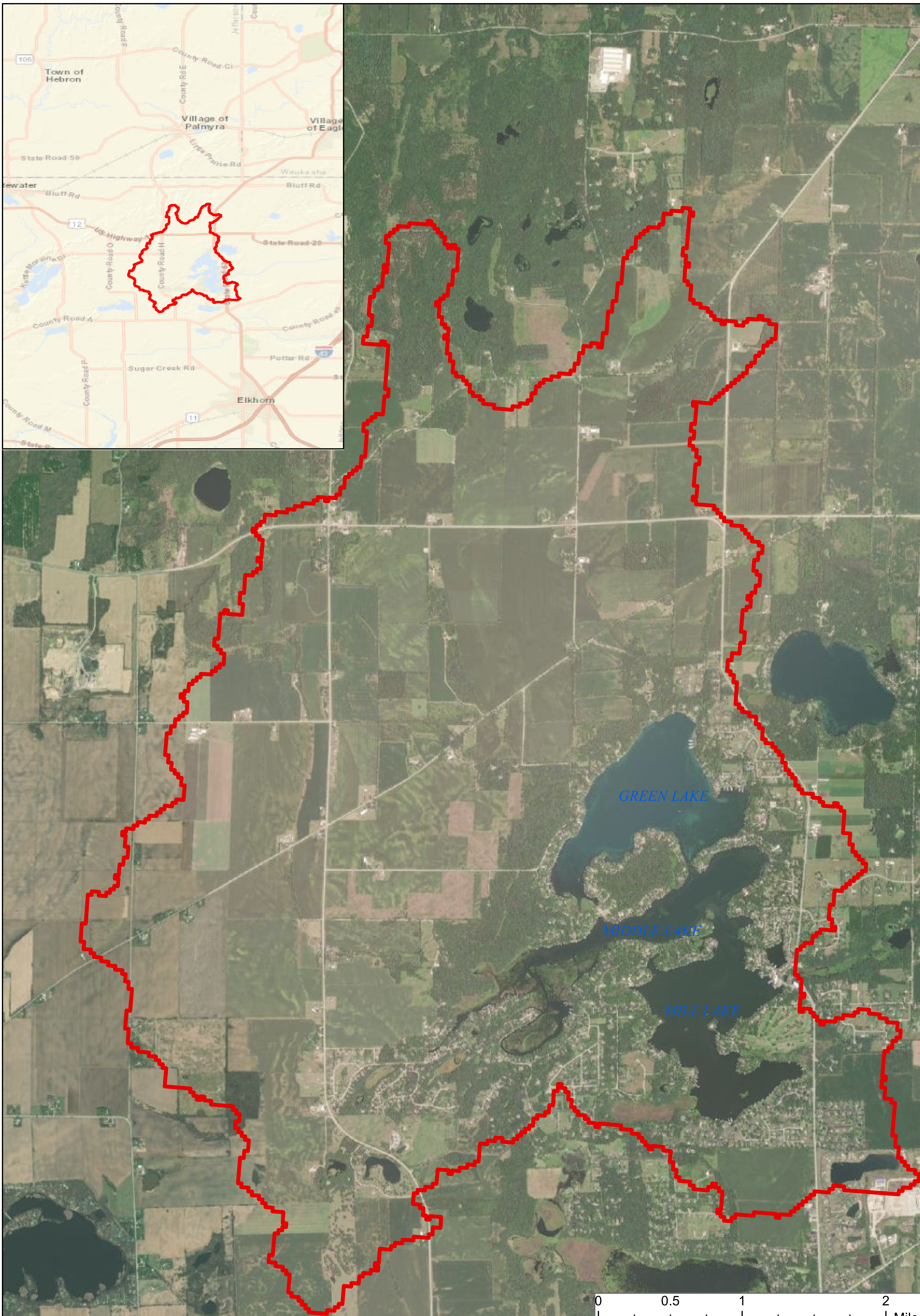
Appendix A: Supporting Figures



Legend

Watershed Boundary

Watershed Boundary to Route 12 Outlet = 13.1 square miles

Delineation performed by USGS Stream Stats

Website: https://streamstats.usgs.gov/ss/

Lauderdale Lakes
Location Map

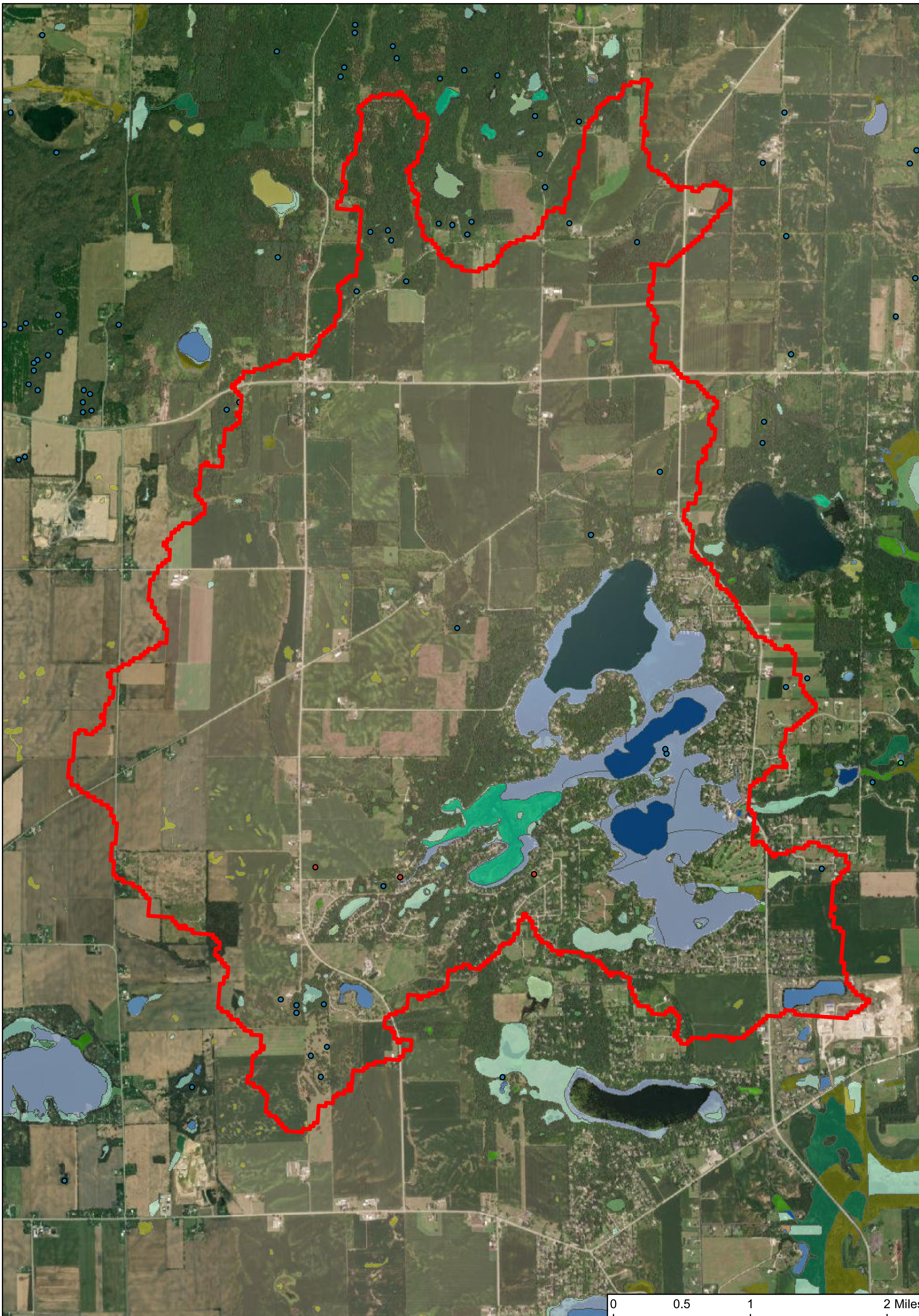
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Figure 1

Mequon, WI - MOW5536 | November 2021

C:\Users\MKDempsey\Documents\ArcGIS\Packages\1. Location Map_7A4DA429-CFF5-4A52-B263-EE85E8D74E3E\v107\1. Location_Map.mxd 11/22/2021 5:11:02 PM



- Aquatic bed
- Aquatic bed, Open Water
- Deep water lake
- Emergent/wet meadow
- Emergent/wet meadow, Aquatic bed
- Emergent/wet meadow, Flats/unvegetated wet soil
- Emergent/wet meadow, Open Water
- Filled/drained wetland, Emergent/wet meadow
- Filled/drained wetland, Flats/unvegetated wet soil
- Filled/drained wetland, Forested
- Filled/drained wetland, Forested, Emergent/wet meadow
- Filled/drained wetland, Scrub/shrub
- Filled/drained wetland, Scrub/shrub, Emergent/wet meadow
- Flats/unvegetated wet soil
- Forested
- Forested, Emergent/wet meadow
- Forested, Open Water
- Forested, Scrub/shrub
- Open Water
- Scrub/shrub
- Scrub/shrub, Emergent/wet meadow
- Lauderdale Lake Watershed Boundary (Stream Stats)
- Excavated pond
- Filled excavated pond
- Filled/drained wetland
- Wetland too small to delineate

Lauderdale Lakes
Wetland Inventory

Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

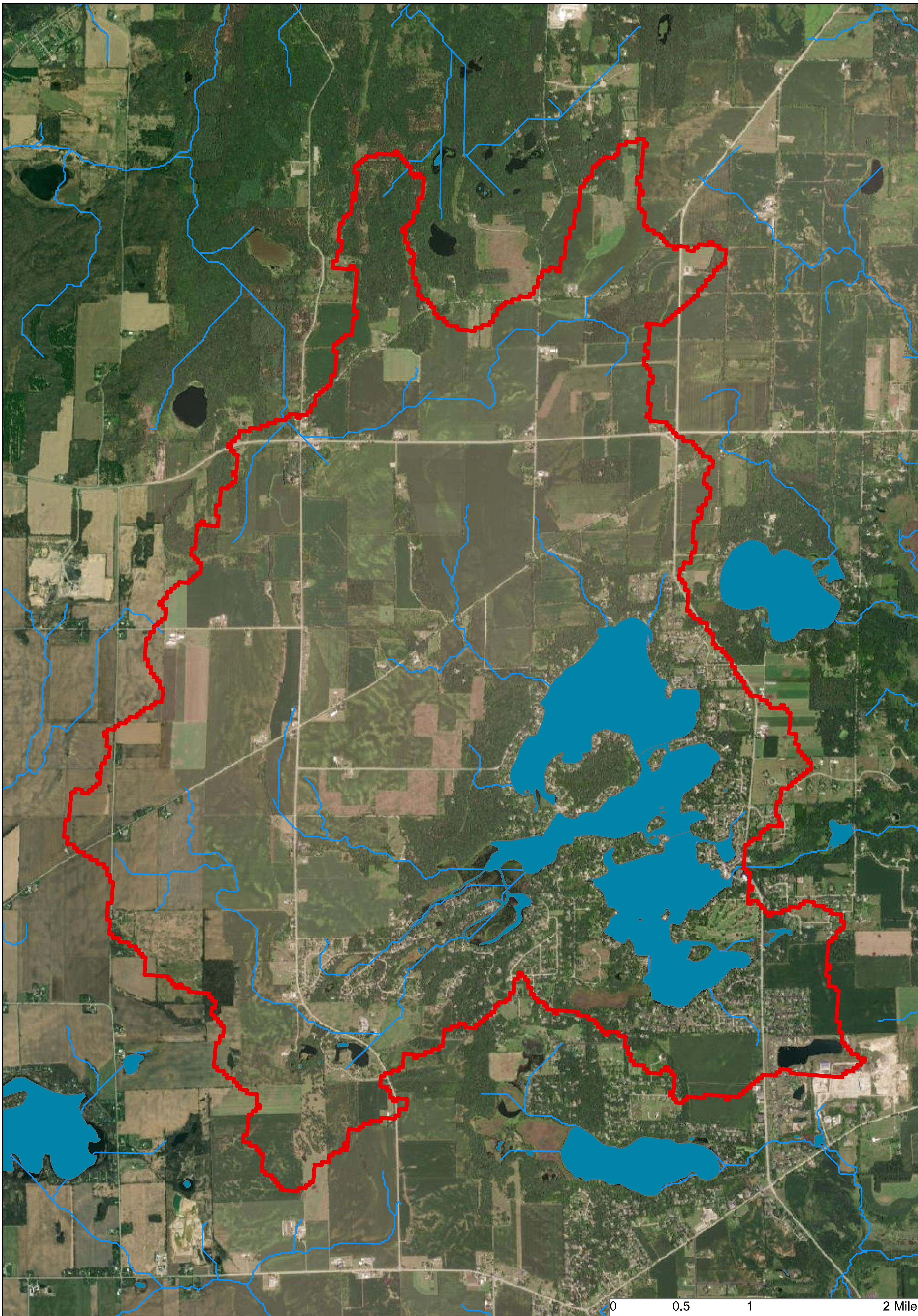
Geosyntec consultants

Figure

2

Mequon, WI - MOW5536 | November 2021

C:\Users\MKDempsey\Documents\ArcGIS\Packages\2. Wetland Inventory_D0ED6A59-B7B2-4DEF-AB97-690BF11A9F98\v107\8. Wetland Inventory.mxd 11/22/2021 12:32:19 PM



WDNR Identified Lakes/Ponds

Lauderdale Lake Watershed Boundary (Stream Stats)

Overland Flow Path

Overlad flow paths defined using ArcGIS builtin Arc Hydro function and Walworth County one foot contours.

Lauderdale Lakes
Existing Hydrology

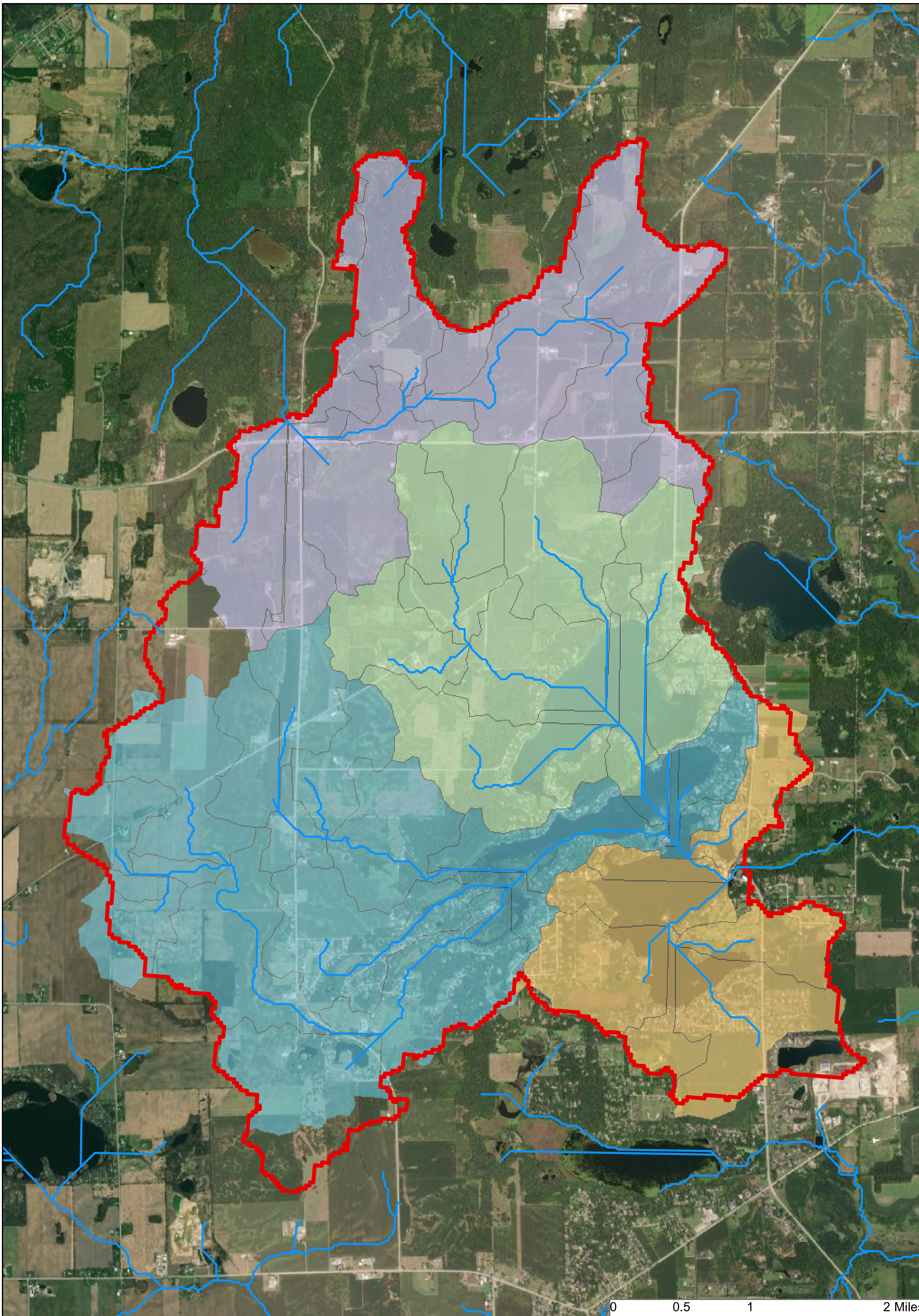
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Figure 3

Mequon, WI - MOW5536 | November 2021

\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\MXD\10. Existing Hydrology.mxd 11/22/2021 2:50:08 PM



Middle Lake Watershed
Green Lake Watershed
Mill Lake Watershed
Not Tributary
Lauderdale Lake Watershed Boundary (Stream Stats)
Overland Flow Path

Overlad flow paths defined using ArcGIS builtin Arc Hydro function and Walworth County one foot contours.

Lauderdale Lakes
Updated Tributary Areas

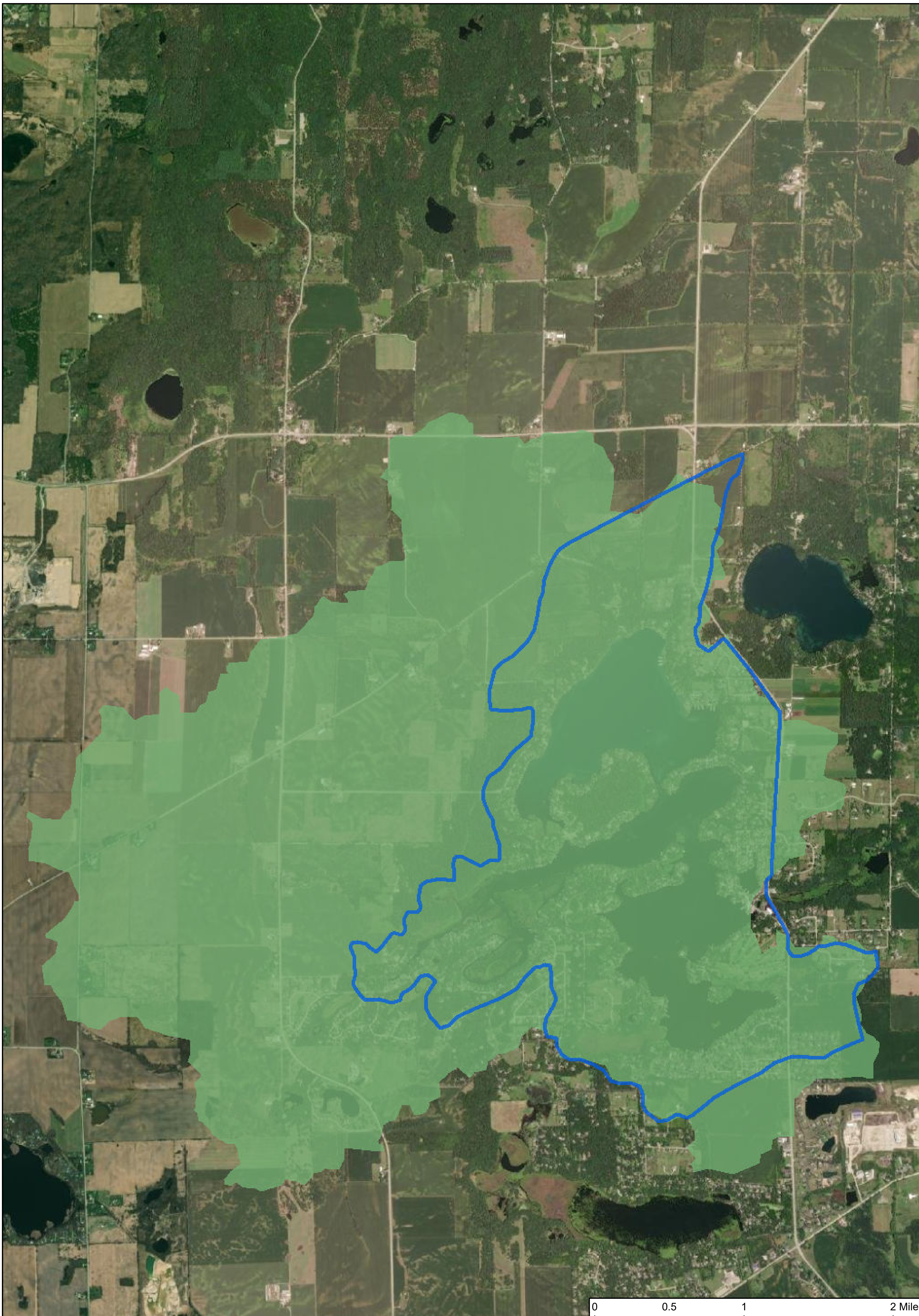
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Figure 4

Mequon, WI - MOW5536 | November 2021

\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\MXD\7. Updated Tributary.mxd 11/22/2021 3:22:10 PM



Geosyntec Study Area

USGS Study Area

Lauderdale Lakes
USGS Study Area Boundary VS
Geosyntec Study Areas

Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

N

Geosyntec
consultants

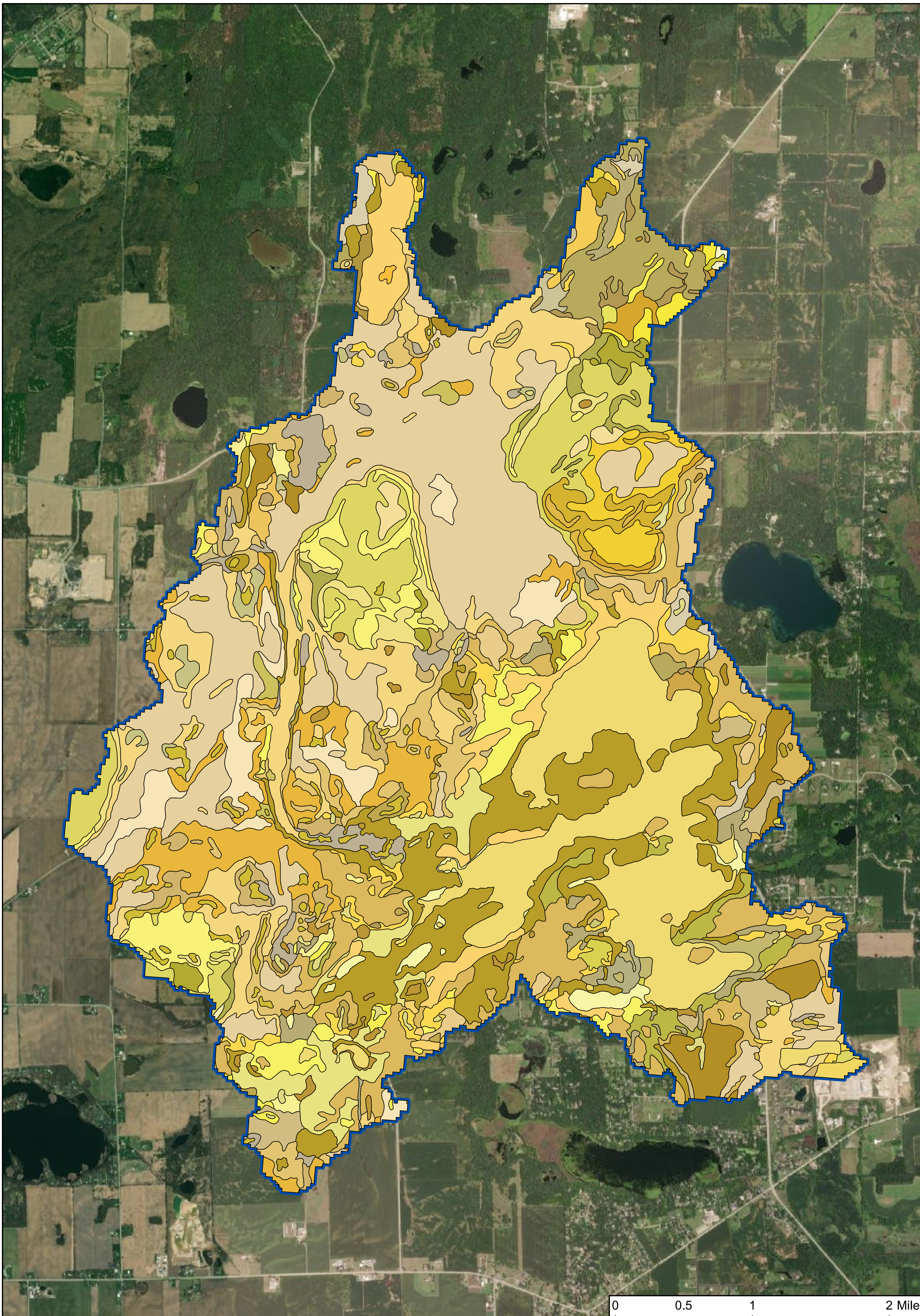
Figure

5

Mequon, WI - MOW5536

November 2021

\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\MXD\11. USGS vs Geosyntec Areas.mxd 11/22/2021 3:38:38 PM



Soil Type

Ac, BpB, BpC2, CeB2, CeC2, CeD2, CfC3, CfD3, CkD2, ClC2, CrD2, CrE2, CtB, CtE, Dt, EgA, FmB, FmC2, FoB, FoC2, FsA, FsB, FsC2, GP, GsB, GsC2, GsD2, HeB, HfE, Ht, JuA, LyB, LyC2, LzD2, Mf, MpB, MpC2, MuA, MuB, MvB, MwD2, MxC2, MxD2, Pa, Ph, PsA, PsB, PsC, PtA, PtB, PtC2, RaA, RsF, SeA, SeB, Sm, TxA, W, WeA, WhA, WhB, WhC2

Lauderdale Lake Watershed Boundary (Stream Stats)

