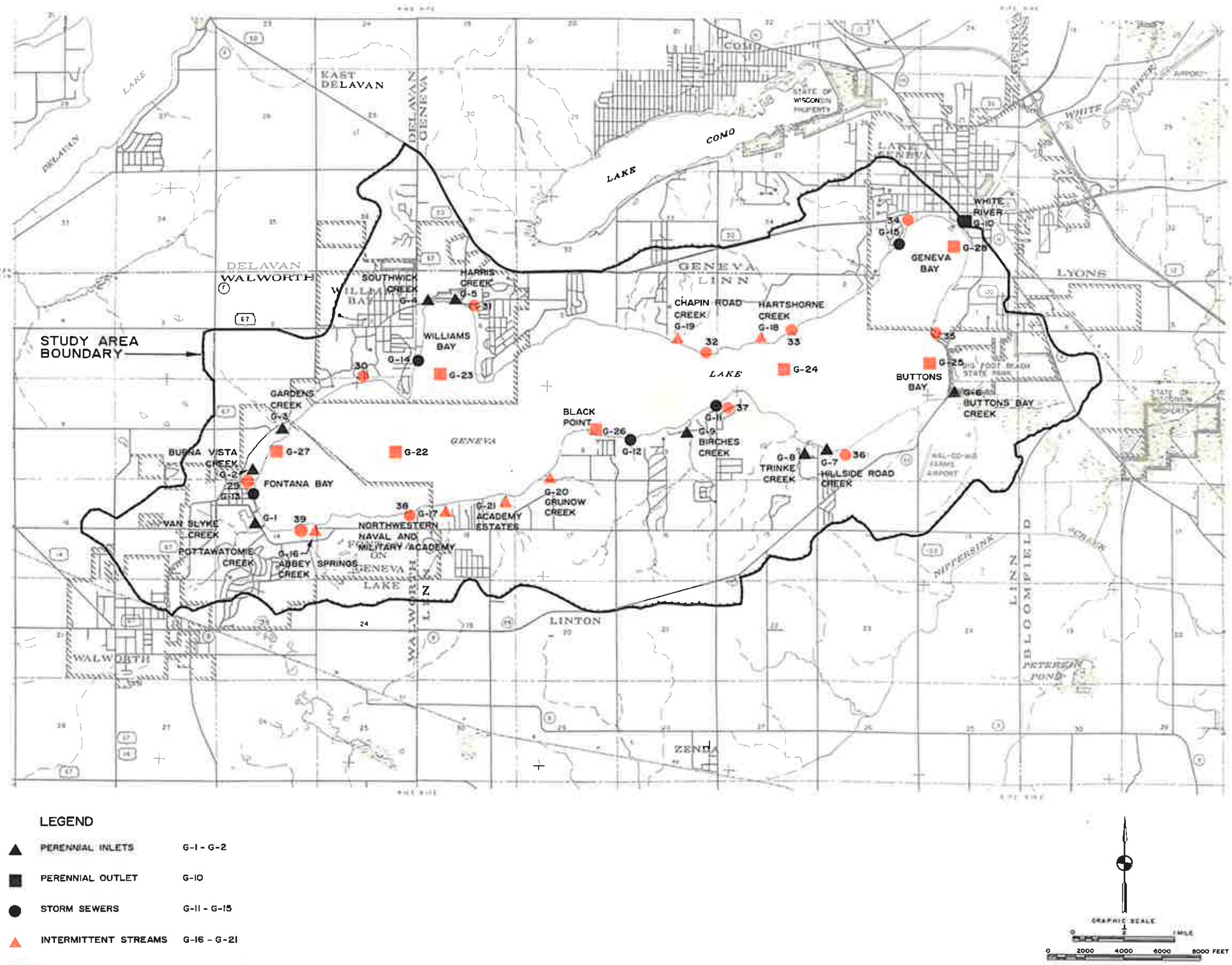
The three previously mentioned lake sampling sites plus a fourth site, located on Buttons Bay (G-25), were also used for zooplankton studies. In addition, phytoplankton (floating microscopic plants) samples taken at each of the four sites were used to estimate the primary productivity of the lake--as measured by chlorophyll-a concentration. Periphyton (attached algae) production, as measured by chlorophyll-a concentration, in Geneva Lake was also determined on two occasions. The periphyton were collected from artificial substrates located in six feet of water at the east and west ends of the lake for four weeks in spring--April to May 1976--and fall--September to October 1977.

Variations in lake level were noted from readings taken at an existing staff gauge located in the lagoon near the outlet dam spillway maintained by the Geneva Lake Level Corporation. The index of the gauge was resurveyed for the study. In addition, the water level of the White River was monitored approximately 50 feet below the dam.

The perennial streams, intermittent streams, storm drains, groundwater wells, and atmospheric bulk-precipitation were monitored to provide information on the transport of pollutants into Geneva Lake. Nine perennial streams--G-1 to G-9--entering the lake were sampled from May 1976 through May 1977. Biological, physical, and chemical analyses were performed on samples collected

Map 10

WATER QUALITY SAMPLING STATIONS ON GENEVA LAKE: 1976-1977



Source: Geneva Lake Environmental Agency.

biweekly from May to September 1976 and monthly during the other periods of the study. Stream discharge was measured on each sampling date, and total discharge was estimated from weekly staff gauge readings and stage-discharge curves. Below normal precipitation during the study period and winter ice conditions precluded measurement of discharges on some sample dates. In addition, the perennial stream discharging to Buttons Bay did not have a perceptible discharge between July 1976 and April 1977 and no samples could be taken. In November 1976, an additional sampling station was established on Abbey Channel at the South Shore Drive bridge in Fontana.

Six of the numerous small intermittent streams in the direct drainage area tributary to Geneva Lake were also selected for monitoring--G-16 through G-21. The parameters monitored were the same as for the perennial streams with the exception that samples were taken and discharge measured once a month during flow periods. Frequently, these intermittent streams did not flow for the entire month and samples had to be taken during periods of flow. Two of the intermittent streams, Academy Estates and Grunow, flowed continuously for 10 and 11 months of the study, respectively.

In addition to the regular sampling regime, the perennial streams, intermittent streams, and several storm drains were sampled during spring runoff and during several storm events to assess the pollutant loadings to Geneva Lake. The introduction of contaminants to Geneva Lake from snowmelt was evaluated from a single event--February 12, 1977--when a warm spell, accompanied by a trace of precipitation, produced flows in the intermittent streams and in several storm sewers. Additional data regarding the impact of spring runoff and storm events would have been desirable, but were not obtained. The absence of heavy precipitation prevented adequate sampling of all five of the storm drains selected for monitoring, as only three drains flowed at the time of sampling.

Twenty-two shallow groundwater wells were established around the lake on a paired, upland-lowland basis. The wells were established after the initial water quality sampling program had started and were monitored from August 1976 through May 1977. Groundwater elevations in all the wells were measured monthly; eight paired wells were sampled monthly for chemical analyses. Six of the monthly well samples were from the same paired upland-lowland wells to provide a continuous profile of groundwater quality in various areas of the Geneva Lake direct tributary drainage area. The other two samples were taken on a rotating basis from a series of three paired upland-lowland wells to provide an evaluation of the effect a particular land use had upon groundwater quality.

Since precipitation and atmospheric fallout may contribute pollutants to a lake, bulk precipitation samples were collected monthly and/or bimonthly in a dustfall container located on a pier extending out into the lake in the City of Lake Geneva. The necessary equipment was installed on September 7, 1976. Consequently, atmospheric contributions were measured for eight months of the study and were extrapolated over the entire study year to provide annual estimates of loadings from direct atmospheric fallout and precipitation.

PHYSICAL AND CHEMICAL CHARACTERISTICS

Lake Water Quality

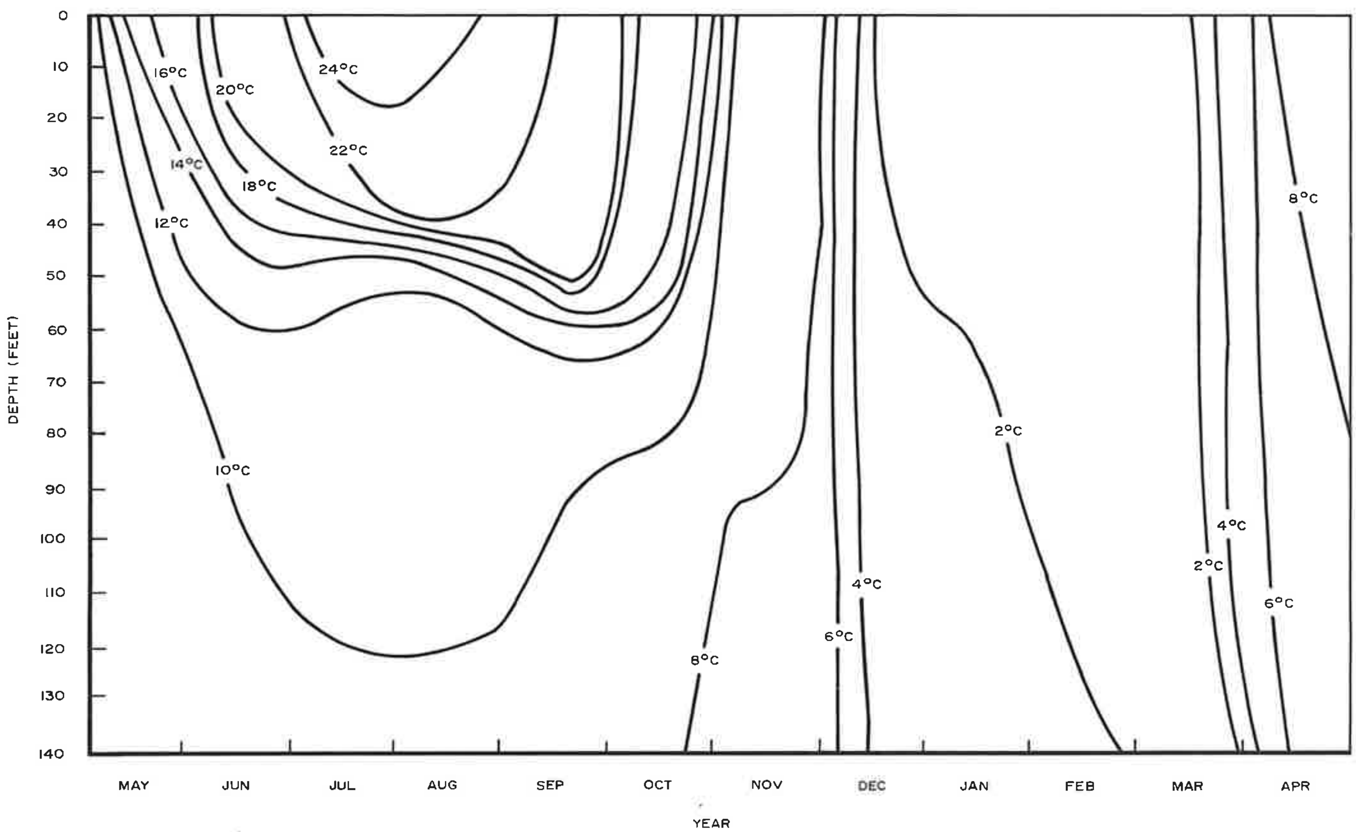
Temperature Variation and Dissolved Oxygen Concentrations: As shown in Figure 3, the water in Geneva Lake exhibited a wide range of temperatures during the study period. In summer, the surface waters reached a temperature of 75°F, while in winter, the temperature reached 39°F. Normally, a lake remains at a temperature of about 39°F; however, during the winter of 1976/1977, lake temperature was lower--35°F--because air temperatures were below normal and the lake water became cooler than normal prior to ice formation. Geneva Lake froze over completely on December 29, 1976, although both Williams Bay and Geneva Bay, as well as other portions of the shoreline, were ice covered by December 22, 1976.

Summer and winter stratification periods are particularly critical to aquatic organisms in a lake. During winter stratification, the water beneath the ice is "stagnant," or not circulating, and in the absence of contact with the atmosphere, oxygen is provided only from the chemical and biological processes occurring in the lake. During summer stratification, a lake is divided into three regions: an upper warm circulating region or epilimnion, a middle barrier region of rapidly decreasing temperature and poor circulation called the thermocline, and a lower cold, noncirculating region or hypolimnion. The temperature and oxygen profiles for Fontana Bay--the deepest sampling station--are presented in Figure 4. During summer, the epilimnion in Geneva Lake extended from the surface to approximately 29.4 feet, the thermocline extended between 29.7 feet and 51.9 feet, and the hypolimnion extended from 52.3 feet to the bottom. Based on these measurements, it was estimated that 40.6 percent of the lake volume circulated during the summer stratification period, and that 23.8 percent was stagnant. The remaining 35.6 percent was below the thermocline, but circulated to a limited extent. That lower portion of Geneva Lake remains at less than 16°C during the summer and provides suitable temperatures to support cold water fish species, such as trout and cisco.

The summer and winter stratification of a lake is particularly important to the aquatic organisms in the lake because these periods affect the distribution of dissolved oxygen. Generally, stagnant (noncirculating) water which is not in contact with the atmosphere becomes devoid of oxygen as a result of animal respiration and the decomposition of organic materials in the lake water and bottom sediments. During the winter of 1976/1977, the dissolved oxygen concentrations in Geneva Lake exceeded 5.0 parts per million (ppm), a concentration considered necessary to support aquatic life. Dissolved oxygen concentrations recorded during the study period in Fontana Bay are shown in Figure 5. However, during the summer stratification period, the dissolved oxygen was depleted in the hypolimnion. Dissolved oxygen concentrations in the hypolimnion reached the critical level in late July, and it was estimated that the largest volume of poorly oxygenated water existed in early October, just prior to the fall turnover. During this period, lake water in Fontana Bay below 121 feet was completely devoid of oxygen and water below 46 feet contained less than 5.0 ppm of oxygen. Three parts per million of dissolved oxygen is often considered the lower limit for supporting most species of fish. Consequently, during summer stratification, Geneva Lake had

Figure 3

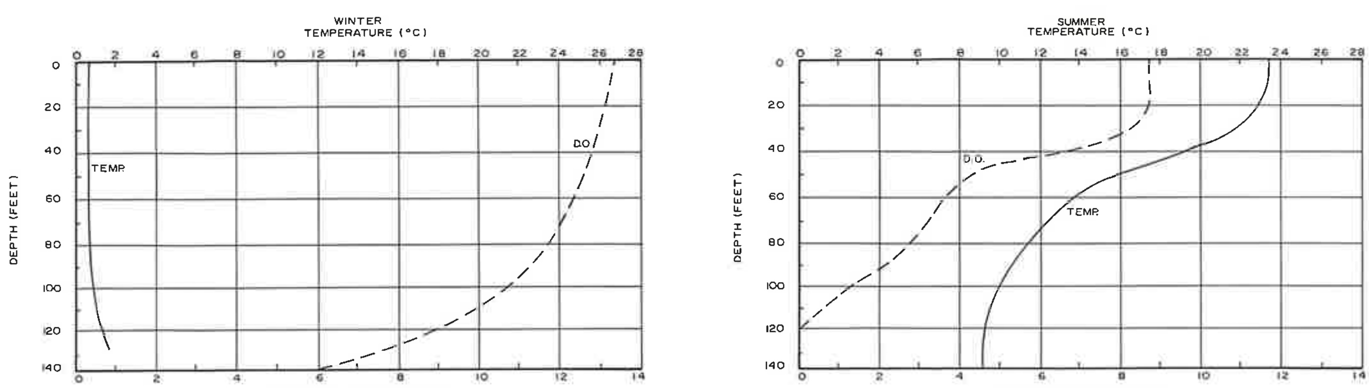
TIME-DEPTH DIAGRAM OF TEMPERATURE (°C) IN FONTANA BAY



Source: Geneva Lake Environmental Agency.

Figure 4

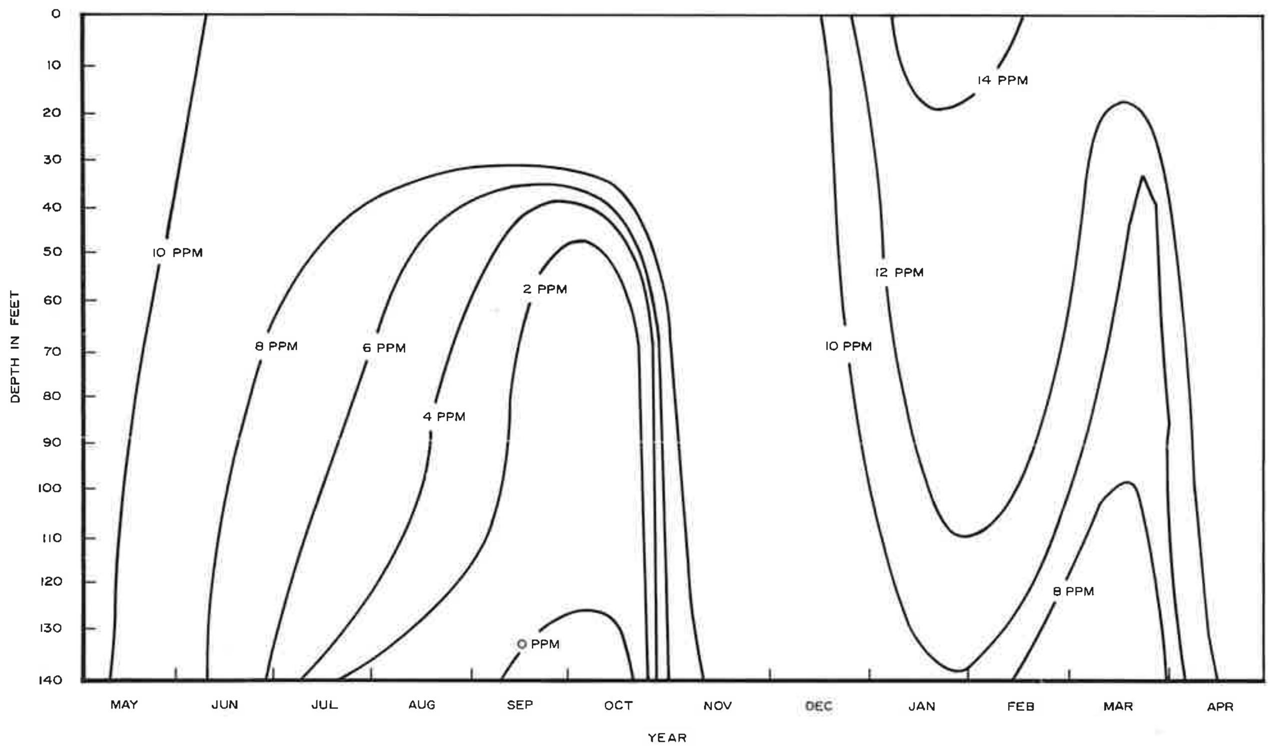
WINTER AND SUMMER TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR FONTANA BAY: 1976-1977



Source: Geneva Lake Environmental Agency.

Figure 5

TIME-DEPTH DIAGRAM OF DISSOLVED OXYGEN LEVELS IN FONTANA BAY: MAY 1976-APRIL 1977



Source: Geneva Lake Environmental Agency.

sufficient oxygen to support fish to a depth of 75 feet and, therefore, throughout a volume representing approximately 62.3 percent of the total volume of the lake.

Both the Williams Bay and Geneva Bay sampling locations were shallower than the Fontana Bay sampling station, but both experienced low dissolved oxygen levels at about the same water depths as did Fontana Bay. During the summer stratification, dissolved oxygen reached a critical level of 3.0 ppm or less below 52 feet in both bays.

Phosphorus and Nitrogen Concentrations: Concentrations of nutrients in Geneva Lake are important for assessing the degree of eutrophication, or aging, which the lake is experiencing. Average annual phosphorus and nitrogen concentrations for Geneva Lake are presented in Table 8. Nutrient concentrations on an average annual basis were always found to be highest at the Fontana Bay sampling station. Both the Williams Bay and Geneva Bay sampling stations were much shallower and included only a small portion of the hypolimnetic layer of Geneva Lake. Consequently, discussion of the nutrient content in the lake is based primarily upon data collected at the Fontana Bay sampling station.

As shown in Figures 6 and 7, concentrations of phosphorus and nitrogen in the lake varied with depth and season. During stratification, nutrient concentrations were lower in the epilimnion and higher in the hypolimnetic layer

Table 8

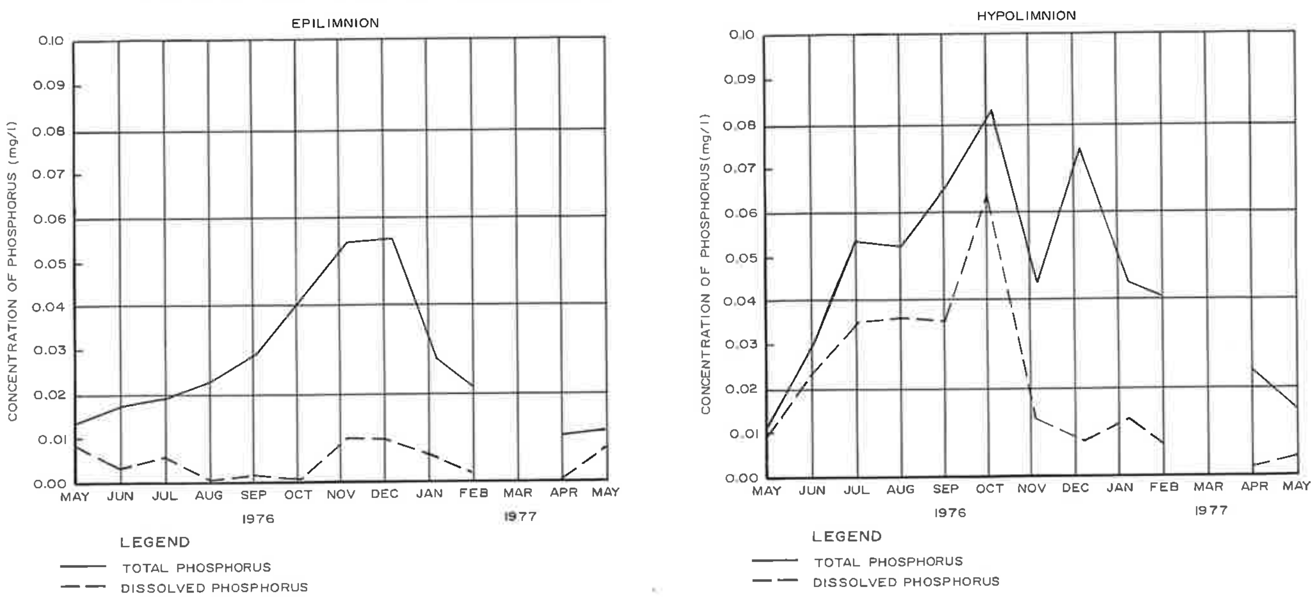
AVERAGE ANNUAL CONCENTRATIONS OF PHOSPHORUS AND NITROGEN MEASURED IN MILLIGRAMS PER LITER RECORDED FOR FONTANA BAY, GENEVA BAY, AND WILLIAMS BAY SAMPLING STATIONS: MAY 1976-MAY 1977

Parameter and Site	Epilimnion	Hypolimnion	Composite Average
Phosphorus			
Dissolved			
Fontana Bay...........	0.006	0.022	0.012
Geneva Bay............	0.006	0.014	0.009
Williams Bay..........	0.004	0.009	0.006
Combined Average	--	--	0.009
Total			
Fontana Bay...........	0.025	0.044	0.033
Geneva Bay............	0.028	0.040	0.031
Williams Bay..........	0.024	0.037	0.029
Combined Average	--	--	0.031
Nitrogen			
Inorganic			
Fontana Bay...........	0.067	0.163	0.100
Geneva Bay............	0.048	0.097	0.063
Williams Bay..........	0.051	0.077	0.062
Combined Average	--	--	0.075
Total			
Fontana Bay...........	0.377	0.512	0.457
Geneva Bay............	0.397	0.400	0.405
Williams Bay..........	0.385	0.413	0.398
Combined Average	--	--	0.420

Source: Geneva Lake Environmental Agency.

Figure 6

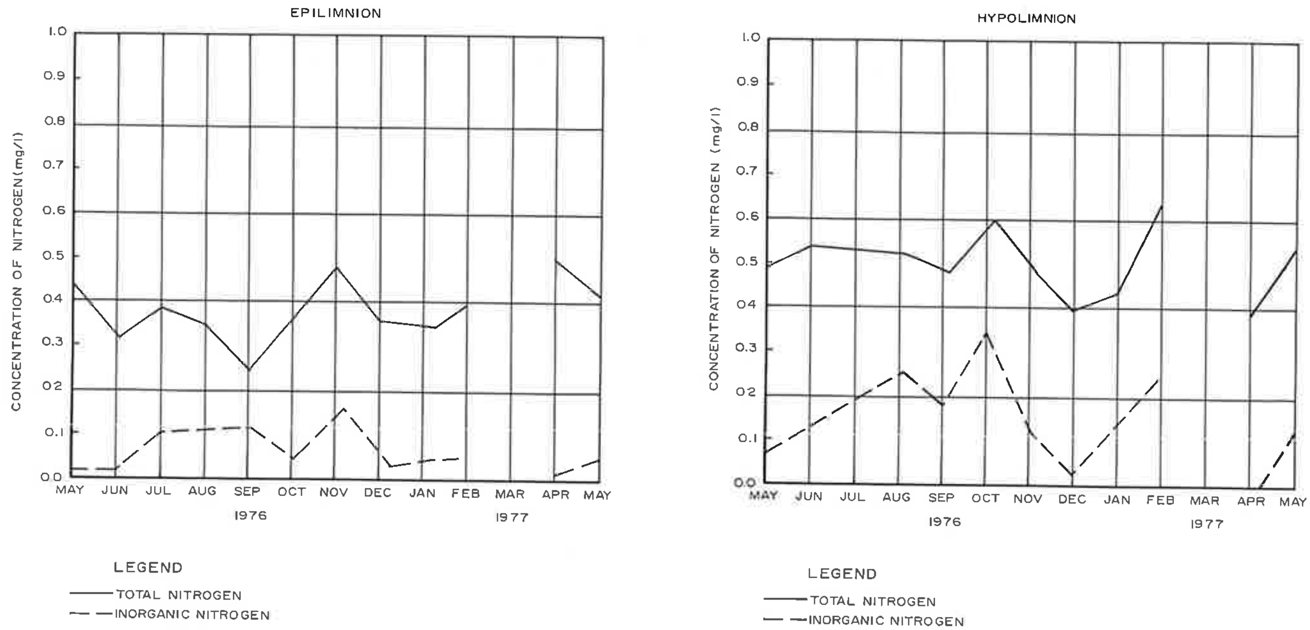
CONCENTRATIONS OF DISSOLVED AND TOTAL PHOSPHORUS IN THE EPILIMNION AND HYPOLIMNION IN FONTANA BAY: MAY 1976-1977



Source: Geneva Lake Environmental Agency.

Figure 7

CONCENTRATIONS OF INORGANIC AND TOTAL NITROGEN IN THE EPILIMNION AND HYPOLIMNION IN FONTANA BAY: MAY 1976-MAY 1977



Source: Geneva Lake Environmental Agency.

of the lake. This situation is normal for lakes which are deep enough to stratify. During the growing season nutrients become depleted in the upper waters as plants utilize them for growth. In the lower waters of a lake, decomposition and other processes result in an accumulation of nutrients.

A composite average nutrient concentration for all depths was evaluated. The highest average concentration of dissolved inorganic phosphorus in Fontana Bay--0.026 milligram per liter (mg/l)--was found in October just prior to the fall turnover, as shown in Figure 8. However, the figure shows that the average total phosphorus concentration in Fontana Bay was found to be highest in December--0.058 mg/l. The difference can, in part, be attributed to an increased organic phosphorus content associated with decomposition of a fall algal bloom. The lowest average concentration of dissolved phosphorus--0.003 mg/l--and total phosphorus--0.010--was found in late spring during the spring turnover period. Average inorganic nitrogen concentrations in Fontana Bay--0.185 mg/l, as shown in Figure 9--were found to be highest in August. A high nitrogen concentration at this time would not normally be expected, but the accumulation of ammonia from protein decomposition in the hypolimnion may have been partially responsible for these high levels. The total nitrogen concentration fluctuated during the study, but average concentrations were generally highest during late spring and late fall and were attributed to the increased circulation of organic matter during the turnover periods.

An evaluation of data from all the chemical sampling stations in the lake, as shown in Table 8, indicated that Geneva Lake had relatively low average annual concentrations of phosphorus and nitrogen. The average annual concentrations of dissolved and total phosphorus were 0.009 mg/l and 0.031 mg/l, respectively. For nitrogen, the average annual concentrations of inorganic and total nitrogen were 0.075 mg/l and 0.420 mg/l, respectively.

The ratio of total nitrogen to total phosphorus (N:P) in lake water often indicates which nutrient is the factor limiting aquatic plant growth in a lake.[1] Where the N:P is greater than 14:1, the aquatic plant growth in the lake is generally thought to be phosphorus limited. If the ratio is less than 10:1, nitrogen is generally believed to be the limiting nutrient. Although the actual limiting nutrients may vary from species to species and from time to time over the course of a year, these ratios are generally recognized to be useful criteria in the judgment of this issue. As shown in Table 9, in Geneva Lake the N:P ratio was greater than or equal to 14:1, except in September 1976, November 1976, and December 1976, when the ratios were 11:7, 11:6, and 5:8, respectively. This indicates that the aquatic plant growth in Geneva Lake is limited by phosphorus during the peak growing periods.

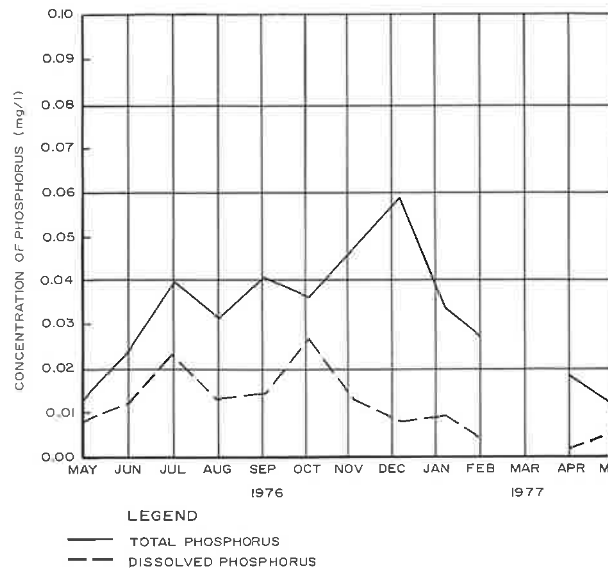
Various methods are available for assessing potential nuisance problems associated with nutrient enrichment of a lake. One of these is a comparison of the concentration of inorganic phosphorus and inorganic nitrogen present during the spring turnover with the values determined by Sawyer in 1947 that can be expected to produce nuisance growths of vegetation in a lake.[2] Sawyer's work indicated that if the concentrations of inorganic phosphorus and inorganic nitrogen exceeded 0.01 mg/l and 0.30 mg/l, respectively, a lake may be expected to produce excessive growths of algae or aquatic plants. In both 1976 and 1977, the dissolved inorganic phosphorus during the spring turnover--

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

[2] C. N. Sawyer, "Some New Aspects of Phosphates in Relation to Lake Fertilization," Sewage and Industrial Wastes, Vol. 24, No. 6, 1947.

Figure 8

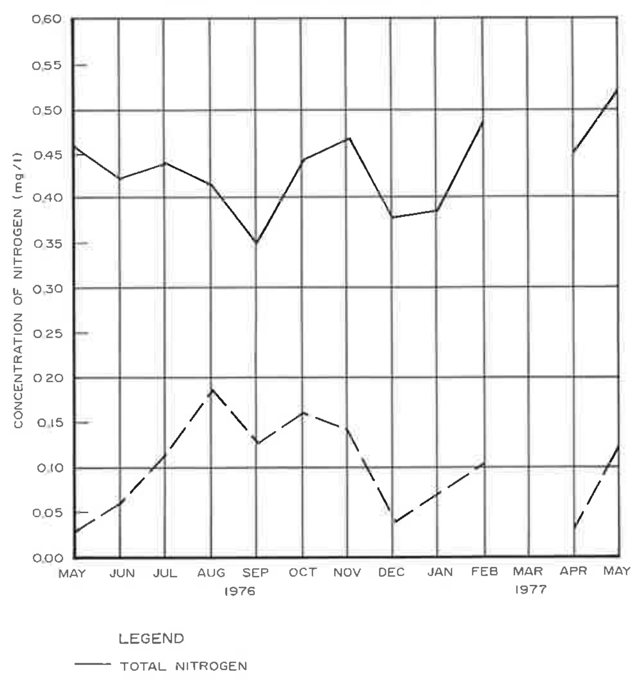
AVERAGE CONCENTRATION FOR ALL DEPTHS OF DISSOLVED AND TOTAL PHOSPHORUS IN FONTANA BAY: MAY 1976-MAY 1977



Source: Geneva Lake Environmental Agency.

Figure 9

AVERAGE CONCENTRATION FOR ALL DEPTHS OF INORGANIC AND TOTAL NITROGEN IN FONTANA BAY: MAY 1976-MAY 1977



Source: Geneva Lake Environmental Agency.

April to May--was below 0.01 mg/1, and the inorganic nitrogen concentration was below 0.3 mg/1. Consequently, Geneva Lake did not exhibit the excessive algal or aquatic plant growth which characterizes many lakes in southeastern Wisconsin. The absence of algal blooms contributes to the clarity and "clean" appearance of Geneva Lake. The results indicated that the nutrient enrichment problem is not as severe in Geneva Lake as it is on many of the other lakes of this Region. However, the Regional Planning Commission reported in 1979 that, based on the measured in-lake phosphorus concentrations, Geneva Lake did not meet the SEWRPC-adopted planning standards associated with the national goal to attain water quality suitable for fishable/swimmable conditions. The Commission staff's assessment was based upon the then-estimated pollutant loadings which, if sustained, would be expected to result in a long-term change in the lake's trophic status.

Additional Physical and Chemical Analyses: Other physical, chemical, and biological parameters included in the water quality analyses of Geneva Lake are presented in Table 10. Data for Fontana Bay were used for the physical and chemical analyses, as this station was considered representative of the other sampling stations on the lake.

Table 9

NITROGEN-PHOSPHORUS RATIO FOR GENEVA LAKE: MAY 1976-MAY 1977

Sampling Date	Nitrogen (milligram per liter)	Phosphorus (milligram per liter)	Nitrogen to Phosphorus Ratio
May 27, 1976..........	0.63	0.01	63.0
June 17, 1976.........	0.40	0.01	40.0
July 27, 1976.........	0.56	0.04	14.0
August 23, 1976.......	0.55	0.03	18.3
September 18, 1976....	0.47	0.04	11.7
October 9, 1976.......	0.59	0.04	14.7
November 6, 1976......	0.58	0.05	11.6
December 21, 1976.....	0.35	0.06	5.8
January 22, 1977......	0.48	0.03	16.0
February 26, 1977.....	0.72	0.02	36.0
April 2, 1977.........	0.45	0.01	45.0
May 3, 1977...........	0.44	0.01	44.0

Source: Geneva Lake Environmental Agency.

Table 10

SELECTED WATER QUALITY PARAMETERS MEASURED IN FONTANA BAY: SPRING 1976-WINTER 1977

Parameter	Season			
	1976			1977
	Spring (April-June)	Summer (July-September)	Fall (October-December)	Winter (January-February)
Hydrogen-ion Concentration (pH - standard units)...............	8.2	8.0	8.1	8.2
Chloride (milligrams per liter)......	13.0	13.8	13.9	14.4
Specific Conductance (micromhos per square centimeter at 25°C)......	429.0	420.0	410.0	379.0
Biochemical Oxygen Demand (milligrams per liter of oxygen)....	1.2	1.1	1.3	1.6
Transparency (Secchi Disc feet)......	11.0	9.6	9.8	18.0

Source: Geneva Lake Environmental Agency.

Geneva Lake is an alkaline, hard water lake, typical of lakes in southern Wisconsin. It has a high concentration of dissolved solids--specific conductance--which is normally associated with hard water lakes. In addition, the hydrogen-ion content (pH) is typical of alkaline lakes with moderate fertility and a normal level of photosynthetic activity.

Seasonal chloride concentrations ranged from 13.0 to 14.4 mg/l. These values are considered typical of lakes in southeastern Wisconsin. As set forth in Table 11, chloride concentrations in southeastern Wisconsin lakes generally lie in the range of from 10 to 40 mg/l. This contrasts with the normally expected background chloride concentrations of about 5 to 10 mg/l, and is attributed to the long-term increases in chloride which accompany human activities. Sources of chlorides include road deicing salt, treated and untreated sewage, animal wastes, water softeners, and natural leaching of minerals.

The water transparency, or depth to which one can see in a lake, is affected by many factors. It is not a precise measurement of a lake's water quality; however, it is a parameter to which laymen can easily relate. The general association is that the greater the transparency, the "cleaner" the lake. In Geneva Lake, the water ranged from 8 to 18 feet, with an annual average transparency of about 11 feet. During the summer, when water transparency in a lake is usually the poorest, Geneva Lake had an average transparency of nine feet. This value indicates that Geneva Lake is one of the clearest lakes in southeastern Wisconsin.

Other water quality parameters investigated were associated with biological evaluations, such as dominant algal forms and estimates of the primary productivity in the lake. Primary productivity refers to the production of plant life in a lake and is comparable to a farmer determining the production of corn from a field. The primary productivity was estimated by measuring the average amount of chlorophyll-a--a plant pigment--present per volume of water in the upper six feet of the lake. The amount of chlorophyll-a present is an indicator of the biomass of live algae in the water, and its concentration is useful in determining the trophic status of lakes and hence their suitability for certain water uses. Average monthly concentrations of chlorophyll-a are set forth in Table 12. For the period studied, high primary productivity existed in January, with secondary peaks in April and November--spring and fall turnover. Although the data are not presented, it was apparent that lower primary productivity levels existed during the summer--June to August. The data indicated a low level of primary productivity in Geneva Lake as compared to most lakes in southern Wisconsin. This was consistent with the other water quality indicators--good transparency, low fertility, and low phytoplankton counts--which reflect the relationship between the trophic status of Geneva Lake and many other of the more eutrophic lakes in the Region.

Tributary Stream Water Quality

Numerous intermittent and 10 perennial streams flow into Geneva Lake. Streams pick up materials as they flow over the land surface, and may also receive effluents from various sources such as roof eaves and sump pump drains, storm sewers, and other sources. These sources represent an important source of pollutants to a lake.

Table 11

CHLORIDE CONCENTRATIONS IN REPRESENTATIVE LAKES IN SOUTHEASTERN WISCONSIN

Lake	County	Period of Record	Mean Chloride (milligrams per liter)	Number of Samples
Ashippun........	Waukesha	April 1975 - April 1978........	18.1	11
Eagle...........	Racine	July 1975 - April 1979.........	28.5	4
Geneva..........	Walworth	November 1973 - April 1979.....	14.5	15
George..........	Kenosha	February 1976 - July 1977......	34.3	6
Lac La Belle....	Waukesha	March 1976 - March 1977........	18.0	17
North...........	Waukesha	September 1973 - April 1979....	14.5	12
Oconomowoc......	Waukesha	September 1973 - April 1979....	15.2	11
Okauchee........	Waukesha	September 1973 - April 1978....	14.6	21
Paddock.........	Kenosha	September 1973 - July 1977.....	24.5	9
Pewaukee........	Waukesha	June 1972 - March 1979.........	36.6	11
Pike............	Washington	August 1973 - November 1975....	28.8	11
Wandawega.......	Walworth	March 1979 - April 1979........	4.7	2

Source: Wisconsin Department of Natural Resources and SEWRPC.

Perennial Streams: The average annual concentrations of selected water quality parameters for the nine perennial streams that were sampled and for the outlet--White River--of Geneva Lake are given in Table 13. Of the nine streams, one stream--tributary to Buttons Bay--was not considered a representative perennial stream because it had a perceptible flow on only four of 16 sampling dates.

The perennial streams exhibited substantial differences in water quality. In an attempt to identify differences in the water quality, the nine streams were ranked 1 through 9, as shown in Table 14, for individual chemical parameters. A stream with the highest concentration of a parameter was assigned a value of 1, and the stream with the lowest concentration received a value of 9. The average rank for all parameters indicated differences in the overall water quality of the perennial streams. Based upon the above method of evaluation, Buena Vista and Buttons Bay Creeks possessed the poorest water quality, while Trinke and Hillside Creeks showed evidence of water quality degradation. Harris Creek had the best water quality, and Gardens Creek exhibited the second best water quality.

As previously indicated, Buttons Bay Creek was an atypical perennial stream because it flowed intermittently. It was evaluated as a perennial stream because flow persisted in the streambed throughout the year and, in normal years, the stream has a more continuous flow. Nutrient contaminants--total phosphorus and ammonia and Kjeldahl nitrogen--were highest in Buttons Bay Creek, averaging 1.43 mg/l and 1.22 mg/l, and 5.57 mg/l, respectively. In addition, the dissolved solids--conductivity--and chloride levels were high when compared to the other perennial streams, averaging 756 micromhos per square centimeter ($\mu mho/cm^2$) and 47.8 mg/l, respectively. The reason for the higher concentrations of these pollutants in Buttons Bay Creek was not ascertained. The elevated pollutant levels may have resulted from the flushing of materials into the streambed during the nonflowing, or restricted, flow periods. However, land use data and field observations indicated that domestic

Table 12

AVERAGE MONTHLY CONCENTRATIONS OF CHLOROPHYLL-A FOR GENEVA LAKE SAMPLING STATIONS: MAY 1976-MAY 1977

Month	Chlorophyll-a (micrograms per liter)
May 1976 - August 1976....................	--[a]
September 1976...........................	2.9
October 1976.............................	2.7
November 1976............................	5.7
December 1976............................	No sample
January 1977.............................	10.3
February 1977............................	3.6
March 1977...............................	No sample
April 1977...............................	4.8
May 1977.................................	3.4

[a]Data for May, June, July, and August 1976 omitted.

Source: Geneva Lake Environmental Agency.

Table 13

AVERAGE ANNUAL CONCENTRATIONS/VALUES OF SELECTED WATER QUALITY PARAMETERS FOR NINE PERENNIAL STREAM INLETS AND THE WHITE RIVER OUTLET OF GENEVA LAKE: MAY 1976-MAY 1977

	Name of Stream									
Parameter[a]	Pottawatomie	Buena Vista	Gardens	Southwick	Harris	Buttons Bay	Hillside	Trinke	Birches	White River
Hydrogen-Ion Concentration (pH - standard units)...............	8.0	8.4	8.0	8.1	7.6	7.4	7.9	7.6	7.7	8.2
Specific Conductance (micromhos per square centimeter at 25°C)......	737	1,080	687	661	720	756	772	610	653	481
Chloride............................	39.4	168.0	21.3	28.5	19.3	47.8	48.4	14.9	15.6	35.9
Suspended Solids....................	9.9	12.5	5.1	17.9	9.8	6.4	17.2	7.8	6.9	5.1
Ammonia Nitrogen....................	0.047	0.353	0.026	0.096	0.069	1.220	0.226	0.471	0.124	0.112
Nitrate and Nitrite Nitrogen.........	0.49	1.34	4.73	0.46	0.38	0.68	0.24	0.32	0.13	0.05
Total Kjeldahl Nitrogen..............	0.340	0.992	0.194	0.389	0.339	5.570	0.556	1.090	0.350	0.456
Dissolved Phosphorus (filtered)......	0.014	0.868	0.012	0.071	0.016	0.879	0.040	0.074	0.034	0.027
Total Phosphorus.....................	0.036	0.935	0.024	0.083	0.032	1.430	0.078	0.112	0.048	0.052
Biochemical Oxygen Demand (milligrams per liter of oxygen)....	1.2	2.1	1.1	1.5	1.2	1.5	2.2	2.0	1.8	2.2
Fecal Coliform Bacteria (colonies per 100 milliliters).......	141	116	52	265	26	55	526	273	29	225
Fecal Streptococcus Bacteria (colonies per 100 milliliters)......	156	213	100	535	135	179	421	387	147	199
Fecal Coliform - Fecal Streptococcus Ratio[b]..........	0.90	0.54	0.50	0.50	0.19	0.31	1.25	0.71	0.20	1.13

[a]All values are presented in milligrams per liter unless otherwise specified.

[b]Average fecal coliform-fecal streptococcus of each sample date.

Source: Geneva Lake Environmental Agency.

Table 14

RANKING OF PERENNIAL TRIBUTARIES BY SELECTED POLLUTION PARAMETERS IN THE GENEVA LAKE DIRECT TRIBUTARY DRAINAGE AREA

	Ranking by Stream[a]								
Parameter	Pottawatomie	Buena Vista	Gardens	Southwick	Harris	Buttons Bay	Hillside	Trinke	Birches
Specific Conductance...........	4.0	1.0	6.0	7.0	5.0	3.0	2.0	9.0	8.0
Chloride........................	4.0	1.0	6.0	5.0	7.0	2.5	2.5	9.0	8.0
Ammonia Nitrogen...............	8.0	3.0	9.0	6.0	7.0	1.0	4.0	2.0	6.0
Nitrate and Nitrite Nitrogen...	4.5	2.0	1.0	4.5	6.0	3.0	8.0	7.0	9.0
Total Kjeldahl Nitrogen........	7.5	3.0	9.0	5.0	7.5	1.0	4.0	2.0	6.0
Dissolved Phosphorus...........	8.0	2.0	8.0	3.5	8.0	1.0	5.0	3.5	6.0
Total Phosphorus...............	7.5	2.0	7.5	4.0	9.0	1.0	5.0	3.0	6.0
Biochemical Oxygen Demand......	8.0	2.0	8.0	5.5	8.0	5.5	2.0	2.0	4.0
Average Rank[b]	6.4	2.0	6.8	5.1	7.2	2.3	4.4	4.7	6.6

[a]The lower the number for individual rankings of each parameter, the higher the concentration of each parameter.

[b]The lower the average ranking, the less desirable the water quality of the specific stream.

Source: Geneva Lake Environmental Agency.

animal wastes from pastureland may have been responsible for the elevated amounts of contaminants. In addition, the direct drainage area of Buttons Bay Creek contains a sanitary landfill which may have served as a source of chlorides, dissolved solids, and nutrients.

Measured water quality conditions indicated that Buena Vista Creek possessed the poorest overall water quality of the perennial streams. Buena Vista ranked highest in concentrations of chloride--168 mg/l--and dissolved solids--1,080 umho/cm^2--with levels much higher than encountered in the other streams. Excluding Buttons Bay Creek, the nutrient concentrations for Buena Vista were several times higher than levels recorded for the other perennial streams, with total phosphorus and nitrate and nitrite nitrogen having average values of 0.93 mg/l and 1.34 mg/l, respectively. In addition, the five-day biological oxygen demand (BOD)--2.1 milligrams per liter of oxygen (mg/l O_2)--which is indicative of organic waste pollution in Buena Vista Creek, was higher than in all the other perennial streams except Hillside Creek. The source of the organic waste pollution in Buena Vista Creek was identified as seepage from the infiltration ponds of the Fontana Sewage Treatment Plant. Dissolved substances such as chloride, phosphorus, ammonia, and organic nitrogen percolate through the soil beneath the infiltration ponds and seep into the creek. The bacteria data did not reflect this sewage source because the effluent is chlorinated prior to conveyance to the infiltration ponds. Buena Vista does not discharge a large volume of water to Geneva Lake, but historically, prior to expansion of additional treatment facilities in 1978, it was an important source of nutrient pollution to the lake.

Both Hillside Creek and Trinke Creek had intermediate water quality. Both streams demonstrated slightly above-normal levels of nitrogen--ammonia (0.23 mg/l, 0.47 mg/l), Kjeldahl nitrogen (0.56 mg/l, 1.09 mg/l)--and total phosphorus (0.08 mg/l, 0.11 mg/l). In addition, both streams demonstrated a slightly higher BOD--2.2 mg/l O_2 and 2.0 mg/l O_2--than the remaining perennial streams. Hillside Creek also contained elevated levels of dissolved solids--772 µmho/cm^2--and chloride--48.4 mg/l. The data indicated that organic waste material--fecal matter--was entering these streams. Both Hillside and Trinke Creeks exhibited higher than average fecal coliform (526 and 273 colonies/100 ml) and fecal streptococcus (421 and 387 colonies/100 ml) counts. The fecal coliform-fecal streptococcus ratios (1.25 and 0.71) indicated that the pollution source was from animal and, possibly, human wastes.[3] Since about 44.7 percent of the direct drainage area of the creek was in residential land use, it is possible that some septic tank seepage into the stream was occurring. The dominant land use in the Trinke Creek drainage area was agricultural cropland--50.3 percent--with only 14.5 percent residential and 9.2 percent pastureland uses. However, the high water table in this subwatershed and the presence of septic systems in the residential areas upstream from the sampling station suggest that the impact of the residential land use upon the water quality of Trinke Creek could be significant. The nutrient levels in the creek may also reflect contamination from agricultural use of chemical fertilizers and domestic animals.

