LAKE MANAGEMENT PLAN

TWIN LAKES PROTECTIVE AND REHABILITATION DISTRICT

CONTENTS

1. INTRODUCTION

In early 1991, the Twin Lakes Protective and Rehabilitation District asked Discovery Group, Ltd. and Blue River Science to jointly assist the District's Planning Committee prepare a Lake Management Plan for the Twin Lakes, which consist of Lake Mary and Lake Elizabeth. The planning process has been funded jointly by the Wisconsin Department of Natural Resources, through the Wisconsin Lake Management Planning Project Grant Program and the District.

The purpose of the plan is to address concerns of the District regarding water quality, lake use, and land uses within the watershed. The lake management planning process has been undertaken concurrently with the preparation of a Master Plan for the Village of Twin Lakes, whose boundaries are coterminous with the District boundaries. Discovery Group, Ltd. has been the consultant to the Village of Twin lakes for the preparation of the Master Plan.

The specific goals of the Lake Management Plan are to:

- Increase technical knowledge of the lake and watershed conditions
- Assess lake user needs
- Educate the general public about lake and watershed conditions and steps that can be taken to improve those conditions
- Recommend public policies and implementation measures with respect to management of the lake resource
- Evaluate potential to obtain additional public access

The planning process has involved a series of work sessions with the District's Planning Committee and several public information meetings. In the summer of 1991, Discovery Group, Ltd. conducted a Needs Assessment Survey consisting of a questionnaire survey distributed to all property owners in the District. Approximately 2100 surveys were distributed. Questionnaires were returned by 784 respondents, representing a 37.2 percent response rate. The complete tabulation of the survey questionnaire responses is attached to the Lake Management Plan as Appendix A.

During the planning period two newsletters have been sent to all residents of the District announcing public information meetings and providing updates on progress with the preparation of the Lake Management Plan.

In Summer, 1991, Blue Water Science monitored lake conditions. The purpose of the monitoring conducted in conjunction with the Lake Management Plan has been to update data and compare changes in the lakes with data assembled in the late 1960's as part of the studies preceding the preparation of the Lake Use Reports prepared by Wisconsin Department of Natural Resources and the data collected in the late 1970's as part of the Feasibility Study conducted by the Office of Inland Lake Renewal, Wisconsin Department of Natural Resources.

As part of the 1991 lake monitoring study, water samples were collected at spring turnover in April and in June, July, and August at one station on Lake Mary and two stations on Lake Elizabeth. A special substudy was conducted to determine the impact of motor boating on water quality. The water quality investigation has utilized underwater video, as well as aerial photographic surveys, to evaluate lake conditions and update baseline data. The report on water quality is attached as Appendix B Water Quality Analysis

Concurrent with the in-lake water quality analysis, Blue River Science has analyzed watershed conditions and recalculated a nutrient and hydrologic budget for each of the lakes. The report on watershed conditions is attached as Appendix C Watershed Analysis

The background information represented by the Needs Assessment Survey and the scientific information on water quality and watershed conditions have been analyzed to prepare the recommendations set forth in this plan. The recommendations include watershed management recommendations, in-lake use management recommendations, and lake use recommendations. A separate section of the Lake Management Plan examines alternative lake access sites.

The Lake Management Plan should be considered part of a long-range planning process, rather than an end in itself. Most of the actions recommended in the plan represent steps to preserve the relatively high water quality that the lakes now enjoy. The major thrust of the plan is to address the long-term management of the lake and the watershed, as opposed to short-term "quick fixes."

It should also be noted that the policies and implementation measures recommended in the Lake Management Plan are intended as advisory recommendations. All specific actions, guidelines, and rules for the District must be approved by the District Commissioners and approved by a majority of the electorate attending an Annual Meeting. Recommendations which require the adoption of ordinances or regulations by the Village of Twin Lakes also require approval of the Village Board of Trustees.

2. PHYSICAL DESCRIPTION

2.A. Location

Both Lake Mary and Lake Elizabeth are located in the Village of Twin Lakes in Kenosha County. The southern end of Lake Elizabeth extends south of the state line into McHenry County, Illinois.

Both lakes are in the Nippersink Creek subwatershed of the Fox River system. The two lakes are connected by a narrow outlet at the southern end of Lake Mary. The water in the lakes flows in a generally southward direction into the North Branch of Nippersink Creek in Illinois, east of Richmond.

2.B. Glacial Origin

The Twin Lakes are natural bodies of water of glacial origin, similar to most of the other lakes in southeastern Wisconsin. The lakes are located within the lateral moraine of the Lake Michigan Lobe of the Late Wisconsin Ice Sheet. The lakes were formed from the melting of ice blocks that were separated from the continental glacier as it retreated from southeastern Wisconsin approximately 15,000 years ago.

The lakes lie in an area of unconsolidated glacial sediments, primarily ice-contact and outwash deposits about 150 feet thick. The glacially deposited materials are underlain by bedrock formations of Precambrian, Cambrian, Ordovician and Silurian ages.

2.C. Lake Mary Basin Characteristics

2.C.1. Lake Mary - Size and Shape

Lake Mary is a medium sized body of water of moderate depth. It has a surface area of 315 acres and contains 1,957.2 acre feet of water. The surface elevation of Lake Mary is 793.9 feet above mean sea level. Lake levels are maintained by a concrete spillway located on the outlet connecting Lake Mary to Lake Elizabeth. The spillway serves to maintain the level of Lake Mary 0.6 feet above the normal water level of Lake Elizabeth, which is downstream.

The Lake Mary basin is fairly regular in shape, except for two bays on the southwest end. A shallow bar trending in a northeast-southwest direction extends through the middle of the lake, separating the main basin from the shallower waters in the western half of the lake.

The maximum depth in the main basin of Lake Mary is 33 feet. The mean depth is nine feet. The lake has a "shoreline development factor," which is defined as the ratio of the shoreline to the circumference of a circle with the same area as the lake, of 1.41. This implies relatively slight shoreline irregularity.

The maximum length of Lake Mary is 6,000 feet. The theoretical maximum wave height on the lake is 1.4 feet.

2.C.2. Lake Mary - Shore Conditions

Sand predominates along 32 percent of the shoreline, sand and gravel cover 24 percent, and soft sediments cover 44 percent. Sand and gravel predominate along the wave washed shores, where water turbulence holds finer sediments in suspension. Finer sediments appear beyond a depth of about five feet, where wave action has less impact on keeping them suspended. Muck bottoms exist in shallow protected bays, particularly on the western side of the lake, which is both shallower and on the lee side of the lake.

Nearly all of the Lake Mary shoreline is developed in single-family homes and cottages. There are several multifamily residential developments along the north shore.

2.C.3. Lake Mary - Drainage Basin Characteristics

Lake Mary has a relatively small watershed of 1,432 acres with a ratio of watershed area to lake area of only 4.56:1.

It should be noted that there are discrepancies in various measurements of the Lake Mary watershed. The 1969 Lake Use Report prepared by the Wisconsin Department of Natural Resources includes a 635-acre internally drained subbasin located northeast of Lake Mary within the drainage area. The total watershed acreage with the internally drained subbasin included within the Lake Mary watershed is 2,067 acres. The resulting watershed to lake surface area ratio is 6.56:1.

The Fox River Watershed Map produced by SEWRPC for the Areawide Water Quality Planning and Management Program shows the internally drained basin outside the Lake Mary subbasin. The acreages and watershed to lake surface ratio in the SEWRPC reports coincide with the figures used in this report and are shown in Tables 2.1 and 2.2.

The land uses in the Lake Mary watershed are slightly over 40 percent urban in character. The remainder of the area is wetland, woodlands, agricultural land, and undeveloped open space. While there remains a considerable amount of open land, the watershed is not considered a predominantly agricultural area. The remaining cultivated lands are mostly within the limits of the Village of Twin Lakes and are expected to be developed as market demand for urban uses increases.

The Village of Twin Lakes draft Master Plan indicates future urban development of over 80 percent of the watershed. Most of the currently undeveloped area on the north side of Lake Mary is expected to be developed at Residential - Medium Density ranging from 1 to 5 dwelling units per acre. There is expected to be infill development and redevelopment in the commercial districts in the downtown area and along North Lake Avenue.

Table 2.1 Lake Mary Physical Characteristics

Area	315 acres	
Shore Length	3.5 miles	
Shoreline Development Index	1.41	
Maximum Width	3,400 feet	
Maximum Length	6,000 feet	
Maximum Depth	33 feet	
Mean Depth	9 feet	
Percent of Area Less than 3 Feet Deep	17.9 percent	
Percent of Area More than 20 Feet Deep	12.2 percent	
Volume	1,957 acre feet	
Watershed Area	1,432 acres	
Ratio of Watershed Area to Lake Area	4.56:1	
Exchange Time	1.92 years	(Based on 7" runoff from watershed)

Source: Lake Use Report No. FX-17, Marie Lake, Kenosha County, Wisconsin,
Wisconsin Department of Natural Resources, 1969
(Modified to reflect revised watershed area delineations)

Table 2.2 Lake Mary Drainage Basin - Land Use Characteristics

Land Uses	**Acres**
Urban	
Residential	325 acres
Commercial	19 acres
Industrial	0 acres
Government, Institutional	7 acres
Transportation, Utilities	164 acres
Recreational	40 acres
Urban Subtotal	555 acres
Rural	
Woodlands	229 acres
Wetlands	25 acres
Agricultural, Open Space	308 acres
Rural Subtotal	562 acres
Surface Water	315 acres
Total Watershed	**1,432 acres**

Source: Discovery Group, Ltd., 1991

2.D. Lake Elizabeth Basin Characteristics

2.D.1. Lake Elizabeth - Size and Shape

Lake Elizabeth is a natural body of water located south and downstream from Lake Mary. The lake has a surface area of approximately 637.8 acres and contains 6,900 acre feet of water.

The surface elevation is 793.3 feet above mean sea level, approximately six inches lower than Lake Mary. The lake level is controlled in part by a dam located at the south end of Lake Elizabeth. The dam was reconstructed in 1984.

Lake Elizabeth is an elongated basin which extends for a maximum length of 1.9 miles in a generally north-south direction. Maximum width is 0.8 miles. The lake has a total shoreline length of 5.4 miles. The "shoreline development index" is 1.55, which indicates a slightly irregular shoreline.

The maximum depth of Lake Elizabeth is 32 feet. The mean depth is 11 feet. Approximately 21 percent of the basin has water deeper than 20 feet, while 15 percent has water less than 3 feet deep. The southern end of the lake, which extends into Illinois, is extremely shallow and is only accessible by smaller fishing boats and nonmotorized craft. A bay at the north end of Lake Elizabeth, known locally as Cappelen's Bay, is relatively shallow and has several prominent rocks at its entrance which pose a rock hazard.

The west shore of Lake Elizabeth is relatively gradual and the lake bottom slopes gradually to the center of lake. Water depths of less than 5 feet extend up to 600 feet from shoreline. The east shore is relatively steep and the lake bottom drops off sharply near the shoreline.

2.D.2. Lake Elizabeth - Shore Conditions

The entire east shore and the west shore in the vicinity of Lakeview Park and Esch Subdivision have gravel bottom, constituting 70 percent of the shoreline. A small section on the north shore and some of the west shore is sand, constituting 5 percent of the shoreline. The remainder of the shoreline, including the southern end of the lake and northwest shore, are muck and marl.

Approximately 40 percent of the shoreline is occupied by marsh. Nearly all of the nonmarsh frontage is developed as single-family homes and cottages.

2.D.3. Lake Elizabeth - Drainage Basin Characteristics

Lake Elizabeth has a total watershed drainage area of 5,931 acres. The ratio of watershed area to lake area is 10.03:1.

It should be noted that there are discrepancies between various measurements of the Lake Elizabeth watershed. The 1969 Lake Use Report prepared by the Wisconsin Department of Natural Resources shows a slightly larger watershed than the more recent watershed delineations made by SEWRPC as part of the Areawide Water Quality Planning and Management Program. The watershed acreages in this report and shown in Tables 2.3 and 2.4 are based on the more recent SEWRPC delineations.

Land uses in the Lake Elizabeth watershed are predominantly agricultural and open space. Urban land uses, primarily single-family residential, constitute 663 acres, or 11.2 percent of the total watershed area.

The Village of Twin Lakes draft Master Plan indicates future urban development of approximately 30 percent of the Lake Elizabeth watershed. Future development is expected to occur on both the east and west sides of the lake, contiguous with existing development areas. Area outside the Village of Twin Lakes Urban Service Area is expected to remain largely undeveloped or developed at densities less than one dwelling unit per acre. The portion of the watershed in Illinois, much of which is wetland, is expected to developed.

Table 2.3 Lake Elizabeth Physical Characteristics

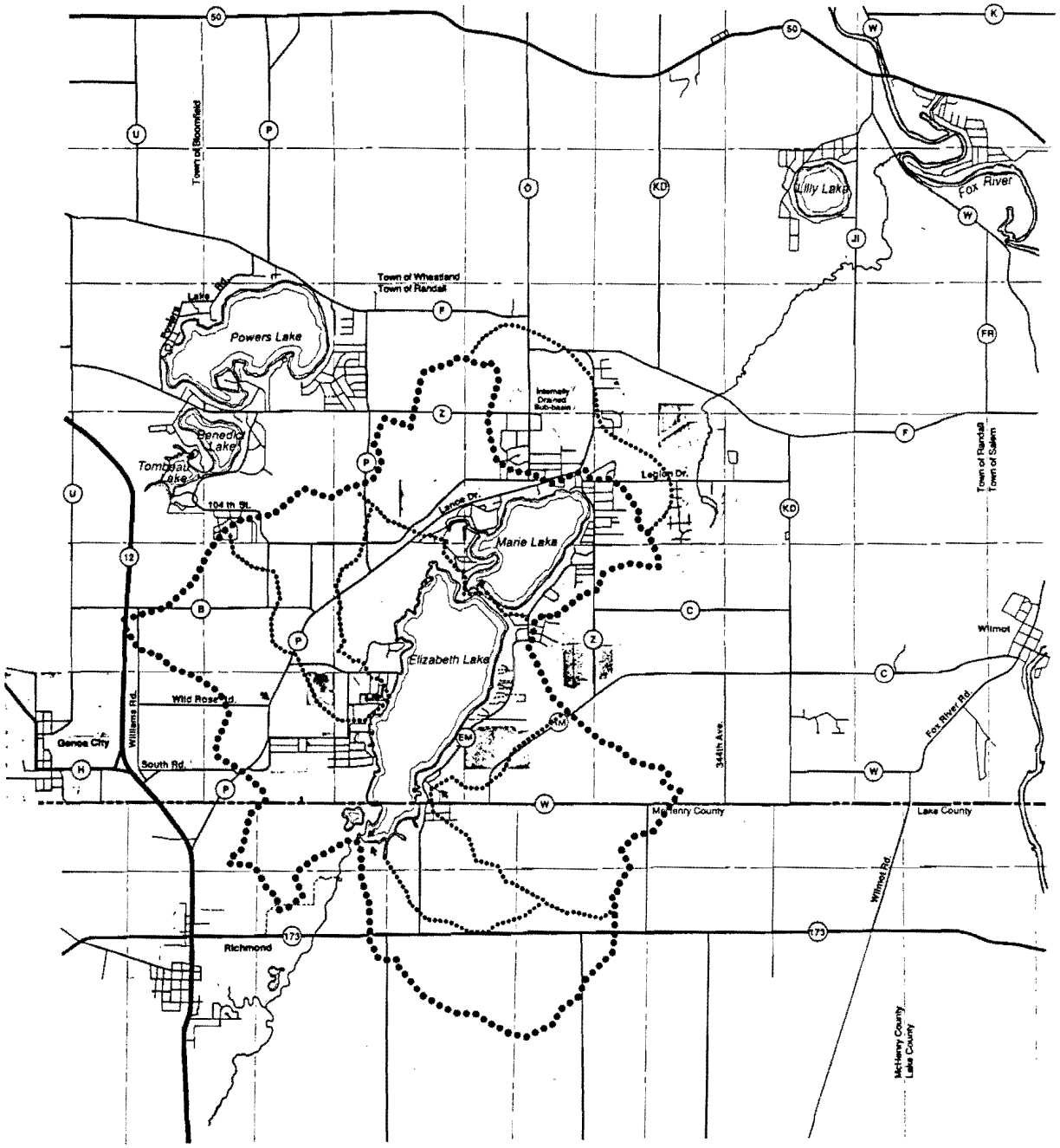
Area	637.8 acres	
Shore Length	5.4 miles	
Shoreline Development Index	1.55	
Maximum Width	4,224 feet	
Maximum Length	10,032 feet	
Maximum Depth	32 feet	
Mean Depth	11 feet	
Percent of Area Less the 3 Feet Deep	15.0 percent	
Percent of Area More than 20 Feet Deep	21.0 percent	
Volume	6,900 acre feet	
Watershed Area	5,931 acres	
Ratio of Watershed Area to Lake Area	10.03:1	
Exchange Time	1.85 years	(Based on 7" runoff from watershed)

Source: Lake Use Report No. FX-7, Elizabeth Lake, Kenosha County, Wisconsin
Wisconsin Department of Natural Resources, 1969
(Modified to reflect revised watershed area delineations)

Table 2.4 Lake Elizabeth Drainage Basin - Land Use Characteristics (1991)

Land Uses	**Acres**
Urban	
Residential	460 acres
Commercial	8 acres
Industrial	0 acres
Government, Institutional	10 acres
Transportation, Utilities	175 acres
Recreational	10 acres
Urban Subtotal	663 acres
Rural	
Woodlands	254 acres
Wetlands	312 acres
Agricultural, Open Space	4,065 acres
Rural Subtotal	4,631 acres
Surface Water	637 acres
Total Watershed	**5,931 acres**

Source: Discovery Group, Ltd., 1991



Watershed Boundaries

EXTRATERRITORIAL AREA
VILLAGE OF TWIN LAKES, WISCONSIN

NORTH

0 1000 2000 4000 8000
Feet

camiros ltd.
Planning, Zoning
Development Economics,
and Landscape Architecture

3. NEEDS ASSESSMENT

3.A Survey Description

As part of the background preparation for the Lake Management Plans for Lake Mary and Lake Elizabeth, Discovery Group, Ltd. conducted a Needs Assessment for the lakes. The assessment is based on findings of a community opinion survey of all property owners in the District. The survey was conducted in June, 1991. Approximately 2,100 surveys were distributed by mail to all property owners in the District; 784 surveys were returned. The response rate for the surveys was 37.3 percent.

The survey responses have been cross-tabulated in order to identify the different responses from property owners with frontage on Lake Mary and Lake Elizabeth and responses from nonlakefront property owners.

The survey response tabulations are attached as Appendix A to this report.

Other information incorporated into the needs assessment are priorities established by the District Grant Committee at meetings conducted on October 13, 1990 and November 17, 1990. Minutes of the District Annual Meetings since 1975 have been reviewed to identify issues that have come before the Board.

3.B Priority Issues

The following issues are priority issues:

- Boat Use

  Number of Boats
  Speed of Boats
  Size of Boats
  Water Skiing
  Jet Skiing

- Water Quality

  General Water Quality
  Aquatic Vegetation Growth
  Algae Growth

- Loss of Wetlands
- Sedimentation
- Public Access
- Condition of the Fishery

- Other Issues

  Enforcement
  Litter
  Shoreline Erosion
  Stormwater Runoff
  Snowmobile Use

It should be noted that many of the issues are interconnected. For example, stormwater runoff is closely associated with water quality, sedimentation, and many other issues.

It should also be noted that the Village and the District are limited by Wisconsin laws with respect to the types of actions that can be undertaken locally to address various issues. For example, the District or Village may not directly regulate the size of boats, even though boat size is considered a serious problem by many respondents.

3.C Boat Use Issues

The number, speed, and size of boats on the two lakes ranks as the highest priority concern in the community survey, as well as in previous rankings by the District Grant Committee. Of particular concern to a large number of survey respondents is the impact of jet skis.

3.C.1. Number of Boats (Weekend)

The number of boats using the lakes on weekends is perceived as a serious problem by 55.2 percent of overall survey respondents and as a minor problem by 24.4 percent of the respondents.

Weekend boat use is a more severe problem on Lake Mary than on Lake Elizabeth. Among lakefront property owners, 44.2 percent of the owners on Lake Elizabeth and 67.7 percent of the owners on Lake Mary consider the number of weekend boats a serious problem.

3.C.2. Number of Boats (Weekday)

The number of boats using the lakes on weekdays is not considered nearly as serious a problem as weekend use. Among overall respondents, 7.9 percent consider weekday use a serious problem and 26.3 percent consider weekday use a minor problem.

Interestingly, more nonlakefront owners consider weekday use a more serious problem than lakefront owners, with 11.4 percent considering weekday use a serious problem and 32.5 percent considering it a minor problem.

3.C.3. Speed of Boats

Among the overall respondents, boat speeds are considered a serious problem by 44.1 percent and as a minor problem by 30.0 percent.

More nonlakefront property owners consider speed a serious problem than do lakefront owners.

3.C.4. Size of Boats

Boat size is considered a serious problem by 30.7 percent of overall respondents and as a minor problem by 26.7 percent.

More nonlakefront property owners consider size a serious problem than do lakefront owners.

3.C.5. Water Skiers

Water skiers are considered a serious problem by 29.0 percent of overall survey respondents and a minor problem by 34.6 percent. Many survey respondents included supplemental notes expressing concern about safety with respect to water skiers and swimmers.

Slightly more nonlakefront property owners consider water skiers a serious problem than do lakefront property owners.

3.C.6. Jet Skiers

Jet skiers are considered a serious problem by 48.9 percent of the overall respondents and as a minor problem by 23.6 percent. Many survey respondents included supplemental notes expressing concern about safety problems, noise and environmental damage resulting from jet skiers.

More lakefront property owners on Lake Mary (54.8 percent) consider jet skiers a serious problem than do owners on Lake Elizabeth or nonlakefront property owners.

An overwhelming majority (82.7 percent) of all categories of survey respondents would like to see operations of jet skiers limited by time and/or location of operations.

3.D. Water Quality Issues

Water quality issues have ranked as the second highest priority issues in both the community survey and in previous District Grant Committee rankings. Water quality issues include general water quality and algae and aquatic vegetation growth.

3.D.1. General Water Quality

General water quality is identified as a serious problem by 34.3 percent of the total survey respondents and as a minor problem by 32.5 percent.