N

Lauderdale Lakes
Soils Map

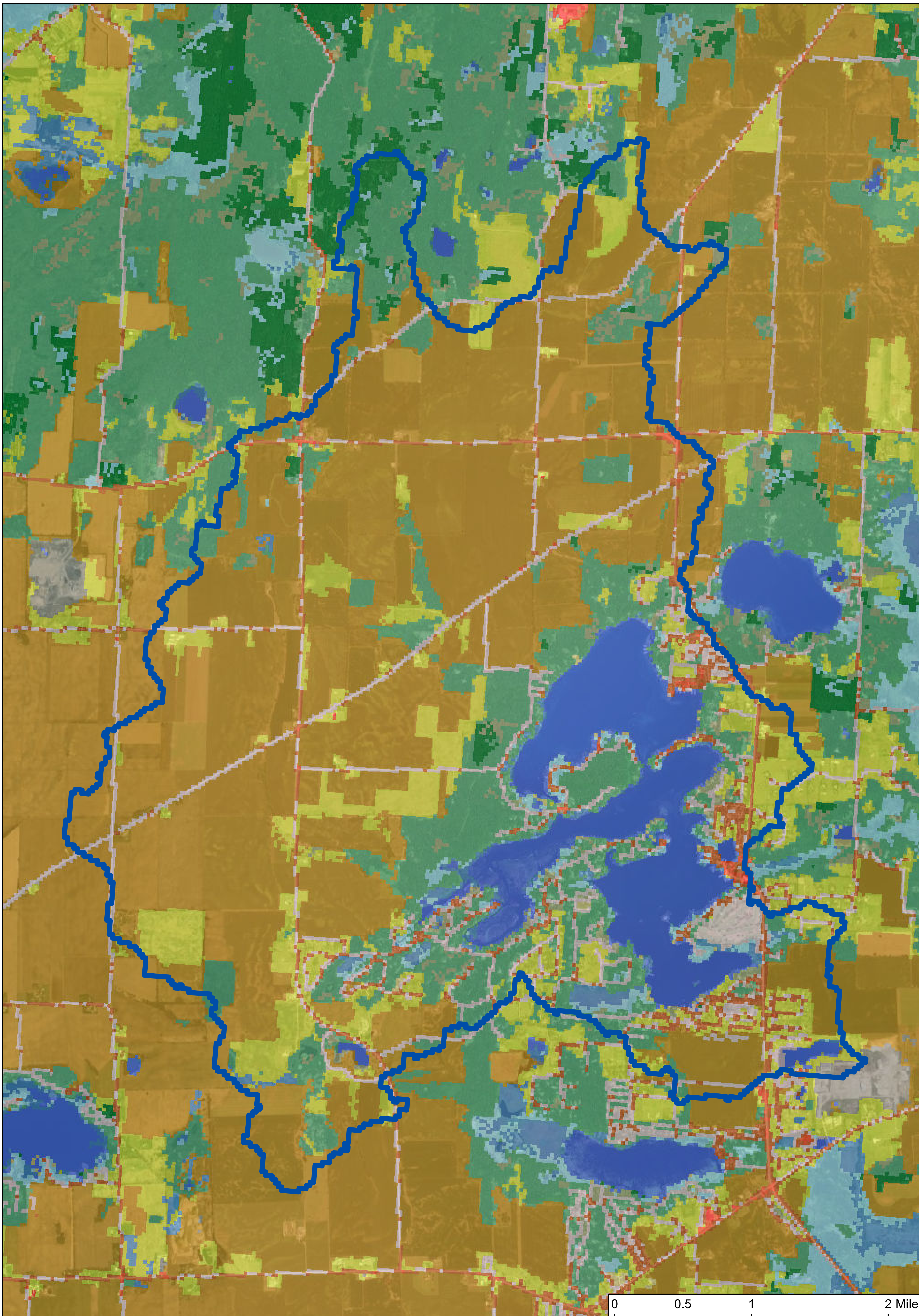
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Mequon, WI - MOW5536 | November 2021

Figure
6

C:\Users\MKDempsey\Documents\ArcGIS\Packages\3. Soils Map_9B766406-62F8-421D-A4F5-73254AD2E3FE\v107\6. Soils Map.mxd 11/22/2021 12:59:55 PM



2016 National Land Cover Database

- Woody Wetlands
- Shrub/Scrub
- Open Water
- Mixed Forest
- Herbaceuous
- Hay/Pasture
- Evergreen Forest
- Emergent Herbaceuous Wetlands
- Developed, Open Space
- Developed, Medium Intensity
- Developed, Low Intensity
- Developed, High Intensity
- Deciduous Forest
- Cultivated Crops
- Barren Land
- Lauderdale Lake Watershed Boundary (Stream Stats)

N

Lauderdale Lakes Land Cover

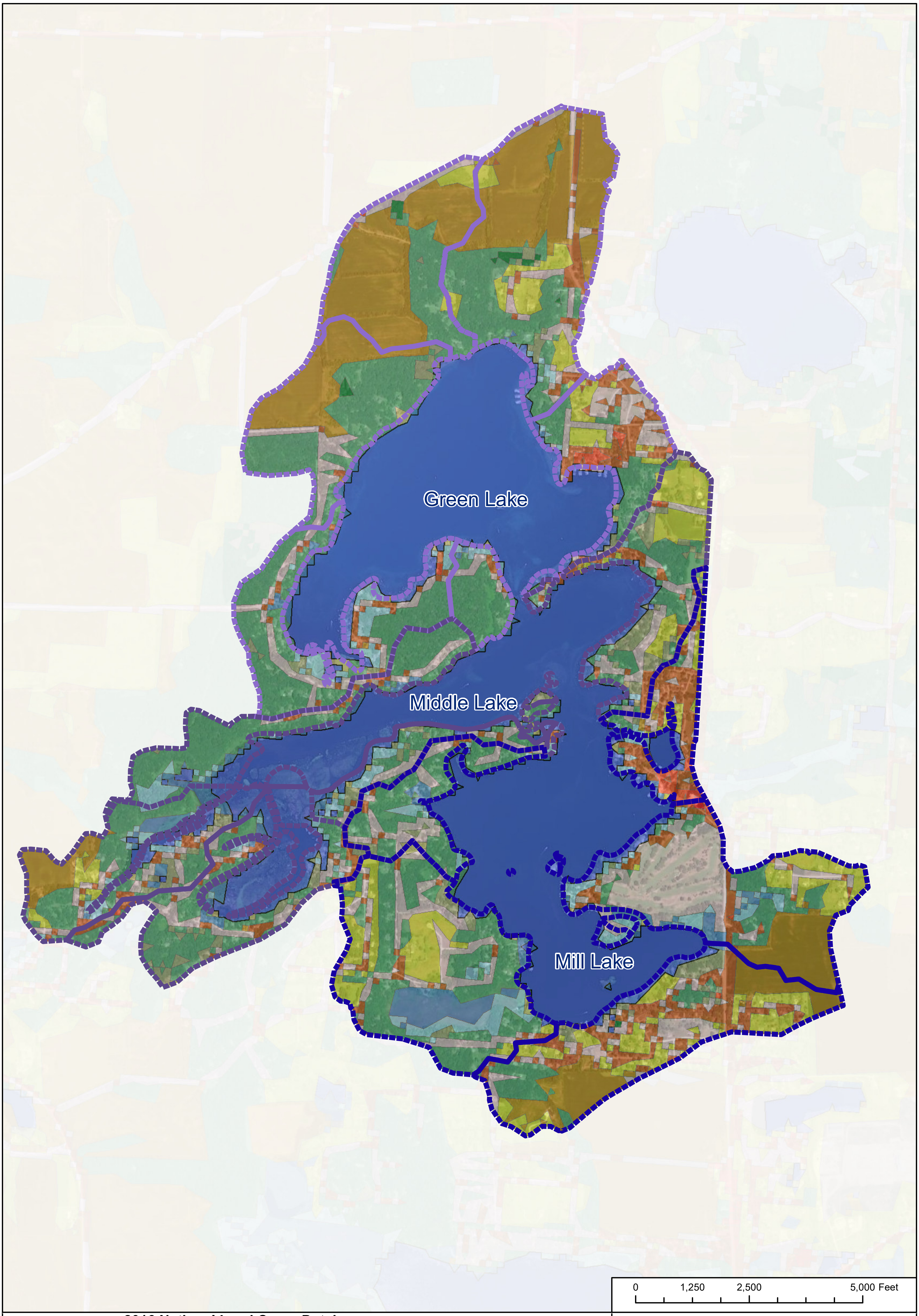
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Mequon, WI - MOW5536 | November 2021

Figure 7

\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\MXD\9. Land Cover.mxd 11/22/2021 3:02:45 PM



Watershed

- Green Lake
- Middle Lake
- Mill Lake

2016 National Land Cover Database

Barren Land	Developed, Medium Intensity	Herbaceuous
Cultivated Crops	Developed, Open Space	Mixed Forest
Deciduous Forest	Emergent Herbaceuous Wetlands	Open Water
Developed, High Intensity	Evergreen Forest	Shrub/Scrub
Developed, Low Intensity	Hay/Pasture	Woody Wetlands

N

Lauderdale Lakes Tributary Area Land Cover Overview

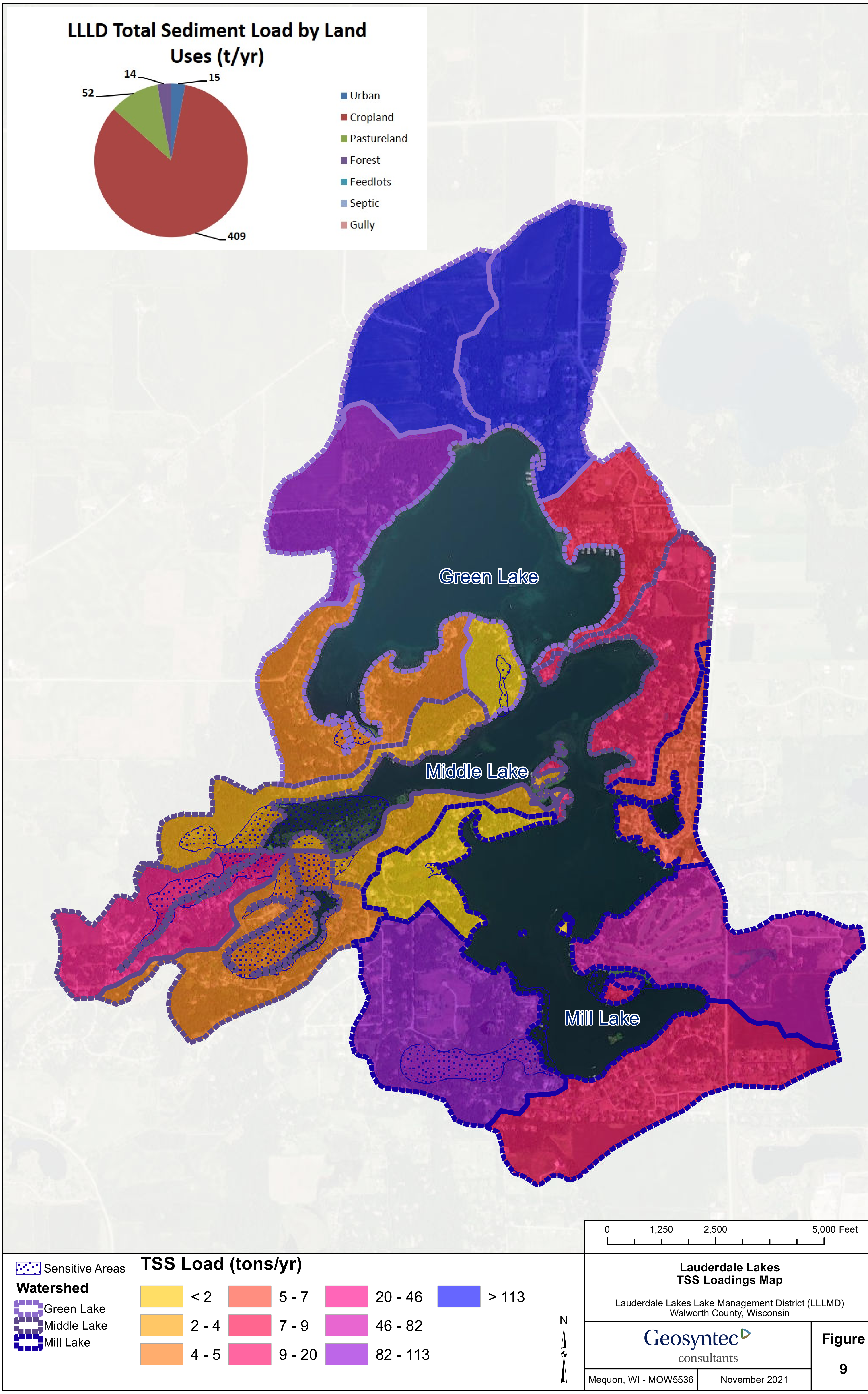
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

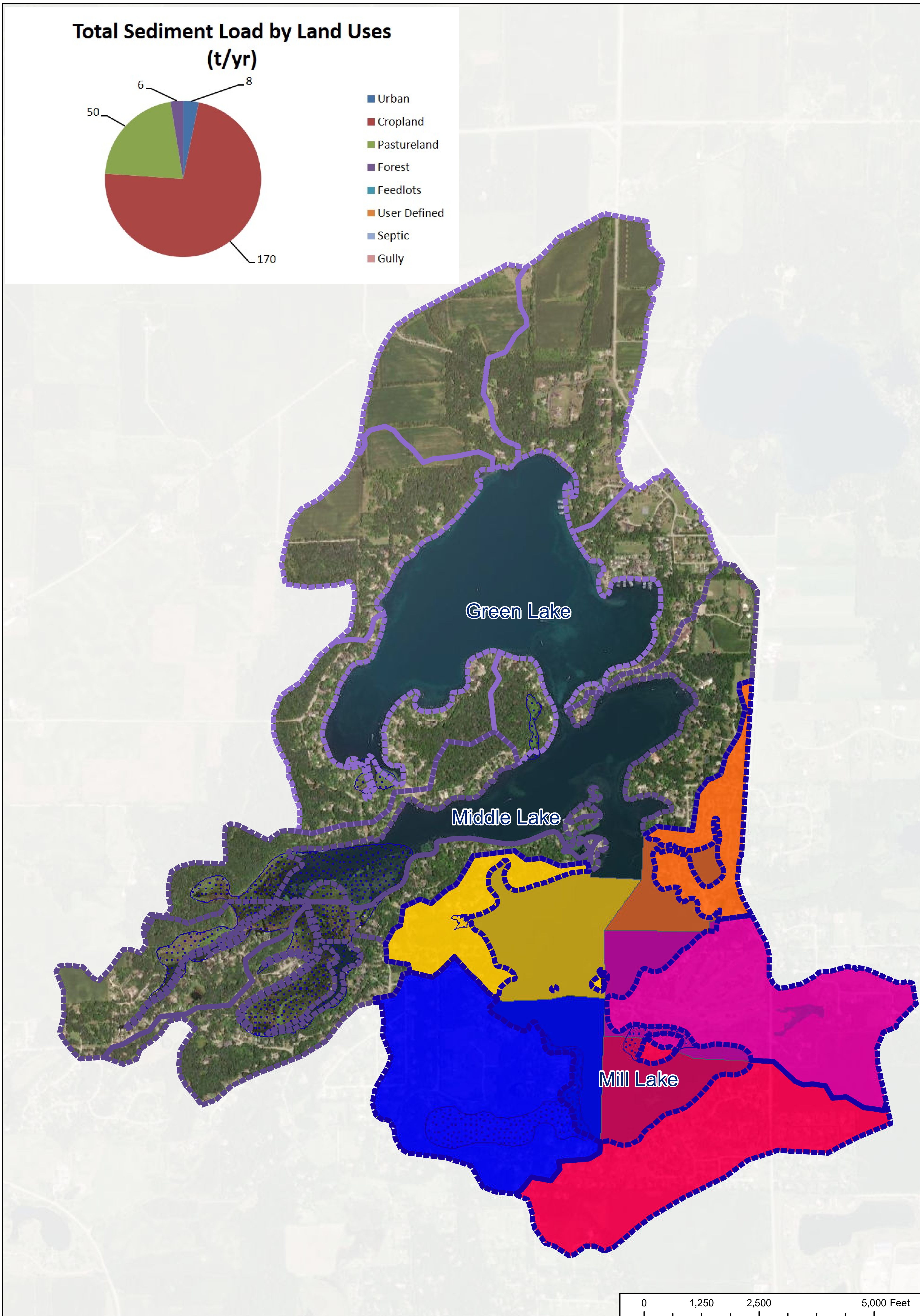
Mequon, WI - MOW5536 | December 2021

Figure 8

C:\Users\MKDempsey\Documents\ArcGIS\Packages\8. Tributary Land Cover Area_99AD1BD5-12DA-457A-9FC1-95345E9906DE\v10\12. Tributary Land Cover Area.mxd 12/2/2021 4:14:06 PM



\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\Phosphorus Loading and Reductions\TSS Loadings.mxd 11/21/2021 10:09:12 AM



Sensitive Areas

Watershed

Green Lake

Middle Lake

Mill Lake

TSS Load (tons/yr)

< 1 | 1 - 7.5 | 7.5 - 20 | 20 - 83 | > 83

N

Lauderdale Lakes
Mill Lake TSS Loadings

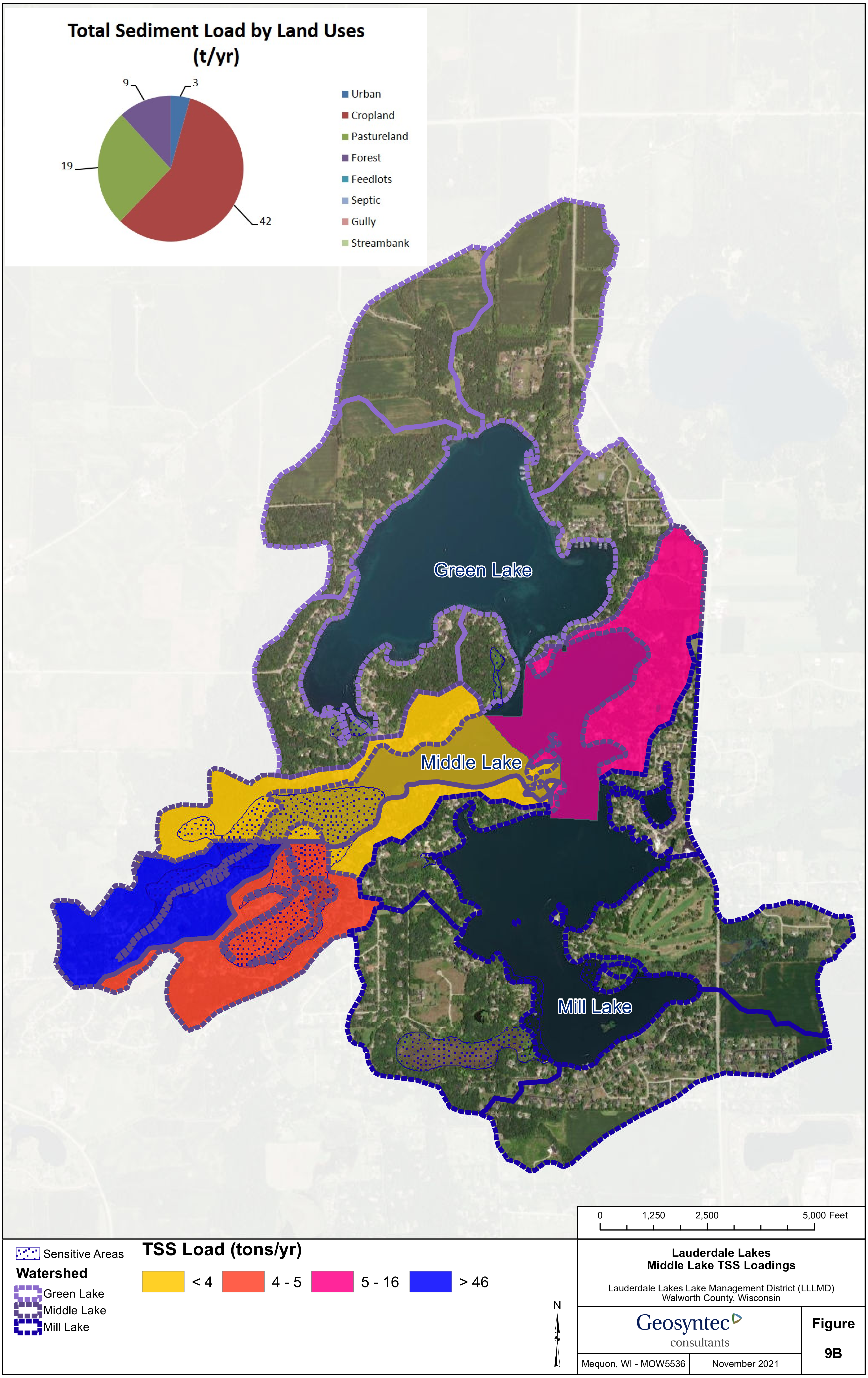
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

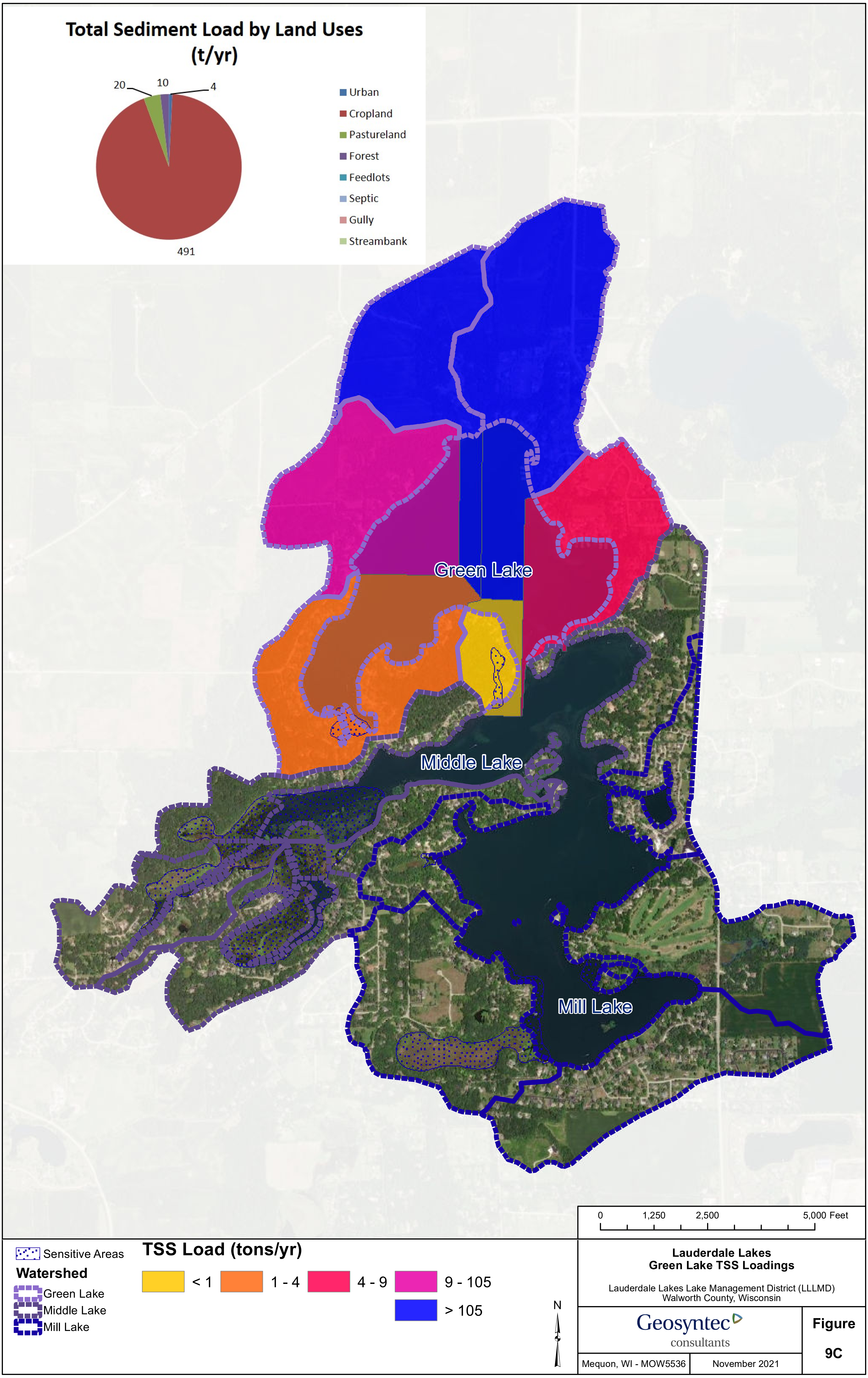
Mequon, WI - MOW5536 | November 2021

Figure 9A

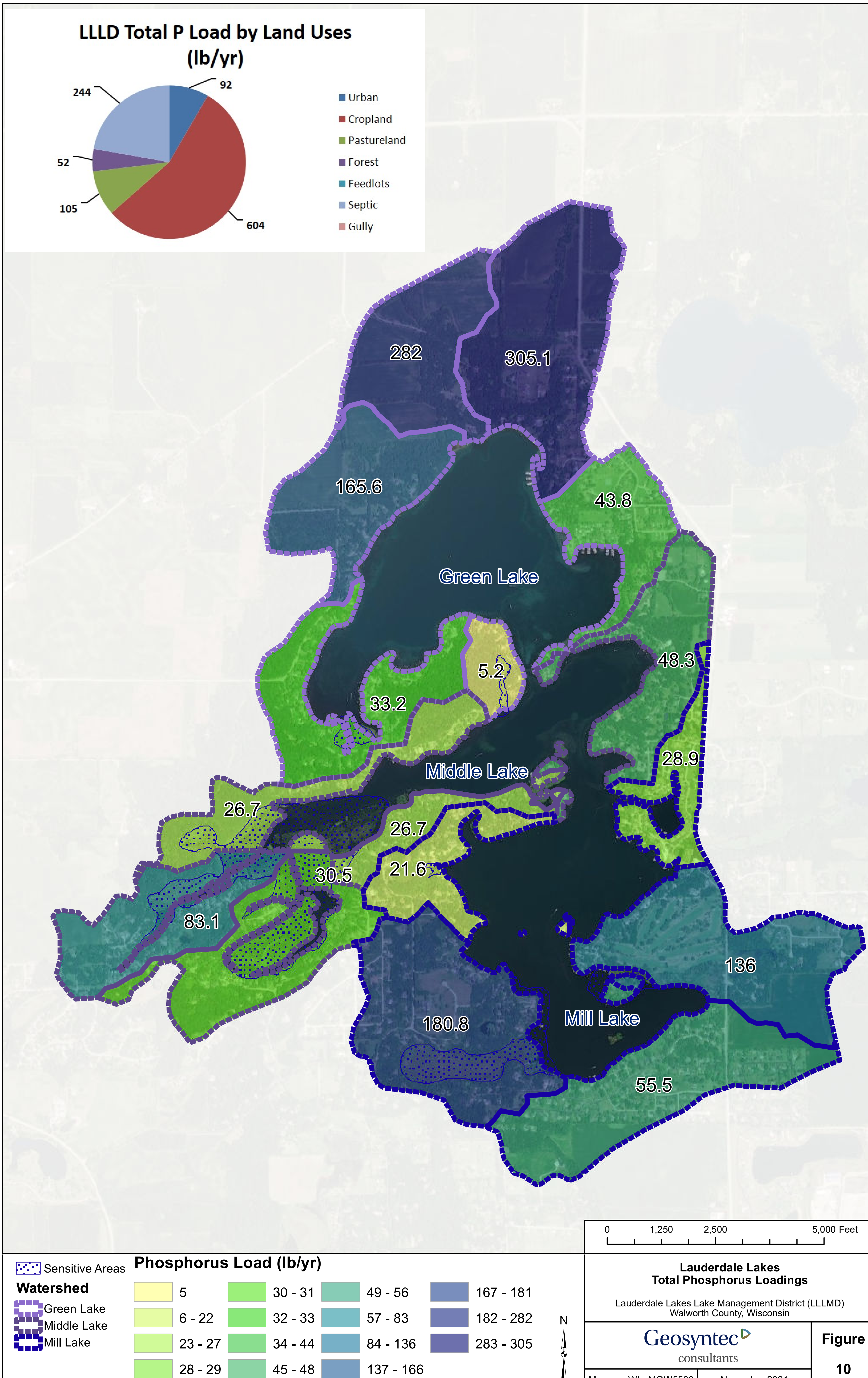
\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\Phosphorus Loading and Reductions\TSS Loadings.mxd 11/22/2021 4:10:23 PM