Harris Creek, which enters Geneva Lake at Williams Bay, had the highest rating and the most desirable water quality of the perennial streams studied. This

---

[3]Biological Analysis of Water and Wastewater--Application Manual AM302, Millipore, 1973.

can be attributed to the limited urban development in the subwatershed. Only 1.3 percent of the watershed is in residential land use, with 33.5 percent in agricultural use. However, 31.2 percent of the watershed is marsh and wetland; woodlands comprise an additional 16.3 percent. One of the benefits of retaining land adjacent to lake tributaries in a natural state, and especially the preservation of wetlands, was reflected in the enhanced water quality of Harris Creek.

In general, the other perennial streams--Birches, Southwick, Gardens, and Pottawatomie Creeks--possessed desirable water quality. Gardens Creek exhibited the highest nitrate and nitrite nitrogen concentrations--4.73 mg/l--of any of the perennial streams. The nitrate and nitrite nitrogen levels were generally 10 times higher than those of the other streams--excluding Buena Vista. The reason for the high nitrate-nitrite levels in Gardens Creek was unknown, but the high percentage of land devoted to agricultural cropland--40.9 percent of the direct drainage area of the stream--suggests possible runoff of chemical fertilizers. However, intensive use of chemical fertilizers in residential areas could also account for some of the elevated nitrate and nitrite nitrogen levels.

Intermittent Streams: Six of the numerous intermittent streams in the direct drainage area were sampled during the study. Water quality data for these streams are set forth in Table 15. These streams flowed for varying periods ranging from 5 to 11 months of the 14-month study period. However, most of the streams flowed for only short periods during a particular month.

In general, the water quality of the intermittent streams was similar to that in the perennial streams. Certain intermittent streams possessed higher concentrations of various chemical parameters than the perennial streams, but this may be attributed to the fact that the intermittent streams flowed only during periods of heavy precipitation. Large quantities of runoff carrying contaminants would be introduced into the streams during those events.

Although the water quality in these streams varied, generally the intermittent streams were characterized by similar water quality. Except for Elgin Club Creek, no intermittent stream had a significantly higher concentration of a particular parameter than another. The higher concentrations of chloride, suspended solids, BOD, and bacteria for Elgin Club Creek probably resulted from sampling at the height of the intensity of a rain shower in April 1976. The low levels of pollutants in, and the low discharge rates of, the intermittent streams indicated that the intermittent streams were not an important source of pollutants to Geneva Lake.

Storm Events

An evaluation of changes in the water quality of the tributary streams during spring runoff and storm events was important in assessing the introduction of pollutants to Geneva Lake. Along with the tributary streams, storm sewers also contributed contaminants during these weather events. The study period was characterized by below-normal precipitation. Consequently, the water quality impacts of weather events on pollution loadings on Geneva Lake may not have reflected the magnitude of pollutant loadings entering the lake during a year of normal precipitation. Also, due to the small drainage area, runoff

Table 15

AVERAGE ANNUAL CONCENTRATIONS/VALUES OF SELECTED WATER QUALITY PARAMETERS FOR SIX INTERMITTENT TRIBUTARY INLETS TO GENEVA LAKE: MAY 1976-MAY 1977

Parameter [a]	Name of Stream					
	Academy Estates	Grunow	Elgin Club	Hartshorne	Northwestern Naval and Military Academy	Abbey Springs
Hydrogen-Ion Concentration (pH - standard units)	8.2	7.6	7.8	8.0	7.7	7.9
Specific Conductance (micromhos per square centimeter at 25°C)	678	678	629	595	718	619
Chloride	25.6	22.3	64.0	49.5	44.8	48.4
Suspended Solids	26.3	8.3	175.9	16.9	16.2	10.9
Ammonia Nitrogen	0.065	0.110	0.120	0.156	0.108	0.112
Nitrate and Nitrite Nitrogen	0.73	0.18	0.28	0.27	0.80	0.16
Total Kjeldahl Nitrogen	0.271	0.469	0.283	0.414	0.176	0.502
Dissolved Phosphorus (filtered)	0.065	0.112	0.298	0.202	0.129	0.126
Total Phosphorus	0.070	0.171	0.338	0.279	0.139	0.155
Biochemical Oxygen Demand (milligrams per liter of oxygen)	2.3	2.3	5.4	4.1	3.5	2.6
Fecal Coliform Bacteria (colonies per 100 milliliters)	83	100	856	605	208	144
Fecal Streptococcus Bacteria (colonies per 100 milliliters)	225	168	2,973	1,379	372	240
Fecal Coliform - Fecal Streptococcus Ratio [b]	0.37	0.59	0.29	0.44	0.56	0.60

[a]All values are presented in milligrams per liter unless otherwise specified.

[b]Average fecal coliform - fecal streptococcus of all sample dates.

Source: Geneva Lake Environmental Agency.

changes in the tributary streams and storm sewers were very rapid and it was not possible to sample all stations at the time of maximum runoff. It was apparent during the study that 0.5 to 1.0 inch of precipitation was necessary to produce changes in the streamwater quality.

Two weather events were fully sampled: the initial runoff from snowmelt on February 12, 1977, which was accompanied by a trace of precipitation; and a spring rain event on March 4, 1977, when 0.6 inch of rain fell within the previous 12-hour period. The water quality of the tributary streams during the snowmelt and rain event was variable, but most streams showed similar changes. In a few cases, the expected change in a particular chemical parameter took place at an earlier or later period following the precipitation. Changes in the water quality of a particular stream were dependent upon the size of the stream, the tributary land uses, the stream water quality under normal flow conditions, and the type of weather event.

The impacts of the weather events were evaluated by comparing the average concentration values of the chemical parameters for the perennial streams to average concentration values recorded during a particular weather event. The comparisons are presented in Tables 16 and 17. Three storm drains were sampled on the same dates and are also included in these evaluations of pollutant loading.

The data indicated that snowmelt increased the concentration of contaminants in the streams. The greatest increase was in the amounts of nutrients--nitrogen and phosphorus--which showed an approximate doubling of concentration when compared to normal flow conditions. While the individual stream concentrations of chloride varied, levels increased, possibly as a result of runoff carrying salt residue remaining on streets following applications to facilitate deicing. Minor increases were recorded for levels of sediment (suspended solids) and organic matter (BOD). However, these parameters did not vary as much because the ground was still frozen, limiting the runoff of these materials. The decrease shown in concentrations of dissolved solids (conductivity) and bacteria could be expected because of dilution by the snowmelt.

Table 16

EFFECT OF A RAIN EVENT ON THE WATER QUALITY OF TRIBUTARY STREAMS AND STORM DRAINS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: MARCH 4, 1977

Parameter[a]	Perennial Streams		Intermittent Streams		Storm Drains		
	Normal	Rain Event	Normal	Rain Event	Fontana	Williams Bay	Lake Geneva
Hydrogen-Ion Concentration (pH - standard units)..............	7.9	7.8	7.9	7.6	7.5	7.4	7.5
Specific Conductance (micromhos per square centimeter at 25°C)......	754	635	705	372	725	639	277
Chloride............................	40.8	59.5	38.6	38.4	1,950.0	130.0	45.0
Suspended Solids....................	10.5	6.3	17.6	13.4	180.0	29.2	25.3
Ammonia Nitrogen....................	0.163	0.987	0.065	0.470	0.903	0.788	1.100
Nitrate and Nitrite Nitrogen.........	0.087	1.570	0.303	0.738	1.370	2.780	1.510
Total Kjeldahl Nitrogen..............	0.509	3.670	0.282	0.925	2.380	2.320	2.490
Dissolved Phosphorus (filtered)......	0.116	0.728	0.041	0.726	0.280	0.669	1.210
Total Phosphorus.....................	0.143	1.080	0.070	0.812	0.675	1.000	1.470
Biochemical Oxygen Demand (milligrams per liter of oxygen)....	1.4	4.3	1.8	10.3	3.6	8.8	13.1
Fecal Coliform Bacteria (colonies per 100 milliliters)......	210	10	392	15	105	220	100
Fecal Streptococcus Bacteria (colonies per 100 milliliters)......	271	132	405	194	800	1,200	2,050

[a]All values are presented in milligrams per liter unless otherwise specified.

Source: Geneva Lake Environmental Agency.

Table 17

EFFECT OF SNOWMELT RUNOFF ON THE WATER QUALITY OF TRIBUTARY STREAMS AND STORM DRAINS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: FEBRUARY 12, 1977

Parameter[a]	Perennial Streams		Storm Drains		
	Normal	Snowmelt	Fontana	Williams Bay	Lake Geneva
Hydrogen-Ion Concentration (pH - standard units)..............	7.9	7.8	7.4	7.4	7.8
Specific Conductance (micromhos per square centimeter at 25°C)......	754	681	2,880	3,456	5,601
Chloride............................	40.8	54.2	928.0	1,173.0	2,144.0
Suspended Solids....................	10.5	13.5	309.0	41.6	151.0
Ammonia Nitrogen....................	0.163	0.318	2.210	2.060	2.570
Nitrate and Nitrite Nitrogen.........	0.87	1.70	1.10	0.94	0.62
Total Kjeldahl Nitrogen..............	0.509	0.868	4.060	3.690	4.250
Dissolved Phosphorus (filtered)......	0.116	0.232	0.300	0.492	0.672
Total Phosphorus.....................	0.143	0.266	2.360	0.712	1.160
Biochemical Oxygen Demand (milligrams per liter of oxygen)....	1.4	1.5	8.6	4.4	3.4
Fecal Coliform Bacteria (colonies per 100 milliliters)......	210	51	220	154	940
Fecal Streptococcus Bacteria (colonies per 100 milliliters)......	271	107	2,020	--	--

[a]All values are presented in milligrams per liter unless otherwise specified.

Source: Geneva Lake Environmental Agency.

The storm water effluents contained high concentrations of all pollutants, including dissolved solids and bacteria. These concentrations were expected because of an initial flushing of pollutants which occurred in the storm sewers. The high chloride content of the storm sewer effluent provided evidence of the effects of salt runoff from winter street salting operations. The three storm sewer discharges were atypical in that the concentrations of organic wastes (BOD) and bacteria were not as high as might be anticipated. All three villages have separate sanitary sewer and storm sewer systems rather than a combined sewer system, so that levels of bacteria and organic matter were less than would be expected for a combined sewer system.

The runoff associated with the rain event on March 4, 1977, included some pollutants normally associated with spring runoff. Consequently, chemical characteristics of runoff associated with this storm event might not be applicable at another season of the year. The rain event produced a uniform response in the tributary streams, with most streams exhibiting the same direction of change in chemical characteristics from levels recorded during normal flow conditions. Again, the perennial streams exhibited an increase in the level of nutrients, with higher levels recorded than were found during the snowmelt event. However, some differences in water quality were apparent between the two weather events. The organic matter load (BOD) and nutrient level increases were believed associated with the fact that the ground surface had thawed, which permitted an increased loading of these parameters. However, the sediment load of the streams decreased rather than increased. It appeared that the vegetative cover in the subwatersheds minimized erosion and sedimentation. In addition, the absence of heavy precipitation--exceeding 1.0 inch--contributed to the limited amount of sediment transported by the streams.

The intermittent streams flowed during the rain event, which provided for data collection on transported materials. Water quality changes were similar to those found for the perennial streams with a few exceptions. Generally, the nutrient load in the intermittent streams was lower than in the perennial streams. One of the greatest differences was the higher organic matter (BOD) load in the intermittent streams--10.3 mg/l--when compared to the perennial streams--4.3 mg/l.

The storm sewers contained high levels of pollutants compared to the tributary streams. However, compared to the snowmelt event, the level of pollutants in the storm sewers was generally lower or remained unchanged during the rain event. Generally, the storm sewer effluent contained the highest levels of pollutants of all water sources entering Geneva Lake.

Because of their continuous discharge, the perennial streams were the most important contributor of pollutants to Geneva Lake. However, none of the concentrations measured were high enough to constitute serious sources of pollution. Storm sewers may be important contributors because of the high concentrations of pollutants in their effluent, but the magnitude of the effect would depend upon the amount and intensity of precipitation and runoff. With the exception of the Grunow and Academy Estates streams, which flowed during most of the year, the intermittent streams, which exhibited low discharge rates, did not appear to be major sources of pollutants to the lake.

The primary pollutants transported to Geneva Lake by the tributary streams and storm sewers were nutrients--nitrogen and phosphorus--in various forms. Other contaminants such as dissolved salts, including chloride, and bacteria were transported in lower amounts, primarily from storm sewers. The transport of organic matter (BOD) and sediments (suspended solids) was generally low. The low BOD levels in all the surface waters can be attributed to the absence of high amounts of raw organic waste material in the subwatersheds of the tributary streams and to the separate sewer systems of the incorporated municipalities. Sediment transport to the lake appeared minimal and was primarily from the storm sewers. In part, this was true because many of the drainage areas tributary to streams flowing into the lake have dense vegetative cover. However, based upon field observation, several tributary streams had a greater sediment load than the data indicated. Pottawatomie Creek and Elgin Club Creek possessed much higher sediment loads during periods of heavy precipitation than were measured during the study. The sediment loads of the streams and the sediment pollution to Geneva Lake were probably underestimated in the study because of the abnormally low precipitation.

Groundwater Quality

Eight paired, upland-lowland wells were sampled on a monthly basis from August 1976 to May 1977 to evaluate groundwater quality within the Geneva Lake direct tributary drainage area. Except for Well No. 34a, all of the permanent wells were situated on "lowland" sites within 70 feet of the lakeshore.

The groundwater quality for six of these permanent wells is presented in Table 18. A groundwater source--Well No. 30, George Williams College Camp--considered to be unpolluted and uncontaminated, was utilized for water quality comparisons with the other sampled wells. Further, the average concentrations of chemical parameters for the six wells were also used for comparisons. However, both of these comparative references were considered atypical of natural groundwater in their nitrate nitrogen concentration. Uncontaminated groundwater could be expected to contain less than 0.5 mg/l of nitrate nitrogen.[4]

The groundwater from the six permanent wells did not exhibit evidence of gross contamination. However, water samples from several wells contained higher concentrations of certain pollutants than either the average concentrations of the reference sample--Well No. 30--or the average concentrations of the six wells. Groundwater from four wells--Nos. 31, 35, 37, and 38--had above-average levels of conductivity, which indicated contamination with dissolved solids. The dissolved solids concentration of the groundwater in the vicinity of these wells was supported by the fact that these same samples had elevated concentrations of chlorides. However, the elevated chloride levels would not completely account for the higher dissolved solids value of these wells. In some locations, the dissolved solids contamination appeared to be seasonal. For example, samples from Well No. 35 showed considerable fluctuations in conductivity and chloride concentrations, with the highest levels present during the summer. However, in other areas--Williams Bay Park, Well No. 31--the groundwater demonstrated only small seasonal fluctuations. A review of land use patterns in the vicinity of the above wells did not suggest a possible source of dissolved solids. Septic tank leachate has been implicated as a source of increasing dissolved solids levels in groundwater, especially where salt is used in softening the water supply. This source was suspected as contributing to the dissolved solids levels in the groundwater near the Northwestern Military and Naval Academy--Well No. 38. However, septic tank leachate does not appear to be the only dissolved solids source affecting the groundwater, as two of the wells--Nos. 31 and 35--are located in areas served by sanitary sewers. Runoff of salt from highways accumulated during winter road salting operations may have also been a source of dissolved solids and chloride in the groundwater. Water samples from the well located in Library Park--Well No. 35--within the City of Lake Geneva had elevated levels of all nutrients except nitrates, suggesting an influx of nitrogen and phosphorus. Groundwater from the other wells sampled had higher-than-average levels of one or two nutrients, but concentrations were generally variable.

In addition to the six permanent wells sampled, three pairs of wells were sampled on a rotating basis to evaluate the effects of septic tank leachate

---

[4]R. D. Cotter, et al., Water Resources of Wisconsin-Rock-Fox River Basin, U. S. Geological Survey, 1969.

Table 18

MEAN VALUES OF WATER QUALITY PARAMETERS SAMPLED IN SIX PERMANENT GROUNDWATER WELLS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: AUGUST 1976-MAY 1977

Parameter[a]	Well Numbers						Average
	30	31	34a	35	37	38	
Temperature (°C)	11.1	10.6	12.8	10.1	11.9	12.4	11.5
Hydrogen-Ion Concentration (pH - standard units)	7.3	7.3	7.4	7.2	7.1	7.2	7.2
Specific Conductance (micromhos per square centimeter at 25°C)	661	1,039	576	1,063	1,059	1,028	904
Chloride	20.6	80.5	23.6	106.0	58.6	81.6	61.8
Ammonia Nitrogen	0.048	0.124	0.231	0.117	0.056	0.212	0.131
Nitrate and Nitrite Nitrogen	3.03	0.13	0.04	0.04	3.90	0.14	1.20
Total Kjeldahl Nitrogen	0.311	0.225	0.728	0.753	0.343	0.658	0.503
Dissolved Phosphorus	0.050	0.028	0.098	0.030	0.039	0.018	0.044
Total Phosphorus	0.070	0.122	0.378	0.044	0.122	0.058	0.132

[a]All values are presented in milligrams per liter unless otherwise specified.

Source: Geneva Lake Environmental Agency.

(Well No. 36/36a), urban development (Well No. 39/39a), and sewage infiltration ponds (Well No. 29/29a) on groundwater. A comparison of the groundwater chemistry from the "upland" and "lowland" wells in each of these areas demonstrated no definite differences in groundwater quality. In addition, a comparison of average groundwater quality for all upland wells to that of all lowland wells indicated no significant differences in water quality.

Seasonal trends in the quality of the groundwater varied with the different parameters measured. Some chemical parameters such as conductance and chloride concentrations showed a seasonal variation, whereas dissolved phosphorus, pH, and nitrates did not. Also, seasonal variations were not evident in all wells. Generally, concentrations of the various parameters were highest in spring--April to May--and summer--August to September--with lower concentrations during other seasons of the year. Dissolved solids (conductivity and chloride levels) were highest in summer, while some nutrient concentrations were highest in spring.

Atmospheric Loading

The contributions of nitrogen and phosphorus as dry fallout in particulate matter from the atmosphere were determined from bulk precipitation samples collected in dustfall samplers at Lake Geneva from September 1, 1976 to June 3, 1977. The samples were collected monthly or bimonthly and the contents analyzed for their concentration of the various nutrient forms. The monthly nutrient loads to Geneva Lake for the seven sample periods are given in Table 19.

Average nutrient loading rates to Geneva Lake were calculated from the bulk precipitation data and are presented in Table 20. However, nitrates were determined only on three samples, so nitrate loading rates and any calculations involving the nitrate values are only crude approximations. Despite the limitations of the data, the average nutrient loading rates to Geneva Lake were similar to others reported for southern Wisconsin. Only the total nitrogen loading rates appeared to be low (approximately 35 percent less than rates for the Madison area). The fact that the precipitation was below normal during the study period accounts for the difference.

Table 19

ATMOSPHERIC NUTRIENT LOADING INTO GENEVA LAKE: SEPTEMBER 1976-MAY 1977

Parameter	Loading (pounds per month)							Total Pounds
	September	October	November	December	February	March	May	
Dissolved Phosphorus............	--	130	68	1,118	213	134	378	2,041
Total Phosphorus................	1,342	294	219	298	311	311	786	3,561
Ammonia Nitrogen................	--	--	2,231	463	2,673	2,982	7,737	16,086
Nitrate and Nitrite Nitrogen....	3,650	--	--	--	--	2,725	1,377	7,752
Total Kjeldahl Nitrogen.........	552	573	3,347	3,164	10,724	5,295	11,798	35,471
Inorganic Nitrogen..............	--	--	--	--	--	5,707	9,114	14,821
Total Nitrogen..................	4,202	--	--	--	--	8,020	13,175	25,397

Source: Geneva Lake Environmental Agency.

Table 20

COMPARISON OF ATMOSPHERIC NUTRIENT LOADING RATES FOR GENEVA LAKE WITH OTHER AREAS OF SOUTHERN WISCONSIN: 1976

Parameter	Location and Loading Rates (pounds per acre per year)		
	Lake Geneva	Madison[a]	SEWRPC
Dissolved Phosphorus................	0.29	0.13	--
Total Phosphorus....................	0.65	0.70	0.50
Ammonia Nitrogen....................	4.07	6.07	--
Nitrate and Nitrite Nitrogen........	4.94[b]	5.80	--
Kjeldahl Nitrogen...................	8.20	8.70	--
Inorganic Nitrogen..................	12.08[b]	11.87	--
Total Nitrogen......................	14.44[b]	20.56	40.0

[a]J. W. Kluesener, Nutrient Transport Transformation in Lake Wingra, Wisconsin, Ph.D. Thesis, University of Wisconsin-Madison, 1972.

[b]Based upon three samples (117 days), values are approximations.

Source: Geneva Lake Environmental Agency and SEWRPC.

LAKE BUDGETS

Hydrologic Budget

An important part of assessing the water quality of Geneva Lake was determining the hydrologic budget. Quantitative knowledge of the water contribution from various sources, the water lost, and the retention time is necessary in the formulation of any lake protection or rehabilitation plan. The major water sources investigated during this study were direct precipitation, perennial tributaries, intermittent tributaries, storm sewers, and groundwater seepage. Direct runoff from shoreland was not measured.

As shown in Table 21, the major water contributor--50.6 percent--to Geneva Lake was atmospheric precipitation. Based upon precipitation data recorded at Lake Geneva, 24.72 inches of precipitation fell on the lake surface, which contributed approximately 10,867.0 acre-feet of water per year. Ten perennial streams discharge water into Geneva Lake. The nine monitored perennial streams contributed a total of 7,891.7 acre-feet, or about 36.7 percent of the total water input to the lake. The tenth stream was considered a minor water source to the lake, and was not monitored. Inflow from Pottawatomie Creek totaled an estimated 2,731.3 acre-feet, or 35 percent of the total inflow from perennial streams. Hillside Creek and Buttons Bay Creek contributed the smallest amounts

Table 21

HYDROLOGIC BUDGET FOR GENEVA LAKE

Item	Acre-Feet	Percent of Total
Input		
Perennial Streams		
Pottawatomie	2,731.3	--
Southwick	1,335.0	--
Gardens	1,261.3	--
Buena Vista	1,178.5	--
Birches	509.4	--
Harris	399.0	--
Trinke	319.2	--
Hillside	89.3	--
Buttons Bay	68.7	--
Subtotal	7,891.7	36.7
Intermittent Streams		
Grunow	191.5	--
Hartshorne	187.2	--
Abbey Springs	126.1	--
Academy Estates	92.4	--
Elgin Club	69.4	--
Northwestern Naval and Military Academy	28.5	--
Subtotal	695.1	3.2
Atmospheric Precipitation	10,867.0	50.6
Groundwater	1,962.6	9.1
Storm Drains	79.5	0.4
Total	21,495.9	100.0
Output		
Streams		
White River	8,353.5	38.5
Evaporation	13,334.4	61.5
Total	21,687.9	100.0
Correction for Change in Lake Level	- 527.9	--
Total	21,160.0	--
Lake Volume	299,183.7	--
Residence Time[a]	13.9 years	--

[a]"Residence time" is the estimated time period required for the full volume of the lake to be replaced by inflowing waters, during a period of normal precipitation.

Source: Geneva Lake Environmental Agency.

of the total from the perennial streams: 89.3 acre-feet (1.1 percent) and 68.7 acre-feet (0.9 percent), respectively. The below-normal rainfall during the study period (24.72 inches versus the normal 30.50 inches) greatly reduced the water inflow from Hillside, Buttons Bay, and Birches Creeks. As expected, the intermittent streams supplied a small amount of water to Geneva Lake, 695.1 acre-feet, or 3.2 percent of the total. Six of the small intermittent streams were measured; and it was assumed that the remaining unmonitored intermittent streams would have had an insignificant effect on the hydrologic budget. However, it should be noted that five of the monitored intermittent streams supplied more water to the lake than either Hillside Creek or Buttons Bay Creek, both of which are perennial streams.

Table 22

COMPUTED DISCHARGE FROM STORM SEWERS LOCATED IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE FOR DRY AND NORMAL YEARS

Storm Sewer	Discharge (acre-feet per year)	
	Dry Year[a]	Normal Year
Williams Bay		
Congress Street..........	5.3	8.3
East Park...............	32.4	50.6
Lake Geneva		
Library Park.............	15.7	24.5
Fontana		
Beach House..............	13.8	21.5
Lake Avenue..............	5.8	9.0
Fontana Shores...........	1.1	1.7
Kensie Street............	1.7	2.6
Country Club.............	2.2	3.4
Lagoon...................	1.4	2.2
Total	79.4	123.8

[a] The dry study year received 0.64 of the precipitation expected in a normal year.

Source: Geneva Lake Environmental Agency and SEWRPC.

Groundwater enters Geneva Lake from various sources, including subsurface discharge into the lake basin, terrestrial springs, artesian wells, and shoreline seepage. Undoubtedly, a significant portion of the water contributed by the perennial and intermittent tributaries was actually groundwater. The groundwater contribution was calculated indirectly, assuming that the total water inflow was equal to the total water losses, with adjustment for changes in the lake level. Based upon these assumptions, and correcting for a 0.1-foot drop in lake level during the study period, the contribution from groundwater was estimated to be 1,962.6 acre-feet, which represented 9.1 percent of the total water contribution. However, this groundwater volume represented only subsurface discharge into the lake and shoreline seepage. Differences in groundwater levels in the 11 sets of upland-lowland wells indicated that Geneva Lake is a groundwater flow-through lake, meaning groundwater flows into the lake at one end, but away from the lake at the other end. Shallow groundwater flows toward and enters Geneva Lake from all directions except from the northeast corner of the lake. Wells near the City of Lake Geneva and those east of the City indicated that groundwater recharge is occurring.

A total of nine storm drains were used to calculate the urban hydrologic runoff contribution to Geneva Lake. Although these nine storm drains are the only storm drains which discharge directly to the lake, urban runoff can also enter the lake through direct overland flow, or via other tributary sources such as streams. The volume of water contributed by these storm sewers was calculated using runoff values derived from the land use, soil type, and area drained by each storm sewer. The runoff values are also based upon the normal precipitation rates derived from 36 years of data. Because these runoff values were based upon average precipitation, the discharge of the storm sewers was converted to represent the dry year during which the study was conducted. This was done by applying a correction factor since the dry year contributed 0.64 of a normal year precipitation. As shown in Table 22, the amount of water contributed by the storm drains to Geneva Lake during this study was estimated to be 79.5 acre-feet, or 0.4 percent of the total inflow to the lake.

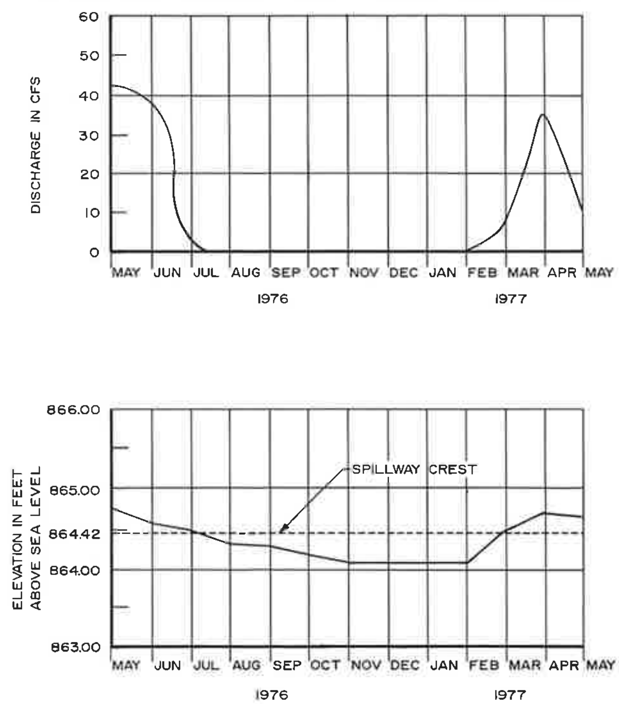
The major water losses, which are presented in Table 21, from Geneva Lake were through evaporation--approximately 13,334.4 acre-feet, or 61.5 percent--and surface water discharge to the White River totaling approximately 8,353.5 acre-feet, or 38.5 percent of the total water output from the lake. The evaporation loss was based upon pan evaporation rates measured by the U. S. Weather Station at Rockford, Illinois. Discharge to the White River is controlled at the dam by sluice gates and a spillway, with a crest at 864.42 feet NGVD (National Geodetic Vertical Datum). Lake level fluctuations and discharge rates are presented in Figure 10. During the study period, the sluice gates were open for approximately three months and water flowed over the spillway for about five months. For the remainder of the study period, the lake level was below the spillway crest and the only water loss at the dam was through leakage in the sluice gates, which was estimated to be about 0.17 cubic foot per second (cfs). Data collected by the Geneva Lake Level Corporation between 1950 and 1973 indicated that the lake level is higher than the spillway crest generally from April through July. The total water outflow from Geneva Lake exceeded the water inflow. This difference resulted in a decrease in the lake level of 0.1 foot. As mentioned previously, it was assumed that this loss was the result of evaporation.

The hydrologic budget for a lake can be used for calculating the lake's flushing rate or, conversely, the retention time of the water in the basin. Generally, a short retention time is desirable because, barring any gross pollution sources, it permits rapid renewal of the lake water and thereby aids in maintaining desirable water quality conditions in the lake. Based upon the lake volume and the hydrologic budget during the study period, Geneva Lake had an estimated retention time of 13.9 years. This is about average for lakes as large as Geneva Lake. The average retention time for Geneva Lake is probably shorter during periods of normal precipitation.

This study must be considered representative of dry year hydrologic loading estimates. Because of variations in the evaporation data from year to year, and other complexities involved in attempting to extrapolate data, the calculation of the budget for normal or wet years is difficult. Nevertheless, such an estimate is presented later in this report.

Figure 10

MONTHLY AVERAGE DISCHARGE FROM, AND LAKE LEVELS OF, GENEVA LAKE: MAY 1976-MAY 1977



NOTE: GATES OPEN ONLY DURING THE MONTH OF MAY, 1976

Source: Geneva Lake Environmental Agency.

NUTRIENT LOADING TO GENEVA LAKE

Nitrogen

As shown in Tables 23 and 24, approximately 122,234 pounds of nitrogen entered Geneva Lake during the study year. Of this amount, 72.3 percent was inorganic nitrogen (ammonia nitrogen and nitrate and nitrite nitrogen) and 27.7 percent was organic nitrogen. The form in which nitrogen entered the lake is significant because inorganic nitrogen, and especially nitrate nitrogen, is the form which plants utilize. This estimate of nitrogen loading does not include nitrogen fixation by algae in the lake, which requires further investigation.

Atmospheric dustfall and precipitation were the primary sources of nitrogen, accounting for approximately 71,757 pounds, or 58.7 percent of the total; perennial streams were the second most important source, contributing about 39,676 pounds, or 32.5 percent. The intermittent streams, groundwater seepage, and storm drains combined contributed the remaining 10,801 pounds, or 8.8 percent, of the nitrogen loading to Geneva Lake. Approximately 11,232 pounds per year, or 9.2 percent of the nitrogen entering the lake, was removed from the lake through outflow to the White River. However, an undetermined amount of nitrogen is taken out of the water column through removal of weeds and fish and deposition in bottom sediments.

Loading of the various forms of nitrogen is presented in Table 24. The atmosphere was the primary contributor of all nitrogen forms except nitrate and nitrite nitrogen. The perennial streams contributed a higher percentage of nitrate and nitrite nitrogen--47.9 percent--than did the atmospheric sources--40.1 percent. The higher nitrate and nitrite nitrogen contribution by the perennial streams was primarily due to the high concentrations in one stream, Gardens Creek. As shown in Table 25, approximately 56.5 percent of the total

Table 23

ESTIMATED NITROGEN LOADING TO GENEVA LAKE AND NITROGEN LOSSES THROUGH THE WHITE RIVER OUTFLOW: MAY 1976-MAY 1977

Source	Contribution (pounds per year)	Percent of Total
Loadings		
Perennial Streams...........	39,676	32.5
Intermittent Streams........	1,314	1.1
Atmosphere..................	71,757	58.7
Groundwater Seepage.........	8,719	7.1
Storm Sewers................	768	0.6
Total	122,234	100.0
Losses		Percent of Total Loading
White River Outflow.........	11,232	9.2

Source: Geneva Lake Environmental Agency.

Table 24

NITROGEN LOADING TO GENEVA LAKE FROM VARIOUS SOURCES, AND LOSSES THROUGH THE WHITE RIVER OUTFLOW: MAY 1976-APRIL 1977

Source	Contribution (pounds per year)	Percent of Total
Inflow		
Perennial Streams		
Ammonia Nitrogen	2,672	9.5
Nitrate and Nitrite Nitrogen....	28,852	47.9
Total Kjeldahl Nitrogen.........	10,824	17.5
Inorganic Nitrogen..............	31,524	35.7
Organic Nitrogen................	8,152	24.0
Intermittent Streams		
Ammonia Nitrogen................	163	0.6
Nitrate and Nitrite Nitrogen....	742	1.2
Total Kjeldahl Nitrogen.........	572	0.9
Inorganic Nitrogen..............	905	1.0
Organic Nitrogen................	409	1.2
Atmosphere		
Ammonia Nitrogen................	24,261	86.4
Nitrate and Nitrite Nitrogen....	24,183	40.1
Total Kjeldahl Nitrogen.........	47,574	76.8
Inorganic Nitrogen..............	48,444	54.9
Organic Nitrogen................	23,313	68.7
Groundwater Seepage		
Ammonia Nitrogen................	667	2.4
Nitrate and Nitrite Nitrogen....	6,159	10.2
Total Kjeldahl Nitrogen.........	2,560	4.1
Inorganic Nitrogen..............	6,826	7.7
Organic Nitrogen................	1,893	5.6
Storm Sewers		
Ammonia Nitrogen................	279.0	1.0
Nitrate and Nitrite Nitrogen....	343.1	0.6
Total Kjeldahl Nitrogen.........	395.1	0.7
Inorganic Nitrogen..............	622.2	0.7
Organic Nitrogen................	145.3	0.5
Total Loading of All Sources		
Ammonia Nitrogen................	28,042	100.0
Nitrate and Nitrite Nitrogen....	60,279	100.0
Total Kjeldahl Nitrogen.........	61,925	100.0
Inorganic Nitrogen..............	88,321	100.0
Organic Nitrogen................	33,912	100.0
Outflow		
White River Outflow		Percent of Total Input
Ammonia Nitrogen................	2,751	9.8
Nitrate and Nitrite Nitrogen....	444	0.7
Total Kjeldahl Nitrogen.........	10,788	17.4
Inorganic Nitrogen..............	3,195	3.6
Organic Nitrogen................	8,037	23.7

Source: Geneva Lake Environmental Agency.

Table 25

NITROGEN LOADING TO GENEVA LAKE FROM PERENNIAL STREAMS AND PERCENT CONTRIBUTION OF EACH STREAM: MAY 1976-APRIL 1977

Stream	Loading							
	Ammonia Nitrogen		Nitrate and Nitrite Nitrogen		Total Kjeldahl Nitrogen		Total Nitrogen	
	Pounds per Year	Percent	Pounds per Year	Percent	Pounds per Year	Percent	Pounds per Year	Percent
Pottawatomie....	333	12.5	4,285	14.9	2,237	20.6	6,522	16.4
Buena Vista.....	926	34.7	3,831	13.3	2,620	24.2	6,451	16.3
Gardens.........	86	3.2	16,314	56.5	662	6.1	16,976	42.8
Southwick.......	348	13.0	1,646	5.7	1,419	13.1	3,065	7.7
Harris..........	44	1.6	288	1.0	268	2.5	556	1.4
Buttons Bay.....	238	8.9	1,638	5.7	1,679	15.5	3,317	8.4
Hillside........	54	2.0	68	0.2	170	1.6	238	0.6
Trinke..........	569	21.3	427	1.5	1,371	12.7	1,798	4.5
Birches.........	74	2.8	355	1.2	398	3.7	753	1.9
Total	2,672	--	28,852	--	10,824	--	39,676	--

Source: Geneva Lake Environmental Agency.

nitrate nitrogen from the nine perennial streams came from Gardens Creek. Other perennial streams which were important contributors of nitrate and nitrite nitrogen were Pottawatomie Creek and Buena Vista Creek, which contributed 14.9 percent and 13.3 percent, respectively. The remaining perennial streams contributed about 15.3 percent of the nitrate and nitrite nitrogen. The high nitrate and nitrite nitrogen contribution from Gardens Creek was due to a high concentration of this nutrient in the streamwater and not to high discharge rates. The reason for the high concentration of nitrate and nitrite nitrogen in the water was not identified. The major land use in the Gardens Creek subwatershed was agricultural cropland and woodland, but neither land use appeared to be the source of the nitrates and nitrites. If runoff associated with agricultural fertilization practices were responsible, the concentrations in the stream would have been much more seasonal than was measured. Further study to identify the source of the nitrate and nitrite nitrogen in Gardens Creek is warranted. Buena Vista Creek supplied the largest amount of ammonia nitrogen--34.7 percent--and Kjeldahl nitrogen--24.2 percent--of any perennial stream. These concentrations were attributed, at the time of the study, to seepage from the Fontana Sewage Treatment Plant infiltration ponds. However, additional treatment facilities which began operation in 1978 have alleviated the excessive loading to Buena Vista Creek.

Phosphorus

The estimated total phosphorus loading to Geneva Lake, as presented in Table 26, was 9,717 pounds per year during the study period. Dissolved phosphorus, which is the form directly available for use by plants, accounted for 5,305 pounds per year, or 54.6 percent of the total phosphorus entering the lake. The remaining 4,412 pounds, or 45.4 percent, were in forms generally not readily utilized by plants. The atmosphere was the most important source of total phosphorus, contributing 4,777 pounds, or 49.2 percent of the total, with the perennial streams contributing 3,749 pounds, or 38.6 percent. The remaining portion of the total phosphorus was from intermittent streams--252 pounds, or 2.6 percent--groundwater seepage--672 pounds, or 6.9 percent--and storm sewers--267 pounds, or 2.7 percent. The perennial streams contributed more dissolved phosphorus--3,160 pounds, or 59.6 percent--than the

Table 26

MEASURED DISSOLVED AND TOTAL PHOSPHORUS LOADINGS TO GENEVA LAKE: 1976-1977

Item	Contribution	
	Pounds per Year	Percent of Total
Inflow		
Perennial Streams		
Dissolved Phosphorus........	3,160	59.6
Total Phosphorus............	3,749	38.6
Intermittent Streams		
Dissolved Phosphorus........	219	4.1
Total Phosphorus............	252	2.6
Atmosphere		
Dissolved Phosphorus........	1,570	29.6
Total Phosphorus............	4,777	49.2
Groundwater Seepage		
Dissolved Phosphorus........	224	4.2
Total Phosphorus............	672	6.9
Storm Sewers		
Dissolved Phosphorus........	132	2.5
Total Phosphorus............	267	2.7
Total		
Dissolved Phosphorus........	5,305	100.0
Total Phosphorus............	9,717	100.0
Outflow		
White River		
Dissolved Phosphorus........	241	4.5
Total Phosphorus............	600	6.2

Source: Geneva Lake Environmental Agency.

atmosphere--1,570 pounds, or 29.6 percent. Based upon the sampling data, the remaining 575 pounds, or 10.8 percent of the dissolved phosphorus, was contributed by intermittent streams--219 pounds, or 4.1 percent--groundwater seepage--224 pounds, or 4.2 percent--and storm sewers--132 pounds, or 2.5 percent.

The percentage of total phosphorus contributed to the lake by atmospheric fallout appeared high in comparison with atmospheric loading on other lakes; however, the average rate of phosphorus entering the lake by direct fallout--0.65 pound per acre per year--was considered average. It was believed that bulk precipitation from the atmosphere assumed major importance in Geneva Lake because of the lake's large surface area.

Most of the phosphorus contributed by the perennial streams during the study period was from Buena Vista Creek. As shown in Table 27, this stream contributed an estimated 80.3 percent of the dissolved phosphorus and 71.8 percent of the total phosphorus contributed by the perennial streams which drain into Geneva Lake. In addition, Buena Vista Creek contributed 27.7 percent of the total phosphorus and 47.8 percent of the dissolved phosphorus loadings to Geneva Lake. The contribution from Buena Vista Creek is important because much of the phosphorus was in the soluble form which is readily available for aquatic plant and algae growth. In addition, the major proportion of the phosphorus is from a known source, the Village of Fontana on Geneva Lake sewage treatment plant, and abatement action can be implemented.

Table 27

PHOSPHORUS LOADING TO GENEVA LAKE FROM PERENNIAL STREAMS AND PERCENT CONTRIBUTION OF EACH STREAM: MAY 1976-APRIL 1977

Stream	Loading			
	Dissolved Phosphorus		Total Phosphorus	
	Pounds per Year	Percent	Pounds per Year	Percent
Pottawatomie......	96	3.0	306	8.2
Buena Vista.......	2,537	80.3	2,691	71.8
Gardens...........	67	2.1	108	2.9
Southwick.........	243	7.7	293	7.8
Harris............	12	0.4	24	0.6
Buttons Bay.......	66	2.1	112	3.0
Hillside..........	12	0.4	25	0.7
Trinke............	91	2.9	140	3.7
Birches...........	36	1.1	51	1.3

Source: Geneva Lake Environmental Agency.

It is believed that seepage from the infiltration ponds at the Fontana on Geneva Lake sewage treatment plant was responsible for the high phosphorus concentrations during the sample period in Buena Vista Creek. Pottawatomie Creek and Southwick Creek contributed 8.2 percent and 7.8 percent of the total phosphorus and 3.0 percent and 7.7 percent of the dissolved phosphorus, respectively, entering the lake. Both streams had high rates of discharge to Geneva Lake, with Pottawatomie representing the major water source of all the tributary streams. The discharge volume was primarily responsible for the high phosphorus loading rates of these streams.

The intermittent streams, groundwater seepage, and storm drains were minor contributors of phosphorus to the lake. As shown in Table 26, in the sample year all three sources combined contributed approximately 10.8 percent of the dissolved phosphorus and 12.2 percent of the total phosphorus.

Small amounts of phosphorus were removed from Geneva Lake through the White River outlet. Approximately 4.5 percent of the dissolved and 6.2 percent of the total phosphorus entering the lake was lost through the outlet. The remainder of the phosphorus remained in the lake and was utilized for biological production. In addition to being removed through losses through the lake outlet, phosphorus was removed through chemical precipitation and/or particle absorption with subsequent deposition in the bottom sediments, and through removal of fish, plants, or other biological material from the lake.

Existing 1975 and forecast year 2000 phosphorus sources to Geneva Lake were identified and quantified using Commission 1975 land use inventory data; Commission planned year 2000 land use data, derived from the adopted regional land use plan; and the Commission water quality simulation model. Table 28 sets forth the estimated phosphorus loads to Geneva Lake under existing 1975 and anticipated year 2000 conditions, assuming that no nonpoint source controls are implemented in the lake watershed. It is estimated that under the conditions existing in 1975, the total phosphorus load to Geneva Lake during an average year was 13,270 pounds.[5] Direct atmospheric fallout and mal-

[5]For the purpose of this discussion, phosphorus loading rates have been rounded from values presented in Table 28.

Table 28

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO GENEVA LAKE: 1975 AND 2000

Source	Existing 1975			Anticipated 2000[a]		
	Extent (acres)	Total Loading (pounds per year)	Percent Distribution	Extent (acres)	Total Loading (pounds per year)	Percent Distribution
Residential Land	2,624	945	7.2	3,100	1,150	13.0
Commercial Land	118	110	0.8	138	120	1.3
Industrial Land	18	15	0.1	21	20	0.2
Governmental and Institutional Land	191	160	1.2	204	170	1.9
Transportation, Communication, and Utility Lands	911	780	5.9	1,040	890	10.0
Construction and Extractive Lands	101	1,300	9.8	117	1,450	16.2
Recreational Land	742	190	1.4	854	210	2.3
Septic Tank Systems[b]	661	1,915	14.4	63	180	2.0
Fontana Sewage Treatment Plant[c]	--	2,320	17.5	--	--[e]	--
Urban Subtotal	--	7,735	58.3	--	4,190	46.9
Agricultural Land	4,144	350	2.6	3,585	325	3.6
Water[c]	5,425	2,620	19.8	5,425	2,620	29.4
Woodlands	2,566	380	2.9	2,465	370	4.1
Wetlands	496	--	--	492	--	--
Open Land	868	105	0.8	763	105	1.2
Livestock[d]	1,263 animal units	2,075	15.6	800 animal units[f]	1,315	14.8
Rural Subtotal	--	5,530	41.7	--	4,735	53.1
Total	--	13,265	100.0	--	8,925	100.0

[a]Assumes provision of sanitary sewer service as recommended in the regional water quality management plan; assumes no nonpoint source control.

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

[c]Includes the atmospheric loading to the surface area of Geneva Lake.

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

[e]Phosphorus loads under year 2000 conditions reflect elimination of loading to the lake from the Fontana sewage treatment facility.

[f]The anticipated reduction in the number of animal units present in the watershed in the year 2000 is based on historic trends in livestock numbers recorded between 1975 and 1985.

Source: Geneva Lake Environmental Agency and SEWRPC.

functioning septic tank systems were estimated to contribute 2,620 pounds, or 20 percent, and 1,915 pounds, or 14 percent, respectively, of the phosphorus entering the lake. In addition, an estimated 2,320 pounds, or 18 percent, of the phosphorus load to the lake was a consequence of overflow from seepage ponds at the Fontana on Geneva Lake sewage treatment facility to Buena Vista Creek and subsequent deposition in the lake. The remaining land uses in the Geneva Lake direct tributary drainage area--residential, commercial, industrial, governmental and institutional, transportation, construction, recreational, agricultural, woodlands, wetlands, and other open land and livestock operations--contributed an estimated 6,415 pounds, or 48 percent of the phosphorus load to the lake.

The Commission also estimated that under year 2000 conditions, the total phosphorus load to the lake would be approximately 8,930 pounds per year, or about 30 percent less than the estimated 1975 loadings. There would be an estimated decrease of 2,320 pounds of phosphorus entering the lake following abandonment of the Fontana on Geneva Lake sewage treatment facility by 1984, as recommended in the areawide water quality management plan. As discussed in Chapter IX, "Recommended Plan," sewage presently treated at the Fontana facility was recommended in 1979, to be diverted and treated at a regional sewage treatment facility in the Town of Sharon and subsequently discharged to Piscasaw Creek. In addition, there would be a reduction of about 1,732 pounds--from about 1,915 pounds in 1975 to approximately 180 pounds in the year 2000--entering the lake from malfunctioning septic systems. There would be an anticipated loading of 1,315 pounds, or 15 percent, and 2,620 pounds, or 29 percent, respectively, from livestock operations and direct atmospheric fallout. Other major sources of phosphorus, under year 2000 conditions, would be residential land, representing 1,150 pounds, or 13 percent, and land used for transportation, construction, and excavation representing about 2,350 pounds, or 26 percent. The remaining land uses in the Geneva Lake direct drainage area--commercial, industrial, governmental and institutional, agricultural and recreational, woodlands, and other open lands--would contribute the remaining 1,310 pounds, or 15 percent, of the phosphorus load to the lake.

Sediment Loading

Sediment transported to a lake contributes to its pollution. The sediment deposition results in filling portions of the lake, creating shallow areas capable of supporting rooted plant growth. In addition, the sediments transport nutrients--especially phosphorus--to the lake. Sediment is derived from soil erosion in the direct tributary drainage area, debris carried in rural and urban storm water runoff, atmospheric fallout and washout, and shoreline erosion. Sediment transfer to the lake from the tributaries and storm sewers was measured during this study. Sediment loading values from atmospheric fallout were estimated using values determined in similar studies elsewhere. Shoreline erosion, as a sediment source, was not quantified as part of the sediment budget. The volume of sediment from shoreline erosion was not considered significant, although some areas of shoreline erosion do exist around the lake.

As presented in Table 29, the sediment loading to Geneva Lake was estimated to total 1,714,400 pounds per year. The dominant sediment source to Geneva Lake was estimated to be atmospheric fallout and washout, which contributed 85.0 percent of the total during the study year. The perennial streams, intermittent streams, and storm sewers were estimated to contribute 12.6 percent, 1.2 percent, and 1.2 percent, respectively, of the total sediment loading.

Estimating the atmospheric sediment loadings was difficult because the Geneva Lake area is a semi-rural area with insufficient population to classify it as an urban residential district, yet the population density is too high for it to be considered a strictly rural area. A study conducted in Beloit, Wisconsin, in 1970 showed a dry sediment fallout rate of 265 pounds per acre per year for the City and 188 pounds per acre per year for a nearby rural area.[6] An average of the urban and rural values found in the Beloit study--225 pounds per acre per year--was utilized in this study. The Beloit study did not include sediments contributed by washout during precipitation. To estimate the additional sediments contributed by washout, a ratio of dry fallout to washout of 4.36 to 1.00, determined in a Milwaukee County study conducted in 1971, was applied to the Beloit data. The resulting atmospheric sediment loading rates utilized in the study were 225 pounds per acre per year dry fallout and 52 pounds per acre per year wet fallout, with a combined bulk sediment loading of 277 pounds per acre per year. This latter value appears reasonable and applicable to the Geneva Lake area when compared to background levels of 188 pounds per acre per year in a rural area and approximate values of 265 pounds per acre per year for residential districts.

---

[6]Wisconsin Chemical & Testing Company, Air Pollution Study for the City of Beloit, 1969-1970.