Among property owners with lake frontage, water quality is considered a slightly more serious problem. Water quality is considered a serious problem by 36.1 percent of the owners on Lake Elizabeth and 36.7 percent of the owners on Lake Mary; 28.9 and 36.7, respectively, consider water quality a minor problem on each lake. More property owners on Lake Mary consider water quality a serious or minor problem than do owners on Lake Elizabeth.

3.D.2. Aquatic Vegetation Growth

Aquatic vegetation is considered a serious problem by 49.1 percent of the overall survey respondents and a minor problem by 28.2 percent.

Aquatic vegetation growth is considered a more serious problem on Lake Mary than on Lake Elizabeth. Among lakefront property owners, aquatic vegetation growth is considered a serious problem by 54.2 percent of the owners on Lake Elizabeth and 57.7 percent of the owners on Lake Mary.

3.D.3. Algae Growth

Algae growth is considered a serious problem by 39.7 percent and as a minor problem by 31.8 percent of all property owners in the District.

Algae growth is considered a more serious problem on Lake Mary than on Lake Elizabeth. Among lakefront property owners, algae growth is considered a serious problem by 39.8 percent of the owners on Lake Elizabeth and 46.0 percent of the owners on Lake Mary.

3.E. Loss of Wetlands

Loss of wetlands is considered a serious problem by 42.1 percent of overall survey respondents and a minor problem by 20.9 percent.

Stricter Village wetland and shoreland zoning to protect remaining natural areas is favored by 81.1 percent of the overall survey respondents. District purchase of wetlands or purchase of conservation easements to protect the wetlands is favored by 68.9 percent of the overall survey respondents.

Support for strict wetland zoning and the purchase of wetlands by the District is strong among both lakefront and nonlakefront property owners.

Wetland loss was ranked as tied for third highest priority concern of the District Grant Committee.

3.F. Sedimentation

Sedimentation is considered a serious problem by 43.4 percent of the overall survey respondents and a minor problem by 28.7 percent. More property owners on Lake Mary (49.2 percent) considered sedimentation a serious problem than do property owners on Lake Elizabeth (47.0 percent) or nonlakefront property owners (35.7 percent).

Sedimentation tied with wetland destruction and enforcement as the third highest priority concerns of the District Grant Committee

3.G. Public Access

More public access to the lakes is opposed by 77.3 percent of overall survey respondents. Among lakefront property owners, opposition was 90.0 percent from Lake Elizabeth owners and 89.5 percent by Lake Mary owners. Additional public access is opposed by 56.4 percent of nonlakefront property owners.

3.H. Condition of the Fishery

The decline of the fishery is considered a serious problem by 43.0 percent of the overall survey respondents and a minor problem by 23.2 percent. The decline of the fishery is considered an equally serious problem by both lakefront and nonlakefront property owners.

Of the overall respondents, 47.9 percent fish either frequently or occasionally. A higher percent of lakefront property owners fish frequently than nonlakefront property owners.

3.I. Other Issues

3.I.1. Enforcement

Current enforcement of lake use regulations by the lake patrol is considered adequate by 49.4 percent of the overall respondents and inadequate by 24.1 percent. While the overall satisfaction with enforcement is relatively high, there were some supplemental comments attached to the surveys which criticized specific aspects of enforcement.

3.I.2. Litter

Litter is considered a serious problem by 45.6 percent of overall respondents and is considered a minor problem by 33.3 percent of the respondents. More nonlakefront property owners consider litter to be a serious problem than lakefront property owners.

3.I.3. Shoreline Erosion

Shoreline erosion is considered a serious problem by 25.4 percent of the overall survey respondents and a minor problem by 32.3 percent. Shoreline erosion is considered a greater problem by lakefront property owners than by nonlakefront property owners.

3.I.4. Stormwater Runoff

Stormwater runoff, which causes many other lake problems, is considered a serious problem by 26.8 percent of the overall survey respondents and a minor problem by 26.9 percent. Lakefront and nonlakefront property owners are equally concerned about the problems of stormwater runoff.

3.I.5. Noise from Snowmobilers

Noise from snowmobilers is considered a serious problem by 19.8 percent of the overall survey respondents and a minor problem by 26.9 percent. The level of concern is roughly equivalent between lakefront and nonlakefront property owners.

4. WATERSHED MANAGEMENT RECOMMENDATIONS

4.A. Watershed Management Issues

Watershed management measures are practices and regulations within drainage areas which are intended to eliminate or significantly reduce the level of the pollutants, nutrients, and sediments entering the lakes and other water bodies. These measures include managing the type and density of land uses in the watershed, controlling nonpoint sources of pollution on both urban and rural lands, and managing the point sources of pollution, particularly on-site sewage disposal systems.

In the case of Twin Lakes, many good watershed management practices are in place. Nearly all of the Village of Twin Lakes is served by the Village's sewage treatment plant which is located in Section 22, on the northeast side of the Village. The effluent from the treatment facility flows into Bassett Creek which flows into a different watershed. The construction of the treatment plant in the early 1960's removed nearly all domestic sanitary sewage from flowing into the lakes, which was formerly the primary source of phosphorus and other pollutants. Nearly all of the watershed areas in both basins, which are expected to develop in the foreseeable future, are in the Twin Lakes Urban Service Area and are expected to be served by the Village's treatment facility.

In addition to removal of the domestic sewage from entering the lakes, there has been some ditch construction, particularly in the northeast section of the Village, which has transferred some of the surface stormwater drainage from the Lake Mary drainage basin into the Bassett Creek drainage basin via the drainage ditch along the north side of the former railroad corridor.

Because most of the shoreline and a large portion of the watersheds for both lakes are located in the Village of Twin Lakes, the Village has the opportunity to directly control land uses and land use practices which would affect water quality. This level of jurisdictional consistency is relatively unique. The Village has begun to pay more attention to both development densities and site planning and design practices which would affect the watershed.

While much has been accomplished by the Village and the District over the past two decades, there remain several areas where additional management practices are recommended. These areas include:

- Construction Site Erosion Controls
- Urban Stormwater Management
- Rural Nonpoint Source Controls
- On-Site Sewage Disposal System Management - Extraterritorial Area
- Land Use and Zoning Regulations
- Wetland Preservation

- Groundwater Recharge Area Management
- Shoreline Management

4.B. Construction Site Erosion Controls

4.B.1. General Description

Previous experience in Wisconsin and throughout the country has indicated the importance of land disturbance during construction and development as a major nonpoint source of pollutants. Because of the relatively rapid rates of growth and new development in the Twin Lakes basin, construction activity is expected to be one of the leading sources of sediments entering the lakes.

The recent study of the nearby Powers Lakes watershed, which has comparable current development patterns as the Twin Lakes watershed, indicates that development under construction is responsible for approximately 40 percent of the overall sediment loading and over 20 percent of the phosphorus loading in the lakes. Because of the more rapid rates of development forecasted for the Twin Lakes area, the relative importance of construction site erosion as a source of sediments and pollutants will likely be higher than the figures indicated above for current conditions.

Construction site erosion control measures are temporary measures that can reduce sediment and pollutant loadings. The principles and practices of construction site erosion and sediment control are well established and many communities throughout Wisconsin have adopted construction site erosion and sediment control ordinances.

The Wisconsin League of Municipalities in cooperation with Wisconsin Department of Natural Resources has prepared a model ordinance and an accompanying "Wisconsin Construction Site Best Management Practices Handbook" which sets forth guidelines for construction site erosion and sediment control. Construction erosion and sediment control measures may be expected to reduce pollutant loadings from construction sites by about 75 percent.

The provisions of the model ordinance and the handbook are based on the following specific principles:

1. "Clean water" from upslope areas must be diverted around disturbed areas to keep the clean water clean and to minimize the amount of water that must be handled in the disturbed area.

2. The disturbed area's size and the duration of disturbance must be minimized to the extent practicable to minimize the amount of pollutants leaving the site.

3. While the site is disturbed, temporary measures must be used to trap pollutants and prevent their movement off site.

4. Runoff channels must be protected to prevent scour and erosion that generate pollutants.

5. Maintenance is necessary to keep best management practices functioning properly.

Some of the specific practices involved in implementing the principles described above include revegetation practices such as temporary seeding, mulching, and sodding, and runoff control

measures such as filter fabric fences, straw bale barriers, inlet protection devices, diversion swales, sediment traps and sediment basins.

4.B.2. Best Management Practices

The model ordinance as described in the "Best Management Practices Handbook" has been adopted by Walworth County. Kenosha County has provisions in the "Kenosha County Subdivision Control Ordinance" which require the preparation and submittal of erosion and sedimentation control plans prior to construction. SEWRPC has recommended that Kenosha County adopt an ordinance similar to Walworth County's, based on the model promulgated by the Wisconsin League of Municipalities and WDNR.

4.B.3. Existing Regulations

The Village of Twin Lakes currently does not have provisions in either its Zoning Ordinance or Subdivision Ordinance to control construction site erosion and sedimentation. In spite of the absence of direct controls or guidelines, the Village Plan Commission and the Village Board have been able to encourage erosion and sediment controls as part of the general review and approval process.

4.B.4. Recommendation

It is recommended that the Village adopt the Model Construction Site Erosion Control Ordinance, which is attached to the Lake Management Plan as Appendix D. The Village and its consulting engineer should utilize the "Wisconsin Construction Site Best Management Handbook" as a guide for implementation of the ordinance.

4.C. Stormwater Management Controls

4.C.1. General Description

As the Twin Lakes basin develops and becomes more urban in character there are several effects on the watershed. Urbanization has the effect of covering a greater proportion of the land with impervious surfaces, such as structures, roads, and parking lots. Covering area with impervious material reduces surface storage and infiltration and increases the volume and velocity of runoff. Urbanization tends to encourage artificial drainage systems, such as paved gutters and storm sewers, which often replace natural drainage channels. As a result of these factors, urbanization often results in higher volume and rates of runoff and an increase in sediment, nutrient, and pollutant loading in surface water bodies.

In response to the effects of urbanization of watersheds many communities have adopted policies and regulations which manage the effects of stormwater runoff on both the land and water resources. Stormwater management has developed as an important design factor for all residential, commercial, and industrial developments. Stormwater management needs to be an integral part of both comprehensive land use planning and lake management planning.

Historically, most stormwater management practices have focused on the conveyance of stormwater through ditches and storm sewers off of the development site. The primary purpose of this type of system is to provide efficient drainage from the site to increase its usability and reduce on-site flooding. Typically, catch basins and grates are constructed as part of storm sewers to catch sediments before they flow into lakes and other surface water bodies.

While storm sewer conveyances will always be an important part of a comprehensive drainage and stormwater management system, an alternative approach to stormwater management, which has gained wide acceptance in many communities, is an emphasis toward on-site stormwater management.

The central concept of on-site stormwater management is to delay runoff and increase infiltration of stormwater in the ground before it enters surface waters. A second key concept is detaining or retaining stormwater either on-site or as close to the site as practicable. Thus, the emphasis of most modern stormwater management controls and guidelines is to encourage development practices which incorporate stormwater management into the site planning and the original site construction.

On-site stormwater management controls generally refer to permanent structures and practices that are put into place to detain, retain, filter and/or control stormwater runoff on the development site. In some instances it may be more practical and economic to master plan stormwater basins and conveyances for an assemblage of several development sites so that the stormwater structures can be better sited with respect to natural topography.

4.C.2. Stormwater Management Planning

The National Association of Home Builders (NAHB) and other organizations and associations involved in land development have promulgated the following set of basic principals related to development and stormwater management planning:

- A basinwide or watershed stormwater management plan designed to meet the objectives of stormwater control should be a primary goal of the goal sector.
- The quantity of runoff from any given site should not differ significantly from that generated before development.
- Capital costs, operation, and maintenance costs, liability, public convenience, risk of significant water-related damage, and environmental protection and enhancement should all be taken into account in the development of stormwater management program.
- Natural features of a site should be preserved to enhance water pollution control, to maximize economic and environmental benefits, and to improve the effectiveness of natural systems.
- Site specific characteristics vary considerably because of the natural environment and the regulations governing the development process. Stormwater management design parameters should be flexible to meet site characteristic variations.
- A balance between private and public ownership, operation, and maintenance responsibilities is necessary in developing a stormwater management program for an area.
- Use of combinations of "wet" and "dry" basins should be considered in stormwater management planning.

- Use of stormwater management facilities should be evaluated on the basis of their ability to reduce storm drainage facility costs, reduce erosion and sediment production, reduce maintenance costs of downstream natural channels, and reduce downstream flood losses and possibly the size of the floodplain.

- Groundwater recharge should be considered in siting and designing stormwater retention and detention structures.

4.C.3. Existing Regulations

The Village of Twin Lakes currently has provisions in its Subdivision Ordinance (Chapter 16) to require specifications related to drainage ditches, water courses and culverts (Section 16.36.140). The Subdivision Ordinance (Section 16.28.030) also requires subdividers to reserve stormwater drainage easements for all natural water courses and man-made channels.

The Village has constructed approximately twenty-four storm sewers and/or ditches to convey stormwater from developing areas. Most of the storm sewers have catch basins and grates to reduce sediments and debris from entering the lake.

The Village does not have any comprehensive stormwater plans which consider the entire basin or subbasins. Nor does the Village have any ordinances other than the Subdivision Ordinance which requires on-site management of stormwater.

In recent years, the Village Plan Commission and Village Board have successfully negotiated with individual developers to provide stormwater basins on-site. These negotiations have generally occurred on a case-by-case basis without pre-existing standards.

4.C.4. Recommendations

The Village should consider having a qualified consulting engineer prepare stormwater management plans for those basins and subbasins expected to be developed in the near future. The preparation of such basinwide stormwater management plans should be undertaken by the Village prior to development, or undertaken at the time that large scale development is proposed. In either case, the primary emphasis of the basinwide stormwater management plans should be to encourage on-site stormwater management controls which detain or retain as much of the runoff as practicable on or near the site of development.

Acquisition of base information which would be necessary for the preparation of a stormwater management plan for all or portions of the lake basins is identified in Chapter NR 119 Lake Management Planning Grants as an "eligible activity" for funding. The District should consider preparation of a stormwater management plan as a future fundable activity.

The Village should also consider adopting an Erosion Control and Stormwater Management Ordinance which requires developers to provide a runoff control plan for all land disturbing activities. A Model Erosion Control and Stormwater ordinance is attached to this report as Appendix E. The model requires that the peak rate of runoff after development not be greater than the peak rate which would have resulted from the site in its undeveloped state.

4.D Rural Nonpoint Source Controls

4.D.1. General Description

Rural nonpoint source controls refer primarily to erosion from agricultural and other rural lands. Rural sources of run-off and pollution are of concern in both the Lake Mary and Lake Elizabeth basins, but are of greater concern in the Lake Elizabeth basin where a higher proportion of the watershed is expected to remain in agricultural use.

The Kenosha County Agricultural Soil Erosion Control Plan prepared by SEWRPC in 1989 identifies all of the Twin Lakes direct drainage basin, exclusive of the portion in Illinois, as having a "T-factor" of 1.0 times T value or less, which is the lowest classification for soil loss. The term T-factor refers to the maximum annual average rate of soil loss that can be sustained without impairing the productivity of the soil. T-factor comparisons are generally relied on as an indicator of agricultural erosion problems and are widely used by conservation planners to prioritize areas for erosion controls.

Because of the relatively low T-factor, the agricultural land in the Twin Lakes basins are ranked as Priority D, the lowest priority for conservation practices.

In spite of the relatively good factors related to agricultural land erosion in the Twin Lakes basin, SEWRPC has recommended a variety of soil erosion control practices throughout the County. These include:

- Conservation Tillage
- Crop Rotation
- Contouring
- Contour Strip Cropping
- Cover Cropping
- Terracing
- Grassed Waterways
- Permanent Vegetative Cover

4.D.2. Specific Sites

In its 1980 draft "Feasibility Study Alternatives - Management Alternatives" WDNR identified a specific agricultural field between Zerfos Drive and Grace Street/Catherine Avenue, which is close to an intermittent stream and lagoon. The study recommended the construction of berms to keep soil erosion within the agricultural area.

A second specific site, which was used as pastured area and cattle holding area, between Highway "P" and Spiegellhoff Road was identified as an area of concern. There is a pond on the site which is the headwaters of an intermittent stream which flows into Lake Elizabeth.

Areal and field surveys in Summer 1991 indicated that there was virtually no contour farming, contour stripping, or terracing in the watershed. Most of the cultivated land is planted in corn; however, there are many fields which are kept in a fallow condition and/or pastured lightly. Most of the intermittent drainageways are either grassed or retain natural vegetation along their banks. Unlike many more intensively farmed areas, many of the farms have retained woodlots and fallow lowland fields.

4.D.3. Recommendation

The District should contact Kenosha County, the Soil Conservation Service and the County Soil and Water Conservation District (SWCD), to request an assessment of conservation practices in the Twin Lakes Basin.

4.E. On-Site Sewage Disposal System Management - Extraterritorial Area

With the construction of the sewage treatment plant in the Village of Twin Lakes in the 1960's, most of the private septic systems were replaced with public sanitary sewer service. This has sharply reduced private sewage as a source of pollutants and nutrients in the lakes.

The public sanitary sewer system completely surrounds the portion of the lakes that lie in Wisconsin and can potentially serve nearly all development in the Village limits. The Twin Lakes Sanitary Sewer Service Area, which is delineated by SEWRPC and approved by the Village, includes nearly all of the land in the Village, except for environmental corridors and land immediately adjoining the Village limits which is expected to develop prior to 2000.

The Village requires all new development to connect to the sewer system. It is recommended that any subdivisions with five or more lots outside the Village, but within the Village's extraterritorial area, be required to be connected to a public sanitary sewer. At the present time this requirement would require annexation, since there are no sanitary or utility districts with operating sewage collection systems within the one and one-half mile extraterritorial area.

It should be noted that a facility planning program was initiated in 1990 to investigate alternative means of sanitary sewage disposal in the Powers Lake, Benedict Lakes and Tombeau Lake area. This study will investigate serving this area by public sanitary sewers.

4.F. Land Use Regulation

4.F.1. General Description

Nearly all of the Lake Mary and approximately one half of the Lake Elizabeth watersheds are within the Village of Twin Lakes. All of the shoreline of both lakes in Wisconsin is within the Village. Fortunately, this level of single jurisdictional control enables the Village direct control of the land uses affecting most of the drainage area.

4.F.2. Existing Village Land Use Regulations

The Village of Twin Lakes has a Zoning Ordinance (Chapter 17) and a Subdivision Ordinance (Chapter 16). Both of these codes are currently being recodified.

4.F.3. Village Master Plan

The Village has contracted with Discovery Group, Ltd. to work with the Plan Commission to prepare a Master Plan. A draft of the Master Plan has been completed and is currently being reviewed by the Village. The Master Plan calls for maintaining relatively low development densities.

The draft Master Plan calls for the long-term development of approximately 60 acres of identified High Density Residential development area at densities ranging from 4 to 8 dwelling units per acre. Approximately 1,300 acres are indicated as Medium Density Residential development areas planned for densities ranging from 1 to 5 dwelling units per acre. Most of the land outside the existing Village limits, but within the Village's planning area, is expected to develop at densities averaging less than one dwelling unit per acre.

After review and modification, the Village is expected to adopt the draft Master Plan and pursue changes in the Zoning Ordinance and Subdivision Ordinance to bring these codes into consistency with the Master Plan.

4.F.4. Extraterritorial Controls

The Village has also recently begun the process for Extraterritorial Zoning. This process requires the Village and the affected Towns to jointly prepare a land use plan for the Extraterritorial Area which extends one and one half miles around the Village. The Extraterritorial Zoning powers don't extend into Illinois, nor would they affect areas within the potential extraterritorial area of another incorporated municipality in Wisconsin.

4.F.5. Kenosha County Zoning

The portions of both watersheds outside the direct zoning and regulatory control of the Village are currently zoned by respective county zoning ordinances. The portion of the watershed for both Lake Mary and Lake Elizabeth in the Town of Randall is controlled by the Kenosha County Zoning Ordinance. Most of the land is currently zoned either A-1 (Agricultural Preservation, A-2 (General Agriculture), C-1 (Lowland Conservancy Resource), or C-2 (Upland Conservancy Resource). Virtually no undeveloped land is currently zoned for development.

4.F.6. McHenry County Zoning

In McHenry County, nearly all of the cultivated agricultural land and undeveloped uplands are zoned A-1 (Agriculture). Most of the marsh and wetland complex at the south end of Lake Elizabeth is inappropriately zoned R-1 Neighborhood Residential. Although these wetlands are not directly tributary to Lake Elizabeth, since they are at the outlet to the lake, they are valuable with respect to fish and wildlife habitat and should be preserved.

4.G. Wetland Preservation

4.G.1. General Description

Wetlands are extremely important to preserving the condition of the overall lake ecosystem. Some of the values usually associated with wetlands include:

- Filtering or storage of sediments, nutrients, heavy metals and organic compounds that would otherwise drain into open water bodies
- Shoreline protection against soil erosion
- Maintenance of stable water levels
- Provision of breeding, nesting, resting, and feeding grounds for fish and wildlife
- Provision of storm and flood water storage capacity
- Provision of recreational and aesthetic amenities

In the Twin Lakes basins there are several key wetland complexes which are critical to preserving the quality of lakes.

4.G.2. Lake Mary Wetlands

In the Lake Mary basin the key wetland complex is on the west side of the lake, north of Indian Point. The wetland is approximately 25 acres in size. It is predominantly a scrub/shrub wetland type with mostly broadleaf deciduous vegetation. The north and west sides of the wetland are partially forested. The lake shore is developed on land that has been filled.

A man-made channel extends into the wetland from the lake. The channel is narrow and not navigable by larger motorboats. Two storm sewers off of Bayview Avenue have outlets in the wetland.

4.G.3. Lake Elizabeth Wetlands

There are 315 acres of wetlands in the Lake Elizabeth watershed. In addition, there is a large wetland complex at the southern end of the lake, which is not in the direct tributary area, but is important to the overall vitality of the lake ecosystem.

The largest wetland complex in the Lake Elizabeth basin is located on the northwest side of the lake. The wetland is a combination of emergent, wet meadow and scrub/shrub wetlands. There are submerged and floating aquatic beds on the lake side of the wetland.