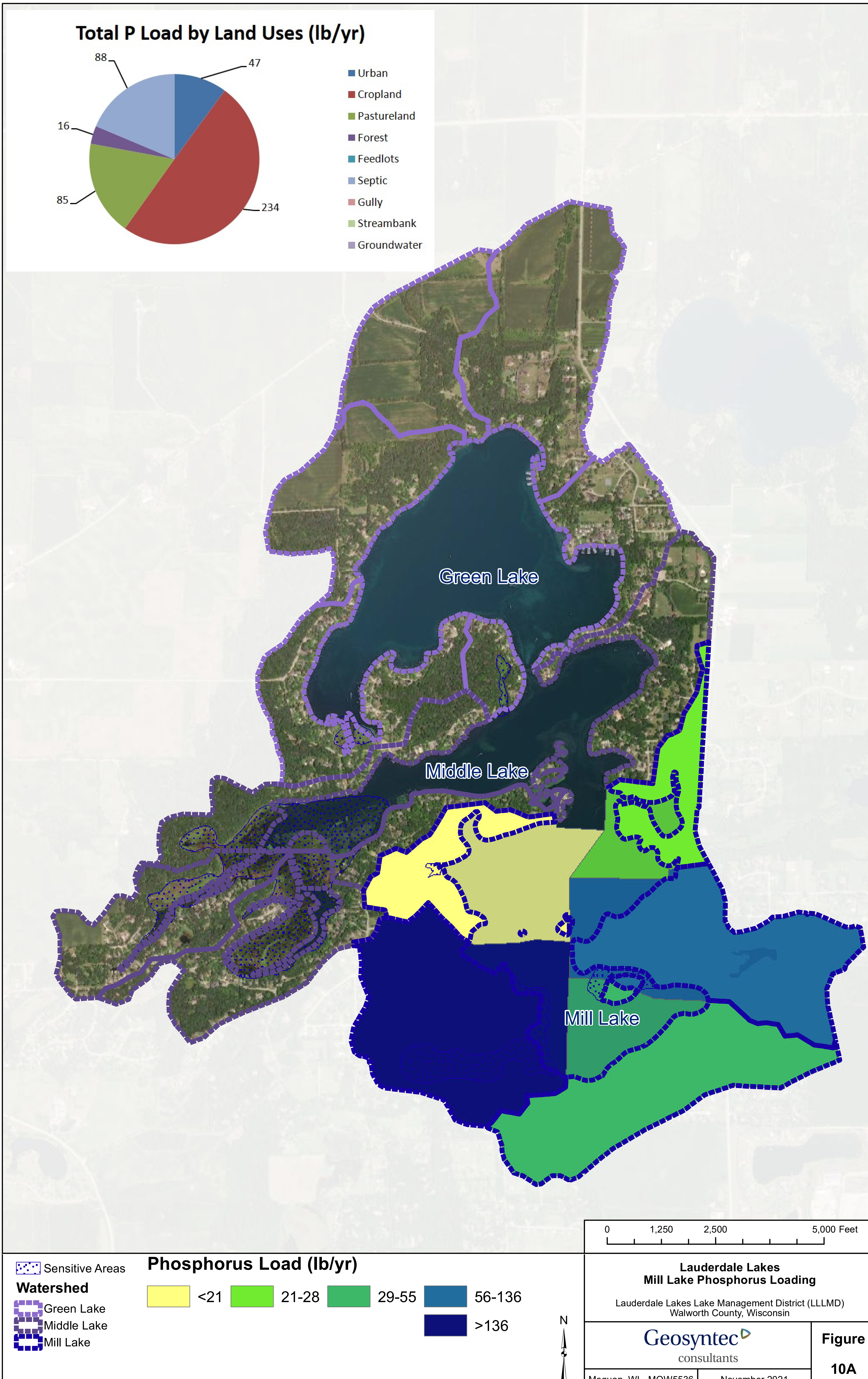
\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\Phosphorus Loading and Reductions\TSS Loadings.mxd 11/22/2021 4:11:52 PM



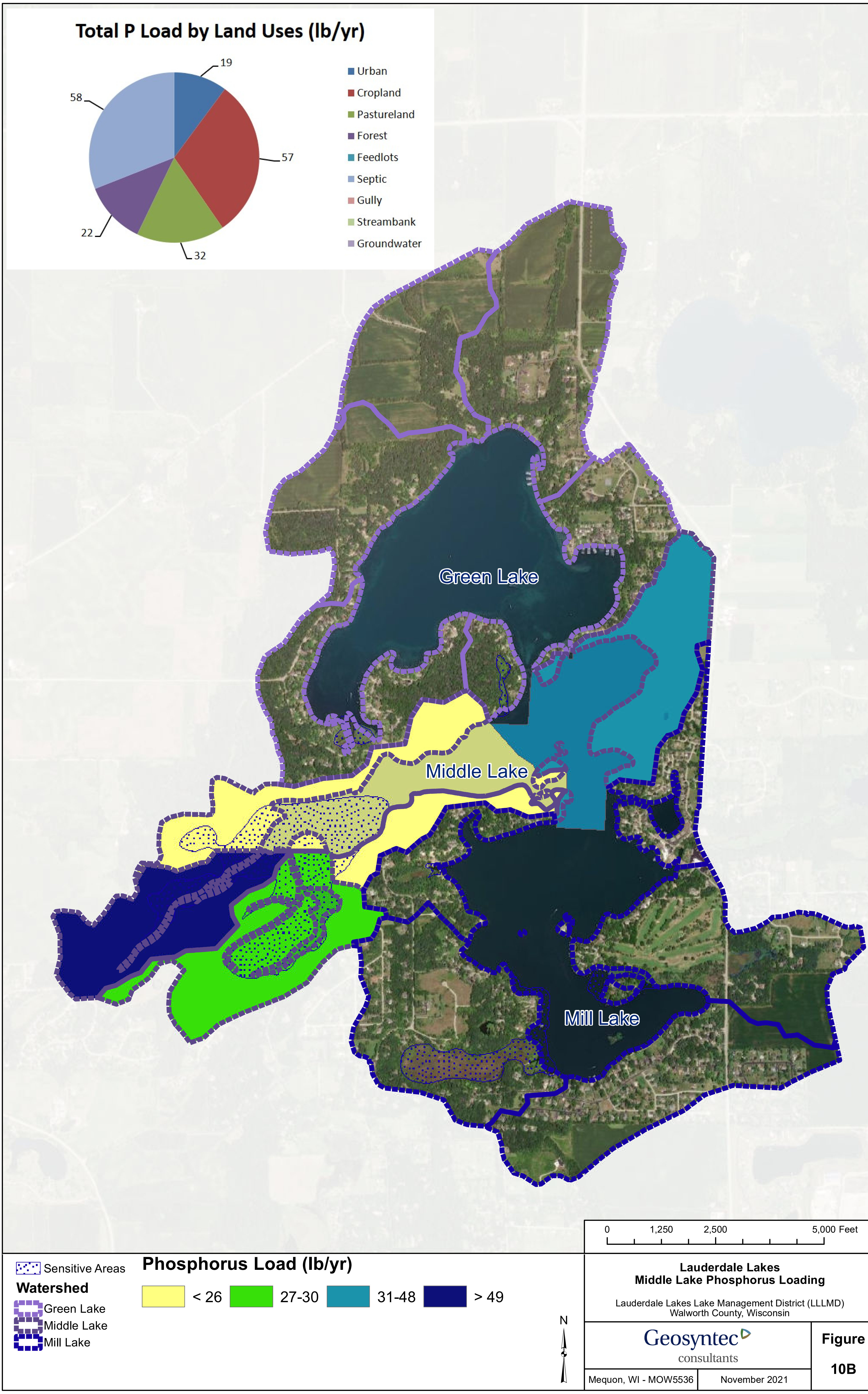
\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\Phosphorus Loading and Reductions\TSS Loadings.mxd 11/22/2021 4:13:05 PM



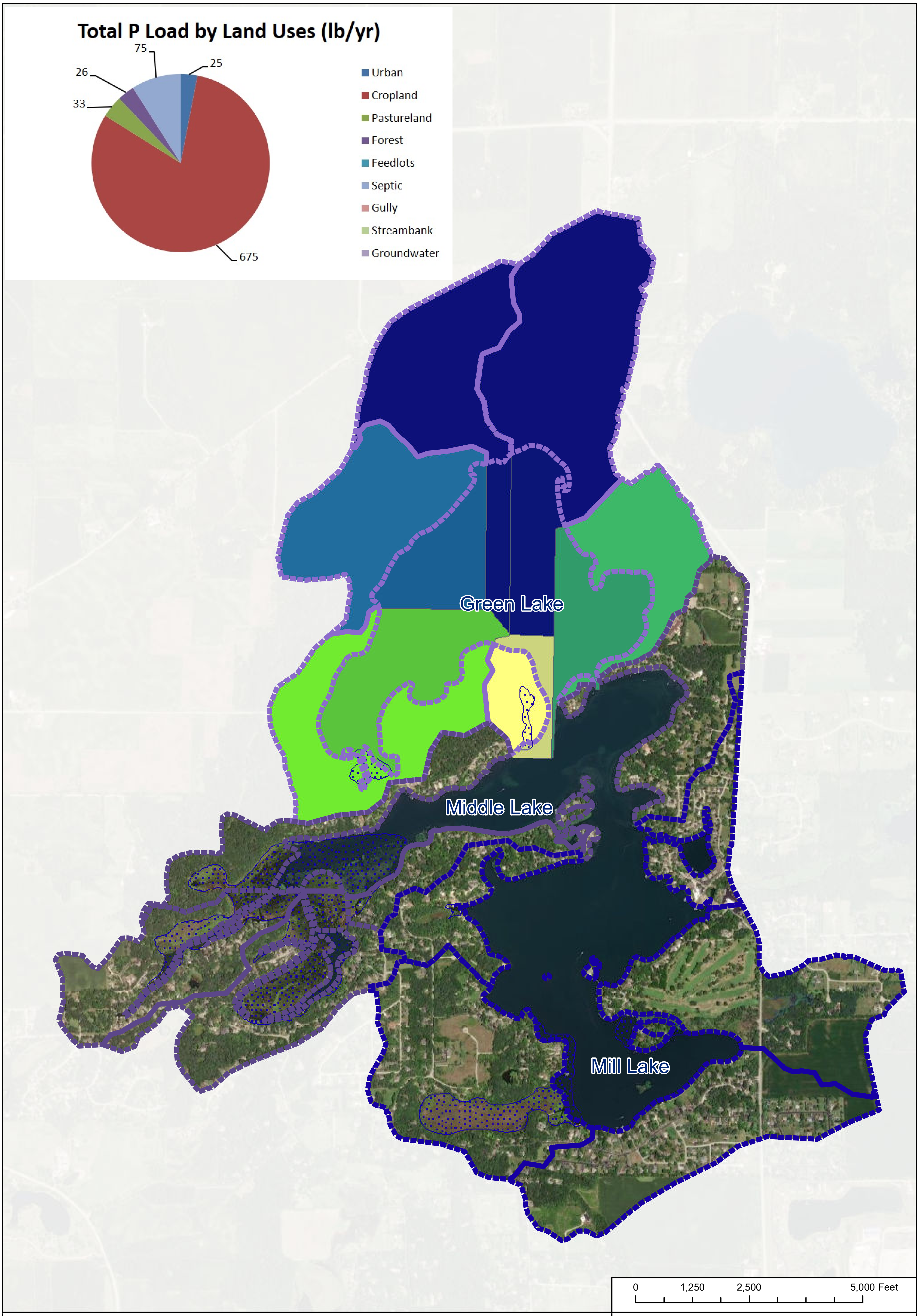
\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\Phosphorus Loading and Reductions\Phosphorus Loadings.mxd 11/22/2021 4:00:53 PM



\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\Phosphorus Loading and Reductions\Phosphorus Loadings.mxd 11/22/2021 3:55:11 PM



\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\Phosphorus Loading and Reductions\Phosphorus Loadings.mxd 11/22/2021 3:52:45 PM



Sensitive Areas

Watershed

Green Lake

Middle Lake

Mill Lake

Phosphorus Load (lb/yr)

< 5 | 5 - 33 | 33 - 43 | 43 - 165 | > 165

N

Lauderdale Lakes
Green Lake Phosphorus Loading

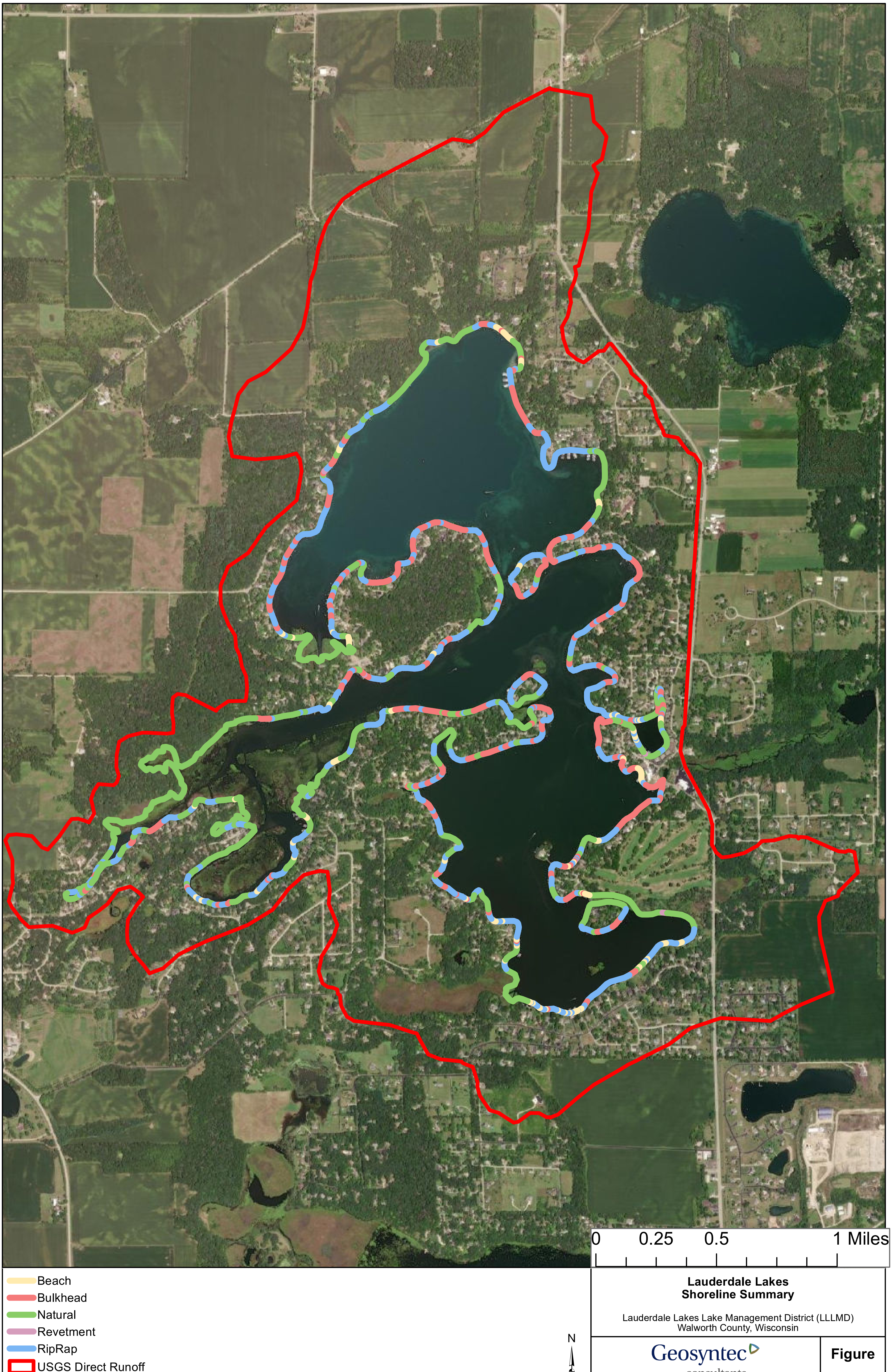
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Mequon, WI - MOW5536 | November 2021

Figure 10C

\\Oakbrook-01\Data\prj1\WATER RESOURCES - 1840\MOW5536 - Lauderdale Lakes Wsd Grant\GIS\Phosphorus Loading and Reductions\Phosphorus Loadings.mxd 11/22/2021 3:48:40 PM



Lauderdale Lakes Shoreline Summary

Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Figure 11

Mequon, WI - MOW5536 | November 2021

C:\Users\MKDempsey\Documents\ArcGIS\Packages\11. Shoreline Summary_A4361040-A82B-4C7B-8FBF-7029A6E0111C\v107\3.A Shoreline Summary.mxd 11/22/2021 11:16:00 AM

- Shoreline
- Lauderdale Lake Watershed Boundary (Stream Stats)
- Sensitive
- Waterbodies

N

Lauderdale Lakes
Wave Analysis

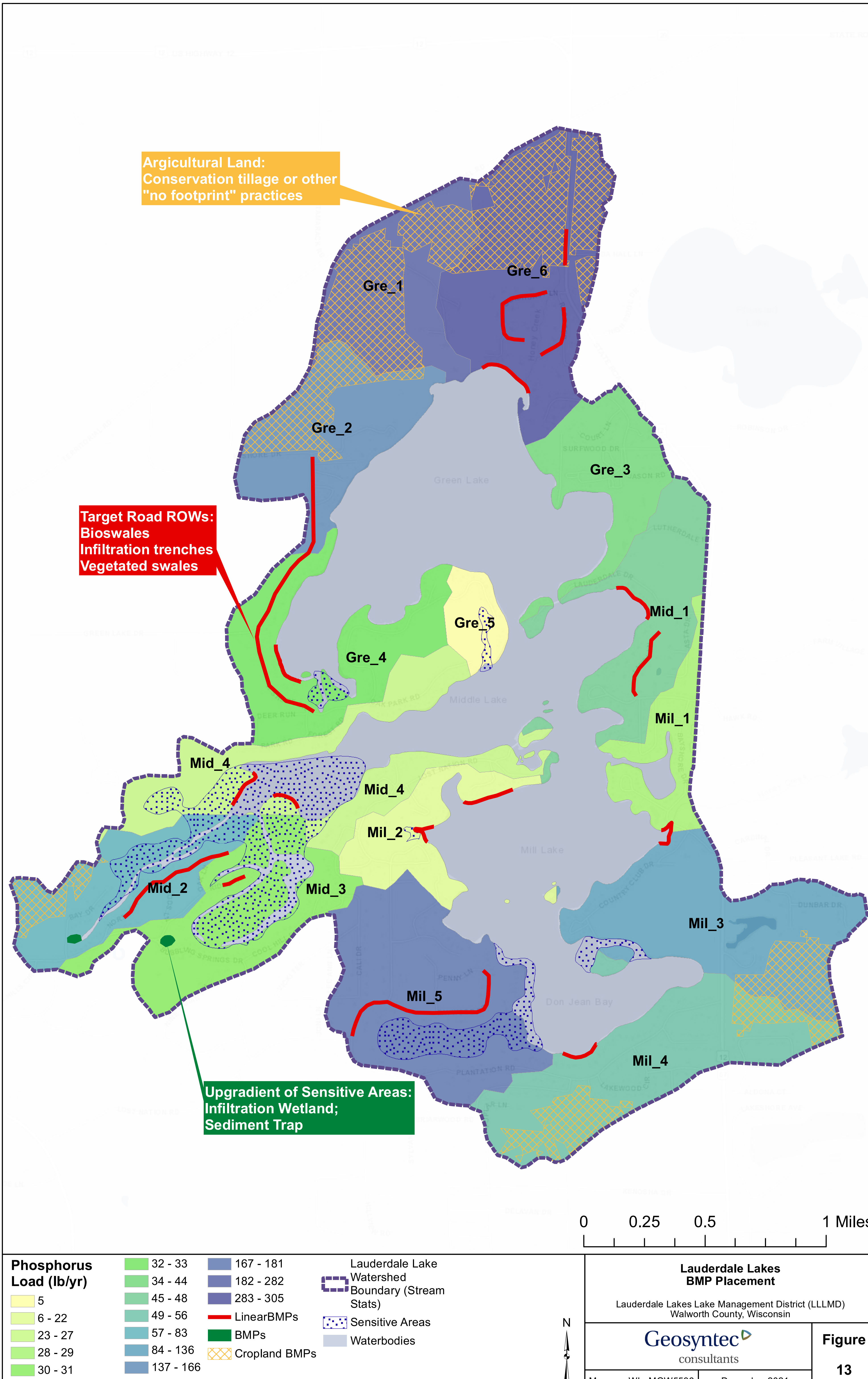
Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Mequon, WI - MOW5536 | November 2021

Figure
12

C:\Users\MKDempsey\Documents\ArcGIS\Packages\12. Wave Analysis_46515018-C98D-432C-993B-0307D869D358\v108\3. Wave Analysis.mxd 11/22/2021 11:12:03 AM



C:\Users\lhauser\Documents\ArcGIS\Packages\13. BMP Placement_E96198B1-5E03-45C2-A402-B3B5FB99D188\v10\5. Loadings Workmap.mxd 12/2/2021 9:38:55 AM

Appendix B: September 2021 Site Visit

GEOSYNTEC CONSULTANTS
Photographic Record

Project: Lauderdale Lakes (MOW5536)	**Site Location:** Walworth County, Wisconsin
Weather: 71°F, dry and sunny; during previous day the area experienced 0.02 inches of rain.	

Photograph 1

Date: September 8, 2021

Direction: East

Comments: Culvert 1 located under private driveway on Territorial Road. Western side of driveway.

Photograph 2

Date: September 8, 2021

Direction: West

Comments: Culvert 1 located under private driveway on Territorial Road. Eastern side of driveway.

GEOSYNTEC CONSULTANTS **Photographic Record**	
Project: Lauderdale Lakes (MOW5536)	**Site Location:** Walworth County, Wisconsin
Weather: 71°F, dry and sunny; during previous day the area experienced 0.02 inches of rain.	

Photograph 3

Date: September 8, 2021

Direction: West

Comments: Culvert 2 located under private driveway on Territorial Road. Eastern side of driveway.

Photograph 4

Date: September 8, 2021

Direction: N/A

Comments: Approximate diameter of Culvert 2 shown to be 12 inches.

GEOSYNTEC CONSULTANTS
Photographic Record

Project: Lauderdale Lakes (MOW5536)	**Site Location:** Walworth County, Wisconsin
Weather: 71°F, dry and sunny; during previous day the area experienced 0.02 inches of rain.	

Photograph 5

Date: September 8, 2021

Direction: Northeast

Comments: Culvert 2 located under private driveway on Territorial Road. Western side of driveway.

Photograph 6

Date: September 8, 2021

Direction: Northwest

Comments: Culvert 3A located on the east side of Highway H; could not access west side. Culvert 3B located on the south side of Green Lake Drive. Both culverts appeared dry and surrounded by overgrown vegetation.

GEOSYNTEC CONSULTANTS
Photographic Record

Project: Lauderdale Lakes (MOW5536)	**Site Location:** Walworth County, Wisconsin

Weather: 71°F, dry and sunny; during previous day the area experienced 0.02 inches of rain.

Photograph 7

Date: September 8, 2021

Direction: N/A

Comments: Approximate diameter of Culvert 3B measured at 24 inches; Culvert 3A assumed to be the same.

Photograph 8

Date: September 8, 2021

Direction: South

Comments: Culvert 3B located on the north side of Green Lake Drive.

GEOSYNTEC CONSULTANTS
Photographic Record

Project: Lauderdale Lakes (MOW5536) | **Site Location:** Walworth County, Wisconsin

Weather: 71°F, dry and sunny; during previous day the area experienced 0.02 inches of rain.

Photograph 9

Date: September 8, 2021

Direction: North

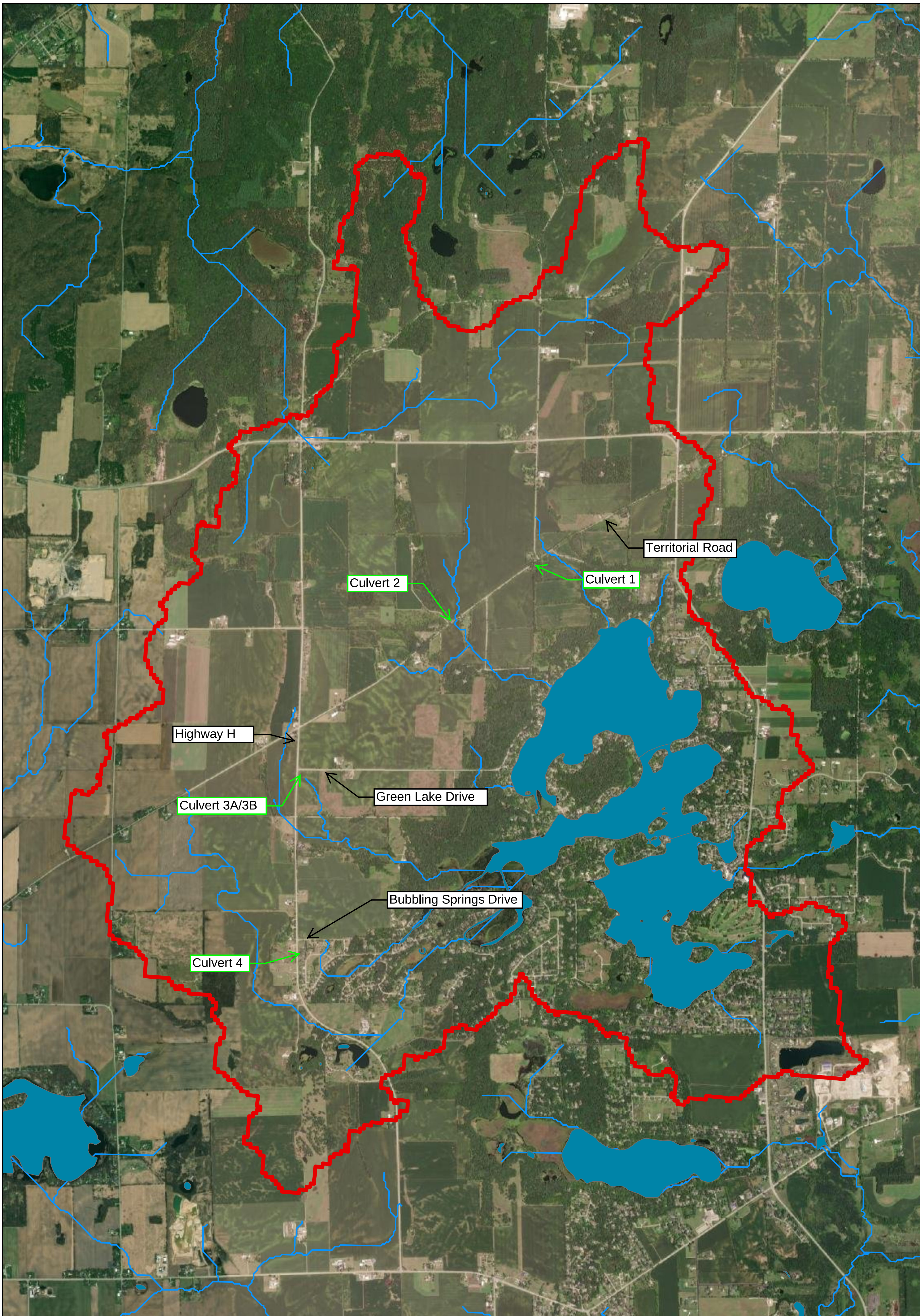
Comments: Culvert 4 located possibly on private property along Highway H just south of Bubbling Springs Drive. Utility poles were also located near this culvert (within 10 feet). Conditions in and around pipe were dry; other end of culvert not located.

Photograph 10

Date: September 8, 2021

Direction: N/A

Comments: Approximate diameter of Culvert 4 measured at 18 inches.