Table 29

SEDIMENT (SUSPENDED SOLIDS) CONTRIBUTED TO GENEVA LAKE BY TRIBUTARIES AND THE ATMOSPHERE: MAY 1976-APRIL 1977

Item	Amount (pounds)	Percent of Major Category	Percent of Total
Inflow			
Perennial Streams			
Pottawatomie	62,196	28.9	3.7
Buena Vista	33,249	15.4	1.9
Gardens	16,115	7.5	0.9
Southwick	69,783	32.4	4.2
Harris	4,016	1.8	0.2
Buttons Bay	10,703	5.0	0.6
Hillside	4,032	1.9	0.2
Trinke	9,313	4.3	0.5
Birches	6,033	2.8	0.4
Subtotal	215,440	100.0	12.6
Intermittent Streams			
Academy Estates	6,308	30.5	0.4
Grunow	3,210	15.5	0.2
Elgin	2,488	12.0	0.1
Hartshorne	1,858	9.0	0.1
Northwestern Naval and Military Academy	6,798	32.9	0.4
Subtotal	20,662	100.0	1.2
Atmosphere[a]	1,457,685	100.0	85.0
Storm Sewers	20,577	100.0	1.2
Total Input	1,714,364	--	100.0
Outflow			
White River	91,112	100.0	5.3
Retention	1,623,252	94.7	94.7

[a]Calculated based on estimated 277 pounds per year per acre and surface area of Geneva Lake.

Source: Geneva Lake Environmental Agency.

In many lake systems, tributary streams are the major source of sediments, especially where large streams flow through the lake. However, Geneva Lake is a headwaters lake without large tributaries. The watershed area for Geneva Lake is quite small compared to the lake area and the numerous tributaries entering the lake are small, rarely exceeding one mile in length. In addition, the watershed is generally well vegetated, soil erosion is not severe, and the volume of sediments transported by the tributary streams is small. However, suspended sediments transported to Geneva Lake by the tributary streams can be controlled, whereas atmospheric sources cannot. The two largest sediment contributors among the perennial streams were Southwick and Pottawatomie Creeks, which contributed 32 percent and 29 percent, respectively, of the total sediment entering the lake from perennial streams. Southwick Creek exhibited the highest annual average suspended solids content--17.9 mg/l--of all of the perennial streams tributary to the lake. The other seven perennial streams contributed much lower amounts, together totaling about 39 percent of the total suspended sediments transported to the lake by streams. The higher sediment contributions from Pottawatomie and Southwick Creeks was due, in part, to their high discharge rates of 890 and 435 million gallons per year, respectively. In addition, the high sediment loading carried by these two creeks may be related to the character of the land use of the areas they drain, since both watersheds had higher proportions of land in residential use--Southwick 23 percent and the Pottawatomie 29 percent--than the other tributaries. Sediment losses via the White River outlet were small, totaling about 91,112 pounds per year, or about 5 percent of the total sediment loading to Geneva Lake. In general, the sediment loading to Geneva Lake is not considered excessive for a lake of its size. If the sediments were distributed over the drainage area to the lake--which is equal to about twice the lake surface area--they would amount to less than one-fiftieth of an inch per year.

Bacteria Loading

During the study, fecal coliform and fecal streptococcus bacteria levels were monitored in the tributary streams, storm sewers, and lake outlet, and within the lake at various swimming beaches. The major purpose of the bacterial monitoring was to identify sources of human and animal fecal pollution. Both fecal coliform and fecal streptococcus bacteria are found in the intestines of warm-blooded animals, including man, but they are generally held to survive for only short periods--24 to 48 hours--in natural waters. Their presence provides an indication of fecal pollution and the possible presence of pathogenic organisms which may represent a hazard to public health and may threaten the safe recreational use of a lake. Since both these indicators have a short life span in natural waters, calculation of a bacterial loading budget is of little significance except during evaluation of continued bacterial pollution.

The criteria utilized in evaluating the bacterial contamination in Geneva Lake were centered on the type of fecal pollution, and the average number of both fecal coliform and fecal streptococcus bacteria present. As shown in Table 30,

Table 30

INTERPRETATION OF FECAL COLIFORM TO FECAL STREPTOCOCCI RATIO

Ratio of Measured Fecal Coliform/ Fecal Streptococcus	Assuming Implications Concerning Sources of Pollutants
Less than or equal to 0.7	Strong evidence that pollution is derived predominately or entirely from livestock or poultry
Between 0.7 ad 1.0	Suggests a predominance of livestock and poultry waste in mixed pollution sources
Between 1.0 and 2.0	Interpretation (of ratios and associated pollution sources) unclear
Between 2.0 and 4.0	Suggests a predominance of human waste in mixed pollution sources
Equal to or greater than 4.0	Strong evidence that pollution is derived from human wastes

Source: Biological Analysis of Water and Wastewater--Application Manual AM302, Millipore, 1973.

Table 31

ANNUAL FECAL COLIFORM AND FECAL STREPTOCOCCUS BACTERIA LOADING RATES TO GENEVA LAKE FROM TRIBUTARY STREAMS AND STORM SEWERS, AND LOSS RATES THROUGH THE WHITE RIVER: MAY 1976-APRIL 1977

Item	Colonies per 100 Milliliters Fecal Coliform	Percent of Total Loading	Colonies per 100 Milliliters Fecal Streptococcus	Percent of Total Loading
Loadings				
Perennial Streams				
Pottawatomie	6.08×10^{12}	33.0	1.31×10^{13}	30.1
Buena Vista	1.21×10^{12}	6.6	2.04×10^{12}	4.7
Gardens	5.94×10^{11}	3.3	1.85×10^{12}	4.2
Southwick	3.89×10^{12}	21.1	1.03×10^{13}	23.6
Harris	5.91×10^{11}	3.2	2.46×10^{12}	5.6
Buttons Bay	4.12×10^{11}	2.2	9.41×10^{11}	2.2
Hillside	5.99×10^{11}	3.3	6.57×10^{11}	1.5
Trinke	1.81×10^{12}	9.8	1.87×10^{12}	4.3
Birches	1.82×10^{11}	1.1	2.34×10^{11}	0.5
Subtotal	1.54×10^{13}	83.6	3.35×10^{13}	76.7
Intermittent Streams				
Academy Estates	2.35×10^{11}	1.3	4.47×10^{11}	1.0
Grunow	1.13×10^{11}	0.6	1.95×10^{11}	0.4
Elgin Club	1.10×10^{12}	6.0	3.64×10^{12}	8.3
Hartshorne	5.62×10^{11}	3.1	6.56×10^{11}	1.5
Northwestern Naval and Military Academy	1.05×10^{11}	0.6	1.74×10^{11}	0.4
Abbey Springs	3.98×10^{11}	2.2	3.98×10^{11}	0.9
Subtotal	2.51×10^{12}	13.8	5.51×10^{12}	12.5
Storm Sewers	4.74×10^{11}	2.6	4.71×10^{12}	10.8
Loading Total	1.84×10^{13}	100.0	4.37×10^{13}	100.0
Losses				
White River	7.30×10^{12}	39.7	4.89×10^{12}	11.2

Source: Geneva Lake Environmental Agency.

the ratio of fecal coliform to fecal streptococcus bacteria (FC-FS ratio) provided a means of evaluating whether the fecal pollution was from human or animal sources. The standard for determining the recreational safety of water is based upon the average number of fecal coliform found in five samples taken over a 30-day period. Water is considered safe for full body contact if the average count is less than 200 fecal coliform colonies per 100 milliliters (colonies/ml). The recreational safety of the tributary streams was evaluated by the Geneva Lake Environmental Agency based on an average monthly fecal coliform bacteria count of 1,000 colonies/ml. Streams with fecal coliform counts at or below this level are considered safe for partial body contact.

The bacteria loading to Geneva Lake from various sources is given in Table 31. The bacteria loading rate did not include measurement of the direct contribution of wastes by humans and/or animals swimming in or otherwise near the lake. The perennial streams were the largest contributors of fecal coliform and fecal streptococcus to the lake, delivering about 84 percent and 77 percent, respectively, of the total load. Intermittent streams contributed approximately 14 percent and 12 percent, respectively, of the fecal coliform and fecal streptococcus entering Geneva Lake. Storm sewers added about 3 percent and 11 percent, respectively, of the fecal coliform and fecal streptococcus entering the lake. Among the perennial streams, Pottawatomie exhibited the highest rate of bacteria loading to Geneva Lake, providing about 33 and 30 percent, respectively, of the fecal coliform and fecal streptococcus load. Southwick Creek exhibited the second highest bacteria loading--21 and 24 percent, respectively, of the fecal coliform and fecal streptococcus load--to the lake.

Table 32

AVERAGE ANNUAL FECAL COLIFORM AND FECAL STREPTOCOCCUS CONCENTRATIONS IN STREAMS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: MAY 1976-APRIL 1977

Item	Fecal Coliform (colonies per 100 milliliters)	Fecal Streptococcus (colonies per 100 milliliters)	Fecal Coliform-Fecal Streptococcus Ratio[a]
Input			
Perennial Streams			
Pottawatomie	141	156	0.90
Buena Vista	116	213	0.54
Gardens	52	100	0.52
Southwick	265	535	0.49
Harris	27	135	0.20
Buttons Bay	55	179	0.31
Hillside	526	421	1.25
Trinke	273	387	0.71
Birches	29	147	0.20
Intermittent Streams			
Academy Estates	83	225	0.37
Grunow	100	168	0.59
Elgin Club	865	2,973	0.29
Hartshorne	605	1,379	0.44
Northwestern Naval and Military Academy	208	372	0.56
Abbey Springs	144	240	0.60
Storm Sewers	216	1,514	0.14
Output			
White River	225	199	1.13

[a]Average fecal coliform-fecal streptococcus of each sample date.

Source: Geneva Lake Environmental Agency.

The average bacterial concentrations measured in the various perennial and intermittent streams are presented in Table 32. The data indicated that the concentrations in Pottawatomie Creek--141 colonies/100 ml of fecal coliform and 156 colonies/100 ml of fecal streptococcus--were relatively low. Consequently, the high contributions of this creek may be attributed to the high rate of discharge of the stream to the lake. Loading rates from Southwick Creek are also high as a consequence of high flow rates.

The monthly bacteria concentrations and the average annual FC-FS ratio indicated that bacteria in Pottawatomie Creek were derived primarily from animal sources. Fecal bacteria in Southwick Creek also appeared to be derived primarily from animal sources.

Of particular interest were the bacteria concentrations found in Trinke and Hillside Creeks. As shown in Tables 31 and 32, Trinke Creek ranked third in fecal coliform loading--1.81 x 10^{12} colonies/100 ml--and second in annual fecal coliform concentration--273 colonies/100 ml. Hillside Creek ranked eighth in fecal streptococcus bacteria loading, providing less than 2 percent of the total loading to the lake, but exhibited the highest concentration of fecal coliform bacteria--526 colonies/100 ml. In addition, despite a four-fold difference in discharge between Harris Creek--130 million gallons per year--and Hillside Creek--29.7 million gallons per year--both had about the same measured bacterial loading of fecal coliform bacteria. In Hillside and Trinke Creeks the bacterial loading appeared to be a result of the high bacteria concentrations rather than discharge rates. As shown in Table 33, these streams demonstrated the highest annual average FC-FS ratios, 1.22 and 1.48,

Table 33

FECAL COLIFORM TO FECAL STREPTOCOCCUS RATIO FOR TRIBUTARIES OF GENEVA LAKE: 1976-1977[a]

Item	May	June	July	August	September	October	November
Inflow							
Perennial Streams							
Pottawatomie	0.54	2.23	1.43	1.42	N/A	0.55	0.34
Buena Vista	1.56	2.70	1.23	0.40	0.34	0.63	0.08
Gardens	0.80	1.97	1.43	0.04	0.03	0.21	0.19
Southwick	0.55	1.14	1.24	0.43	0.02	0.29	0.97
Harris	0.73	0.31	0.10	0.04	0.03	1.77	0.30
Buttons Bay	N/A	0.49	Dry	Dry	Dry	Dry	Dry
Hillside	0.63	4.50	2.46	0.36	0.32	0.64	0.88
Trinke	3.83	1.32	2.18	0.99	0.17	0.51	0.93
Birches	0.39	2.43	0.13	0.02	0.04	1.63	0.03
Intermittent Streams							
Academy Estates	0.29	0.35	0.18	0.38	0.54	0.03	Dry
Grunow	0.49	0.77	1.15	0.01	0.63	0.83	Dry
Elgin Club	0.69	2.04	Dry	Dry	Dry	Dry	Dry
Hartshorne	2.55	0.36	Dry	Dry	Dry	Dry	Dry
Northwestern Naval and Military Academy	1.09	0.11	0.87	Dry	Dry	Dry	Dry
Abbey Springs	0.66	0.83	0.29	Dry	Dry	Dry	Dry
Outflow							
White River	3.06	1.50	2.05	1.25	0.01	N/A	0.55

Item	December	January	February	March	April	Annual Average
Inflow						
Perennial Streams						
Pottawatomie	0.32	2.88	0.25	0.33	0.09	0.94
Buena Vista	0.18	1.80	0.14	0.27	0.57	0.83
Gardens	0.27	0.96	0.08	0.22	0.24	0.54
Southwick	1.72	1.02	0.15	0.11	0.31	0.66
Harris	1.75	2.50	0.18	0.50	1.49	0.81
Buttons Bay	Dry	Dry	Dry	0.10	0.05	0.21
Hillside	0.97	2.50	0.22	0.13	0.98	1.22
Trinke	3.50	2.98	1.07	0.09	0.24	1.48
Birches	0.27	0.04	0.09	0.02	0.07	0.43
Intermittent Streams						
Academy Estates	Dry	Dry	Dry	0.05	0.31	0.27
Grunow	Dry	Dry	0.21	0.04	0.18	0.48
Elgin Club	Dry	Dry	Dry	0.16	0.19	0.77
Hartshorne	Dry	Dry	Dry	0.09	0.28	0.82
Northwestern Naval and Military Academy	Dry	Dry	Dry	0.07	0.33	0.49
Abbey Springs	Dry	Dry	Dry	0.03	0.90	0.54
Outflow						
White River	0.70	0.21	4.72	0.38	0.13	1.32

NOTE: N/A indicates data not available.
Consult Table 30 for an interpretation of fecal coliform-fecal streptococcus ratios.

[a]Underlined values represent fecal coliform-fecal streptococcus values that are indicative of human waste sources.

Source: Geneva Lake Environmental Agency.

respectively, indicating that the bacteria sources were a mixture of animal and human fecal material. On several occasions, monthly ratios indicated a predominance of human fecal waste. Both creeks flow through residential areas where onsite septic tank sewage disposal systems are located on soils with limitations for this type of waste treatment.

While the intermittent streams accounted for a small amount of the fecal coliform bacteria loading to Geneva Lake--14 percent versus 84 percent for the perennial streams--the intermittent streams were found to have higher annual average bacterial counts. Elgin Club Creek and Hartshorne Creek were the largest contributors, supplying 6 percent and 3 percent, respectively, of the total fecal coliform bacteria loading to the lake. Most of the intermittent streams flow for only a few months of the year--usually in spring--thus providing a seasonal effect on bacteria loading to the lake. The higher average bacterial concentrations for Elgin Club and Hartshorne Creeks were the result of a single sample taken in April 1976 at the height of a rain storm. Based upon the FC-FS ratio, most bacteria in the intermittent streams appear to be derived from nonhuman sources.

Table 34

MONTHLY AVERAGE CONCENTRATIONS OF FECAL COLIFORM MEASURED AT PUBLIC SWIMMING BEACHES ON GENEVA LAKE: SUMMERS 1975-1977

Site	Fecal Coliform Colonies per 100 Milliliters								
	1975			1976			1977		
	June	July	August	June	July	August	June	July	August
City of Lake Geneva									
East End of Beach	20	22	38	10	30	38	28	10	10
Swim Pier	14	80	18	20	13	38	10	12	10
West Bend of Beach	14	16	18	18	245	27	12	26	12
Village of Fontana on Geneva Lake									
North End of Beach	432	16	15	12	10	22	65	54	75
Swim Pier	16	26	16	16	10	75	176	202	34
South End of Beach	12	28	10	14	28	43	58	98	28
Village of Williams Bay									
East End of Beach	10	10	10	92	16	10	18	10	10
Swim Pier	20	12	14	18	10	10	100	90	10
Harris Creek Mixing Zone	108	204	30	708	155	210	30	468	62
West End of Beach	--	--	--	18	32	10	--	--	13
Linn Township									
Hillside Creek Mixing Zone	1,308	7,730	7,350	828	1,824	908	594	314	506
Hillside Swim Area	42	10	10	46	42	113	424	90	12
Linn Pier Swim Area	12	52	24	26	13	23	34	88	106

NOTE: Underlined values represent averages that exceeded the criterion for public swim beaches as established by the Wisconsin Division of Health: the average of not less than five samples taken within 30 days shall not exceed 200 colonies per 100 ml.

Source: Geneva Lake Environmental Agency.

As shown in Table 31, bacterial loading from the nine storm sewers evaluated was lower than the loading from the nine perennial and six intermittent streams measured, contributing 3 percent of the fecal coliform and 11 percent of the fecal streptococcus load. However, during both the spring runoff event and storm runoff events, bacterial concentrations, especially the fecal streptococcus bacteria in storm water, were higher than in the perennial or intermittent stream waters. Compared to data in the literature on fecal bacteria concentration in storm water, the bacterial concentrations exhibited were not high. This may be attributed to the fact that all the municipalities have separate sanitary and storm sewer systems, and therefore the FC-FS ratios in the storm sewer measurements demonstrated animal waste rather than human waste as the source of bacterial contamination.

Bacterial concentrations in the White River draining the lake were generally intermediate in the range of concentrations found in the perennial streams tributary to the lake, but much higher than concentrations found in the lake itself. Apparently the White River was receiving bacteria from sources other than the lake outflow.

As shown in Table 33, the FC-FS ratios for tributary streams indicated that bacteria were primarily derived from animal sources; only 14 of 134 measurements--about 10 percent--indicated contamination from human fecal material. Seven of these measurements were taken on Hillside and Trinke Creeks, indicating that there may be occasional human bacterial contamination of these creeks. In addition, nine of the 14 periods when FC-FS ratios were indicative of human waste contamination occurred during May, June, and July, when seasonal residents were present, while the other five events occurred in December and January.

Bacterial surveys of various swimming beaches located around the lake, including several near perennial stream outlets, have been conducted since 1975. As shown in Table 34, only rarely have the fecal coliform bacterial counts exceeded permissible levels--200 colonies/100 ml--which indicates that Geneva Lake is currently safe for all recreational uses. However, within the mixing zone for Hillside and Harris Creeks, fecal coliform bacteria were found to occasionally exceed recommended levels for recreational use. The lakeshore zone in which the discharge from Hillside Creek mixes with the lake waters consistently exhibited excessive levels of fecal coliform during the period of data collection. However, the bacteria were rapidly diluted as the counts at the swimming beach, situated about 60 feet away, were found to be within the state-recommended limits for recreational use. These results support other bacterial data which indicate that seepage from septic tank sewage disposal systems in the tributary drainage area were contaminating Hillside Creek. On occasion, the mixing zone for Harris Creek was found to exceed criteria for bacteriological safety; however, since Harris Creek drains a marsh area, the source of bacteria is believed to have been wildlife.

In summary, bacteria contamination, which could interfere with recreation on Geneva Lake, was found only on a highly localized basis. The contamination generally occurred close to shore, primarily in the mixing zones of some tributaries and storm sewers. Because of the dilution effect of the lake on the discharges, as well as the short life span of fecal coliform and fecal streptococcus bacteria in lake waters, bacterial contamination of the lake was not found to be a major problem, and it may be concluded that bacteria loadings from various tributaries have a negligible effect upon the recreational safety of Geneva Lake.

Biochemical Oxygen Demand (Organic Waste Loading)

The introduction of carbonaceous, biodegradable, organic materials into a lake is important because oxygen is removed from the water as the materials decompose. Where large organic loads are transported to a lake, oxygen in the lower hypolimnion waters is rapidly depleted. In addition, materials which are decomposed may contribute to the sediment and nutrient buildup in a lake. Many different sources and forms of organic materials exist. Leaves and other decaying vegetation, pollen spores from molds and fungi, and the parts and excretory products of animals all add organic material to a lake. In most instances of excessive organic waste pollution, the source is related to human activity. The major organic contributors to streams are domestic waste seepage from onsite septic tank sewage disposal systems, effluent from wastewater treatment plants, and animal wastes from farms. In a few instances, these sources may result in the discharge of pollutant materials directly into a lake.

The organic material loadings presented in Table 35 do not include a measure of all organic matter transported to Geneva Lake. The reason for the limitation was that the test employed the five-day biochemical oxygen demand (BOD), which provides an indirect measure of the organic material present in the sample, expressed as the amount of oxygen that would be required by the decomposers in breaking down the material. The amount of organic material contributed by direct atmospheric fallout and washout was estimated from data taken in other areas.

The total amount of biodegradable organic material entering Geneva Lake was estimated at 186,092 pounds of BOD per year. The atmosphere was the primary source, accounting for an estimated 147,373 pounds, or about 79 percent of the total loading. The perennial and intermittent streams contributed about

Table 35

CONTRIBUTIONS OF BIODEGRADABLE ORGANIC MATERIALS TO GENEVA LAKE: MAY 1976-APRIL 1977

Source	Five-Day Biochemical Oxygen Demand (pounds per year)	Percent of Major Category	Percent of Total
Perennial Streams			
Pottawatomie	8,924	30.2	4.80
Buena Vista	5,313	18.0	2.80
Gardens	3,834	13.0	2.10
Southwick	4,827	16.3	2.60
Harris	984	3.3	0.53
Buttons Bay	1,904	6.4	1.00
Hillside	527	1.8	0.28
Trinke	1,949	6.6	1.10
Birches	1,295	4.4	0.69
Subtotal	29,557	100.0	15.90
Intermittent Streams			
Academy Estates	574	9.6	0.30
Grunow	2,087	34.8	1.10
Elgin Club	289	4.8	0.20
Hartshorne	796	13.3	0.40
Northwestern Naval and Military Academy	129	2.2	0.10
Abbey Springs	2,118	35.3	1.10
Subtotal	5,993	100.0	3.20
Atmosphere	147,373	100.0	79.20
Storm Sewers	3,169	100.0	1.70
Total	186,092	--	100.00

Source: Geneva Lake Environmental Agency.

29,557 pounds, or 16 percent, and 5,993 pounds, or 3 percent, respectively. The smallest portion of the load was from storm sewers, which contributed about 2 percent.

As shown in Table 35, Pottawatomie Creek contributed the highest organic load, about 30 percent of the total loading from all perennial streams. Other perennial tributaries that contributed greater than 10 percent of the loading were Buena Vista Creek, contributing about 18 percent; Southwick Creek, contributing about 16 percent; and Gardens Creek, contributing about 13 percent. The remaining 22 percent of the annual organic load from perennial streams was contributed by Harris, Buttons Bay, Hillside, Trinke, and Birches Creeks.

The difference in organic loading of the individual streams may be due either to higher average concentrations or to higher discharges. As shown in Table 36, the average annual BOD concentration for the perennial streams was low, with little difference in concentration between individual streams. On the other hand, a comparative ranking of perennial streams with regard to loading and discharge, as presented in Table 37, illustrates the resulting close correlation between loading rate and amount of discharge. Both Trinke and Buena Vista Creeks appeared to exhibit slightly higher organic loading to the lake than would be expected on the basis of discharge. However, both

Table 36

AVERAGE ANNUAL CONCENTRATIONS OF ORGANIC MATTER IN PERENNIAL AND INTERMITTENT STREAMS TRIBUTARY TO GENEVA LAKE: MAY 1976-APRIL 1977

Stream	Organic Material Concentration (BOD - milligrams per liter of oxygen)
Perennial Streams	
Pottawatomie	1.2
Southwick	1.5
Gardens	1.1
Buena Vista	2.1
Birches	1.8
Harris	1.2
Trinke	2.0
Hillside	2.2
Buttons Bay	1.5
Intermittent Streams	
Grunow	2.3
Hartshorne	4.1
Abbey Springs	2.6
Academy Estates	2.3
Elgin Club	5.4
Northwestern Naval and Military Academy	3.5

Source: Geneva Lake Environmental Agency.

Table 37

ORGANIC LOADING FROM PERENNIAL AND INTERMITTENT STREAMS TRIBUTARY TO GENEVA LAKE: MAY 1976-APRIL 1977

Stream	Organic Loading (pounds per BOD per year)	Rank	Discharge (million gallons per year)	Rank
Perennial Streams				
Pottawatomie	8,924	1	890.0	1
Southwick	4,827	3	435.0	2
Gardens	3,834	4	411.0	3
Buena Vista	5,313	2	284.0	4
Birches	1,795	7	166.0	5
Harris	984	8	130.0	6
Trinke	1,949	5	104.0	7
Hillside	527	9	29.7	8
Buttons Bay	1,904	6	22.4	9
Intermittent Streams				
Grunow	2,087	2	62.4	1
Hartshorne	796	3	61.0	2
Abbey Springs	2,118	1	41.1	3
Academy Estates	574	4	30.1	4
Elgin Club	289	5	22.6	5
Northwestern Naval and Military Academy	129	6	9.3	6

Source: Geneva Lake Environmental Agency.

streams had higher average annual concentrations than other perennial streams. Both Birches and Harris Creeks appeared to exhibit lower organic loading to the lake than might be expected based upon discharge. This finding was consistent with the better water quality of these streams as evidenced by other chemical parameters.

Organic loading of the intermittent streams appeared to be generally correlated to stream discharge, with those streams having the largest discharge exhibiting the greatest loading rate. However, Abbey Springs had the highest organic loading rate but ranked third in terms of discharge. This may be attributed in part to the small, but rather continuous, flow of this stream.

To summarize, the biodegradable organic loading to Geneva Lake was found to be relatively low in relation to the size of the tributary drainage area. No specific, major organic waste pollution sources were evident within the watershed. The majority of the organic loading appeared to be derived from natural sources, such as leaves and other plant materials, and from atmospheric fallout and washout.

TROPHIC STATUS

Trophic Condition Rating

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

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

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

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

Nutrient-loading data may be used to assess the trophic state of a lake. Eutrophication refers to the accelerated biological productivity of a lake due to excessive nitrogen, phosphorus, and sediment loading. These factors enhance the growth of algae and other aquatic plants and contribute to the filling in of a lake basin. The net results may interfere with recreational use of the lake, and, on a long-term basis, may result in the eventual extinction of the lake.

Excessive nitrogen and phosphorus loadings have been associated with an accelerated rate of eutrophication. However, the nitrogen availability in most lakes in southeastern Wisconsin exceeds the phosphorus availability, so that phosphorus is usually considered the limiting nutrient, generally regulating biological productivity in a lake. As previously mentioned, the water use objectives for Geneva Lake, as recommended in the adopted regional water quality management plan, are full recreational use and the support of a healthy cold water fishery. The water quality standards adopted by the Southeastern Wisconsin Regional Planning Commission to support these objectives include standards for temperature, pH, dissolved oxygen, fecal coliform, residual chlorine, and total phosphorus. These standards are discussed in some detail in Chapter VII of this report. Based on the results of the regional water quality study, it has been determined that pollutant reduction measures should be directed toward the achievement of an in-lake total phosphorus standard of 0.02 milligram per liter during spring turnover. The long-term achievement of this standard was considered the most critical, since the other standards are generally met or are considered to be of secondary importance in Geneva Lake, and reduced phosphorus concentrations may be expected to have the most beneficial impact on the lake's water quality.

The manner in which the phosphorus and nitrogen concentrations affect the chemical conditions in Geneva Lake depends on complex physical and biological activities associated with their respective cycles within the lake. A widely applied method of evaluating the impact of nutrient loadings on the water quality of a lake is to compare measured loading rates to loading rate limits as estimated by Vollenweider based on a study of 30 lakes.[7] Vollenweider established provisional loading rates which were considered acceptable or permissible for the maintenance of lake water quality. The permissible loading rates established by Vollenweider relate to the nutrient assimilative capacity of a lake based on mean depth.

The water quality analyses indicated that the nutrient loading to Geneva Lake was 23.08 pounds per acre per year for nitrogen, and 1.80 pounds per acre per year for phosphorus. Vollenweider estimated the acceptable or permissible loadings to Geneva Lake for nitrogen to be 18.52 pounds per acre per year, and for phosphorus to be 1.20 pounds per acre per year. Thus, the "permissible" loading rates were exceeded, although the nutrient loading rates estimated from the field studies did not exceed the critical loading rates of 37.05 pounds per acre per year for nitrogen and 2.40 pounds per acre per year for phosphorus. The desirable water quality enjoyed by residents and users of Geneva Lake can partially be attributed to the fact that the loading of nutrients has not exceeded the critical level. Perceived degradation in water quality conditions over the past few years may be attributed, in part, to the

[7] R. A. Vollenweider, "Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, With Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication," Reference DAS/CSI/6827, Organisation for Economic Cooperation and Development, Directorate for Scientific Affairs, Paris, France.

fact that nutrient loading has exceeded the permissible loading rates and may be approaching the critical rate. This situation may be more serious, if one considers that the Geneva Lake nutrient loading rates were based upon a field study made during a period of low precipitation.

The trophic status of Geneva Lake was evaluated by the application of two commonly used methods: the Lake Condition Index and the Dillon and Rigler Model. Uttormark and Wall[8] developed a method for lake classification based on four indicators of eutrophication: dissolved oxygen levels, water clarity (transparency), occurrence of fish winterkills, and recreational use impairment due to algae blooms and/or aquatic macrophyte growth. A measure--referred to as a Lake Condition Index--was devised in which points are assigned for the undesirable symptoms of water pollution. A lake which exhibits no undesirable symptoms of eutrophication receives no points, and has a Lake Condition Index of zero. Conversely, a lake with all the undesirable characteristics in the most severe degree has a Lake Condition Index of 23. Using the Uttormark-Wall classification system, Geneva Lake received a Lake Condition Index of 5, which is indicative of mesotrophic lakes. This value is higher--that is, more eutrophic--than for only one of the 18 rated lakes in Walworth County, and higher than for only six of the 65 rated lakes in the seven-county Southeastern Wisconsin Region, as shown in Table 38. Therefore, based on the Lake Condition Index, Geneva Lake is less eutrophic than approximately 90 percent of the lakes in southeastern Wisconsin.

Dillon and Rigler[9] developed a model for predicting the total phosphorus concentration of a lake during spring turnover, based on the physical characteristics of the lake, hydrologic data, and phosphorus loading data. The predicted phosphorus concentrations can also be correlated to average summer chlorophyll-a and Secchi Disc (water transparency) levels. Using phosphorus loads estimated by the Regional Planning Commission's water quality simulation model, the Dillon and Rigler model was applied to Geneva Lake under the existing 1975 conditions. The model analysis resulted in a predicted total phosphorus concentration of 0.04 mg/l for Geneva Lake. This predicted value is above the Commission-recommended phosphorus standard of 0.02 mg/l established for lakes to support recreational use and cold water fish and aquatic life. For Geneva Lake, an average summer chlorophyll-a concentration of 12.5 micrograms per liter (ug/l) and an average summer Secchi Disc depth of 5.7 feet are also predicted. These data indicate that Geneva Lake would be classified as a mesotrophic lake.

Based on the above classifications and analyses, it may be concluded that the characteristics of Geneva Lake are indicative of a mesotrophic lake. At present, Geneva Lake does not exhibit the degree of eutrophication which characterizes the majority of lakes in southeastern Wisconsin. However, the trophic status of Geneva Lake could change rapidly. The preponderance of blue-green algae in the lake may be the first evidence of this change. The data

---

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

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

Table 38

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

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

[a]Lake Condition Index Trophic Classification
- 0-1 very oligotrophic
- 2-4 oligotrophic
- 5-9 mesotrophic
- 10-12 eutrophic
- 13-23 very eutrophic

Source: SEWRPC.

demonstrated a need to identify sources of nutrients to the streams and to institute control practices. An example of the benefits that may be derived from an abatement program can be demonstrated by Buena Vista Creek. If the total phosphorus entering the lake from this creek were reduced by 90 percent, the phosphorus loading to Geneva Lake would be reduced by 25 percent, from 1.80 pounds per acre per year to 1.35 pounds per acre per year--compared to a "permissible" rate of 1.20 pounds per acre per year. Such a reduction in the phosphorus load would enhance lake water quality and slow the current rate of eutrophication of Geneva Lake.

Chapter V

NATURAL RESOURCE BASE AND RECREATIONAL ACTIVITIES

AQUATIC RESOURCES

Vascular Plants

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

Aerial photographs and field surveys--obtained by the linear transect method--were employed to determine the abundance and distribution of aquatic macrophytes in Geneva Lake. In addition, the frequency of occurrence and relative abundance of each of the 22 macrophyte species identified were also determined. Table 39 sets forth the macrophytes identified and the frequency of occurrence and relative abundance of each species. Illustrations of representative macrophyte species identified in Geneva Lake are set forth in Appendix A.

Rooted aquatic macrophytes were found to grow at considerable depths in Geneva Lake, with an average depth limit of 20 feet; although a few plants (Cladophora) were found to grow to a depth of more than 25 feet. Macrophytes were also collected at 517 sites, or 82 percent, of the 627 sampling sites around the lake shore. However, due to the steep slope of much of the lake basin, macrophytes were generally limited to a narrow band, extending only 200 to 300 feet from the shoreline, around most of the lake. The three major lake embayments--Williams Bay, Buttons Bay and Geneva Bay--were exceptions. In Geneva Bay and Buttons Bay, vegetation extended 1,500 to 2,000 feet from the north shoreline. Aerial photographs revealed that rooted aquatic plants were abundant in the three bay areas, but sparse in other areas of the lake. It was estimated that macrophytes were present over 965 acres, or 18 percent, of the total lake surface. The areas of rooted macrophytes in Williams Bay, Geneva Bay, and Buttons Bay were estimated to be 96, 103, and 287 acres, respectively. While the vegetation may be sufficiently abundant to represent a nuisance in some of the bays, overall, Geneva Lake has a low density of aquatic vegetation.

Stonewort (Chara sp.), a macroscopic algae, was the most abundant macrophyte species found in the lake. It was present at 50 percent of the sites surveyed

Table 39

SPECIES OF AQUATIC MACROPHYTES IN GENEVA LAKE: 1976

Scientific Name	Common Name	Frequency of Occurrence (percent)	Relative Abundance (percent)
Chara sp.	Muskgrass or stonewart	50.1	30.1
Myriophyllum exalbescens	Northern milfoil	35.1	21.1
Myriophyllum spicatum	Eurasian milfoil	8.6	5.1
Potamogeton pectinatus	Sago pondweed	19.9	12.0
Potamogeton gramineus	Variable pondweed	6.1	3.6
Potamogeton zosteriformis	Flat-stem pondweed	4.6	1.9
Potamogeton crispus	Curlyleaf pondweed	1.9	1.1
Potamogeton amplifolius	Bigleaf pondweed	1.2	0.8
Potamogeton praelongus	White-stem pondweed	0.8	0.4
Potamogeton natans	Floating-leaf pondweed	0.3	0.2
Potamogeton nodosus	Longleaf pondweed	0.2	0.1
Potamogeton richardsonii	Red-head pondweed	0.2	0.1
Potamogeton foliosus	Leafy pondweed	0.2	0.1
Vallisneria americana	Eel grass	15.9	9.6
Najas gracillina	Bushy naiad	6.6	3.6
Najas flexilis	Slender naiad	4.6	2.8
Najas marina	Spiny naiad	0.2	0.1
Ceratophyllum demersum	Coontail	3.8	2.3
Ranunculus longirostris	White water buttercup	1.9	1.2
Utricularia vulgaris	Common bladderwort	1.0	0.6
Utricularia minor	Northern bladderwort	0.2	0.1
Elodea nuttallii	Waterweed	0.6	0.3
Other	--	--	2.8

Source: Geneva Lake Environmental Agency.

and comprised about 30 percent of the total macrophytes sampled. It was collected at depths ranging from 1 to 23 feet, and was found growing on gravel, rubble, muck, and silt. Stonewort appeared capable of growing anywhere in the lake where light penetration was sufficient and competition from other plants was not intense. On occasion, stonewort was found mixed with other vegetation, but generally it grew in monotypic, large dense mats on the lake bottom. Northern milfoil (Myriophyllum exalbescens) was the second most abundant species of vegetation and the most abundant rooted vascular plant found in Geneva Lake. It was present at 35 percent of the sites inventoried and constituted about 21 percent of the macrophytes sampled. Northern milfoil was usually found growing in association with other vegetation such as pondweeds (Potamogeton spp.), eel grass (Vallisneria americana), and stonewort (Chara sp.), but was occasionally found in pure stands. Sago pondweed (Potamogeton pectinatus) was the next most abundant species encountered. It was present at 20 percent of the sites surveyed and comprised about 12 percent of the total macrophytes sampled. The pondweeds (Potamogeton spp.) were the largest group of aquatic vegetation present--10 species were found in the lake. However, the relative abundance of the pondweeds was less than that of either stonewort or water milfoil.

The steep slopes of the lake basin, extensive shoreline development, and wave action limit the growth of emergent or floating leaf (free and attached) vegetation in the lake. Neither of these vegetative forms were recorded during the survey. However, several artificial lagoons adjacent to the lake contained water meal (Wolffia sp.), duckweeds, (Spirodella sp. and Lemna sp.) and a few emergent vegetation forms including cat-tail (Typha sp.), sedges (Carex spp.), and rushes (Scirpus spp.).

The aquatic macrophytes present in Geneva Lake have substantially changed over the 10-year period from 1967 to 1977. The Wisconsin Department of Natural Resources (DNR) conducted an inventory of aquatic plants in Geneva Lake in 1967. Of the five most abundant species identified in 1977, only two species, stonewort and eel grass, were identified as dominant in the 1967 survey. The two species of water milfoil (M. exalbescens and M. spicatum) identified as dominant in this report were not found during the 1967 survey. A primary concern of the Geneva Lake Environmental Agency is the increase in the abundance of the Eurasian strain of milfoil (M. spicatum) in Geneva Lake. Eurasian water milfoil is one of the most common nuisance plants in Wisconsin. It could become a serious nuisance in Geneva Lake because it is an alien species which has the ability to compete successfully with natural plant communities and may replace them. Eurasian milfoil was first reported in Wisconsin in 1933 near Tomahawk, Wisconsin, and has since spread throughout the state. Within 20 years, Eurasian milfoil became the dominant aquatic macrophyte species in Lake Mendota, Madison, Wisconsin.[1] Eurasian milfoil represented only 5 percent of the vegetation found during this study; however, it may be more prevalent, as the field investigation was conducted after the peak growth period--July--for this species. The large increase in Eurasian milfoil as a proportion of the Geneva Lake plant community warrants close observation. It would be undesirable for this species to become dominant and replace native plant species present in the lake because of the inevitable decrease in species diversity and the concomitant negative impacts on the Lake's fish and wildlife.

Plankton

Plankton are primarily microscopic plants and animals found floating free in the open water of a lake. Plankton are divided into two groups: phytoplankton, or microscopic plants, which includes single celled, colonial, and filamentous algae; and zooplankton, which includes several animal types, but primarily animals called microcrustaceans.

Both phytoplankton and zooplankton were sampled biweekly from May through September and monthly during the other months of the study. No samples were collected from Buttons Bay in December 1976. Standing crops and diversity for the species of phytoplankton and zooplankton sampled were estimated. Because of the low phytoplankton population, several methods of collection were employed in the initial phase of the study. Analysis of composite water samples--taken at depths of one inch, three feet, and six feet--was selected as the best sampling method. Illustrations of representative plankton species identified in Geneva Lake are set forth in Appendix A.

[1]S. A. Nichols and S. Mori, "The Littoral Macrophyte Vegetation of Lake Wingra," Wisconsin Academy of Sciences, Arts and Letters, Volume 59, 1971.

Phytoplankton: Phytoplankton are the primary producers of a lake ecosystem because they utilize solar energy and inorganic materials to produce organic matter through photosynthesis. The organic matter produced represents the base of the food chain upon which all other organisms living in the lake depend. Photosynthesis is also a major source of oxygen in the lake water. In addition, because phytoplankton are primary producers, they are usually the first aquatic organisms to respond to nutrient enrichment and are, therefore, important indicators of the trophic status of a lake. When nutrient enrichment occurs, the phytoplankton increase in abundance--with less desirable algal species sometimes reaching concentrations which degrade water quality.

Four major phyla of algae are found in freshwater systems: Cyanophyta or blue-green algae, Chlorophyta or green algae, Chrysophyta or yellow-green algae, and Pyrrophyta or yellow-brown algae. The blue-green algae are usually considered a group indicative of a lake undergoing an excessive rate of eutrophication because they tend to predominate in nutrient rich lakes. Some species can fix their own nitrogen, and can also out compete other algal phyla for the raw materials utilized for photosynthesis. Blue-green algae are considered a nuisance because they float near the surface thus decreasing water transparency, and often produce aesthetically displeasing scums or slimes on the surface. In addition, because of the presence of a gelatinous sheath, many blue-green algae clump together producing obnoxious masses of vegetation. Also, when blue-green algae decompose, they tend to produce offensive odors. Green algae are generally considered a more desirable algal form. They rarely clump together, are generally smaller in size, and tend to be more widely distributed throughout the water column. As a result, they do not reduce water transparency as much as blue-green algae do and are aesthetically less offensive. Only under special conditions do green algae "bloom" such that they greatly affect the color and transparency of water. Most of the planktonic green algae in Geneva Lake belonged to a special group called Desmids. Yellow-green algae are also considered a desirable algal form. The dominant type of yellow-green algae found in Geneva Lake, as well as in other hard-water lakes, are diatoms. Yellow-green algae rarely produce aesthetically unpleasant conditions in a lake, and in larger "clean" lakes, diatoms are often the dominant phytoplankton.

The population of phytoplankton in a lake is controlled by the interaction of factors which include light, temperature, and nutrients. As these factors vary, their interaction with one another changes, which may affect the abundance, dominance, and diversity of the phytoplankton population and the water quality in a lake. The species and seasonal abundance of phytoplankton found in Geneva Lake are listed in Tables 40 and 41, respectively. In most lakes, algae reach their greatest abundance during the spring and fall turnover periods when nutrients from the bottom waters are circulated into the upper zone of the lake where light is sufficient for plankton to carry on photosynthesis. The effect of this nutrient enrichment during the turnover periods was apparent in terms of increased diversity in the Geneva Lake phytoplankton population. During the spring turnover, the plankton population consisted of about 48 percent blue-green algae, 49 percent green algae, and 3 percent yellow-green algae, or diatoms. During summer stratification, the blue-green algae increased in abundance until October, when they constituted 99 percent of the plankton population, with one species (*Anacystis thermalis*) representing over 90 percent of the total algae population. In fall, during the fall turnover, the diatoms increased in abundance and a good diversity was

Table 40

SEASONAL ABUNDANCE OF THE DOMINANT PHYTOPLANKTON IDENTIFIED IN GENEVA LAKE: MAY 1976-APRIL 1977

Algae	Organisms per Liter Times 10					
	May	June	July	August	September	October
Blue-green						
Anacystis thermalis.......	--	1.15	2.21	8.93	9.52	23.01
Ocillatoria tenius........	0.22	0.51	--	1.92	2.16	1.02
Anabaena flos-aquae.......	--	--	0.25	0.69	0.48	--
Gomphosphaera wichurae....	--	0.02	0.02	0.11	0.01	0.01
Diatoms (yellow-green)						
Dinobryon cylindricum.....	0.01	0.69	--	0.04	--	--
Fragilaria capucina.......	0.01	--	--	0.18	--	1.15
Green						
Oocystis borgie...........	--	0.06	--	0.14	0.12	--
Yellow-Brown						
Ceratium hirundenella.....	--	0.05	0.01	0.05	0.01	--
Total Dominant Phytoplankton	0.24	4.88	2.49	12.06	12.30	25.19

Algae	Organisms per Liter Times 10				
	November	January	February	April	May
Blue-green					
Anacystis thermalis.......	1.44	0.38	--	0.29	--
Ocillatoria tenius........	1.44	1.44	0.58	0.72	--
Anabaena flos-aquae.......	--	0.14	--	--	--
Gomphosphaera wichurae....	0.11	0.01	0.01	0.48	0.19
Diatoms (yellow-green)					
Dinobryon cylindricum.....	--	--	--	--	--
Fragilaria capucina.......	1.42	0.14	--	--	--
Green					
Oocystis borgie...........	--	--	--	--	--
Yellow-Brown					
Ceratium hirundenella.....	0.01	--	--	--	0.02
Total Dominant Phytoplankton	4.42	2.11	0.59	1.49	0.21

NOTE: Phytoplankton samples not collected in December or March.

Source: Geneva Lake Environmental Agency.

again apparent, with the phytoplankton population consisting of 56 percent blue-green, 4 percent green, and 40 percent yellow-green algae. The poor diversity from August to October and the high percentage of blue-green algae present at all times in the lake indicated that Geneva Lake may be undergoing a change in trophic status. Based upon the phytoplankton population only, Geneva Lake exhibited characteristics of a slightly eutrophic lake during late summer.

It is noted that additional phytoplankton sampling has been conducted since the completion of the above-referenced data collection. This information indicates that the total population and species composition has not changed significantly.

Zooplankton: The zooplankton population is also an important aspect of a lake ecosystem. Zooplankton graze on phytoplankton and, in turn, serve as prey for many other carnivorous organisms in the lake. Zooplankton occupy a much broader depth range in the water column than do phytoplankton. Many zooplankton are photosensitive and avoid light by vertical migrations to deeper and darker water. At night, the zooplankton migrate to the surface waters to feed on phytoplankton. A 62-foot vertical tow was utilized for collecting zooplankton. In a body of water as deep as Geneva Lake, it was possible that some species were located at depths exceeding 62 feet, and, therefore, their true abundance would not be determined. However, a representative sample could be collected utilizing this type of equipment.

Twenty-two species of zooplankton were collected in Geneva Lake. Zooplankton species found are listed in Table 42, and seasonal distribution and concentrations are set forth in Table 43. Of the two major zooplankton groups, Copepods were present in

Table 41

SPECIES OF PHYTOPLANKTON FOUND IN GENEVA LAKE: MAY 1976-MAY 1977

CYANOPHYTA (blue-green)
Agmenellum quadriplicatum
Anabaena circinalis
Anabaena constricta
Anabaena flos-aquae
Anacystis cyania
Anacystis montana
Anacystis termalis
Aphanizomenon flos-aquae
Coccochloris stagnina
Cylindrosperum stagnale
Gomphosphaera wichurae
Lyngbya versicolor
Oscillatoria limosa
Oscillatoria rubescens
Oscillatoria tenius
CHLOROPHYTA (green)
Chlamydomonas dinobryoni
Chlamydomonas spp.
Chlamydonomas reinhardi
Chlorella ellipsoides
Chlorella vulgaris
Cosmarium boytrytis
Elakatorthrix gelatinosa
Oocystis borgei
Pediastrum boryanum
Scenedesmus quadricauda
Sphaerosystis schroeteri
Staurastrum peradoxum
Staurastrum punctulatum
Zygnema spp.
CHRYSOPHYTA (diatoms) (yellow-green)
Asterionella gracillima
Cocconeis pedicules
Cocconeis scutellum
Fragilaria capucina
Fragilaria croteninsis
Synedra ulna
Tabularia fenestrata
Tabularia flocculosa
Dinobryon cylindricum
Dinobryon sociale
PYRROPHYTA (yellow-brown)
Ceratium hirundenella

Source: Geneva Lake Environmental Agency.

Table 42

SPECIES OF CLADOCERA AND ZOOPLANKTON FOUND IN GENEVA LAKE: 1976

CLADOCERA
Eubosmina coregoni
Bosmina longirostis
Daphnia longiremis
Daphnia galiata memdotae
Daphnia retrocurva
Daphnia pulicaria
Chydorus sphericus
Leptodora kindtii
Sida crystallina
Diaphanosoma leuchtenbergianum
Moina spp.
COPEPODA
Attheyella illinoisinia
Tropocyclops prasinus
Ectocyclops phaleratus
Cyclops bicuspidatus thomasi
Orthocyclops modestus
Mesocyclops edax
Cyclops bicuspidatus
Senecilla calanoides
Epischura lacustris
Leptodiaptomus siciliodes
Skistodiaptomus pallidus

Source: Geneva Lake Environmental Agency.

greater numbers than Cladocerans during most of the sampling period. The four dominant species of zooplankton sampled were Cyclops thomasi, Daphnia longiremis, Eubosmina coregoni, and Tropocyclops prasinus. These species were collected at all sampling stations in relatively large numbers.