The second largest wetland area is located in the southwest corner of the lake adjacent to the state line. This wetland area extends south across the state line into the main wetland complex at the outlet to Lake Elizabeth. Most of this area is emergent wetland meadow. The Kenosha County Park and Open Space Plan identifies a portion of this wetland as a "natural area of countywide or regional significance."

The third largest wetland complex is located east of Lake Victoria, a small pond located approximately one-quarter mile east of East Lake Shore Drive. The wetlands draining into the pond are a combination of scrub/shrub wetlands and emergent, wet meadow. Approximately 30 acres of the originally mapped wetland has been cultivated and is no longer considered wetland for regulatory purposes.

There are several smaller wetlands inland on both the east and west sides of the lake.

4.G.4 Existing Regulations

The existing Village Floodplain and Shoreland-Wetland Regulations are based on the model promulgated by the WDNR. The existing ordinance, which was adopted in 1988, affords adequate regulatory protection to all the wetlands in the Village.

Wetlands in the Town of Randall are regulated by the Kenosha County ordinances.

4.G.5 Wetland Acquisition

While existing regulations provide adequate regulatory protection to prevent filling and development, acquisition of wetlands provides the greatest assurance that the wetland areas will be permanently preserved in a natural, open condition.

Approximately 45 acres of the wetlands in Section 32 at the southwest corner have been proposed for acquisition by WDNR. Other wetlands have been discussed for possible acquisitions associated with development approvals of adjoining uplands.

4.G.6. Nonnative Species Management

Purple loosestrife and other nonnative species have invaded some of the drainageways and peripheral wetlands. Where these species have become established they have crowded out native plants and reduced the diversity of the wetlands.

The District should work with WDNR to undertake programs to control the spread of these nonnative species.

4.H. Groundwater Recharge Area Management

Groundwater is the single largest source of water supply entering into the Twin Lakes and preserving the quality of the groundwater is essential to protecting the lakes, as well as assuring safe, potable water supplies for the community.

In recent years there has been increasing interest in using local land use regulations to help preserve the quality of groundwater. To date, there has been no zoning in the Twin Lakes area, either by the Village or Kenosha County, based on protecting groundwater recharge areas. This is an issue that has been raised at each public information meeting on this project. While it is outside the scope of the Lake Management Plan to delineate vulnerable groundwater recharge areas, there is a series of steps recommended for local governments in a recent publication entitled Groundwater Protection Through Local Land Use Controls, published by the Wisconsin Geological and Natural History Survey (Special Report No. 11, 1991).

The publication recommends the following specific steps to begin to incorporate groundwater protection into local regulations:

- Revise local ordinances on the basis of readily obtainable information about groundwater
- Identify and regulate vulnerable areas where the soils are susceptible to infiltration and contaminants
- Identify and regulate sensitive areas where contaminants can enter important aquifers
- Delineate and regulate wellhead protection areas
- Identify and regulate areas of suspected groundwater contamination

While delineation of groundwater recharge areas and other areas of groundwater supply sensitivity is beyond the scope of this phase of the Lake Management Plan, this is an issue that has been identified at every public information meeting as a priority topic.

Conducting the scientific research to support local regulations protecting the groundwater supply should be a high priority project for the District over the next several years. The acquisition of physical, chemical and biological information on groundwater within the watershed is identified in Chapter NR 119 as an "eligible activity" for funding under Lake Management Planning Grants. The District should consider including an investigation of groundwater impact as a fundable future project.

5. IN-LAKE MANAGEMENT RECOMMENDATIONS

In-lake management practices refer to specific practices within the lakes proper that the District, the Village, and private landowners can undertake to improve water quality. In-lake management practices include:

- Dredging
- Aquatic Plant Management

  Macrophyte Harvesting

  Herbicide Application

  Bottom Management

5.A. Dredging

5.A.1. General Description

Dredging has been used in several areas in the Twin Lakes to remove sediment deposits which have accumulated to the point where the waters are too shallow for safe navigation and other uses. In addition to removing bottom sediments, dredging in some circumstances may be considered as a means of reducing vegetation by removal of nutrient rich muck and accumulated organic matter. There is also some evidence that creating a deeper lake bed may cause less light to reach deeper areas, also reducing vegetation.

It should be noted that dredging is often considered a method for restoring shallow waters and shoreline areas to their original condition. In many instances, this is not the case. Many homes along the shoreline were built on former marshlands where the muck bottoms are a natural condition. While some botttom areas have accumulated sediments and muck due to sedimentation from surrounding uplands, in other areas the shallow mucky conditions are natural.

5.A.2. Methods of Dredging

There are two primary methods of dredging: hydraulic and mechanical.

Mechanical dredging utilizes dragline equipment, consisting of a bucket suspended from a boom to physically remove the sediment. For small to medium sized inland lakes, the dragline equipment can be situated onshore. Sediment dredged from the lake is either stockpiled onshore or placed directly on trucks and transported to a disposal site.

Hydraulic dredging employs a rotating cutterhead to loosen sediment, which is then excavated with a high capacity pump. The removed dredge spoil slurry is pumped directly to a disposal area through a movable large diameter pipe. The dredge spoil solids are allowed to settle in the disposal site and the resultant "clean" water may be discharged back to the water body or

allowed to evaporate. As a practical matter, hydraulic dredging requires a disposal site relatively near to the dredge site.

In the Management Plan for Powers Lake (1991), SEWRPC estimates the cost of hydraulic dredging is $4.00 to $6.00 per cubic yard of sediment, measured in place. The estimated cost for mechanical dredging is $3.00 to $3.50 per cubic yard, measured in place.

5.A.3. Disposal of Dredge Spoils

The primary drawback to dredging is the difficulty in finding suitable spoil sites within a distance that is economical. Locating a dredge spoil site frequently causes a serious constraint on the feasibility of dredging.

The criteria for a suitable dredge spoil disposal site include:

- Location in relatively close proximity to the dredge site: one-half mile for hydraulic dredging and two miles for mechanical dredging
- Open land not nearer than 300 feet from existing development
- Not within a 100-year floodplain
- Not within 300 feet of a navigable waterbody or wetland
- Slopes no greater than 6 percent

In the Twin Lakes area the cost for land meeting the criteria described above would be from $3,000 to $5,000 per acre.

WDNR would need to approve a disposal site.

5.A.4. Sediment Problem Areas

Various areas on both lakes have been identified as problem areas with respect to the shallowness of the water and the deposition of sediments. Specific areas include:

- Lake Mary
  Indian Point (North and South Bay)
  Southeast Shore (East Lake Shore Drive)
- Lake Elizabeth
  West Shore
  Cappelan's Bay

5.A.5. Previous Dredging Feasibility Analysis

1980 Feasibility Study Results - Management Alternatives (WDNR)

The 1980 Feasibility Study Results - Management Alternatives prepared by WDNR considered dredging the north and south bays on the southwest side of Lake Mary and the west shore on Lake Elizabeth. The primary focus of the WDNR study was to examine alternative techniques to vegetation growth.

The report indicated that dredging the bays of Lake Mary to a hard bottom in the shallow (littoral) area would not be an effective way to permanently remove vegetation, although it would temporarily reduce the density of macrophyte growth. WDNR estimated that 250,000 cubic yards of material would need to be removed from the two bays.

The report indicated that 480,000 cubic yards of sediment could be removed from the west shore of Lake Elizabeth to deepen the littoral area by an average of eight feet. A second alternative would be to dredge only limited channels. As in Lake Mary, the effect on vegetation reduction would be temporary.

1981 Dredging Feasibility Study (District)

A dredging feasibility study was done in 1981 which indicated that 439,000 cubic yards of sediment material would need to be dredged from Lake Mary. It was recommended that approximately 714,000 cubic yards should be dredged from Lake Elizabeth. This amount of material would require approximately 160 acres for disposal at an average depth of 5 feet. Current costs for this type of comprehensive approach to dredging both lakes would range from $4,000,000 to $6,500,000.

The study was accepted by the District, but put on file because of lack of funding availability.

1990 District Board Resolution

In Spring 1990, the District Board approved a resolution for the District to seek suitable upland disposal sites.

Since then, no further action has been taken by the District or Village on public financed dredging; however the District has agreed to help find, where feasible, a suitable site for dredging spoils from privately financed dredging.

5.A.6. Private Dredging

Various locations on both the lakes have been dredged in previous years. All of the recent dredging has been done by individual property owners or groups of property owners. Neither the District nor the Village have undertaken dredging, primarily because of the costs and the lack of available outside funding.

Recent private dredging includes:

- 1987-88 Indian Point Area (South Bay - Lake Mary)
  Lake Mary Outlet
- 1988-89 Esch Road Area
  Steinhert Area

Private dredging has been discussed for both bays on the Lake Mary and the canal area between First and Second Streets, off of Lake Elizabeth.

5.A.7. Dredging Policy Recommendation

Previous studies and reports appear to indicate that dredging would provide only limited and temporary relief from vegetation growth. More recent studies have suggested that dredging may actually encourage growth of some types of weeds.

The costs for comprehensive dredging of the shallow bays on Lake Mary and the shallow west shore areas on Lake Elizabeth would be prohibitive without outside funding. No outside funding programs for comprehensive dredging are currently available.

Limited dredging to provide better access and facilitate navigation would be effective in the bays on Lake Mary, in Cappelen's Bay on Lake Elizabeth, at Mad Dan's on Lake Elizabeth and at several other limited areas on the west shore of Lake Elizabeth. Dredging would benefit property owners in these areas.

It is recommended that the District and the Village adopt a policy of working with property owners in these areas to identify specific dredging target areas and spoil which would enhance navigation and access. The District and Village should also assist in finding suitable disposal sites which meet the criteria described above. However, all funding for either feasibility studies or actual dredging and disposal should be borne by the private property owners.

5.B. Aquatic Plant Management

5.B.1. General Description

Although aquatic macrophyte and phytoplankton are important to the overall health of the lake, excessive or unwanted aquatic plant growth can disrupt the natural ecosystem, detract from the aesthetic quality of the lake, and interfere with such recreational lake uses as boating and swimming. In aquatic plant management, a balance needs to be struck between controlling unwanted nuisance vegetation and preserving aquatic plants in those areas where it is essential to protecting the fishery and maintaining a balanced ecosystem.

Any program to manage aquatic plants needs to be done within the context of recognizing that plant growth is a natural process which will occur in all lakes as they age. There are many factors which influence the growth of aquatic plants including lake age, soil conditions, climate, and nutrient loading. While nutrients are not the only function of aquatic plant growth, they are the primary factor that can be influenced by management practices. For this reason the "first line of defence" in controlling aquatic plant growth is managing nutrients in the watershed.

In-lake management practices, such as macrophyte harvesting, chemical treatment, and bottom management are important tools, but for the most part must be viewed as temporary and generally rather costly means to address the problems.

5.B.2. Aquatic Plant Problem Areas

While aquatic plants are commonly perceived as a problem on both lakes, the incidence of aquatic plant growth is not significantly greater than found in previous plant surveys in 1951 and 1970. Most of the aquatic plants, with the exception of Eurasian water milfoil, are native species. Many of the plant communities provide important habitat for fish. The presence of plants in the lakes helps control the growth of algae.

Plants are most abundant in the shallow areas with depths of fifteen feet or less. The most abundant plants are the Sago pondweed group, Wedgeon grass (Ruppia sp.), Stonewart (Charo group), White lillies and Spatterdock, and Eurasian water milfoil. Cattail and Bullrushes are abundant along in the wetland areas.

The most significant problems with the aquatic plant community is the presence of Eurasian water milfoil, which is a nonnative species. Once established, Eurasian water milfoil forms a dense mat which chokes out other vegetation and causes severe problems for boaters and other lake users.

Eurasian water milfoil is well-established in Lake Elizabeth where it forms a nearly continuous band around the lake a depths of 10 to 15 feet. In Lake Mary, Eurasian water milfoil is present only in limited areas, most notable at the northeast corner of Lake Mary near several large pipes which empty stormwater into the lake.

Eurasian water milfoil cannot be effectively eradicated by mechanical cutting and there is some evidence that cutting actually increases its rate of growth. The only effective means of eradication is to physically remove the entire plant, including the root system. Eradication may be feasible where growth is very limited, but it is not economically feasible where it has been firmly established.

5.B.3. Aquatic Macrophyte Harvesting

Mechanical harvesting of aquatic macrophytes is conducted with specialized harvesting equipment, consisting of an apparatus which cuts four to six feet below the water surface and a conveyor system which picks up the cut plants to be hauled to shore. Plant material needs to be hauled to a location away from the lake in order to prevent nutrients from the removed material being washed back into the lake.

Harvesting costs for lakes in southeastern Wisconsin average about $550 per acre.

More limited forms of mechanical harvesting occur regularly, particularly on the northeast shores of both lakes, due to raking of mats of floating aquatic plants which are cut loose from plant beds by motorboats and blown by the prevailing southwest winds onto the shoreline. Property owners generally rake these loose plant materials ashore. The Village provides regular pick-up of these materials.

Previous Reports on Harvesting

The 1980 WDNR Feasibility Study indicated that mechanical weed harvesting in both lakes would be effective on a temporary basis.

The primary advantages to this form of aquatic plant management are:

- Discrete areas of the lake can be treated without damaging or disturbing other areas which should be managed for plant growth
- Plant biomass and nutrients are removed from the lake
- All species in a particular area can be controlled

The primary disadvantages are:

- Relatively high cost for either contract harvesting or purchasing equipment
- Harvesting needs to be done 2 to 3 times each summer to be effective

- Harvesting only removes material relatively near the surface; root structures and plant materials remain below 5 to 8 feet.

Mechanical harvesting is generally not eligible for State or Federal funding.

Harvesting Policy Recommendation

While harvesting is an effective means of temporarily controlling nuisance weed growth in specific areas that impedes navigation and other uses of the lakes, harvesting is not an effective long-term solution to aquatic plant management. Nor is it practical to harvest a sufficient area to provide general benefits to all lake users. Although State and Federal funding for puchasing harvesting equipment is available up to 50% of the capital cost, it is an expensive option.

The District and/or Village should support and finance harvesting in specific areas where there is public access to the shore. These include all public swimming areas and all public landings or public piers that are available for public use on a not-for-profit basis.

A second area where limited harvesting by the District may be practical and necessary is to cut navigation channels through the growth of Eurasian water milfoil on Lake Elizabeth. In years when the growth is particularly bad, Eurasian water milfoil can effectively block access into the deeper open waters on the lake. Limited navigation channels should be cut at points where there would be the greatest boat usage.

At this time Eurasian water milfoil is not firmly established in Lake Mary to require cutting navigation channels. Because of the limited extent of Eurasian water milfoil growth in Lake Mary, the lake may be good candidate for an eradication program. Such a program would require divers mechanically removing the plant including its entire root system. The WDNR currently has a pilot eradication program on Lac LaBelle in Waukesha County. pending the outcome of that program, Eurasian water milfoil eradication may be feasible in Lake Mary.

Neither the District nor the Village should financially support harvesting in other locations which would not provide equal benefit to all lake users. However, to continue to facilitate private raking and collection of floating weed mats, the Village should continue to provide collection and disposal of these materials.

5.B.4. Herbicide Application

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

Many herbicides are approved by the U.S. Environmental Protection Agency (EPA) for use on public waters, however, only several are in general use in Wisconsin. Each herbicide can be used against certain species, but will be ineffective in controlling others. Use of only one chemical would probably result in the simple replacement of the target species with one of the unaffected species.

Like mechanical harvesting, herbicide applications are a short-term approach to aquatic plant management. There are, however, some advantages and disadvantages of using aquatic herbicides either in combination with harvesting or as an alternative approach.

The primary advantages of herbicide use over mechanical harvesting are lower costs and the relative ease of application.

Some of the disadvantages include:

- Unknown long-term effects on the ecosytem
- Elimination of certain species may cause an increase in the growth of other species
- Dead material is not removed from the lake and the nutrient materials are merely recycled as they are released into the water
- Decomposition of dead plant material may consume dissolved oxygen and increase the potential for fish kills
- Areas need to be retreated each season and weed beds may require multiple applications in a single season

Herbicide applications must be approved by WDNR.

Previous Herbicide Use

To be prepared based on WDNR permit records.

Herbicide Application Recommendation

As with mechanical harvesting, herbicide application may be an effective short-term method to control aquatic macrophyte and algae growth on a season to season basis. The policies of the District and Village should be similar.

The District and/or Village should consider supporting and financing limited herbicide applications only as part of a carefully monitored integrated management plan in specific areas where there is public access to the shore. These include all public swimming areas and all public landings or public piers that are available for public use on a not-for-profit basis.

Neither the District nor the Village should financially support herbicide application in other locations which would not provide equal benefit to all lake users. The District should discourage any herbicide applications which are not carefully monitored. Because of the unknown potential long-term damage that may be caused to the lake ecosystem, a very cautious approach should be taken in the use of herbicide applications.

In all instances, herbicide application should only be considered a "last resort" management practice.

5.B.5. Bottom Management

Bottom Management involves the use of lake-bottom covers and light screens which create physical barriers to plant growth and to sunlight reaching plants.

Bottom covers can be effectively used to create swimming beaches on muddy shores and improve the appearance of individual lakefront properties. They may also be effective in temporarily opening channels for motorboating, although motorboats tend to churn up sediments in shallow areas which quickly recover the covers or screens.

Any installation of bottom covering would require WDNR approval.

Bottom Covering Recommendation

Bottom coverings are an effective temporary method of improving the usability of limited areas. The Village and/or District should consider the use of this technique in public use areas, such as swimming areas, public landings, and public piers.

The technique does not appear to be a cost effective or long-term method of controlling aquatic vegetation. While the District should not oppose the limited use of bottom covers within 30 feet of the shoreline for the improvement of individual private properties, the use of bottom covers should not be considered as a long-term measure to control plant growth or as a method suitable for larger areas.

6. LAKE USE RECOMMENDATIONS

Concurrent with the preparation of the Lake Management Plan, the District's Lake Regulations Committee has been developing recommended regulations for boating and other activities in the lake. The recommendations of the Rules Committee were based in part on the Needs Assessment Survey conducted as part of the Lake Management Plan preparation.

The Committee's recommendations were presented to the electorate of the District at the Annual Meeting on May 23, 1992. After review by WDNR and approval by the Village Board the regulations will be published as part of an informational brochure to be made available at public access points.

Note: The lake use regulations below include WDNR regulations, as well as proposed local regulations, which in some instances are more restrictive than WDNR rules. At this time, the regulations which are more restrictive than WDNR regulations are only proposals and have not yet been approved by either WDNR or the Village Board.

6.1. Hours and Speed Limits

Sunset to Sunrise is always Slow-No-Wake.

Additional Summer (Memorial Day to Labor Day) Restrictions:

10 mph . . . Sunrise to 9:00 AM
40 mph . . . 9:00 AM to 8:00 PM
Slow-No-Wake . . . 8:00 PM to Sunset

6.2 Age Restrictions - Motorboat Operations

Persons under 10 years may not operate a motorboat.

Persons 10 to 12 years may operate with parent or guardian.

Persons 12 to 16 years may operate with parent or guardian or with a DNR Boating Safety Course Certificate.

6.3 Jet Ski (PWC) Operations

Jet Skis, Wave Runners or any type of personal watercraft (PWC) must adhere to the same rules as other watercraft plus the following specific rules:

No person under the age of 12 may operate a PWC.

A person between the ages of 12 and 16 may operate a PWC if they have a DNR Boating Safety Course Certificate.

All persons riding a PWC must wear a USCG approved Personal Flotation Device (PFD).

PWC's may not be operated from sunset to sunrise.

PWC's may not be used to tow persons on water skis, aquaplanes or similar devices.

PWC's may not be operated within 100 feet of a motorboat, person or the tow rope of a motorboat engaged in towing a person on water skis, aquaplane or similar device.

6.4. Water Skiing

Prohibited at all times within 200 feet of shore.

Prohibited within 100 feet of any occupied anchored boat.

Prohibited within 100 feet of any PWC and the tow rope must not get within 100 feet of a PWC.

Must operate in a counter-clockwise pattern inside the traffic lane.

Persons being towed shall wear an approved PFD.

No more than 2 tow lines and/or 2 persons being towed.

Towlines may not exceed 75 feet.

6.5 Alcoholic Beverages

No open containers of alcoholic beverages are permitted on the lakes at any time.

6.6. 200-Foot Shore Zone

No person shall operate a watercraft in excess of Slow-No-Wake within 200 feet of the shoreline.

6.7 Restricted Areas (See Map)

Within 100 feet of any dock, raft, pier, buoyed area or skin diver's flag is Slow-No-Wake.

6.8 Hazard Areas (See map)

Lake Mary

Buoyed rock bar in center of lake.

Lake Elizabeth

Buoyed series of rock bars at Northwest end of lake.
Large, very shallow buoyed rock bar on West side of lake.
Buoyed submerged trestle crossing South end of lake.