WDNR Identified Lakes/Ponds

Lauderdale Lake Watershed Boundary (Stream Stats)

Overland Flow Path

Overlad flow paths defined using ArcGIS builtin Arc Hydro function and Walworth County one foot contours.

N

Lauderdale Lakes Watershed Boundary Map

Lauderdale Lakes Lake Management District (LLLMD)
Walworth County, Wisconsin

Geosyntec consultants

Mequon, WI - MOW5536 | June 2021

Figure 2

E:\Lauderdale Lakes\Existing Conditions Assessment\MXDs\Watershed Hydrology.mxd 6/2/2021 8:34:04 PM

Appendix C: Previous Watershed Reports

USGS Hydrology and Water Quality of Lauderdale Lakes Report (1996)

HYDROLOGY AND WATER QUALITY OF LAUDERDALE LAKES, WALWORTH COUNTY, WISCONSIN, 1993–94

By Herbert S. Garn, Daniel L. Olson, Tracy L. Seidel, and William J. Rose

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 96-4235

Prepared in cooperation with the
LAUDERDALE LAKES LAKE MANAGEMENT DISTRICT

Madison, Wisconsin
1996

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
6417 Normandy Lane
Madison, WI 53719

Copies of this report can be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225-0286

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To Obtain
inch (in.)	25.4	millimeter
inch (in.)	25,400	micrometer
mile (mi)	1.609	kilometer
pound (lb)	453.6	gram
acre	0.4048	hectare
foot (ft)	0.3048	meter
acre-foot (acre-ft)	1,233	cubic meter
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
pound per square mile (lb/mi^2)	0.175	kilogram per square kilometer
gallon per day (gal/d)	3.785	liter per day
gram per square meter per year ($g/m^2/yr$)	0.0002	pound per square foot per year

Temperature can be converted to degrees Celsius (°C) or degrees Fahrenheit (°F) by use of the equations:

°C = 5/9 (°F-32).

°F = 9/5 (°C) + 32.

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter (µg/L) is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million. Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm).

Hydrology and Water Quality of Lauderdale Lakes, Walworth County, Wisconsin, 1993–94

By Herbert S. Garn, Daniel L. Olson, Tracy L. Seidel, *and* William J. Rose

Abstract

Water and phosphorus budgets were determined for the Lauderdale Lakes (the interconnected Green, Middle, and Mill Lakes) in Walworth County, southeastern Wisconsin to provide background information for a wastewater management plan to limit the input of phosphorus to the lakes. The most significant components of the water and phosphorus budgets were determined independently by intensive data collection from November 1993 through October 1994. In addition to development of the water and phosphorus budgets, in-lake water quality, and trophic state of the lakes were evaluated.

The lakes (treated as one lake with three basins) have a total surface area of 807 acres. The lakes have a surface-water outlet, but have no major surface inlets. Lake level is controlled by a dam and weir at the outlet. Maximum depths of Green, Middle, and Mill Lakes are about 60, 50, and 50 feet, respectively. The total drainage area of the lakes measured from the outlet is 16.1 square miles; only about 2.5 square miles, however, contribute surface runoff directly to the lake. About 70 percent of the 14.7-mile shoreline length is developed. Shoreline development includes 1,010 houses, of which about 30 percent are used year-round.

Ground water and precipitation are the primary water-budget inflow components, and during the study period represented 72 and 24 percent of the total annual inflow, respectively. Surface-water inflow from the small nearshore contributing drainage area accounted for only 4 percent of the inflow budget. Total annual phosphorus input to the lakes was 846 pounds. Although surface water accounted for only 4 percent of the water budget, it represented 51 percent of the total annual phosphorus input. Phosphorus input from septic systems was the second largest source, with a probable annual input of 210 pounds, accounting for 25 percent of the total. Positive ground-water gradients to the lake and phosphorus concentrations in ground water were verified by data from nearshore observation wells. Phosphorus concentrations in ground water exceeded background concentrations of 0.008 milligrams per liter in three out of six observation wells in the inflow area of the lakes. Overall, the phosphorus loading to the lakes is small and lake-water quality is good. The trophic state indices calculated for the lakes ranged from oligotrophic to mesotrophic but were in the mesotrophic class for most of the year. An equation to predict phosphorus concentration at spring turnover from loading estimates was fairly accurate in predicting the measured phosphorus concentration for Lauderdale Lakes.

INTRODUCTION

The Lauderdale Lakes are a chain of three interconnected lakes—Green, Middle, and Mill Lakes—in north-central Walworth County in southeastern Wisconsin (fig. 1). The lakes are about 6.5 mi north of Elkhorn and 9 mi southeast of Whitewater, Wis.

Residents along the shore have expressed concern about water quality of the lakes, including problems with increased macrophyte growth since about 1990. Macrophytes (rooted aquatic plants) grow in high densities that interfere with boating and swimming in the shallower bays of the lakes. About 60 percent of macrophytes are Eurasian watermilfoil (G.T. Petersen, Lauderdale Lakes Lake Management District, oral commun., 1993). Macrophytes have been harvested since 1991 in the areas of heavy growth, primarily in Middle and Mill Lakes. In 1994, an estimated wet weight of 565.6 tons of plant material was removed from the lakes (Douglas Rubnitz, Lauderdale Lakes

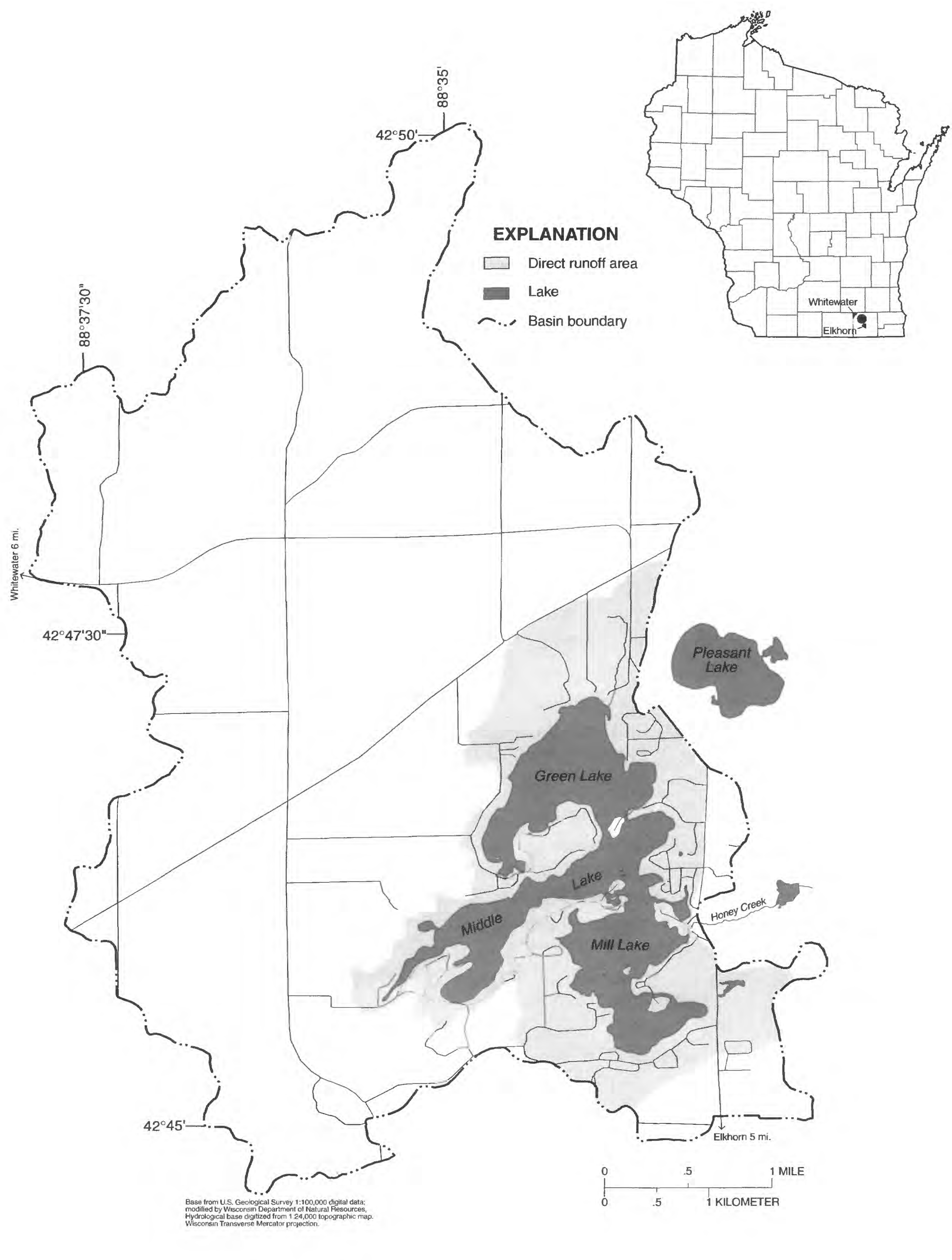


Figure 1. Location of Lauderdale Lakes (Green, Middle, and Mill) drainage basin, Walworth County, Wisconsin, and direct-runoff area.

Lake Management District, written commun., 1995). The Lauderdale Lakes Lake Management District began large-scale harvesting of macrophytes in 1991, which had not been necessary since the 1950's (Southeastern Wisconsin Regional Planning Commission, 1991). The Lake District also began inspections of individual wastewater systems around the lake and was concerned over the number of failing septic systems.

The Lauderdale Lakes Improvement Association has been conducting periodic lake monitoring since the late 1970's. Historical in-lake water-quality data are available for the lakes beginning in 1979, and earlier in-lake data collected by others are available back to 1973 (G.T. Petersen, written commun., 1993). The lake association had contracted with a consultant to collect chemical data during spring turnover every 3 years. This triennial sampling indicated that total phosphorus concentrations in the spring for the three lakes ranged from 10 to 37 µg/L. Concentrations greater than 20 µg/L are commonly considered indicative of eutrophic conditions. Secchi-disc depth measurements ranged from 6.1 to 14.3 ft.

The Lake Management District intends to prepare a wastewater-management plan to limit the input of phosphorus to the lake. Additional information on the hydrology of the lakes and on sources and amounts of phosphorus entering the lakes is needed. Moreover, determination of the trophic state of the lakes is needed for evaluating the effectiveness of the plan. To collect and interpret the necessary information, the U.S. Geological Survey (USGS), in cooperation with the Lauderdale Lakes Lake Management District, studied the lakes during 1993–94. Results of this study may be useful to local and State agencies for developing and assessing lake and watershed management plans and for maintaining or improving lake-water quality.

Purpose and Scope

This report describes the water budget of the lakes, current lake-water quality, major phosphorus loads and a phosphorus budget for the lakes, and the trophic state of the lakes. The report gives water and total phosphorus budgets for Lauderdale Lakes from November 1, 1993, through October 31, 1994, and describes the phosphorus loading in relation to the trophic state of the lakes. Data were collected from October 1993 through October 1994. Specific data collected during the study have been published separately (Holmstrom and others, 1995; Wisconsin District Lake-Studies Team, 1995).

Acknowledgments

The authors thank Gerald T. Petersen and Charles H. Sharpless of the Lauderdale Lakes Lake Management District for their support and assistance during the study. Many thanks also go to local observers Curt Rinda, Robert Skor, Frank Bell, and Joseph Volpe. Curt Rinda recorded daily precipitation and pan evaporation and collected runoff samples; Robert Skor, Frank Bell, and Joe Volpe watched for storms and assisted in collecting runoff samples. Partial funding for this study was provided by the Lake Planning Grant Program of the Wisconsin Department of Natural Resources.

LAKE AND DRAINAGE-BASIN CHARACTERISTICS

The Lauderdale Lakes are ground-water drainage lakes; that is, inflow is primarily from ground water and outflow is by a surface outlet (Shaw and others, 1993). The drainage area of the lakes measured from the outlet is 16.1 mi^2 (Henrich and Daniel, 1983); most of this area, however, does not contribute surface runoff to the lake. Some of the listed drainage areas for these topographically defined watersheds include areas of closed depressions, or noncontributing areas. The area contributing surface runoff to the lakes—called the direct-runoff area in this report—was delineated on a topographic map on the basis of field observations and was digitized to compute area, which (excluding the lakes) is 1,580 acres (fig. 1).

Topography of the basin is generally hilly to rolling, and local relief is 50 to 100 ft. Most of the area is used for agriculture (Southeastern Wisconsin Regional Planning Commission, 1991). Surface materials in the basin are typical of glacier end moraines and glaciated uplands, with pitted outwash and other ice-contact deposits (Borman, 1976; Haszel, 1971). Moderately deep to deep soils are well drained and are underlain by a subsoil of clay loam. Unconsolidated surface deposits are mainly sand and gravel that are extremely well drained but poorly sorted and stratified. The deposits are relatively thick, generally about 100 to 400 ft thick over dolomite bedrock (Mudrey and others, 1982; Borman, 1976). The saturated thickness of the sand and

Table 1. Physical characteristics of Lauderdale Lakes, Walworth County, Wis.

Characteristic	Amount
Lake type: Ground-water drainage lake	
Lake surface area	807 acres[1]
Total drainage basin area	9,500 acres
- Contributing area of direct surface runoff	1,600 acres[2]
Shoreline length	14.7 miles
- Shoreline developed	70 percent
Volume	11,560 acre-feet[3]
Mean depth	14.3 feet
Maximum depth	57 feet

[1]Excludes islands; digitized from 1:24,000-scale topographic map.
[2]See text for explanation.
[3]For water-surface elevation of 884.60 feet above sea level.

gravel materials in the drainage area of the lakes ranges from less than 100 to 300 ft. Hydraulic conductivities for the sand and gravel aquifer range from about 80 to 400 ft/d. The general direction of ground-water flow in the vicinity of Lauderdale Lakes is eastward. Concentrations of dissolved solids and hardness in ground water in the sand and gravel aquifer are very high; median concentrations are about 350 and 330 mg/L, respectively.

The revised total surface area of the lakes is 807 acres (excluding islands): Green Lake, about 298 acres; Middle Lake, 245 acres, including a 120-acre shallow marshy area at the west end; and Mill Lake, 264 acres. The large bay (Don Jean Bay) on the south end of Mill Lake is less than 5 ft deep. A bathymetric map of the lakes surveyed in 1966 listed the lakes' surface area as 834 acres and volume as 12,700 acre-ft (Wisconsin Department of Natural Resources, written commun., 1993). Depth contour lines on this map were digitized and areas and volumes were recalculated. The physical characteristics of the lakes are summarized in table 1. Maximum depths of Green, Middle, and Mill Lakes are about 60, 50, and 50 ft, respectively. About 60 percent of Middle Lake and 47 percent of Mill Lake is equal to or less than 5 ft deep.

The lakes have a surface-water outlet on the southeast side (Honey Creek) but no major inlets. Surface water enters the lakes from the direct runoff area by way of a few ephemeral drainageways or as overland flow. Lake level is controlled by a dam and flow over a weir at the outlet. The lake level, which fluctuates little, is maintained at a minimum elevation of 883.96 ft set by the Wisconsin Department of Natural Resources (Joseph Skidmore, WDNR, written commun., 1994). The original dam was constructed in the mid-1800's for the operation of a sawmill; the present-day dam was constructed in 1962.

The 14.7 mi shoreline is about 70 percent developed, primarily as single-family housing units on small lots (Southeastern Wisconsin Regional Planning Commission, 1991). Shoreline developments include 1,010 houses, of which about 30 percent are year-round residences (1990 census data); the remainder are seasonal homes (G.T. Petersen, oral commun., 1995; Tim McCauley, Southeastern Wisconsin Regional Planning Commission, written commun., 1995). Other developments around the lakes include a golf course, a boat marina, and condominiums on Mill Lake; and a Girl Scout camp, a large Bible camp, a densely developed trailer park, and condominiums on Green Lake. The area is a focus for significant urban development, which is accelerating. In many cases, land some distance from the lake has been subdivided and developed. An aerial photograph of the Lauderdale Lakes area is included at the front of this report.

METHODS OF DATA COLLECTION AND ANALYSIS

The general equation describing the water budget of Lauderdale Lakes can be stated as "Inflow plus precipitation equals outflow plus evaporation plus change in storage," and can be written as follows:

$$\Delta S = P+S_i+G_i-E-S_o-G_o, \qquad (1)$$

where

ΔS is change in lake storage,
P is precipitation on the lake,
S_i is surface-water inflow to the lake,
G_i is ground-water inflow to the lake,
E is evaporation from the lake,
S_o is surface-water outflow from the lake, and
G_o is ground-water outflow from the lake.

The significant components of the lake's water budget were measured directly. The greatest emphasis on data collection was directed toward those components that were expected to be the most important in the phosphorus budget.

Data-collection sites used in the study are shown in figure 2. Data collection began in October 1993 and continued through October 1994, with emphasis on the open-water period. Budget components that were not

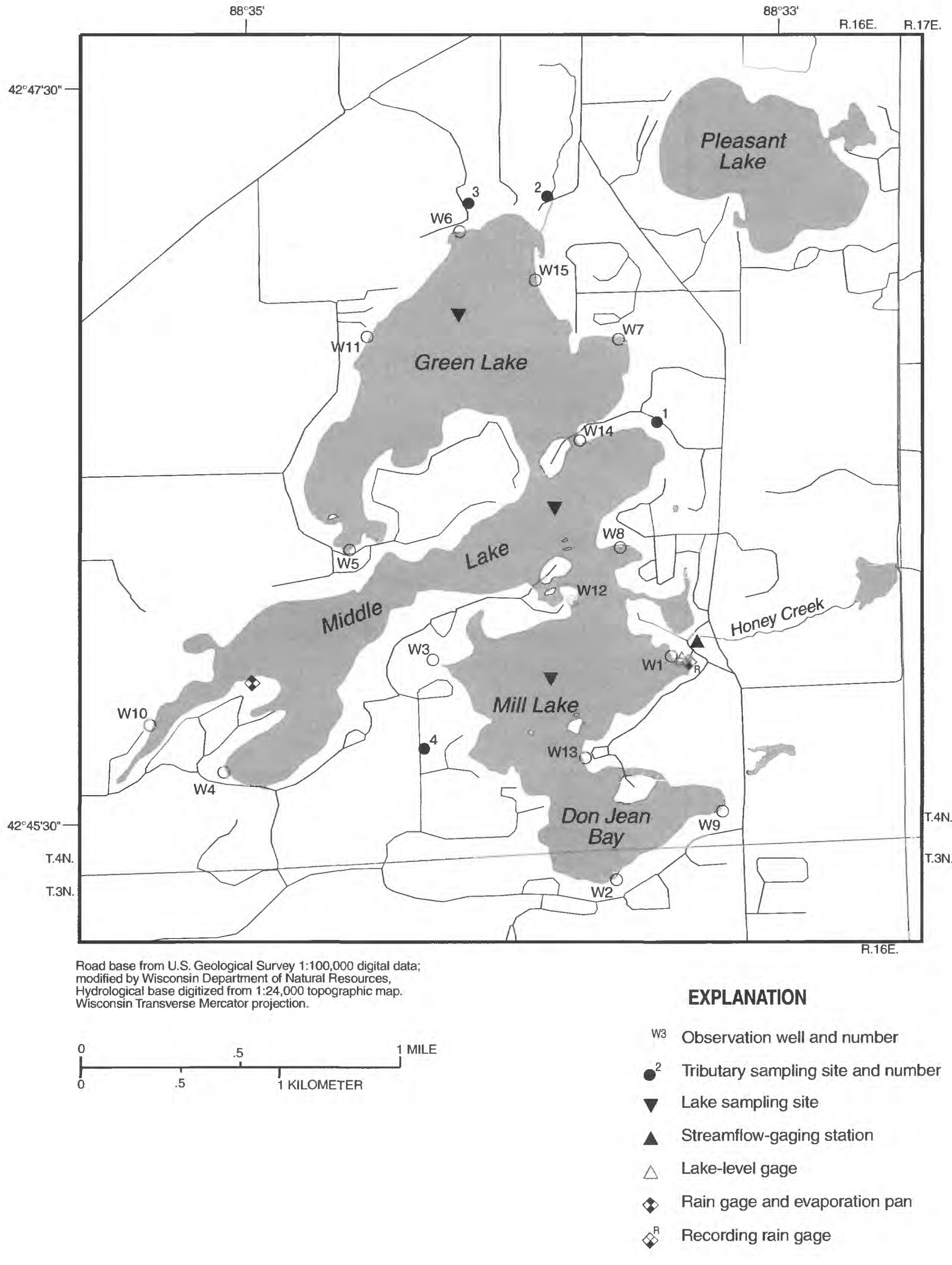


Figure 2. Location of data-collection sites at Lauderdale Lakes, Walworth County, Wisconsin, October 1993–October 1994.

measured directly were estimated from data collected at nearby sites, data from the scientific literature, and reconnaissance data or observations from the study area.

Measurement of Precipitation and Evaporation

Precipitation was measured with rain gages at two sites from June through October 1994 (fig. 2). One of the gages, an 8-in.-diameter recording rain gage, at the lake-level gage near the outlet, recorded rainfall at 15-minute intervals. The other, a nonrecording gage on the west end of Middle Lake, was read daily by a local observer. An average of the two gages was used. Precipitation records from the National Weather Service stations at Whitewater and Eagle (National Oceanic and Atmospheric Administration, 1994) were used for the remainder of the year when these gages were not operating.

Lake-evaporation estimates were based on evaporation from a Class A evaporation pan at the nonrecording rain gage on the west side of Middle Lake and from pan evaporation data at the National Weather Service station at Arlington University Farm. A local observer recorded pan readings daily from June through October 1994. A pan coefficient of 0.77 was used to convert pan evaporation to lake evaporation (Farnsworth and others, 1982).

Measurement of Lake Stage and Contents

The water level of Lauderdale Lakes was recorded at 15-minute intervals at a gage in the bay near the dam. The datum at 0.00 ft gage height of the gage is at an elevation of 879.57 ft above mean sea level. Lake-storage volume and a lake-stage/lake-volume relation were derived by digitizing the bathymetric map of the lake basin. Changes in lake storage were computed by use of lake stage measurements from the recording gage.

Measurement of Streamflow and Estimation of Runoff

Although no major streams flow into the lakes, direct runoff can flow into the lakes during snowmelt and heavy rainfall. Runoff from small ephemeral streams enters Green Lake on the north side (site 2, drainage area of 79 acres; site 3, drainage area of 91 acres), Middle Lake on the east side (site 1, drainage area of 35 acres), and Mill Lake (site 4, drainage area of 11 acres); drainageways in the remaining areas are absent or poorly defined. A constructed drain in a large swale area (about 80 acres) on the south side of Don Jean Bay that was not monitored directs surface runoff from lawns and streets directly into the lake (fig. 3). Runoff was monitored at four sites tributary to the lakes (fig. 2) by observers who recorded flow depths and velocities and by multistage point samplers (J.D. Dewey, U.S. Geological Survey, written commun., 1978). Estimates of surface runoff were estimated on the basis of observations of magnitude and duration of runoff at these sites and comparison with data from nearby USGS recording streamflow gages. Hydrograph separation into base flow and direct runoff components (Chow, 1964, p. 14–11) was applied to the discharge records (Holmstrom and others, 1995) from the USGS gaging stations on Jackson Creek near Elkhorn (05431014) and Jackson Creek Tributary near Elkhorn (054310157).

Surface water leaves the lake through the weir at Lauderdale into Honey Creek. Surface-water outflow from Lauderdale Lakes was monitored by a continuous-recording gage on Honey Creek immediately downstream from the dam. Streamflow data were collected and were processed according to procedures described by Rantz and others (1982).

Estimation of Ground-Water Flow

Fifteen shallow, 1/2-in.-small-diameter piezometers (observation wells) were installed along the shoreline of Lauderdale Lakes (fig. 2) to determine vertical hydraulic gradients and to collect samples of ground water for the determination of dissolved phosphorus concentrations. Piezometers were installed within 14 ft of the water's edge—on the average, 4 ft from the water's edge. Water levels in the piezometers were measured monthly.

Ground-water inflow and outflow were estimated by use of the Darcy equation according to a method used by Rose (1993) in a similar study of Balsam Lake in northwestern Wisconsin, and by Goddard and Field (1994) in a study of Whitewater and Rice

Figure 3. Constructed drain that carries surface runoff into Don Jean Bay of Mill Lake.

Lakes in southeastern Wisconsin. A detailed description of the method is given by Rose (1993).

Several simplifying assumptions about ground-water flow and its relation to the lakes were necessary because the scope of the study did not allow for more vigorous analysis. Ground-water exchange with the lake was assumed to be at a steady state; that is, the rate and direction of flow through the lake bottom at any location did not vary with time. This assumption was justified because the hydraulic gradient was determined for 5 to 12 dates at the piezometer sites and the gradients did not vary significantly with time.

The method that was used to calculate ground-water flow requires a value for the hydraulic conductivity ratio (k_i/k_o), where k_i is the vertical hydraulic conductivity of inflow areas and k_o is the vertical hydraulic conductivity of outflow areas. A ratio of 5 was used for this study. The rationale for using different values for inflow and outflow areas is explained in Rose (1993).

Sampling of Lake Water, Streamwater, and Ground Water for Determination of Water Quality

Physical and chemical sampling of Lauderdale Lakes was done once each month in November 1993 and April, October, and November 1994 and twice each month in May through September 1994. Three sites were sampled (fig. 2) at the deepest part of each lake: Green Lake has a depth of 57 ft; Middle Lake, a depth of 52 ft; and Mill Lake, a depth of 52 ft. All water samples were analyzed by the Wisconsin State Laboratory of Hygiene using standard analytical methods (Wisconsin State Laboratory of Hygiene, 1993).

Depth profiles of water temperature, specific conductance, pH, and dissolved oxygen were determined at all lake sites by use of a multiparameter water-quality meter. The meter was calibrated to known standards before lake monitoring began. The dissolved-oxygen function of the meter was calibrated by use of the air-calibration method and was checked on the lake by the Winkler method. Depth-profile readings were made at 3-ft intervals.

Discrete water samples were collected 1.5 ft below the lake surface by use of a Kemmerer-type water sampler and at 1.5 ft above the lake bottom by use of a horizontal (alpha) Van Dorn-type sampler. Two additional samples were collected at depths based on thermal stratification—one near the bottom of the epilimnion (the upper warmer, mixed layer) and the other near the middle of the hypolimnion (the lower, cooler layer of the lake). Samples collected for dissolved constituents were filtered in the field with a filtering unit equipped with a 0.45-µm-pore-size filter. Samples for determination of chlorophyll *a* concentration were collected from the top 1.5 ft of the lakes at each site by use of a Kemmerer-type sampler and filtered through a 5.0-µm-pore-size filter.

Water outflow from Lauderdale Lakes was sampled for determination of total phosphorus concentration. Flow-integrated samples were collected manually by use of the equal-width-increment (EWI) method (Edwards and Glysson, 1988). Water samples were collected approximately monthly at the lakes' outlet to determine the amount of phosphorus leaving the lakes in surface outflow. Total phosphorus discharge in the outflow was calculated by use of the streamflow and concentration integrating technique described by Porterfield (1972).

Water samples for determination of total phosphorus were collected by local observers and USGS personnel at the mouths of four ephemeral streams entering the lakes. Surface runoff to Lauderdale Lakes was sampled for total phosphorus concentration during storm and snowmelt runoff. Two sites tributary to Green Lake, one site tributary to Middle Lake, and one site tributary to Mill Lake were monitored (fig. 2). Samples at these sites were obtained by observers taking "grab" (bottle-dipped) samples and by the use of multistage point samplers.

Water samples for determination of dissolved phosphorus concentration were collected approximately monthly from the observation wells by use of a peristaltic pump. Samples were filtered in the field with a filtering unit equipped with a 0.45-µm-pore-size filter.