Of primary interest were changes in the zooplankton population structure, which may be associated with the increased eutrophication of Geneva Lake. Data collected during this study compare reasonably well with the results of

Table 43

CONCENTRATIONS OF DOMINANT ZOOPLANKTON IN GENEVA LAKE: MAY 1976-MAY 1977

Organisms	Organisms per Liter					
	May	June	July	August	September	October
Cladocera						
Daphnia longiremis.........	19	22	22	36	36	--
Daphnia galeata mendata....	--	--	--	--	--	--
Eubosmina coregoni.........	31	14	--	5	7	--
Bosmina longirostis........	--	--	--	--	--	--
Daphnia spp................	--	--	--	--	--	--
Copepoda						
Cyclopoid						
Tropocyclops prasinus....	5	--	22	--	--	11
Ectocyclops phaleratus...	--	7	--	--	--	--
Orthocyclops modestus....	--	14	7	--	--	6
Cyclops thomasi..........	--[a]	77	37	36	7	17
Other Cyclops............	--	--	22	5	--	--
Calanoid						
Diaptomus spp............	--	62	30	17	22	6
Epischura lacustris......	--	--	--	--	--	--
Total Dominant Zooplankton	55	196	140	99	72	40

Organisms	Organisms per Liter				
	November	January	February	April	May
Cladocera					
Daphnia longiremis.........	21	--	5	--	--
Daphnia galeata mendata....	--	--	--	--[a]	21
Eubosmina coregoni.........	--	7	19	7	7
Bosmina longirostis........	14	--	--	--	14
Daphnia spp................	--	--	14	--	21
Copepoda					
Cyclopoid					
Tropocyclops prasinus....	--	--	34	22	--
Ectocyclops phaleratus...	--	--	--	--	--
Orthocyclops modestus....	--	--	--	--	--
Cyclops thomasi..........	35	7	43	100	43
Other Cyclops............	--	--	--	21	--
Calanoid					
Diaptomus spp............	7	22	5	7	--
Epischura lacustris......	--	--	--	7	--
Total Dominant Zooplankton	77	36	120	164	106

NOTE: Zooplankton samples not collected in December and March.

[a]Presence noted but not counted.

Source: Geneva Lake Environmental Agency.

a study of Geneva Lake zooplankton conducted by Torke in 1974.[2] Two of the four dominant zooplankton collected during this study--C. thomasi and D. longiremis--were found by Torke in 1974; however, he did not collect T. prasinus or E. coregoni. The presence of E. coregoni in this study was significant because it has been suggested that replacement of E. coregoni by B. longirostris is characteristic of a lake undergoing a change in trophic status as a result of increased nutrient enrichment. While both species were collected during this study, B. longirostris was sampled less frequently and in lower numbers than E. coregoni. In addition, Torke reported that Leptodiaptomus siciliodes was one of the dominant zooplankton species sampled in 1974; however, during this study, only a few individuals were collected.

A comparison of the findings of the zooplankton study results with studies conducted at the turn of the century also indicate changes in the zooplankton population of Geneva Lake. Limnoclaenis marcrurus was found by Forbes and Juday during a study conducted in 1901, but was not collected during the current investigation. It is believed that this species has become extinct in all inland lakes except for some of the Great Lakes. Juday also found Epischura lacustris in deep portions of Geneva Lake;[3] however, it was found on only one occasion--April--in small numbers during this study. An analysis of the zooplankton population indicates that Geneva Lake was an oligotrophic lake around 1900 but has undergone change. Geneva Lake still contains some zooplankton species characteristic of "clean" oligotrophic lakes, but the presence of more tolerant zooplankton forms indicates an accelerated eutrophication rate over the past 75 years.

Benthic Animals

The benthic community of a lake includes animals living on or in the bottom substrate. The distribution and abundance of these aquatic organisms is affected by temperature, dissolved oxygen, type of substrate, food availability, cover, and competition. The benthic community was quantitatively sampled with a Ponar Dredge during summer stratification--September 18, 1976--and spring circulation--April 23, 1977--at Williams Bay (G-22, G-23), Black Point (G-26), Gardens Point (G-27), and Geneva Bay (G-28) (see Map 11 for site locations). The sampling stations, the benthic organisms found, and their tolerance to low oxygen concentrations are set forth in Tables 44 and 45. Four of the five sampling stations--G-22, G-23, G-26, and G-27--were located in the profundal zone of the benthic community. The profundal zone is characterized by low light levels, a finely divided organic bottom layer of muck, and varying chemical conditions. The other sampling station--G-28--was located in the littoral zone which had sufficient light for plant growth, a coarser, less-organic bottom, and more uniform chemical conditions. Illustrations of representative benthic species identified in Geneva Lake are set forth in Appendix A.

The animals found in the benthic samples from Geneva Lake included snails, clams, insect larva, worms, and leeches, with snails and clams dominating the population, However, in many instances, only the shells of the snails or clams

---

[2]Information provided by Byron G. Torke, Professor of Zoology, Ball State University, Muncie, Indiana, 1977.

[3]C. Juday, "Diurnal Movement of Plankton Crustacea," Wisconsin Academy of Sciences, Arts and Letters, 1901.

Table 44

BENTHIC ORGANISMS FOUND IN GENEVA LAKE: SEPTEMBER 1976 AND APRIL 1977

Phylum	Class	Order	Genera
Mollusca	Gastropoda (snails)	--	*Viviparus* spp. *Planorbis* spp. *Helisoma campanulata* *Helisoma antrosa* *Amnicola* spp. *Lymnaea* spp. *Physa* spp.
	Pelecypoda (clams)	--	*Sphaerium* spp. *Pisidium* spp.
Arthropoda	Insecta (insects)	Tricoptera (caddisfly)	*Leptocerus americanus* *Phryganea* spp.
		Ephemeroptera (mayfly)	*Hexagenia* spp.
		Diptera (true fly)	*Chironomus* spp.
Annelida	Oligochaeta (segmented worms)	--	*Tubifex* spp. *Branchuria sowerbyi*
	Hirundinea (leeches)	--	*Nephelopsis obscura*

Source: Geneva Lake Environmental Agency.

were found and it was not possible to determine if the animals inhabited the area sampled or if the shells were transported from another area. However, the number of empty snail shells always greatly exceeded the number of living snails. With the exception of the snail *Viviparus* sp., the animals sampled in the profundal zone were forms capable of surviving low oxygen conditions.

The influence of more favorable and constant physical and chemical conditions in the littoral zone of the benthic community was evident by the greater number of organisms found at this site when compared to samples from stations in the profundal zone. In addition, species less tolerant of low oxygen concentrations were present at this station.

The benthic sampling conducted during this study represented a qualitative survey of benthic organisms inhabiting Geneva Lake; consequently, not all the benthic organisms living in the lake were sampled. However, the data indicated that benthic animals persisted to moderate depths in the lake. At depths greater than 50 feet, physio-chemical conditions were such that the distribution of benthic organisms was restricted. Although the data were not quantitative, it was apparent that Geneva Lake had a high snail population. In part, this explains the prevalence of swimmer's itch in the lake. Snails serve as the intermediate host for the duck parasite responsible for swimmer's itch. As will be discussed in Chapter VI, parts of the lake are treated each year with copper sulfate and lime to control the snail population. This annual treatment would account for the large number of empty snail shells in the profundal zone samples. In addition, it is possible that this control practice may have a detrimental effect on other benthic organisms in the lake.

Table 45

CONDITIONS AT GENEVA LAKE BENTHIC SAMPLING SITES, BENTHIC ORGANISMS FOUND, AND THEIR TOLERANCE TO LOW OXYGEN LEVELS: 1976-1977

Site[a]	Season	Depth (feet)	Dissolved Oxygen (parts per million)	Organisms Found	Tolerance to Low Oxygen Levels
G-22 (profundal)	Fall	137	0.0	Viviparus Sphaerium	intolerant facultative
G-23 (profundal)	Spring	73	7.5	Chironomus Tubifex	tolerant tolerant
	Fall	75	1.2	Viviparus Tubifex	intolerant tolerant
G-26 (profundal)	Spring	63	8.0	Tubifex Viviparus Physa Helisoma antrosa Sphaerium Lymnea Amnicola	tolerant intolerant tolerant tolerant facultative tolerant tolerant
	Fall	51	1.4	Planorbus Chironomus Viviparus Tubifex	facultative tolerant intolerant tolerant
G-27 (profundal)	Spring	85	7.3	Tubifex Chironomus	tolerant tolerant
	Fall	74	1.4	Chironomus Pisidium	tolerant facultative
G-28 (littoral)	Spring	16	8.3	Tubifex Chironomus Viviparus Physa Helisoma antrosa Branchiura sowerbyi	tolerant tolerant intolerant tolerant tolerant tolerant
	Fall	18	8.0	Viviparus Planorbus Helisoma campanulata Helisoma antrosa Amnicola Chironomus Natarsia Leptocerus americanus Hexagenia Nephelopsis obscura Phryganeidae	intolerant facultative tolerant tolerant facultative tolerant intolerant tolerant facultative facultative intolerant

[a]See Map 11.

Source: Geneva Lake Environmental Agency.

Fish Resources

The size and depth of Geneva Lake provide suitable habitat for cold water fish species. Geneva Lake also supports a good population of warmwater game fish and panfish. The lake has one of the most diverse fish populations in southern Wisconsin. The 20 species of game fish sampled in Geneva Lake and tributary streams during the study are set forth in Table 46.

Historically, numerous types of game fish have been stocked in Geneva Lake by the DNR. The stocking record for the period 1957 to 1985 is shown in Table 47. Six species of game fish have been stocked in Geneva Lake since 1957. Stocking was resumed in 1982, after being discontinued for six years. The Village of Fontana and the DNR reached an agreement concerning boat launching fees in

Table 46

SPECIES OF GAME FISH SAMPLED IN GENEVA LAKE AND THE STREAMS TRIBUTARY TO THE LAKE: 1976-1977

Common Name	Scientific Name
Black Crappie............	*Pomoxis nigromaculatus*
Bluegill.................	*Lepomis machrochirus*
Brook Trout[a]............	*Salvelinus fontinalis*
Brown Trout..............	*Salmo trutta*
Bullheads................	*Ictalurus* spp.
Carp.....................	*Cyprinus carpio*
Cisco....................	*Coregonus artedi*
Grass Pickeral...........	*Esox americanus vermiculatus*
Green Sunfish............	*Lepomis cyanellus*
Lake Trout...............	*Salvelinus namaycush*
Largemouth Bass..........	*Micropterus salmoides*
Northern Pike............	*Esox lucius*
Pumpkinseed..............	*Lepomis gibbosus*
Rainbow Trout............	*Salmo gairdneri*
Rock Bass................	*Ambloplites rupestris*
Sauger...................	*Stizostedion canadense*
Smallmouth Bass..........	*Micropterus dolomieui*
Walleye..................	*Stizostedion vitreum vitreum*
Yellow Perch.............	*Perca flavescens*
White Perch..............	*Morone americana*

[a]Found only in the streams of the watershed.

Source: Geneva Lake Environmental Agency.

Table 47

GAME FISH STOCKED IN GENEVA LAKE: 1957-1985

Year	Species	Number
1985[a]	Brown Trout	2,000
	Lake Trout	20,000
	Northern Pike	2,500
1984	Brown Trout	2,000
	Lake Trout	13,000
	Walleye	101,026
1983	Lake Trout	3,100
	Northern Pike	1,300
1982	Walleye	109,000
1976	Lake Trout	47,000
1975	Lake Trout	15,000
1974	Lake Trout	20,000
1973	Lake Trout	14,000
1972	Walleye	100,350
1969-1971	--	--
1968	Walleye	184,525
1967	Walleye	105,600
1966	Walleye	110,200
1963-1965	--	--
1962	Smallmouth Bass	6,800
1961	Rainbow Trout	62,129
	Smallmouth Bass	1,000
1960	Northern Pike	670
1959	Walleye	11,900
1958	Rainbow Trout	394
	Walleye	49,500
1957	Brown Trout	4,919
	Rainbow Trout	47,260
	Walleye	49,500

[a]Tentatively scheduled for fall stocking season.

Source: Wisconsin Department of Natural Resources.

1982 and fish management technical assistance has been resumed. Illustrations of representative fish species identified in Geneva Lake are set forth in Appendix A.

The cold-water fishery in the lake includes trout and cisco. The predominant trout species in the lake are brown trout (Salmo trutta) and lake trout (Salvelinus namaycush). A few rainbow trout (Salmo gairdneri) and brook trout (Salvelinus fontinalis) are also found in individual tributary streams. Two streams--Van Slyke Creek and Pottawatomie Creek situated at the west end of the lake--support a naturally reproducing brown trout population. The upper reaches of the Van Slyke Creek also support a naturally reproducing population of brook trout, although it is believed that this population is decreasing due to degradation of the stream habitat.

The trout fishery in Geneva Lake resulted primarily from stocking by both the Wisconsin Department of Natural Resources and private individuals over the last 100 years. Although rainbow trout have not been stocked in the lake for several years, private landowners have stocked some riparian streams with rainbows. During heavy rains and high-flow periods, they have escaped into the lake; however, their life expectancy in the lake is believed to be relatively short. As shown in Table 47, brown trout fingerlings are being stocked in the lake by the DNR and in 1984, 2,000 five-inch-long fingerlings were stocked. Lake trout fingerlings were most recently stocked in Geneva Lake in 1984, with 13,000 seven-inch-long fingerlings stocked by the DNR. Local sportsmen have reported catching lake trout of legal size.

The shallow water cisco (Coregonus artedi) fishery present in the lake is unique for southeastern Wisconsin. Generally, most of the lakes in southeastern Wisconsin do not have water quality conditions suitable for cisco. Spectacular die-offs of cisco in Geneva Lake have been recorded as far back as the 1940's, presumably from sudden fluctuations in water temperature and from dissolved oxygen depletion at lower depths. However, a large die-off has not occurred since 1973. The cisco population in Geneva Lake is heavily parasitized by the tapeworm Triaenophorus crassus.[4] This tapeworm uses the northern pike (Esox lucius) as the primary host and the cisco as the secondary host. The fishery is underutilized by the public as a result of the parasitic infestation.

Walleye (Stizostedion vitreum vitreum) have been the most frequently stocked fish in Geneva Lake. In 1984, approximately 101,000 three-inch-long fingerlings were stocked in the lake. There is a naturally reproducing population of walleye in Geneva Lake; however, it is believed that stocking has increased the number of fish available for sportsmen.

Good populations of smallmouth bass (Micropterus dolomieui) and largemouth bass (Micropterus salmoides) and northern pike are present in the lake and represent an important fishery. Natural reproduction appears sufficient to maintain substantial populations of these species. An abundant panfish population consisting of bluegills (Lepomis machrochirus), black crappie (Pomoxis nigromaculatus), white bass (Morone americana), and rock bass (Ambloplites

---

[4]C. Brynildson, "Parasitic Infestation of the Cisco in Geneva Lake, Walworth County" Wisconsin Department of Natural Resources, Fish Management Bureau, Technical Note, November 9, 1969.

rupestris) are present and heavily utilized by fishermen. Other species common to the fishery are pumpkinseeds (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), and bullheads (*Ictalurus* spp.). Rough fish, such as carp (*Cyprinus carpio*), white suckers (*Catostomus commersoni*), dogfish (*Lota lota*), and gar (*Lepisosteus* sp.), are present in the lake but are not reported to be a problem.

Wildlife Resources

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

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

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

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

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

4. Location with Respect to Other Wildlife Habitat Areas. It is very desirable that the wildlife habitat area 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).

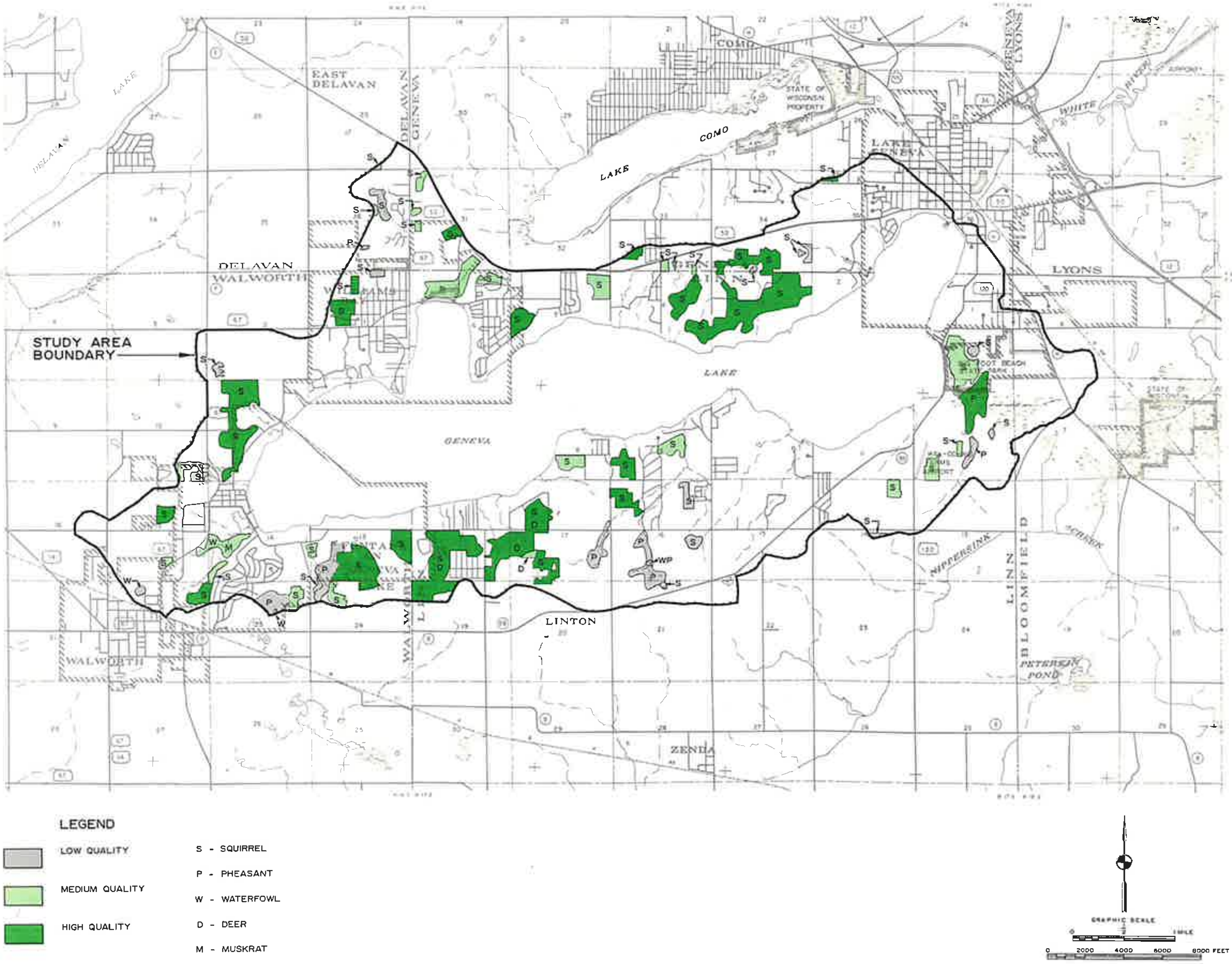
On the basis of these five criteria, the wildlife habitats in the Geneva Lake watershed were rated as high, medium, or low quality. The quality ratings used are defined below:

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

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

Map 11

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



Source: SEWRPC.

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

As shown on Map 11, in 1980 the Geneva Lake direct drainage area contained approximately 2,116 acres of wildlife habitat. The upland woods situated primarily in the northeastern and southwestern portion of the drainage area provide high-quality squirrel and deer habitat. Other sections of woodland scattered throughout the drainage basin provide medium- to low-quality squirrel, deer, and pheasant habitat. Relatively large wetland complexes along the eastern boundary of the drainage basin, north of Williams Bay and west of the Village of Walworth, provide high- and medium-quality pheasant, muskrat, and waterfowl habitat.

Woodlands

Woodlands in southeastern Wisconsin are defined as areas containing 17 or more trees per acre which have at least a four-inch diameter measured at breast height--that is, measured at 4.5 feet above ground. In addition, the native woodlands are classified as dry, dry-mesic, mesic, wet-mesic, and wet hardwoods forests and conifer swamp forests. The latter three woodland classifications are also considered wetlands, but for the purposes of this report are discussed in this section. The drainage area directly tributary to Geneva Lake contains four of the six native woodland classifications.

Specifically, as shown on Map 12, in 1980 upland woods in the Geneva Lake drainage basin, totaling approximately 2,515 acres, included southern dry-mesic hardwoods characterized by northern red oak (Quercus borealis), shagbark hickory (Carya ovata), and white ash (Fraxinus americana) and southern mesic hardwoods dominated by sugar maple (Acer saccharum) and basswood (Tilia americana). A high-quality mesic woodland is located on the northeast side of the lake in Sections 2 and 3, Town 1 North, Range 17 East (Town of Linn). Between 80 and 100 acres of this mesic woodland are in proximity to the Wychwood Estate. Further, the quality of this woodland is such that it warrants inclusion in the state scientific area preservation program which is conducted by the Wisconsin Department of Natural Resources, Scientific Areas Preservation Council.

Lowland woods in the Geneva Lake drainage basin include scattered small stands of southern wet to southern wet-mesic hardwoods. These areas are characterized by black willow (Salix nigra), cottonwood (Populus deltoides), green ash (Fraxinus pennsylvanica), and American elm (Ulmus americana), and are generally associated with the wetland complexes on the north end of Williams Bay and the west end of Geneva Lake in the Village of Fontana on Lake Geneva. Isolated stands of wet to wet-mesic hardwoods also occur in Big Foot State Park, Township 1 North, Range 17 East (Town of Linn), and in the Big Foot Country Club, Township 1 North, Range 16 East (Town of Walworth).

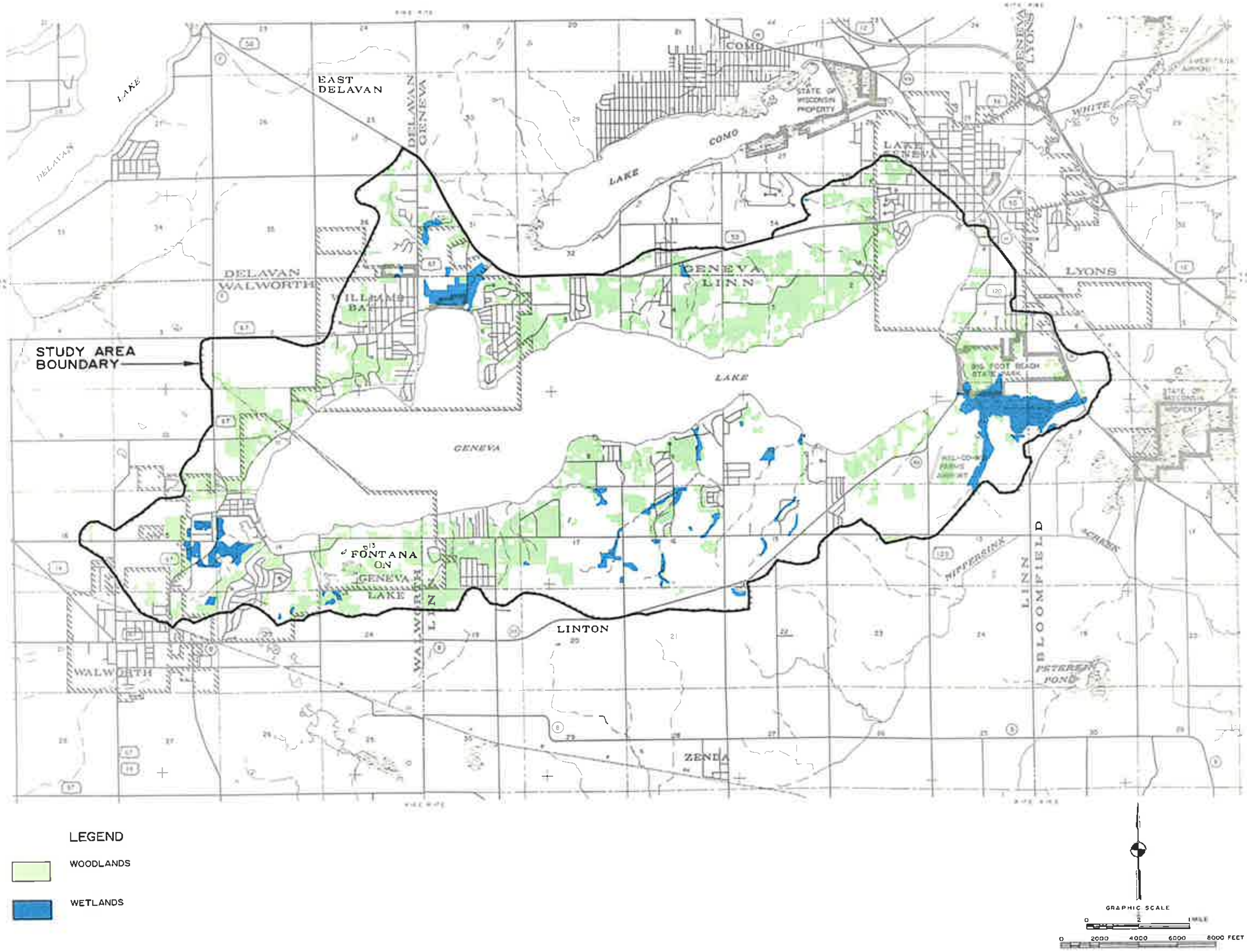
Wetlands

Wetlands in southeastern Wisconsin are classified as shrub-carr, fresh meadow, sedge meadow, low prairie, fens, bogs, shallow marsh, and deep marsh. The major wetland communities located in the Geneva Lake drainage basin, which totaled approximately 492 acres in 1980, are shown on Map 12, and include sedge meadows, fresh meadows, shrub-carrs, and some shallow marshes and fens.

Sedge meadows are considered to be stable communities that will perpetuate themselves if dredging activities and water level changes are prevented from occurring. Sedge meadows in southeastern Wisconsin are characterized by the tussock sedge (Carex stricta) and, to a lesser extent, by Canada bluejoint grass (Calamagrostis canadensis). Sedge meadows that are drained or disturbed to some extent typically succeed to shrub-carrs. Shrub-carrs, in addition to the sedges and grasses found in the sedge meadows, contain an abundance of

Map 12

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



Source: SEWRPC.

willows (Salix spp.) and red osier dogwood (Cornus stolonifera). In extremely disturbed shrub-carrs, the willows, red osier dogwood, and sedges are replaced by such exotic plants as honeysuckle (Lonicera sp.), buckthorn (Rhamnus sp.), and the very agressive reed canary grass (Phalaris arundinacea).

Fresh meadows are essentially lowland grass meadows which have become dominated by such forbs as the marsh (Aster simplex), red-stem (Aster puniceus), and New England (Aster novae-angliae), asters, and giant goldenrod (Solidago gigantea). A fresh meadow associated with a sedge meadow and shrub-carr complex is located immediately south of the Big Foot Beach State Park.

Several small fen communities were noted within the wetland complexes located in the Villages of Fontana on Geneva Lake and Williams Bay. Fens are rare, specialized plant communities growing on waterlogged organic soils associated with alkaline springs and seepages. Characteristic plants include shrubby cinquefoil (Potentilla fruticosa), Riddell's goldenrod (Solidago riddellii), Grass of Parnassus (Parnassia glauca), white lady-slipper (Cypripedium candidum), and ladies' tresses orchids (Spiranthes spp.). A shallow marsh is associated with the fen located north of the Williams Bay.

The springs associated with the wetland complexes on the west end of the lake and north of the Village of Williams Bay are trout spawning springs. In order to maintain the high water quality within these springs, it is essential that the associated wetlands be maintained in an undisturbed condition.

ENVIRONMENTAL CORRIDORS

The Environmental Corridor Concept

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

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

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

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

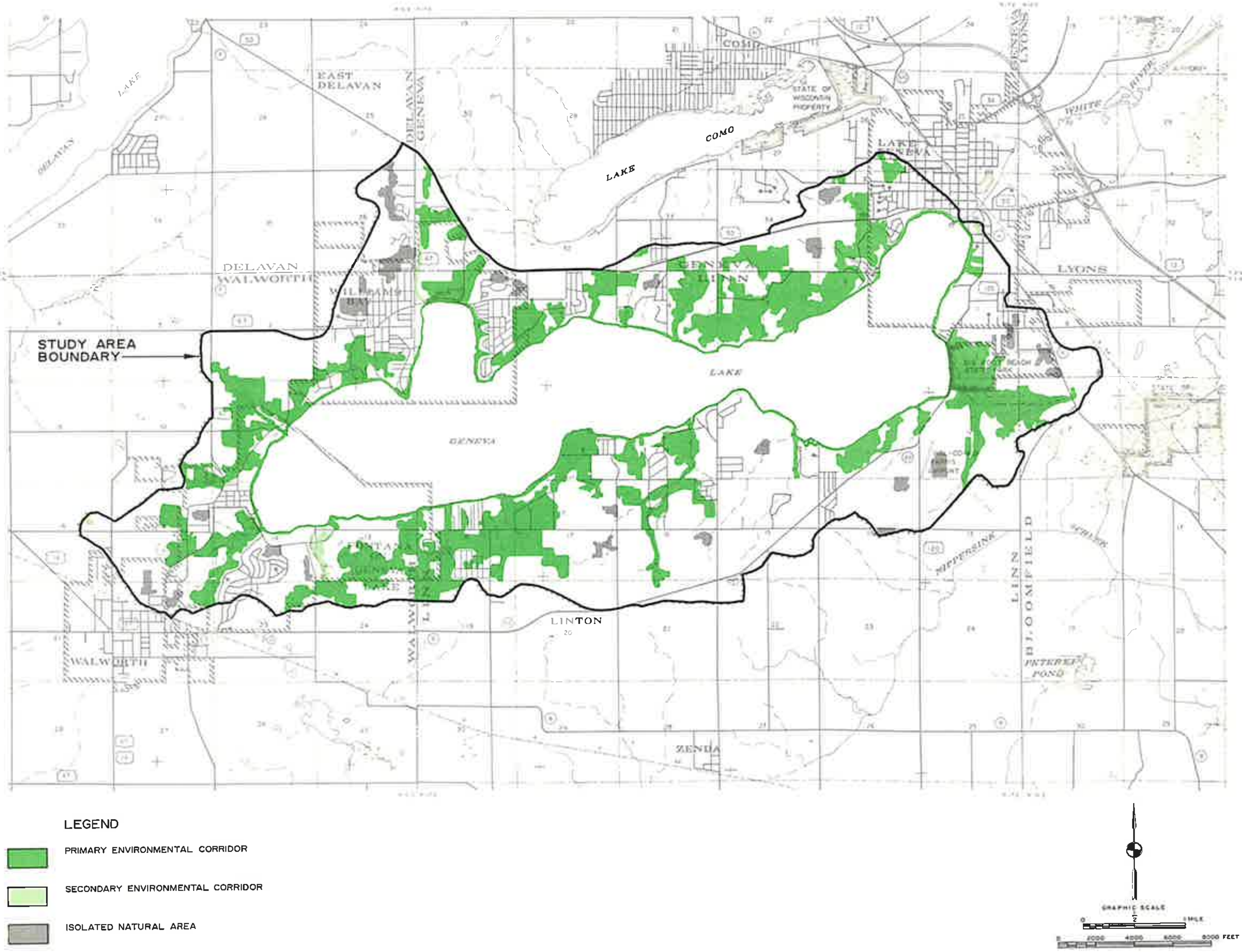
The primary environmental corridors in southeastern Wisconsin generally lie along major stream valleys and around major lakes, and contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all of the major bodies of surface water and related undeveloped floodlands and shorelands. As shown on Map 13, primary environmental corridors in the Geneva Lake direct drainage area in 1980 encompassed 3,469 acres, or 27 percent of the drainage area.

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

Secondary Environmental Corridors: The secondary environmental corridors in the Geneva Lake direct drainage area are located generally along intermittent streams or serve as links between segments of primary environmental corridors. These secondary environmental corridors contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive agricultural purposes or urban land uses. Secondary environmental corridors facilitate surface water drainage, maintain "pockets" of natural resource features, and provide for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species.

Map 13

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



Source: SEWRPC.

Such corridors, while not as important as the primary environmental corridors, should be preserved in essentially open, natural uses as urban development proceeds within the direct drainage area, particularly when the opportunity is presented to incorporate the corridors into urban stormwater detention areas, associated drainageways, and neighborhood parks. As shown on Map 13, secondary environmental corridors encompassed 40 acres, or less than 1 percent of the direct drainage area.

Isolated Natural Areas: In addition to the primary environmental corridors, other, small concentrations of natural resource base elements exist within the Geneva Lake direct tributary drainage area. These concentrations are isolated from the environmental corridors by urban development or agricultural lands and, although separated from the environmental corridor network, have important natural values. These isolated natural areas may provide the only available wildlife habitat in a localized area, provide good locations for local parks and nature study areas, and lend an aesthetic character or natural diversity to an area. Important isolated natural features include a geographically well-distributed variety of isolated wetlands, woodlands, and wildlife habitat. These isolated natural features should also be protected and preserved in a natural state whenever possible. Such isolated areas five or more acres in size within the Geneva Lake direct tributary drainage area as of 1980 are shown on Map 13. The combined area of the isolated natural areas identified on the map totals about 300 acres, or 2 percent of the direct drainage area.

Aesthetics

The unique beauty of the Geneva Lake area with its steep, wooded, north and south shores has been acclaimed since the time of original settlement by Europeans. In addition, Geneva Lake's water clarity is itself an aesthetic feature. Beginning in the 1870's, a number of large estates were established in the Geneva Lake drainage basin. The natural beauty of the area was enhanced as a result of the professional landscaping, architectural design, and maintenance of these estates. The planning of roads and building sites to enhance the aesthetics of the watershed also attests to the foresight of the early estate residents. In addition, the campuses of such institutions as the Northwestern Military and Naval Academy and the Yerkes Observatory, both established around the turn of the century, were planned with great care and respect for the natural features of the area.

Historically, a continuous shorepath around the lake, which follows an ancient Indian trail, has been accessible to and utilized by the public. This privilege, often referred to as "the right of prescription," has been unsuccessfully contested from time to time by a few owners of lakeshore property.

Public excursion boats have provided sightseeing trips around the lake for generations to view the large estates with their interesting architectural and landscape designs, and the natural beauty of Geneva Lake. Colorama tours by both boat and automobile are popular in the fall of the year. A number of fine books have also been published regarding both the natural and the man-made beauties of Geneva Lake.

Recreational Use

Fishing: Data published in 1969 indicated that on an average weekday, 30 fishing boats were on Geneva lake at a given time. On weekends and holidays the average fishing boat count averaged 53 per day, with as many as 114 fishing craft present at one time. An aerial survey conducted by the Regional Planning Commission on a Saturday in August of 1974, identified 96 fishing boats present on the lake. More recent estimates by operators of the municipal launching sites and operators of liveries have indicated that as many as 160 fishing boats are launched or rented per day on weekends and holidays, and that as many as 120 boats are launched or rented on weekdays. These more recent estimates must be considered conservative, because residents of the municipalities have free launching rights and their presence is not recorded at the municipal sites.

Increased waterskiing and power boating, especially on weekends and holidays, has produced a conflict between fishermen and the power boaters. As a result, little fishing is done during the middle of the day, when power boats are most prevalent on the lake.

An intensive creel census conducted in 1968 provided estimates of fishing pressure and fish harvest on Geneva Lake. The surveys indicated that the lake received 25 man-hours of fishing per acre of water during a year--20 hours in summer and 5 hours in winter.[5] Compared to other lakes in southern Wisconsin, Geneva Lake did not receive intense fishing pressure at the time of this survey. The climatic conditions which affect recreation on large lakes--storms, wind, and winter ice conditions--tend to lower the number of man-hours on the lake. With the general increase in fishing activity in Wisconsin in the last 12 years, fishing pressure may have increased. The cited survey also revealed that the harvest was 23 fish per acre--14 in summer and 9 in winter. This was below the 47 fish per acre that is the southeastern Wisconsin average. The Geneva Lake basin configuration is characterized by a small littoral zone--which is the area where fish are most readily found--and this may be the cause of the lower catch per acre.

Although there were no data available regarding the pounds of fish caught per acre, it appears that Geneva Lake would rank high in comparison with other lakes in southeastern Wisconsin. The catch per unit effort was above the regional average, with Geneva Lake anglers catching 0.92 fish per hour compared to 0.81 fish per hour for the Region.

Hunting, Trapping, and Wildlife Observation: A variety of wildlife habitat exists in the Geneva Lake watershed. Many of the larger estates and undeveloped lands offer excellent habitat in which a wide variety of wildlife may be seen. In addition, because of its size, depth, and source of water, Geneva Lake stays ice free much later in the fall than do surrounding lakes. Consequently, many species of waterfowl remain at the lake throughout the fall and into early winter. Further, many species of waterfowl winter in Pottawatomie Creek, which remains open throughout the year.

Hunting and trapping within the Geneva Lake direct drainage area takes place on a very limited basis. Linn Township has added restrictions, beyond those established by the State, regulating the discharge of firearms and trapping in areas close to the lake as well as within platted subdivisions. Hunting and trapping are forbidden within the incorporated municipalities of Fontana on Geneva Lake, Lake Geneva, and Williams Bay. However, the limited areas within the direct drainage area that do allow hunting, trapping, and wildlife observation are being threatened by residential development.

Swimming: Swimming is a primary recreational activity at the six public beaches on the lake. The Villages of Fontana on Geneva Lake and Williams Bay, the City of Lake Geneva, and Big Foot State Park each have one beach; the Town of Linn has two beaches. The total lake frontage at the six beaches is about 4,300 feet and the combined recreational area of all six beaches is 6.4 acres. The individual acreages and frontages of the beaches are as follows: City of Lake Geneva, 1.00 acre and 750 feet; Fontana on Geneva Lake, 3.25 acres and 550 feet; Linn Pier Beach, 0.25 acre and 50 feet; Hillside Road

[5] Lake Geneva, Walworth County, Wisconsin, Lake Use Report No. FX-1. Prepared by the Wisconsin Department of Natural Resources for SEWRPC, 1969.

Beach 0.25 acre and 50 feet; Big Foot State Park, 0.9 acre and 1,900 feet; and Williams Bay, 0.75 acre and 1,000 feet. In addition, many of the subdivisions around the lake have private beaches and/or swimming piers.

Beach use is dependent upon weather conditions and the day of the week. Conversations with beach operators during the study indicated that weekday use per beach can range from 100 people in Fontana to 200 people at the Big Foot and Williams Bay beaches. Lake residents enjoy free access to the beaches and are not included in any surveys. Weekend usage was estimated to be much higher, ranging from 500 people at Fontana on Geneva Lake and Big Foot beaches to 800 people at the City of Lake Geneva Beach. Holidays and weekends are the busiest time of the year, with individual counts ranging from 750 at Big Foot to 1,000 at the City of Lake Geneva Beach.

Skin diving is also a popular activity at the lake. The large area of clear, deep water in association with steep dropoffs is challenging to divers. Under the Uniform Lake Law Ordinance, all skin divers must register with the Water Safety Patrol before diving. Portions of Fontana Bay and Williams Bay are closed to skin diving from June 15 through September 15.

Public Access: A list of access sites on Geneva Lake is presented in Table 48. Approximately 0.8 mile, or 4.0 percent of the 20.2 miles of shoreline, is available for lake access. The survey showed that the lake has five improved

Table 48

ACCESS SITES ON GENEVA LAKE: 1984

Location	Name/Owner	Type	Condition[a]	Lake Frontage (feet)	Spaces for Car-Trailers	Spaces for Cars
Town 1 North, Range 17 East, Section:						
4	Chapin Road/Town..........	Ramp[c]	N	66	0	0
6	Williams Bay.............	2 ramps[c]	G	100	200	100
6	Hansons/Village[b].........	Livery[c]	G	50	0	20
6	Fishing Hut/Village[b].....	Livery[c]	G	50	0	16
6	Carlson/Village[b].........	Livery[c]	G	40	0	35
6	Gage/Private.............	2 ramps	G	300	0	0
8	Black Point/Town.........	Walk-in-trail	N	66	0	0
8	Lake View/Town...........	Walk-in-trail	N	150	0	0
9	Woodale/Town.............	Walk-in-trail	G	60	6	0
10	Linn Pier/Town...........	Ramp[c]	G	75	25	0
11	Hillside/Town............	Ramp[c]	G	60	35	6
12	Van Dyke/Private.........	Livery[c]	G	150	0	55
18	Shadow Lane/Town.........	Ramp[c]	G	66	4	0
18	Walk Access/Town.........	Walk-in-trail	G	10	0	0
18	Yacht Club/Private.......	Ramp	G	100	40	20
18	Boat Co./Private.........	Ramp	G	120	40	20
Town 1 North, Range 16 East, Section:						
12	Abbey Sprigs/Private.....	Ramp	G	400	40	20
13	Public Road/Village......	Ramp[c]	G	66	50	20
14	Abbey/Private............	2 Ramps	G	1,000+	50+	200
14	Gordey/Private...........	Ramp[c]	G	100	10	5
14	Fontana..................	Ramp[c]	G	66	60	100+
Town 2 North, Range 16 East, Section:						
6	Lake Geneva..............	2 ramps[c]	G	1,000	30	Unlimited
16	Library Park/City........	Ramp	G	800	Unlimited	Unlimited
35	Shady Lane/Town..........	Walk-in-trail	N	66	0	0

[a]Code: G = Good.
N = Maintenance needed.

[b]Leased privately.

[c]Available to the public at posted times, fees, and regulations.

Source: Wisconsin Department of Natural Resources.

sites operated by municipalities which provide adequate boat launching and parking facilities. Many of the other access sites have either limited parking areas or limitations on the size of craft that can be launched. However, small boats can be launched from these sites, as some liveries allow launching of smaller craft, and some walk-in sites may be used for launching canoes. Boat launching fees vary from one public launching site to another, but at most sites it is pro-rated by the type of boat. Residents of the municipalities have free launching at their respective launching sites.

The Wisconsin Department of Natural Resources, under guidelines established in the Wisconsin Administrative Code, Chapters NR 1.90 and NR 1.92, recommended that at least one access and public boat launching site open to the general public be provided on all major inland lakes. The DNR recommendation for a publicly owned boat access on Geneva Lake is met by a boat access maintained by the Village of Fontana.[6]

Approximately 68 boats per day were launched from the municipal public launching sites on weekends and holidays during the study period. The count does not include residents, who have free launching privileges. The number of weekday boat launches is difficult to determine because several of the sites have free or unattended launching. In addition to municipal launching sites, 10 liveries rent boats. Although the majority of boats rented are fishing craft, several of the liveries also rent power boats.

<u>Boating</u>: Geneva Lake's size, depth, and water quality make it one of the best-suited lakes in southeastern Wisconsin for boating. Boat service facilities are available in the lake communities and, as mentioned above, there are several rental facilities located around the lake. Boat usage on Geneva Lake, especially of power boats, has been a primary concern of many residents in the watershed. Surveys and inventories show that the number of boats on the lake and the type of boating vary, depending upon the time of day, day of the week, time of the year, and weather conditions.

The Geneva Lake Water Safety Patrol--1973 to 1977--and the Geneva Lake Environmental Agency--1979 through 1985--conducted annual boat counts of the total number of boats docked and moored, and of the number of boats being used on the lake. Table 49 sets forth the results of these surveys taken from 1973 through 1985. In 1985, the Geneva Lake Environmental Agency boat count (Wednesday, August 7, 1985) revealed a total of 4,459 boats in use and moored on the lake; of this total, 2,598, or 58 percent, were power-boats; 974, or 22 percent, were sail boats; and 887, or 20 percent, were canoes, dinghies or fishing boats. From 1973 to 1985, the average number of boats in use and moored on the lake increased by 22 percent.

Estimates of the number of boats in use on the lake at a given time on a given day were also made by the Water Safety Patrol during the study period. Weekend counts were made at approximately 1:00 p.m. on each day. These weekend counts included both fishing boats--which are discussed above--and other types. These counts showed approximately 325 boats in use on Saturday, July 16, 1977; 500 boats in use on Sunday, July 3, 1977; and 500 boats in use on Sunday, July 17, 1977. Estimates made over the July 4, 1977 holiday revealed that about 650

---

[6]Information provided by Mr. Ronald Piening, DNR Waters Classification Specialist, August 19, 1983.

Table 49

BOAT CENSUSES FOR GENEVA LAKE: 1973-1985[a]

Boat Type	1973	1974	1975	1976	1977	1978[b]	1979	1980	1981	1982	1983	1984	1985
Motor	2,154	2,566	2,206	2,196	2,817	--	2,254	2,180	2,440	2,398	2,305	2,451	2,598
Sail	780	746	714	948	862	--	961	778	823	778	891	861	974
Other--Row, Canoe, Dinghy, and Small Fishing	719	606	763	572	493	--	829	898	1,259	1,136	870	1,131	887
Total	3,653	3,918	3,683	3,716	4,172	--	4,044	3,856	4,522	4,312	4,066	4,443	4,459

NOTE: This count includes all boats docked and moored as well as all boats in use at the times of the survey.

[a]Geneva Lake Water Safety Patrol conducted the 1973-1977 censuses; Geneva Lake Environmental Agency conducted the 1979 through 1985 censuses.

[b]No census conducted in 1978.

Source: Geneva Lake Environmental Agency.

boats were in use on the lake at one time. Excellent weather conditions, and sail boat races--which accounted for approximately 100 boats each day--may have increased the total number of boats inventoried. The majority of the vessels inventoried during the weekend censuses were power boats. However, since fishing always decreased between 10:00 a.m. and 5:00 p.m., the potential total daily use of the lake by fishing boats probably is greater than indicated by these surveys.

An average area of 15.9 acres per power or sail boat is considered suitable by SEWRPC for the safe and enjoyable use of a boat on a lake. Based on this criterion, a total of 331 boats would be the maximum number of boats that should be in use on Geneva Lake at a given time. In the aforementioned inventories, the number of acres per boat was 16.2, 8.2, and 84.4, respectively. Consequently, the number of boats operating on Geneva Lake is sometimes in excess of levels generally considered to be safe and enjoyable.

Recreational Rating: The Wisconsin Department of Natural Resources has developed a rating technique to summarize the outdoor recreational value of inland lakes. The quality of fishing, swimming, boating, and aesthetics for Geneva Lake was evaluated in 1969. As shown in Table 50, Geneva Lake scored 68 out of a possible 72 rating points, placing it among those lakes in southeastern Wisconsin providing diverse, high-quality outdoor recreational opportunities. To ensure that Geneva Lake will continue to provide such recreational opportunities, the resource values of the lake must be protected and preserved. Geneva Lake received the highest possible rating in every category except aesthetics, which was lowered by the lack of wild shoreline on the lake.

Table 50

RECREATIONAL RATING OF GENEVA LAKE: 1969

Fish: X 9 High production X 9 No problems Subtotal: 18	___ 6 Medium production ___ 6 Modest problems such as infrequent winterkill, small rough fish problems	___ 3 Low production ___ 3 Frequent and over-bearing problems such as winterkill, carp, excessive fertility
Swimming: X 6 Sand or gravel (50% or more) X 6 Clean water X 6 No algae or weed problems Subtotal: 18	___ 4 Sand or gravel ___ 4 Moderately clean ___ 4 Moderate algae or weed problems	___ 2 Sand or gravel (<25%) ___ 2 Turbid or darkly stained ___ 2 Frequent algae or weed problems
Boating: X 6 Adequate depths (75% of basin>5') X 6 Adequate size for extended boating (>1,000 acres) X 6 Good water quality Subtotal: 18	___ 4 Adequate depths (25-75% of basin >5' deep) ___ 4 Adequate size for some boating (200-1,000 acres) ___ 4 Some inhibiting factors such as weedy bays, algae blooms, etc.	___ 2 Adequate depths (50% of basin) ___ 2 Limit of boating challenge and space (<200 acres) ___ 2 Overwhelming inhibiting factors such as weed beds throughout
Aesthetics: ___ 6 Existence of 25% or more wild shore X 6 Varied landscape X 6 Few nuisances such as excessive algae, carp, dumps, etc. Subtotal: 14	___ 4 Less than 25% wild shore ___ 4 Moderately varied landscape ___ 4 Moderate nuisance conditions	X 2 No wild shore ___ 2 Unvaried landscape ___ 2 High nuisance condition
Total Quality Rating: 68 out of a possible 72		

Source: Wisconsin Department of Natural Resources.

Chapter VI

MANAGEMENT AND LEGAL CONSIDERATIONS AFFECTING WATER QUALITY

SEWAGE DISPOSAL

Because of the potential aesthetic, public health, and pollution problems associated with improper disposal of sanitary sewage, the sound management of sanitary wastewater is one of the most important lake water quality management efforts. This management activity must address both privately owned, onsite, sewage disposal methods and public sanitary sewerage systems.