6.9 Swimming

Swimming is permitted in designated public swimming areas (Buoyed):

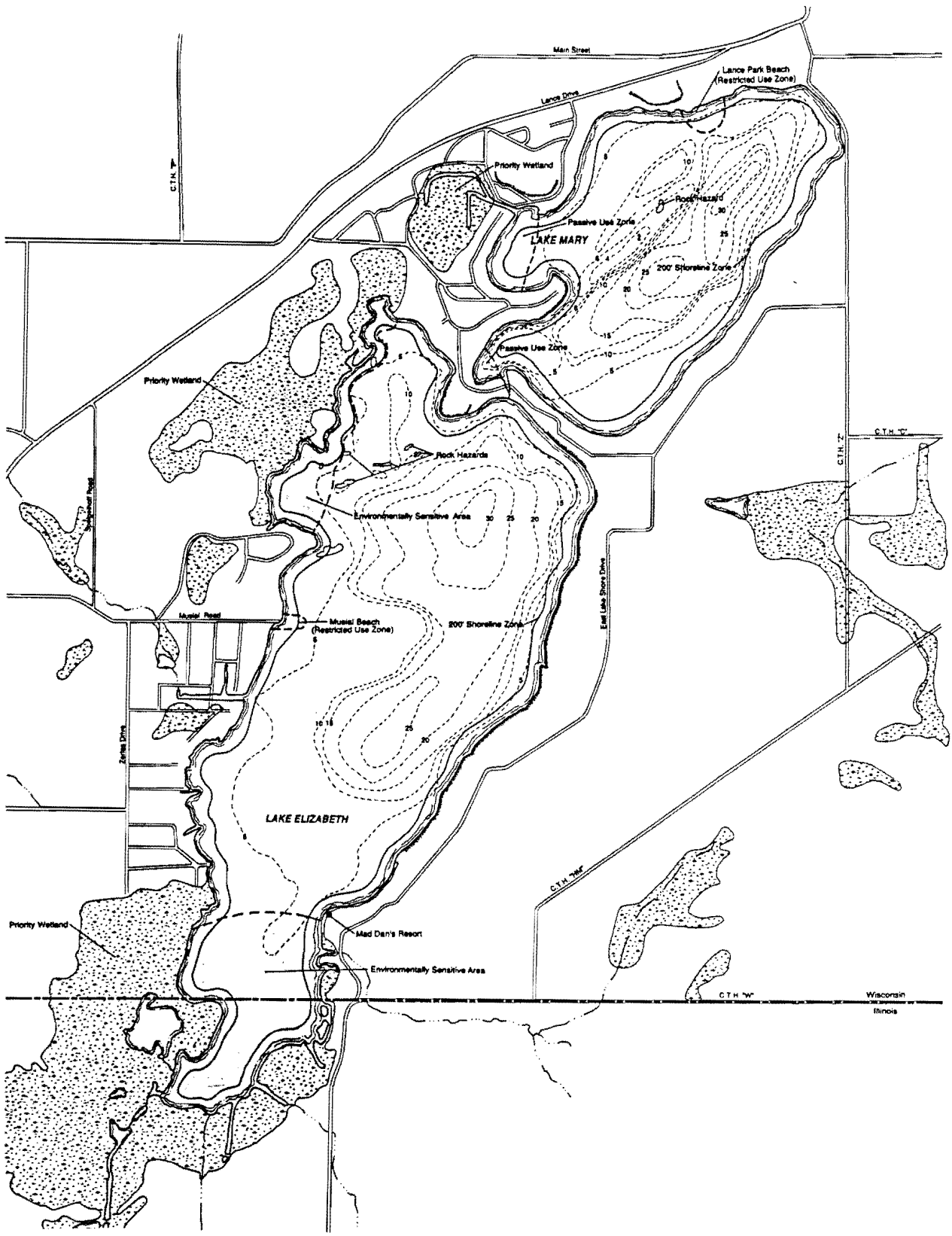
Lance Park Beach - North side of Lake Mary

Musial Beach - West side of Lake Elizabeth

Swimming is prohibited from unmanned, unanchored boats.

Swimming is prohibited more than 200 feet from shore, unless in marked swim area or within 25 feet of an anchored raft or boat.

Flotation devices are prohibited unless they are USCG approved PFDs.



Regulation Recommendations

LAKE MANAGEMENT PLAN
TWIN LAKES, WISCONSIN

0 300 600 1200 1800
FEET

NORTH

camiros ltd.
Planning, Zoning,
Development Economics,
and Landscape Architecture

7. PUBLIC ACCESS

7.A. WDNR Public Access Policy

Wisconsin Law provides that the public have access to all lakes and rivers in Wisconsin. The implementation of this public policy has taken a number of different forms and the guidelines are in the process of being reviewed.

However, there are some guidelines which the State is currently following to assure compliance with the policy. The general guideline for access is that all inland lakes in the range of 250 to 999 acres, which includes both Lake Mary and Lake Elizabeth, must have at least one public access ramp and a total of one car-trailer parking site per 15 to 20 acres of surface area.

In addition to the parking requirement, other guidelines for public site acquisition involving WDNR funding include:

- Acquire lot size of 1/2 acre or more.
- Provide adequate areas for turnarounds, buffer, ramp, roadway, and parking. The minimum width of an access to assure adequate buffering between public and private sites is 60 feet, but the Department shall attempt to acquire 100 feet.
- Acquire access sites adjoining public roadways.
- Acquire sites that allow safe access to and from public roadways.
- Acquire, to the extent possible, sites that do not require extensive dredging or filling and have minimal slope, have upland soils, and require a minimum of shoreline alteration.
- Acquire sites having the least potential for disturbance to existing land uses in the vicinity and to the natural resources. The Department or sponsor will review surrounding land ownership, existing and expected recreational use, and recreation service data where available, among other things, in determining the type of access to develop at any site.
- Satisfy requirement on internal checklists.

7.B. Existing Public Access

7.B.1. Lake Mary Public Access

Adequate public access is currently provided at Lance Park.

7.B.2. Lake Elizabeth Public Access

The WDNR has indicated in a letter dated February 13, 1991 that in order for Lake Elizabeth to meet the adequate public access definition there should be 32 car-trailer parking spaces (10 feet X 40 feet each) that are located within 1/4 mile of the launch site.

The launch fees should not exceed the current price of admission to state parks which is currently $3.50 (Wisconsin resident) and $6.00 (nonresident). Higher fees may be charged if justified by actual launch maintenance and if approved by the Department.

In order for the WDNR to recognize a lake as having adequate public access, the Department, the Village, or the District must own the access site or have a lease or easement from the owner.

Private access may be considered 50 percent of the required access. In the case of Lake Elizabeth, Mad Dan's Resort provides a launch ramp and with ample car-trailer spaces. The use of privately owned access to meet the public access requirement must be approved by the Department.

Assuming that privately owned access at Mad Dan's can be used to meet 50 percent of the 32-space requirement. The Department or the Village/District needs to provide a public access point with 16 car-trailer spaces that meet the WDNR guidelines.

7.C. Recommendation

7.C.1. Lake Mary

Existing public access to Lake Mary is provided at Lance Park. No additional access should be provided.

7.C.2. Lake Elizabeth

The current public access site at the end of Musial Road is not an ideal landing area. The lake is very shallow at that point and the landing shares the same area with a public beach. The nearest potential car-trailer parking spaces are at the public park, approximately 2,400 feet to the west.

Access alternatives include:

- Acquisition of an additional lot(s) adjoining the Musial Road ramp
- Public acquisition of an adequately sized lot on Lake Elizabeth. Potential lots that have been considered include:

    a. The parcel immediately south of Mad Dan's. This parcel already has ramps, since the site was formerly a commercial marina.

    b. A parcel at the south end Cappelen's Bay.

    c. A parcel on the southeast shore north of Mad Dan's.

    Note: The draft Master Plan for the Village of Twin Lakes indicates the need for a neighborhood park in the southeast quadrant of the Village. It may be feasible to meet the public access requirements with a neighborhood park in this area.

- Entering into a contract agreement with Mad Dan's Resort to provide public access at existing ramps within or adjoining the resort site

The Village should consider opportunities to purchase any undeveloped sites on the either side of the Lake Elizabeth that become available and would met minimum criteria for public access. To provide adequate access, sites should be at least one acre, with public road access, and be adequately buffered from adjoining private homes.

The WDNR has indicated in a letter dated March 11, 1991 that 50 to 75 percent funding would be available for acquisition and improvements.

8. INFORMATION AND EDUCATION PROGRAM

The primary purpose for the Information and Education Program (I & E) for the Twin Lakes is to communicate the ecological basis of the recommended projects. In addition, the involvement of resident and nonresident lake users, community leaders, and the general public to support lake and watershed water quality improvement practices is important. With the recognition that numerous "encounters" are often required to motivate positive action, several information and education activities are suggested.

The objectives of the Information and Education Program are five-fold and are described below:

- Educate watershed residents and the general public regarding nonpoint pollution sources to the Twin Lakes caused by land use activities, in both urban and rural settings.

- Increase the awareness and understanding of the Twin Lakes and their watershed as an ecosystem. Foster the understanding that the lakes' water quality is a reflection of their watershed. Point out the benefits achieved using watershed "best management practices" combined with in-lake projects.

- Instill a sense of stewardship or ethic for natural resources within the Twin Lakes watershed. Create an awareness of natural resources and the effect that human activity has on the environment. Emphasize that everyone is responsible for conserving soil and water resources.

- Achieve participation and support for the Twin Lakes water quality improvement projects through the involvement with lake users, watershed property owners, local sportsmen's clubs, environmental organizations, and the Village of Twin Lakes.

- Coordinate and cooperate with federal, state, and local governmental agencies and their nonpoint source pollution control programs and advocate the suitable governmental program plans of action as ways to protect water quality in the Twin Lakes.

To meet the objectives of the Education and Information Program, there are a variety of approaches to disseminating information. This list of 12 activities is not all inclusive and the District may have additional approaches. Some of these activities are already being implemented by the Lake District.

1. Lake Information and Eduction Committee: To broaden the base of community support and give local people a sense of "ownership," a Lake Information and Education Committee could be established that is separate from the Lake District Board. The committee should consist of up to 15 members including both lakefront and lakefront property owners, and representatives from business, agricultural organizations, sportsmen's clubs, education and local media.

2. Newsletter: Two newsletters were produced as a part of the Lake Management Planning Program. The newsletter should be continued. Suggested newsletter article topics include:

    A. Updates on new projects.

B. Information on lake use regulations.

C. General information on the watershed and lake management concepts.

D. Updates on state regulations.

E. News articles on activities of other lake districts.

F. Notice of meetings and special events.

3. Slide and Video Programs: A slide program on work that has been done in the Twin Lakes could be developed for presentations at public information and lake association meetings, area schools and to local civic and service clubs. A video report emphasizing underwater environments in the Twin Lakes was provided as part of this Lake Management Planning Program. It could be updated and expanded in the future.

4. Fact Sheets: To disseminate basic information about the project, fact sheets could be created to meet the particular needs of watershed landowners. Examples of facts sheet are:

   A. Causes and problems created from nonpoint source pollution and possible solutions.

   B. A "Shoreland Owner's Guide" emphasizing lakeshore housekeeping practices "Do's and Don'ts" to minimize nonpoint source pollution and improve lake water quality.

   C. "Farmer's Guide," a financial and technical brochure that explains what conservation programs are available and which agency administer them, and what type of agricultural land qualifies for cost sharing.

5. Tours: Conduct tours of specific watershed, lakeshore and in-lake implementation practices. Landowners and other individuals needing specific information and first-hand exposure to the best management practices and measures should be invited to the event(s).

6. One-Day Workshops: Workshops designed to provide technical information on best management practices could be provided for watershed residents. Examples of workshop topics are:

   A. Stormwater management for water quality enhancement, as well as flooding considerations.

   B. Ecological aquascaping for water quality and wildlife enhancement.

C. Nutrient management and conservation tillage on agricultural lands.

D. Installation, care and maintenance of on-site sewage treatment systems.

E. Good housekeeping on lakeshore lots.

7. Field Day Bus Trips: To inform watershed and village residents of successful implementation projects outside of the Twin Lakes watershed, a bus could be chartered to transport interested individuals for first-hand exposure to these projects. One possible bus trip could be to the Lake Delavan restoration project.

8. Area School Participation: To help foster the protection of natural resources for future generations, the area schools could participate in specific programs. High school and middle school science teachers could be contacted to determine the interest in devising school environmental education projects involving the Twin Lakes.

9. Media: A program to involve the media in covering lake and watershed events can begin with a meeting with area newspapers to acquaint editors and reporters with the Twin Lakes Management Plan. The following media activities are possibilities:

   A. News releases can be sent to these area newspapers and to radio stations to announce project events such as tours, bus trips, public information meetings, workshops, and demonstration project installments.

   B. Newspaper feature articles can be sought to provide the general public with in-depth coverage on the progress of various projects.

   C. A newspaper column could be written as a vehicle to inform the public. General information on nonpoint source pollution and best management practices, lakeshore management, and lawn and yard care could be topics for the column.

   D. Radio public service announcements could be used to announce upcoming project events and meetings.

10. Conferences: Presentations and exhibits on the Twin Lakes water quality improvement implementation project would be given at local and regional conferences.

11. Contests: Contests could be used to encourage involvement in the protection of the Twin Lakes water quality and to act as an educational tool to address the importance of water quality. Fishing contests, sailing contests, and lake shoreline weed collection contests could all be used to promote aspects of the Twin Lakes ecological workings.

To implement these activities all at once would be an ambitious undertaking. There are options for implementing some or all of these activities. Several types of programs could be organized depending on the approach of the Lake District. Several ideas are outlined below:

- Coordinate with the Kenosha County Land Conservation Department, McHenry County (Illinois), WDNR, and/or the U.W. Extension, to organize a program that could carry out several of the information and education activities. The level of effort that could be expended by the state and county agencies is dependent on their other commitments and it is difficult to predict how much time they could contribute.

- Form a Regional Lakes Association and pool resources to help fund some activities.

- Become a Priority Lake by petitioning the WDNR for that status. Some of the funds that would be available could support, in part, a position to pursue many of the listed information and education activities.

- If future lake management projects or monitoring programs are to be conducted, have the consultant conduct several of the information and education activities.

APPENDIX A

NEEDS ASSESSMENT SURVEY

Needs Assessment Survey

As part of the background preparation for the Lake Management Plans for Lake Mary and Lake Elizabeth, Discovery Group, Ltd. has conducted a needs assessment for the lakes. The assessment is based, in part, on findings of a community opinion survey of all full-time and part-time property owners in the District. The survey was conducted in June, 1991. Approximately 2100 surveys were distributed by mail to all property owners in the District; 784 surveys were returned. The response rate for the surveys was 37.2%.

The survey responses have been cross-tabulated in order to identify the different responses from property owners with frontage on Lake Mary and Lake Elizabeth and responses from nonlakefront property owners.

The following is a summary of the survey responses and a complete set a tabulations.

SUMMARY OF SURVEY RESPONSES

PART A RESPONDENT PROFILE

A.1. Is your property in Twin Lakes your primary residence?

A. Yes	458	(58.4%)
B. No	323	(41.2%)
No Opinion	3	(0.4%)

A.2. Does your property have lake frontage or deeded lake access?

A. Yes, Lake Elizabeth	249	(31.8%)
B. Yes, Lake Mary	248	(31.6%)
C. No	280	(35.7%)
No Opinion	7	(0.9 %)

PART B LAND USE PLANNING ISSUES

B.1. Should the Village encourage more development of all types in order to expand the tax base and provide employment opportunities?

A. Yes	376	(48.0%)
B. No	344	(43.9%)
No Opinion	52	(6.6%)

B.2. Should the Village require developers to pay for the costs of development through development fees?

A. Yes	696	(88.8%)
B. No	30	(3.8%)
No Opinion	50	(6.4%)

B.3. Should the Village undertake efforts to diversify the economic base and reduce the dependence of the local economy on tourism and second home development?

A. Yes	490	(62.5%)
B. No	179	(22.8%)
No Opinion	83	(10.6%)

B.4. Should the Village limit the location, density, and type of multi-family apartment and condominium development through restrictive zoning?

A. Yes	680	(86.7%)
B. No	62	(7.9%)
No Opinion	35	(4.5%)

B.5. Should the Village encourage primarily single-family home development?

A. Yes	616	(78.6%)
B. No	97	(12.4%)
No Opinion	59	(7.5%)

B.6. Should the Village undertake efforts, such as streetscape improvements and facade renovations, to revitalize the Downtown business district, even if results in additional costs to the taxpayer?

A. Yes	168	(21.4%)
B. No	557	(71.0%)
No Opinion	51	(6.5%)

B.7. Should the Village allow new shopping centers or retail business districts to be created in locations other than the Downtown area and North Lake Avenue (CTH "EM")?

A. Yes	392	(50.0%)
B. No	323	(41.2%)
No Opinion	57	(7.3%)

B.8. Should the Village allow new individual retail businesses, such as restaurants, taverns and convenience stores to be located in areas other than the Downtown area and North Lake Avenue (CTH "EM")?

A. Yes	424	(54.1%)
B. No	308	(39.3%)
No Opinion	43	(5.5%)

B.9. Should the Village encourage more light industry, warehousing, and distribution centers?

A. Yes	499	(63.6%)
B. No	214	(27.3%)
No Opinion	61	(7.8%)

B.10. Should the Village purchase additional land for expansion of the Village Industrial Park on the north side of the Village near the existing industrial park?

A. Yes	321	(40.9%)
B. No	300	(38.3%)
No Opinion	147	(18.8%)

B.11. Should the Village adopt an Appearance Code to regulate the design and maintenance of properties in the Village of Twin Lakes?

A. Yes	533	(68.0%)
B. No	173	(22.1%)
No Opinion	72	(9.2%)

B.11.a. If you answered yes to Question 11, should single-family residences be exempted from Appearance Code regulations?

A. Yes	145	(18.5%)
B. No	399	(50.9%)
No Opinion	35	(4.5%)

B.12. Does Twin Lakes need more public parks or a community center, even if it results in additional cost to the taxpayer?

A. Yes	143	(18.2%)
B. No	582	(74.2%)
No Opinion	55	(7.0%)

B12.a. If you answered yes to Question 12, what part of the Village needs additional parks?

A. Eastside - North	35	(4.5%)
B. Eastside - South	42	(5.4%)
C. Westside - North	24	(3.1%)
D. Westside - South	22	(2.8%)

B.13. Do you favor school district consolidation?

A. Yes	363	(46.3%)
B. No	131	(16.7%)
No Opinion	271	(34.6%)

B.14. Do you favor additional annexations?

A. Yes	255	(32.5%)
B. No	275	(35.1%)
No Opinion	235	(30.0%)

B.15 Should the Village exercise its powers granted by Wisconsin law to regulate subdivisions in its 1.5-mile extraterritorial area?

A. Yes	516	(65.8%)
B. No	99	(12.6%)
No Opinion	150	(19.1%)

PART C LAKE PLANNING ISSUES

C.1. Which lake do you use most frequently?

A. Lake Mary	374	(47.7%)
B. Lake Elizabeth	284	(36.2%)
C. Do Not Use Lakes	116	(14.8%)
No Opinion	10	(1.3%)

C.2. Should the Lake District encourage more public access to the lakes?

A. Yes	132	(16.8%)
B. No	606	(77.3%)
No Opinion	46	(5.9%)

C.3. How often do you use the lakes for the following activities?

Fishing		
Frequently	242	(30.9%)
Occasionally	133	(17.0%)
Seldom	168	(21.4%)
Never	170	(21.7%)
Ice Fishing		
Frequently	60	(7.7%)
Occasionally	49	(6.3%)
Seldom	124	(15.8%)
Never	430	(54.8%)
Power Boating		
Frequently	275	(35.1%)
Occasionally	80	(10.2%)
Seldom	79	(10.1%)
Never	250	(31.9%)
Water Skiing		
Frequently	185	(23.6%)
Occasionally	77	(9.8%)
Seldom	95	(12.1%)
Never	314	(40.1%)
Jet Skiing		
Frequently	35	(4.5%)
Occasionally	13	(1.7%)
Seldom	47	(6.0%)
Never	550	(70.2%)
Sailing		
Frequently	76	(9.7%)
Occasionally	52	(6.6%)
Seldom	83	(10.6%)
Never	448	(57.1%)
Canoe/Kayaking/Rowing		
Frequently	77	(9.8%)
Occasionally	91	(11.6%)
Seldom	127	(16.2%)
Never	356	(45.4%)

Swimming		
Frequently	380	(48.5%)
Occasionally	140	(17.9%)
Seldom	93	(11.9%)
Never	96	(12.2%)
Snowmobiling		
Frequently	71	(9.1%)
Occasionally	48	(6.1%)
Seldom	89	(11.4%)
Never	450	(57.4%)

C.4. How serious do you consider the following problems?

General Water Quality		
Serious Problem	269	(34.3%)
Minor Problem	255	(32.5%)
No Problem	129	(16.5%)
No Opinion	57	(7.3%)
No. of Boats (Weekends)		
Serious Problem	433	(55.2%)
Minor Problem	191	(24.4%)
No Problem	65	(8.3%)
No Opinion	48	(6.1%)
No. of Boats (Weekdays)		
Serious Problem	62	(7.9%)
Minor Problem	206	(26.3%)
No Problem	377	(48.1%)
No Opinion	73	(9.3%)
Speed of Boats		
Serious Problem	346	(44.1%)
Minor Problem	235	(30.0%)
No Problem	105	(13.4%)
No Opinion	53	(6.8%)
Size of Boats		
Serious Problem	241	(30.7%)
Minor Problem	209	(26.7%)
No Problem	221	(28.2%)
No Opinion	67	(8.5%)
No. of Water Skiers		
Serious Problem	227	(29.0%)
Minor Problem	271	(34.6%)
No Problem	168	(21.4%)
No Opinion	64	(8.2%)

No. of Jet Skiers		
Serious Problem	383	(48.9%)
Minor Problem	185	(23.6%)
No Problem	101	(12.9%)
No Opinion	66	(8.4%)
Decline of Fishery		
Serious Problem	337	(43.0%)
Minor Problem	182	(23.2%)
No Problem	73	(9.3%)
No Opinion	132	(16.8%)
Excessive Noise		
Serious Problem	223	(28.4%)
Minor Problem	249	(31.8%)
No Problem	173	(22.1%)
No Opinion	76	(9.7%)
Excessive Algae		
Serious Problem	311	(39.7%)
Minor Problem	249	(31.8%)
No Problem	80	(10.2%)
No Opinion	78	(9.9%)
Excessive Aquatic Weeds		
Serious Problem	385	(49.1%)
Minor Problem	221	(28.2%)
No Problem	47	(6.0%)
No Opinion	68	(8.7%)
Stormwater Runoff		
Serious Problem	210	(26.8%)
Minor Problem	211	(26.9%)
No Problem	136	(17.3%)
No Opinion	157	(20.0%)
Shoreline Erosion		
Serious Problem	199	(25.4%)
Minor Problem	253	(32.3%)
No Problem	138	(17.6%)
No Opinion	133	(17.0%)
Water Levels		
Serious Problem	176	(22.4%)
Minor Problem	271	(34.6%)
No Problem	172	(21.9%)
No Opinion	104	(13.3%)
Loss of Wetland		
Serious Problem	330	(42.1%)
Minor Problem	164	(20.9%)
No Problem	115	(14.7%)
No Opinion	117	(14.9%)

Sediment in Shallow Areas		
Serious Problem	340	(43.4%)
Minor Problem	221	(28.2%)
No Problem	58	(7.4%)
No Opinion	98	(12.5%)
Noise From Snowmobiles		
Serious Problem	155	(19.8%)
Minor Problem	211	(26.9%)
No Problem	224	(28.6%)
No Opinion	133	(17.0%)
Litter From Lake Users		
Serious Problem	355	(45.3%)
Minor Problem	261	(33.3%)
No Problem	68	(8.7%)
No Opinion	50	(6.4%)

C.5. Should any of the following activities be limited?