HYDROLOGY

Precipitation and Evaporation

The total precipitation for the study year was 25.65 in. (fig. 4), about 83 percent of the long-term (1961–90) average annual precipitation based on the record at Whitewater. The long-term average annual precipitation at Whitewater is 32.44 in. (Pamela Naber-Knox, Wisconsin State Climatologist, University of Wisconsin-Extension, written commun., 1995). Evaporation for the study period was 26.23 in.

Lake Storage

Water-level fluctuations for Lauderdale Lakes are shown in figure 4. Stage is referenced to the datum of the gage (879.57 ft above sea level). During November 1993 through October 1994, stage fluctuated 0.63 ft, from a low of 4.79 ft on January 21, 1994 to a high of 5.42 ft on December 6 and 10, 1993. The corresponding lake storage fluctuated 494 acre-ft, from 11,390 to 11,880 acre-ft.

Streamflow and Runoff

Because no perennial streams flow into Lauderdale Lakes, ephemeral surface runoff from the nearshore contributing drainage area and drainageways was estimated for November 1993 through October 1994 by a runoff and drainage-area comparison with Jackson Creek and Jackson Creek Tributary near Elkhorn (Holmstrom and others, 1995). These creeks, whose drainage areas are 8.96 and 4.34 mi^2, respectively, have a base-flow component, and their hydrographs were separated to determine the direct-runoff component. Runoff periods so identified compared well with precipitation periods measured at Lauderdale Lakes.

Two methods were used to estimate runoff to the lakes from results of the hydrograph separation. In the first method, the unit-area direct runoff from the hydrograph separation of the comparison drainages was applied to the nearshore contributing area, resulting in an estimated 370 acre-ft of runoff. In the second method, results from the hydrograph separation were combined with observations and estimates of peak flows at the four monitored ephemeral drainages. On

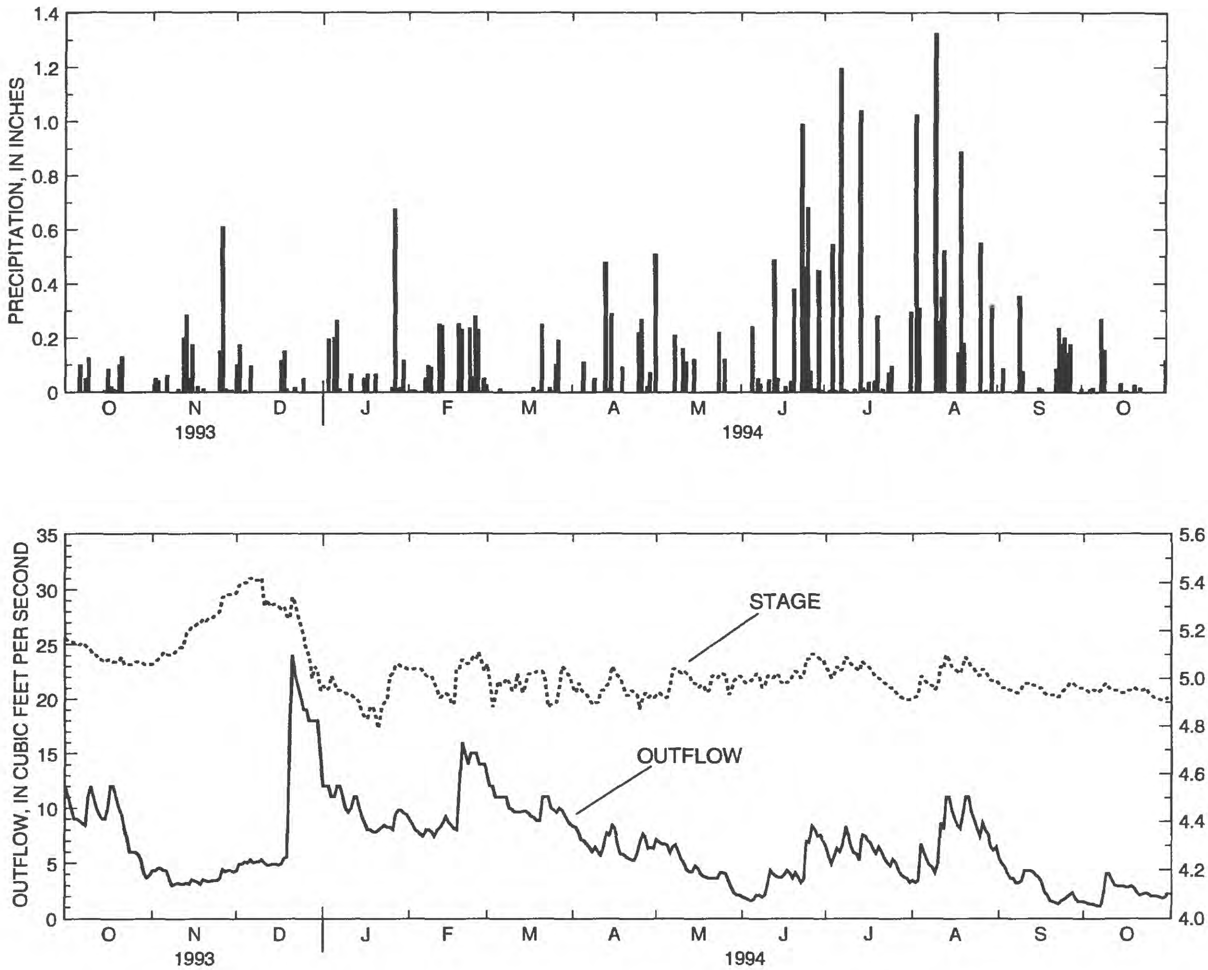


Figure 4. Daily precipitation, outflow from, and stage for Lauderdale Lakes, Walworth County, Wis., October 1993–October 1994.

the basis of the runoff at Jackson Creek, a major event on February 18–20, 1994, represented as much as 70 percent of the annual direct runoff. Rainfall and snowmelt depleted the entire snowpack of about 2.1 in. of water equivalent in 2 days and resulted in heavy runoff over frozen soils. Estimates of peak flow from this event and the duration of flow at the monitored drainages were made in the field, and volumes were calculated by assuming a simple triangle hydrograph. Total runoff volume for this February event was then adjusted to an annual volume of 310 acre-ft. This value was thought to be more representative than that resulting from the first estimating method and was used in subsequent analysis.

Surface-water inflow was the smallest component in the water budget for Lauderdale Lakes. The runoff observed in February on frozen ground is probably typical for this area and represents most of the annual surface-water inflow. Little runoff was observed during the summer in response to rainfall. Rainfall would have to exceed an estimated 3 to 4 in/hr (the infiltration capacity of the soils) before surface runoff would begin on unfrozen ground.

Streamflow from the outlet of Lauderdale Lakes is shown in figure 4. Mean daily outflow ranged from 1.1 ft^3/s on October 6–7, 1994 to 24.0 ft^3/s on December 21, 1993. Total outflow from the lake for the study period was 4,700 acre-ft.

Ground-Water Flow

Knowledge of the direction of ground-water flow is essential for determining those areas where contaminant transport to the lakes by ground water is possible. Any contamination from ground-water sources normally occurs where the ground-water gradients are positive, or into the lake. A water-table map prepared by Borman (1976) shows that regional ground-water movement is from west to east. Data from the near-shore observation wells installed for this study support Borman's findings. Water levels were higher than the lake surface in wells on the west side of the lakes, indicating positive gradients and flow into the lakes in these regions (fig. 5). Along the eastern shores of the lakes, water levels in the wells were generally lower than the lake surface, indicating negative gradients or outflow from the lakes in these regions. Wells W6 and W9 were in transition regions where flow directions changed during the year. Ground-water flow was always toward the lake along 54 percent of the lakes' shoreline, flow was always away from the lakes along 39 percent of their shoreline, and 7 percent of shorelines were in the transitional regions where flow direction reversed during the year.

Total ground-water inflow was about six times greater than ground-water outflow during the study period. Annual inflow to the lakes was estimated to be 5,160 acre-feet; outflow was estimated to be 850 acre-feet. Water levels in well WK-31 (Holmstrom and others, 1995), a well in Niagara Dolomite in Waukesha County, 23 mi northeast of Lauderdale Lakes, were slightly above the long-term average in November 1993, but were below average from May to December 1994. The record for this monitoring well began in 1947. Ground-water discharge to lakes is generally correlated with ground-water levels; thus, the computed inflow is probably near or slightly below the long-term average based on the water-level record at well WK-31.

Annual Water Budget

The annual water budget for the year of study (November 1993–October 1994) is shown in table 2 and figure 6. Ground water was the dominant inflow component, accounting for 72 percent of the total inflow; precipitation accounted for 24 percent. Surface-water inflow accounted for only about 4 percent of the total.

Table 2. Annual water budget for Lauderdale Lakes, Walworth County, Wisconsin, November 1993–October 1994

Budget item	Flow volume (acre-feet)	Percentage of total inflow or outflow
Inflow:		
Precipitation	1,725	24
Surface inflow	310	4
Ground water	5,160	72
Total inflow	7,195	100
Outflow:		
Evaporation	1,764	24
Surface outflow	4,700	64
Ground water	850	12
Total outflow	7,314	100
Change in lake storage	-115	
Budget residual	-4	

Surface-water outflow from the lakes into Honey Creek, the dominant outflow component in the budget, accounted for 64 percent of the total outflow volume. Evaporation, the next largest component, accounted for 24 percent of the total outflow.

The hydraulic residence time of the lakes (the average length of time water remains in the lake or the time required to replace the volume of the lake, calculated by dividing the lake volume by the volume of water passing through the lake) was about 1.6 years. Knowledge of the hydraulic residence time is important for determining the response time of the lake to changes in nutrient loading (Garn and Parrott, 1977) and is used in various lake loading models such as that by Vollenweider (1975). Flushing rate, another commonly-used term (the average number of times per year that the lake volume is replaced), is the inverse of residence time.

As mentioned previously, precipitation during the study period was about 83 percent of the normal annual precipitation. Runoff in the region also was below normal during the study year (Holmstrom and others, 1995). At the Mukwonago River at Mukwonago, northeast of the study area, streamflow for the year was 90 percent of the long-term (1973–94) average. Runoff for the year at Jackson Creek Tributary near Elkhorn was 61 percent of the 1984–94 average.

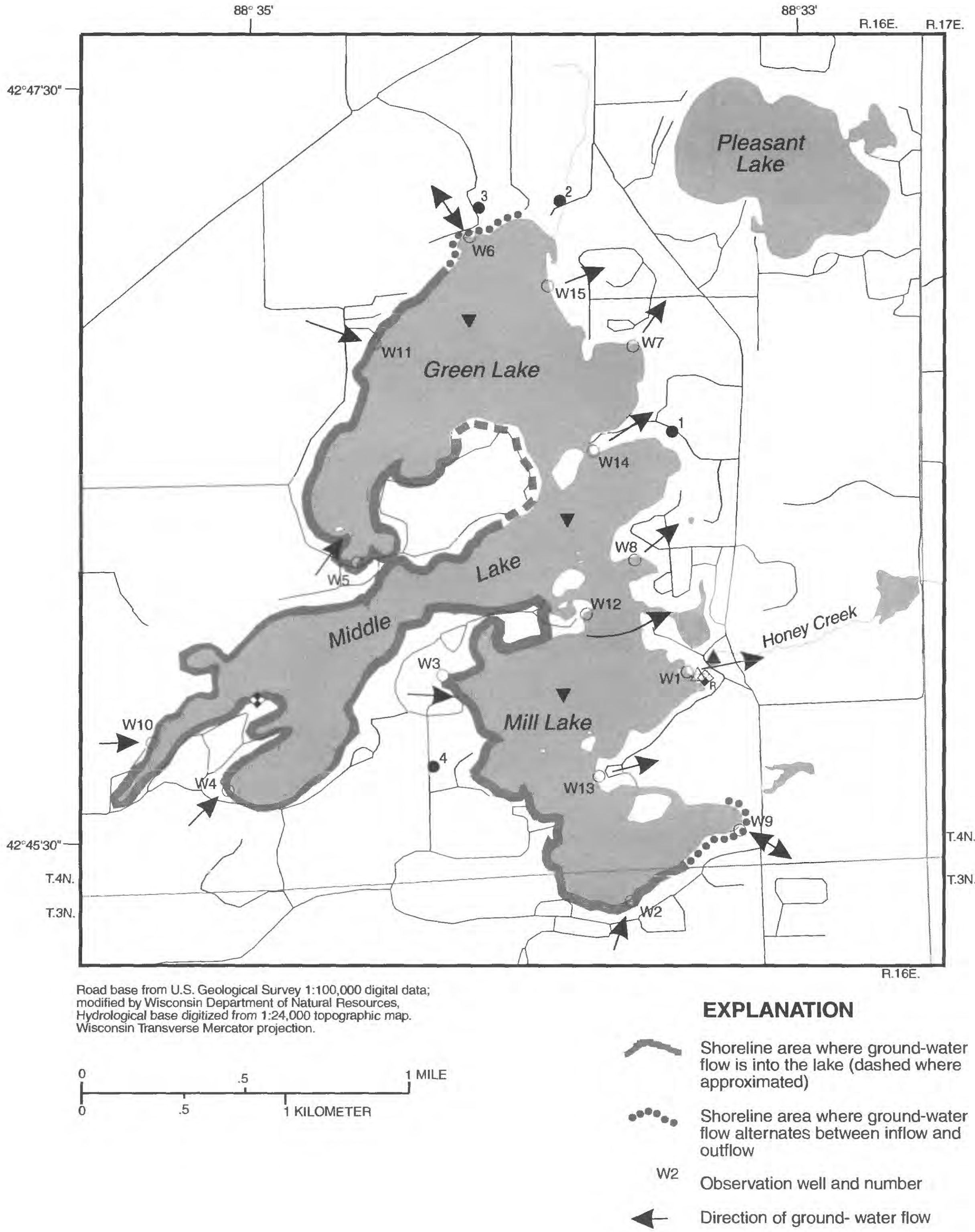


Figure 5. Location of observation wells and direction of ground-water flow at Lauderdale Lakes, Walworth County, Wisconsin.

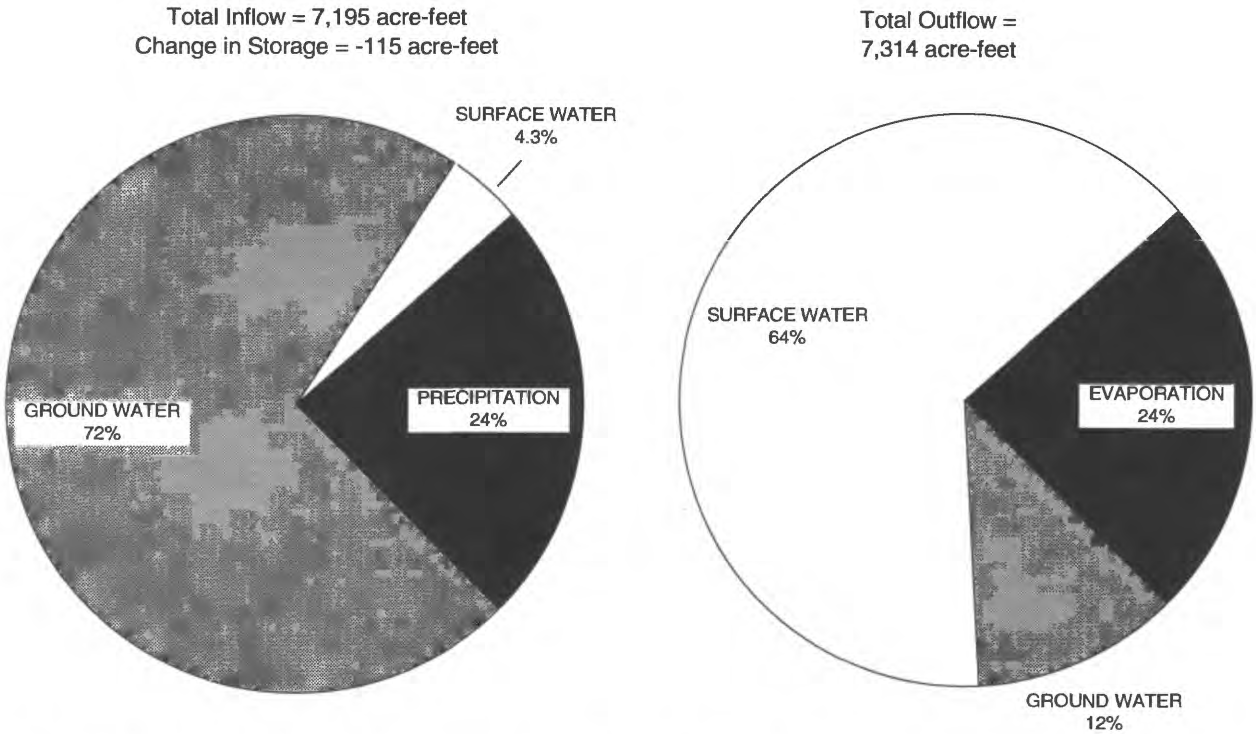


Figure 6. Annual inflows and outflows for Lauderdale Lakes, Walworth County, Wis., November 1, 1993, through October 31, 1994.

WATER QUALITY

Physical and Chemical Characteristics

Water-quality data were collected at the three Lauderdale Lakes 15 times during open-water periods between November 1, 1993 and November 30, 1994. For each sample date and lake, the data consist of water samples for total phosphorus at various depths and a surface chlorophyll *a* sample, Secchi-disc depth reading, lake-stage reading, and a depth profile of the water temperature, pH, specific conductance, and dissolved oxygen. Concentrations of major cations and anions were determined for samples collected on 3 of the 15 dates, during spring and fall turnover when the lakes were mixed. The data, including temperature and dissolved oxygen profiles, were published in the U.S. Geological Survey's annual data reports (Holmstrom and others, 1995; Wisconsin District Lake-Studies Team, 1995).

Water Temperature

Of all the sampling dates, complete water-column mixing in all three lakes was observed only on November 10, 1993, and in Middle and Mill Lakes on November 2, 1994. Almost complete mixing was observed in Green and Middle Lakes on April 18, 1994. Lauderdale Lakes are thermally stratified during the summer. In July, the epilimnion in Green, Middle, and Mill Lakes extended to a depth of about 20, 15, and 15 ft, respectively. The metalimnion in the three lakes extended to 36, 34, and 33 ft, respectively. The metalimnion is the layer of water that includes the thermocline, the zone where the greatest temperature gradient occurs, usually greater than 1°C per meter of depth (Wetzel, 1983, p. 75). The thermocline develops in the spring and reaches its maximum gradient in late summer. The hypolimnion extends from the bottom of the metalimnion to the lake bottom.

Dissolved Oxygen

In Lauderdale Lakes, dissolved oxygen concentrations at most depths and times are sufficient to support all aquatic life. At various times during the summer and at various depths in the hypolimnion, however, dissolved oxygen concentrations become insufficient for most aquatic life.

When the thermocline develops in early summer and prevents the mixing of surface and bottom water, the supply of dissolved oxygen to the hypolimnion may be cut off. The oxygen demand of decaying organic matter on the lake bottom depletes the dissolved oxygen in water near the bottom. This oxygen depletion (anoxia) begins at the lake bottom and progresses upward. The period of stratification for Green and Middle Lakes began in late May 1994, and for Mill Lake began about mid-April 1994. The stratification period ended with mixing in all three lakes about mid-October 1994. During the late summer, the hypolimnion in all three lakes became anoxic and unable to support aquatic life. The hypolimnion in Middle and Mill Lakes became anoxic on July 5, and it became anoxic in Green Lake on July 22. The anoxic zone reached a maximum of 27 feet in Green Lake on September 15, a maximum of 24 feet in Middle Lake on August 31, and 30 feet in Mill Lake on August 2 and 31.

Hypolimnetic anoxia is common in thermally-stratified eutrophic lakes. One of the concerns associated with anoxia is that phosphorus may be released internally from bottom sediments (if phosphorus concentration in the sediments is sufficiently high) during periods of anoxia and that this internal loading may represent a significant proportion of the total phosphorus load. If phosphorus concentration of the near-lake-bottom water samples is much greater than that of surface samples and increases during the summer, internal phosphorus loading is the probable cause.

Hardness

Average hardness on turnover dates for each of the three lakes, in milligrams per liter as $CaCO_3$, are given below:

Lake	11-10-93	4-18-94	11-02-94
Green	225	240	245
Middle	260	280	260
Mill	250	275	240

The overall average hardness for Lauderdale Lakes was 253 mg/L as $CaCO_3$. Water whose hardness exceeds 180 mg/L as $CaCO_3$ is described as very hard (Hem, 1985, p. 159). Hardness is caused primarily by the presence of calcium and magnesium. Calcium concentrations ranged from 38 to 42 mg/L in Green Lake, 44 to 55 mg/L in Middle Lake, and 37 to 50 mg/L in Mill Lake; magnesium concentrations ranged from 32 to 34 mg/L in Green Lake, 34 to 36 mg/L in Middle Lake, and 32 to 36 mg/L in Mill Lake. Sulfate concentrations were fairly constant for the three sampling times, averaging 30, 33, and 31 mg/L as SO_4, respectively, for each of the lakes. Chloride concentrations also were fairly consistent, averaging 19, 19, and 20 mg/L for each lake, respectively.

Hardness and concentrations of calcium and magnesium were greatest at Middle Lake because of significant discharge of ground water concentrated in several springs in the northwest shallow arm of the lake. Calcium and magnesium concentrations measured in the shallow arm were as high as 74 and 37 mg/L; hardness was 330 mg/L as $CaCO_3$, and specific conductance was about 680 µS/cm. These measurements are fairly close to those for inflowing ground water, whose specific conductance was 740 µS/cm and calcium and magnesium concentrations were 87 and 38 mg/L. Historically, residents have complained about the development of a grayish or milky coloration in the bay, usually in spring (Peter Donoghue, Lauderdale Lakes Lake Management District, oral commun., 1994; and Albert Marth, resident, oral commun., 1995), a phenomenon that was also observed in late May 1994 during this study. This recurring "whitening" of the bay is probably caused by the precipitation of calcite ($CaCO_3$) or "marl" when the photosynthesis of intensively growing macrophytes in the bay upsets the chemical equilibrium of dissolved $CaCO_3$ and CO_2 in the water (Wetzel, 1983, p. 205–206). The photosynthetic use of CO_2 by submersed aquatic plants and the resulting increase in pH is a common mechanism that induces the precipitation of $CaCO_3$ in hardwater, calcareous lakes. Artificially raising the pH in a bay-water sample by titration techniques resulted in precipitation and milky turbidity at pH of 9.5 to 10. In an intensive study at the inlet of Delavan Lake at Delavan, 10 mi south of Lauderdale Lakes, from April through September 1994, pH values in the shallow, heavily vegetated inlet to the lake commonly exceeded 9.5 in May and June and at times exceeded 10 (Holmstrom and others, 1995). The concentration of calcium and precipitation of calcite may be important in limiting the solubility of phosphate (Wetzel, 1983) and thus influencing plankton productivity. The availability of phosphorus may also be decreased by its co-precipitation with calcite.

Phosphorus

Historical phosphorus data provided by the Improvement Association for Lauderdale Lakes (G.T. Petersen, written commun., 1993) are shown in figure 7. Monitoring in the past was usually done triennially, during spring turnover. Monthly total phosphorus concentrations at the lake surface for Lauderdale Lakes, in micrograms per liter, for November 1993 through October 1994 were the following:

Month	Green Lake	Middle Lake	Mill Lake
November	12	10	11
April	5	6	9
May	8	14	10
June	9	10	13
July	8	10	14
August	7	9	13
September	10	10	14
October	14	8	11
Average	9	10	12

Total phosphorus concentrations at the lake surface were lowest in the spring and highest in the summer and fall.

Monthly concentrations of total phosphorus, in micrograms per liter, 1.5 ft above the lake bottom in Lauderdale Lakes for November 1993 through October 1994, were the following:

Month	Green Lake	Middle Lake	Mill Lake
November	13	9	10
April	8	8	46
May	16	22	66
June	25	40	80
July	40	46	108
August	53	46	44
September	42	35	38
October	([1])	87	53
Average	28	37	56

[1]Not available

Concentrations near the bottom were lowest in the spring and highest in the summer and fall. Mill Lake is the most nutrient-enriched of the three lakes. These relatively low concentrations, however, indicate that only minor amounts of phosphorus are being released from the sediments during anoxia in the summer.

The following nitrogen:phosphorus ratios were computed from concentrations in the surface samples for the three turnover dates:

Lake	11-10-93	4-18-94	11-02-94
Green	76:1	196:1	61:1
Middle	133:1	333:1	116:1
Mill	93:1	136:1	80:1

The average ratios for Green, Middle, and Mill Lakes were 111:1, 194:1, and 103:1; respectively. The data indicate that the lake is phosphorus limited. In general, a nitrogen:phosphorus ratio greater than 15:1 indicates that phosphorus is the nutrient limiting plant growth (Lillie and Mason, 1983, p. 63).

Chlorophyll *a*

Chlorophyll *a* is a green photosynthetic pigment in plant cells, including algae. Its concentration in water is commonly used as an indicator of algal biomass in lakes. Few historical data are available for chlorophyll *a* in Lauderdale Lakes. The Southeastern Wisconsin Regional Planning Commission (1991, p. 36) reported results from two studies done in 1972 and 1979. Chlorophyll *a* in Middle Lake samples collected during June, August and November 1972 ranged from 4.1 to 5.2 µg/L. Chlorophyll *a* concentrations in August 1979 were 2.8 µg/L in Green Lake, 3.2 µg/L in Middle Lake, and 3.8 µg/L in Mill Lake.

During this study, chlorophyll *a* concentration in Green Lake ranged from 0.8 to 6.9 µg/L; in Middle Lake, concentration ranged from 1.1 µg/L to 6.2 µg/L; and in Mill Lake, concentration ranged from 1.2 to 8.0 µg/L. Following are monthly chlorophyll *a* concentrations, in micrograms per liter, in Green, Middle, and Mill Lakes during the study period:

Month	Green Lake	Middle Lake	Mill Lake
November	5.6	2.0	1.9
April	0.8	2.3	4.6
May	1.4	1.4	1.8
June	5.1	4.7	4.5
July	3.4	3.6	6.7
August	2.7	3.3	7.8
September	2.2	3.4	5.1
October	6.0	3.0	5.3
Average	3.4	3.0	4.7

The average concentrations are low compared to those in other southeastern Wisconsin lakes.