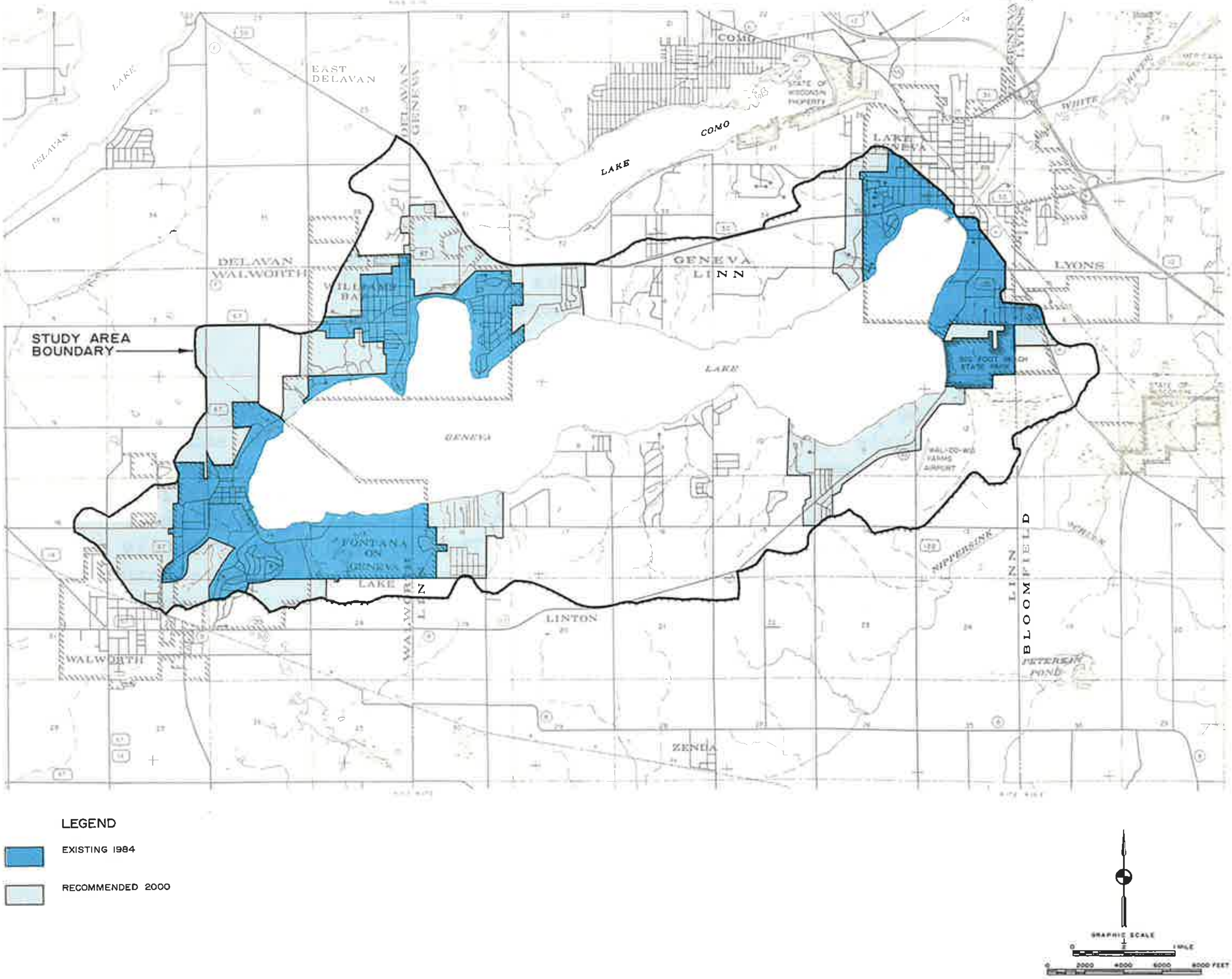
Sanitary Sewer Service

In 1984, about 4,300 persons, or 57 percent of the resident population of the drainage area directly tributary to Geneva Lake, received public sanitary sewer service from systems operated by either the City of Lake Geneva or the Villages of Fontana and Williams Bay. The existing 1984 and proposed year 2000 sanitary sewer service areas--as embodied in the adopted regional water quality management plan--are delineated on Map 14. The regional plan presently calls for the Lake Geneva sewage treatment plant to be expanded to serve both the Lake Geneva and Lake Como sewer service areas. The Lake Geneva plant would provide an advanced level of treatment and would discharge the treated effluent primarily to land--but would have the ability to discharge also to the White River during certain times of the year, depending upon river flows and temperatures. In addition, the plan recommends that a new sewage treatment plant be constructed at Walworth to serve the Villages of Walworth and Fontana. That plant would also provide an advanced level of treatment with discharge into Piscasaw Creek. The plan further recommends that the Village of Williams Bay sewer system be connected to the Walworth County Metropolitan Sewerage District (Walcomet) sewer system via a connection trunk sewer system which could connect to the Walcomet system at the northeast end of Delavan Lake. These recommendations are contained in the areawide water quality management plan as documented in SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume Three, Recommended Plan, June 1979, as amended by the recommendations set forth in SEWRPC Amendment to the Regional Water Quality Management Plan--2000, Geneva Lake Area Communities, December 1983, and in SEWRPC Amendment to the Regional Water Quality Management Plan--2000, Village of Williams Bay/ Walworth County Metropolitan Sewerage District, March 1985. The implementation of these point source pollution abatement recommendations will eliminate the discharge of all public sewage treatment plant effluent in the drainage area directly tributary to Geneva Lake.

That portion of the existing service area of the City of Lake Geneva sewage treatment plant lying within the drainage area directly tributary to Geneva Lake totals about 1.31 square miles, with a resident population of about 975 persons. That portion of the existing service area of the Village of Fontana sewage treatment plant lying within the drainage area directly tributary to

Map 14

EXISTING (1984) AND PROPOSED (2000) SANITARY SEWER SERVICE AREAS FOR THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE



Source: SEWRPC.

Geneva Lake totals about 1.26 square miles with about 1,630 persons. The entire 1.21-square-mile service area of the Village of Williams Bay, which has a resident population of about 1,700 persons, lies within the drainage area directly tributary to Geneva Lake. The service area of the Village of Walworth sewage treatment plant does not include any area lying within the drainage area directly tributary to Geneva Lake.

As of 1984, about 3,890 acres, or about 30 percent, of the drainage area directly tributary to Geneva Lake were served by a public sanitary sewerage system. Approximately 3,250 additional acres of the direct drainage area are proposed to be served by public sanitary sewers by the year 2000. In all, a total of 7,140 acres, or 55 percent of the direct drainage area, will be served by sanitary sewers by the year 2000. It should be noted that a precise delineation of the plan year 2000 sewer service area is subject to refinement by the joint efforts of the local management agencies and the Regional Planning Commission, as recommended in the regional water quality management plan.

Onsite Sewage Disposal

The sanitary and household wastewaters from approximately 3,330 persons, or 43 percent of the population residing in the drainage area directly tributary to Geneva Lake as of 1984, 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 are used to store wastewater temporarily prior to being periodically pumped, with the wastes being conveyed by truck to a sewage treatment plant or land disposal site. As of 1984, approximately 1,200 septic tank systems, mound systems, and holding tanks were known to exist in the drainage area directly tributary to the lake.

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

Providing that 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 layer of impervious soil or bedrock, the system should operate with few problems for periods of up to 20 years. However, as previously noted, not all residential areas within the Geneva Lake direct drainage area are located in areas covered by soils suitable for septic tank use. It has been estimated that as of 1984, 667 septic systems, or about 40 percent, are located on soils with limitations for such use.

Failure of a septic tank system occurs when the soil surrounding the seepage area will no longer accept or properly stabilize the septic tank effluent, when the groundwater rises to levels which will no longer allow for uptake of liquid effluent by the soils, or when age or lack of proper maintenance cause the system to malfunction. Hence, septic system failure may result from improper location, poor installation, or inadequate maintenance. In many older, improper installations, 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 be a health hazard and add excessive nutrients to lake waters. A precise identification of septic system problems requires a sanitary survey.

Mound systems utilize mechanical facilities to pump septic tank effluent through one-inch-diameter, perforated distribution pipes placed in fill on top of the natural soil. When in place, this fill takes on the appearance of a mound; hence, the systems are commonly called "mound systems." A typical installation, designed to accommodate wastes from a four-bedroom, single-family home, might have a mound 64 feet wide by 84 feet long, or 5,376 square feet in areal extent, and would represent about 12 percent of the total area of a one-acre lot. At its highest point, the mound would be approximately five feet in height. As of 1984, there were about 50 mound systems in the Geneva Lake direct drainage area.

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 jurisdiction. As noted in Chapter III, the drainage area directly tributary to Geneva Lake includes portions of the City of Lake Geneva; Villages of Fontana, Walworth, and Williams Bay; and Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth, all in Walworth County. It should be noted that zoning in the five unincorporated towns in the direct drainage area is under the jurisdiction of the Walworth County Zoning Ordinance. The four cities and villages each administer their own zoning regulations. Consequently, five local zoning ordinances are administered within the drainage area directly tributary to Geneva Lake. The zoning ordinance for the City of Lake Geneva was initially approved and adopted in 1962 and was most recently revised in 1983. The zoning ordinances for the Villages of Fontana, Walworth, and Williams Bay were initially approved and adopted in 1971, 1967, and 1974, respectively, and were most recently revised in 1983, 1975, and 1985, respectively. The Walworth County Zoning Ordinance was initially approved and adopted by Walworth County in September 1974 and ratified by the Town of Bloomfield in August 1975, Town of Delavan in November of 1974, and Town of Geneva in September 1974, and was most recently amended by the County in June 1983. A summary of the zoning districts available for use in the nine local civil divisions is presented in Appendix B. The areas of land placed in each of the districts are shown on Map 15.

In addition to the five general zoning ordinances administered in the Geneva Lake direct drainage area, the Walworth County Board of Supervisors adopted a Shoreland Zoning Ordinance in 1974. This ordinance, prepared pursuant to the requirements of the Wisconsin Water Resources Act of 1965, imposes special land use regulations on all unincorporated lands located within 1,000 feet of the shoreline of 37 lakes and ponds in the County 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 Zoning Ordinance is similar in content to the Walworth County Zoning Ordinance but includes additional regulations intended to protect waterways and their attendant shorelines.

Chapter 330 of the Wisconsin Statutes requires that counties regulate the use of all wetlands five acres or larger in area located in shoreland areas of the unincorporated areas of the county--that is, regulate the use of all wetlands in 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 Walworth County were prepared for the Wisconsin Department of Natural Resources (DNR) by the Regional Planning Commission in 198 . In accordance with Chapter 115 of the Wisconsin Administrative Code, Walworth County has updated its shoreland zoning regulations and attendant maps to preclude further loss of wetlands in the shoreland areas. These zoning modifications and maps were adopted in 1983. In accordance with Chapter NR 117, cities and villages are also required to protect shoreland-wetland areas following the receipt of final wetland inventory maps from the DNR. To date, none of the incorporated areas in the drainage area directly tributary to Geneva Lake have received these final maps.

EXISTING LAKE MANAGEMENT

Lake management activities which have been used or are underway include macrophyte harvesting, chemical control of macrophytes and algae, water quality monitoring, and air quality monitoring. Each of these programs is discussed below.

Aquatic Plant Management

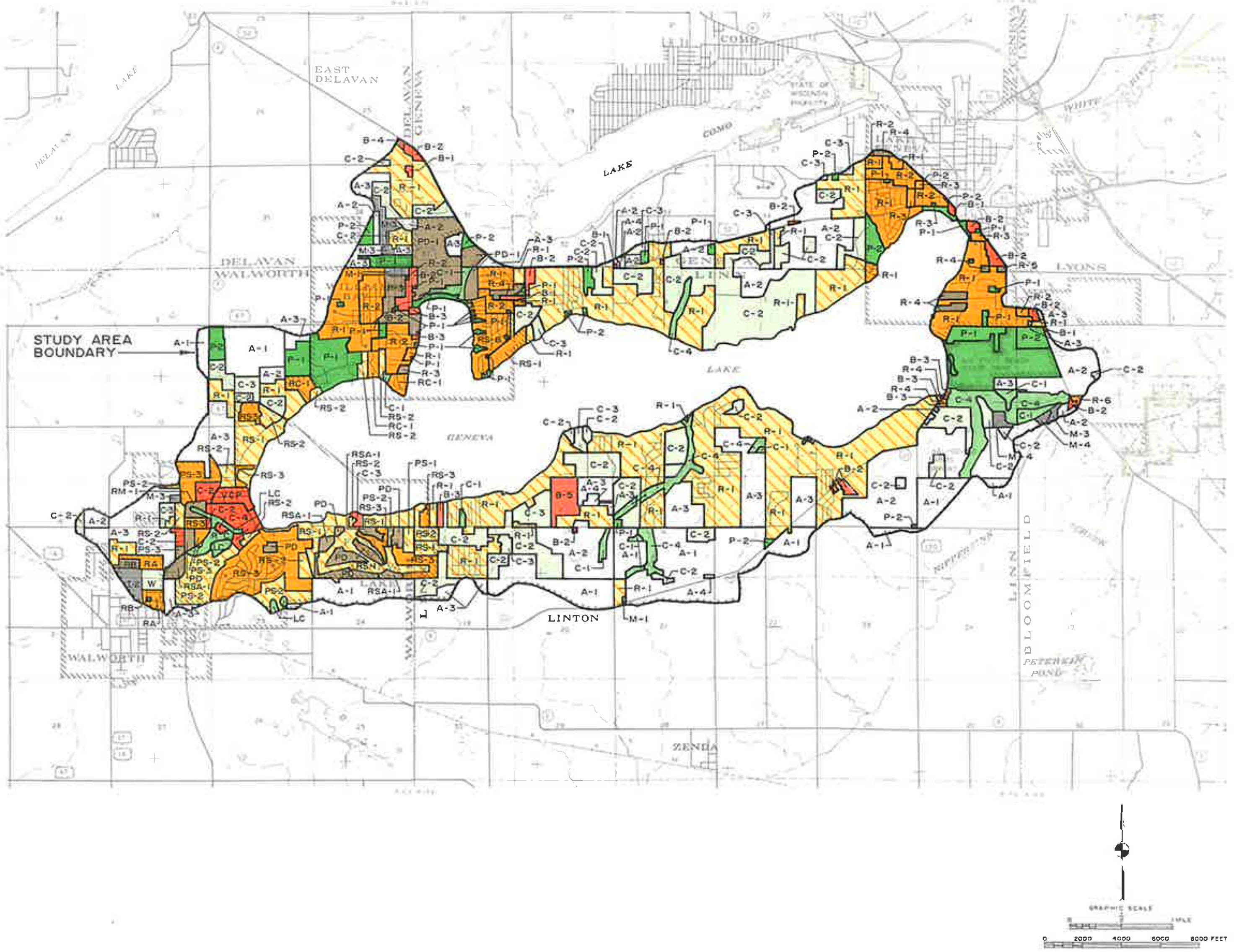
Records of aquatic plant management efforts were not maintained by the Wisconsin Department of Natural Resources prior to 1950. Therefore, the efforts to manage the aquatic plants in Geneva Lake were first recorded in 1950. Aquatic plant management for Geneva Lake can be categorized as macrophyte harvesting, chemical macrophyte control, and chemical algae control. In addition, the lake is treated for control of swimmer's itch.

Macrophyte Harvesting: Limited and sporadic localized harvesting of aquatic macrophytes has been conducted on Geneva Lake. However, nuisance concentrations of aquatic weeds generally do not occur to a large enough extent to require harvesting. No extensive harvesting of aquatic macrophytes has occurred on Geneva Lake since 1976.

Chemical Macrophyte Control: Since 1941, the use of chemicals to control aquatic plants has been regulated in Wisconsin, although chemicals were used to control aquatic plant growth in lakes and streams prior to this date. In 1926, sodium arsenite, an agricultural herbicide, was first applied to lakes in the Madison (Wisconsin) area. By the 1930's, sodium arsenite was widely used for aquatic plant control, and no other chemicals were applied in significant amounts to control macrophytes. As indicated in Table 51, a total of 40,548 pounds of sodium arsenite were applied to Geneva Lake between 1950 and

Map 15

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



LEGEND FOR MAP 15

ZONING DISTRICT CLASSIFICATION

- (yellow hatched) LOW-DENSITY URBAN RESIDENTIAL (CONTAINS DISTRICTS PERMITTING FROM 0.7 TO 2.2 DWELLING UNITS PER NET ACRE)
- (orange) MEDIUM-DENSITY URBAN RESIDENTIAL (CONTAINS DISTRICTS PERMITTING FROM 2.3 TO 6.9 DWELLING UNITS PER NET ACRE)
- (brown) HIGH-DENSITY URBAN RESIDENTIAL (CONTAINS DISTRICTS PERMITTING FROM 7.0 TO 17.9 DWELLING UNITS PER NET ACRE)
- (red) BUSINESS (CONTAINS DISTRICTS PERMITTING NEIGHBORHOOD-ORIENTED, COMMUNITY-ORIENTED, HIGHWAY-ORIENTED, AND OFFICE DEVELOPMENT)
- (gray) MANUFACTURING (CONTAINS DISTRICTS PERMITTING LIGHT INDUSTRIAL DEVELOPMENT, QUARRYING, AND RELATED DEVELOPMENT)
- (dark green) PARK(CONTAINS DISTRICTS PERMITTING PUBLIC AND PRIVATE RECREATIONAL AND RELATED OPEN SPACE DEVELOPMENT)
- (green) LOWLAND CONSERVANCY (CONTAINS DISTRICTS WHICH SERVE TO PROTECT THE NATURAL RESOURCES WITHIN WETLANDS AND RELATED OPEN SPACE AREAS)
- (light green) UPLAND CONSERVANCY (CONTAINS DISTRICTS WHICH SERVE TO PROTECT SIGNIFICANT WOODLANDS AND RUGGED TERRAIN)
- (white) GENERAL AGRICULTURAL (CONTAINS DISTRICTS WHICH PROVIDE FOR CROP PRODUCTION AND RAISING OF LIVESTOCK)

ZONING DISTRICTS BY CIVIL DIVISION

CITY OF LAKE GENEVA

BASIC DISTRICTS

R-1	SINGLE-FAMILY RESIDENCE DISTRICT
R-2	DUPLEX RESIDENCE DISTRICT
R-3	GENERAL RESIDENCE DISTRICT
R-4	PLANNED RESIDENTIAL DEVELOPMENT DISTRICT
R-5	MOBILE HOME PARK RESIDENCE DISTRICT
P-1	PARK DISTRICT
P-2	INSTITUTIONAL PARK DISTRICT
C-2	LOWLAND RESOURCE CONSERVATION DISTRICT
B-1	DOWNTOWN BUSINESS DISTRICT
B-2	GENERAL BUSINESS DISTRICT

VILLAGE OF FONTANA-ON-GENEVA LAKE

BASIC DISTRICTS

RS-1	SINGLE-FAMILY RESIDENTIAL DISTRICT
RS-2	SINGLE-FAMILY RESIDENTIAL DISTRICT
RS-3	SINGLE-FAMILY RESIDENTIAL DISTRICT
RSA-1	SINGLE-FAMILY ATTACHED RESIDENTIAL DISTRICT
VCP	VILLAGE CENTER PRESERVATION DISTRICT
RM-1	MULTIPLE-FAMILY RESIDENTIAL DISTRICT
PD	PLANNED DEVELOPMENT DISTRICT
RC	RESTRICTED CONSERVANCY DISTRICT
LC	LIMITED CONSERVANCY DISTRICT
C-2	GENERAL COMMERCIAL DISTRICT
C-3	LAKESHORE COMMERCIAL DISTRICT
C-4	RESORT COMMERCIAL DISTRICT

PERFORMANCE STANDARD DISTRICTS

PS-1	PERFORMANCE STANDARD DISTRICT-RURAL
PS-2	PERFORMANCE STANDARD DISTRICT-INTERMEDIATE
PS-3	PERFORMANCE STANDARD DISTRICT-MIXED

OVERLAY DISTRICT

OIP	INSTITUTIONAL AND PUBLIC SERVICE DISTRICT

VILLAGE OF WALWORTH

BASIC DISTRICTS

RA	SINGLE-FAMILY RESIDENCE DISTRICT
RB	MULTI-FAMILY RESIDENCE DISTRICT
I-2	INDUSTRIAL DISTRICT
W	CONSERVANCY DISTRICT

Source: Local Units of Government and SEWRPC.

VILLAGE OF WILLIAMS BAY

BASIC DISTRICTS

R-1	SINGLE-FAMILY RESIDENTIAL DISTRICT
R-2	SINGLE-FAMILY RESIDENTIAL DISTRICT
R-3	MULTI-FAMILY RESIDENTIAL DISTRICT
R-4	MULTI-FAMILY RESIDENTIAL DISTRICT
RC-1	RECREATIONAL CAMP DISTRICT
RS-1	SINGLE-FAMILY RESIDENTIAL DISTRICT
RS-2	SINGLE-FAMILY RESIDENTIAL DISTRICT
RS-6	CEDAR POINT PARK SUBDIVISION
B-1	NEIGHBORHOOD BUSINESS DISTRICT
B-2	COMMUNITY BUSINESS DISTRICT
B-3	WATERFRONT BUSINESS DISTRICT
M-1	INDUSTRIAL DISTRICT
C-1	CONSERVANCY DISTRICT
P-1	PUBLIC AND SEMIPUBLIC
PD-1	PLANNED DEVELOPMENT DISTRICT

TOWNS OF BLOOMFIELD, DELAVAN, GENEVA, LINN, AND WALWORTH

A-1	PRIME AGRICULTURAL LAND DISTRICT
A-2	AGRICULTURAL LAND DISTRICT
A-3	AGRICULTURAL LAND HOLDING DISTRICT
A-4	AGRICULTURAL-RELATED MANUFACTURING, WAREHOUSING AND MARKETING DISTRICT
C-1	LOWLAND RESOURCE CONSERVATION DISTRICT (NONSHORELAND)
C-2	UPLAND RESOURCE CONSERVATION DISTRICT
C-3	CONSERVANCY-RESIDENTIAL DISTRICT
C-4	LOWLAND RESOURCE CONSERVATION DISTRICT (SHORELAND)
P-1	RECREATION PARK DISTRICT
P-2	INSTITUTIONAL PARK DISTRICT
R-1	SINGLE-FAMILY RESIDENCE DISTRICT (UNSEWERED)
R-4	MULTIPLE-FAMILY RESIDENCE DISTRICT (SEWERED OR UNSEWERED)
R-6	PLANNED MOBILE HOME PARK RESIDENCE DISTRICT
B-1	LOCAL BUSINESS DISTRICT
B-2	GENERAL BUSINESS DISTRICT
B-3	WATERFRONT BUSINESS DISTRICT
B-4	HIGHWAY BUSINESS DISTRICT
B-5	PLANNED COMMERCIAL-RECREATION BUSINESS DISTRICT
M-1	INDUSTRIAL DISTRICT
M-3	MINERAL EXTRACTION DISTRICT
M-4	SANITARY LANDFILL DISTRICT

Table 51

CHEMICAL CONTROL OF AQUATIC PLANTS AND SWIMMER'S ITCH IN GENEVA LAKE: 1950-1984

		Algae Control			Swimmer's Itch Control		Macrophyte Control				
Year	Total Acres Treated	Copper Sulfate (pounds)	Blue Vitriol (pounds)	A & V-70	Copper Sulfate/ Copper Carbonate (pounds)	Copper Sulfate/ Lime (pounds)	Sodium Arsenite (pounds)	2,4-D (gallons)	Diquat (gallons)	Endothal	Aquathol
1950	--	--	1,050.0	--	--	--	1,200	--	--	--	--
1951	--	--	1,365.0	--	--	--	2,600	--	--	--	--
1952	--	--	1,280.0	--	--	--	1,188	--	--	--	--
1953	--	--	660.0	--	--	--	1,000	--	--	--	--
1954	--	--	1,410.0	--	--	--	720	--	--	--	--
1955	--	--	770.0	--	--	--	960	--	--	--	--
1956	--	--	1,000.0	--	--	--	2,360	--	--	--	--
1957	--	--	1,800.0	--	--	--	2,080	--	--	--	--
1958	278.0	--	1,450.0	--	150.0/400.0	--	1,920	--	--	--	--
1959	318.0	400.0	1,800.0	--	--	--	1,920	--	--	--	--
1960	435.4	--	1,550.0	--	--	--	2,160	--	--	--	--
1961	271.3	--	1,400.0	--	50.0/200.0	--	1,680	--	--	--	--
1962	22.0	--	1,500.0	--	--	--	2,040	--	--	--	--
1963	140.0	1,200.0	--	--	250.0/500.0	--	--	--	--	--	--
1964	112.0	900.0	--	--	450.0/900.0	--	--	--	--	--	675.0 pounds
1965	331.3	1,720.0	--	--	450.0/900.0	--	12,960	--	1.0	--	600.0 pounds
1966	112.0	400.0	--	--	--	350.0/720.0	--	--	3.0	--	--
1967	23.0	--	--	--	--	400.0/800.0	5,760	--	3.0	--	500.0 pounds/ 70.0 gallons
1968	31.0	--	--	--	200.0/400.0	--	--	--	5.1	--	400.0 pounds/ 120.0 gallons
1969	26.0	60.0	--	--	--	250.0/650.0	--	--	34.0	--	1,000.0 pounds/ 30.0 gallons

Table 51 (continued)

Year	Total Acres Treated	Algae Control: Copper Sulfate (pounds)	Algae Control: Blue Vitriol (pounds)	Algae Control: A & V-70	Swimmer's Itch Control: Copper Sulfate/ Copper Carbonate (pounds)	Swimmer's Itch Control: Copper Sulfate/ Lime (pounds)	Macrophyte Control: Sodium Arsenite (pounds)	Macrophyte Control: 2,4-D (gallons)	Macrophyte Control: Diquat (gallons)	Macrophyte Control: Endothal	Macrophyte Control: Aquathol
1970	81.9	215.0	--	--	362.0/725.0	--	--	--	42.5	66.0 gallons	650.0 pounds
1971	105.5	400.0	--	--	325.0/650.0	87.5/175.0	--	--	20.0	--	1,550.0 pounds/ 65.0 gallons
1972	88.3	190.0	--	--	350.0/700.0	50.0/100.0	--	--	30.0	--	1,590.0 pounds/ 59.5 gallons
1973	77.7	103.0	--	--	350.0/700.0	25.0/50.0	--	25.0	20.0	--	1,630.0 pounds/ 48.0 gallons
1974	86.4	390.0	--	--	350.0/700.0	110.0/225.0	--	30.0	17.5	1,070.0 pounds/ 18.0 gallons	--
1975	92.3	--	214.7	10.0 pounds/ 13.0 gallons	--	350.0/800.0	--	7.5	32.5	1,400.0 pounds/ 7.0 gallons	--
1976	51.7	115.0	--	15.0 pounds/ 3.0 gallons	--	410.0/725.0	--	2.0	17.5	1,900.0 pounds/ 17.0 gallons	--
1977	30.3	--	--	20.0 gallons	--	529.0/1,075.0	--	1.0	16.8	19.3 gallons	--
1978	31.1	--	--	11.0 gallons	--	--	--	19.2	--	250.0 pounds 16.5 gallons	--
1979	18.4	4.0	--	10.0 pounds/ 5.5 gallons	--	170.0/350.0	--	17.0	12.0	6.0 gallons	--
1980	30.2	30.5	--	7.2 gallons	90.0/175.0	227.0/455.0	--	32.0	8.7	16.0 gallons	--
1981	18.3	--	--	7.0 gallons	415.0/825.0	--	--	25.5	--	--	5.0
1982	11.4	--	--	11.8 gallons	--	--/296.0	--	26.5	5.2	--	8.0
1983	5.7	--	--	14.0 gallons	--	--/250.0	--	5.0	6.5	--	3.5
1984	6.2	--	--	1.5 gallons	--	105.0/325.0	--	--	1.5	--	--
Total	2,835.4	6,127.5	17,249.7	35.0 pounds/ 94.0 gallons	3,792.0/7,775.0	3,063.5/6,996.0	40,548	190.7	276.8	4,620.0 pounds/ 165.8 gallons	8,595.0 pounds/ 409.0 gallons

Source: Wisconsin Department of Natural Resources.

Table 52

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 constitutes 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.

1967. The amounts of sodium arsenite applied to the 10 lakes receiving the largest amounts of sodium arsenite in southeastern Wisconsin, which do not include Geneva Lake, are shown in Table 52.

The sodium arsenite was usually sprayed within 200 feet of the shoreline. Treatment typically occurred between mid-June and mid-July. The amount of sodium arsenite used was calculated to result in a concentration of about 10 parts per million sodium arsenite in the treated lake water. Most of the sodium arsenite remained in the water column for less than 120 days. The arsenic residue was naturally converted from the highly toxic trivalent form to a less toxic and less biologically active pentavalent form. Much of the arsenic residue was deposited in the lake sediments. Algae, diatoms, and macrophytes have been known to concentrate arsenic in their tissue to levels exceeding 2,000 micrograms per gram (µg/g) dry weight. However, biomagnification of arsenic through the food chain has not been known to occur.

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

During anaerobic conditions, arsenic may be released from the bottom sediments to the water. In this way, some arsenic probably continues to be "flushed out" of Geneva Lake through the outlet. In addition, the arsenic-laden sediments are continually being covered by new sediments. Therefore, the level of arsenic in the water and in the surface sediments may be expected to decrease with the passage of time.

As shown in Table 51, the aquatic herbicides 2,4-D, Diquat, Endothal, and Aquathol have also been applied to Geneva Lake to control aquatic macrophyte growth. All of these chemical herbicides were applied after 1963. As shown in Table 51, in 1984 there was very limited use of chemicals to control macrophytes on Geneva Lake. Presently, the Geneva Lake Association applies for the necessary Department of Natural Resources permits for chemical treatment, which are required under Chapter NR 107 of the Wisconsin Administrative Code. Application of chemicals is conducted on a contractual basis by a local operator. All aquatic plant control chemicals used today must be approved by the U. S. Environmental Protection Agency and Wisconsin Department of Natural Resources. Moreover, the Federal Insecticide, Fungicide, and Rodenticide Act as amended in 1972 requires that all pesticides be registered.

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

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

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

3. Since much of the dead plant material is not removed from the lake, the nutrients contained in the plant material will later be released to the water. Decomposition of the dead plant bodies also consumes dissolved oxygen and increases the potential for fish kills.

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

5. Adverse impacts on other aquatic organisms may be expected. Diquat has been known to kill the zooplankton Daphnia (water fleas) and Hyalella (scuds) at the concentrations used for macrophyte control. Both Daphnia and Hyalella are important fish foods, and Daphnia is a primary food for the young of nearly all fish species.[1]

Chemical Algae Control: Algicides, such as copper sulfate, Blue Vitriol, and A & V-70, have been applied to Geneva Lake to control nuisance algae blooms. The specific concentrates of copper sulfate, Blue Vitriol, and A & V-70-plus applied to Geneva Lake, beginning as early as 1950, are shown in Table 51. In 1984, there was very limited use of chemicals to control algae on Geneva Lake.

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

The advantages and disadvantages of chemical macrophyte control discussed above also apply to the chemical control of algae. Like arsenic, copper, the active ingredient in algicides, may accumulate in the bottom sediments. Excessive levels of copper are toxic to fish and benthic animals.

Chemical Control of Swimmer's Itch: As shown in Table 51, copper sulfate-lime and copper sulfate-copper carbonate mixtures have historically been applied along swimming beaches at Geneva Lake to kill snails. In 1984, approximately 6.0 acres of the lake were treated to eliminate snails and reduce the incidence of swimmer's itch. As discussed in Chapter V, snails are the intermediate host of a microscopic parasite which inbeds in skin, causing temporary itching and discomfort. Chemical treatment of beaches usually occurs in late June or early July, when concentrations of the problem organisms are greatest.

Water Quality and Air Quality Sampling

In recent years, the Geneva Lake Environmental Agency has expanded its monitoring programs to include atmospheric deposition, groundwater monitoring, and the use of the Geneva Lake Quality Index.

Atmospheric Deposition Monitoring: The atmospheric deposition monitoring was initiated out of concern over the contribution of atmosphere washout and fallout to the nutrient budgets of Geneva Lake. An effort to further assess that contribution led to the Agency becoming involved in the Wisconsin Acid Deposition Research Program (WADRP) in 1982. This program, a combined effort of the Wisconsin Department of Natural Resources, the Wisconsin Utilities Association, and the Wisconsin Public Service Commission, established a monitoring station in the Geneva Lake area maintained and operated by the Agency under contract to the DNR. Although the major purpose of this program was to assess acid deposition and its sources, nutrient deposition was also monitored through the analysis of all wet deposition on a per-event basis.

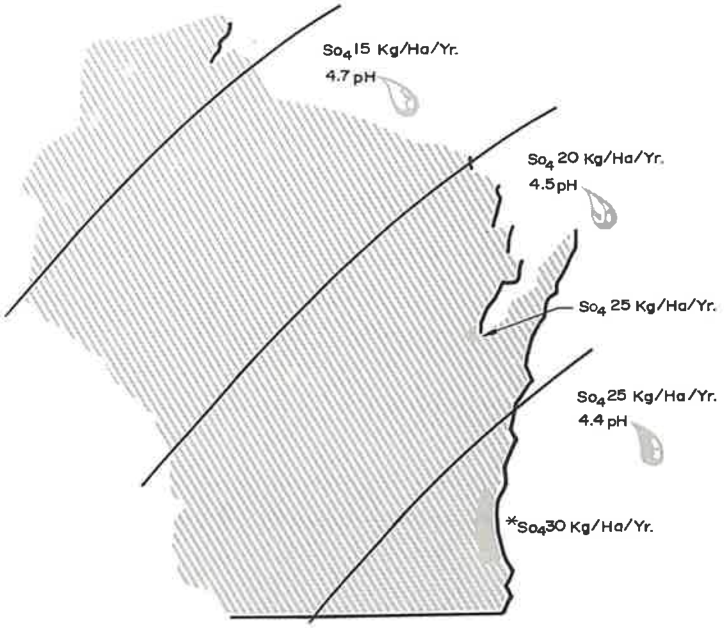
The WADRP findings have shown a gradient of acid deposition across the State, with the highest deposition taking place in southeastern Wisconsin (see Figures 11 and 12). This would suggest that rainfall in southeastern Wisconsin is more acidic than rainfall in northwestern Wisconsin. The impacts of this acid deposition are not yet fully understood. However, because of Geneva Lake's high alkalinity, the lake has the ability to neutralize this acid deposition.

In 1984, when the WADRP ended, the monitoring station became a part of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN). The Agency continues to maintain and operate the station under contract to the DNR. The major objective of the NADP/NTN is to collect atmospheric deposition data over a long period of time to document changes in wet deposition. To date, not enough information has been collected to show any trends in atmospheric deposition at the City of Lake Geneva site.

Groundwater Monitoring: Ongoing Agency groundwater monitoring includes the Wisconsin Pollutant Discharge Elimination System (WPDES) monitoring for the Villages of Williams Bay and Fontana, and U. S. Geological Survey groundwater elevation monitoring at the City of Lake Geneva and the Village of Fontana. Additionally, shallow groundwater elevations are periodically monitored at 11 wells installed around the lake during 1976.

Figure 11

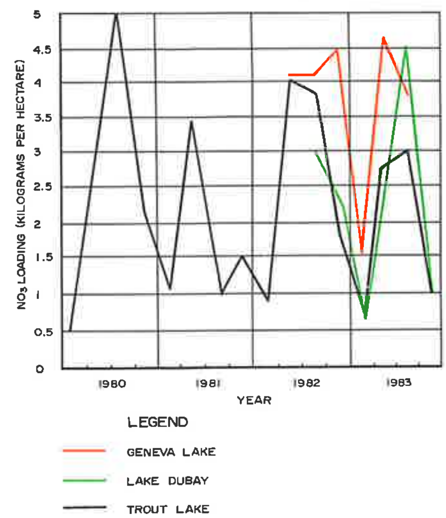
ACID DEPOSITION IN WISCONSIN



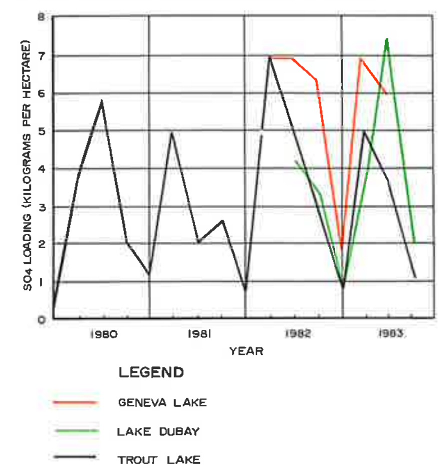
*Estimated values based on preliminary data.

Southeastern Wisconsin gets the most acidic deposition (dark portion of map—pH 4.4). The least is in northwestern Wisconsin (light portion of map—pH 4.7). Annual sulfate (SO_4) deposition is shown in kilograms per hectare per year (kg/ha/yr). Sensitive resources are considered at risk when the annual sulfate dose approaches 20 kg/ha/yr.

QUARTERLY NITRATE LOADING AT THREE MONITORING SITES IN WISCONSIN



QUARTERLY SULFATE LOADING AT THREE MONITORING SITES IN WISCONSIN



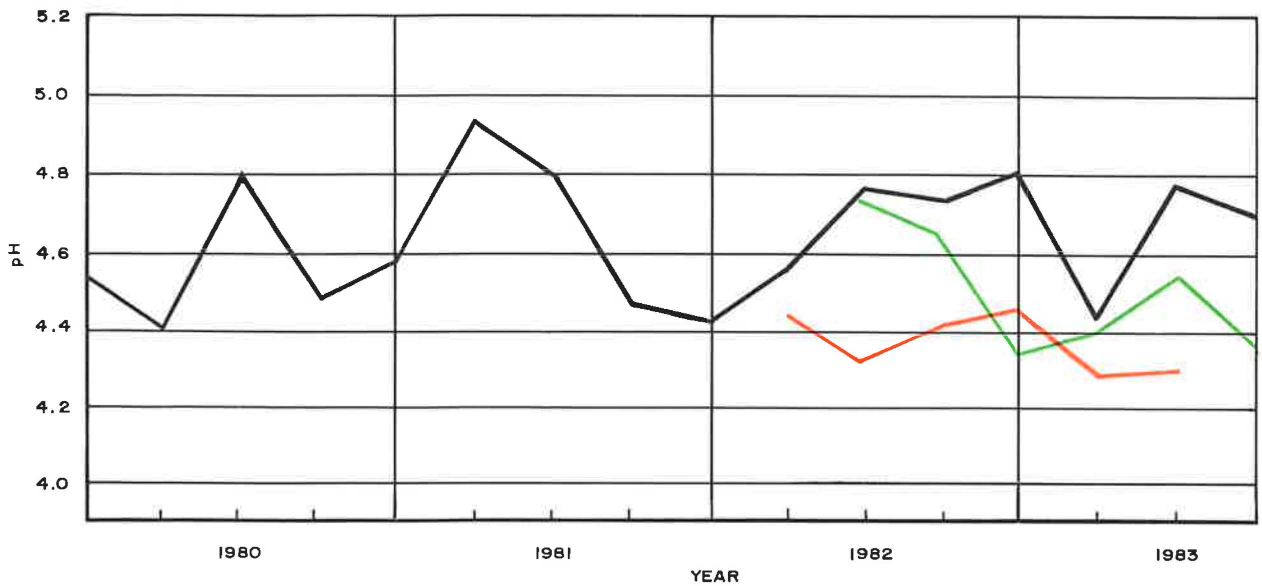
Source: "The Acid Test," Wisconsin Natural Resources, Volume 8, Number 6.

The WPDES groundwater monitoring is required by the DNR for the operation of sewage treatment plant effluent seepage cells by both the Villages of Fontana and Williams Bay. The impact of these seepage cells on the local groundwater movement and the quality is assessed through biannual monitoring of up-gradient and down-gradient wells. The seepage cells will be abandoned upon implementation of recommendations contained in the adopted areawide water quality management plan.

Sewage treatment plant effluent is generally high in dissolved solids such as chlorides, nitrogen, and sulfates. As shown in Table 53, data collected since 1979 at the old Fontana potable well located approximately one-third of a mile down groundwater gradient from the Fontana seepage ponds have shown increased levels of dissolved solids, specifically chlorides, nitrate, nitrate nitrogen, sulfate, and hardness.

Figure 12

PRECIPITATION pH AT THREE ATMOSPHERE MONITORING STATIONS IN WISCONSIN



Source: "The Acid Test," Wisconsin Natural Resources, Volume 8, Number 6.

Table 53

SELECTED GROUNDWATER DATA FROM THE FONTANA SEWAGE TREATMENT PLANT'S ABANDONED POTABLE WELL: 1979-1984

Component	1979	1980	1981	1982	1983	1984
Chlorides (mg/l)..	51.2	91.8	96.5	127.0	218.5	221.5
Nitrates (mg/l)...	0.217	0.106	0.010	0.016	0.017	1.770
Sulfate (mg/l)....	40.9	56.5	28.5	73.8	63.9	31.9
Hardness (mg/l CaCOg).....	259	352	468	381	421	380
Total Dissolved Solids (mg/l)....	480	554	460	702	873	782

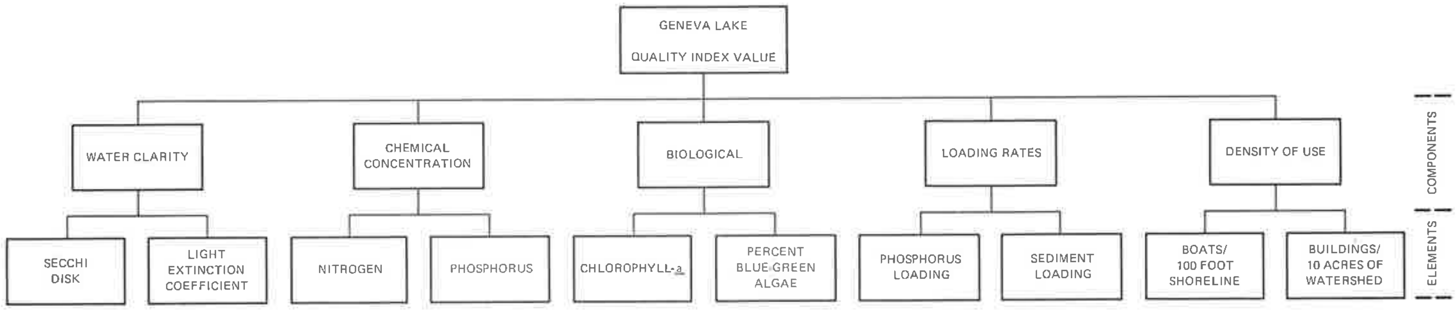
Source: Geneva Lake Environmental Agency.

Groundwater monitoring in the vicinity of the Village of Williams Bay seepage ponds has been conducted since June 1983. Not enough data have been collected to assess the impact of these ponds on local groundwater conditions.

Geneva Lake Quality Index: The Geneva Lake Quality Index (GLQI) is a lake assessment technique that was designed by the Geneva Lake Environmental Agency with the financial support of the Committee to Save Geneva Lake. The GLQI examines 10 different parameters at representative times throughout the year, not only to measure in-lake conditions but also to assess certain features of the watershed and the lake-watershed relationship, as shown in Figure 13.

Figure 13

GENEVA LAKE QUALITY INDEX FLOW CHART



1. MODEL IS COMPOSED OF FIVE COMPONENTS AND 10 ELEMENTS.
2. ELEMENTS OF EACH COMPONENT ARE ASSIGNED ELEMENT POINTS BASED UPON DATA.
3. ELEMENT POINTS OF EACH COMPONENT ARE ADDED TOGETHER FOR A COMPONENT VALUE.
4. COMPONENT VALUES ARE MULTIPLIED BY AN IMPORTANCE FACTOR FOR A WEIGHTED COMPONENT VALUE.
5. WEIGHTED COMPONENT VALUES ARE ADDED TOGETHER FOR A LAKE QUALITY INDEX.
6. INDEX RANGE 0 TO 100, WITH THE LOWER THE VALUE THE HIGHER THE QUALITY.

Source: Geneva Lake Environmental Agency.

The Index attempts to consider some of the many interrelated factors that affect lake quality, as shown in Figure 14. It assumes that the land uses in the lake watershed will affect the pollutant loading to the lake, which will in turn affect the in-lake nutrient levels, the biological community, and lake water clarity. The Index is comprised of five components that each have two elements. Points are assigned to each component based upon the data collected, the literature findings, and the history of Geneva Lake quality. The points for each component are then weighted in terms of their perceived relative importance to the lake environment to arrive at the Geneva Lake Quality Index value. The computation of the GLQI permits an annual assessment of the lake condition. It also establishes a measure against which the future health of the lake may be judged.

Lake quality data collected for use in the Geneva Lake Quality Index indicate that overall lake quality has changed little since 1981, as shown in Table 54. A comparison of selected components from the GLQI with data collected in 1976 indicates a slight increase in water quality over the last eight years, as shown in Table 55.

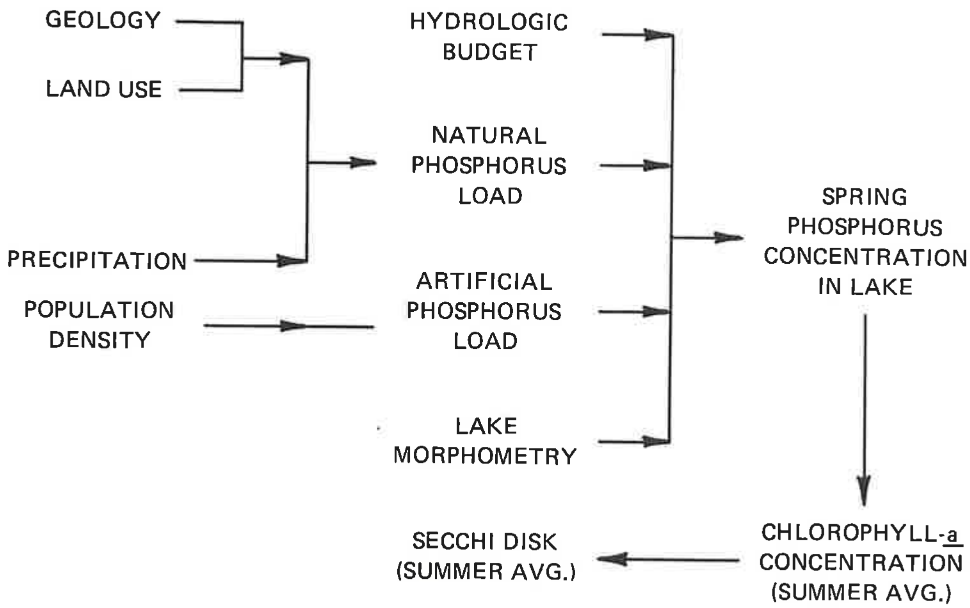
The elimination of the Fontana sewage treatment plant effluent overflow into Geneva Lake in 1979 may be responsible for the recent reduction in total in-lake phosphorus. A slight increase in secchi disk readings and a recent decrease in chlorophyll-a levels may be the manifestation of the reduced phosphorus loading and in-lake concentration. Total nitrogen levels have fluctuated, with a gradual increase shown in the last few years. Despite the increase, total nitrogen values are still less than the 1.36 mg/1 reported by Prescott in 1940.[2] Recent chloride data indicate that chloride concentrations have continued to rise. Concern over the chloride levels and their continual increase is discussed in a previous chapter of this report.

---

[2]G. W. Prescott, Algae of the Western Great Lakes Area, Cranbrook Institute of Science, Bulletin No. 31, 1951.

Figure 14

FACTORS AFFECTING LAKE QUALITY



Source: P. J. Dillon, 1974 "A Critical Review of Vollenweider's Nutrient Budget Models and Other Related Models." Water Resource Bulletin Volume 10.

Table 54

GENEVA LAKE QUALITY INDEX DATA: 1981-1984

Component	1981	1982	1983	1984
Water Clarity				
Secchi Disk[a]	4.2	4.2	4.0	4.0
Light Extinction Coefficient[a]	0.2859	0.3514	0.3725	0.3635
Chemical Concentration				
Total Nitrogen (mg/l)[b]	0.655	0.340	0.529	3.719
Total Phosphorus (mg/l)[b]	0.024	0.025	0.020	0.023
Biological				
Chlorophyll-a (mg/l)[a]	4.7	4.4	2.2	2.7
Percent Blue-Green Algae[a]	46.5	44.0	57.5	46.0
Loading Rates				
Phosphorus (pounds/acre)[c]	2.98	2.97	2.81	3.02
Sediment (tons/acre)[c]	4.18	4.18	4.17	4.18
Density of Use				
Boats per 100-Foot Shoreline[d]	4.2	4.0	3.8	4.2
Buildings per 10 Acres of Watershed[d]	5.1	2.6	5.2	5.3

[a]Based upon nine sample dates.

[b]Based upon a composite of six samples, each taken at a different depth, during spring turnover at the deepest point.

[c]Based upon land use data annually updated.

[d]Annual counts.

Source: Geneva Lake Environmental Agency.

Table 55

SELECTED GENEVA LAKE WATER QUALITY DATA

Component	1976	1981	1982	1983	1984
Secchi Disk (m)[a]	3.7	4.2	4.2	4.0	4.0
Chlorophyll-a (mg/m^3)[a]	3.6	4.7	4.4	4.4	2.7
Total Nitrogren (mg/l)[b]	0.462	0.656	0.375	0.540	0.912
Total Phosphorus (mg/l)[b]	0.011	0.025	0.025	0.020	<0.01
Chlorides (mg/l)[b]	13.8	N/A	N/A	26.5	23.5

NOTE: N/A indicates data not available.

[a]Average of at least nine samples taken throughout the year.

[b]Composite of six samples at various depths collected at spring turnover at the lake's deepest point.

Source: Geneva Lake Environmental Agency.

Bacterial surveys of various swimming beaches located around the lake, which were discussed in Chapter IV, continue to be conducted by the Geneva Lake Environmental Agency. Data for the 1984 sampling season are shown in Table 56. These data indicate that, overall, fecal coliform bacteria concentrations have not changed significantly since initiation of the beach sampling program in 1975. These concentrations do not interfere with recreational use of the lake.