Swimming		
Limited by Location of Operation	132	(16.8%)
Limited by Time of Operation	29	(3.7%)
Limited by Location and Time	71	(9.1%)
Not Limited	428	(54.6%)
No Opinion	57	(7.3%)
Power Boating		
Limited by Location of Operation	107	(13.6%)
Limited by Time of Operation	207	(26.4%)
Limited by Location and Time	272	(34.7%)
Not Limited	115	(14.7%)
No Opinion	33	(4.2%)
Water Skiing		
Limited by Location of Operation	81	(10.3%)
Limited by Time of Operation	211	(26.9%)
Limited by Location and Time	300	(38.3%)
Not Limited	105	(13.4%)
No Opinion	34	(4.3%)
Jet Skiing		
Limited by Location of Operation	139	(17.7%)
Limited by Time of Operation	128	(16.3%)
Limited by Location and Time	382	(48.7%)
Not Limited	54	(6.9%)
No Opinion	33	(4.2%)
Fishing		
Limited by Location of Operation	19	(2.4%)
Limited by Time of Operation	29	(3.7%)
Limited by Location and Time	46	(5.9%)
Not Limited	547	(69.8%)
No Opinion	78	(9.9%)

Other Boating		
Limited by Location of Operation	36	(4.6%)
Limited by Time of Operation	56	(7.1%)
Limited by Location and Time	117	(14.9%)
Not Limited	407	(51.9%)
No Opinion	100	(12.8%)
Snowmobiling		
Limited by Location of Operation	89	(11.4%)
Limited by Time of Operation	98	(12.5%)
Limited by Location and Time	279	(35.6%)
Not Limited	161	(20.5%)
No Opinion	100	(12.8%)

C.6. Should the Lake District purchase or obtain conservation easements for wetlands and other environmentally sensitive areas to protect lake water quality?

A. Yes	540	(68.9%)
B. No	99	(12.6%)
No Opinion	125	(15.9%)

C.7. If aquatic vegetation (weeds) needs to be removed, what method do you prefer?

A. Herbicide	29	(3.7%)
B. Mechanical Harvesting	328	(41.8%)
C. Combination of Herbicide and Harvesting	268	(34.2%)
No Opinion	134	(17.1%)

C.8. Is current marking of navigational hazards in the lake adequate?

A. Yes	359	(45.8%)
B. No	207	(26.4%)
No Opinion	202	(25.8%)

C.9. Is current Lake Patrol enforcement of the lake use regulations adequate?

A. Yes	387	(49.4%)
B. No	189	(24.1%)
No Opinion	192	(24.5%)

C.10. Should lake front property owners who directly benefit from special projects, such as dredging, be assessed for those projects?

A. Yes	383	(48.9%)
B. No	290	(37.0%)
No Opinion	90	(11.5%)

C.11. Should the Lake District charge registration or user fees for all boats used on the lake?

A. Yes	417	(53.2%)
B. No	280	(35.7%)
No Opinion	67	(8.5%)

C.12. Should the Village enact stricter wetland/shoreland zoning to protect the remaining natural areas?

A. Yes	636	(81.1%)
B. No	67	(8.5%)
No Opinion	67	(8.5%)

C.13. Since state law does not allow restrictions on the size of boats or motors, do you think a speed limit would help make the lakes safer?

A. Yes	560	(71.4%)
B. No	163	(20.8%)
No Opinion	51	(6.5%)

SUMMARY OF ADDITIONAL COMMMENTS

The following comments were received along with the completed questionnaires. Many of the comments were received in the form of letters.

- Lakefront owners taxes are too high already. 21
- Nonproperty owners should pay higher user fees. 12
- Discourage commercial development. 11
- Stricter rules for jet skis are needed. 10
- Twin Lakes should be kept as a small residential and second home community. 8
- More patrol boats and stricter enforcement are needed on the lake. 8
- The Village should protect wetlands and other natural areas. 8
- Noise control should be greater enforced. 6
- Restrictions should be set limiting the number of boats that can be launched. This might ease traffic congestion on the lake. 6
- Control speeding boats. 5
- Objections to the Stumph Real Estate development that is filling the wetlands 4
- Improve the appearance of downtown storefronts. 4
- Seaweed and muck in the bays are a big concern. 3
- The speed should be limited on all boats after dark. 3
- Keeping up the quality of the lake should not be the sole responsibility of those with lakefront property. 2
- Local people should not have to pay the same user fees that out of state people pay. 2
- The survey is biased in favor of lake residents. 2
- The survey is biased against seasonal residents, who are also property tax payers. 2
- Businesses should pay for the cost of revitalizing the downtown. 2
- An age limit should be set concerning the operation of boats. 2
- Special hours should be set for water skiers. 2
- Relocate the lumber company. 2
- The new Twin Lakes Marina is an eyesore. 2

- Increase the number of policemen.	2
- Dredge channels.	2
- Control barking dogs in the Village.	1
- Since the government controls the lake, the government should pay for all projects concerning the lake.	1
- The Village should be more active in developing programs for children, such as swimming lessons.	1
- Extend the appearance and maintenance code to cover vacant lots.	2
- The population of Twin Lakes is not large enough to support added retail establishments.	1
- The Village does not need any more taverns.	1
- Improve lake access for nonlake frontage property owners.	1
- Development should be away from the downtown.	1
- It's unfair that nonresidents have to buy a nonresident fishing license to fish from their own properties.	1
- The Village should not adopt developer fees which would discourage development.	1
- Nonresident property owners should be eligible for resident fishing licenses.	1
- Boats with larger horsepower motors should be charged additional launch fees.	1
- Maintain the boat ramps in better condition.	1

APPENDIX B

WATER QUALITY ANALYSIS

B.1. Lake Water Chemistry

Lake water chemistry is the basis for many biological interactions. The presence or absence of oxygen affects fish as well as the concentration of nutrients which in turn affect algae. Temperature differences are important to note because they affect how a lake mixes and affects the rate of chemical reactions.

Nutrients such as phosphorus, nitrogen and potassium are responsible for plant and algae growth. The nutrient that most often controls aquatic plant growth in lakes is phosphorus, although nitrogen can control growth for certain parts of the year. Rooted aquatic plants get most of their nutritional needs and phosphorus from lake sediments, where as algae get their nutritional requirements from the water column. Therefore, the greater the phosphorus concentration in the water column, generally the greater the algae growth. Nitrogen concentrations should also be looked at also. At nitrogen to phosphorus ratios less than about 16, nitrogen can become the nutrient that influences algae growth.

Most lake management programs look at ways to control phosphorus in order to control algae. Objectives of the water chemistry monitoring program for Twin Lakes were to determine the source of nutrients (which fuel algae growth) and then determine what influences their concentrations. Potential sources of nutrients include lake sediments, stormwater runoff, boats stirring up lake sediments, groundwater inputs, and rainfall. Potential influences on nutrient concentrations include temperature, oxygen, conductivity, alkalinity, pH and calcium concentrations.

B.1.a. Previous Water Chemistry Studies

Water chemistry information for Twin Lakes goes back at least 40 years, starting with data found in a fish survey for Lakes Mary and Elizabeth from August 1, 1951. Lake studies were conducted in 1967 and 1977 and water quality data for Lake Mary were listed in a fishery survey from 1970. A summary of these data are listed in Tables B.1 and B.2.

Water transparency in 1951 is comparable to what was found in 1991. Phosphorus concentrations reported in 1966 are also comparable to concentrations measured in 1991. The temperature and oxygen profile from 1951 (Table B.2) indicates the lakes were stratified by temperature and that a small volume of the deep water was without oxygen.

Table B.1 Comparison of Water Quality Results From Previous Studies

Lake Mary

	Secchi Disc (feet)	Phosphorus (ug/l)	Chlorophyll a (ug/l)	Conductivity (mmhos/cm)	pH (su)	Alkalinity	Ca (mg/l)
August 1951	8	—	—	—	8.4	—	—
April 1966	—	13	—	343	7.9	191	29.5
August 12, 1966	9	26	—	406	8.5	170	13.8
August 25, 1966	—	23	—	407	8.5	171	13.4
1970 (Fish Survey)	5 (July)	47 (August)	—	—	—	—	—
1977 May-Sept (Range)	6.6 (4.8-9.5)	32	8.5 (7.2-11.3)	—	—	—	—
1991 June-August	8.2	18	5	—	—	—	—

Lake Elizabeth

	Secchi Disc (feet)	Phosphorus (ug/l)	Chlorohpyll a (ug/l)	Conductivity (mmhos/cm)	pH (su)	Alkalinity	Ca (mg/l)
August 1951	7	—	—	—	8.4 Top 7.8 Bottom	—	—
April 1960	—	39	—	453	8.0	190	19.0
March 7, 1966	—	26	—	393	—	180	19.0
August 12, 1966	10	16	—	391	8.4	168	15.3
August 25,1966	—	20	—	391	8.4	168	15.4
1977 May-Sept. (Range)	5.8 (4.8-7.3)	—	10.2	—	—	—	—
1991 June-August (Range)	7.1 (5.0-10.0)	17	6 (4.0-9.0)	—	—	—	—

Table B.2 Temperature and Dissolve Oxygen Measurements from 1951 for Lake Mary and Lake Elizabeth

Source: WDNR Fish Survey Report, C.L. Cline, 1951

August 1, 1951 - Lake Mary

Depth (in feet)	Temperature (Degrees F.)	DO (mg/l)
0	83	9.8
5	82	10.0
10	80	10.5
15	78	8.9
20	73	4.1
25	71	1.3
30	69	0.0
32	69	0.0

Secchi: 8'
pH 8.4

August 1, 1951 - Lake Elizabeth

Depth (in feet)	Temperature (DegreesF.)	DO (mg/l)
0	80	10.3
5	80	10.2
10	79	10.0
15	78	8.7
20	77	6.2
25	73	0.3
30	70	0.0
32	70	0.0

Secchi: 7'
pH 8.4

B.1.b. Water Chemistry Sampling Methods Used in This Study

Water chemistry sampling was conducted in May, June, July and August 1991 on Lakes Mary and Elizabeth. Surface water samples were collected 1 foot below the surface and deep water samples were collected with a Van Dorn sampler approximately 1 to 2 feet off the lake bottom. Lake Mary had one station at the deepest spot in the lake and Lake Elizabeth had two stations at deep holes in the north and south basins. For the boating impact study, deep water samples were collected by scuba diving. All water chemistry analyses were performed by the Wisconsin State Lab of Hygiene in Madison, using standard analytical methods.

B.1.c. Water Chemistry Results and Discussion

The water chemistry sampling results for 1991 are shown in Tables B.3, B.4 and B.5. Temperature and oxygen profiles (Table B.3 and B.4) indicate ample oxygen down to at least 20 feet in both lakes to support fish (based on 3.0 mg/l requirement for warm water fish). Low or no oxygen is found at about 22 feet or deeper on several occasions throughout the summer, in both lakes.

The temperature profile indicates the lakes are well mixed in spring and late summer. When they thermally stratify, the mixing depth is around 20 feet, meaning the top 20 feet of water is mixing and exposed to the atmosphere. This exposure to the atmosphere is important because it is one way oxygen is replenished in the lake. It appears that when the lakes do thermally stratify, they are only weakly stratified.

The water chemistry results summarized in Table B.5 indicate that there are generally low algae densities (based on chlorophyll a) with above average water clarity (compared to secchi disc readings for other lakes in the area). Phosphorus in the surface water is usually low although it is elevated in the bottom waters. These elevated phosphorus concentrations may represent phosphorus release from the bottom sediments. The total nitrogen to total phosphorus ratios (generally around 30 or greater) indicate that both lakes are phosphorus rather than nitrogen limited.

Another way to aid in interpreting what some of the water chemistry concentrations mean is to convert them into an index. The index is called the Trophic State Index (TSI) and is based on 3 parameters: the concentration of total phosphorus, the concentration of chlorophyll and the secchi disc transparency. The index ranges from 1 to 100, with 1 being the best and 100 being the worst. The concentrations of these parameters found in the Twin Lakes in the spring and summer of 1991, have been converted to TSI numbers and are shown in Table B.6.

The TSI values for spring are different between Lake Mary and Lake Elizabeth. Lake Elizabeth has higher values than Lake Mary, which would indicate that Lake Elizabeth is more fertile and there should be more algae growth. However, summertime average values for each lake are similar, indicating that each lake has similar water quality in summer. The reason Lake Elizabeth improved from spring (May) to summer is not exactly clear. It may be that calcite precipitation occurs and removes a portion of the phosphorus from the upper water. Calcium concentrations, measured in 1966, declined from spring (April) to summer (August), indicating that calcium probably precipitated and settled out of the upper water (epilimnion). However, this does not prove that phosphorus was removed with the calcite precipitation, it could have been removed in the spring clear water phase with diatom decline and sedimentation.

In the 1991 study, summertime phosphorus concentrations in the upper water are lower compared to the deeper water and are reflected in the Tropic State Index (Table B.6). Although there are lower phosphorus concentrations in the upper water, apparently phosphorus in the entire water column contributes to algae growth. The TSI numbers for summer water column phosphorus, secchi disc, and chlorophyll are in close agreement The summer epilimnion phosphorus concentration is not in agreement. Apparently, the Twin Lakes mix often enough that phosphorus from the entire water column is used by algae.

Table B.3 Temperature and Dissolved Oxygen Profiles for Lake Mary

Lake Mary

Depth (feet)	May 1991 Temp (c)	May 1991 DO mg/l	June 1991 Temp (c)	June 1991 DO mg/l	July 1991 Temp (c)	July 1991 DO mg/l	Aug. 1991 Temp (c)	Aug. 1991 DO mg/l
0	12	9.5	27.5	—	27.8	7.2	23.5	8.0
3	12	9.2	27.5	—	28.0	7.6	23.5	8.0
6	12	9.2	27.5	—	27.5	7.6	23.5	8.4
9	12	8.9	27.5	—	27.5	7.5	23.2	8.2
12	12	9.0	27.5	—	27.5	7.4	23.0	6.8
15	12	8.7	27.5	—	27.0	7.2	23.0	6.4
18	12	8.7	27.5	—	27.0	6.8	22.5	6.3
21	12	8.7	25.0	—	24.0	2.5	22.0	6.4
24	12	8.7	24.0	—	22.0	1.0	22.0	6.0
27	12	8.6	21.0	—	19.0	0.2	22.0	4.4
30	12	8.5	18.0	—	16.5	0.2	20.3	0.4

Table B.4 Temperature and Dissolved Oxygen Profiles for Lake Elizabeth

Lake Elizabeth (South)

	May 1991		June 1991		July 1991		Aug. 1991	
Depth (feet)	Temp (c)	DO mg/l	Temp (c)	DO mg/l	Temp (c)	DO mg/l	Temp (c)	DO mg/l
0	12	9.4	26.0	—	27.5	8.2	24.0	8.0
3	12	9.5	26.0	—	27.5	8.2	24.0	8.0
6	12	9.3	26.0	—	27.5	8.2	23.9	8.2
9	12	9.3	26.0	—	27.5	8.2	23.5	8.4
12	12	8.8	26.0	—	27.0	7.6	23.2	8.2
15	—	—	26.0	—	26.0	6.6	23.0	8.1
18	—	—	25.5	—	25.0	4.6	23.1	8.2
21	—	—	25.0	—	24.0	1.4	23.0	8.6
24	—	—	21.5	—	22.0	0.3	22.2	9.2
27	—	—	—	—	—	—	22.2	6.4

Lake Elizabeth (North)

	May 1991		June 1991		July 1991		Aug. 1991	
Depth (feet)	Temp (c)	DO mg/l	Temp (c)	DO mg/l	Temp (c)	DO mg/l	Temp (c)	DO mg/l
0	12	9.8	27.0	—	27.5	8.0	23.2	8.2
3	12	9.5	27.0	—	28.0	8.0	23.2	8.2
6	12	9.6	27.0	—	28.0	8.0	23.2	8.6
9	12	9.6	27.0	—	28.0	8.0	23.2	8.4
12	12	9.6	27.0	—	28.0	8.1	23.0	7.6
15	12	9.6	26.5	—	28.0	8.0	23.0	6.9
18	12	9.6	26.0	—	28.0	8.0	23.0	7.0
21	12	9.5	23.0	—	27.0	7.4	22.1	7.4
24	12	9.3	18.0	—	21.0	0.4	22.0	7.0
27	12	9.4	—	—	—	—	22.0	1.8
30	12	9.4	—	—	—	—	19.0	0.3

Table B.5 Summary of Water Chemisry Data for Twin Lakes for the Summer of 1991.

Results are from surface water collection, 1 foot below the surface, and for total phosphorus, bottom samples were also collected, with the depth (in feet) indicated in parentheses.

M = Lake Mary E-N = Lake Elizabeth (North) E-S = Lake Elizabeth (South)

Date	Total Phosphorus (mg/l)			Secchi Disc Depth (in feet)			Chlorophyll a (mg/l)			Total Kjeldahl Nitrogen (mg/l)			Ammonia Nitrogen (mg/l)			Nitrate Nitrogen (mg/l)			Conductivity (mmhos/cm)		
	M	E-N	E-S	M	E-N	E-S	M	E-N	E-S	M	E-N	E-S	M	E-N	E-S	M	E-N	E-S	M	E-N	E-S
May 2, 1991	13	21	22	9.5	5.0	5.0	3.0	9.0	7.0	600	600	700	37	19	22	<7	32	34	450	410	410
*bottom (depth)	*17 (29)	*29 (27)	*30 (15)																		
June 29, 1991	14	10	10	8.5	9.0	10.0	3.0	4.0	4.0	600	600	500	20	23	16	36	<7	10	510	490	490
*bottom (depth)	*28 (28)	*23 (23)	*20 (22)																		
July 20, 1991	15	12	81**	9.2	6.3	6.0	6.0	5.0	5.0	700	700	600	66	26	7	<7	<7	<7	570	495	500
*bottom (depth)	*31 (30)	*18 (23)	*23 (21)																		
August 20, 1991	4	12	14	7.0	5.6	5.7	6.0	9.0	7.0	700	600	600	12	<5	5	<7	<7	<7	510	490	495
*bottom (depth)	*17 (30)	*27 (28)	*14 (27)																		

** This value of 81 mg/l appears to be high and probably represents a field or lab error.

Table B.6 Spring (May 2, 1991) Concentrations and Summer Averages (June, July and August 1991) for Total Phosphorus, Secchi Disc and Chlorophyll.

	Lake Mary		Lake Elizabeth	
	Measurement	TSI	Measurement	TSI
TP - spring epilimnium	13 ppb	44	22 ppb	51
TP - spring water column*	15 ppb	46	26 ppb	54
Secchi - spring	9.5 ft.	45	5.0 ft.	54
Chlorophyll a - spring	3 ppb	44	8 ppb	50
TP - summer epilimnion	10 ppb	40	13 ppb	44
TP - summer water column*	18 ppb	48	17 ppb	48
Secchi - summer	8.2 ft.	48	7.1 ft.	49
Chlorophyll a	5 ppb	47	6 ppb	48

* Water column values are the average of top and bottom water concentrations.

B.2. Aquatic Plants

The objectives of the aquatic plant survey were to characterize the types of plants and where they were growing in Lake Mary and in Lake Elizabeth. Although the plants may seem to be thick in some areas, there are also vast areas where plants are not growing. In general, aquatic plants are good for a lake because they can maintain good water quality as a substratum for attached algae growth. Attached algae take nutrients out of the water. Also, aquatic plants stabilize the bottom sediments and can serve as structures for fish. Without plant growth in the Twin Lakes, both lakes would have more algae growing in the open water and they would be much more turbid.

B.2.a. Previous Aquatic Plant Surveys

Aquatic plant surveys were conducted in conjunction with fish surveys in 1951 and 1970. The plant species and their abundance are listed in Table B.7 and B.8 and their distribution is shown in Figure B.1. The survey in 1970 found 6 plant species that were found in the 1950 survey. Eurasian water milfoil is now abundant in Lake Elizabeth and present in Lake Mary, but was first collected in the lakes in 1976 (reported in WDNR 1980).

B.2.b. Methods Used in This Survey

Aquatic plant surveys were conducted on both Lake Mary and Lake Elizabeth on July 20 and 21, 1991. The approach was based on the Jesson and Lound (1962) method of using transects around the lake and sampling at depth intervals of 0-1.5 feet; 1.5-5.0 feet; 5.0-10.0 feet; and 10.0-20.0 feet.

At each station plants were quantified to density, based on sampling with a rakehead. The rating system was based on the following characterizations of plant growth: scarce, present, common or abundant. The ratings represent plant densities that range from plants that were scattered to plants that were dominant for a station.

A Lowrance X-16 recording sonar made traces of the canopy for transects. In addition, scuba diving was used on several transects and underwater conditions were recorded with a Hi-8 Sony video camcorder. Plant distribution was aided by aerial photographs taken in July and August, 1991.

B.2.c. Results and Discussion

Tabulation of plant distributions for Lake Mary and Lake Elizabeth show some similarities and differences (Table B.7 and B.8). Both lakes have Eurasian water milfoil (EWM) and Ruppia, but have different distribution patterns. In Lake Mary, EWM is only found in three small areas (less than 2 acres total area) in the vicinity of the stormwater sewer outfalls. In Lake Elizabeth, EWM nearly formed a collar or a ring around the entire lake. Although Ruppia was present, it was not as extensively colonized in Lake Elizabeth as it was in Lake Mary. Ruppia is fairly rare in Wisconsin in that it prefers brackish water. The high conductivity in the Twin Lakes probably accounts, in part, for Ruppia being present.

In Lake Mary there is a distinct zonation with Chara being dominant in water less than 5 feet, with Sago pondweed being dominant from 5 to 10 feet, and with Ruppia being dominant from 10 to 17 feet. In Lake Elizabeth the zonation is different. On the western side of the lake, Chara is present, but EWM is found where Sago pondweed is found in Lake Mary. EWM is about the only dominant plant on the eastern side of the lake, with other plant growth lacking. EWM can be a nuisance plant species and at the present time its distribution is limited in Lake Mary.

EWM is very adept at colonizing areas that are disturbed. It is recommended that plant disturbances in Lake Mary be kept to a minimum by either limiting or excluding mechanical harvesting or herbicide application in water deeper than 5 feet.