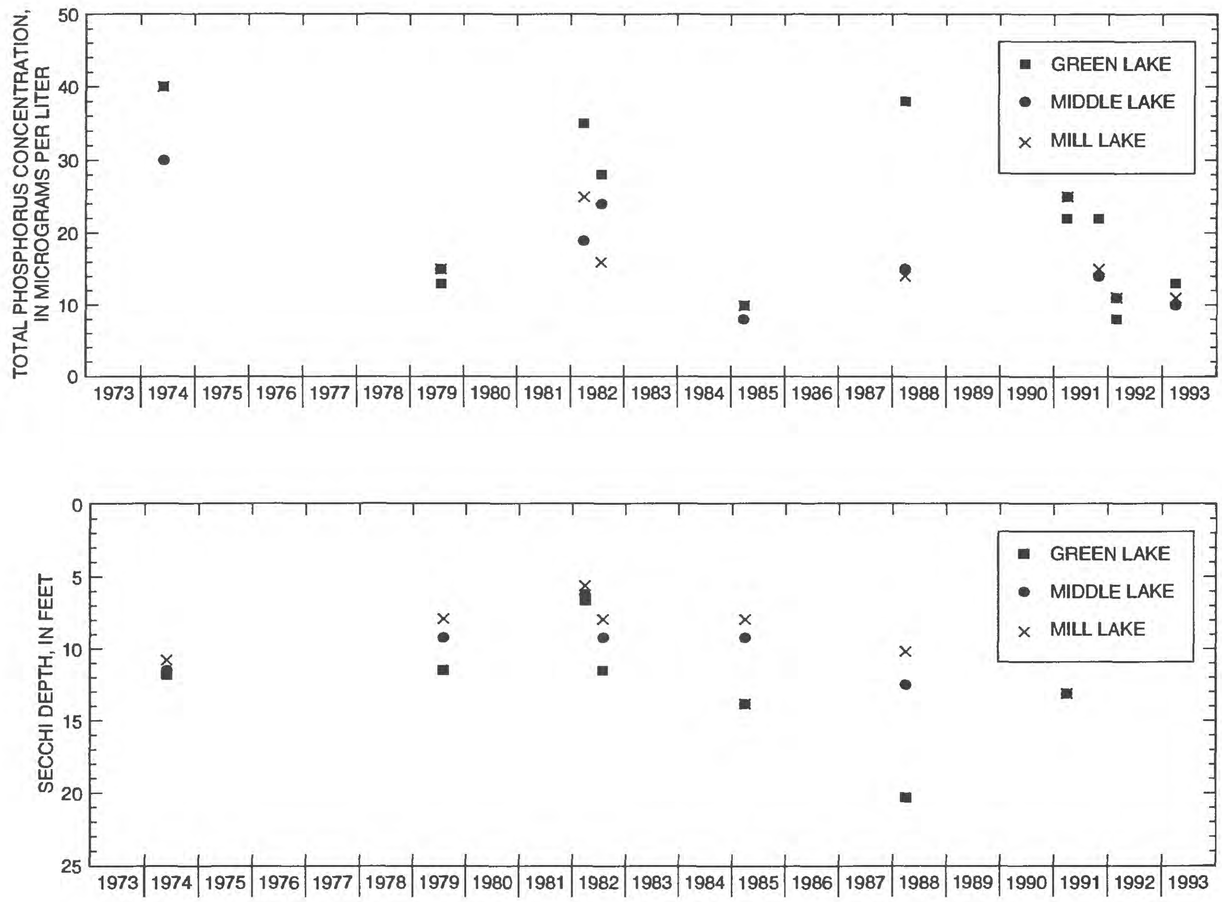


Figure 7. Historical total phosphorus concentrations at lake surface and Secchi depths for Lauderdale Lakes, Walworth County, Wis., 1973–93 (1974 value is a 3-year average for 1973–75; see text).

Water Clarity

The depth of photosynthetic activity in a lake depends on the depth of light penetration, which is influenced largely by water clarity, or transparency of the water. The Secchi disc is commonly used to measure water clarity. This device is usually an 8-in.-diameter disc with black and white alternating quadrants. The Secchi depth is the average of the depth at which the disc is no longer visible from the water surface as it is being lowered into the water and the depth at which the disc becomes visible when raised again. This measurement is made on the shady side of the boat. Factors that affect water clarity include water color, algae populations, and suspended sediment. Algae concentration is usually the dominant factor affecting clarity in most lakes; therefore, Secchi depth is commonly inversely related to chlorophyll *a*. Generally, Secchi depths are greatest in the spring, fall, and winter, and least in the summer when algae populations are the greatest. Average monthly Secchi depths for November 1993 through October 1994, in ft, for Green, Middle, and Mill Lakes were the following:

Month	Green Lake	Middle Lake	Mill Lake
November	11.8	14.4	13.1
April	17.7	11.2	8.5
May	19.7	17.1	13.1
June	8.5	7.5	6.9
July	9.2	7.2	6.2
August	11.5	8.9	6.2
September	13.8	10.5	7.2
October	13.1	14.8	11.8
Average	13.2	11.4	9.1

During the study period, Secchi depth generally was greatest in Green Lake, the largest and deepest lake, and least in Mill Lake, the smallest and shallowest lake.

Historical data for Secchi depth from 1973 to 1991, provided by the Lauderdale Lakes Improvement Association, are shown in figure 7. These data also show an increasing Secchi depth from Mill Lake to Middle Lake to Green Lake. Most of the measurements were made in April, the time of year when Secchi depth is usually greatest. Measurements in 1979 and also 1982 were made in August, and the depth shown for 1974 is a 3-year average (1973–75). In comparing the April and May 1994 depths with the historical data, the 1994 Secchi depths are greater than most of the historical depths, and it appears that water clarity may have improved slightly since the 1970's, as was also indicated by the historical total phosphorus data.

Phosphorus Budget

A lake's phosphorus budget includes an evaluation of the following terms, which may be expressed in pounds per year: Inflow loading = Outflow loading + Net Sedimentation + Change in storage (Moore and Thornton, 1988). The equation for the total phosphorus budget is similar to that for the water budget (eq. 1), which may be rewritten as

$$P+S_i+G_i = S_o+G_o+\Delta S, \qquad (2)$$

each of the components having a quantity of phosphorus associated with it. The amount of phosphorus leaving by evaporation is assumed to be zero and is omitted from the equation. Net sedimentation is the result of all physical, chemical, and biological processes causing transfer of phosphorus between the lake water and bottom sediments. Generally, it is not feasible to measure net sedimentation directly, so it was estimated in this study by a mass-balance approach. Independent determination of the change in phosphorus stored in lake water and sediment and of the amount leaving by ground-water outflow was beyond the scope of this study. The inflow components of the budget were of particular interest for evaluating the relative sources of phosphorus contributing to the total loading of the lakes. Because of the limitations of evaluating some of the outflow components (in particular, ground-water outflow), all outflow loadings were not computed.

Budget Components

Phosphorus inputs from precipitation were estimated from amounts of precipitation measured at the Lauderdale Lakes rain gages and National Weather Service Whitewater station and from average phosphorus concentration in precipitation measured at Delavan. Field and Duerk (1988), in their study of nearby Delavan Lake, reported a volume-weighted average concentration of 0.02 mg/L total phosphorus in precipitation. The total phosphorus loading to Lauderdale Lakes from precipitation was estimated to be 94 lb for the study year.

Samples of runoff for analysis of total phosphorus concentrations were collected near the mouths of four ephemeral drainages flowing into the lakes (fig. 2). Grab samples were obtained by observers during storms in February, March, April, and July. No runoff during spring and summer was of sufficient magnitude to trigger sample collection by the multistage point samplers installed in these drainages. Two samples were obtained at site 1, two at site 2, and three at site 4; none were obtained from site 3 because of the lack of runoff in this tributary. Total phosphorus concentrations in runoff samples ranged from 0.113 to 0.84 mg/L; the highest concentrations were found early in the year (Holmstrom and others, 1995). The greatest concentration was measured at site 2; the drainage area contributing to this site has a high proportion of agricultural land and also produces the greatest amount of runoff.

Total phosphorus load from the direct-runoff area was estimated by using a mean concentration of 0.53 mg/L for the runoff in February and March and a mean concentration of 0.30 mg/L for runoff later in the spring and in summer. According to the runoff estimates, more than 90 percent of the annual phosphorus load was transported in February and March. The total annual estimated phosphorus loads from the identified tributary drainage areas were the following:

Site and acreage:	*Pounds of phosphorus per year*
Site 1 (35 acres)	12.2
Site 2 (79 acres)	38.3
Site 3 (91 acres)	16.6
Site 4 (11 acres)	4.8
Swale, Don Jean Bay (80 acres, not monitored)	37.8

The greatest loads were produced by the contributing drainage areas at site 2 and the swale on Don Jean Bay.

Total annual phosphorus load from the direct-runoff area to the lakes (including the tributaries and shoreline drainage) was estimated to be 430 lb, which is equivalent to a yield of 175 lb/mi^2. This yield is somewhat lower than the phosphorus-export coefficients recommended by Panuska and Lillie (1995), possibly because of the mixture of land uses and soils that yield less runoff.

Observation wells installed around the lakeshore were sampled to determine the concentrations of dissolved phosphorus in ground water entering and leaving the lake (table 3). An average background concentration of 0.008 mg/L was used to estimate the background phosphorus load from ground-water inflow for the area where gradients were into the lake (fig. 5). The annual total phosphorus load contributed by ground water (for this background concentration) was estimated to be 112 lb. Phosphorus concentrations in water from some of the observation wells greatly exceeded the background level and were probably affected by septic tank effluent and other sources; therefore, loading estimates were made separately for that from "background" ground water and that from septic systems. The number of observation wells and their spacing were not sufficiently detailed for the purpose of directly calculating the combined load from unaffected ground water and septic systems by use of all of the concentration data.

Lakeshore septic systems may be a significant source of phosphorus loading to lakes. Phosphorus loading from nearshore septic systems was estimated separately by applying per capita export coefficients from households to onsite septic systems and from septic systems to the lake. Positive ground-water gradients to the lake and phosphorus concentration in ground water were verified by data from the nearshore observation wells. The latest population and occupancy information; site-specific soil, topography, and environmental information; and septic-system characteristics were evaluated and used to estimate the quantity of phosphorus from near-lake systems that entered the lakes.

The total annual mass of phosphorus entering the lake was estimated as the sum of contributions from all the systems by use of procedures outlined in Garn and Parrott (1977) and Reckhow and others (1980). The following general expression (after Reckhow and others, 1980) was used in the calculations:

$$M = E_s \text{ (\#capita-years) } (1\text{-}SR), \qquad (3)$$

where

- M is the annual mass (load) of phosphorus entering the lake from septic systems (lb/yr),
- E_s is the export coefficient to septic tank systems (per capita export from household to septic tank, (lb/capita-yr),
- #capita-years is the number of people using septic systems affecting the lake multiplied by the fraction of year occupying the residence, and
- SR is the soil-retention coefficient, the fraction of phosphorus retained between the septic system and the lake.

Population and occupancy information were obtained from 1990 census data and local information. Of the approximately 1,010 housing units around Lauderdale Lakes, about 30 percent are year-round residences (G.T. Petersen, oral commun., 1995). Of the 70 percent seasonal residences, 60 percent of the total were assumed to be occupied during the summer and on weekends (160 days) and 10 percent to be occupied during summer only (92 days). The average number of persons per household for Lauderdale was assumed to be 2.60, on the basis of 1990 census data (Tim McCauley, Southeastern Wisconsin Regional Planning Commission, written commun., 1995).

Not all households and facilities around the lake are likely to affect the lake, however, because ground-water gradients in part of the area are out of and away from the lakes. In this study, the number of residences potentially affecting the lake was determined for the area within 250 ft of the shoreline where ground-water gradients were into the lake. Residences with drainfields greater than 250 ft from the shoreline were assumed not to affect the lake on the basis of soils information and information from Reckhow and others (1980). The number of residences within this 250-ft zone was determined from 1992 aerial photos obtained from Walworth County Agricultural Stabilization and Conservation Service (written commun., 1995). The number of residences in this zone used in the calculations was 374 of the 1,010. Number of residences obtained from a more detailed septic survey would probably be more accurate. Number of capita-years was calculated by multiplying

Table 3. Water levels and dissolved phosphorus concentrations in samples from observation wells near Lauderdale Lakes, Walworth County, Wis., 1993–94

[Water levels referenced to lake stage gage; datum of gage is 879.57 ft above sea level; mg/L, milligrams per liter; --, data not available; <, less than. Well locations shown in fig. 5]

Well number	Date	Water level (feet)	Lake stage (feet)	Phosphorus ortho-phosphate as P, dissolved (mg/L)
		Flow direction: out of lake		
1	11/30/93	4.27	5.37	--
	12/21/93	4.32	5.34	--
	02/01/94	3.91	5.04	--
	03/16/94	4.23	5.02	--
	05/05/94	4.23	5.00	--
	05/12/94	4.20	5.00	0.039
	06/13/94	4.10	5.00	.052
	07/21/94	4.05	4.99	.099
	08/24/94	4.04	5.02	.119
	09/28/94	3.89	4.97	.103
	11/01/94	3.79	4.93	.088
7	12/01/93	5.18	5.38	--
	12/21/93	5.24	5.34	--
	02/01/94	4.71	5.04	--
	03/16/94	5.29	5.02	.005
	05/05/94	5.02	5.00	--
	05/12/94	4.82	5.00	.002
	06/13/94	4.40	5.00	.002
	07/21/94	4.30	4.99	.005
	08/24/94	4.39	5.02	<.002
	09/28/94	4.21	4.97	<.002
	11/01/94	4.27	4.93	<.002
8	12/01/93	4.50	5.38	--
	12/21/93	4.58	5.34	--
	02/01/94	4.15	5.04	--
	03/16/94	4.56	5.02	--
	05/05/94	4.53	5.00	--
	05/12/94	4.50	5.00	.010
	06/13/94	4.38	5.00	.008
	07/21/94	4.32	4.99	.004
	08/24/94	4.28	5.02	.002
	09/28/94	4.13	4.97	.002
	11/01/94	4.04	4.93	<.002
12	06/16/94	4.72	5.00	.004
	07/21/94	4.74	4.99	.006
	08/24/94	4.72	5.02	.120
	09/28/94	4.62	4.97	.002
	11/01/94	4.55	4.93	<.002

Table 3. Water levels and dissolved phosphorus concentrations in samples from observation wells near Lauderdale Lakes, Walworth County, Wis., 1993–94—Continued

Well number	Date	Water level (feet)	Lake stage (feet)	Phosphorus ortho-phosphate as P, dissolved (mg/L)
		Flow direction: out of lake—continued		
13	06/16/94	4.83	5.00	.008
	07/21/94	4.92	4.99	.002
	08/24/94	5.00	5.02	.002
	09/28/94	4.87	4.97	.004
	11/01/94	4.86	4.93	<.002
14	06/13/94	4.28	5.00	.003
	07/21/94	4.20	4.99	.005
	08/24/94	4.16	5.02	.007
	09/28/94	4.02	4.97	.003
	11/01/94	3.89	4.93	.005
15	06/16/94	4.23	5.00	.011
	07/21/94	4.14	4.99	.005
	08/24/94	4.06	5.02	.003
	09/28/94	3.92	4.97	.006
	11/01/94	3.78	4.93	.005
		Flow direction: into lake		
2	12/01/93	5.76	5.38	.018
	12/21/93	5.82	5.34	--
	02/01/94	5.42	5.04	--
	05/05/94	5.49	5.00	--
	05/12/94	5.46	5.00	.010
	06/13/94	5.40	5.00	.014
	07/21/94	5.43	4.99	.415
	08/24/94	5.51	5.02	.023
	09/28/94	5.37	4.97	.032
	11/01/94	5.29	4.93	.021
3	12/01/93	6.08	5.38	.003
	12/21/93	6.12	5.34	--
	03/16/94	5.99	5.02	.004
	05/05/94	5.82	5.00	--
	05/12/94	5.79	5.00	<.002
	06/16/94	5.63	5.00	.003
	07/21/94	5.59	4.99	.010
	08/24/94	5.57	5.02	.004
	09/28/94	5.47	4.97	.007
	11/01/94	5.42	4.93	.004

Table 3. Water levels and dissolved phosphorus concentrations in samples from observation wells near Lauderdale Lakes, Walworth County, Wis., 1993–94—Continued

Well number	Date	Water level (feet)	Lake stage (feet)	Phosphorus ortho-phosphate as P, dissolved (mg/L)
Flow direction: into lake—continued				
4	12/01/93	5.40	5.38	.042
	12/21/93	5.43	5.34	--
	02/01/94	4.96	5.04	--
	03/16/94	5.17	5.02	.036
	05/05/94	5.12	5.00	--
	05/12/94	5.10	5.00	.032
	06/16/94	5.02	5.00	.036
	07/21/94	5.05	4.99	.048
	08/24/94	5.05	5.02	.041
	09/28/94	5.03	4.97	.044
	11/01/94	5.00	4.93	.043
5	12/01/93	6.09	5.38	.003
	12/21/93	6.11	5.34	--
	02/01/94	5.75	5.04	--
	03/16/94	5.21	5.02	.009
	05/05/94	5.82	5.00	--
	05/12/94	5.79	5.00	<.002
	07/21/94	5.66	4.99	.008
	08/24/94	5.69	5.02	.006
	09/28/94	5.54	4.97	.002
	11/01/94	5.49	4.93	.003
10	12/21/93	6.28	5.34	--
	02/01/94	5.90	5.04	--
	03/16/94	6.08	5.02	.023
	05/05/94	5.94	5.00	--
	05/12/94	5.91	5.00	.013
	06/16/94	5.78	5.00	.023
	07/21/94	5.74	4.99	.390
	08/24/94	5.73	5.02	.062
	09/28/94	5.66	4.97	.029
	11/01/94	5.62	4.93	.025
11	12/21/93	5.71	5.34	--
	03/16/94	5.61	5.02	.013
	05/05/94	5.44	5.00	--
	05/12/94	5.39	5.00	.003
	06/13/94	5.25	5.00	.012
	07/21/94	5.16	4.99	.147
	08/24/94	5.11	5.02	.009
	09/28/94	4.99	4.97	.016
	11/01/94	4.92	4.93	.012

Table 3. Water levels and dissolved phosphorus concentrations in samples from observation wells near Lauderdale Lakes, Walworth County, Wis., 1993–94—Continued

Well number	Date	Water level (feet)	Lake stage (feet)	Phosphorus ortho-phosphate as P, dissolved (mg/L)
		Flow direction: transition		
6	12/01/93	5.38	5.38	--
	12/21/93	5.43	5.34	--
	03/16/94	5.28	5.02	.049
	05/05/94	5.15	5.00	--
	05/12/94	5.11	5.00	.048
	06/13/94	4.99	5.00	.545
	07/21/94	4.84	4.99	.435
	08/24/94	4.79	5.02	.165
	09/28/94	4.70	4.97	.094
	11/01/94	4.61	4.93	.083
9	12/21/93	5.42	5.34	--
	03/16/94	5.26	5.02	.005
	05/05/94	5.08	5.00	.007
	05/12/94	5.03	5.00	.004
	06/16/94	4.81	5.00	.012
	07/21/94	4.78	4.99	<.002
	08/24/94	4.90	5.02	.004
	09/28/94	4.77	4.97	.002
	11/01/94	4.72	4.93	--

the number of residences by the number of persons per household by the fraction of year occupied.

The major sources of wastewater to septic tanks are sinks, bathtubs and showers, appliances, garbage disposals, and toilets. Each source contributes different amounts of nutrients. Phosphorus in wastewater originates mainly from toilet wastes and phosphate detergents.

E_s, the per capita export of phosphorus from the household to the onsite septic system, was estimated from coefficients given in the literature (Garn and Parrott, 1977; Reckhow and others, 1980). The selected coefficients are slightly on the low side of those in the literature to account for the ban on sale of phosphate-based detergents. Reckhow and others (1980, p. 56) reported that in areas where a phosphate detergent was banned, median phosphorus loading was 0.8 to 1.2 lb/capita-yr. Per capita load without a ban ranged from about 1.8 to 6.6 lb; the median was about 2.9 lb. Although a phosphate ban indicates that a loading approaching 1.0 lb would be likely, the increasing use of automatic dishwashers and garbage disposals may offset the effectiveness of a ban. Automatic dishwasher detergents are not included in the ban, and their phosphate content typically is 3 to 9 percent phosphate by weight, equivalent to 0.6 to 1.1 g of phosphorus per tablespoon of detergent. A most likely median loading of 1.8 lb/capita-yr was selected for subsequent calculations. Reckhow and others (1980) also recommend selecting a low and a high value to account for the wide range and uncertainty in selecting values; therefore, a low of 1.1 and a high of 2.2 lb/capita-yr were selected for the estimates.

Many factors influence the quantity of phosphorus eventually reaching the lake from the septic systems. The factors involve physical and biological site characteristics, properties of the soil, and properties of the septic system (Reckhow and others, 1980). These factors include

- phosphorus-adsorption capacity of soil,
- drainage of soil (depth to water table or impermeable material),

- permeability of soil,
- land slope,
- distance from lake,
- uptake of phosphorus by plants,
- age of system, and
- use and maintenance of system.

Septic systems, if working properly, are effective in removing phosphorus. Generally, removal capacity increases with decreasing particle size of soil, decreasing pH of soil, increasing content of clay and amounts of iron and aluminum in soil, increasing reaction time, and increasing depth to water table (Garn and Parrott, 1977). A soil has a finite adsorption capacity, which may be reduced by drainfield effluent over time; new septic systems provide more soil retention of phosphorus than old systems. In addition to age, maintenance of septic systems also influences the effectiveness of the system. If scum and sludge are allowed to build up in the tank to a point at which solids are carried out into the drainfield, soil spaces may become plugged, and system failure may result. Septic-system failures and water contamination are most likely in soils where water tables are high, or perched; in shallow soils over bedrock; on steep slopes that allow effluent to surface; and in very coarse-textured soils that are low in organic matter, high in permeability, and low in phosphorus-retention capacity.

SR, the soil-retention coefficient (the fraction of phosphorus retained by the soil or otherwise retained between the septic system and lakeshore), was estimated on the basis of these various site-specific factors. The coefficient may range from 0 to 1.0. If all phosphorus from septic systems is assumed to reach the lake, then *SR*=0; if no phosphorus is assumed to reach the lake, then *SR*=1.0. In this evaluation, systems greater than 250 ft from the lakeshore were assumed to have no effect on the lake (*SR*=1.0). For septic systems that were determined to be failing within the 250-ft zone, *SR*=0.25. The Lake Management District has a septic inspection, pumping, and corrective action program; it has been inspecting septic systems since 1991. The inspections are nearly completed, and replacement or repairs to many systems are planned to be completed in 1997. On the basis of inspection data, a failure rate of 10 percent of the systems was used in the calculations (Charles H. Sharpless, Lauderdale Lakes Lake Management District, written commun., 1995).

The factors considered in estimating *SR* included primarily phosphorus-adsorption capacity of the soils in the area and drainage, permeability, and slope of the soils. In the nearshore area, soils consist predominantly of the Casco-Rodman Complex, Rodman-Casco Complex, and Casco-Fox Silt Loam (Haszel, 1971; Natural Resources Conservation Service, Walworth County, written commun., 1995). These are loamy soils over sand and gravel; they are excessively drained—subsoil permeabilities are greater than 20 in/hr—and they are classified as a poor filter and as having severe limitations for septic-tank absorption fields. *SR* coefficients for these types of soils may range from 0.2–0.6. *SR* also includes a fraction of the phosphorus that is removed through storage in sludge in the septic tank, which amounts to about 20 to 30 percent of the incoming wastewater (Doenges and others, 1990). Therefore, as with the selection of an E_s value, a "most likely" *SR* of 0.85 was used in the calculations for the "most likely" case, and a low value of 0.5 and high value of 0.9 also were evaluated.

In summary, the following "most likely," low, and high annual phosphorus loads from septic systems were estimated by use of the "most likely," low, and high values for the coefficients:

Estimate	E_s, in pounds per capita-yr	1-*SR*	Phosphorus load, in pounds per year
"Most likely"	1.8	0.15	210
Low	1.1	.10	95
High	2.2	.50	670

The "most likely" load estimate of total phosphorus that reaches the lakes annually from near-lake septic systems is 210 lb. Because of the uncertainties associated with this load, low and high estimates also are presented to suggest the possible range of loads. The low and high estimates represent 13 and 51 percent, respectively, of the total annual phosphorus input to Lauderdale Lakes. The most likely estimate was used as the most probable loading in the evaluation. In the future, assuming all failed systems are corrected and a proposed systematic pumping program is in place, the load from septic systems is estimated to be about 100 lb annually; this is less than one-half of the present load.

Phosphorus concentration in ground water from the nearshore observation wells verified that septic systems and possibly other sources (perhaps fertilizer applications) were affecting ground water. Phosphorus concentrations in ground water (table 3) greatly exceeded 0.008 mg/L in three out of six wells located in the inflow area of the lakes. Concentrations at wells

2, 10, and 11 (fig. 2) were unusually high (15 to 50 times the background concentration) in July, corresponding to the heavy use season. At well 6, in the transition zone on the north side of Green Lake, the extremely high phosphorus concentrations could not be explained by the information available; the high concentrations occurred during the summer when the flow direction was primarily out of the lake. The high phosphorus concentrations in the ground water were almost as great as those measured in surface runoff. Wells 11 and 4 (where concentrations also were above normal) are in an area of failed septic systems identified by the inspections (Charles H. Sharpless, written commun., 1995).

Annual Total Phosphorus Budget

The total annual phosphorus input to Lauderdale Lakes for the study year was estimated to be 846 lb. The greatest sources of phosphorus input to the lakes were surface runoff and septic systems (table 4; fig. 8). Total phosphorus input for the study year probably represents a below-average input, particularly from surface runoff, because precipitation during the year was below average.

Not included in the preceding estimate of annual phosphorus load to the lakes is the nutrient contribution from waterfowl. Nutrients added by waterfowl are generally thought to be relatively unimportant and are seldomly estimated; moreover, behavior of aquatic birds is variable, and population data are difficult to obtain. For these reasons, a detailed estimate of the loading from this source was not within the scope of this study. Phosphorus loading from waterfowl droppings may, however, be a significant fraction of the total phosphorus loading from all sources where waterfowl populations are large (Scherer and others, 1995; Manny and others, 1994). An escalating population of resident geese is a growing problem in many areas. The increasing numbers of geese are resulting in more complaints about nuisance geese, which are becoming common in urbanized areas where grassy lawns of lakefront homes, golf courses, and parks furnish ideal grazing and resting sites. A newspaper article in the Wisconsin State Journal (December 23, 1995, "Nuisance Geese To Hear Explosions") related the growing problems of nuisance populations at Oconomowoc and Beaver Dam Lakes in Wisconsin.

Approximately 550 Canada geese were concentrated in the ice-free, open-water area of the springs on

Table 4. Annual total-phosphorus inputs for Lauderdale Lakes, Walworth County, Wis., November 1993–October 1994

Budget item	Total phosphorus load (pounds)	Percent of total inputs
Inputs:		
Precipitation	94	11
Surface runoff	430	51
Ground water	112	13
Septic systems	210	25
Total inputs	846	100

the west end of Middle Lake in March 1994. High densities of geese were also observed in the summer and fall during the study. Because geese spend much of the day feeding on land near the lake or returning to the lake to roost, a significant proportion of their droppings may be deposited directly into the water or washed in from lakeshore areas and boat docks. Manny and others (1994) estimated that a goose produces about 33 g dry weight of droppings per day and that the mean proportion of phosphorus by weight was 0.015, resulting in a mean daily phosphorus loading of 0.49 g per goose. The mean daily loading rate for ducks was assumed to be 0.46 (the mean duck/goose weight ratio) of that for geese, or 0.22 g of phosphorus per duck. Although no other waterfowl population data are available for Lauderdale Lakes, a conservative estimate of number of geese and ducks times number of days that they were present might be about 400,000 and 275,000, respectively. These numbers are based on the few observations, a maximum assumed population of 5,000 geese during migration, and information from Manny and others (1994). A total annual loading by waterfowl based on these assumptions could be as much as 560 lb. Even with the application of a factor of 0.5 to account for time that the waterfowl were not on the lakes, or phosphorus not entering the lakes, the annual loading by waterfowl could potentially still be as much as 280 lb, or about 25 percent of all inputs.

Scherer and others (1995) also present a procedure for estimating phosphorus loading from waterfowl. They found that total phosphorus from waterfowl droppings was 25 to 34 percent of the annual load to an urban lake; almost all of this loading, however, originated from food within the lake and probably represented internal recycling because the surrounding urban setting contained no feeding areas.