GOVERNMENTAL AGENCIES AND LOCAL ORGANIZATIONS WITH WATER QUALITY MANAGEMENT RESPONSIBILITIES

A number of local state, and federal agencies and local organizations are responsible for Geneva Lake water quality management. These agencies include: the Geneva Lake Environmental Agency, and seven other local agencies concerned with lake management; a town sanitary district; five civil towns, one city, and three villages; the County; the county land conservation committee; the Regional Planning Commission; the Wisconsin Department of Natural Resources; the Wisconsin Department of Health and Social Services; the University of Wisconsin-Extension; the U. S. Environmental Protection Agency; the U. S. Department of Agriculture, Soil Conservation Service; and the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service. One additional agency which could be established in the lake drainage area is an inland lake protection and rehabilitation district. A discussion of the duties and functions of each of these units and agencies of government with respect to surface water quality management is presented in Chapter VI, Volume One, of SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000. The role of each of these agencies in lake water quality management is briefly discussed below.

Geneva Lake Environmental Agency

The Geneva Lake Environmental Agency was formed under Section 66.30 of the Wisconsin Statutes and is a local, intermunicipal, lake management agency. Elected officials from the five participating political subdivisions having all or part of their municipal limits within the watershed--the City of Lake Geneva and the Villages of Fontana and Williams Bay and Towns of Linn and

Table 56

AVERAGE MONTHLY FECAL COLIFORM BACTERIA CONCENTRATIONS AT GENEVA LAKE'S PUBLIC SWIMMING BEACHES: 1984

Swimming Beach	Colonies per 100 Milliliters		
	June	July	August
Williams Bay			
West End	40	25	12
Swim Area	40	20	10
Harris Mixing Zone	96	93	16
East End	44	18	10
Lake Geneva			
East End	54	23	10
Swim Pier	12	10	12
West End	104	12	16
Hillside Road			
100 Feet South of Lake	932[a]	332[a]	406[a]
Creek Mixing Zone	314[a]	148	46
Swim Area	60	65	20
Linn Pier			
Swim Area	58	58	14
Fontana			
Storm Sewer Mixing Zone	50	127	26
North End Guard Zone	14	17	10
Swim Pier	10	12	18
Abbey Channel	48	48	20

[a]Underlined averages exceed criteria for public swimming beaches.

Source: Geneva Lake Environmental Agency.

Walworth--serve as the Agency's Board of Directors. The Agency's primary responsibility is the provision of technical and educational information to maintain the desirable quality of both the land and water resources of the Geneva Lake watershed through proper land use and lake management. Agency activities include groundwater and surface water quality monitoring, periodic inventory and assessment of the biological communities, review and assessment of urban development within the watershed, conduct of educational programs for schools, public officials, and the general public, and the conduct of natural resource inventories and studies as needed. In addition, the Agency encourages the adoption of environmentally sound protective ordinances and acts as a vehicle through which the different communities can express concerns about the management of Geneva Lake and work jointly to maintain its desirable qualities.

Geneva Lake Law Enforcement Agency

The Geneva Lake Law Enforcement Agency, established in 1971, is comprised of members from the police forces of communities surrounding the lake. Police officers from the communities cruise the lake in a police boat enforcing the provisions of the state boating law, as well as the Joint Uniform Lake Law Ordinance. In addition to law enforcement, the officers are involved in public education and are available for assistance in emergencies.

Geneva Lake Level Corporation

The Geneva Lake Level Corporation was formed on April 24, 1894, to establish a spillway crest, dam, and sluice gate to be used for maintaining the lake level. The Corporation is comprised of eight directors who are responsible for the maintenance of the lake at a level that causes minimal problems associated with ice in the spring and lake-level fluctuation throughout the year. The Corporation has established a staff gage at the spillway crest and has made weekly lake-level readings since 1894. These readings are published in a monthly report of the Corporation.

Lake Geneva Water Safety Patrol

The Lake Geneva Water Safety Patrol was founded in 1927 to educate the lake population concerning boating safety. This scope was broadened in the early 1930's to include swimming safety instruction and the provision of lifeguards for area beaches. The Patrol is a nonprofit corporation with a 25-member board of directors. The Patrol employs a summertime staff of about 50 persons, including a director, assistant directors, swimming instructors, safety patrol boat crews, and lifeguards. Safety Patrol lifeguards man all six public beaches, and several private beaches on a contractual basis. The budgets of the operational staff and the boat operations are funded by private donations.

Geneva Lake Association

The Geneva Lake Association, Inc., organized in 1935, was originally known as the Geneva Lake Property Owners Association. The organization subsequently was renamed the Geneva Lake Civic Association and, more recently, the Geneva Lake Association. The Association is comprised of fee-paying property owners who elect directors and officers. It is open to anyone who is interested in promoting the general welfare and conservation of the Geneva Lake area. The Association has been active in establishing sanitation ordinances, protecting property, zoning, and the use of property boundary markers.

Committee to Save Geneva Lake

The Committee to save Geneva Lake was formed in 1977 in response to the pollution of Buena Vista Creek. After the resolution of this problem, the Committee expanded its scope of activity to become an environmental advocate for the lake. The Committee to Save Geneva Lake is financed through voluntary contributions, which help to fund the maintenance of the Geneva Lake Water Quality Index. The Committee publishes a lake environmental newsletter, works with local government for the development of sound environmental policies, and offers legal assistance in cases affecting the lake.

Geneva Lake Land Conservancy

The Geneva Lake Land Conservancy was incorporated in 1982 in order to meet the need for a local land trust which could provide landowners with options for the protection of the lake through sound land use. The Conservancy can purchase or accept donations of real estate or conservation easements on land in the Geneva Lake area.

Geneva Lake Association Environmental Education Foundation

The Geneva Lake Association Environmental Education Foundation, Inc., annually awards scholarships to qualified students of high academic standing at the four lake area high schools who demonstrate significant interest and intend further study in the environmental science field. The Foundation also provides student scholarships to Department of Natural Resources field courses in conjunction with the Geneva Lake Environmental Agency. Scholarship funding is by donation only.

Sanitary Districts

Sanitary districts may be created under Section 60.30 of the Wisconsin Statutes to plan, construct, and maintain centralized sanitary sewerage systems. In addition, town sanitary districts have limited authority to construct and maintain storm sewer systems and provide garbage and refuse collection and disposal. Such districts have also been used as an organizational vehicle for lake macrophyte harvesting on some lakes in southeastern Wisconsin. Presently, the only sanitary district in the watershed is the Linn Sanitary District. The main function of this sanitary district is to contract for solid waste collection and disposal for the area of Linn Township adjacent to Geneva Lake.

Towns

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

Cities and Villages

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

Counties

Counties are authorized to engage in soil and water conservation projects, lake and river improvements, property acquisitions, water protection, and solid waste management. In addition, counties may regulate nonpoint source pollution through their planning, zoning, subdivision, building, and health code authorities. County shoreland regulations apply to all areas within 1,000 feet of a lake, pond, or flowage and within 300 feet of a river or stream, or to the landward side of the floodplain, whichever is greater. Shoreland regulations impose special restrictions on the location of certain structures and establish restrictions on tree cutting, filling, grading, and certain agricultural practices within the shoreland areas.

County Land Conservation Committees

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

Regional Planning Commission

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

Wisconsin Department of Natural Resources

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

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

Wisconsin Department of Health and Social Services, Division of Health

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

University of Wisconsin-Extension

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

U. S. Environmental Protection Agency

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

U. S. Department of Agriculture, Soil Conservation Service

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

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

The U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, administers the federal Agricultural Conservation Program (ACP), which provides grants to rural landowners in partial support of approved soil, water, woodland, wildlife, and other conservation practices. These grants are awarded under yearly and long-term assistance programs, providing guaranteed funds for carrying out approved conservation work plans. Grants from the federal Agricultural Conservation Program are important to implementation of the areawide water quality management plan. In addition, the Agricultural Stabilization and Conservation Service has new authority under Section 208(J) of the Federal Water Pollution Control Act to administer a cost-sharing grant program for the purpose of installing and maintaining agricultural measures found needed to control nonpoint source pollution.

Inland Lake Protection and Rehabilitation Districts

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

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

that the positive public duty of this state as trustee of waters requires affirmative steps to protect and enhance this resource and protect environmental values.

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

The lake district has powers to enter into contracts; to own property; to disburse money; and to bond, borrow, and levy special assessments to raise money. Specifically, lake districts have the power to:

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

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

3. Implement lake rehabilitation techniques, including aeration, diversion, nutrient removal or inactivation, selective discharge, dredging, sediment covering, and drawdown.

4. Construct and operate water level control structures.

5. Control nonpoint source pollution.

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

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

- A county board member who is also on the Land Conservation Committee, who is appointed by the county board.

- A representative of the town, village or city which has the highest assessed valuation within the district, appointed by that governing body.

To date, no such district has been created to serve Geneva Lake.

PRIVATE ACTION FOR WATER POLLUTION CONTROL

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

Chapter VII

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS

The areawide water quality management plan prepared and adopted by the Regional Planning Commission, and set forth in SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, recommends water use objectives and supporting water quality standards for all major lakes and streams in the Region. The water use objectives recommended for Geneva Lake are full recreational use and support of a healthy, coldwater fishery. The water quality standards which support these objectives and existing (1976/1977) conditions in Geneva Lake are set forth in Table 57. Standards are recommended for temperature, pH, dissolved oxygen, fecal coliform, residual chlorine, un-ionized ammonia nitrogen, and total phosphorus.

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

The phosphorus concentration in a lake is directly related to the phosphorus load contributed to the lake via tributary runoff and atmospheric sources, although recycling of phosphorus from the lake bottom sediments may also occur. Figure 15 indicates the total phosphorus concentrations expected to be attained in Geneva Lake over the long term during spring turnover under alternative water quality management actions in the lake watershed. Failure to implement management measures in the lake watershed may be expected to result in continued excessive phosphorus levels, and a resulting decrease in water quality and water use potential. Complete implementation of the plan recommendations set forth in this report should result in the achievement of the phosphorus standard of 0.02 mg/l and subsequently provide water quality suitable for a full range of recreational use opportunities and for the support of a healthy coldwater fishery.

Table 57

RECOMMENDED WATER QUALITY STANDARDS TO SUPPORT RECREATIONAL AND COLDWATER FISH AND AQUATIC LIFE USE AND EXISTING (1976-1977) CONDITIONS IN GENEVA LAKE

Water Quality Parameter	Water Quality Standard	1976/1977 Conditions
Maximum Temperature[a,b]	70° F	76° F
pH Range	6.0-9.0 (standard units)	8.2
Minimum Dissolved Oxygen[b]	5.0 mg/l	4.0
Maximum Fecal Coliform[c]	200/400 MFFCC/100ml	9
Maximum Total Residual Chlorine	0.01 mg/l	--
Maximum Un-ionized Ammonia Nitrogen	0.02 mg/l	0.13
Maximum Total Phosphorus[d]	0.02 mg/l	0.03 mg/l
Other[f]	--[e]	--

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

[b]Dissolved oxygen and temperature standards apply to streams and the eplimnion of stratified lakes and to 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]Shall not exceed a monthly geometric mean of 200 per 100 ml based on not fewer than five samples per month nor a monthly geometric mean of 400 per 100 ml in more than 10 percent of all samples during any month.

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

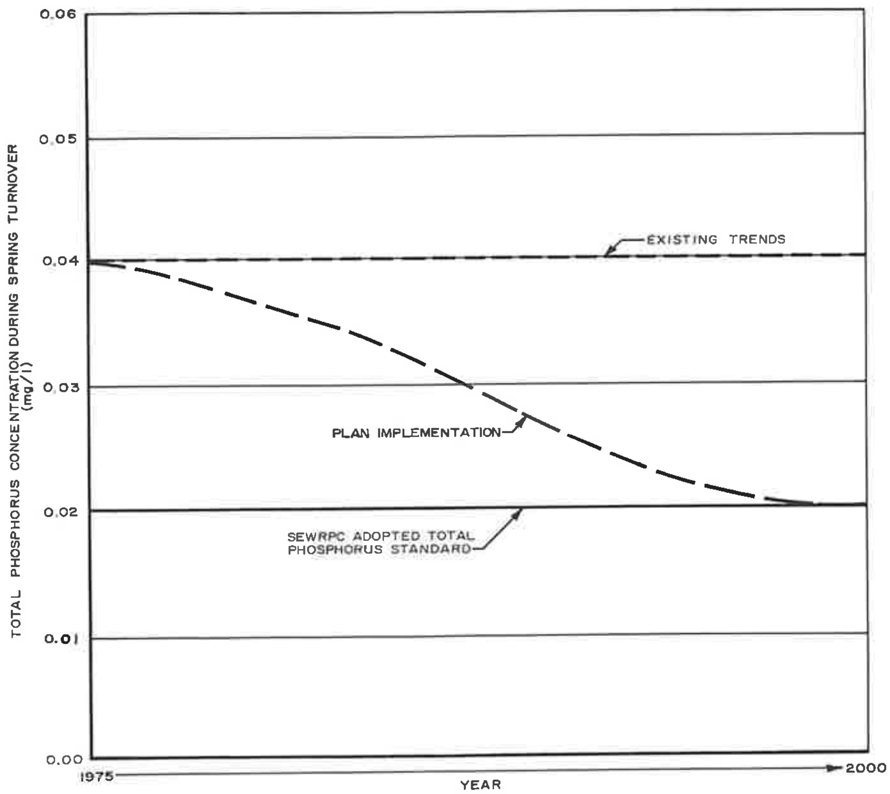
[e]All waters shall meet the following minimum standards at all times and under all flow conditions: Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating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

[f]Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life. The determination of the toxicity of a substance shall be based upon the available scientific data base. References to be used in determining the toxicity of a substance shall include, but not be limited to, Quality Criteria for Water, EPA-440/9-76-003, U. S. Environmental Protection Agency, Washington, D. C., 1976; Water Quality Criteria 1972, EPA-R3-73-003, National Academy of Sciences, National Academy of Engineering, U. S. Government Printing Office, Washington, D. C., 1974; and the Federal Register, "Environmental Protection Agency, Water Quality Criteria Documents; Availability," November 28, 1980. Questions concerning the permissible levels, or changes in the same, of a substance or combination of substances or undefined toxicity to fish and other biota shall be resolved in accordance with the methods specified in Water Quality Criteria 1972 and Standard Methods for the Examination of Water and Wastewater, 14th Edition, American Public Health Association, New York, 1975, or other methods approved by the Department of Natural Resources.

Source: SEWRPC.

Figure 15

TOTAL PHOSPHORUS LEVELS IN GENEVA LAKE UNDER ALTERNATIVE POLLUTION CONTROL ACTIONS



NOTE: TOTAL PHOSPHOROUS CONCENTRATIONS ARE SIMULATED USING THE DILLON–RIGLER MODEL.

Source: SEWRPC.

Chapter VIII

ALTERNATIVE WATER QUALITY MANAGEMENT MEASURES

INTRODUCTION

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

FUTURE LAND USE AND ASSOCIATED ZONING ORDINANCE MODIFICATIONS

A fundamental and basic element of any water quality management effort for Geneva Lake is the promotion of good land use 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, ultimately, the water quality of the lake. Existing 1980 and proposed year 2000 land use patterns in the direct drainage area are discussed in Chapters III and IX, respectively, while existing zoning regulations in the area are discussed in Chapter VI. Suggested modifications to the existing zoning designed to protect the water quality of Geneva Lake, while accommodating anticipated population growth and attendant development, are also presented in Chapter IX.

POINT SOURCE POLLUTION CONTROL

As discussed in Chapter VI, the adopted areawide water quality management plan recommends that the proposed Village of Walworth sewage treatment plant serve as an areawide facility, providing sewage treatment to the Villages of Fontana and Walworth. The plant is to provide an advanced level of treatment, with discharge of treated effluent to Piscasaw Creek. The City of Lake Geneva sewage treatment plant would also serve as an areawide facility, providing service to the City of Lake Geneva and Lake Como sanitary sewer service areas. The Lake Geneva plant would provide an advanced level of treatment and discharge treated effluent primarily to land, with the ability to discharge to the White River during certain times of the year. The regional plan further recommends that the Village of Williams Bay sanitary sewer system be connected to the Walworth County Metropolitan Sewage District sewer system by a connecting trunk sewer. The existing and proposed sanitary sewer service areas in the drainage area directly tributary to Geneva Lake are shown on Map 14 in Chapter VI.

As of 1984, there were no private wastewater treatment facilities in operation, nor any known industrial point sources of wastewater, which required treatment or elimination in the drainage area directly tributary to Geneva Lake.

NONPOINT SOURCE POLLUTION CONTROL

Nonpoint sources of water pollution include urban sources--such as runoff from residential, commercial, industrial, transportation, and recreational land uses, construction activities, and septic tank systems--and rural sources--such as runoff from cropland, pastureland, woodlands, livestock wastes, and atmospheric contribution.

The water quality analyses presented in this report indicated that nutrient loads from nonpoint sources in the tributary area would need to be reduced to meet the recommended water use objectives and supporting water quality standards. Alternative nonpoint source control measures are set forth in Table 58. An estimated 25 percent reduction in the urban and rural nonpoint source loads from the tributary drainage area would be needed to meet the recommended water use objectives and supporting standards, and would ultimately result in a phosphorus concentration during spring turnover of 0.02 milligram per liter (mg/l) in Geneva Lake. A detailed field survey is required to evaluate the urban and rural nonpoint source pollution problems in a specific area and to formulate recommendations for, and determine the costs of, abating pollution from such sources. Such an inventory and assessment could best be conducted by the staff of the Geneva Lake Environmental Agency with assistance from the Walworth County Land Conservation Committee and the U. S. Soil Conservation Service.

LAKE MANAGEMENT TECHNIQUES

The applicability of specific in-lake rehabilitation techniques is dependent on the physical and chemical characteristics of a lake, the effectiveness of the method for improving lake water quality, the need for instituting an in-lake rehabilitation or restoration program, and the costs. As discussed in SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative Plans, Geneva Lake is a large, deep body of water with few serious limitations to its use as a fishery and recreational resource. Standard in-lake rehabilitation techniques for water quality improvement, such as hypolimnetic aeration, dredging, drawdown, nutrient inactivation, dilution flushing, and selective discharge, would be either unnecessary or technically and financially infeasible. However, alternative measures for limiting concentrations of aquatic macrophytes and minimizing the swimmer's itch problem at the lake need to be evaluated.

Table 58

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

Applicable Land Use	Control Measures[a]	Summary Description[b]	Approximate Percent Reduction of Released Pollutants[c]	Assumptions for Costing Purposes
Urban	Litter and pet waste control ordinance	Prevent the accumulation of litter and pet wastes on streets and residential, commercial, industrial, and recreational areas	2-5	Ordinance administration and enforcement costs are expected to be funded by violation penalties and related revenues
	Improved timing and efficiency of street sweeping, leaf collection and disposal, and catch basin cleaning	Improve the scheduling of these public works activities, modify work habits of personnel, and select equipment to maximize the effectiveness of these existing pollution control measures	2-5	No significant increase in current expenditures is expected
	Management of onsite sewage treatment systems	Regulate septic system installation, monitoring, location, and performance; replace failing systems with new septic systems or alternative treatment facilities; develop alternatives to septic systems; eliminate direct connections to drain tiles or ditches; dispose of septage at sewage treatment facility	10-30	Replace one-half of estimated existing failing septic systems with properly located and installed systems and replace one-half with alternative systems, such as mound systems or holding tanks; all existing and proposed onsite sewage treatment systems are assumed to be properly maintained; assume system life of 25 years. The estimated cost of a septic tank system is $2,300 and the cost of an alternative system is $4,500. The annual maintenance cost of a disposal system is $45. A holding tank would cost $1,300 with an annual operation and maintenance cost of $1,200. However, because septic system management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, these costs are not included as part of the areawide water quality maintenance plan
	Increased street sweeping	On the average, sweep all streets in urban areas an equivalent of once or twice a week with vacuum street sweepers; require parking restrictions to permit access to curb areas; sweep all streets at least eight months per year; sweep commercial and industrial areas with greater frequency than residential areas	30-50	Estimate curb miles based on land use, estimated street acreage, and Commission transportation planning standards; assume one street sweeper can sweep 2,000 curb miles per year; assume sweeper life of 10 years; assume residential areas swept once weekly, commercial and industrial areas swept twice weekly. The cost of a vacuum street sweeper is approximately $38,000. The cost of the operation and maintenance of a sweeper is about $10 per curb/mile swept.
	Increased leaf and clippings collection and disposal	Increase the frequency and efficiency of leaf collection procedures in fall; use vacuum cleaners to collect leaves; implement ordinances for leaves, clippings, and other organic debris to be mulched, composted, or bagged for pickup	2-5	Assume one equivalent mature tree per residence plus five trees per acre in recreational areas; 75 pounds of leaves per tree; 20 percent of leaves in urban areas not currently disposed of properly. The cost of the collection of leaves in a vacuum sweeper and disposal is estimated at $25 per ton of leaves

Table 58 (continued)

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

Table 58 (continued)

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

Table 58 (continued)

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

Table 58 (continued)

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

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

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

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

Source: SEWRPC.

Aquatic Plant Harvesting

Macrophyte harvesting practices on Geneva Lake have been sporadic and scattered. Historically, a limited amount of weed harvesting has taken place around docks, piers, and swimming areas. However, as discussed in Chapter VI, macrophyte harvesting has not taken place on Geneva Lake since 1976. Macrophyte harvesting would be beneficial in those areas where excessive weed growth limits or precludes recreational use of the lake. Harvesting of the vegetative material from the lake would limit accumulation of decaying organic material, and excessive nutrients which stimulate further weed and algae growth would be removed from the water column. This limited harvesting could best be accomplished on a site-specific basis by individual lakefront property owners. It does not appear to be necessary to initiate a comprehensive harvesting program using conventional weed harvesting equipment. However, removal of weeds by the use of small-scale harvesting equipment, hand removal, or the use of temporary bottom-covering materials or surface screens for light control on a localized basis could preclude or further minimize the use of chemicals for weed control.

Chemical Applications for Control of Macrophytes, Algae, and Swimmer's Itch

Chemical applications for the control of macrophytes, algae, and swimmer's itch are currently used on Geneva Lake, but the use of such substances has declined dramatically over the last 10 years. In 1984, only about 6.5 acres of Geneva Lake were chemically treated. Chemical control of weeds and algae alone is generally not recommended over the long term unless other practices, such as harvesting or land management practices intended to reduce nutrient concentrations entering the lake, prove to be impractical or ineffective. This determination is based upon the evaluation of chemical control of macrophytes and algae presented in Chapter VI. All chemical treatment programs require a permit from the Wisconsin Department of Natural Resources, and the treatment of areas larger than one acre requires the supervision of Department of Natural Resources staff.

Consideration should be given to limiting the use of chemicals to reduce the incidence of swimmer's itch. Chemicals applied to swimming areas to eradicate snails may kill other nontarget aquatic organisms, including zooplankton, aquatic insects, and fish. Furthermore, reducing the swimmer's itch problem by killing snails only in those limited areas where treatment is permitted has limited effectiveness. Management measures other than chemical treatment for alleviating the swimmer's itch problem at Geneva Lake include a public education program to inform beach users about the problem, and about relatively simple measures that can be taken to reduce or preclude the irritation associated with the larval infestations. The program should include preparation of a brochure discussing the seasonal prevalence of the organisms and those areas where swimmer's itch has historically been the most severe.

Fish Management

Geneva Lake supports a well-balanced fishery characterized by a high diversity of gamefish, including trout, walleye, northern pike, smallmouth bass, cisco, and panfish. Presently, there is an approved public access site on Geneva Lake, and fish management assistance can be provided by the Department of

Natural Resources. Following discussions with the area DNR fishery manager, the following alternative measures were recommended for inclusion in future fish management efforts at Geneva Lake:

1. Development of a periodic fish surveillance program by the Geneva Lake Environmental Agency and the Wisconsin Department of Natural Resources to monitor the success of the fish-stocking programs which were resumed in 1982.

2. Conduct of a creel census (a survey of sport fishing) by the Wisconsin Department of Natural Resources to determine the composition of the angler catch and the numbers of each species harvested.

Chapter IX

RECOMMENDED PLAN

INTRODUCTION

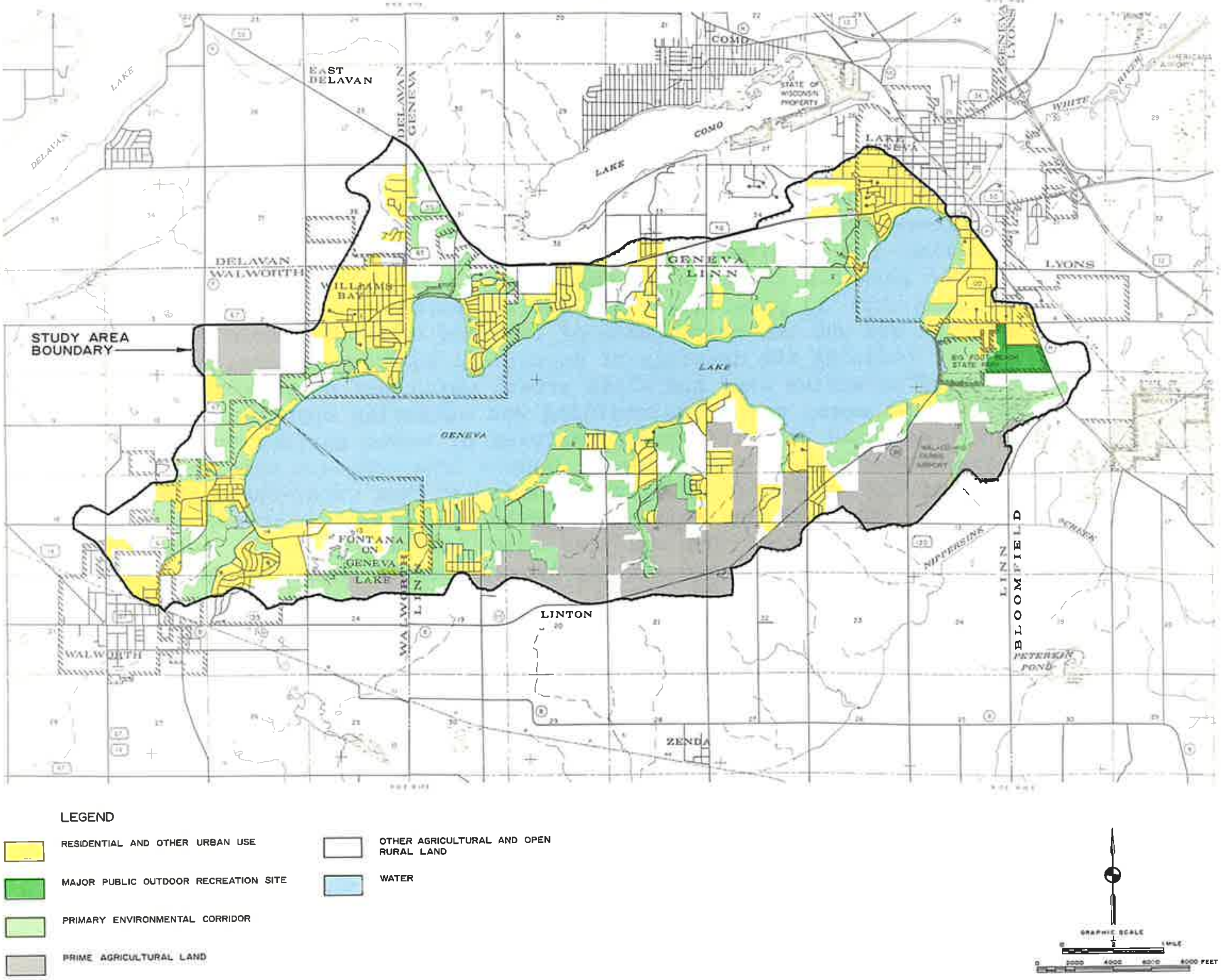
This chapter presents a recommended management plan for Geneva Lake. The plan is based upon the land use, land and water management, and biological and water quality inventory findings; pollution source analyses; land use and population forecasts; and alternative water quality management plan evaluations presented in the previous chapters of this report. The plan sets forth the recommended means for: 1) providing water quality suitable for full body contact recreational use and the maintenance of fish and other desirable forms of aquatic life; 2) reducing the severity of occasional aquatic nuisance problems such as caused by excessive weed and algae growth which may constrain or preclude certain water uses; and 3) maintaining and enhancing opportunities for water-based recreational activities. The analyses of water quality conditions and water-based recreational activities at Geneva Lake indicate that the general condition of the lake water quality is good, but that water-based recreation is somewhat inhibited by nuisance growths of aquatic macrophytes and algae, and by swimmer's itch. The analyses also indicate that the nutrient loading to Geneva Lake is moderate and may be expected to result in an accelerated rate of eutrophication. Therefore, the recommended plan is directed toward the attainment of improved land use and land management practices to reduce nonpoint source pollution and the resulting excessive nutrient loads entering the lake. The development of the recommended plan involved careful consideration of many tangible and intangible factors bearing upon water quality management and water pollution control, with primary emphasis upon the degree to which the desired water use objectives may be expected to be met, and upon the cost-effectiveness of the recommended measures. The plan development process involved review of preliminary drafts of the recommended plan by the Geneva Lake Environmental Agency.

LAND USE

The basis for the land use recommendations for the drainage area directly tributary to Geneva Lake is the adopted regional land use plan, as set forth in SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000. The regional land use plan recommends that additional urban land use development occur at medium and low densities in the lake watershed. Such urban uses should be permitted to occur, however, only in those areas of the watershed which can be readily served by centralized sanitary sewerage facilities, are covered by soils suitable for the intended use, and are not subject to special hazards such as flooding. By the year 2000, planned urban development in the drainage area directly tributary to Geneva Lake would increase an estimated 12 percent over the 1980 level. The land use plan recommendations are shown on Map 16 and presented in Table 59.

Map 16

GENERALIZED LAND USE PLAN FOR THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE: 2000



Source: SEWRPC.

Table 59

RECOMMENDED PLAN YEAR 2000 LAND USE IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE

Land Use Category	Acres	Percent of Major Categories	Percent of Study Area
Urban			
Residential	3,117	58.0	24.3
Commercial	138	2.6	1.1
Industrial	21	0.4	0.2
Governmental and Institutional	204	3.8	1.6
Transportation, Communication, and Utilities	1,040	19.3	8.1
Recreational	854	15.9	6.7
Urban Total	5,374	100.0	42.0
Rural			
Agricultural	3,585	48.2	28.0
Water	27	0.4	0.2
Wetlands	492	6.6	3.8
Woodlands	2,465	33.2	19.3
Other Open Land	863	11.6	6.7
Rural Total	7,432	100.0	58.0
Direct Drainage Area Total	12,806	--	100.0

Source: SEWRPC.

In general, prime agricultural lands, located south of Geneva Lake, are recommended to be preserved in agricultural use. Certain areas lying north, west, south, and southeast of the main lake basin form linear patterns or environmental corridors of concentrated high-value natural resource features and are, therefore, recommended to be permanently preserved in essentially natural, open space uses.

The regional land use plan can be an effective tool for water quality preservation and enhancement only if local action is taken to adopt and implement the plan. The City of Lake Geneva, the Villages of Fontana, Walworth, and Williams Bay, and the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth, together with Walworth County, all have authority and responsibility for local land use planning and plan implementation in the direct drainage area of the lake.

ZONING ORDINANCE MODIFICATION

As noted in Chapter V, an abundance of valuable natural resource base features is located within the Geneva Lake drainage area. In order for the existing zoning ordinances to be effective tools for the preservation of these natural resource features, certain modifications are required. As previously noted, the responsible officials in Walworth County and the nine civil divisions located partially within the drainage area directly tributary to Geneva Lake should review the existing zoning ordinances and amend and modify the ordinances and district maps as necessary to better preserve and enhance the existing natural resource base within the direct drainage area. As a point of departure for such revisions, the zoning districts and attendant regulations described below should be considered, where appropriate.

Lowland Conservancy District

A Lowland Conservancy District should be used to preserve, protect, and enhance the remaining significant wetlands in the drainage area directly tributary to Geneva Lake. No new urban development should be permitted in this district. A Lowland Conservancy District should be added to the zoning ordinance of the Village of Fontana. As discussed in Chapter VI, Walworth County has a Lowland Conservancy District which is used in the unincorporated areas of the County and is compliant with the requirements set forth in Chapter NR 115 of the Wisconsin Administrative Code. The City of Lake Geneva and the Village of Williams Bay have zoning districts which basically could be used, but which will need to be modified to conform to the requirements of Chapter NR 117 of the Wisconsin Administrative Code. The Village of Walworth does not have any wetlands which require application of a Lowland Conservancy District.

Upland Conservancy District

An Upland Conservancy District should be used to preserve, protect, and enhance the remaining significant woodlands, related scenic areas, and wildlife habitat areas in the drainage area directly tributary to Geneva Lake, while permitting rural estate residential development that would help to maintain the rural character of these areas. An Upland Conservancy District should be added to the zoning ordinances of the City of Lake Geneva and the Village of Fontana. The existing Upland Conservancy Districts applied in the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth should be adequate for the intended purpose and can be used. There are no areas in the Village of Walworth or the Village of Williams Bay requiring the use of this type of district.

Park and Recreation District

A Park and Recreation District should be used to protect public and private recreational areas in the drainage area directly tributary to Geneva Lake from encroachment by less desirable or incompatible land uses. This district would prohibit the conversion of private recreational sites to residential or other incompatible uses without the prior approval of the appropriate governing body. A Park and Recreation District should be added to the zoning ordinances of the Villages of Fontana and Walworth, and additional lands in the City of Lake Geneva should be added to that City's park district. The existing park districts applied in the Village of Williams Bay and the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth should be adequate for the intended purpose.

POINT SOURCE POLLUTION CONTROL

The extension of sanitary sewer service to portions of the drainage area directly tributary to Geneva Lake, as described in the preceding chapter and recommended in the adopted regional water quality management plan, is recommended to reduce the number of malfunctioning septic tank systems and to provide an appropriate means of sewage treatment for planned future urban development. Sewage treatment would be provided to appropriate portions of the drainage area by the City of Lake Geneva areawide sewage treatment plant and a new Village of Walworth areawide sewage treatment facility. Sanitary sewage from the Village of Williams Bay would be treated by the Walworth County Metropolitan Sewerage District (Walcomet) sewage treatment facility. Following construction of the proposed treatment plant and connection of Williams Bay to the Walcomet system, existing sewage treatment facilities in the Villages of Fontana, Walworth, and Williams Bay would be abandoned.

NONPOINT SOURCE POLLUTION CONTROL

Urban Nonpoint Source Pollution Controls

The implementation of nonpoint source water pollution controls in urban areas will require the cooperative efforts of the Walworth County Board of Supervisors; the Walworth County Board of Health; the Walworth County Land Conservation Committee; the Geneva Lake Environmental Agency; the City of Lake Geneva; the Villages of Fontana, Walworth, and Williams Bay; and a new septic system management district. The recommended responsibilities of each of these governmental agencies--consistent with their legal authorities under existing state and federal laws--are summarized in Table 60. Urban nonpoint source pollution controls applicable in the drainage area directly tributary to Geneva Lake, which are discussed further below, include a septic tank system management program, a construction erosion control program, and development and implementation of urban land management activities.

Septic Tank System Management Program: The basic objective of a septic tank system management program is to ensure the proper installation, operation, and maintenance of existing septic tank systems, and of any new systems that may be required to serve existing urban development in the drainage area directly tributary to Geneva Lake.

A septic tank system management program should include provisions assuring proper management of those systems not eliminated by the construction of the recommended sanitary sewerage facilities. A septic tank system management program is recommended to include the establishment of an active Management District or Sanitary District to administer funds; inspect, design, and construct upgraded systems; ensure proper operation and maintenance of the systems; and monitor the performance of systems. Such a district was recommended in the final environmental impact statement for the wastewater treatment facilities in the Geneva Lake area, prepared by the U. S. Environmental Protection Agency.[1] Some of these services are presently the responsibility of the Walworth County Zoning and Sanitation office. However, a Management District could expand services to include administration of an inspection program and technical assistance.

The major responsibility of the new Management District would be to establish and implement an onsite septic system management plan. A major component of that plan would be a regular inspection program. Such a program should include the visual inspection and, as appropriate, the testing of each onsite sewage

[1]U. S. Environmental Protection Agency, Final Environmental Impact Statement--Wastewater Treatment Facilities for the Geneva Lake Area, Walworth County, Wisconsin, 1984.

Table 60

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

Urban Nonpoint Source Management Agency	Local Land Use Planning and Zoning	Undertake Septic System Management Program	Undertake Construction Erosion Control Program	Develop and Implement Detailed Plan for Urban Practices	Conduct Education and Information Program	Provide Technical Assistance	Provide Fiscal Support to Land Conservation Committee
Walworth County (pertains to unincorporated areas)	X	--	X	--	X	--	X
Walworth County Board of Health	--	X	--	--	X	--	--
Walworth County Land Conservation Committee	--	--	--	--	--	X	--
City of Lake Geneva	X	--	X	X	X	--	--
Village of Fontana	X	--	X	X	X	--	--
Village of Walworth	X	--	X	X	X	--	--
Village of Williams Bay	X	--	X	X	X	--	--
Geneva Lake Environmental Agency	--	--	--	X	X	X	--
Septic System Management District	--	X	--	--	X	X	--

Source: SEWRPC.

disposal system by trained and experienced personnel. The purpose of the inspection would be to identify any malfunctioning sewage disposal systems. The adopted regional water quality management plan generally envisioned that each system would be inspected once every five years and, accordingly, about one-fifth of all such systems would be inspected annually. The adopted regional plan also envisioned that the inspection programs would be designed to best meet local needs, and recognized that the frequency of inspections may vary depending upon the areas and the potential for onsite sewage disposal problems. The inspection program may result in the issuance of orders, as necessary, to abate improper practices and take appropriate corrective measures. Where potential problems are identified in the inspection program, water-saving devices or "graywater-blackwater" separation systems could be recommended. A secondary benefit of an inspection program would be the knowledge system owners would gain from the periodic inspection of these systems and identification of shortcomings.

A continuing educational effort should also be included in the management plan. Homeowners should be advised of the rules, regulations, and system limitations governing onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs.

Establishment and operation of such a district program would cost approximately $45,000 per year in the areas concerned.

Construction Erosion Control Program: It is recommended that Walworth County, the City of Lake Geneva, the Villages of Fontana, Walworth, and Williams Bay, and the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth take steps to ensure the reduction of water pollution--particularly nutrient pollution--from soil erosion attendant to construction activities on lands undergoing changes in use. It is recommended that the designated urban management agencies establish construction erosion control programs and review their subdivision regulations, zoning ordinances, and building codes for the inclusion of appropriate erosion control measures in order to assure that such regulations, ordinances, and codes address administrative procedures, erosion control performance standards, and enforcement provisions.

It is recommended that either or both the local zoning ordinances and land division ordinances be properly expanded to require the submittal of an erosion control plan by all land developers, and that such erosion control plans be reviewed and approved by the Land Conservation Committee. It is further recommended that each designated agency adopt the appropriate ordinance modifications, require the submittal of erosion control plans for all construction projects, and review such plans with technical assistance from the Walworth County Land Conservation Committee, in conjunction with local municipal engineers. Furthermore, each designated urban management agency should provide for the proper inspection and enforcement of the erosion control measures to be implemented. The review and evaluation of the plans and control measures implemented should be based on criteria set forth in the Soil and Water Technical Guide of the U. S. Department of Agriculture, Soil Conservation Service. Enforcement would be through the land subdivision, zoning, and building code approval authorities of each designated management agency. The Southeastern Wisconsin Regional Planning Commission has published model ordinances in Appendices H through J of SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, and can assist in the development of the required regulations, upon request.

Development and Implementation of Urban Land Management Practices: The development of urban nonpoint source pollution abatement practices should be a highly localized, detailed, and individualized effort, as it requires highly specific knowledge of the physical, managerial, social, and fiscal considerations that affect the local landowners concerned. Accordingly, it is recommended that the Geneva Lake Environmental Agency work with property owners in the application of the land management practices recommended herein to effect a reduction of approximately 25 percent in urban nonpoint source pollution runoff.

It is recommended that the Geneva Lake Environmental Agency, in cooperation with the previously described urban nonpoint source water pollution control management agencies, identify the specific nonpoint sources of pollution within the urban areas of the watershed, and develop programs to control these sources. These designated agencies should inventory and assess the existing land management practices, and determine the extent and location of problem areas. Furthermore, the appropriate pollution control measures for these problem areas, and the estimated effectiveness and costs of these control measures, should be assessed. Finally, a program for implementing and financing the recommended control measures should be developed.

It is recommended that the following urban nonpoint source control measures be implemented, as applicable, throughout the drainage area tributary to Geneva Lake: a public education program to provide information on the relationship of land management practices to water quality; improved street cleaning and maintenance; the proper collection and disposal of leaves, grass clippings, and other vegetative debris; the proper use of fertilizers and pesticides, and other lawn and garden care measures; improved refuse collection and disposal; the proper vegetative management of shoreland areas; the adequate maintenance of stormwater drainage ditches and storm sewer systems, including discharge sites; the proper disposal of litter and pet wastes; and other measures as locally identified. It is further recommended that the designated agencies seek technical assistance in preparing and implementing these detailed practices from the Walworth County Land Conservation Committee. Finally, it is recommended that publications identifying specific residential land management practices beneficial to water quality be prepared and distributed to property owners with the assistance of the University of Wisconsin-Extension Service, and that the Walworth County office of the University of Wisconsin-Extension Service assist in providing the public education program.

Rural Nonpoint Source Pollution Controls

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of the Geneva Lake Environmental Agency, Walworth County, and the Walworth County Land Conservation Committee. The recommended responsibilities of each governmental agency are summarized in Table 61.

The development of rural nonpoint source pollution abatement practices should also be a highly localized, detailed, and individualized effort. Accordingly, it is recommended that the Walworth County Land Conservation Committee, in cooperation with the Geneva Lake Environmental Agency, develop plans setting forth detailed rural soil and water conservation practices for each farm in the watershed. It is recommended that the Geneva Lake Environmental Agency act as the lead agency in the preparation of such plans. As the lead agency, the

Table 61

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

Rural Nonpoint Source Management Agency	Local Land Use Planning and Zoning	Develop Livestock Waste Control Program	Develop and Implement Detailed Plan for Rural Practices	Conduct Education and Information Program	Provide Technical Assistance	Provide Fiscal Support to Land Conservation Committee
Walworth County (pertains to unincorporated areas)...	X	X	--	X	--	X
Walworth County Land Conservation Committee.....	--	X	X	--	X	--
Geneva Lake Environmental Agency.......	--	--	--	X	--	--

Source: SEWRPC.

Agency should formally request that the County Land Conservation Committee work with landowners to design drainage practices applicable for each land parcel for the control of agricultural nonpoint source pollution in the lake watershed. The final plans should include estimates of soil loss, and recommended abatement measures for each identified source. The estimated cost and effectiveness of each practice recommended should also be identified. Agricultural nonpoint source pollution abatement measures which may be appropriate for use in the drainage area directly tributary to Geneva Lake include crop rotation, conservation tillage, grassed waterways, vegetative buffer strips, diversions, terraces, contour strip-cropping, and livestock waste control. The agricultural areas in the lake watershed with relatively steep slopes and located in proximity to the lake are particularly susceptible to erosion, and are potentially most harmful to the lake environment. Such areas should receive priority for planning and implementation of control measures. It is envisioned that the Geneva Lake Environmental Agency--through an intergovernmental memorandum of understanding--will cooperate with the Walworth County Land Conservation Committee in the necessary detailed planning.

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

LAKE REHABILITATION TECHNIQUES

As discussed in Chapter VIII, the applicability of specific in-lake rehabilitation techniques is dependent on the physical and chemical characteristics of a lake, the effectiveness of the method for improving lake water quality, the need for implementing a lake rehabilitation program, and the costs. Geneva Lake is the largest, deepest inland lake in the Region, and has some of the best water quality of any lake in southern Wisconsin. Accordingly, potential in-lake rehabilitation techniques were evaluated by the Commission staff following consultations with a member of the staff of the Geneva Lake Environmental Agency. That evaluation revealed that standard in-lake rehabilitation techniques utilized to improve water quality--hypolimnetic aeration, dredging, drawdown, nutrient inactivation, dilution flushing, and selective discharge--would be neither technically nor financially possible, and would be ineffective in improving the water quality of Geneva Lake. However, other recommended in-lake management measures, including water quality monitoring, designed to alleviate occasional nuisance conditions caused by excessive weed and algae growth and outbreaks of swimmer's itch are discussed below. Also discussed are management techniques designed to assess the condition of the fishery and maintain the viability of the sport fishing resource.

It is recommended that the Geneva Lake Environmental Agency, as created under the provisions of Section 66.30 of the Wisconsin Statutes, serve as the lead agency in the continued study of Geneva Lake. It is also recommended that this agency assist directly in the implementation of the watershed and in-lake management measures presented in this report, and in a summary report prepared in 1980.[2] It is recommended that the Agency coordinate the plan implementation activities of local and state agencies and private citizens.

It is further recommended that the Agency continue to conduct an in-lake water quality sampling program to assess the effects, over time, of the implemented lake management measures. This sampling program would, at a minimum, consist of measurements of soluble and total phosphorus; nitrate-, nitrite-, organic-, and ammonia-nitrogen; chlorophyll-a; water clarity; chlorides; total dissolved solids; and specific conductance. The sampling program would also include the development of temperature and dissolved oxygen profiles at least twice each summer and once during each spring turnover. All measurements and profiles should be obtained at the deepest point in the lake. In addition, a sediment sampling and analysis program to evaluate the deposit of chemical residues as a result of the treatment of macrophytes should be initiated. Lake freeze-up and thaw dates, as well as snow cover conditions, should be recorded annually. Such a data collection program would have an estimated cost of $1,500 per year, assuming that the samples will be collected by the staff of the Geneva Lake Environmental Agency. In addition, surveys of fish, macrophytes, algae, and zooplankton should periodically be conducted by, or with the technical assistance of, the Wisconsin Department of Natural Resources.

The Geneva Lake Quality Index (GLQI) is a means of monitoring several of the recommended measurements. The GLQI is a simple means of evaluating some of the data generated in a lake water quality sampling program. It would be advantageous to use the GLQI as one means of evaluating trends in the water quality of Geneva Lake. Consequently, continued use of this analytical tool is recommended.

The potential effect of atmospheric fallout and washout on the water quality of Geneva Lake necessitates continual atmospheric monitoring. Continued operation of the National Atmospheric Deposition Program/National Trend Network station in the watershed is a cost-effective means of collecting wet depositional data that are compatible with data collected at more than 200 other sites in the United States. The Geneva Lake Environmental Agency is under

---

[2]Geneva Lake Environmental Agency, Geneva Lake Water Quality Report with Recommendations for a Lake Management Plan, 1980.

annual contract to the Wisconsin Department of Natural Resources for the continued operation of this station on a time and material basis. The Agency should continue to operate the station.

The Geneva Lake Environmental Agency should continue groundwater elevation monitoring at 11 wells in the Lake Geneva and Fontana areas, also. Originally, these remaining 11 wells were part of a lakewide, lowland-upland, 22-well network that was installed for the collection of information for this report in 1976. It is recommended that the Geneva Lake Environmental Agency evaluate the existing groundwater elevation monitoring network to determine whether it should be modified or expanded.

The Wisconsin Pollutant Discharge Elimination System groundwater monitoring near the sewage treatment plant effluent seepage ponds should be continued until both seepage ponds in the area are abandoned, and for a period of at least two years thereafter. The potential impacts of these seepage ponds on groundwater quality even after abandonment warrants such continued groundwater monitoring. As the Geneva Lake Environmental Agency has done this monitoring since it was first required, the Agency is the logical organization to continue this monitoring. The cost of this monitoring approximates $300 per year.

Because of the potential environmental hazards and unknown ecological consequences associated with the use of chemicals to control aquatic macrophytes and algae, it is recommended that the application of chemicals to control the occasional and localized nuisance growths of these plants be curtailed on Geneva Lake. Furthermore, the deposition of dead plant material following chemical treatment of aquatic macrophytes upon the lake bottom releases additional nutrients to the water column and serves to contribute to the buildup of both toxic substances and organic matter in the lake water. The use of chemicals is recommended only as a last resort when other plant management alternatives are not feasible.

As previously discussed, occasional nuisance growth of aquatic macrophytes occurs around docks, piers, beaches, and other areas used intensively for recreation on Geneva Lake. Methods other than chemical spraying should be evaluated by individual property owners, and include the use of small-scale mechanical harvesters, individual hand removal by raking, and the use of temporary bottom or surface screens for light control. Most of these methods are highly flexible in that control efforts can be directed to specific areas requiring treatment. Such methods would not interfere with the recreational use of the lake and, properly conducted, would not damage fish spawning areas.

Many of these techniques are in the experimental stage and may not by themselves abate nuisance weed problems. However, any type of weed management program should be an integrated program considering a range of techniques and the combined impact of these techniques on the lake environment. As previously discussed, the most important component of any integrated weed management program is the control of nutrient and sediment loading to the lake.