Since the last plant survey of 1967 and 1970, the major change has been the introduction of EWM. Spiny naiad was not reported in 1950, but has been in the lake since at least 1967 and is still there today.

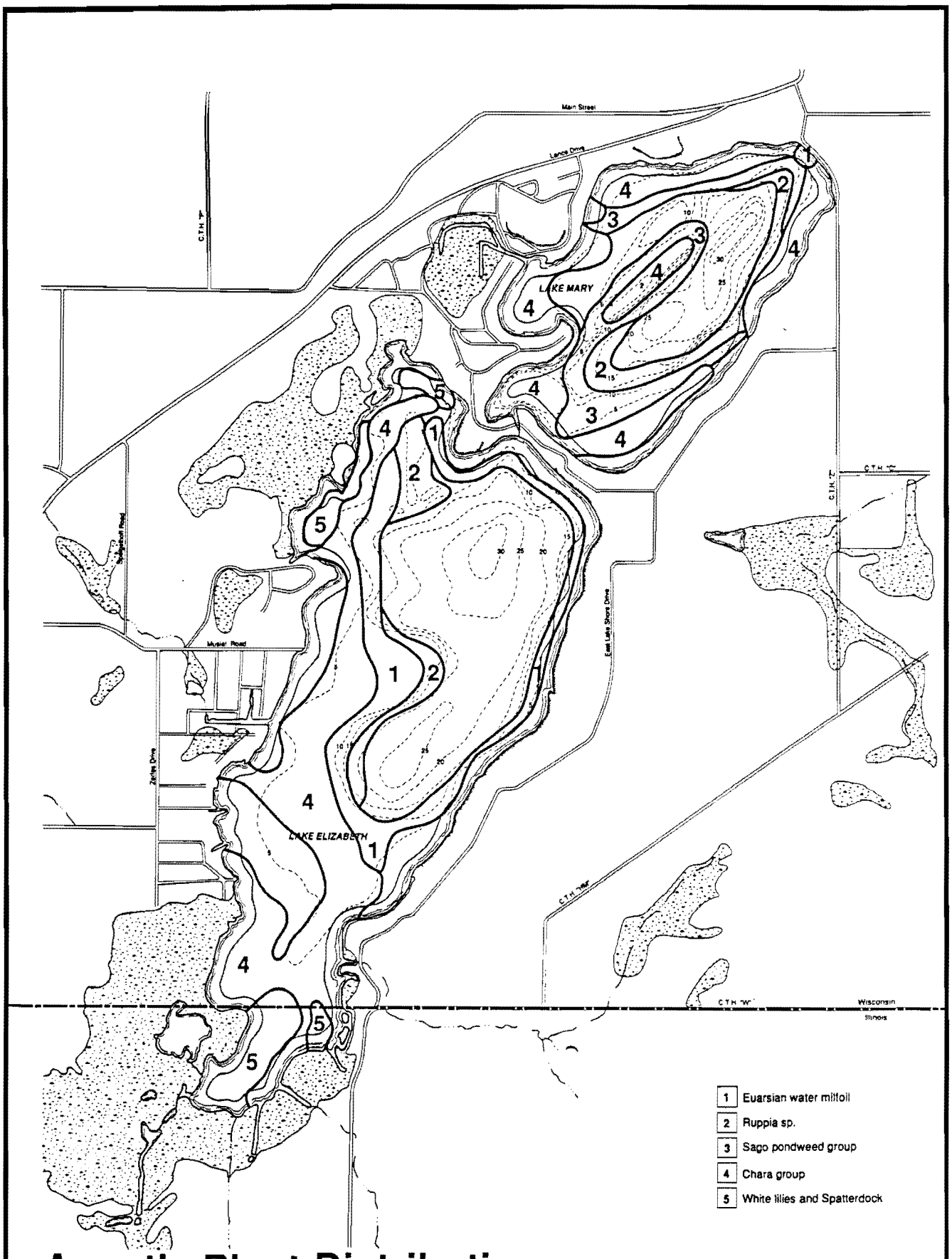
Depth of colonization has not changed much over the years. In 1967, plants were reported to depths of 14 feet in Lake Elizabeth and to 20 feet in Lake Mary. In 1991, plants were found to depths of 13 feet in Lake Elizabeth and to 17 feet in Lake Mary. These findings indicate that Lake Mary has better water clarity than Lake Elizabeth and that Lake Mary's water clarity may have decreased slightly since 1967.

Table B.7 Summary of Aquatic Plant Surveys - Lake Mary

Aquatic Vegetation		August 1, 1951	July 28, 1970	August 7, 1967	July 20, 1991
Common Name	Scientific Name	Abundance	Abundance	Abundance	Abundance
Sage pondweed	Potamogeton pectinatus	Very Abundant	Abundant	Abundant	Abundant
Water milfoil	Myriophyllum sp.	Very Abundant	Abundant	Present	Common
Eurasian water milfoil	Myriophyllum spicatum	—	—	—	Common
Stonewart	Chara	Abundant	Abundant	Abundant	Abundant
Whitestem pondweed	Potamogeton praelangus	Abundant	—	Present	—
Floating leaf pondweed	Potamogeton natans	—	Present	Present	—
Narrow leaf pondweed	Potamogetan sp.	Abundant	—	—	—
Flat stem pondweed	Potamogetan zosteriformis	Common	Present	Present	Common
Broadleaf pondweed	Potamogetan amplifolius	—	—	Present	Present
Pondweed	Potamogetan friesii	Common	—	—	—
Curly leaf pondweed	Potamogetan crispus	Scarce	Common	Present	Scarce
Water weed	Anacharis accidintalis	Common	Common	Present	—
Bushy pondweed	Najas flexilus	Common	—	Present	Common
Wild celery	Vallisneria americana	Common	Common	Present	Common
Soft stem bullrush	Scirpus validus	Scarce	Present	—	Present
Cattail	Typhia latifolia	—	Present	—	—
Spatterdock	Nuphar adverna	Scarce	—	—	—
White water lily	Nymphaea odorata	Scarce	Common	—	—
Bullrush	Scirpus americanus	—	—	—	—
Coontail	Ceratophyllum demersum	—	Common	Present	Common
Spiny naiad	Najas marina	—	Abundant	Abundant	Abundant
Richardson pondweed	Potamogetan richardsonii	—	Common	—	Present
Variable pondweed	Potamogetan gramineus	—	Present	Present	—
Water stargrass	Heteranthera dubia	—	Present	—	Present
Quillwart	Isoetes sp.	—	Present	—	—
Wedgeon grass	Ruppia sp.	—	—	Abundant	Abundant
Fern pondweed	Potamogetan rabbinsii	—	—	Abundant	—
Bladderwort	Utricularia sp.	—	—	Present	Present

Table B.8 Summary of Aquatic Plant Surveys - Lake Elizabeth

Aquatic Vegetation		August 1, 1951	July 26, 1967	July 20, 1991
Common Name	Scientific Name	Abundance	Abundance	Abundance
Sage pondweed	Potamogeton pectinatus	Very Abundant	—	Abundant
Water milfoil	Myriophyllum sp.	Common	—	Common
Eurasian water milfoil	Myriophyllum spicatum	—	—	Abundant
Stonewart	Chara	Very Abundant	Abundant	Abundant
Whitestem pondweed	Potamogeton praelangus	Abundant	—	—
Floating leaf pondweed	Potamogeton natans	Common	—	Present
Narrow leaf pondweed	Potamogetan (?)	—	—	—
Flat stem pondweed	Potamogetan zosteriformis	Common	—	Present
Broadleaf pondweed	Potamogetan amplifolius	Abundant	—	Present
Pondweed	Potamogetan friesii	Common	—	—
Curly leaf pondweed	Potamogetan crispus	—	—	Scarce
Water weed	Anacharis accidintalis	Common	—	—
Bushy pondweed	Najas flexilus	Common	—	Common
Wild celery	Vallisneria americana	Scarce	Abundant	Common
Soft stem bullrush	Scirpus validus	Abundant	—	Abundant
Cattail	Typhia latifolia	Abundant	Abundant	Abundant
Spatterdock	Nuphar advena	Common	Abundant	Abundant
White water lily	Nymphaea odorata	Common	—	Common
Bullrush	Scirpus americanus	Scarce	Abundant	Abundant
Coontail	Ceratophyllum demersum	—	—	Common
Spiny naiad	Najas marina	—	Abundant	Abundant
Richardson pondweed	Potamogetan richardsonii	—	—	Present
Variable pondweed	Potamogetan gramineus	—	—	—
Water stargrass	Heteranthera dubia	—	—	Present
Quillwart	Isoetes sp.	—	—	—
Wedgeon grass	Ruppia sp.	—	—	Common
Fern pondweed	Potamogetan rabbinsii	—	—	—
Bladderwort	Utricularia sp.	—	—	Present



Aquatic Plant Distribution

LAKE MANAGEMENT PLAN
TWIN LAKES, WISCONSIN

0 300 600 1200 1800 FEET

NORTH

camiros ltd.
Planning, Zoning,
Development Economics,
and Landscape Architecture

B.3. Fish Community

One of the recreational attractions of the Twin Lakes is fishing. An important question concerning this issue is whether the fishing community is good, bad or needs improvement. A fish survey was not included as part of this study. The discussion of the fish community in the Twin Lakes is based on existing information collected by the WDNR.

B.3.a. Previous Studies

The first fish survey for the Twin Lakes was conducted in 1951 and is summarized in Table B.9. Before 1951, walleyes had not been introduced by the WDNR. By the time of the next survey in 1970, walleyes had been stocked for several years. The last WDNR fish survey was conducted on Lake Mary in 1970.

A condensed version of a February 7, 1972 report by Fish Manager Ronald Peining concerning a fish survey conducted in 1970 on Lake Mary is summarized below:

> The fish surveys were begun just after ice out in an effort to sample spawning walleyes and northern pike. One netting and one electrofishing survey were made in early spring and one electrofishing survey was made in early summer to get data on panfish and largemouth bass. Water chemistry and aquatic need surveys were made during the summer months.
>
> Walleyes: This species has been stocked annually, as large fingerlings, since 1964 and biennially since 1968. No walleyes were reported in a survey conducted in 1951. No stocking evidence can be found prior to 1951 or between 1958 and 1963. Generally, the representatives of each year class show good growth rates and appear to have adapted well to the ecosystem for an introduced species. However, no reproduction can be found and apparently, from the percentage of fish captured that are marked, the walleye fishery will eventually collapse if stocking is discontinued.
>
> Fishing success for this species over the years has been sporadic. At times success is very good but is usually short-lived. Generally, the local sportsmen are pleased with the fishery even though large numbers are not caught consistently.
>
> Largemouth Bass: This species has not been stocked for many years and a 1951 survey (before walleyes were established) indicated a very prolific bass fishery. Although not conclusive, because of lack of evidence, the establishment of the walleyes could be the reason for the reduction in the bass population. This is logical since the walleyes are a successful newcomer to an established fishery whose main predictor was bass, which made up the majority of the pound per acre of production of gamefish. Local sportsmen agree that bass fishing success has gone down in recent years. These conclusions are born out in the numbers of bass collected by survey.
>
> Northern Pike: Surveys in 1951 and 1970 indicate that northern pike never were an abundant species. The principal reason probably being that spawning facilities are extremely minimal.
>
> Bluegills and Pumpkinseed Sunfish: By far these are the most abundant fish present. Growth data show a lower than average growth rate and much lower maximum total length for specimens of the same age as computed by Mackenthun's report of 1946.

Other Panfish: These consist of bullheads, crappies and perch. Perch are the most numerous but are of generally small size. The other species, because of their apparent lack of abundance, do not contribute much to the sport fishery.

Rough Fish: There appears to be almost a complete absence of carp and suckers indicating no rough fish problems.

Forage Species: Chubsuckers, golden shiners, blackchin shiners and brook silversides make up the bulk of the forage fish population with golden shiners and brook silverside being the most abundant.

Fisheries Management Recommendation: In general, the lake's fishery appears to be healthy except for the slow-growing panfish. Temperature and oxygen profiles are good and ecologically there appears to be a healthy aquatic environment with good water quality and diverse aquatic plant growth, but not to the extent of having a weed problem. The fishery is historically one of bass, northern pike and panfish, but the successful introduction of walleyes has put the bass fishery in possible jeopardy. The apparent lack of naturally reproducing walleye fishery means that to keep the walleye fishery going, the present program of stocking walleyes every other year should be abandoned and annual stocking shall commence. However, if stocking is curtailed for about four years, the walleye population will probably collapse. The void will probably be filled by either the bass population or the large slow growing bluegill and pumpkinseed populations or a combination of both. The local sportsmen appear to be satisfied with the present situation and will probably continue to be as long as walleyes are stocked. Artificial fisheries such as the one of walleyes probably should never have been started as long as there was a possibility of not being able to maintain it. Such introductions necessarily require a great deal of confidence in the longevity of the management policies existing when making the first introduction of a foreign species into a more or less stable predator-prey balanced fishery.

Table B.9 Fish Summary

Source: WDNR, 1951

Common Name	Scientific Name	Estimate of Total Capture	
		Lake Mary	Lake Elizabeth
Largemouth bass	Micropterus salmaides	150	104
Northern pike	Esox lucius	5	18
Smallmouth bass	Micropterus dolomieu	1	6
Bluegill	Lepomis macrochirus	4,200	3,400
Pumpkinseed	Lepomis gibbosus	150	—
Yellow perch	Perca flavescens	100	15
Black crappie	Pomoxis negramaculatus	3	1,100
Walleye	Stizostedion vitreum	0	13
Pumpkinseed	Lepomis cyanellus	—	25
Warmouth bass	Chaenobryttus coronarius	2	6
Rock bass	Ambloplites rupestris	4	10
Brown bullhead	Ameiurus nebulosus	4	1
Carp	Cyprinus carpio	4	5

B.3.b. Current Conditions

Because no fish surveys have been conducted since 1970, current fishery conditions are based on anecdotal evidence. Stocking of the lakes continues by the Sportsmen Club, with yearling walleyes (4 to 8 inches) being stocked. Fishing success depends partly on whom you speak to. One comment was that a fisherman noticed one of his favorite weed beds was removed by herbicides several years ago, and that bed has not produced since.

Most fishing pressure is for largemouth bass, walleye and panfish. Aquatic plant growth and substrate condition should be conducive to largemouth bass and panfish fisheries and walleye communities will probably never prosper in either Lake Mary or Lake Elizabeth.

A spring fish survey is recommended.

B.4 Impacts of Boats on Water Quality

A concern of District residents has been the impacts of boats on water quality and is a concern voiced by lake users on many lakes in Wisconsin that have significant boat traffic. Scientific investigations on this topic have been sparse. Some studies indicate that boats can stir up sediments and elevate nutrient concentrations in the water column, but these authors caution that lake characteristics vary, and each lake should be studied to determine the boating impact.

A special study was conducted on the Twin Lakes to address the topic of boating impacts on water quality. The results indicate, based on secchi disc readings, nutrient and suspended sediment concentrations and other observations, that boats on Lake Elizabeth and Lake Mary stir up large sized particles in water less than 7 feet deep and the particles settle out in a day or two, based on observations by lake users.

The deep water, greater than 18 feet, does not appear to be adversely impacted in terms of sediment and nutrient suspension (Table B.10 and B.11). The lake depths from 7 to 17 feet do not appear to be adversely impacted primarily because plants are growing at these depths and tend to stabilize sediments and nutrients. The plants dampen the internal waves produced by boat motors.

The situation would be far worse if there were no plants and the sediments were fine grained and organic at these depths. In the Twin Lakes, the bottom sediments are dominated by marl and they are not generally significant nutrient sources, so if they get stirred up they do not automatically bring elevated nutrients into the water column. In lakes where boats have been a problem, the bottom sediments were fine grained, highly organic, nutrient enriched, and aquatic plant growth was limited.

However, in the Twin Lakes there is a potential adverse impact of boat traffic that is unrelated to nutrients, and that is the resuspension of particles in shallow areas. Sediment resuspension in shallow water, less than 3 feet, can have adverse impacts on fish spawning grounds and fish nursery habitat by increasing turbidity, causing redepostion of materials, and destroying emergent and submergent vegetation. Because of these factors, a case can be made restricting boat traffic or making no wake zones in these areas.

Table B.10 Motorboat Impact Study - Lake Mary

Results of the special study on impacts of motorboats on lake water quality conducted on Friday, June 28 and Sunday, June 30, 1991. There was an average of 40-50 boats on each lake on Saturday and Sunday, which is considered to be normal.

Lake Mary - Epilimnion (Top)

	June 28 (Before) (replicate samples)		June 30 (After) (replicate samples)	
Secchi (ft.)	7.5	7.5	8.8	8.8
Total Phosphorus (ppb)	12	12	11	12
Diss P (ppb)	3	3	3	3
Total SS (ppm)	7	6	4	4

Lake Mary - Hypolimnion (Bottom)

	June 28 (Before) (replicate samples)		June 30 (After) (replicate samples)	
Total Phosphorus (ppb)	14	13	27	30
Diss P (ppb)	3	3	4	3
Total SS (ppm)	6	8	6	6
Sample Depth (ft.)	9	9	18	18

Table B.11 Motorboat Impact Study - Lake Elizabeth

Results of the special study on impacts of motorboats on lake water quality conducted on Friday, June 28 and Sunday, June 30, 1991. There was an average of 40-50 boats on each lake on Saturday and Sunday, which is considered to be normal.

Lake Elizabeth - Epilimnion (Top)

	June 28 (Before) (replicate samples)		June 30 (After) (replicate samples)	
Secchi (ft.)	8	8	9	9
Total Phosphorus (ppb)	12	12	10	10
Diss P (ppb)	3	3	3	3
Total SS (ppm)	4	4	4	4

Lake Elizabeth - Hypolimnion (Bottom)

	June 28 (Before) (replicate samples)		June 30 (After) (replicate samples)	
Total Phosphorus (ppb)	11	11	12	12
Diss P (ppb)	3	3	6	3
Total SS (ppm)	5	4	62	3
Sample Depth (ft.)	18	18	22	22

B.5. Summary of Findings

Based on the summertime water quality results, the water quality for the Twin Lakes appears to be very good. This conclusion is based on comparing the Twin Lakes water quality to other lakes in the ecoregion.

If the Twin Lakes were to get a report card based on ecoregion ranges and the Trophic Status Index, Lake Mary would get an "A" (the best) for all three categories (phosphorus, chlorophyll and secchi disc), and Lake Elizabeth would get an "A" for total phosphorus and chlorophyll and a "B" for secchi disc transparency. Basically, the Twin Lakes appear to be at the top of their class for this ecoregion. These grades can vary from year to year, but the trend for the Twin Lakes has been that they are consistently good.

Based on summertime phosphorus concentrations, it would be hard to improve (reduce) phosphorus concentrations in the Twin Lakes because they are already at the lowest concentrations in this ecoregion. Therefore, the target nutrient concentrations for the Twin Lakes should be to maintain summer levels of between 15 to 19 mg/l.

The results from the 1991 lake monitoring had several findings, which are listed below:

Comparing Lake Mary and Lake Elizabeth under Present Conditions

Lake Mary has slightly better water quality than Lake Elizabeth based on secchi disc transparency and spring phosphorus concentrations.

The main source of phosphorus for both lakes is from the watershed. Phosphorus is being released from the bottom sediments, but is less important than what comes in from the watershed.

Both lakes have Eurasian water milfoil, a plant that can grow out of control in some settings. Lake Elizabeth has a more widespread infestation compared to Lake Mary.

Lake Elizabeth is more turbid than Lake Mary, but the cause of the turbidity does not appear to be due to algae rather, lime (calcium carbonate) may be precipitating in the water column and contributing to turbid conditions.

Lake Elizabeth has a larger watershed than Lake Mary, and the higher nutrient readings in Lake Elizabeth compared to Lake Mary can largely be attributed to the greater watershed area.

Both lakes are susceptible to change in water quality based on activities in the watershed.

Comparing Lake Mary and Lake Elizabeth to Past Conditions

For Lake Mary, water clarity and total phosphorus concentrations are roughly the same comparing 1951, 1966 and 1991.

For Lake Elizabeth, there appears to be some degradation. Lake Elizabeth has slightly lower transparency in 1991 compared to 1968, but similar transparency compared to 1951.

For both lakes, Eurasian water milfoil has invaded some time since 1968. No mention was found in reports prior to 1968. It is currently in both lakes. Eurasian water milfoil is more widely colonized in Lake Elizabeth than in Lake Mary. It is hard to say what is inhibiting Eurasian water milfoil in Lake Mary.

Clear Water vs. Turbid Water -- Which way will the Twin Lakes Go?

Both Lake Mary and Lake Elizabeth currently are in a state of clear water/aquatic plant dominance compared to a less desirable state of a turbid water/algae dominated condition. The Twin Lakes are fertile enough to support a well developed aquatic plant community, however; at this time, they are not overly fertile to the degree that nuisance algae blooms have developed.

Maintaining the clear water/aquatic plant conditions should be a priority. A diverse aquatic plant community has many advantages over a community dominated by blue-green algae blooms in summer. The clear water (summer water transparency of 8 feet) condition has been relatively unchanged for the last 40 years, although Lake Elizabeth is showing some signs of increasing algae growth (based on chlorophyll concentrations of secchi disc transparency).

Once a glacial seepage lake (Lake Mary and Lake Elizabeth are both seepage lakes) approaches or exceeds a summertime phosphorus concentration of about 30 parts per billion (mg/l), a chain reaction is set off that can result in a lake becoming dominated by algae blooms, while the aquatic plant community declines. The chain reaction works something like what is shown in Figure B.2 on the following page.