Total phosphorus output from the lakes, measured at the dam outlet, was 162 lb for November 1993

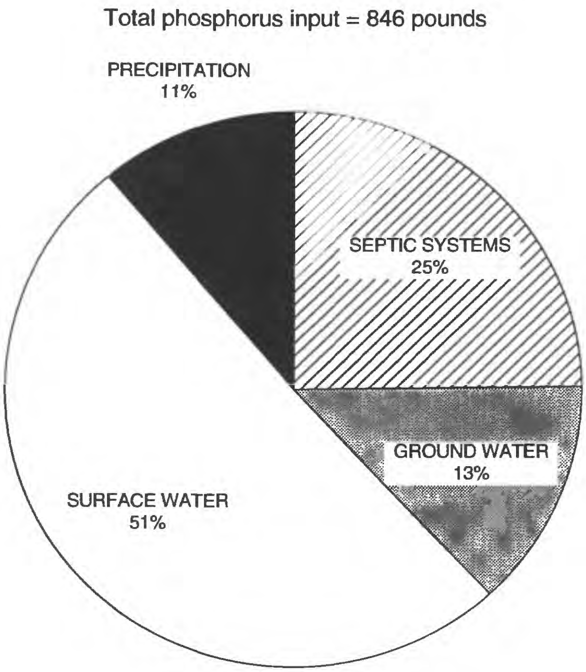


Figure 8. Annual phosphorus inputs for Lauderdale Lakes, Walworth County, Wis., November 1, 1993, through October 31, 1994.

through October 1994 (Holmstrom and others, 1995), or 19 percent of all estimated inputs. A small amount of phosphorus not estimated probably discharges with ground-water outflow. A considerable quantity of phosphorus was removed from the lakes by the macrophyte-harvesting program. In 1994, a total of 565.6 tons (wet weight) of weeds were harvested during the season (Douglas D. Rubnitz, Lauderdale Lakes Improvement Association, written commun., 1995). Eurasian watermilfoil was the dominant submerged aquatic macrophyte species in the lakes. If average dry-weight percentage is assumed to be 7.0 percent of the wet weight (Michael R. Martin, Adirondack Aquatic Institute, N.Y., written commun., 1995; Peterson and others, 1974) and the average phosphorus content is assumed to be 0.30 percent of dry weight (Peterson and others, 1974), then about 240 lb of phosphorus was removed from the lakes by the harvesting program.

Internal Recycling of Phosphorus

Release of phosphorus from the bottom sediments to the overlying water in a lake can be a major component of the phosphorus budget in nutrient-rich lakes. Phosphorus can be released from sediments by a number of mechanisms, including hypolimnetic anoxia, macrophytes, fish, benthic invertebrates (Wetzel, 1983, p. 259–269), and disturbance by motorboats and wave action. Concentrations of phosphorus near the sediments of stratified lakes may equal or exceed 1,000 µg/L (Wisconsin District Lake-Studies Team, 1995, 1996).

Internal recycling and sedimentation of total phosphorus (TP) were evaluated by use of a mass-balance approach according to the following calculation: Net internal recycling or sedimentation = (total inflow TP mass) - (outflow TP mass) - (change in water-column TP mass). Net internal recycling or sedimentation were calculated for each water-quality sampling interval during the study year. Net sedimentation for the year was estimated to be 607 lb. The calculations indicate that sedimentation dominates and that internal recycling, or release of phosphorus from sediments during anoxia, is not a large component of the phosphorus budget. This conclusion is also supported by the relatively low concentrations of phosphorus (usually less than 100 µg/L) measured near the lake bottom (see the section on "Phosphorus" under "Water Quality").

Evaluation of Lake Condition

The water quality of Lauderdale Lakes was evaluated by use of two commonly employed methods: Lillie and Mason's (1983) water-quality evaluation for Wisconsin lakes, and Carlson's (1977) Trophic State Index, or TSI. Vollenweider's (1975) model and Dillon and Rigler's (1974) model were used to evaluate the phosphorus loading to the lakes.

Lillie and Mason's Classification

Lillie and Mason (1983) used a random data set consisting of total phosphorus concentration, chlorophyll *a* concentration, and Secchi depths collected during summer (July–August) to classify Wisconsin lakes. They devised the following classification:

Water-quality index	Approximate total phosphorus range (micrograms per liter)	Approximate chlorophyll *a* range (micrograms per liter)	Approximate water-clarity range (Secchi depth, in feet)
Excellent	<1	<1	>19.7
Very good	1–10	1–5	9.8–19.7
Good	10–30	5–10	6.6–9.8
Fair	30–50	10–15	4.9–6.6
Poor	50–150	15–30	3.3–4.9
Very poor	>150	>30	<3.3

Green Lake's mean 1994 summer total phosphorus and chlorophyll *a* concentration and Secchi depth were 8 µg/L, 3.0 µg/L, and 10.4 ft, respectively, all in the "very good" category. Middle Lake's mean total phosphorus and chlorophyll *a* concentration and Secchi depth were 10 µg/L, 3.4 µg/L, and 8.0 ft, respectively, in the "good" to "very good" category. Mill Lake's mean total phosphorus and chlorophyll *a* concentration and Secchi depth were 14 µg/L, 7.2 µg/L, and 6.2 ft, respectively, in the "good" category. In comparing the 1994 data to a long-term record (1986–95) that is available for Powers Lake, a lake of similar quality on the Walworth-Kenosha County line, the 1994 data are fairly representative of the long-term average (Wisconsin District Lake-Studies Team, 1996).

Carlson's Trophic State Index

Carlson's (1977) Trophic State Index or TSI, also is computed by use of total phosphorus and chlorophyll *a* concentrations and Secchi depths for ice-free periods. Carlson's TSI equations for total phosphorus and chlorophyll *a*, as modified by Lillie and others (1993) to apply to Wisconsin lakes, were used for the evaluation. The Wisconsin Department of Natural Resources has adopted the following TSI ranges to classify the condition of lakes:

TSI	Condition
<40	oligotrophic
40–50	mesotrophic
51–70	eutrophic
>70	hypereutrophic

These ranges are commonly used to make consistent comparisons in lake trophic-state evaluations.

The computed TSI's for the three characteristics of each of the Lauderdale Lakes follow similar patterns for the duration of the study period (fig. 9). TSI's in April and May are generally in the oligo-mesotrophic range; by June and for the remainder of the summer, the TSI's are generally in the mesotrophic range, and some approach the eutrophic range. Overall, these TSI's are low relative to those for other southeastern Wisconsin lakes (Wisconsin District Lake-Studies Team, 1995, 1996) and representative of comparatively "good" trophic conditions.

Vollenweider's Model

Vollenweider (1975) formulated a relation for predicting the trophic state likely to result from external phosphorus loading to lakes. The model, shown graphically in figure 10, relates total phosphorus loading per unit lake surface area to the lake's mean depth and hydraulic residence time. This relation may be used as a general guide for determining phosphorus loading limits to lakes and for predicting changes in the trophic state of lakes. The model illustrates the importance of hydraulic residence time. The loading rate at which a lake may become eutrophic (representing a spring phosphorus concentration of about 20 µg/L) is termed "dangerous," and the loading rate at which a lake may become mesotrophic (representing a spring phosphorus concentration of about 10 µg/L) is termed "permissible." For 1994 data, the Lauderdale Lakes plot near the "permissible" line.

Dillon and Rigler's Model

Loading estimates may be used to predict a lake's phosphorus concentration at spring turnover by use of Dillon and Rigler's (1974a) formula,

$$P = L\,(1\text{-}R_p)/q_s,$$

where P is the predicted phosphorus concentration (g/m^3 or mg/L), L is the areal phosphorus load ($g/m^2/yr$), R_p is the phosphorus-retention coefficient (calculated from actual data or estimated by various methods described by Canfield and Bachman, 1981, and Nurnberg, 1984), and q_s is the areal water load (total inflows divided by lake surface area, in meters per year). Using the data for Lauderdale Lakes, where $L = 0.12$ $g/m^2/yr$, $R_p = 0.81$ ([846 lb TP input - 162 lb TP output] / 846 lb), and $q_s = 2.72$ m, one obtains a mean spring total phosphorus concentration of 8 µg/L. The measured average total phosphorus concentration for the three lakes in spring 1994 was 8.5 µg/L; therefore, the equation accurately predicted phosphorus concentration for spring turnover. Phosphorus concentrations at spring turnover are usually less than those during the summer; thus, the equation may underestimate the summertime phosphorus concentration.

Dillon and Rigler (1974b) also developed a relation to predict summer chlorophyll *a* concentration (chl *a*) from the spring total phosphorus concentration. The equation has the form

$$\log_{10}[\text{chl } a] = 1.45 \log_{10}[\text{TP}] - 1.14.$$

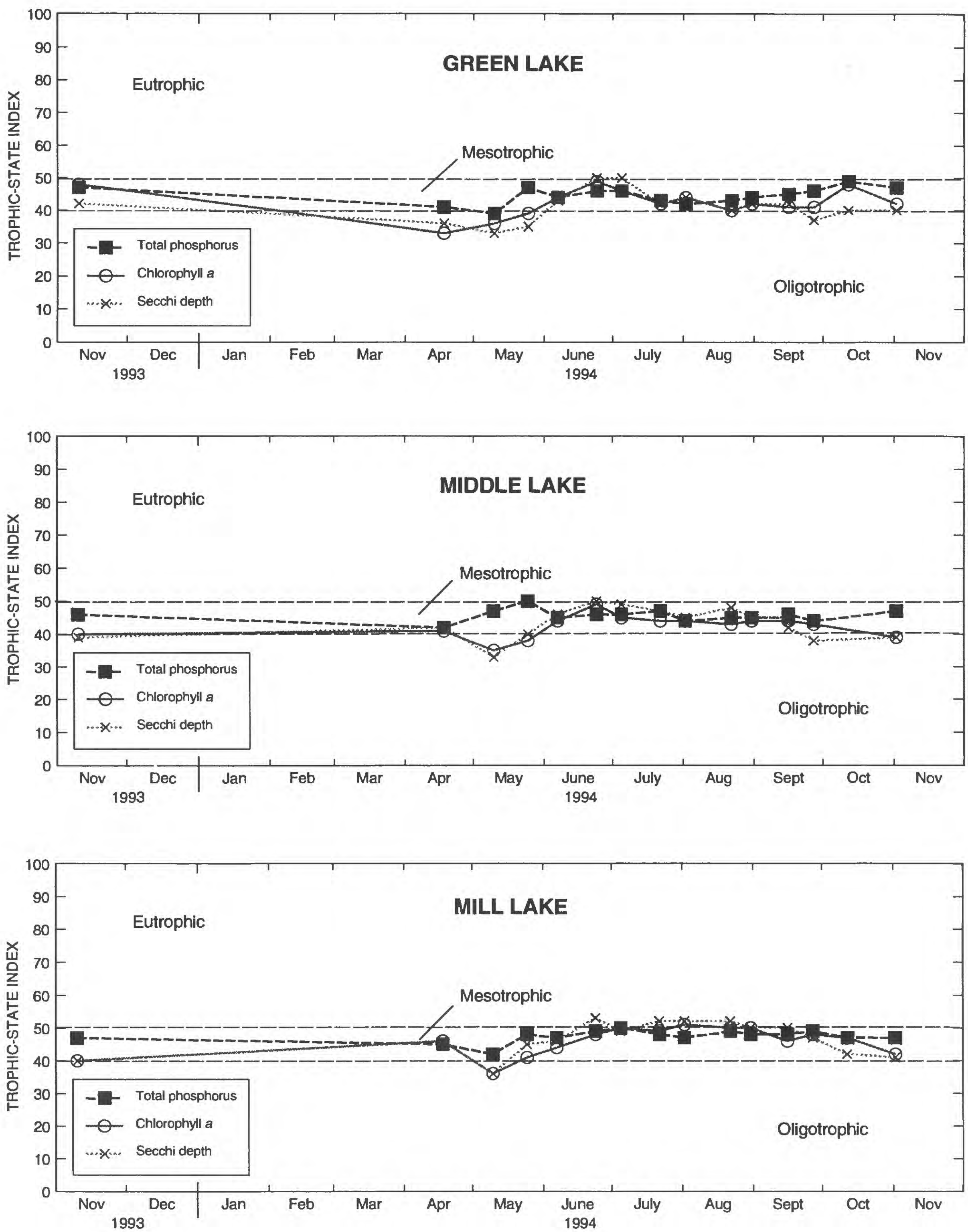


Figure 9. Trophic State Indices for Lauderdale Lakes, Walworth County, Wis., November 1, 1993, through November 30, 1994.

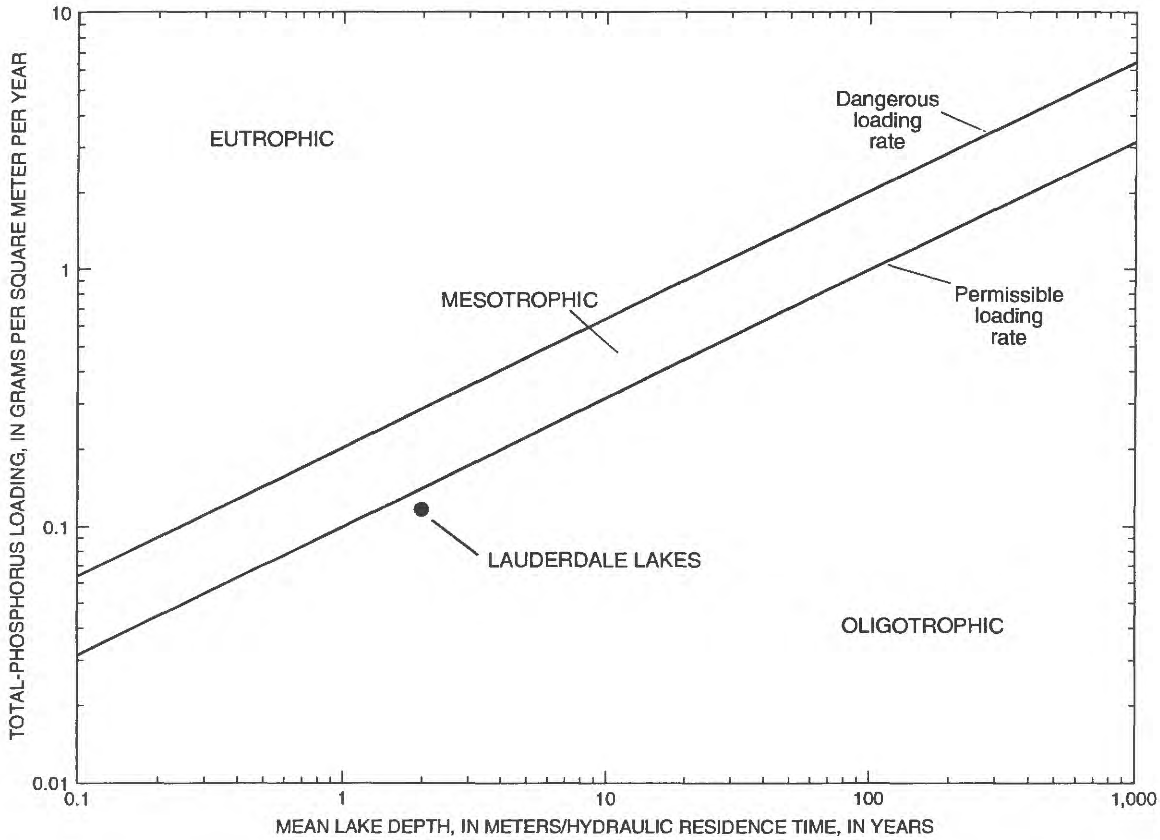


Figure 10. Vollenweider (1975) phosphorus-loading classification for Lauderdale Lakes, Walworth County, Wis., November 1993–October 1994.

Applying the above equation to the spring total phosphorus concentration of 8.5 µg/L for Lauderdale Lakes results in a predicted summer chlorophyll *a* concentration of 1.6 µg/L. This predicted concentration is lower than those observed during June–August (2.7–7.8 µg/L) but close to those observed in the spring (0.8–1.8 µg/L).

CONCLUSIONS

Water and phosphorus budgets were determined for Lauderdale Lakes for the period November 1993 through October 1994. Significant components of the water and phosphorus budgets were measured independently, and other components were estimated. Findings of this study are summarized as follows:

1. Lauderdale Lakes are classified as ground-water drainage lakes; ground water supplied 72 percent of the total inflow. Only 4 percent of the total inflow was from surface water. The total inflow to the lakes was estimated to be about 7,200 acre-ft for the study year. A surface outlet accounted for 64 percent of the total outflow from the lakes.
2. In terms of total phosphorus concentration, chlorophyll *a* concentration, and Secchi depth, and in comparison to other Wisconsin lakes, water quality of Lauderdale Lakes was good to very good. The lakes are thermally stratified in the summer, and the lower depths become anoxic. Phosphorus release from the bottom sediments during anoxia, however, did not seem to be a major problem.
3. Near-lake surface runoff and septic systems were the dominant sources of total phosphorus loading to the lakes. Total annual phosphorus input to the lakes from November 1993 through October 1994 was estimated to be 846 lb. Direct runoff from the near-lake

drainage area made up 51 percent of the total phosphorus loading; septic systems accounted for 25 percent of the total loading. The greatest individual loads were from the contributing drainage areas to site 2, including farm land on the northeast side of Green Lake, and the residential swale area on the southern shore of Don Jean Bay. Phosphorus concentrations in ground water were elevated above background concentrations at three of six observation wells in the area of ground-water inflow, a strong indication that ground water was a source of phosphorus loading.

4. The range of trophic state indices for the lakes was from oligotrophic to mesotrophic, but most were in the mesotrophic class throughout the year.
5. An equation used to predict phosphorus concentration at spring turnover from loading estimates fairly accurately predicted the actual phosphorus concentration for Lauderdale Lakes at the 1994 spring turnover.

REFERENCES CITED

Borman, R.G., 1976, Ground-water resources and geology of Walworth County, Wisconsin: Wisconsin Geological and Natural History Survey Information Circular 34, 45 p.

Canfield, D.E., and Bachman, R.W., 1981, Prediction of total phosphorus concentrations, chlorophyll *a*, and Secchi depths in natural and artificial lakes: Canadian Journal of Aquatic Science, v. 38, p. 414–423.

Carlson, R.E., 1977, A trophic state index for lakes: Limnology and Oceanography, v. 22, no. 2, p. 361–369.

Chow, Ven Te, ed., 1964, Handbook of applied hydrology: New York, McGraw-Hill Book Co. [variously paged].

Dillon, P.J. and Rigler, F.H., 1974a, A test of a simple nutrient budget model predicting the phosphorus concentration in lake water: Journal of the Fisheries Resources Board of Canada, v. 31, p. 1771–1778.

Dillon, P.J. and Rigler, F.H., 1974b, The phosphorus-chlorophyll relationship in lakes: Limnology and Oceanography, v. 19, no. 5, p. 767–773.

Doenges, J.M., and others, 1990, Carrying capacity of public water supply watersheds—a literature review of impacts on water quality from residential development: Connecticut Department of Environmental Protection Bulletin 11 [variously paged].

Edwards, T.K., and Glysson, D.G., 1988, Field methods for measurement of fluvial sediment: U.S. Geological Survey Open-File Report 86-531, 118 p.

Farnsworth, R.K., Thompson, E.S., and Peck, E.L., 1982, Evaporation atlas for the contiguous 48 United States: National Oceanic and Atmospheric Administration Technical Report NWS 33, 26 p.

Field, S.J., and Duerk, M.D., 1988, Hydrology and water quality of Delavan Lake in southeastern Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 87-4168, 61 p.

Garn, H.S. and Parrott, H.A., 1977, Recommended methods for classifying lake condition, determining lake sensitivity, and predicting lake impacts: U.S. Department of Agriculture, Forest Service, Hydrology Paper 2, 49 p.

Haszel, O.L., 1971, Soil survey of Walworth County, Wisconsin: U.S. Department of Agriculture, Soil Conservation Service [variously paged].

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water (3d ed.): U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Henrich, E.W., and Daniel, D.N., 1983, Drainage area data for Wisconsin streams: U. S. Geological Survey Open-File Report 83-933, 322 p.

Holmstrom, B.K., and others, 1995, Water resources data, Wisconsin, water year 1994: U.S. Geological Survey Water-Data Report WI-94-2, 388 p.

Lillie, R.A., Graham, S., and Rasmussen, P., 1993, Trophic state index equations and regional predictive equations for Wisconsin lakes: Wisconsin Department of Natural Resources Research Management Findings, no. 35, 4 p.

Lillie, R.A., and Mason, J.W., 1983, Limnological characteristics of Wisconsin Lakes: Wisconsin Department of Natural Resources Technical Bulletin 138, 116 p.

Manny, B.A., Johnson, W.C., and Wetzel, R.G., 1994, Nutrient additions by waterfowl to lakes and reservoirs—predicting their effects on productivity and water quality: Hydrobiologia, v. 279/280, p. 121–132.

Moore, L., and Thornton, K., eds., 1988, Lake and reservoir restoration guidance manual: U.S. Environmental Protection Agency, EPA 440/5-88-002 [variously paged].

Mudrey, M.G., Jr., Brown, B.A., and Greenberg, J.K., 1982, Bedrock geologic map of Wisconsin: University of Wisconsin-Extension, Geological and Natural History Survey, scale 1:1,000,000.

National Oceanic and Atmospheric Administration, 1994, Climatological data—Wisconsin: Asheville, N.C., National Climatic Data Center, published monthly [variously paged].

Nurnberg, G.K., 1984, The prediction of internal phosphorus load in lakes with anoxic hypolimnia: Limnology and Oceanography, v. 29, no. 1, p. 111–124.

Panuska, J.C., and Lillie, R.A., 1995, Phosphorus loadings from Wisconsin watersheds—recommended phosphorus export coefficients for agricultural and forested watersheds: Wisconsin Department of Natural Resources Research Management Findings, no. 38, 8 p.

Peterson, S.A. Smith, W.L., and Malueg, K.W., 1974, Full-scale harvest of aquatic plants—nutrient removal from a eutrophic lake: Journal of Water Pollution Control Federation, v. 46, no. 4, p. 697–707.

Porterfield, George, 1972, Computation of fluvial-sediment discharge: U.S. Geological Survey Techniques of Water- Resources Investigations, book 3, chap. C3, 66 p.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow: U.S. Geological Survey Water-Supply Paper 2175, 2 v., 631 p.

Reckhow, K.H., Beaulac, M.N., and Simpson, J.T., 1980, Modeling phosphorus loading and lake response under uncertainty—a manual and compilation of export coefficients: Washington, D.C., U.S. Environmental Protection Agency, EPA440/5-80-011, 214 p.

Rose, W.J., 1993, Water and phosphorus budgets and trophic state, Balsam Lake, northwestern Wisconsin, 1987–89: U.S. Geological Survey Water-Resources Investigations Report 91-4125, 28 p.

Scherer, N.M., Gibbons, H.L., Stoops, K.B., and Muller, M., 1995, Phosphorus loading of an urban lake by bird droppings: Lake and Reservoir Management, v. 11, no. 4, p. 317–327.

Shaw, B., Mechenich, C., and Klessig, L., 1993, Understanding lake data: Madison, Wis., University of Wisconsin Extension, Pub. G3582, 20 p.

Southeastern Wisconsin Regional Planning Commission, 1991, A land use plan for the town of La Grange—2010: Waukesha, Wis., Report 168, 124 p.

Vollenweider, R.A., 1975, Input-output models with special reference to the phosphorus loading concept in limnology: Schweizerische Zeitschrift fur Hydrologie, v. 37, no. 1, p. 53–84.

Wetzel, R.G., 1983, Limnology (2d ed.): New York, Saunders College Publishing, 767 p.

Wisconsin District Lake-Studies Team, 1995, Water-quality and lake-stage data for Wisconsin lakes, water year 1994: U.S. Geological Survey Open-File Report 95-190, 157 p.

____1996, Water-quality and lake-stage data for Wisconsin lakes, water year 1995: U.S. Geological Survey Open-File Report 96-168, 123 p.

Wisconsin State Laboratory of Hygiene, 1993, Manual of analytical methods, inorganic chemistry unit: Wisconsin State Laboratory of Hygiene, Environmental Sciences Section [variously paged].

Hey and Associates, Inc Surface Water Runoff Study Report (1998)

Lake File Copy

Hey and Associates, Inc.
240 Regency Court, Suite 201
Brookfield, WI 53045-6190
Office 414.796.0440
Fax 414.796.0045

Final Report

SURFACE WATER RUNOFF STUDY

for the

Lauderdale Lakes Lake Management District

In Cooperation with the
Walworth County Land Conservation Department
and Wisconsin Department of Natural Resources

July, 1998

Project No. W97116

TABLE OF CONTENTS

Page

INTRODUCTION

The purpose of this study was to develop a surface runoff plan for the reduction of sediment and total phosphorus into Lauderdale Lakes, Walworth County, Wisconsin. The U.S. Geological Survey conducted an intensive hydrology and water quality study of Lauderdale Lakes for the period November 1, 1993, through October 31, 1994, which was published in 1996 (Garn, et. al). The USGS study determined that 51 percent of the phosphorus load entering the lake was from surface runoff. Approximately 75 percent of the surface runoff load was from direct sheet flow into the lake. The remaining 25 percent of the load was derived from five tributary drainage areas, four of which were monitored. This study selected the two tributary areas that contributed the highest phosphorus loading. The first area is on the north side of Green Lake, identified in this study as the "North Watershed", and the second is an area directly south of Don Jean Bay, which will be identified in this study as the "South Watershed" (See Figure 1). These two areas consisted of approximately 18% of the surface runoff load. This project will predict total suspended sediment and total phosphorus loads to the lake and recommends best management practices to reduce this loading.

This study was funded through a Lake Planning Grant from the Wisconsin Department of Natural Resources. The Lauderdale Lake Management District provided local cost share for the grant. The Walworth County Land Conservation Department provided technical assistance.

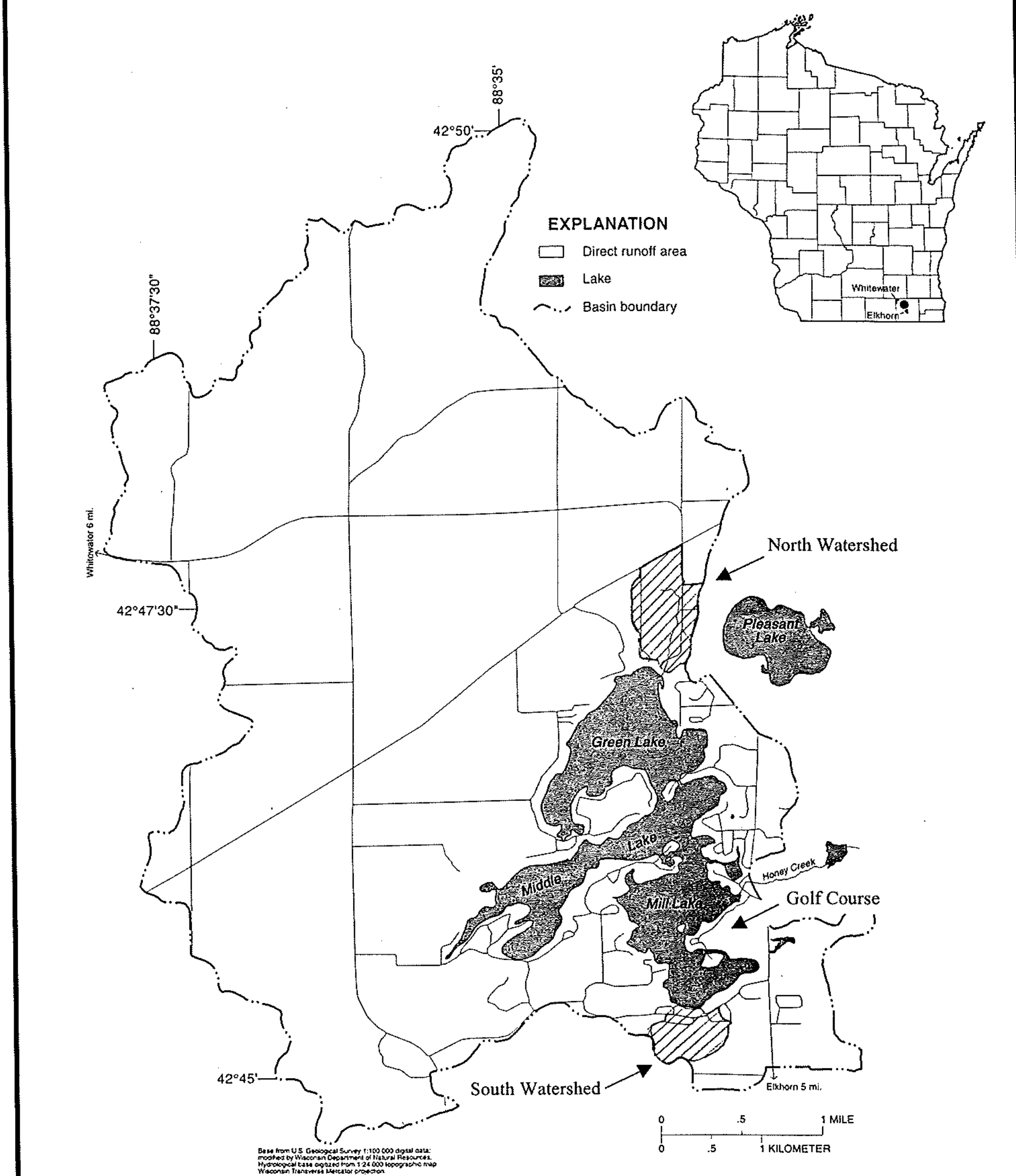
DESCRIPTION OF STUDY AREAS

LOCATIONS

As previously stated, two tributary areas were selected for study in this project. The first area is on the north side of Green Lake, identified in this study as the "North Watershed", and the second is an area directly south of Don Jean Bay, which will be identified in this study as the "South Watershed" (See Figure 1).