The widespread use of chemicals to reduce the number of snails near swimming areas and the associated prevalence of microscopic organisms which cause swimmer's itch is undesirable. The unknown ecological impacts, limited effectiveness, and nonselective nature of the chemicals utilized to kill the snails dictate that such treatment be carefully restricted. It is recommended that a public education program be carried out by the Geneva Lake Environmental

Agency and the Geneva Lake Water Safety Patrol, including the preparation of a brochure explaining the cause of swimmer's itch, the seasonal prevalence of the organisms, and methods which can be utilized to limit or preclude the skin irritation which develops following exposure to the organisms. Lifeguards at public beaches on the lake should make announcements concerning the causes of the problem and methods to minimize the effects. These simple control methods include showering and/or thoroughly wiping dry after leaving the water.

To manage the fishery resources in Geneva Lake, it is recommended that the Wisconsin Department of Natural Resources conduct a fish surveillance program to determine the condition of the sport fishery in the lake, with subsequent stocking of appropriate game fish species, if such a need is justified. It is also recommended that the DNR conduct a creel census to determine the composition of the angler catch and determine if over-harvest of some game species is occurring. In addition, specific schedules for periodic fishery surveys should be established in order to assess and evaluate long-term trends in the total fishery resource in the lake.

COST ANALYSES

Cost estimates--expressed in 1984 dollars--for the recommended nonpoint source pollution controls in the drainage area directly tributary to Geneva Lake and for the recommended in-lake management techniques are set forth in Table 62. The total capital cost of the recommended plan, as shown in Table 62, is about $585,200 over a 20-year plan implementation period, with an average annual operation and maintenance cost of $44,500, resulting in a total annual average cost of about $72,100. Of these totals, about $101,600, or 17 percent of the capital cost; about $14,400, or 32 percent of the annual operation and maintenance cost; and about $17,800, or 24 percent of the total annual cost would be borne by the local units of government. The remaining costs would be borne by individual property owners or by state or federal cost-sharing programs. About $340,000, or 58 percent of the total capital cost of the recommended watershed management measures, is associated with the control of erosion from construction activities, with 75 percent of the erosion control cost being borne by the private sector. The in-lake management costs include a total average annual cost of $1,500 for an in-lake water quality sampling program. Based on the 1985 population of the lake drainage area, the total average annual cost for each lake watershed resident would be about $7.00, or $20 per household. The average annual local public sector cost would be about $2.00 per resident, or $6.00 per household, without any federal or state financial aids. Federal or state grants-in-aid could reduce these costs.

Table 62

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

Water Quality or Lake Management Measure[b]	Estimated Cost 1980-2000					
	Capital[a]		Average Annual Operation and Maintenance		Total Average Annual	
	Total	Local Public Sector	Total	Local Public Sector	Total	Local Public Sector
Sanitary Sewer Service[c]	$ --	$ --	$ --	$ --	$ --	$ --
Septic Tank System Management[d] ...	--	--	--	--	--	--
Rural Land Management	55,400	16,000	11,100	--	13,900	800
Livestock Waste Control	189,400	--	16,400	--	25,900	--
Urban Land Management	300	300	10,000	10,000	10,000	10,000
Construction Erosion Control	340,000	85,000	3,400	800	20,400	5,100
Watershed Management Subtotal	$585,100	$101,500	$40,900	$10,800	$70,200	$15,900
Lake User Management Program	$ 100	$ 100	$ 300	$ 300	$ 400	$ 400
Fish Management[e]	--	--	--	--	--	--
Water Quality Sampling Program ..	--	--	1,500	1,500	1,500	1,500
In-Lake Management Subtotal	$ 100	$ 100	$ 1,800	$ 1,800	$ 1,900	$ 1,900
Total	$585,200	$101,600	$44,500	$14,400	$72,100	$17,800

[a] All costs expressed in January 1984 dollars.

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

[c] Nearly all urban development in the drainage area directly tributary to Geneva Lake is recommended to be served by sanitary sewers by the year 2000. The sewage generated in this area would be conveyed to and treated at the existing City of Lake Geneva and proposed Village of Walworth sewage treatment facilities. The required treatment facilities and major trunk sewers serving the drainage are, together with local hook-up and operation and maintenance of the system, would entail a total capital cost of $10.4 million, with an annual operation and maintenance cost of about $151,200.

[d] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Geneva Lake. However, because septic tank system management is necessary for the preservation of public health and the maintenance of drinking water supplies, its cost is not included in the cost of the recommended plan measures. The estimated expenditures for septic system management in the Geneva Lake drainage basin include a capital cost over the period 1984-2000 of $283,500, with an average operation and maintenance cost of $50,500.

[e] The cost for fish management would be borne by the Wisconsin Department of Natural Resources.

Source: SEWRPC.

Chapter X

SUMMARY

The preparation of the water quality management plan for Geneva Lake as presented herein was a cooperative effort of the Southeastern Wisconsin Regional Planning Commission, the Geneva Lake Environmental Agency, and the Wisconsin Department of Natural Resources. The planning effort included the design and conduct of a water quality sampling program, including samples of not only the lake water quality itself but the quality of all streams and watercourses and storm drains directly tributary to the lake--with field sampling conducted from May 1976 through May 1977--and inventories and analyses of the existing land use pattern, the physiography of the watershed tributary to the lake, the natural resource base of the watershed, recreational use of the lake, and existing management practices in the tributary watershed. Additional information collected as recently as 1985 is also included in the report. The objectives of the plan are to provide a level of water quality in Geneva Lake suitable for the maintenance of fish and aquatic life, to reduce the severity of occasional nuisance conditions caused by excessive weed and algae growth, and to improve opportunities for water-based recreational activities.

Geneva Lake is located within U. S. Public Land Survey Township 2 North, Range 17 East; Township 1 North, Range 17 East; and Township 1 North, Range 16 East, all in Walworth County. The lake has a surface area of 5,425 acres, a maximum depth of 144 feet, and a mean depth of 57 feet. The lake has a direct tributary drainage area of 12,806 acres, or 20.01 square miles.

The drainage area directly tributary to Geneva Lake includes portions of the City of Lake Geneva, the Villages of Fontana, Walworth, and Williams Bay, and the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth.

The type, intensity, and spatial distribution of land use are important factors affecting the water quality of Geneva Lake. As of 1980, approximately 4,778 acres, or about 37 percent of the 12,806-acre drainage area directly tributary to Geneva Lake, were in urban land use, with the dominant urban land use being residential--accounting for 2,786 acres, or about 22 percent of the direct tributary drainage area. The remaining urban land uses--commercial, industrial, governmental and institutional, transportation, communication, utilities, and recreational--constituted about 1,992 acres, or about 15 percent of the direct drainage area. Approximately 8,028 acres, or about 63 percent of the direct tributary drainage area, were in rural land use, with the dominant rural land use being agricultural--accounting for 4,043 acres, or about 32 percent of the direct drainage area. Woodlands and open lands comprised about 3,466 acres, or 27 percent of the direct drainage area. Wetlands and surface water, excluding the surface area of Geneva Lake, accounted for 519 acres, or 4 percent of the direct drainage area.

As of 1984, the sanitary and household wastewaters from an estimated 3,325 persons, or 43 percent of the persons residing in the drainage area directly tributary to the lake, were treated and disposed of through the use of onsite sewage disposal systems. There were approximately 1,600 septic tank systems in the direct tributary drainage area--667 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems. More than 50 holding tanks and 50 mound systems were also known to exist in the direct tributary drainage area as of 1984.

In 1977 approximately 21,496 acre-feet of water entered the lake. Of this total, about 10,867 acre-feet, or 51 percent, was contributed by direct precipitation; about 7,892 acre-feet, or 37 percent, was contributed by inflow from the perennial streams; about 1,963 acre-feet, or 9 percent, was contributed by groundwater; about 695 acre-feet, or 3 percent, was contributed by intermittent steams; and about 79 acre-feet, or less than 1 percent, was contributed by surface runoff discharged directly to the lake. Of the total water output from Geneva Lake, about 61 percent evaporated from the surface of the lake and 39 percent was discharged via the White River.

Monthly temperature and dissolved oxygen profiles indicate that complete mixing of Geneva Lake is restricted during the summer by thermal stratification. The data indicate that Geneva Lake, like other mesotrophic lakes in southeastern Wisconsin, experiences oxygen depletion in the hypolimnion, or bottom water layer. Oxygen depletion in the hypolimnion may increase the release of phosphorus from the bottom sediments and cause fish to migrate upward in the water column, where higher dissolved oxygen concentrations exist. Water clarity, as measured by a secchi disk, ranged from about eight to 20 feet, with an average secchi disk depth of 13 feet in Geneva Lake.

Geneva Lake supports a relatively large and diverse fish community. During the study year, fishery survey reports indicated that 19 species of game fish were sampled in the lake. No threatened or endangered fish species were found in the lake. In addition, from 1957 to 1976, six species of fish were stocked in the lake by the Wisconsin Department of Natural Resources. Stocking of brown trout, lake trout, northern pike, and walleye was resumed in 1982.

The water quality standards for recreational use and the maintenance of fish and aquatic life recommended by the Regional Planning Commission indicate that if nuisance growths of aquatic plants are to be avoided, the total phosphorus concentration of the lake water should not exceed 0.02 milligram per liter during the spring turnover. During the study year, the mean concentration of total phosphorus in the spring in Geneva Lake was about 0.04 milligram per liter, which indicates the potential for nuisance aquatic plant growth to occur in the lake, and the importance of abating pollutant loadings to the lake.

It was estimated from Commission analyses that, under 1975 conditions, the total phosphorus load to Geneva Lake was approximately 13,265 pounds per year. Of this total, about 2,075 pounds, or 16 percent, was estimated to be contributed by livestock operations located in the tributary watershed. Direct atmospheric fallout and washout was estimated to contribute approximately 2,620 pounds, or 20 percent of the total. In addition, effluent from the Fontana sewage treatment plant contributed about 2,320 pounds, or 17 percent of the total.[1] Malfunctioning septic tank systems contributed approximately

[1]Phosphorus loads to the lake from the Fontana sewage treatment plant have been eliminated as a result of the construction in 1978 of a new seepage lagoon for effluent treatment.

1,915 pounds, or 14 percent, of the total phosphorus load to the lake. Runoff from urban land uses--residential, commercial, industrial, governmental and institutional, transportation, and recreational--contributed approximately 2,200 pounds, or 17 percent, of the total phosphorus load to the lake. Runoff from construction and extractive activities contributed about 1,300 pounds, or 10 percent, of the total phosphorus load. Rural sources of phosphorus contributed to the lake included runoff from agricultural lands, woodlands, wetlands, and other open lands; these sources contributed 835 pounds, or about 6 percent, of the annual phosphorus load.

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

If the adopted regional land use plan is implemented, the resident population of the drainage area directly tributary to Geneva Lake may be expected to increase by 26 percent--from approximately 8,011 persons to approximately 10,100 persons--between 1980 and the year 2000. The land use plan recommends that most new residential development in the direct tributary drainage area occur at medium and low densities. The adopted land use plan envisions that approximately 5,374 acres, or 42 percent, of the 12,806-acre direct tributary drainage area will be in urban land use by the year 2000, with the dominant urban land use being residential, encompassing 3,117 acres, or about 58 percent of the total area devoted to urban use. The remaining 2,257 acres, or 42 percent of the urban land, would be devoted to commercial, industrial, governmental and institutional, transportation, communication, recreational, and utility land uses. The plan proposals represent a 12 percent increase in urban land uses in the direct tributary drainage area over the 20-year period.

The Commission estimated that under the plan year 2000 land use conditions, the total phosphorus load to the lake would be 8,925 pounds per year, or about 33 percent less than the estimated 1975 loadings. Major sources of phosphorus under anticipated year 2000 conditions would be direct atmospheric fallout and washout, representing about 2,620 pounds, or 29 percent; runoff from construction and extractive activities, representing about 2,450 pounds, or 16 percent; and residential land, representing about 1,150 pounds, or 13 percent. Livestock operations may be expected to contribute about 1,315 pounds, or about 15 percent of the total phosphorus load. The remaining land uses in the drainage area directly tributary to Geneva Lake--commercial, industrial, governmental and institutional, transportation, agricultural, recreational lands, woodlands, and other open lands--may be expected to contribute the remaining 2,210 pounds, or 25 percent of the phosphorus load to the lake.

There would be an annual decrease of approximately 1,735 pounds of phosphorus--from about 1,915 pounds per year in 1975 to approximately 180 pounds per year in the year 2000--entering the lake from malfunctioning septic tank systems upon the extension of sanitary sewer service to additional residents of the Geneva Lake direct tributary drainage area, and the installation of an onsite sewage disposal system inspection, maintenance, and replacement program as recommended in the adopted regional water quality management plan.

Management measures required to meet the water use objectives for Geneva Lake must address nonpoint sources, as well as point sources, of water pollution.

Commission estimates indicate that there needs to be a 35 percent reduction in the amount of phosphorus contributed to Geneva Lake in order to meet the recommended water use objectives and supporting standards. The extension of sanitary sewer service to approximately 56 percent of the drainage area directly tributary to Geneva Lake is recommended as an important nonpoint source control measure in the adopted regional water quality management plan. This measure, and onsite sewage disposal system inspection, maintenance, and replacement as needed, would minimize pollutant loadings to surface- and groundwater from onsite systems. Sewage treatment would be provided at the City of Lake Geneva sewage treatment plant, at a new sewage treatment plant which would be built by the Village of Walworth, and by the existing Walworth County Metropolitan Sewerage District sewage treatment plant. Nonpoint source pollution control measures would include improved management of both urban and rural land uses to reduce pollutant discharges to the lake by direct overland drainage, by drainage from natural or man-made channels, and by groundwater inflow. These actions would be designed to reduce the in-lake concentration of total phosphorus in Geneva Lake during the spring turnover to the Commission-recommended standard of 0.02 milligram per liter.

Alternative lake rehabilitation and in-lake management techniques were evaluated to examine the feasibility of conducting an in-lake management program. Techniques assessed included hypolimnetic aeration, dredging, sediment covering, drawdown, nutrient inactivation, dilution and flushing, selective discharge, macrophyte harvesting, algae harvesting, chemical controls, and fish management. As a result of these analyses, it is recommended that a limited macrophyte harvesting program be established and that the fishery resources of Geneva Lake be evaluated and managed. Furthermore, the in-lake water quality monitoring program should be continued. In addition, a swimmer's itch management program consisting of a public education program and a detailed research project to investigate alternative means of controlling the organisms which cause the itch should be undertaken.

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

1. The modification of local planning and zoning to conform with the Commission's adopted regional land use plan.

2. The extension of sanitary sewer service to portions of the drainage area directly tributary to the lake for collection and conveyance of sanitary wastewaters, with treatment and discharge at the existing City of Lake Geneva, proposed Village of Walworth, and existing Walworth County Metropolitan Sewerage District sewage treatment plants.

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

4. The establishment of a management district for the inspection, maintenance, and replacement of onsite sewage disposal systems.

5. The implementation and enforcement of construction erosion control ordinances by Walworth County, the City of Lake Geneva, and the Villages of Fontana, Walworth, and Williams Bay.

6. The continuation of an in-lake water quality monitoring program by the Geneva Lake Environmental Agency and initiation of a fishery resource monitoring program by that agency and the Wisconsin Department of Natural Resources.

7. The initiation of a limited macrophyte harvesting program.

8. The development of a swimmer's itch management program by the Geneva Lake Environmental Agency.

Implementation of the recommended nonpoint source controls in the drainage area directly tributary to Geneva Lake and in-lake management measures would entail a total capital cost of about $585,200, with an average annual operation and maintenance cost of about $44,500, and a total average annual cost of $72,100 over a 20-year plan period. About 58 percent of the capital cost of watershed management would be associated with control of erosion from construction activities, with 75 percent of this cost being borne by the private sector. The in-lake management costs include a total average annual cost of $1,500 for an in-lake water quality monitoring program. Based on the estimated 1985 population of the drainage area directly tributary to the lake, the total average annual cost of $72,100 represents approximately $20 per year per household in the lake watershed, or about $7.00 per resident per year. The average annual local public sector cost of the recommended plan is about $17,800, or about $6.00 per household in the lake watershed and about $2.00 per resident.

Geneva Lake is a valuable natural resource in the Southeastern Wisconsin Region. A delicate, complex relationship exists between the water quality conditions of a lake and the land uses within the drainage area directly tributary to the lake. Projected increases in population, urbanization, income, leisure time, and individual mobility forecast for the Region may be expected to result in additional pressure for development in the direct drainage area of lakes in southeastern Wisconsin and for water-based recreation on the lakes themselves. The adoption and administration of an effective water quality management program for Geneva Lake, based upon comprehensive water quality management and related land use plans, will provide the water quality protection needed to maintain conditions in Geneva Lake suitable for recreational use and the maintenance of fish and other aquatic life.

APPENDICES

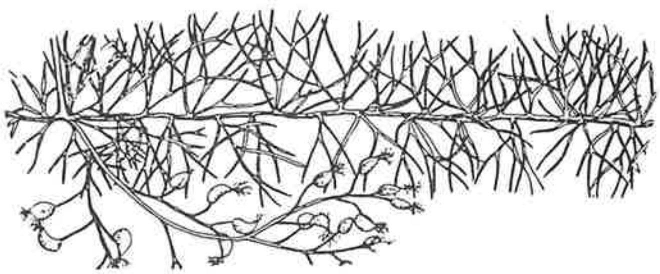
Appendix A

ILLUSTRATIONS OF REPRESENTATIVE BIOTA WHICH MAY BE FOUND IN GENEVA LAKE

Appendix A-1

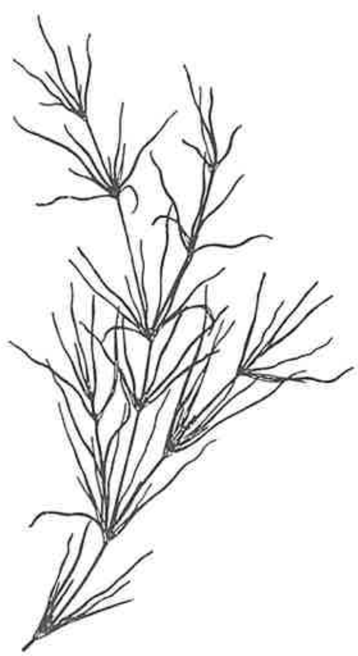
REPRESENTATIVE MACROPHYTES FOUND IN SOUTHEASTERN WISCONSIN LAKES

BLADDERWORT (*Utricularia sp.*)



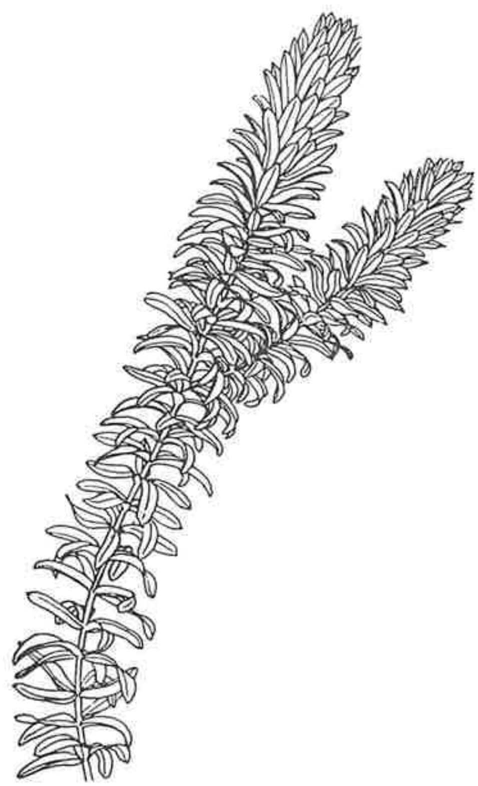
Bladderwort is a carnivorous plant which occurs in shallow ponds and lakes or on wet soils. The small bladders are traps which catch tiny animal life, particularly crustaceans. Bladderwort provides some food and cover for fish. It is never abundant enough to become a nuisance.

BUSHY PONDWEED (*Najas flexilis*)



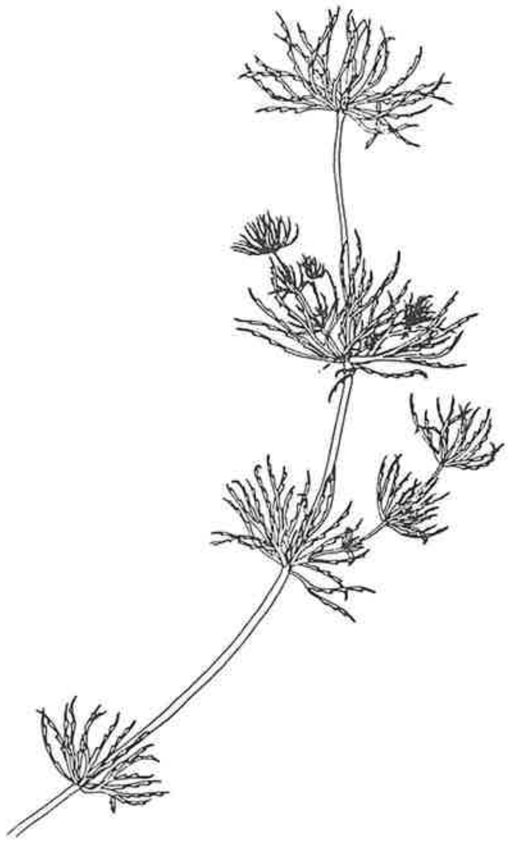
Bushy pondweed is a common species in ponds, small lakes, and slow-moving streams in southeastern Wisconsin. It provides food and cover for fish. Bushy pondweed may become a nuisance during late summer in some lakes.

COMMON WATERWEED (*Anacharis canadensis*)



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

COONTAIL (Ceratophyllum demersum)



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

CURLY LEAF PONDWEED (Potamogeton crispus)

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

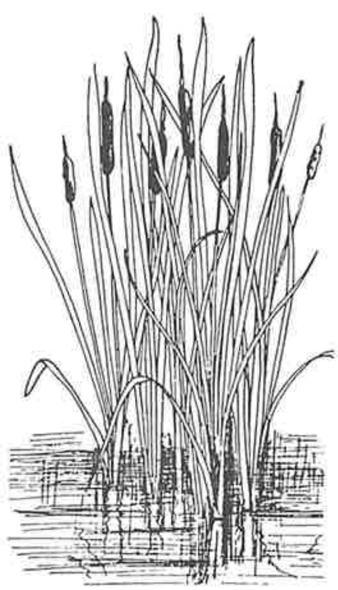
FLOATING LEAF PONDWEED (Potamogeton natans)

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

LARGE LEAF PONDWEED (Potamogeton amplifolius)

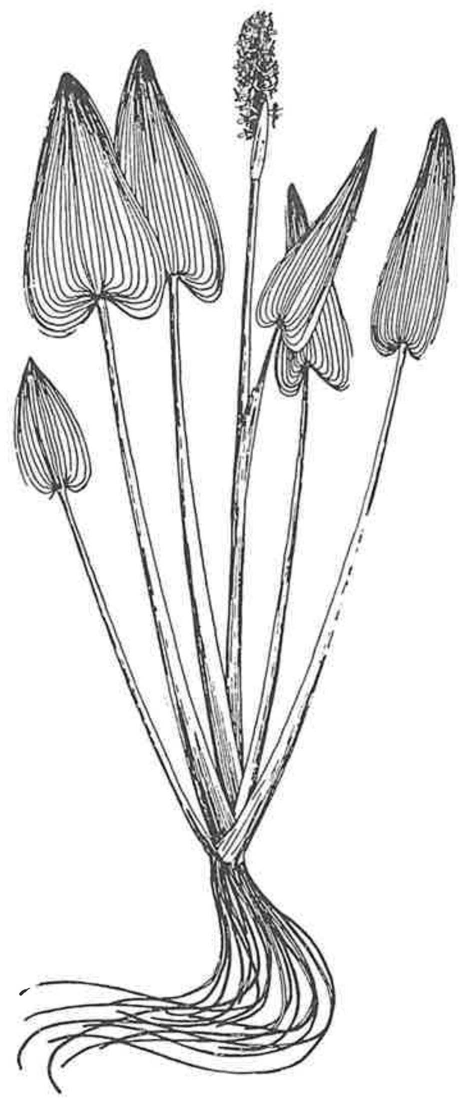
Large leaf pondweed is usually found in relatively hard water. Submersed, it supports insects and provides a good food supply for fish.

NARROW-LEAVED CATTAIL (Typha angustifolia)



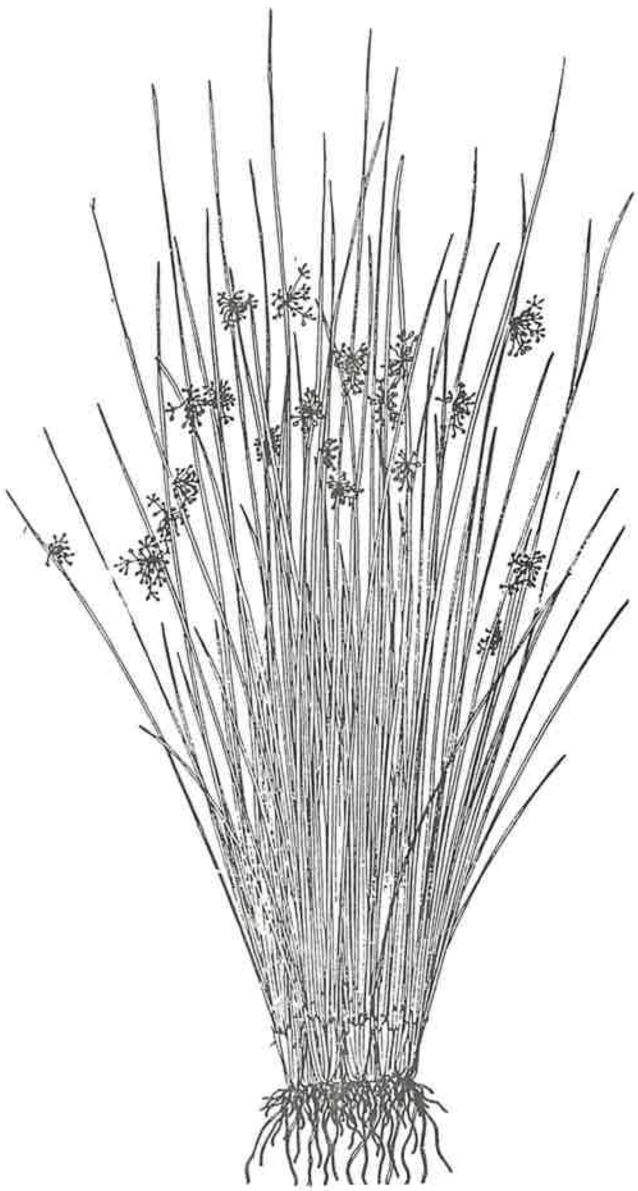
Narrow-leaved cattail may appear in almost any wet place. It is used as a spawning area for sunfish and shelter for various species of young fish, as well as a variety of other forms of wildlife. Cattails often occur in dense stands and therefore may become a nuisance.

PICKEREL WEED (Pontederia cordata)



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

RUSH (Juncus sp.)

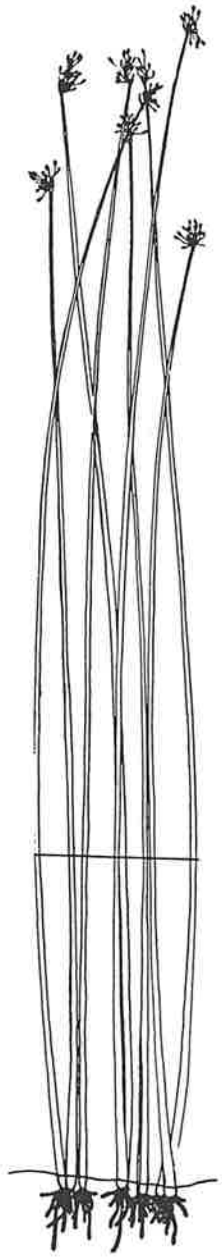


Rushes are an emergent aquatic plant with a widespread habitat which ranges from wet meadows and lakeshores to shallow pools. Thick growths of rushes often form spawning grounds for rock bass, bluegills, and other sunfish.

SAGO PONDWEED (Potamogeton pectinatus)

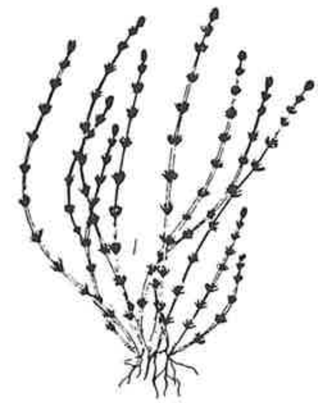
Sago pondweed is found in hard or brackish water of lakes and slow-flowing streams. Sago pondweed provides food and shelter for young trout and other fish.

SOFTSTEM BULRUSH (*Scirpus validus*)



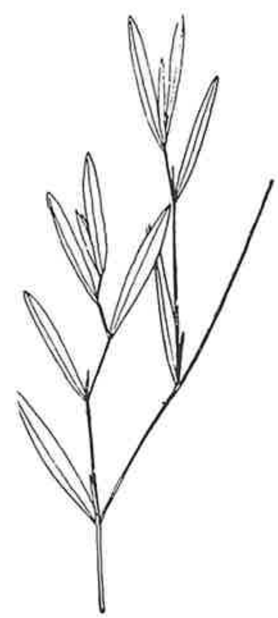
Softstem bulrush is an emergent aquatic species. It supports insects and provides food for young fish and many species of waterfowl.

STONEWORT (*Chara aspera*)



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

VARIABLE PONDWEED (*Potamogeton gramineus*)



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

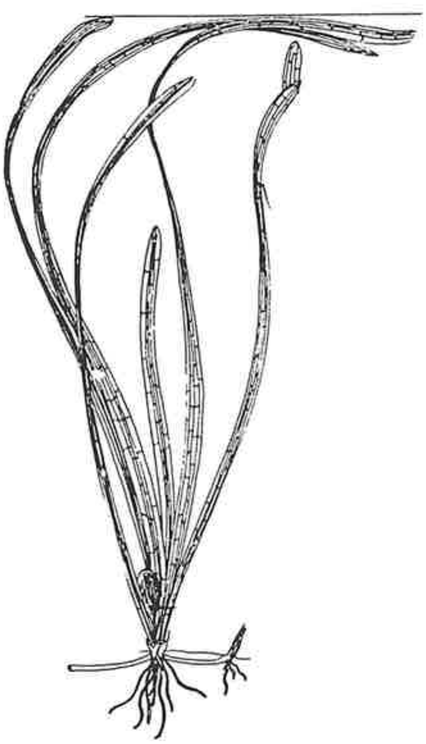
WATER MILFOIL (*Myriophyllum exalbescens*)

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

WATER SMARTWEED (*Polygonum natans*)

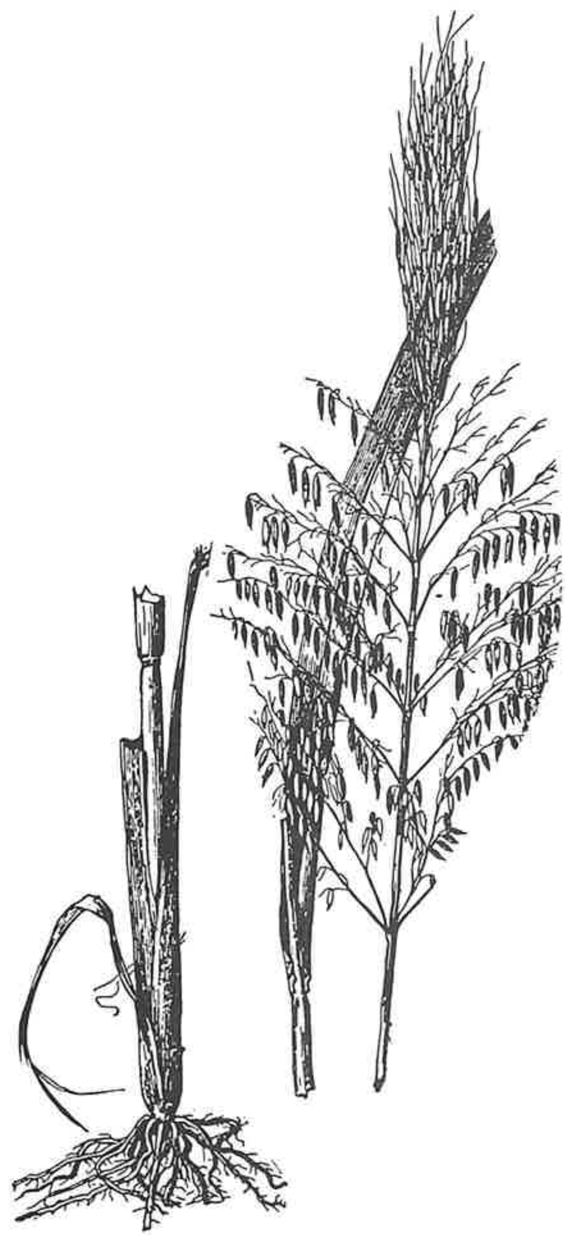
Water smartweed is found along the shoreline of shallow water. It provides food and cover for fish and wildlife. Water smartweed is never abundant enough to cause aquatic nuisance problems.

WILD CELERY OR EEL GRASS (Vallisneria americana)



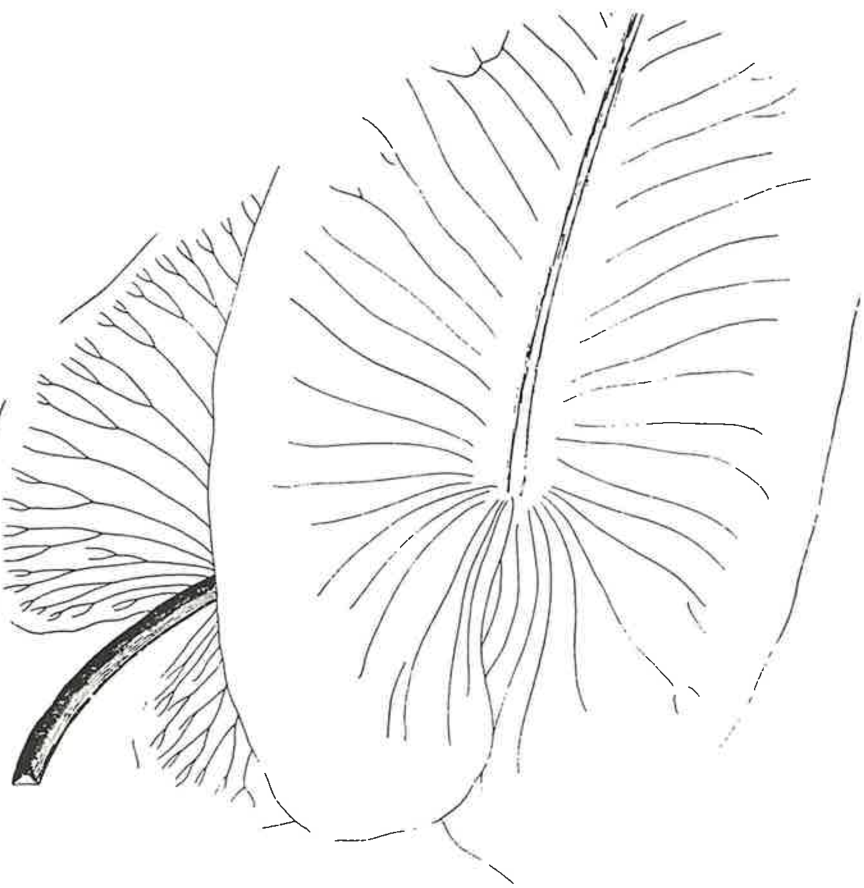
Eel grass is a submersed plant which provides shade, shelter, and food for fish. It supports insects and is a valuable food source for waterfowl. Sometimes forming dense growths, eel grass may be undesirable in swimming areas.

WILD RICE (Zizania aquatica)



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

YELLOW WATER LILY (Nuphar variegatum)



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

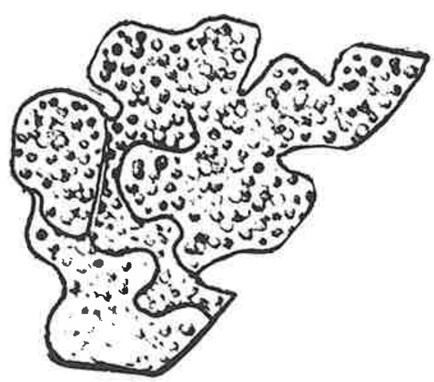
Appendix A-2

REPRESENTATIVE PHYTOPLANKTON FOUND IN SOUTHEASTERN WISCONSIN LAKES

Anabaena

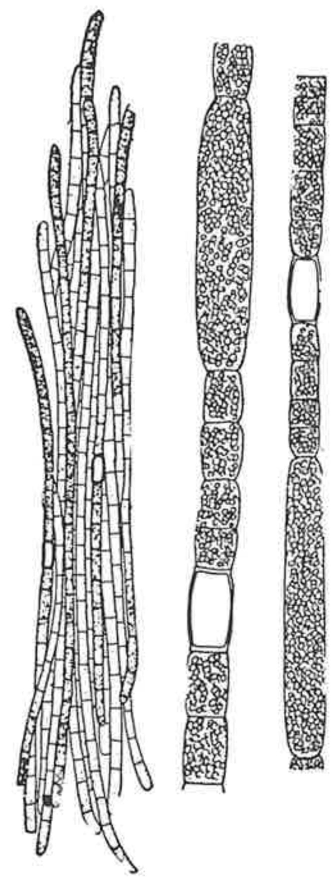
There are many individual species of the bluegreen algae, Anabaena. Some species are solitary while others form aggregated masses of indefinite shape. Anabaena seldom cause disagreeable conditions in lakes and reservoirs when they bloom, as they remain suspended throughout the water column and do not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

Anacystis



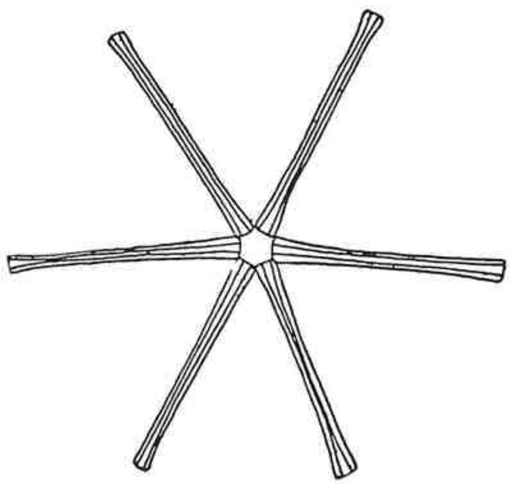
Anacystis is a loose colony of small spherical bluegreen algae cells contained in a gelatinous mass. The colony floats in the water column and is visible to the naked eye. Like Anabaena, Anacystis have been known to cause toxic water supplies.

Aphanizomenon



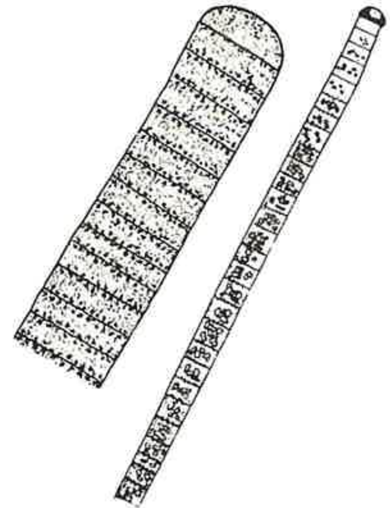
Individual cells of Aphanizomenon form strands which lie parallel in bundles and often occur so abundantly that the water appears to be filled with bits of chopped grass. The individual cells contain air spaces which give the plants great bouyancy. This accounts for the abundant growths of this bluegreen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

Asterionella



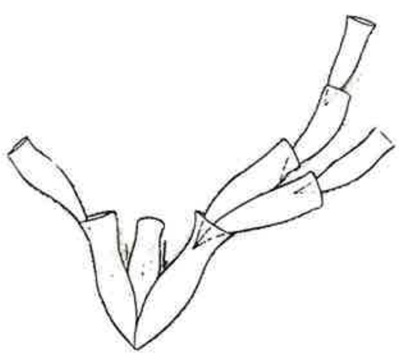
The diatom, Asterionella, usually occurs as a member of lake plankton. It prefers hard-water lakes and is readily identified by the spoke-like arrangement of the rectangular arms about a common center. Asterionella may be so abundant that lake water used for domestic water supplies may have a fishy taste.

Oscillatoria



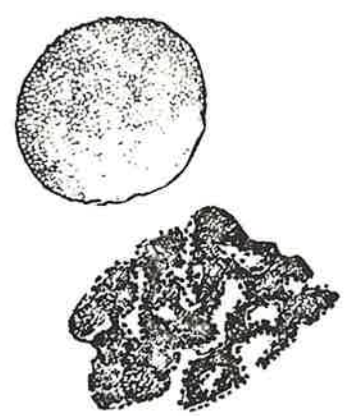
Oscillatoria is a filamentous bluegreen algae that grows in dense darkly colored clumps or mats. A characteristic of this bluegreen algae is the active oscillating movement for which it is named.

Dinobryon



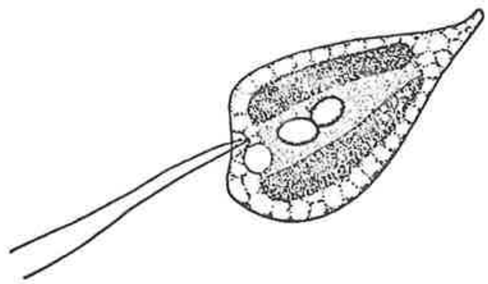
Dinobryon typically inhabit hard water lakes and, under certain conditions, may bloom. Dinobryon may produce disagreeable odors and tastes in domestic water supplies.

Microcystis



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

YELLOW GREEN ALGAE (Chrysophyta)

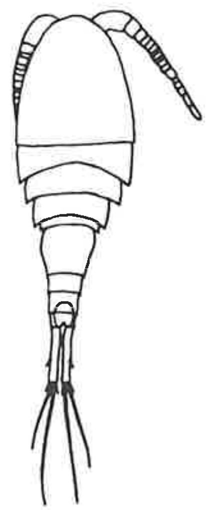


Many freshwater Chrysophyta are restricted to cold brooks, especially mountain streams, springs, and lakes during cool seasons. Most thrive in water relatively free of pollution.

Appendix A-3

A FORM OF ZOOPLANKTON FOUND IN SOUTHEASTERN WISCONSIN LAKES

COPEPODS (Diacyclops thomasi)



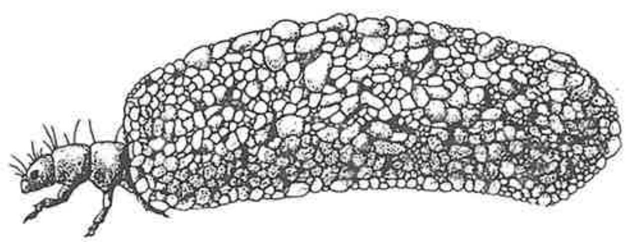
A common example of copepods found in permanent bodies of water of all types from shallow ponds and marshes to lakes is Diacyclops thomasi. The adults are predaceous on other zooplankton and can injure fish fry.

Appendix A-4

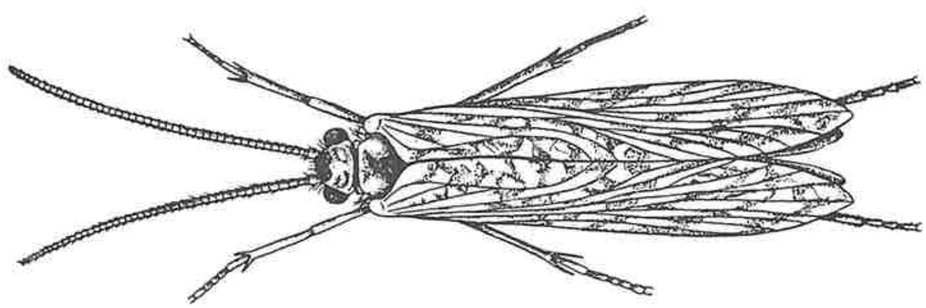
A FORM OF BENTHIC OR BOTTOM DWELLING ORGANISM FOUND IN SOUTHEASTERN WISCONSIN LAKES

CADDISFLIES (Trichoptera)

Caddisfly Larvae and Case



Adult Caddisfly

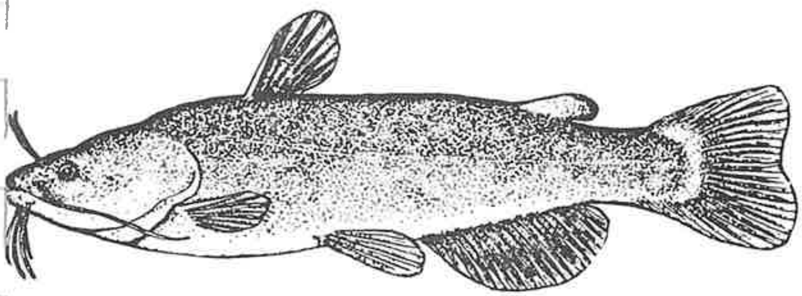


Caddisflies are found in most types of freshwater habitat, including streams, spring seepages, rivers, lakes, marshes, and temporary pools. Their tolerance to organic pollution varies widely, with some species being quite tolerant. Caddisflies are a food source for many species of fish.

Appendix A-5

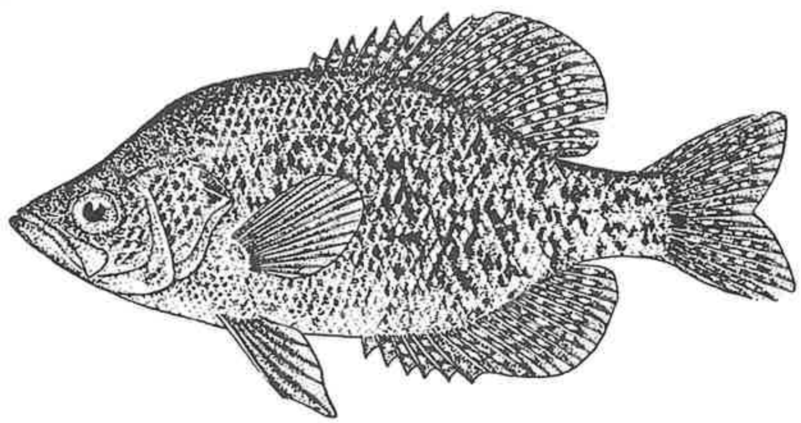
REPRESENTATIVE FISH SPECIES FOUND IN SOUTHEASTERN WISCONSIN LAKES

BLACK BULLHEAD (Ictalurus melas)



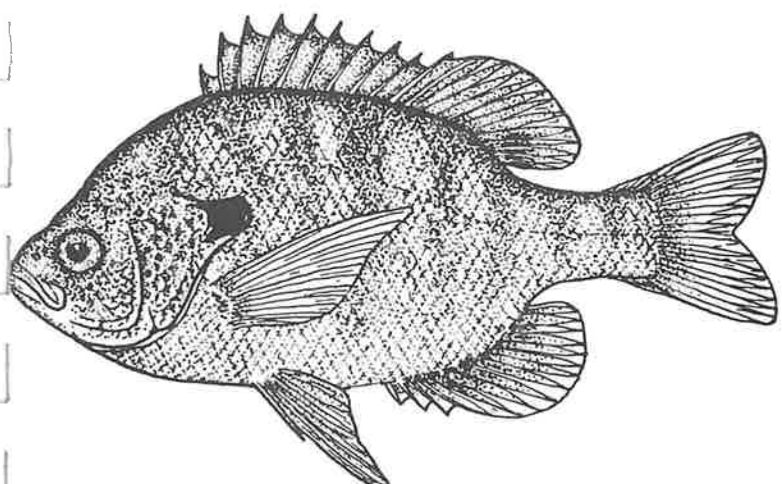
The black bullhead is common in shallow lakes and muddy streams. It nests in shallow water on either a sand or mud bottom. Bullheads are scavengers and will eat whatever food is available, such as minnows, leeches, crayfish, and amphipods.

BLACK CRAPPIE (Pomoxis nigromaculatus)



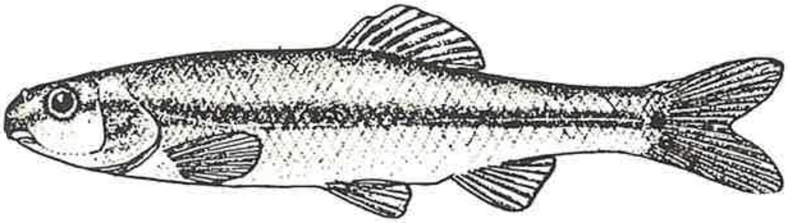
The black crappie prefers large streams and medium-sized lakes. It nests in water between three and six feet deep with a somewhat muddy bottom. Crappies feed on aquatic insects, small crustaceans, minnows, and other small fish.