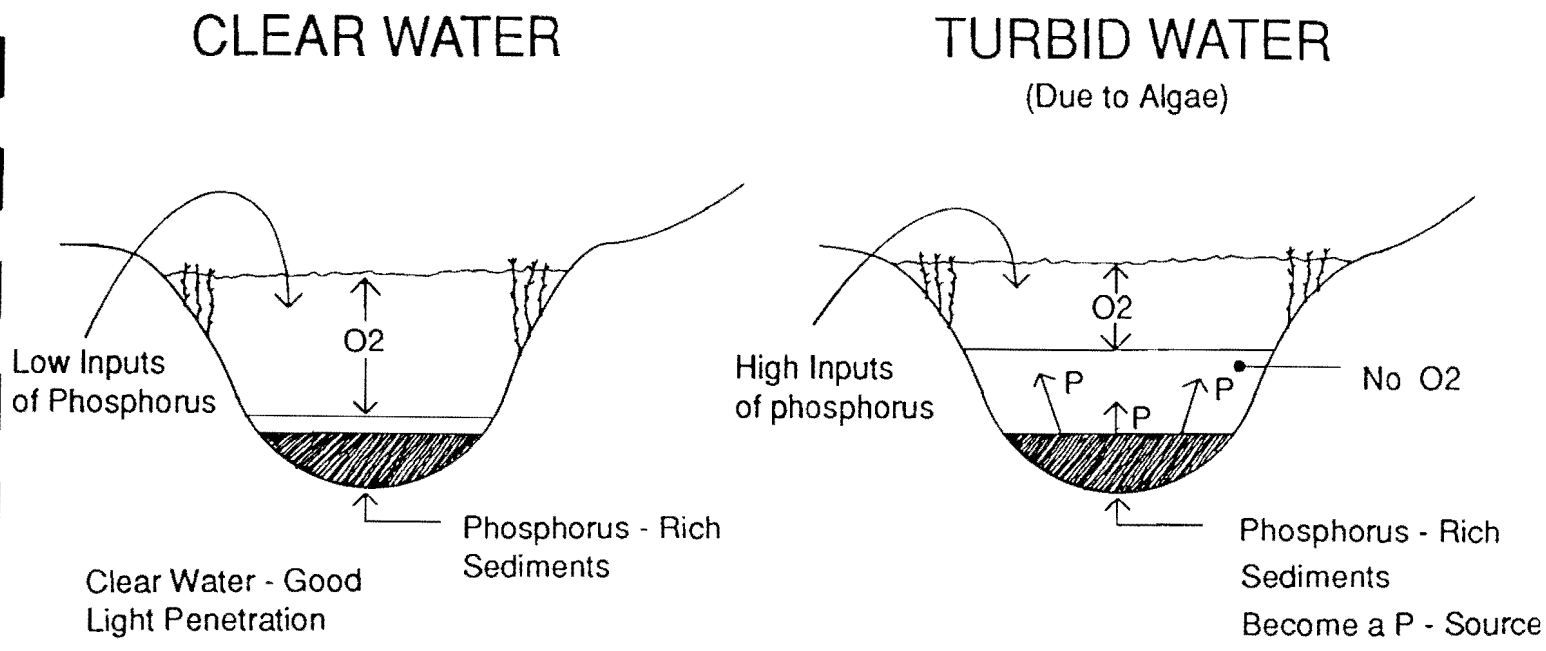


Figure B.2 Transition of a Lake from Clear Water/Plants to Turbid Water/Algae

Clear Water/Plant Phase: Lakes start out with clear water and macrophytes. Watershed nutrient inputs are low. Oxygen is found even in deep water. Sediments accumulate phosphorus, but release very little. Clear water allows gamefish to control undesirable bottom feeding fish such as carp.

Turbid Water/Algae Phase: Changes in the watershed produce a greater nutrient input. Spring algae blooms increase and when they die off and settle to the lake bottom, they exert an oxygen demand that uses up oxygen. Phosphorus that has accumulated in the bottom sediments, but rarely released, now is released in greater magnitude. This phosphorus is used by summertime algae, reducing water clarity. Mixing depths shorten, and rooted plants can no longer grow in deep water (10 to 20 feet) because of reduced light penetration. Fewer plants also mean reduced surface area for attached algae growth so more algae is now free-living than attached. Bottom feeding fish increase in number because gamefish can't see them as well. Bottom feeding fish contribute phosphorus from the lake sediments. The algae blooms that die out at the end of the summer represent a phosphorus load that will be available for algae growth in the spring.

APPENDIX C

WATERSHED ANALYSIS

WATERSHED ANALYSIS

TABLE OF CONTENTS

1. Introduction

The quality of lake water is often a reflection of its watershed. The watershed is the area that captures rain and snow with the runoff flowing by gravity into a stream or storm sewer that flows into the lake. Some runoff flows directly into a lake. When all the water inputs and outputs have been determined, this is referred to as a water budget. In the course of runoff making its way toward the lake, it contacts soils and other surfaces. Sometimes nutrients are removed from runoff and other times nutrients and sediments are picked up and carried along in the runoff. The amount of nutrients that make their way into a lake is referred to as nutrient loading. In a nutrient loading exercise, all of the sources of nutrients are to be determined as well as nutrient losses, so a nutrient budget can be calculated.

After a water budget and nutrient budget have been calculated, then predicting lake phosphorus concentrations is called lake modeling.

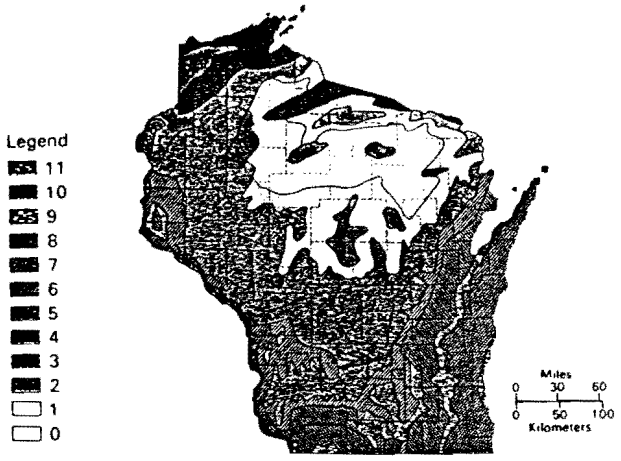
2. Soils in the Watershed

The geology and landforms found in the Twin Lakes' watershed are represented in Figure C.1. The surface geology and geomorphology influence, in part, the type of soils that are formed. Knowing something about the soils in a watershed is important because soils have a direct influence on the amount of nutrients that flow into the lake, which will, in turn, impact lake water quality.

The soils in the Twin Lakes' watershed are well-drained silty clay loams that lie on top of glacial sand, gravel and till. The unconsolidated deposits rest on Silurian dolomite. Dolomite is a type of bedrock (solid rock) that is primarily limestone ($CaCO_3$) with some magnesium ($MgCO_3$). A general soils map for the watershed is shown on Figure C.2.

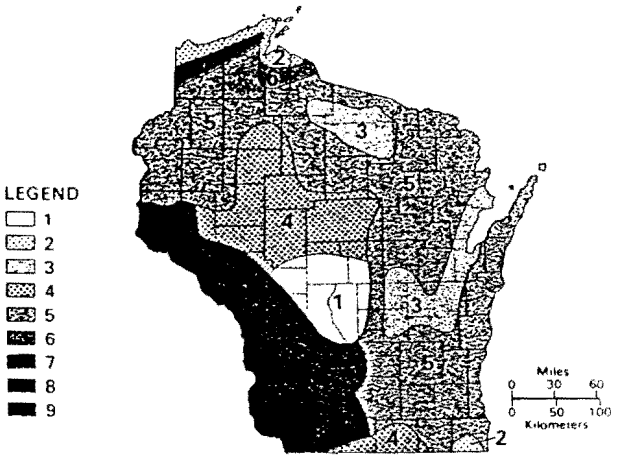
The soils that have developed in the watershed are fairly fertile, based on pounds of available phosphorus per acre (for fertilized fields). Of 26 soil associations delineated on a soils map of Wisconsin (photo mosaic map of Wisconsin), Twin Lakes soils rank 11th out of 26, with 70 pounds of available phosphorus per acre. The highest ranking soil association had 138 pounds of available phosphorus per acre and the lowest had 19 pounds per acre.

Figure C.1 Geology and landforms found in Wisconsin. Twin Lakes' watershed is in Kenosha County and is located in the southeastern part of the state, on the Illinois border (from: Photo Mosaic Soil Map of Wisconsin, F.D. Hole 1967, U.W. Extension A2822).



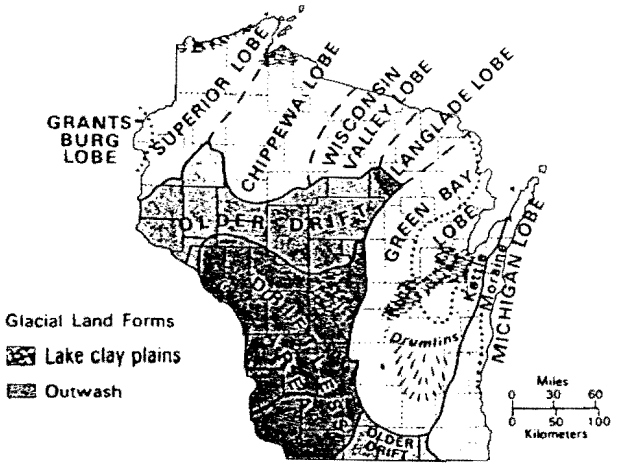
Map 1. BEDROCK GEOLOGY

The oldest rocks, called Precambrian, include igneous rocks, such as granite, and associated metamorphic rocks (0 where data are sparse, 1 elsewhere), trap rock (2), quartzite (3), and sandstone (4). Over that lies Cambrian sandstone (5), Prairie du Chien Dolomite (6), Ancell sandstone (7), Sinnipee Dolomite (8), Maquoketa Shale (9), Silurian dolomite (10), and Devonian shale (11).



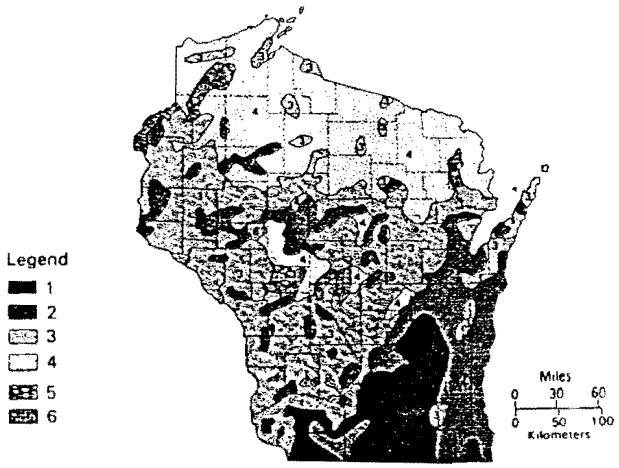
Map 3. LAND-SURFACE FORMS (after the National Atlas)

The flattest area is in Central Wisconsin (1). Undulating plains, with little wetland (2) and with considerable wetland (3) are mostly in the north. Irregular plains, with little wetland (4) and with considerable wetland (5) occupy much of the state. Plains with high hills (6) are in Iron and Ashland Counties. A tableland with escarpment to Lake Superior (7) is in the northwest. Open hills, with broad ridges (8), and narrow ridges with deeply incised valleys (coulees) (9) are in the southwest.



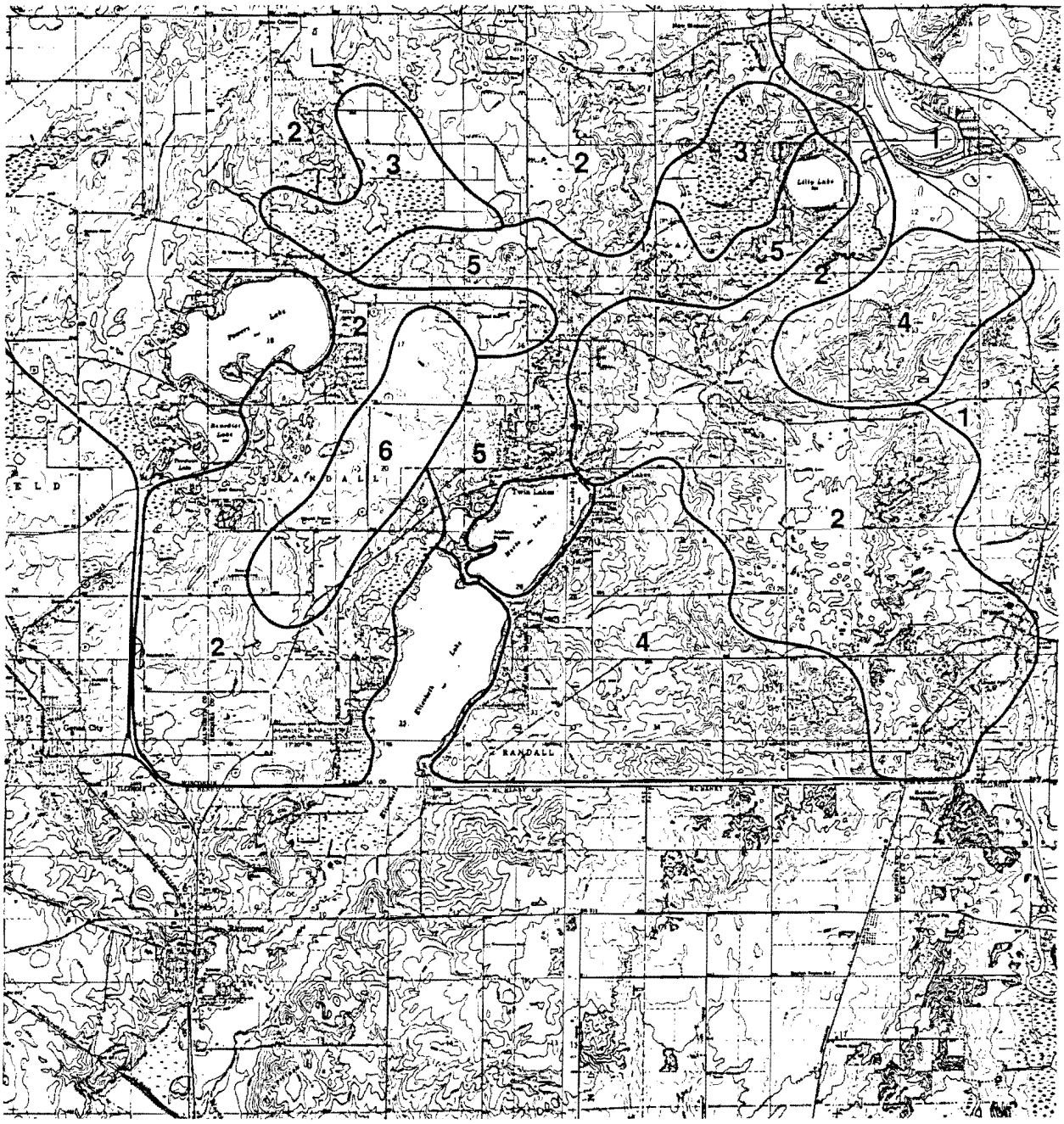
Map 6. GLACIAL GEOLOGY

The last major advance of the ice sheet over Wisconsin was about 16,000 years ago. It covered all but the "driftless" and "older drift" areas. A later ice advanced about 11,000 years ago (dotted boundaries), burying a forest in Manitowoc County. Many land forms were created by the glacial ice and meltwaters: Moraines (solid lines), elongated hills called drumlins, outwash, and lake clay plains. Many peat bogs and lakes occupy glacial pits called kettles.



Map 11. AGRICULTURAL AND FORESTRY LAND USE

The map shows land use in terms of proportions of land devoted to agriculture and forestry. Highly productive farm land (1), with less than 15 percent of woodland, is in southern counties. Productive farm land (2), with the same extent of woodland, is prominent in the east, but is also widely scattered. Agricultural land with 15 to 50 percent in woodland (3), occupies about half of the area of the state. Forest lands, not sandy (4), are prominent in the north. Jack pine (5), and scrub oak (6) sandy lands are concentrated in the central plain and northern counties.



1 **Hebron - Montgomery - Artaker association**: Well-drained to poorly drained soils that have a loam to silty clay subsoil; underlain by clayey to loamy lacustrine and outwash material on hills, knobs and lake plains.

2 **Fox - Casco association**: Well-drained soils that have a clay loam and silty clay loam subsoil; moderately deep to shallow over sand and gravel, on stream terraces.

3 **Houghton - Palms association**: Very poorly drained organic soils, in basins and depressions.

4 **Miami association**: Well-drained soils that have a silty clay loam and clay loam subsoil; formed in thin loess and the underlying loamy glacial till on ridges and knobs.

5 **Casco - Rodman association**: Well drained and excessively drained soils that have a clay loam or gravelly loam subsoil; shallow over sand and gravel, on stream terraces and moraine ridges.

6 **Warsaw - Plano association**: Well-drained soils that have a loam to silty clay loam subsoil; moderately deep to deep over sand and gravel, on stream terraces.

Soil Association Distribution

LAKE MANAGEMENT PLAN
TWIN LAKES, WISCONSIN

NORTH

0 1000 2000 4000 6000
Feet

camiros ltd.
Planning, Zoning
Development Economics,
and Landscape Architecture

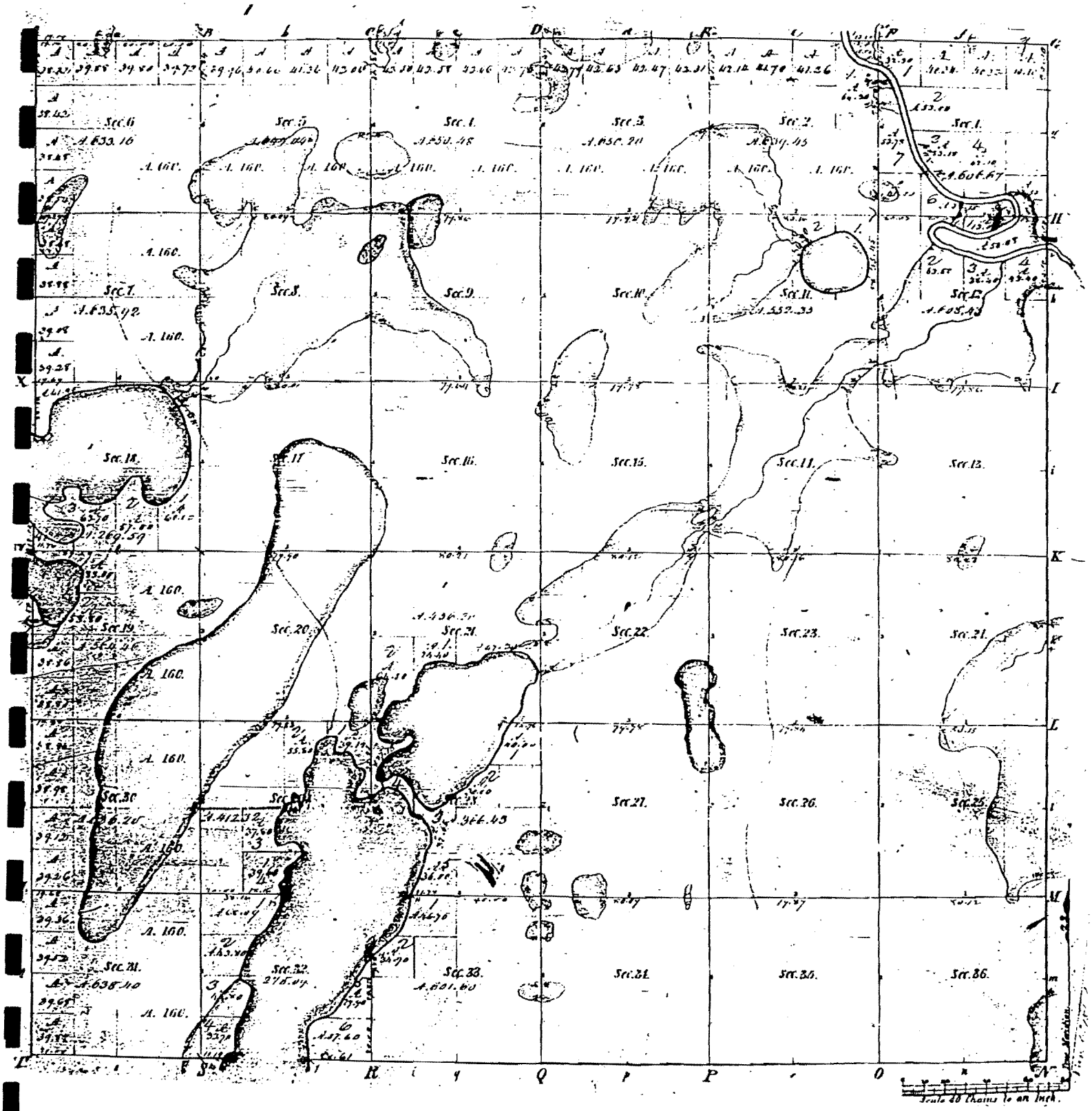
3. Land Use in 1836

The fertility of the soils (as well as climatic conditions and other factors) influence the type of vegetation found in the Twin Lakes watershed. Before nonnative settlement, the vegetation in the Twin Lakes watershed consisted of oak openings, oak forest, wetlands, and prairie. The land use for the 1836 time period was deciphered by SEWRPC based on field notes by the land surveyor who was working in this township in April 1836. A map of the township from 1836 is shown in Figure C.3. A portion of the extensive wetlands found on the northwest side of Lake Elizabeth shows up on the map, but some wetland areas do not. The prairie between Lake Elizabeth and Powers Lake is delineated, and today the prairie area is good farmland. The soils associated with the prairie are unique to the watershed and are delineated as the Warsaw-Plano Association in Figure C.2.

With increasing settlement, the land in the Twin Lakes watershed was converted from woodlands and oak openings to farmland and urban land use. Associated with these changes was an increase in phosphorus inputs to the Twin Lakes. Phosphorus inputs have increased since presettlement days. The increase is due primarily to an increase in the amount of exposed soil, an increase in the amount of fertilizer applied to the land, and to an increase in runoff.

The general outline of Lake Mary and Lake Elizabeth is similar to the configuration found today, indicating that there has not been a significant change in lake water levels since the 1830's. Some settlement may have already occurred around the lakes by the time of this 1836 survey. Small parcels around some shoreline areas of the lakes are delineated on the survey map, indicating claims may have been made and settlement initiated (McHenry County was settled in 1834).

Figure C.3 Township from 1836 that includes the Twin Lakes area. Several wetland areas show up and a large prairie area is delineated to the northwest of Twin Lakes. Primary vegetation in the area was oak forest and oak openings. Large oaks found today are remnants of the old oak forest and oak openings.



4. Watershed Runoff and Water Budget

Calculating a water budget is important for several reasons. By knowing how much water is coming into Twin Lakes, a flushing rate can be calculated which will indicate how fast the volume of water will be replaced in Twin Lakes. Lakes with slow flushing rates (which is the same as long retention times) take longer to respond to water quality improvements in the watershed compared to lakes with fast flushing rates (short retention times). Water retention time is also a factor in lake nutrient modeling, where models predict that the longer the retention time, the greater the phosphorus concentration.

To determine a water budget for a lake the sources of inputs and outputs are needed. For the Twin Lakes, water inputs come from watershed runoff, precipitation (rain and snow falling directly on the lake) and ground water. Water losses from the lake come from surface outflows, groundwater outflows and evaporation. Lake levels also need to be monitored to finish the equation. The water budget for Twin Lakes is estimated because the inputs and outputs were not field measured for this study.

In 1977, a draught year, a runoff study was conducted on a subwatershed of Lake Mary. Runoff from the subwatershed was low, about 1.9 inches per year, and although this may not be representative of the entire watershed, it is the best information available.

For water budget calculations past studies on Lake Mary were considered as well as runoff characteristics from Wind Lake and Powers Lake; lakes that are in the ecoregion, and that were monitored in the late 1980's. In water year 1988, Wind Lake had an average runoff of 3.0 inches and in water year 1989 an average runoff of 3.1 inches (based on acre-feet of inflow divided by direct drainage area (1989 Wind Lake Management Plan, SEWRPC). Powers Lake had an average runoff of 3.9 inches in 1987 and 3.2 inches calculated for a normal year (Powers Lake Management Plan, 1991, SEWRPC). Although these were draught years, they represent data recently collected in watersheds with the same general geological characteristics. Runoff fro Twin Lakes could be higher in a year with more precipitation. For Twin Lakes, a runoff factor of 3.0 inches for Lake Mary and 2.0 inches for Lake Elizabeth were used. For rainfall on the lake surface the long-term average from Lake Geneva of 35.7 inches per year was used.

Groundwater is the last component of the water inputs and an extensive groundwater monitoring effort was conducted in the Twin Lakes watershed in 1977. These data are used for groundwater inflows, even though this was a draught year. Additional study would help to quantify groundwater inputs for normal years.

The outputs of water (or losses) come from evaporation and surface and groundwater outflows. For evaporation from the lake surface the long average from Lake Geneva of 31.8 inches was used. Because outflows were not monitored, it was assumed that the inflows equal the outflows, and the surface and groundwater outflow were estimated by subtraction. The estimated water inputs and outputs are shown in Tables C.1 and C.2.

Based on net water outflows, a water retention time for Lake Mary (887 ac-ft) was estimated to be 2.2 years and the retention time for Lake Elizabeth (2191 ac-ft) was 3.2 years.

Table C.1 Annual Water Budget for Lake Mary

Source	Water Imputs Amount (acre-feet)	Assumption or Basis for Estimate
Precipitation	+937	35.7 in/yr. average for Lake Geneva
Groundwater Inflows	+506	0.7 cfs Flow (equal to 1.16 in/yr.)
Surface Water Inflows	+279	3 in/yr. of Runoff
Total	+1,822	

Source	Water Outputs Amount (acre-feet)	Assumption or Basis for Estimate
Evaporation	-835	31.8 in/yr. average for Lake Geneva
Groundwater Outflow	-710	80% of water input after evaporation is removed
Surface Water Outflow	-177	20% of water input after evaporation is removed. Rarely does water flow through the channel from Lake Mary to Lake Elizabeth.
Total	-1,722	

* Sources for assumption include Powers Lake Management Report, SEWRPC 1991; and Twin Lakes Management Report, WDNR 1980.

Table C.2 Annual water budget for Lake Elizabeth

Source	Water Imputs Amount (acre-feet)	Assumption or Basis for Estimate
Precipitation	+2,029	35.7 in/yr. average for Lake Geneva
Groundwater Inflows	+1,094	2.5 in/yr. = 1.51 cfs, assume more groundwater inflow than Lake Mary because of a larger watershed.
Surface Water Inflows	+875	2.0 in/yr. of Runoff. Areas of watershed do not appear to contribute much surface runoff, hence a lower value than Lake Mary.
Total	+3,998	

Source	Water Outputs Amount (acre-feet)	Assumption or Basis for Estimate
Evaporation	-1,807	31.8 in/yr. average for Lake Geneva
Groundwater Outflow	-1,315	60% of water input after evaporation is removed
Surface Water Outflow	-876	40% of water input after evaporation is removed.
Total	-3,998	

* Sources for assumption include Powers Lake Management Report, SEWRPC 1991; and Twin Lakes Management Report, WDNR 1980.

5. Nutrient Budget

A nutrient budget can be calculated by adding up the pounds of phosphorus that come into the lake. To do this, knowledge of the land use and amount of phosphorus associated with each land use is needed. In addition, one has to account for nutrient inputs from rainfall, groundwater and lake sediments.

To calculate phosphorus inputs from various land use activities, concentration of nutrients in runoff and the volume of the runoff need to be measured. When the concentration and volume have been determined (either from actual measurements in the field or from studies in similar settings where data are assumed to be comparable), then the nutrient concentration is multiplied by the volume of runoff to get the pounds of phosphorus per year that comes from a certain land use. This will give us a quantity of the nutrient expressed as either pounds per acre per year or kilograms per hectare per year.

Here is an example of how it works. Assume that a corn field has four inches of runoff that runs off in one year and that the average phosphorus concentration is 100 parts per billion (mg/m3). If we look at just one hectare of the field, then the volume of water running off is 10.16 cm (4 inches x 2.54 cm/inch = 10.16 cm of runoff) multiplied by 1 hectare (10,000 square meters) = 1,016 cubic meters. Now multiply 1,016 cubic meters by the concentration in the runoff which is 100 mg/m3 to get (100 x 1,016) 101,600 mg (which equals 101.6 grams or 0.101 kilograms). Therefore, the phosphorus export coefficient for this land use is 0.101 kg of P/ha/yr. This loading factor is dependent on the amount of runoff and the nutrient concentration.

To show how the relationships between runoff (in inches) and nutrient concentrations relate to phosphorus loading, a graph has been prepared (Figure C.4). Basically, as runoff from an area increases, as it does in developing areas, the pounds of phosphorus exported also increase.

One condition that is different between present day settings and presettlement settings of the 1830's in Twin Lakes is the amount of runoff that reaches Lake Mary and Lake Elizabeth. Runoff in the 1830's was probably around 1 inch per hectare and today it is probably 2 to 3 inches per hectare. This is one factor that has contributed to an increase in nutrient loading in Lake Mary and Lake Elizabeth in the last 150 years. However, 2 to 3 inches of runoff per year is not high. Runoff in many lake watersheds ranges from 6 inches to 10 inches per year.

Phosphorus input associated with different land uses developed by SEWRPC for watersheds (Powers Lake and Wind Lake) in this ecoregion have been utilized in this study. Runoff nutrient concentrations were not measured in this study. Construction sites have high phosphorus export values because of the high erosion rates associated with the open land. Commercial property has high export values because there is much impervious surface (asphalt, concrete, roof tops) and there is not much infiltration of rainwater. Woodlands and wetlands have low loading factors because stormwater that enters and subsequently leaves a woodland or a wetland does not pick up many nutrients, and in some cases nutrients are removed.

Nutrient loading estimates from land use have been estimated previously (1975 by SEWRPC and 1980 by WDNR) with different results. For this study the latest land use estimates were used (1992 Discovery study), the latest SEWRPC unit loading estimates (Powers Lake 1991) were used (shown in Table C.3), and also the most reliable groundwater data available (WDNR 1980). Phosphorus loading estimates for Lake Mary and Lake Elizabeth for 1992 are shown along with loading estimates for Lake Mary (Table C.4) and Lake Elizabeth (Table C.5).

Figure C.4 Phosphorus loading (kilograms/hectare/year) in relation to the phosphorus concentration in runoff and the amount of surface runoff in one year.

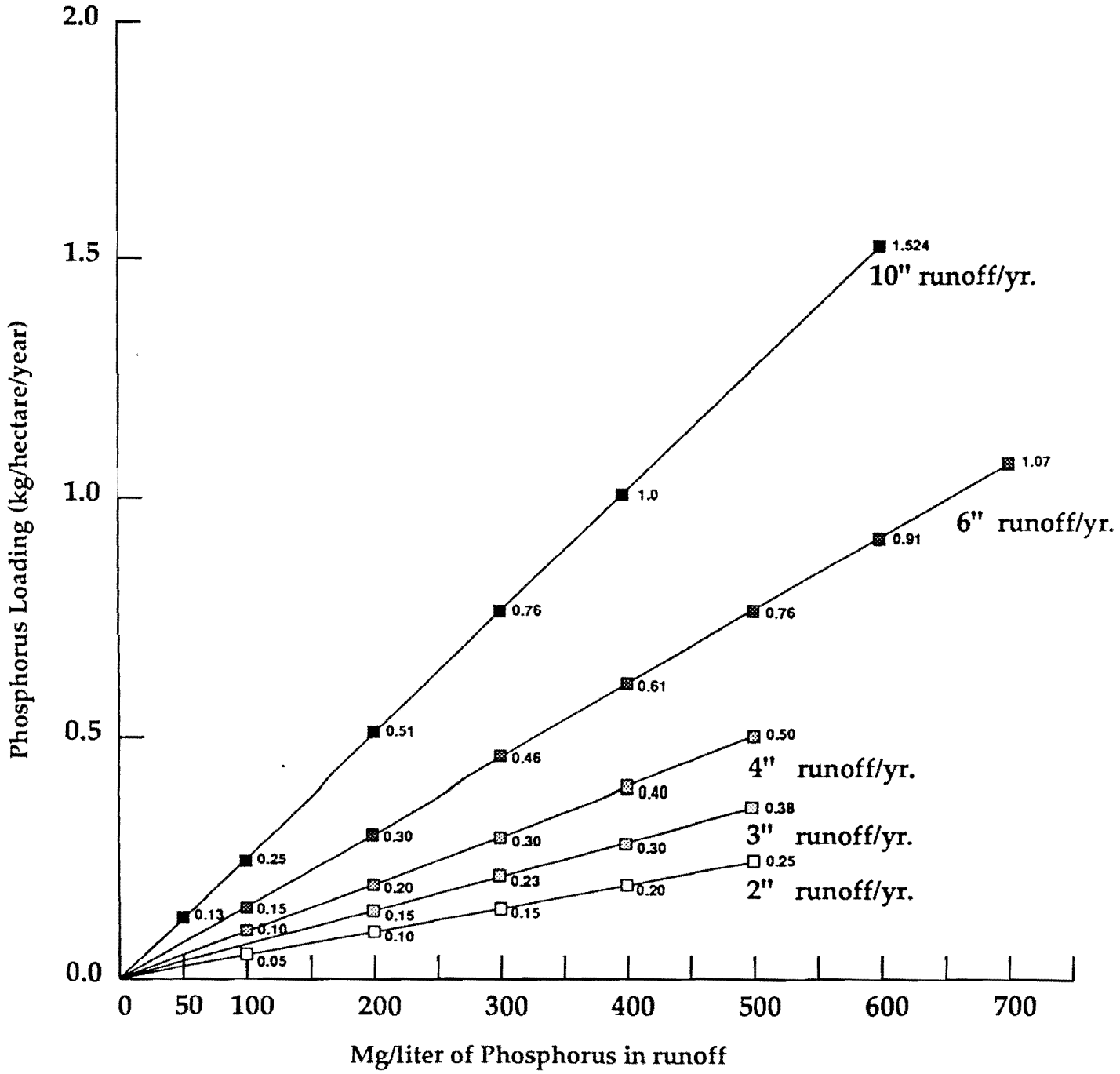


Table C.3 Annual Nutrient Budget for Lake Mary and Lake Elizabeth Showing Nutrient Loading Factors, Acreages, and Annual Phosphorus Loading.

Land use loading factors are from SEWRPC (1991 Powers Lake Study) unless noted; Land use (in acres) is from this study (Discovery Group).

		Lake Mary		Lake Elizabeth	
	Loading Factor (lb/ac/yr.)	Acres	Est. P Loading (lb/ac/yr.)	Acres	Est. P Loading (lb/ac/yr.0)
Residential	0.08	315	25	450	36
Commercial	1.46	19	28	8	12
Government/Inst.	0.57	0	0	10	6
Transportation/Util.	0.34	164	56	175	60
Recreational	0.03	40	1	10	1
Land Under Development	13.0	10	130	10	130
Urban Total		555	240	663	245
Woodlands	0.03	229	7	254	8
Wetlands	0.03	25	1	312	9
Agricultural Use	0.86/0.24*	308	265	4,020	945
Rural Total		562	273	4,586	961
Total Watershed		1,117	513	5,249	1,206
Atmospheric Loading	0.139	315	44	682	95
Groundwater Loading***		—	41		59
Lake Sediment Release	0.5**	—	16	68	34
Total Loading			614lbs		1,395 lbs.

* 0.86 lb/ac/yr was a value from SEWRPC and used for Lake Mary; 0.24 lb/ac/yr was used for Lake Elizabeth, so the phosphorus model using these loadings would better meet observed lake phosphorus concentrations.

** Sediment release rate (0.5 lb/ac/yr.) is from the literature multiplied by 10% of the lake surface area.

*** Ground water loading factor: Lake Mary = 0.7 cfs x 0.03 mg/l Lake Elizabeth = 1.4 cfs x 0.02 mg/l.

Table C.4 Lake Mary Land Uses and Phosphorus Loading Estimates for 1975 (SEWRPC), for 1977 (WDNR) and 1991 (BWS).

	SEWRPC (1975)			WDNR (1980)			BWS(1991)		
	Loading Factor lb/ac/yr	Acres	1975 P Loading lb/ac/yr	Loading Factor lb/ac/yr	Acres	1977 P Loading lb/ac/yr	Loading Factor lb/ac/yr	Acres	1991 P Loading lb/ac/yr
Urban Land	0.28	400	112	—	—	—	—	—	—
Residential	—	—	—	—	—	—	0.08	315	25
Commercial	—	—	—	—	—	—	1.46	19	28
Government/Inst.	—	—	—	—	—	—	0.57	0	0
Transportation/Util.	—	—	—	—	—	—	0.34	164	56
Recreation	—	—	—	—	—	—	0.03	40	1
Land Under Development	45.0	18	816	—	—	—	13.0	10	130
Onsite Systems	3 lb/sys*	2 sys*	6	—	—	—	—	—	—
Urban Subtotal	—	418	934	—	—	—	—	555	240
Livestock Operations	6.6 lbs.**	—	—	—	—	—	—	—	—
Agricultural and Open Space	0.10	1,042	2,151	—	—	—	0.86	308	265
Woodlands	—	—	—	—	—	—	0.03	229	7
Wetlands	—	—	—	—	—	—	0.03	25	1
Rural Subtotal	—	1,042	2,151	—	—	—	—	562	273
Other Watershed				0.11	440	48	—	1,117	513
Atmospheric Loading	0.50	315***	157	0.50	315***	158	0.14	315***	44
Groundwater Loading	—	—	—	0.03	—	42	0.03****	—	41
Lake Sediment Release	—	—	—	—	—	—	0.50	32	16
Total Phosphorus Loading Estimate (lbs.)			3,242			248			614

* Only failing onsite systems considered
** 6.6 lbs. per animal in watershed
*** Lake surface area
**** Phosphorus concentration multiplied by 0.7 cfs

Table C.5 Lake Elizabeth Land Use and Phosphorus Loading Estimates for 1975 (SEWRPC), 1977 (WDNR) and 1991 (BWS).

	SEWRPC (1975)			WDNR (1980)			BWS(1991)		
	Loading Factor lb/ac/yr	Acres	1975 P Loading lb/ac/yr	Loading Factor lb/ac/yr	Acres	1977 P Loading lb/ac/yr	Loading Factor lb/ac/yr	Acres	1991 P Loading lb/ac/yr
Urban Land	0.28	599	159	—	—	59	—	—	—
Residential	—	—	—	—	—	—	0.08	450	36
Commercial	—	—	—	—	—	—	1.46	8	12
Government/Inst.	—	—	—	—	—	—	0.57	10	6
Transportation/Util.	—	—	—	—	—	—	0.34	175	60
Recreation	—	—	—	—	—	—	0.03	10	1
Land Under Development	45.0	25	1,080	—	—	—	13.0	10	130
Onsite Systems	2.9 lb/sys*	17	49	—	—	—	—	—	—
Urban Subtotal	—	624	1,288	—	—	59	—	663	245
Livestock Operations	6.6 lbs.**	—	—	—	—	—	—	—	—
Agricultural and Open Space	0.10	4,556	1,657	—	—	361	0.24	4,020	945
Woodlands	—	—	—	—	—	—	0.03	254	8
Wetlands	—	—	—	—	—	—	0.03	312	9
Rural Subtotal	—	4,556	1,657	—	—	361	—	4,586	961
Other Watershed	—	5,024	2,945	—	—	420	—	5,249	1,206
Atmospheric Loading	0.50	638	319	—	—	319	0.14	682	95
Groundwater Loading	—	—	—	—	—	194	0.02***	—	59
Lake Sediment Release	—	—	—	—	—	—	0.50	68	34
Total Phosphorus Loading Estimate (lbs.)			3,264			933			1,395

* Only failing onsite systems considered
** 6.6 lbs. per animal in watershed
*** Phosphorus concentration multiplied by 1.4 cfs

6. Watershed and Lake Modeling

Lake modeling is a tool that aids in predicting what phosphorus concentrations should be in a lake based on the amount of nutrient that came in on an annual basis. A lake model is useful because it can show if existing conditions are understood and can be used to predict what future conditions could be if changes occurred in the watershed.

The phosphorus lake model used in this report is from Reckhow and Simpson and is shown in Figure C.5. In order to run the model, the nutrient budget and water budget need to be plugged in. The nutrient and water budget numbers used, and the phosphorus model predictions are shown in Table C.6.

For Lake Mary, the phosphorus model closely predicted the observed summer phosphorus concentration. For Lake Elizabeth, two model runs were made because the first run predicted too high of a phosphorus concentration for the lake. The nutrient budget was adjusted downward in order for the predicted model phosphorus concentration to come into line with the observed phosphorus concentrations.

By forcing the lake model to agree with the observed lake concentrations, agricultural loading was reduced by 75%. Thus, the loading factor for Lake Elizabeth was adjusted downward from 0.86 lbs/ac/yr (used by SEWRPC 1991) to 0.24 lbs/ac/yr. This represents a loading decrease from 3,457 lbs/yr to 945 lbs/yr for the agricultural contribution.

The agricultural loading factor probably should have been changed for Lake Mary as well, because Lake Mary's watershed is similar to Lake Elizabeth's in soils and geomorphy, but it was not lowered. If Lake Mary's agricultural loading factor would have been adjusted downward to that of Lake Elizabeth then Lake Mary's phosphorus model would have underestimated the phosphorus concentration in Lake Mary. I suspect the urban loading factor could have been adjusted upward for Lake Mary, but without field data it is difficult to say exactly how high to go. I decided to keep factors unchanged until field sampling would indicate otherwise.

Figure C.5 Phosphorus Model Used for the Twin Lakes Study is from Reckhow and Simpson (1979).

Phosphorus Model

$$\text{Predicted phosphorus concentration (mg/l) that should be found in the lake.} = \frac{L \quad \text{(nutrient budget)}}{11.6 + 1.2\,q's \quad \text{(water budget)}}$$

where

$$L\,9g/m2) = \frac{\text{Mass of phosphorus loading (g)}}{\text{Lake surface area (m2)}}$$

and

$$q's\ (m3/m2) = \frac{\text{Volume of water loaded on to lake surface (m3)}}{\text{Lake surface area (m2)}}$$

Table C.6 **Nutrient Budget and Water Budget Numbers Used for the Reckhow and Simpson Lake Model and Predicted Verses Actual Lake Concentrations.**

	Nutrient Load	Water Load	L	q's	Model P Predictions	Actual Lake P Concentrations
Lake Mary	614	1,722	0.22	0.86	17	16
Lake Elizabeth	1,397	3,998	0.23	0.98	17	27

7. Interesting Findings, Unanswered Questions and Future Considerations

Results of the water quality and watershed analysis revealed some interesting findings, produced several questions and have generated some future considerations.

INTERESTING FINDINGS:

Surface runoff in the Twin Lakes watershed may be 3 inches per year or less.

Agricultural phosphorus inputs from Lake Elizabeth may be less than expected. Apparently, the natural swales in the watershed allow water to infiltrate.

Urban phosphorus inputs from Lake Mary are probably higher than estimated in this report.

Phosphorus retention in the lake basins is around 90%, meaning that for Lake Mary about 600 pounds of phosphorus comes in and only about 50 pounds leave. The rest remains behind. For Lake Elizabeth about 1,400 pounds come in and about 100 pounds leave. There is a huge phosphorus reservoir in these lake sediments.

UNANSWERED QUESTIONS:

Is there a cleansing mechanism in the water column that removes phosphorus? Is it diatoms settling out in June or is it calcite precipitation?

Are elevated phosphorus concentrations in the bottom water due to oxygen depletion and phosphorus release from lake sediments or could they come from calcite precipitation in the epilimnion with dissolution of the settling particles in the hypolimnion?

The answers to these questions have ramifications for watershed modeling and watershed management. Dr. R.E. Stauffer believes calcium precipitates in the column too late in the summer and that phosphorus has been removed by diatom sedimentation in late spring (Dr. R.E. Stauffer, personal communication, April 13, 1992). If this is the case, this is a fairly common occurrence in lakes. However, if the column precipitation removes phosphorus, this is more rare and would indicate that the Twin Lakes have a unique phosphorus removal mechanism.

FUTURE CONSIDERATIONS:

Monitoring nutrient concentrations during storm events for agricultural and urban areas would aid in better defining nutrient loading in the Twin Lakes.

Agricultural phosphorus inputs may be low at this time. As agricultural land is converted into urban land, it is critical that runoff be treated before reaching the Twin Lakes. A stormwater management plan that emphasizes water quality should be implemented.

Future development in Lake Mary's watershed should also follow a stormwater quality management plan.

Erosion control at new construction sites should be implemented and then enforced.

Existing wetlands around the Twin Lakes should be sampled to check their nutrient retention capacity. The best way to do that is by characterizing their soils.

Calcium and phosphorus concentrations should be followed through spring and summer in the Twin Lakes to see if calcite formation is a nutrient removal mechanism.

A new fish survey would characterize existing fishery conditions and aid in stocking and management decisions.