BLUEGILL (Lepomis macrochirus)



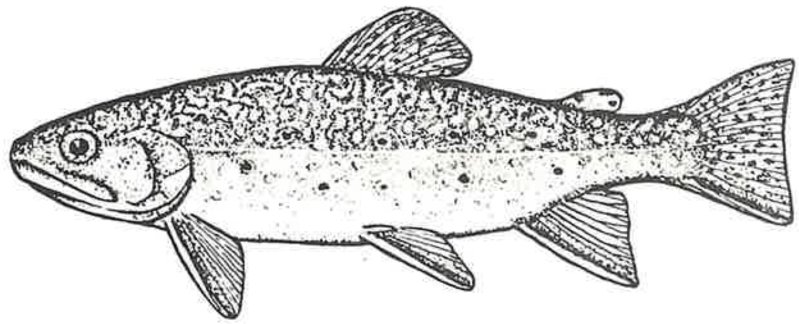
The bluegill is found in nearly all clear water lakes and streams. It nests in shallow areas with sandy bottoms; nests are often crowded together. Bluegills feed on small aquatic insects, worms, snails, and amphipods.

BLUNTNOSE MINNOW (<u>Pimephales</u> <u>notatus</u>)



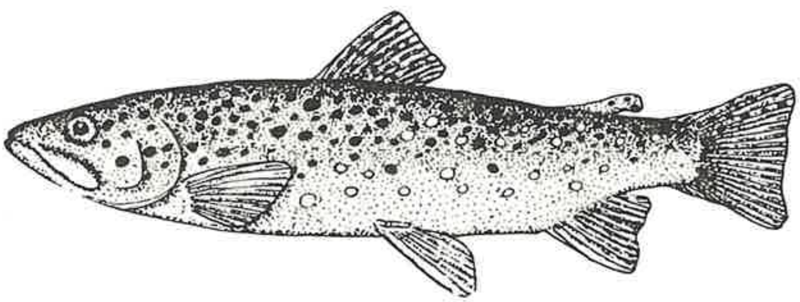
The bluntnose minnow is common in lakes and streams, but not in large rivers. The nest is built under an object, such as a rock or log. Bluntnose minnows feed mainly on algae.

BROOK TROUT (<u>Salvelinus</u> <u>fontinalis</u>)



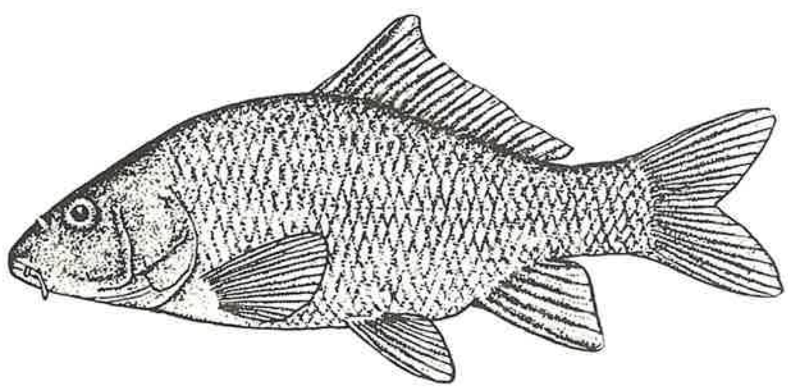
The brook trout, a native species in southeastern Wisconsin, prefers clear brooks and rivers in which the mean annual temperature rarely exceeds 50°F. The nest or redd is built on gravel bottoms in shallow riffle areas. Brook trout feed on adult aquatic insects and their larvae.

BROWN TROUT (<u>Salmo</u> <u>trutta</u>)



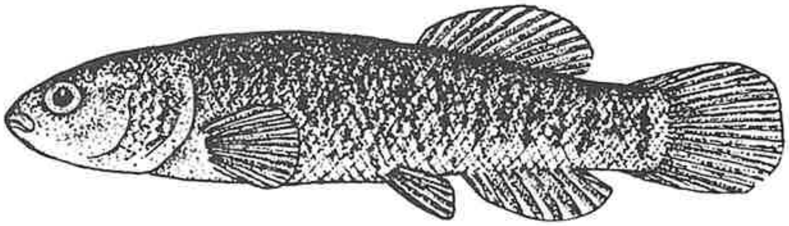
The brown trout is an introduced trout species which has become common in cold water streams. Nests or redds are built on sand and gravel bars at the mouths of tributaries. Young brown trout feed on small crustaceans and aquatic insects. Adults eat small fish, snails, crayfish, and terrestrial insects.

CARP (<u>Cyprinus</u> <u>carpio</u>)



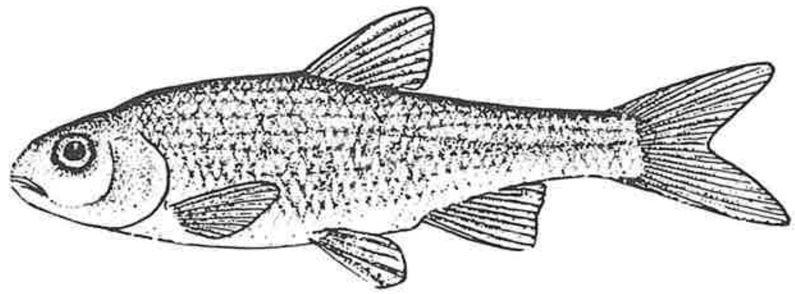
The carp is an introduced species which is tolerant of low dissolved oxygen conditions and prefers warm waters, with shallow mud-bottom lakes. Carp eat a wide variety of food. The uprooting of vegetation during feeding results in suspension of bottom sediments into the water column and a loss of aquatic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

CENTRAL MUDMINNOW (Umbra limi)



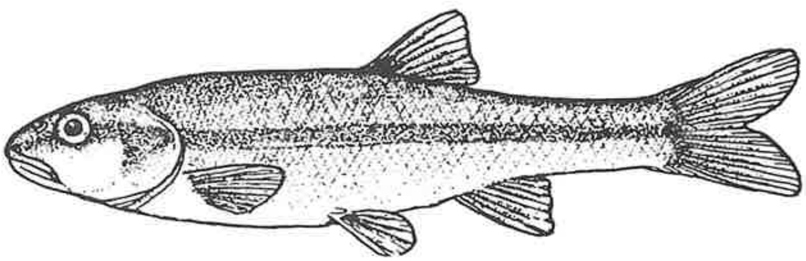
The central mudminnow prefers bog habitats, ditches, and streams with mud bottoms supporting dense aquatic vegetation. Spawning occurs in late spring and early summer. Mudminnows feed on insects, small crustaceans, and worms.

COMMON SHINER (Notropis cornutus)



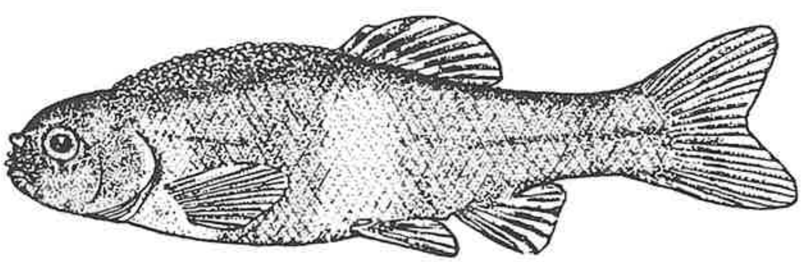
The common shiner occurs in habitats ranging from intermittent streams to large rivers and lakes. Common shiners are a forage fish that have value as a food source for game species. Shiners feed on small insects, crustaceans, and some algae.

CREEK CHUB (Semotilus atromaculatus)



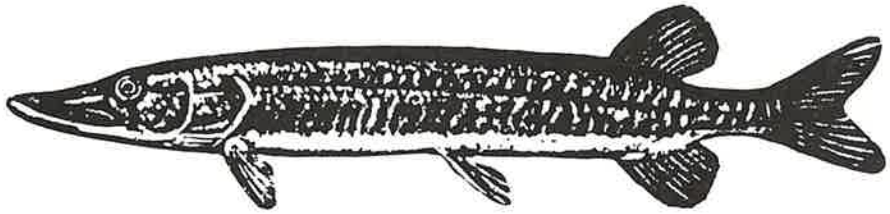
The creek chub prefers small streams and rivers but occasionally is found in lakes and large rivers. Creek chubs are quite common in beaver dam pools and may compete with trout for food. Chubs feed on all types of insects, amphipods, vegetation, and other, smaller fish.

FATHEAD MINNOW (Pimphales promelas)



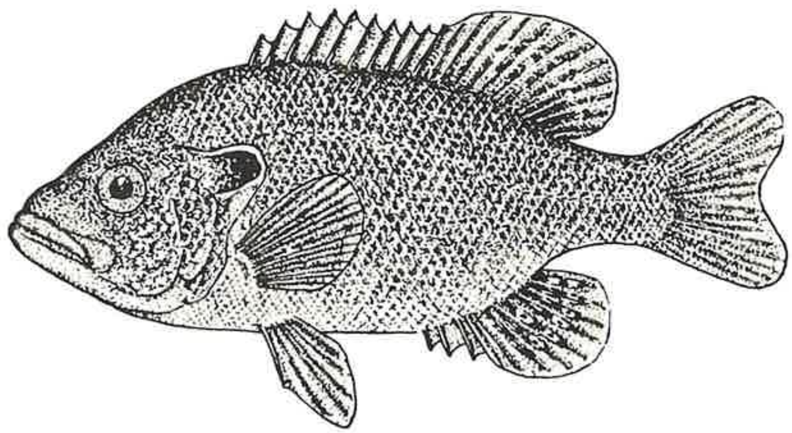
The fathead minnow prefers shallow lakes, ponds, and ditches. Nests are built on the underside of sticks, boards, and rocks in water between 3 and 12 inches deep. The fathead minnow can withstand very low oxygen conditions and, therefore, are very tolerant to pollution. Young fathead minnows feed on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

GRASS PICKERAL (*Esox americanus vermiculatus*)



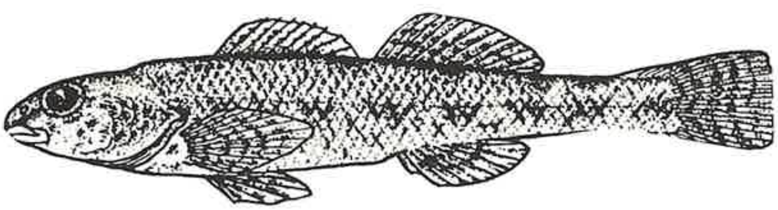
The grass pickerel is common in weedy portions of lakes and rivers. Pickerels are predators and as such feed almost exclusively on other fish. Grass pickerel are too small to have much value as a game fish.

GREEN SUNFISH (*Lepomis cyanellus*)



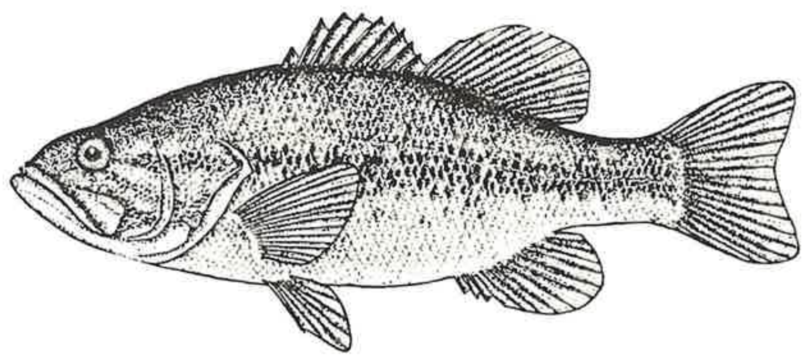
The green sunfish prefers small, shallow lakes and is common in creeks. Green sunfish feed on aquatic insects and any flying insects that happen to fall into the water. Large numbers of stunted adults may occur in some lakes and as such may decrease the viability of the existing fishery.

JOHNNY DARTER (*Etheostoma nigrum*)



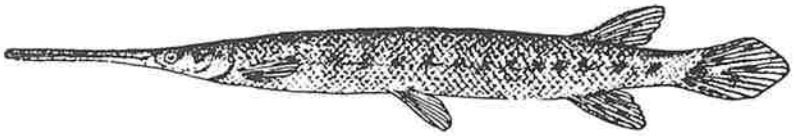
The johnny darter occurs in relatively clean lakes and streams. Nests are built under sticks and stones. The johnny darter feeds on algae and small, immature insects.

LARGEMOUTH BASS (*Micropterus salmoides*)



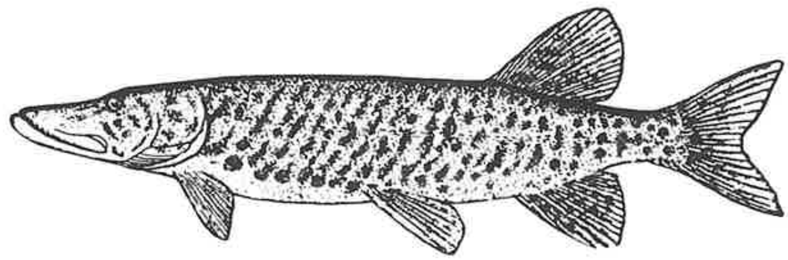
The largemouth bass prefers small- to medium-sized hardwater lakes with clear water, sandy shores, and marginal weed beds. The largemouth bass is carnivorous and as an adult feeds on perch, minnows, and small sunfish.

LONGNOSE GAR (Lepisosteus osseus)



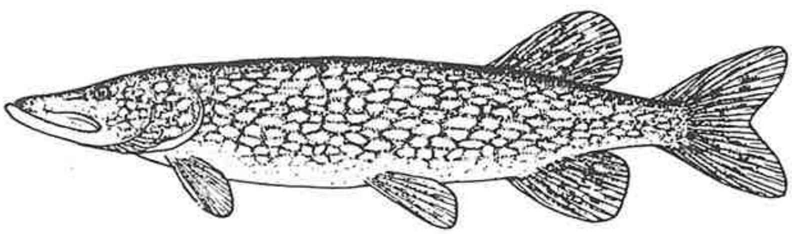
The longnose gar is a warmwater fish that often can tolerate surface waters which are too polluted for other species. Gars feed on game and forage fish and in some instances may alter fish populations enough to damage a fishery resource.

MUSKELLUNGE (Esox masquinongy)



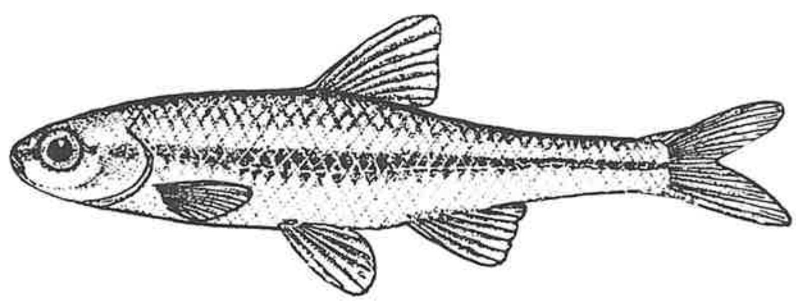
The muskellunge is common in lakes but is seldom abundant because it requires a large area of water to supply enough food for its voracious appetite. Spawning occurs in early May in tributary streams and shallow lake channels. Muskellunge are strictly carnivorous, feeding primarily on perch and suckers.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

NORTHERN PIKE (Esox lucius)



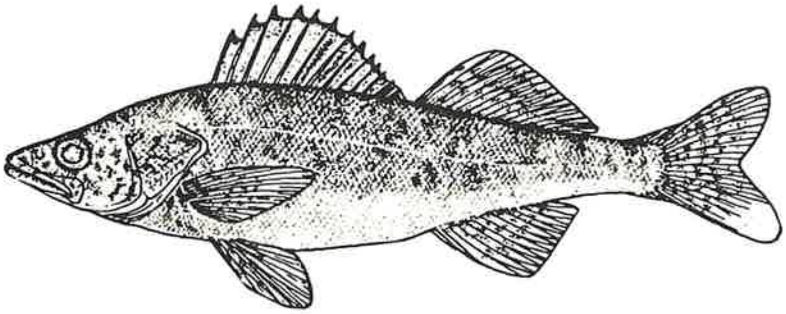
The northern pike is common in southeastern Wisconsin lakes. It feeds on a variety of fish, including perch, small suckers, sunfish, and even smaller northern pike. Spawning occurs immediately after the ice melts in April or early May in wetlands adjacent to lakes and streams.

PUGNOSE SHINER (Notropis anogenus)



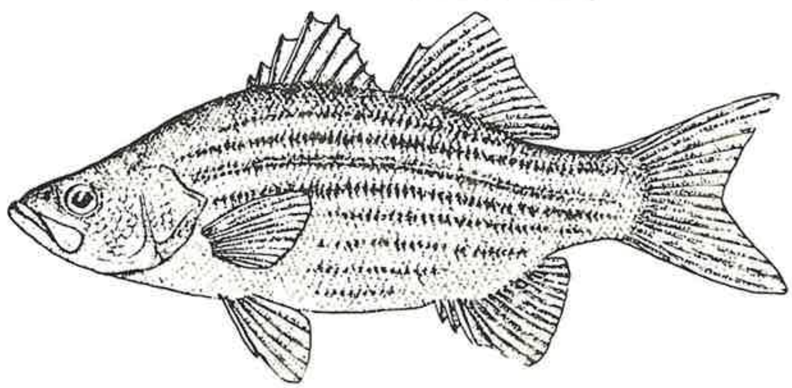
The pugnose shiner is threatened in Wisconsin. This small fish—up to two inches in length—prefers weedy waters in streams and lakes. Little is known about its life history as it is one of the rarest shiners. Changes by man in streams, rivers, and lakes have been responsible for its disappearance and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

WALLEYE (Stizostedion vitreum vitreum)



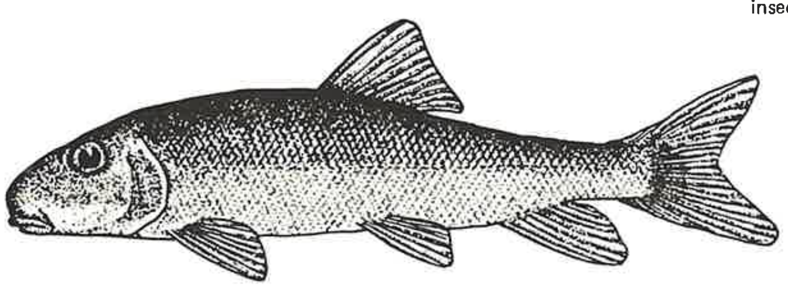
The walleye prefers clean and moderately warm to cold lakes and rivers. Spawning occurs in early spring on sand bars and shoals. Walleye feed on small minnows, small bullheads, and leeches. Walleye are a very desirable game fish.

WHITE BASS (Morone chrysops)



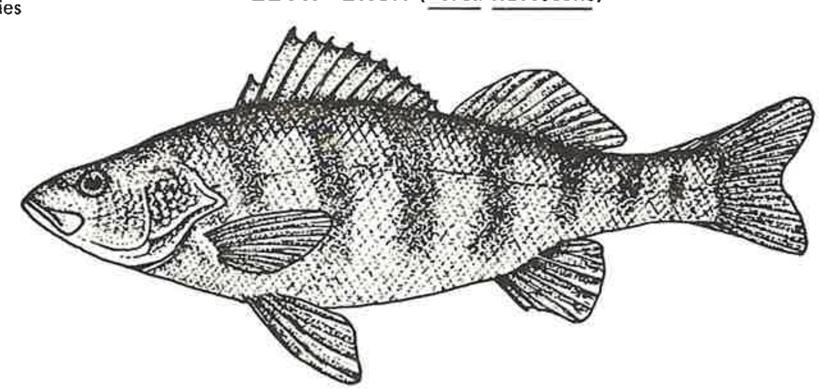
The white bass occurs in large rivers and connected lakes. White bass usually travel in large schools near the surface. Eggs are scattered randomly on shallow bars and gravelly reefs. White bass feed on insects and small fish.

WHITE SUCKER (Catostomus commersoni)



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

YELLOW PERCH (Perca flavescens)



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

Appendix B

SUMMARY OF EXISTING GENERAL ZONING DISTRICTS IN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO GENEVA LAKE

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
City of Lake Geneva								
R-1	Single-Family Residence	Single-family detached dwellings, agriculture on 20-acre tracts, parks, playgrounds, and schools	Home occupations	Art galleries, churches, cemeteries, colleges, multiple-family dwellings, single-family semi-detached dwellings, golf courses, hospitals, libraries, parks, playgrounds, planned developments, resorts, public utilities, governmental services, swimming pools	9,000 square feet	75	324	2.6
R-2	Duplex Residence	Uses permitted in R-1 District, duplex dwellings, churches, lodging rooms	--	Special uses in R-1 District, multiple-family, single-family attached and single-family detached dwellings	One story--10,000 square feet Two story or more--8,000 square feet	75	94	0.7
R-3	General Residence	Uses permitted in R-2 District, libraries, multiple-family dwellings, rooming, boarding, and lodging houses, nursery schools, single-family semi-detached dwellings, single-family attached dwellings, two-family detached dwellings	--	Special uses in R-1 District, clubs lodges, fraternities, nursing homes, parking areas, institutions	Single family--9,000 square feet Two family One story--10,000 square feet Two story or more--8,000 square feet Multiple family 4 bedroom--5,800 square feet/unit; 3 bedroom--4,400 square feet/unit; 2 bedroom--3,200 square feet/unit; 1 bedroom or efficiency--2,800 square feet/unit	75 75 75	30	0.2
R-4	Planned Unit Development	All uses in this district are conditional uses	--	All principal and conditional uses of B-1, B-2, and P-1 Districts; single-family dwellings; multiple-family dwellings; home occupations and professional home offices; and multiple principal structures on one lot	Projects may not exceed the density of the district that the development would have been in were it not a planned unit development: Maximum density--15 units per developable acre		59	0.5
R-5	Mobile Home Park Residence	All uses in this district are conditional uses	--	Single-family detached dwellings, mobile homes, accessory buildings, home occupations, and professional home offices	10 acres minimum development area Maximum density--5 units per developable acre	450	8	<0.1

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
City of Lake Geneva (continued)								
P-1	Park	Parks, playgrounds, forest preserves	--	Swimming pools, beaches, golf courses, marinas, camps, campgrounds, etc.	Sufficient area and width for all uses		339	2.7
P-2	Institutional Park	Churches and associated structures, post offices, city halls, police and fire stations	--	Gymnasiums, cemeteries, municipal garages, sewage treatment and water treatment plants, utility substations, hospitals, nursing homes, schools	Sufficient area and width for all uses		70	0.5
C-1	Lowland Resource Conservation	Boat landings, flood overflow, forest and game management, fishing, impoundments, navigational aids, recreation, swimming beaches, stream bank protection, hiking trails	--	--	--	--	--	--
B-1	Restricted Retail Business	Retail or service establishments; dwelling units and lodging units permitted above first floor	Business signs, off-street parking and loading	See zoning ordinance for complete listing	1,750 square feet plus loading areas	20	5	<0.1
B-2	General Business	Retail or service establishments. See zoning ordinance for complete listing	--	Animal hospitals, gas stations, boarding houses, auto sales and service, kennels	9,000 square feet	75	27	0.2
B2-R	Restricted Business	Single-family residences	--	Offices--see zoning ordinance for complete listing	9,000 square feet	75	--	--
B-3	Planned Business	None--all uses in this district are conditional uses	--	See zoning ordinance for complete listing	Residential uses permitted in R-3 District; business uses--no minimum	No minimum	--	--
M-1	Manufacturing	Industrial and commercial operations, warehouses, wholesale establishments. See zoning ordinance for complete listing	--	Transportation facilities, car lots	Sufficient area and width for all uses (maximum lot coverage--60 percent)	No minimum	--	--
Subtotal							956	7.5

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Village of Fontana-on-Geneva Lake								
RS-1	Single-Family Residential	Single-family dwellings, public parks, playgrounds, utility lines and transformer stations, golf courses, crop and tree farming, and horticulture	Private garages, household employee quarters, greenhouses and sheds, home occupations	Private commercial and noncommercial recreational facilities, historic restorations, two-family dwellings. See zoning ordinance for complete listing	30,000 square feet	100	354	2.8
RS-2	Single-Family Residential	Any use permitted in RS-1 District	Any accessory use permitted in RS-1 District	Any conditional use permitted in RS-1 District; schools, churches, public buildings, inns and restaurants, mobile home parks	15,000 square feet	90	99	0.8
RS-3	Single-Family Residential	Any use permitted in RS-1 District	Any accessory use permitted in RS-1 District	Any conditional use permitted in RS-2 District	7,000 square feet	75	441	3.5
RSA-1	Single-Family Attached Residential	Any use permitted in RS-1 District, duplex residences, attached single-family residences of no more than four units per structure	Any accessory use permitted in RS-2 District	Any conditional use permitted in RS-2 District	No minimum	No minimum	54	0.4
VCP	Village Center Preservation	Any existing use	Any accessory use permitted with existing use	Any use permitted in any other district; expansion of any use other than single-family residential	7,000 square feet single-family residences	75, single-family residences	56	0.4
RM-1	Multiple-Family Residential	Any use permitted in RSA-1 District, except duplex or attached single-family residences in groups of more than two buildings are subject to approval	Any accessory use permitted in RS-2 District, group garage facilities	Any conditional use permitted in RS-2 District	No minimum	No mimimum	21	0.2
PD	Planned Development	Any use permitted in any other district which has been approved as part of a comprehensive site development plan	Any use normally accessory to a permitted use	Any conditional use permitted in any other district, mobile home parks	See zoning ordinance	See zoning ordinance	116	0.9
RC	Restricted Conservancy	Forestry, wildlife, and fish management; wild crop harvesting; fishing; dams; public utility transmission facilities; trails; public parks; access roads	Uses customarily incidental to any of the above uses	Private noncommercial outdoor facilities, utility substations, wastewater treatment facilities	No minimum	No minimum	29	0.2

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Village of Fontana-on-Geneva Lake (continued)								
LC	Limited Conservancy	Any use permitted in RC District, golf courses	Uses customarily incidental to any of the above uses	Any conditional use permitted in RC District, deposit of dredged materials	No minimum	No minimum	31	0.2
C-1	Restricted Commercial	Any use permitted in RM-1 District, except that residential use shall be permitted only in conjunction with or accessory to another permitted principal use; retail stores not exceeding 1,500 square feet in floor area; businesses and professional offices not exceeding 1,000 square feet in floor area	Any accessory use permitted in RM-1 District, garages, off-street parking, signs	Any conditional use permitted in RM-1 District, any use permitted in C-2 District, auto service stations, drive-in food businesses, indoor commercial recreational facilities, roadside stands	No minimum	No minimum	--	--
C-2	General Commercial	Any use permitted in C-1 District, retail shops, public garages, drive-in establishments, service stations, parking lots, transportation terminals. See zoning ordinance for complete listing	Any accessory use permitted in C-1 District	Any conditional use permitted in C-1 District, building supply yards, experimental laboratories, warehousing, automobile sales and service, animal hospitals and kennels, appliance repair shops	No minimum	No minimum	45	0.3
C-3	Lake Shore Commercial	Boat launching ramps and liveries, yachting clubs, private commercial group outdoor recreational facilities	Any accessory use permitted in C-1 District	Any conditional use permitted in C-1 District; boat storage, repair, maintenance	No minimum	No minimum	7	0.1
C-4	Resort Commercial	Hotels, swimming pools, marinas, boat launching and servicing areas	--	--	No minimum	No minimum	56	0.4
PS-1	Performance Standard--Rural	Any existing legal use, certain agricultural uses. See zoning ordinance for complete listing	Any accessory use permitted in RS-1 District; any use normally accessory to existing or permitted use	Any use permitted in RSA-1 District; any conditional use permitted in RS-2 District	30,000 square feet	100	24	0.2

Appendix B (continued)

Zoning Districts		Permitted Uses: Principal	Permitted Uses: Accessory	Conditional/ Special Uses	Area Regulations: Minimum Area	Area Regulations: Minimum Width (feet)	Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
Village of Fontana-on-Geneva Lake (continued)								
PS-2	Performance Standard--Intermediate	Any use permitted in PS-1 District, single-family detached residences, any use permitted in PS-1 District	Any accessory use permitted in PS-1 District	Any use permitted in RM-1 District; any conditional use permitted in PS-1 District	15,000 square feet	90	175	1.4
PS-3	Performance Standard--Mixed	Any use permitted in PS-2 District; any use permitted in RM-1 District	Any accessory use permitted in PS-1 District	Any conditional use permitted in PS-2 District; any other use permitted in any other district	7,000 square feet	75	80	0.6
Overlay Districts								
OP	Parking	Any use permitted in the underlying district, parking facilities, signs and lighting facilities	--	Any conditional use permitted in the underlying basic district	--	--	--	--
OIP	Institutional and Public Service	Any use permitted in the underlying district, schools, churches, libraries and museums, public administration buildings, public utility offices and installations, private lodges and clubs, public and private noncommercial recreational facilities, cemeteries and mausoleums	Any accessory use permitted in the underlying basic district, and other uses normally incidental to the permitted overlay use; service facilities accessory to a permitted principal use	Any conditional use permitted in the underlying basic district, public service yards, radio and television towers, hospitals and nursing homes, service facilities accessory to permitted principal use	--	--	11[a]	0.1
OLS	Lakeshore	Any use permitted in the underlying basic district; any other use normally incidental to the permitted overlay use	Any accessory use permitted in the underlying basic district, any other uses normally incidental to the permitted overlay use; service facilities accessory to a permitted principal use	Any conditional use permitted in the underlying basic district, boating and yacht clubs, private commercial and noncommercial recreational facilities, boat liveries and docking facilities	--	--	--	--
Subtotal							1,588	12.4

Appendix B (continued)

Zoning Districts		Permitted Uses: Principal	Permitted Uses: Accessory	Conditional/ Special Uses	Area Regulations: Minimum Area	Area Regulations: Minimum Width (feet)	Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
Village of Walworth								
RA	Single-Family Residence	Single-family homes, churches, schools, libraries, hospitals, municipal buildings, public parks, playgrounds, recreational and community center buildings and grounds	Uses customarily incidental to any of the principal uses, provided that no such use generates traffic or noise that would create a public or private nuisance	Single-family mobile homes as part of a planned mobile home park, office for mobile home development and service buildings	10,000 square feet	70	54	0.4
RA-2	Two-Family Residence	Any use permitted in RA District, two-family dwellings, rooms for up to four paying guests or boarders	Accessory buildings	--	6,000 square feet	60	--	--
RB	Multiple-Family Residence	Any use permitted in RA District, multiple- and two-family dwellings, hospitals and medical clinics, charitable institutions, storage garages	Accessory buildings	--	Multiple family-- 3,600 square feet Two family-- 6,000 square feet Single family-- 10,000 square feet	70 70 70	13	<0.1
C-1	General Commercial	Any use permitted in RB District, post offices, banks, commercial or professional offices, telephone offices, hotels, motels, theaters, automobile service, bus depots	--	--	Multiple family-- 3,600 square feet Two family-- 6,000 square feet Single family-- 10,000 square feet	75 75 75	--	--
C-2	Highway Commercial	Specialized commercial activities along major highways	Accessory buildings	--	--	75	--	--
C-3	Special Commercial	Stores, offices, shops, services, and agencies. See zoning ordinance for complete listing	--	--	No minimum	No minimum	--	--

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Village of Walworth (continued)								
W	Conservancy	Management of forestry, wildlife, and fish, harvesting of wild crops, hunting, fishing, trapping, dams, power stations, transmission lines, gravel or sand pits and quarries	--	Sewage disposal plants, water pumping or storage facilities, amusement parks, golf courses, driving ranges, and public camping grounds	No minimum	No minimum	33	0.2
PR	Planned Unit Development	Combination of single-family, multiple-family development as well as related commercial uses	--	--	Six acres for total development; residential, same as RB District commercial, same as C-2 District		--	--
I	Industrial	Warehousing, light assembly industries	--	--	--	100	--	--
A	Agricultural	Churches, schools, parks, municipal buildings, farming, roadside stands, water storage, sewage disposal plants, power stations	--	Fur farms, kennels, insect breeding facilities, nurseries, greenhouses	Enough for bonafide farming operation	66	--	--
I-2	General Industrial	All uses permitted in Industrial District, heavy machinery uses, outdoor storage, operations that are dangerous or may constitute a public or private nuisance	--	--	No minimum	150	37	0.3
Subtotal							136	1.0

Appendix B (continued)

Zoning Districts		Permitted Uses: Principal	Permitted Uses: Accessory	Conditional/ Special Uses	Area Regulations: Minimum Area	Area Regulations: Minimum Width (feet)	Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
Village of Williams Bay								
R-1	Single-Family Residential	One-family dwellings	--	Public, parochial, and private elementary and secondary schools, churches, planned residential developments	12,000 square feet	100	190	1.5
R-2	Single-Family Residential	One-family dwellings	--	Public, parochial, and private elementary and secondary schools, churches, planned residential developments, home occupations, and professional offices	7,200 square feet	60	148	1.2
R-3	Multiple-Family Residential	Multiple-family dwellings	--	Public, parochial, and private elementary and secondary schools, churches, planned residential developments, home occupations, and professional offices	12,000 square feet	100	56	0.4
R-4	Multiple-Family Residential	Multiple-family dwellings	--	Public, parochial, and private elementary and secondary schools, churches, planned residential developments, home occupations, and professional offices	15,000 square feet	120	24	0.2
RM-1	Multi-Family Residential	One-family dwellings	--	Two-family/multiple-family residential units	One family-- 7,200 square feet Multiple family-- 1,800 to 3,000 square feet/dwelling	60 100	--	--
RM-2	Multi-Family Residential	One-family dwellings	--	Multiple-family dwellings	15,000 square feet	120	--	--
RS-1	Single-Family Residential	One-family dwellings	--	Cluster residential development	65,000 square feet	200	45	0.4
RS-2	Single-Family Residential	One-family dwellings	--	Cluster residential development	43,560 square feet	200	32	0.3
RS-3	Single-Family Residential	One-family dwellings	--	Cluster residential development	33,600 square feet	175	--	--
RS-4	Single-Family Residential	One-family dwellings	--	Utilities, commercial and recreational facilities, public transportation facilities, vehicle sales, service stations, cluster residential development	21,700 square feet	150	--	--

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Village of Williams Bay (continued)								
RS-5	Single-Family Residential	One-family dwellings	--	Utilities, commercial and recreational facilities, public transportation facilities, vehicle sales service stations, cluster residential development	12,000 square feet	100	--	--
RS-6	Cedar Point Park Subdivision	One-family dwellings	--	See zoning ordinance for complete listing	See zoning ordinance	--	105	0.8
RC-1	Recreational Camp	All uses permitted in single-family residential district, recreational camps, private recreational buildings, private secondary schools and colleges	--	See zoning ordinance for complete listing	12,000 square feet	100	47	0.4
B-1	Neighborhood Business	Retail establishments. See zoning ordinance for complete listing	--	Utilities, commercial recreational facilities, public transportation facilities, vehicle sales, service stations, rest homes	No minimum	No minimum	5.0	<0.1
B-2	Community Business	All uses permitted in B-1 Neighborhood Business District. See zoning ordinance for complete listing	Outside storage requires six-foot-high fence as a vision screen	Utilities, drive-in theaters, motels, funeral homes, drive-in banks, commercial recreational facilities, public transportation facilities, vehicle sales, service stations	No minimum	No minimum	24	0.2
B-3	Waterfront Business	All uses permitted in this district are conditional uses	--	See zoning ordinance for complete listing	Minimum area for the principal structure, off-street parking, and loading areas		12	0.1
M-1	Limited Manufacturing	Automotive body repairs, boat manufacture, bakeries, greenhouses, distributors, painting, printing, warehousing, manufacturing. See zoning ordinance for complete listing	--	Airports, governmental and cultural uses, public transportation facilities, animal hospitals, dumps, incinerators, sewage disposal sites, creameries, manufacturing, outside storage and manufacturing areas, commercial service facilities. See zoning ordinance for complete listing	No minimum	No minimum	15	0.1

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Village of Williams Bay (continued)								
M-2	General Manufacturing	No specified standards	No specified standards	No specified standards	--	--	--	--
A-1	Agriculture	Agriculture, dairying, greenhouses, hatcheries, livestock raising, stables, truck farming	Farm dwellings for laborers and resident owners	Airports, colleges and universities, observatories, hospitals, sanitariums, religious institutions, correctional institutions, cemeteries, animal hospitals, dumps, incinerators, sewage disposal sites, mineral extraction	10 acres	200	--	--
C-1	Conservancy	Fishing, hunting, preservation of scenic, historic, and scientific areas, public fish hatcheries, soil and water conservation, sustained yield forestry, stream bank and lake shore protection, water retention, wildlife preserves	Structures accessory to the principal or conditional uses	Drainage, water measurement and water control facilities, grazing, orchards, truck farming, utilities, wildcrop harvesting	--	--	27	0.2
FH-1	Flood Hazard	See zoning ordinance for complete listing	See zoning ordinance for complete listing	See zoning ordinance for complete listing	--	--	--	--
P-1	Public Service and Institutional	Arboretums, beaches, civic structures, camp sites, parks, playgrounds, recreation buildings, fishing, swimming, boating, skating, skiing, sewage treatment plants, soil and water conservation, water measurement and water control facilities, public works garages, fire and police headquarters, firing ranges, libraries, governmental offices, schools, golf courses, mooring facilities. See zoning ordinance for complete listing	--	See zoning ordinance for complete listing	No minimum	No minimum	194	1.5

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Village of Williams Bay (continued)								
PD-1	Planned Development	Allows for diversification in the relationship of residential, commercial, service, recreational, and conservancy purposes	--	See zoning ordinance for complete listing	7.5 acres	--	267	2.1
Subtotal							1,191	9.3

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth								
A-1	Prime Agricultural Land	Dairying, orchards, raising of grain, sod farming, forest and game management, greenhouses, stables, two single-family dwellings or one two-family dwelling, roadside stands. See zoning ordinance for complete listing	--	Single-family dwellings exceeding limits set forth in principal uses for owners or laborers; commercial feed lots; livestock sales barns; animal hospitals; shelters and kennels; veterinarian services; commercial raising; commercial egg production; airports; governmental and cultural uses; utilities	35 acres	--	1,660	13.0
A-2	Agricultural Land	All principal uses permitted in A-1 Prime Agricultural Land District	--	Same as in A-1 District, ski hills, hunting clubs, recreational camps, campgrounds, riding stables	20 acres	300	1,210	9.5
A-3	Agricultural Land Holding	All principal uses permitted in A-1 Prime Agricultural Land District	--	Same as in A-1 District, ski hills	35 acres	--	920	7.2
A-4	Agricultural-Related Manufacturing, Warehousing, and Marketing	All uses in this district are conditional uses	--	Packaging of fruits and vegetables, hay baling services, production of natural and processed cheese, fluid milk processing, meat packing, sales of farm implements and related equipment, governmental and cultural uses, and utilities. See zoning ordinance for complete listing	Sufficient area for the principal structure and its accessory buildings, off-street parking and loading	--	42	0.3
A-5	Agricultural-Rural Residential	Single-family dwellings, agricultural uses on remnant or marginally productive farmlands	--	Sewage treatment plants, governmental uses, institutional uses, and utilities	40,000 square feet	150	--	--
C-1	Lowland Resource Conservation (nonshoreland)	Boat landing sites, fish hatcheries, forest and game management, hunting and fishing clubs not including buildings, swimming beaches, hiking and nature trails, wild crop harvesting. See zoning ordinance for complete listing	--	Animal hospitals and shelters, kennels, yachting clubs and marinas, hunting and fishing clubs, recreational camps, public or private campgrounds, riding stables	No minimum	No minimum	70	0.5

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth (continued)								
C-2	Upland Resource Conservation	Farming and related agricultural uses when conducted in accordance with the County Conservation Standards, forest preservation, forest and game management, hunting and fishing clubs, parks and recreational areas, stables, single-family detached dwellings	--	Animal hospitals and kennels, ski hills, yachting clubs and marinas, recreational camps, public or private campgrounds, riding stables, planned residential developments	5 acres	300	1,490	11.6
C-3	Conservancy Residential	Forest preservation, forest and game management, single-family detached dwellings	--	Animal hospitals, shelters, and kennels, planned residential developments	100,000 square feet	200	180	1.4
C-4	Lowland Resource Conservation (shoreland)	Recreation, wild crop harvesting, silviculture, pasturing and crop cultivation, construction and maintenance of piers, docks, and walkways, and repair and replacement of existing town and county highways and bridges. See zoning ordinance for complete listing	--	Construction and maintenance of roads necessary for silvicultural or agricultural activities and of nonresidential buildings used solely for wildlife propogation or other purposes compatible with wetland preservation; development of public and private parks and recreation facilities; and construction and maintenance of utility lines and railroad lines	No minimum	No minimum	270	2.1
P-1	Recreation Park	Parks, forest reserves, boat access site, boat rentals, golf courses and country clubs, gymnasiums, ice skating, picnic grounds, athletic fields, playgrounds, recreational access ways, forest and game management	--	Ski hills, yachting clubs and marinas, hunting and fishing clubs, recreational camps, cultural activities, amusement activities, public assembly uses, riding stables, archery ranges, golf driving ranges, firearm ranges, sports fields, skating rinks	Sufficient area for the principal structures, off-street parking and loading	--	150	1.2

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth (continued)								
P-2	Institutional Park	Churches, college dormitories, hospitals, junior colleges, nursing homes, nurseries and day schools, orphanages, retirement homes, universities and colleges, lodges and fraternities	--	Ski hills, yachting clubs and marinas, recreational camps, cultural activities, public assembly uses, riding stables, archery ranges, golf driving ranges, firearm ranges, sports fields, skating rinks, airports	Sewered-- 10,000 square feet Unsewered-- Width and area to be determined in accordance with Section 2.5 of zoning ordinance	100	95	0.7
R-1	Single-Family Residence (unsewered)	Single-family detached dwellings on lots not served by public sanitary sewer; parks and playgrounds	--	Golf courses, planned residential developments, barbering and beauty culture operations, home occupations	Width and area to be determined in accordance with Section 2.5 of zoning ordinance		2,600	20.3
R-2	Single-Family Residence (sewered)	Single-family detached dwellings on lots served by public sanitary sewers; parks and playgrounds	--	Golf courses, planned residential developments, barbering and beauty culture operations, home occupations	15,000 square feet	100	--	--
R-3	Two-Family Residence (sewered or unsewered)	Single-family detached dwellings, two-family dwellings (duplex), parks and playgrounds	--	Golf courses, planned residential developments barbering and beauty culture operations, home occupations	Sewered-- 15,000 square feet Unsewered-- Width and area to be determined in accordance with Section 2.5 of zoning ordinance	100	--	--
R-4	Multiple-Family Residence (sewered or unsewered)	All uses in this district are conditional uses	--	Two-family dwellings, parks and playgrounds, multiple-family dwellings, golf courses, planned residential developments, fraternities, rest homes, barbering and beauty culture operations, home occupations	Two-family-- 12,000 square feet Multi-family-- 15,000 square feet Maximum six dwelling units per net developable acre	80 100	3	<0.1

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth (continued)								
R-5	Planned Residential Development	All uses in this district are conditional uses	--	One-family detached dwellings, one-family semi-detached dwellings, one-family attached dwellings, two-family dwellings, multiple-family dwellings, all principal uses permitted in the local business (B-1) district provided that such uses shall not occupy more than 15 percent of the total development area, golf courses, ski hills, barbering and beauty culture operations, home occupations	Sewered-- Maximum eight dwelling units per developable acre Unsewered-- Area and width to be determined in accordance with Section 2.5 of zoning ordinance		--	--
R-6	Planned Mobile Home Park Residence	All uses in this district are conditional uses	--	Single-family detached dwellings, mobile and modular homes, accessory buildings for the purpose of providing laundry and recreational facilities and for the sale of convenience food and related items primarily for and to mobile home park residents, golf courses, barbering and beauty culture operations, home occupations	10 acres Open space 20 percent of development area exclusive of required yards and access drives	450	3	<0.1
R-7	Mobile Home Subdivision Residence	Mobile and modular homes, single-family detached dwellings, parks and playgrounds	--	Golf courses, planned residential developments, barbering and beauty culture operations, home occupations	Sewered-- 15,000 square feet Unsewered-- Area and width to be determined in accordance with Section 2.5 of zoning ordinance	100	--	--
B-1	Local Business	Bakeries, business offices, clothing stores, drug stores, gift stores, grocery stores, hardware stores, restaurants, supermarkets. See zoning ordinance for complete listing	--	Residential dwelling units--one per principal use when attached to principal structure	Sewered-- 7,500 square feet Unsewered-- Area and width to be determined in accordance with Section 2.5 of zoning ordinance	75	25	0.2

Appendix B (continued)

Zoning Districts		Permitted Uses: Principal	Permitted Uses: Accessory	Conditional/ Special Uses	Area Regulations: Minimum Area	Area Regulations: Minimum Width (feet)	Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth (continued)								
B-2	General Business	All principal uses permitted in B-1 District, hotels, churches, department stores, financial institutions, taverns, secondhand stores, private schools, broadcasting studios, variety stores. See zoning ordinance for complete listing	--	Residential dwelling units--one per principal use when attached to principal structure; animal hospitals, shelters, and clinics; public assembly uses; commercial recreational facilities; drive-in theaters and establishments	Sewered-- 7,500 square feet Unsewered-- Area and width to be determined in accordance with Section 2.5 of zoning ordinance	75	50	0.4
B-3	Waterfront Business	All uses in this district are conditional uses	--	Boat rental and boat access sites, bowling alleys, motels, bait shops, restaurants, skating rinks, supper clubs, swimming beaches and pools, yachting clubs, boat liveries, residential dwelling units--one per principal use when attached to principal structure. See zoning ordinance for complete listing	Sewered-- Minimum, sufficient area for the principal structure and its accessory buildings, off-street parking and loading areas Unsewered-- Determined in accordance with Section 2.5 of zoning ordinance		12	<0.1
B-4	Highway Business	All uses in this district are conditional uses	--	Automobile and truck retail and repair services, taverns, gift sales, motels, restaurants, residential dwelling units--one per principal use when attached to principal structure. See zoning ordinance for complete listing	Sewered-- Minimum, sufficient area for the principal structure and its accessory buildings, off-street parking and loading areas Unsewered-- Determined in accordance with Section 2.5 of zoning ordinance		4	<0.1
B-5	Planned Commercial-Recreation Business	All uses in this district are conditional uses	--	Aircraft fields, amusement parks, campgrounds, drive-in theaters, fairgrounds, health and recreational resorts, golf courses, race tracks, snowmobile trails, swimming beaches. See zoning ordinance for complete listing	No minimum	No minimum	75	0.6

Appendix B (continued)

Zoning Districts		Permitted Uses		Conditional/ Special Uses	Area Regulations		Civil Division Area Zoned Within Direct Drainage Area (acres)	Percent of Direct Drainage Area
		Principal	Accessory		Minimum Area	Minimum Width (feet)		
Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth (continued)								
M-1	Industrial	Auto body repairs, cleaning, distributors, laboratories, printing, warehousing, wholesaling, manufacturing, and retail services. See zoning ordinance for complete listing	--	Living quarters for watchman or caretaker; farm machinery plants; machine shops; painting, manufacture, fabrication, packing, packaging, and assembly of products from furs, glass, metals, paper, leather, plaster, plastics, textiles, and wood; sewage disposal plants	Sewered-- Sufficient area for the principal structure and its accessory buildings, off-street parking and loading areas Unsewered-- Determined in accordance with Section 2.5 of zoning ordinance		5	<0.1
M-2	Heavy Industrial	All principal uses permitted in M-1 Industrial District, freight yards, terminals, transshipment depots, inside storage, breweries	--	Living quarters for watchman or caretaker, crematories, all conditional uses permitted in M-1 Industrial District, outside storage, and manufacturing, wrecking, junk, demolition, and scrap yards	Sewered-- Sufficient area for the principal structure and its accessory buildings, off-street parking and loading areas Unsewered-- Determined in accordance with Section 2.5 of zoning ordinance		--	--
M-3	Mineral Extraction	All uses in this district are conditional uses	--	Aggregate or ready mix plants; clay, ceramic, and refractor minerals mining; crushed and broken stone quarrying; mixing of asphalt; nonmetallic mining services; processing of topsoil; sand and gravel quarrying; washing, refining, or processing of rock, slate, gravel, sand, or minerals; sewage disposal plants	No minimum	No minimum	65	0.5
M-4	Sanitary Landfill	All uses in this district are conditional uses	--	Sanitary landfills, incinerators, sewage disposal plants	No minimum	No minimum	10	<0.1
Subtotal							8,939	70.0
Total							12,806	100.0

[a]The area in this overlay district was included in the underlying basic districts.

Source: SEWRPC.

Appendix C

ACKNOWLEDGEMENT OF ASSISTANCE IN PREPARATION OF GENEVA LAKE STUDY

LOCAL UNITS AND AGENCIES OF GOVERNMENT

City of Lake Geneva
Village of Fontana-on-Geneva Lake
Village of Williams Bay
Town of Walworth
Geneva Lake Civic Association
Lake Geneva Foundation
Geneva Lake Level Corporation
Lake Geneva Water Safety Patrol
Wisconsin Department of Natural Resources
Wisconsin Department of Transportation

COMMERCIAL AND INSTITUTIONAL ESTABLISHMENTS

Abbey Springs, Inc.
Buena Vista Club
Elgin Club
George Williams College Camp
Gordy's Marina
Northwestern Naval and Military Academy
University of Wisconsin-Whitewater

CONCERNED CITIZENS

Susam Swanstrom Chwala
Philip Fogel
Thomas A. Gelderman
Harold Hartshorn
George W. Johnson
Peter Madden