LAND USE

Land use in each of the watersheds primarily consists of agricultural and residential land. Table 1 summarizes the particular land uses in each of the watersheds. Figure 2 provides a graphical representation of the land use information.



Source: USGS, WRIR 96-4235

Location map of Lauderdale Lakes, Walworth County, Wisconsin

FIGURE NO. 1

Surface Water Runoff Study

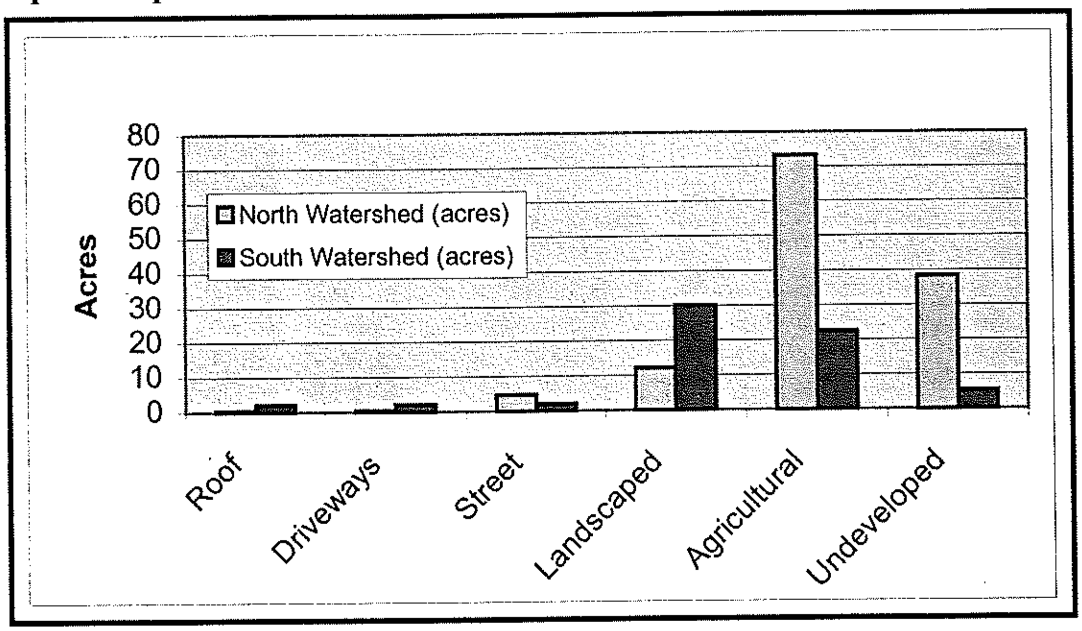
for the Lauderdale Lakes Lake Management District

Hey and Associates, Inc.
240 Regency Court, Suite 201
Brookfield, Wisconsin 53045
Office (414) 796-0440
Fax (414) 796-0445

TABLE 1.
Summary of Land Use in the Lauderdale Lakes Study Watersheds

Land Use	North Watershed (acres)	South Watershed (acres)
Roof	0.42	2.13
Driveways	0.44	1.92
Street	4.78	1.95
Landscaped	12.18	30.12
Agricultural	73.24	22.43
Undeveloped	38.37	5.22
Total	129.43	63.77

FIGURE 2.
Graphical representation of the Land Use in Lauderdale Lakes Study Watersheds



In addition, the North Watershed has 27.5 acres (out of the total of 73.24 acres) of agricultural land that is currently in the federal Conservation Reserve Program and is not farmed.

SOILS

The North and South Watersheds exist on many soil associations. The various soils are summarized in Table 2:

TABLE 2.
Summary of soil types in the North and South Watersheds

Soil Name	Soil Abbrev -iation	Slope %	Hydro-logic Soil Group	Present in North Watershed	Present in South Watershed
Casco Loam	CeB2	2-6, Eroded	B	Res	
Casco Loam	CeD2	12-20, Eroded	B		Res
Casco-Fox Silt Loams	ClC2	6-12, Eroded	B		Ag, Res
Casco-Rodman Complex	CrE2	20-30, Eroded	B		Ag, Res
Fox Silt Loam	FsA	0-2	B	Ag, Res	
Fox Silt Loam	FsB	2-6	B	Ag, Res	Ag, Res
Fox Loam	FoC2	6-12, Eroded	B	Res	
Fox Silt Loam	FsC2	6-12, Eroded	B	Ag	
Juneau Silt Loam	JuA	1-3	B	Res	Ag
McHenry Silt Loam	MpB	2-6	B	Ag	
McHenry Silt Loam	MpC2	6-12, Eroded	B	Ag	
Miami Loam	MwD2	12-20, Eroded	B	Ag	
Miami Loam	MxC2	6-12, Eroded	B	Ag	
Miami Loam	MxD2	12-20, Eroded	B	Ag	
Radford Silt Loam	RaA	0-3	B		Res
Rodman-Casco Complex	RsF	30-45	B	Res	
St. Charles Silt Loam	SeA	0-2	B		Ag, Res
St. Charles Silt Loam	SeB	2-6	B		Ag, Res

All soils in the study area are in the "B" hydrologic soil group. Soils classified in the "B" group, as defined by the Natural Resource Conservation Service (NRCS), have a moderate infiltration rate when thoroughly wet. They consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. In addition, these soils have a moderate rate of water transmission (USDA, 1971).

TOPOGRAPHY

The normal water surface elevation of Lauderdale Lakes is 884 feet MSL, according to the USGS topographic map. Elevations in the North Watershed range from 884 feet to approximately 1020 feet. Elevation in the South Watershed range from 884 feet to approximately 970 feet. A brief description of the geology of the study area can be found in Gain et. al. (1996)

MODELING METHODS

SOURCE LOADING AND MANAGEMENT MODEL (SLAMM)

SLAMM is an urban nonpoint source water quality model. It was strictly developed for modeling urban areas. The model is based on urban runoff monitoring conducted as part of the Nationwide Urban Runoff Project (NURP). SLAMM has been expanded over the years to include a wide variety of source area and outfall control practices. This program can be used to model existing conditions of a drainage area and then add one or more control practices such as; wet detention ponds, infiltration basins, street cleaning, catch basin cleaning, grass swales, and/or porous pavement. Then the results can be compared to see the reduction of pollutants found from the various control practices. As with any modeling efforts is it always recommended to calibrate the modeling results with actual field measured data. However, in this case detailed runoff and pollutant data is not available for use in calibration.

This model calculates pollutants for a specific file of rainfall events. The 1981 rainfall observed at the Milwaukee Nationwide Urban Runoff Project (NURP) sampling locations was used in this modeling. This is considered to be an "average" rainfall year. The program output consisted of total suspended sediment and total phosphorus in pounds for the two watersheds.

The results of the Slamm modeling are summarized in Appendix A of this report.

UNIVERSAL SOIL LOSS EQUATION (USLE)

The USLE was used to calculate total soil loss from all agricultural fields. The USLE was designed to predict the long-term average soil losses in runoff from field areas under specified cropping and management systems (Shen, et. al. 1993). The USLE equation is as follows:

$$A = R\ K\ LS\ C\ P$$

where:
- A = total soil loss (tons/acre)
- R = rainfall erodibility factor
- K = soil erodibility factor (tons/acre)
- LS = topographic factor
- C = cropping-management factor
- P = conservation practice factor

An average annual rainfall erodibility factor of 140 was used for the Lauderdale Lakes area. This number was chosen from a map of rainfall erodibility factors developed by the U.S. Department of Agriculture (Wischmeier and Smith, 1978) for the continental United States.

The soil erodibility factors are published by the Natural Resource Conservation Service for each soil type. A weighted soil erodibility factor was calculated for each agricultural field.

The topographic factor is determined by first chosing a representative slope length and slope of the agricultural field. These numbers were then used in a graph developed by the U.S. Department of Agriculture (Wischmeier and Smith, 1978) to find the topographic factor.

The cropping-management factors and conservation practice factors were chosen from tables published by the U.S. Department of Agriculture and were site specific to the existing and alternative practices on each field. Actual factors chosen can be found in Appendix A.

The USLE calculates the total amount of soil lost from the surface due to erosion. However, it is desired to find the amount of sediment delivered to the watershed outlet. To find this amount a simple relationship between drainage area and sediment delivery ratio was used (Boyce 1975, Frenette et.al. 1987----reprinted in Shen et.al., 1993). The relationship is as follows:

$$SDR = 0.31\ A_t^{-0.3}$$

where:

SDR = sediment delivery ratio
A_t = drainage area (mi^2)

It can be seen in Appendix A that a sediment delivery ratio of 50% was calculated for the North Watershed and 62% for the South Watershed.

The next step was to obtain the amount of total phosphorus in the soil delivered to the watershed outlets. The Walworth County Land conservation office uses a conversion of one pound of total phosphorus per ton of total sediment. This conversion was used in this study.

The results of the USLE modeling are summarized in Appendix B of this report.

WATER QUALITY MODELING SUMMARY

Table 3 summarizes the results of the water quality modeling for the North and South Watersheds under existing land use conditions.

TABLE 3
Summary of Water Quality Modeling Results for Existing Conditions

Watershed	Total Suspend Sediment (lbs/yr)	Total Phosphorus (lbs/yr)
North Watershed	514,257	273
South Watershed	162,993	103
Total	677,250	376

GOALS OF THE SUGAR/HONEY CREEKS PRIORITY WATERSHED PROJECT

Lauderdale Lakes are located in the Sugar/Honey Creek Priority Watershed Project. The watershed project is a state-funded program designed to control nonpoint source pollution. The project, started in 1994, provides technical and financial assistance to landowners in the 167-mile watershed. Lauderdale Lakes are located in the watershed area. A Nonpoint Source Control Plan for the Sugar/Honey Creeks Priority Watershed Project was published in 1997, and outlines specific pollution reduction goals for the Lauderdale Lakes area. The goals are outlined in Table 4.

TABLE 4
Nonpoint Source Pollutant Reduction Goals for Lauderdale Lakes Area

Parameter	Goal
Sediment delivery	34%
Gully erosion	5%
Inlake phosphorus reduction	14%

Source: WDNR, et. al., 1997

The watershed plan recommended, in the Lauderdale Lakes, area that agricultural and riparian residential areas be targeted for controls. The plan also recommended continued inlake monitoring to assess the internal phosphorus loadings in all three lakes.

ALTERNATIVES

Various alternatives were analyzed in this study. Below is a brief summary of each alternative broken down by study area. The results are summarized in Table 5.

NORTH WATERSHED

ALTERNATIVE 1: DO NOTHING

Under the do nothing alternative sediment and nutrient inputs to the lakes will remain the same. Sediment will continue to build up in the lake. Nutrients washed in from runoff will continue to feed algae and rooted aquatic plants. An estimated 514,257 lbs/yr of sediment and 273 lbs/yr of phosphorus would continue to enter the lake from the North Watershed.

ALTERNATIVE 2: DETENTION/WETLAND TREATMENT

This alternative involves construction of a wet detention basin or wetland treatment system to remove sediment and nutrients from the entire upper watershed. An ideal location for the pond is on a vacant lot located in the Gladhurst Subdivision. The location is where two tributaries come together (Figure 2). The detention facility would treat approximately 90-acres of watershed. The pond would need a wet surface area of 1.7 acres to treat the runoff to a 90% suspended solids removal efficiency. This alternative would reduce the suspended solids input to the lake from 514,257 lbs/yr to 56,226 lbs/yr, or a reduction of 458,031 lbs/yr. Phosphorus inputs would be reduced from 273 lbs/yr to 129 lbs/yr, or a 53% reduction. Cost of this alternative is estimated at $65,000 for construction and $40,000 for land acquisition.

A wetland treatment system was evaluated. The system would need a surface area of approximately 3.4-acres, and would not fit on the available land. Therefore, a wetland treatment system would not be feasible for the proposed site.

ALTERNATIVE 3: CONSERVATION COVER

This alternative modeled the watersheds placing all of the agricultural land in conservation cover. This means that the agricultural land is retired from production and a perennial vegetative cover is maintained over the soil (NRCS, NHCP, 1987). A complete description can be found in Appendix C. Implementation of this practice would reduce the sediment inputs by 468,000 lbs/yr to an input of 46,257 lbs/yr, or a 91% reduction. Phosphorus inputs would be reduced from 273 lbs/yr to 39 lbs/yr, or a 86% reduction. Cost of this alternative, following the federal Conservation Reserve Program prototype, is estimated at $75 per acre. The total cost would be $5,475 per year if all the existing agricultural lands in the North Watershed were placed in conservation cover.

ALTERNATIVE 4: RESIDUE MANAGEMENT

This alternative modeled the agricultural land as if farmers were practicing residue management. Residue management is managing the amount, orientation and distribution of crop and other plant residues on the soil surface year-round, while growing crops in narrow slots or tilled strips in previously untilled soil and residue (NRCS, NHCP, 1994). A complete description can be found in Appendix C. Implementation of this practice would reduce the sediment inputs by 304,000 lbs/yr to an input of 210,257 lbs/yr, or a 59% reduction. Phosphorus inputs would be reduced from 273 lbs/yr to 121 lbs/yr, or a 56% reduction. Currently the Sugar/Honey Creek Priority Watershed Project is providing an incentive to eligible farmers of approximately $18.50 per acre to implement residue management. Using this incentive the cost of placing all of the agricultural land in the North Watershed in residue management would be $1,350 per year.

ALTERNATIVE 5: CONTOUR FARMING

This alternative modeled the agricultural land as if farmers were practicing contour farming. Contour farming is sloping the land in such a way that preparing land, planting, and cultivating are done on the contours (NRCS, NHCP, 1980). A complete description can be found in Appendix C. Implementation of this practice would reduce the sediment inputs from 514,257 lbs/yr to an input of 174,257 lbs/yr, or a 66% reduction. Phosphorus inputs would be reduced from 273 lbs/yr to 103 lbs/yr, or a 62% reduction. Currently the Sugar/Honey Creek Priority Watershed Project is providing an incentive to eligible farmers of approximately $9.00 per acre to implement contour farming. Using this incentive the cost of placing all of the agricultural land in the North Watershed in contour farming would be $660.00 per year.

ALTERNATIVE 6: CONTOUR STRIPS

This alternative modeled the agricultural land as if farmers were using contour strips. Contour strips are narrow strips of perennial, herbaceous vegetative cover established across the slope and alternated down the slope with wider cropped strips (NRCS, NHCP, 1997). A complete description can be found in Appendix C. Implementation of this practice would reduce the sediment inputs from 514,257 lbs/yr to an input of 140,257 lbs/yr, or a 73% reduction. Phosphorus inputs would be reduced from 273 lbs/yr to 86 lbs/yr, or a 68% reduction. Currently the Sugar/Honey Creek Priority Watershed Project is providing an incentive to eligible farmers of approximately $13.50 per acre to implement contour strips. Using this incentive the cost of placing all of the agricultural land in the North Watershed in contour strips would be $990.00 per year.

ALTERNATIVE 7: GRASSED WATERWAY

A grassed waterway is a wide, shallow, sod lined channel designed to safely convey water during heavy rainfall. Grassed waterways are used to prevent the formation of gullies. Figure 4 illustrates the typical cross-section of a grassed waterway. Gully erosion is not estimated by the Universal Soil Loss Equation (USLE), therefore, the exact sediment and phosphorus reductions by implementation of this management practice are not known. To protect the grass waterway from high flows during heavy rains, it is recommended that a detention basin be constructed at the upstream area (Figure 2). Cost of a grassed waterway is approximately $2.00 per lineal foot. Approximately 1,000 lineal feet of waterway is needed, for a cost of $2,000. A detention basin would cost approximately $20,000.

ALTERNATIVE 8: CONSERVATION EASEMENTS

Just upstream of the lake, the tributary channel drains through a steep wooded ravine. The ravine is located within a residential development, known as the Gladhurst subdivision (see Figure 2). The tributary runs along several lots. The most important lots are numbers 11, 12, 13, and 14 on the plat. The ravine is a very steep forested area where some erosion has begun. A 20-foot drainage easement currently exists on some of the lots. If these lots were developed and the trees were cut down it may make the banks very unstable and susceptible to erosion. To protect the ravine a conservation easement should acquired on all of the steep slope areas. The following is a list of activities that should be prohibited in the easement:

1. Removal of any vegetation, including trees and shrubs.

2. Runoff from driveways, roofs, and patios should not be drained into the ravine, except through a engineered waterway or pipe to prevent gully erosion.

3. The stream channel should not be relocated. The channel has stabilized itself through years of self-armoring. Disturbance of the channel could damage the natural protection features and cause severe erosion.

The lots along the ravine are currently listed for $26,500 by Remax Realty. The value of a conservation easement would need to be determined by a licensed appraiser. For the purpose of this study a cost of $20,000 for an easement on the four critical lots was assumed.

SOUTH WATERSHED

ALTERNATIVE 1: DO NOTHING

Under the do nothing alternative sediment and nutrient inputs to the lakes will remain the same. Sediment will continue to build up in the lake. Nutrients washed in from runoff will continue to feed algae and rooted aquatic plants. An estimated 162,993 lbs/yr of sediment and 103 lbs/yr of phosphorus would continue to enter the lake from the North Watershed.

ALTERNATIVE 2: DETENTION/WETLAND TREATMENT

The South Watershed was evaluated for installation of a wet detention pond. A pond designed to treat the entire South Watershed would need approximately 0.7 acres in wet surface area with 3 feet of depth. Installation of a wet detention pond would reduce the sediment inputs from 162,993, lbs/yr to an input of 17,198 lbs/yr, or a 89% reduction. Phosphorus inputs would be reduced from 103 lbs/yr to 49 lbs/yr, or a 52% reduction. A pond located at the lower end of the basin on a vacant lot on the corner of Plantation Road and Bay Circle was first evaluated. Based on field visits it was determined that only a portion of the watershed could be diverted into this property. It was concluded that a detention pond designed to treat the entire watershed, including the residential and agricultural areas, was not feasible based on the existing drainage and level of development in the lower watershed.

Construction of a detention pond on the agricultural field was determined to be technically feasible and would need a wet surface area of approximately 0.5 acres. The pond would reduce the sediment loadings to 60,657 lbs/yr or an 88% reduction in total loadings. The estimated cost of wet detention basin in the south watershed is estimated at $50,000.

ALTERNATIVE 3: CONSERVATION COVER

This alternative modeled the watersheds placing all of the agricultural land in conservation cover. This means that the agricultural land is retired from production and a perennial vegetative cover is maintained over the soil (NRCS, NHCP, 1987). A complete description can be found in Appendix C. Implementation of this practice would reduce the sediment inputs from 162,993 lbs/yr to an input of 8,993 lbs/yr, or a 94% reduction. Phosphorus inputs would be reduced from 103 lbs/yr to 26 lbs/yr, or a 75% reduction. Cost of this alternative, following the federal Conservation Reserve Program prototype, is estimated at $75 per acre. The total cost would be $1,682.25 per year if all the existing agricultural lands in the South Watershed were placed in conservation cover.

ALTERNATIVE 4: RESIDUE MANAGEMENT

This alternative modeled the agricultural land as if farmers were practicing residue management. Residue management is managing the amount, orientation and distribution of crop and other plant residues on the soil surface year-round, while growing crops in narrow slots or tilled strips in previously untilled soil and residue (NRCS, NHCP, 1994). A complete description can be found in Appendix C. Implementation of this practice would reduce the sediment inputs from 162,993 lbs/yr to an input of 62,993 lbs/yr, or a 61% reduction. Phosphorus inputs would be reduced from 103 lbs/yr to 53 lbs/yr, or a 49% reduction. Currently the Sugar/Honey Creek Priority Watershed Project is providing an incentive to eligible farmers of approximately $18.50 per acre to implement residue management. Using this incentive the cost of placing all of the agricultural land in the South Watershed in residue management would be $415.00 per year.

ALTERNATIVE 5: CONTOUR FARMING

This alternative modeled the agricultural land as if farmers were practicing contour farming. Contour farming is sloping the land in such a way that preparing land, planting, and cultivating are done on the contours (NRCS, NHCP, 1980). A complete description can be found in Appendix C. Implementation of this practice would reduce the sediment inputs from 162,993 lbs/yr to an input of 58,993 lbs/yr, or a 64% reduction. Phosphorus inputs would be reduced from 103 lbs/yr to 51 lbs/yr, or a 50% reduction. Currently the Sugar Creek Priority Watershed Project is providing an incentive to eligible farmers of approximately $9.00 per acre to implement contour farming. Using this incentive the cost of placing all of the agricultural land in the South Watershed in contour farming would be $200.00 per year.

ALTERNATIVE 6: CONTOUR STRIPS

This alternative modeled the agricultural land as if farmers were using contour strips. Contour strips are narrow strips of perennial, herbaceous vegetative cover established across the slope and alternated down the slope with wider cropped strips (NRCS, NHCP, 1997). A complete description can be found in Appendix C. Implementation of this practice would reduce the sediment inputs from 162,993 lbs/yr to an input of 44,993 lbs/yr, or a 72% reduction. Phosphorus inputs would be reduced from 103 lbs/yr to 44 lbs/yr, or a 57% reduction. Currently the Sugar Creek Priority Watershed Project is providing an incentive to eligible farmers of approximately $13.50 per acre to implement contour strips. Using this incentive the cost of placing all of the agricultural land in the South Watershed in contour strips would be $303.00 per year.

ALTERNATIVE 7: LAKE BUFFER STRIPS

Lake buffer strips are grassed areas along the lake that are allowed to be left un-mowed. The strip of taller grass has the ability to absorb more nutrients than mowed turf and allows the grass to establish a deeper root system, decreasing shore erosion. Riparian properties make up less than 1% of the sediment and phosphorus export from the South Watershed. Therefore lake buffer strips will provide limited water quality benefits. However, lake buffer strips do provide important wildlife habitat benefits that make them worth implementing.

ALTERNATIVE 8: PUBLIC EDUCATION ON LAWN CARE

The South Watershed includes 42 residential lots. Each of these lots is maintained with a turf lawn. Control of fertilizer runoff is important to protecting the lake. While the residential areas contribute only 3% of the sediment load from the South Watershed, they contribute 23% of the phosphorus loading. An education program on fertilizer management could help control a significant source of nutrients to the lake. The following is a list of things local residents can do to reduce the runoff of fertilizers:

1. Have the soil tested for its nutrient needs and follow the recommendations of the test. The University Extension provides soil testing at a nominal fee through the Walworth County Extension Office.

2. Apply fertilizer in several small applications throughout the summer instead of applying the entire dose for the year in one application. Never apply more than is recommended on the manufacturer's label.

3. Leave grass clippings on the lawn. This is equal to one fertilizer application per year.

4. Water the lawn after fertilizing, but do not over water, allowing the water to runoff into the ditch or street.

5. Any fertilizer spilled on roads or sidewalks should be promptly cleaned.

6. Never apply fertilizer to frozen ground.

7. Along ditches, and waterways leave a buffer strip that is not fertilized.

Additional information on safe lawn care can be found in Appendix D of this report. The Lauderdale Lake Management District is planning a public education program on lawn care to begin in the summer of 1998.

ALTERNATIVE 9: DEVELOPMENT CONTROLS

The agricultural area in the South Watershed has recently been sold to a land developer. As of the date of this report the area has not been recorded with Walworth County. The property is currently zoned A-3, agricultural land holding, by the county and township. It is assumed that the property will be developed as residential land use. If the area is converted from tilled field to residential lots it is predicted that the sediment loadings from the agricultural field will drop from the current 150,000 lbs. per year to approxiemntaly 3,000 lbs. per year. Phosphorus loadings will drop from 79 lbs. per year to an estimated 13 lbs. per year, depending on the density of development. The reductions in sediment and phosphorus are caused by conversion of the tilled fields to residential lawns.

While conversion of the agricultural area to residential land use should reduce the amount of sediment and phosphorus entering the lake, other pollutants associated with urban development may increase. Petroleum hydrocarbons, heavy metal, and fecal coliforms are examples of pollutants that may increase without adequate stormwater controls. A stormwater management system that addresses water quality should be installed with any proposed development for the site. If the area is developed as low density residential on large lots, the stormwater system should include grassed waterways and infiltration systems. If a clustered development of higher density lots is developed, wet detention may need to be incorporated into the design. The Lauderdale Lakes Management District should work with Walworth County and the Town of Sugar Creek to assure that adequate stormwater controls are incorporated into the final design of any proposed development.

RESULTS

As previously stated, total suspended sediment and total phosphorus loads were calculated for both the North and the South watersheds. A summary of both watersheds for existing conditions and various alternatives and their respective reductions in loadings are shown in Table 5.

The total phosphorus loadings calculated here are higher than what was calculated in the USGS report. One reason is that the drainage areas are different. The North Watershed is roughly 50 acres larger than in the USGS report and the South Watershed is roughly 15 acres smaller. Watershed delineation's for this study were based on field surveys. Another reason for the difference between the loadings calculated in the USGS report and this study is that the USGS study is for a particular year with precisely measured climatic data (i.e., precipitation, evaporation, etc.), and this study is based on a year with long-term average climatic conditions. In addition, completely different modeling techniques were used to model the watersheds.

RECOMMENDATIONS

FINAL RECOMMENDATION

Modeling results were discussed at a meeting with three representatives from the Lauderdale Lakes Management District; Scott Mason, Jerry Peterson, and WallyYandel, in addition to Bob Wakeman, DNR, and Neal O'Reilly and Tracy Seidel from Hey and Associates, Inc. Our firm also discussed results at a meeting with three representatives from the Walworth County Land Conservation office (WCLC); Brian Semeta, David Duwe, and Faye Anderson. Technical, political, and financial suggestions by all parties were taken into consideration in our final recommendation. Several recommendations will also be made simply based on field observations. Recommendations and the recommended implementation schedule are summarized in Table 6. Figures 2 and 3 show the location of the water quality alternatives, for the North and South Watersheds respectively, and priority listing.

NORTH WATERSHED

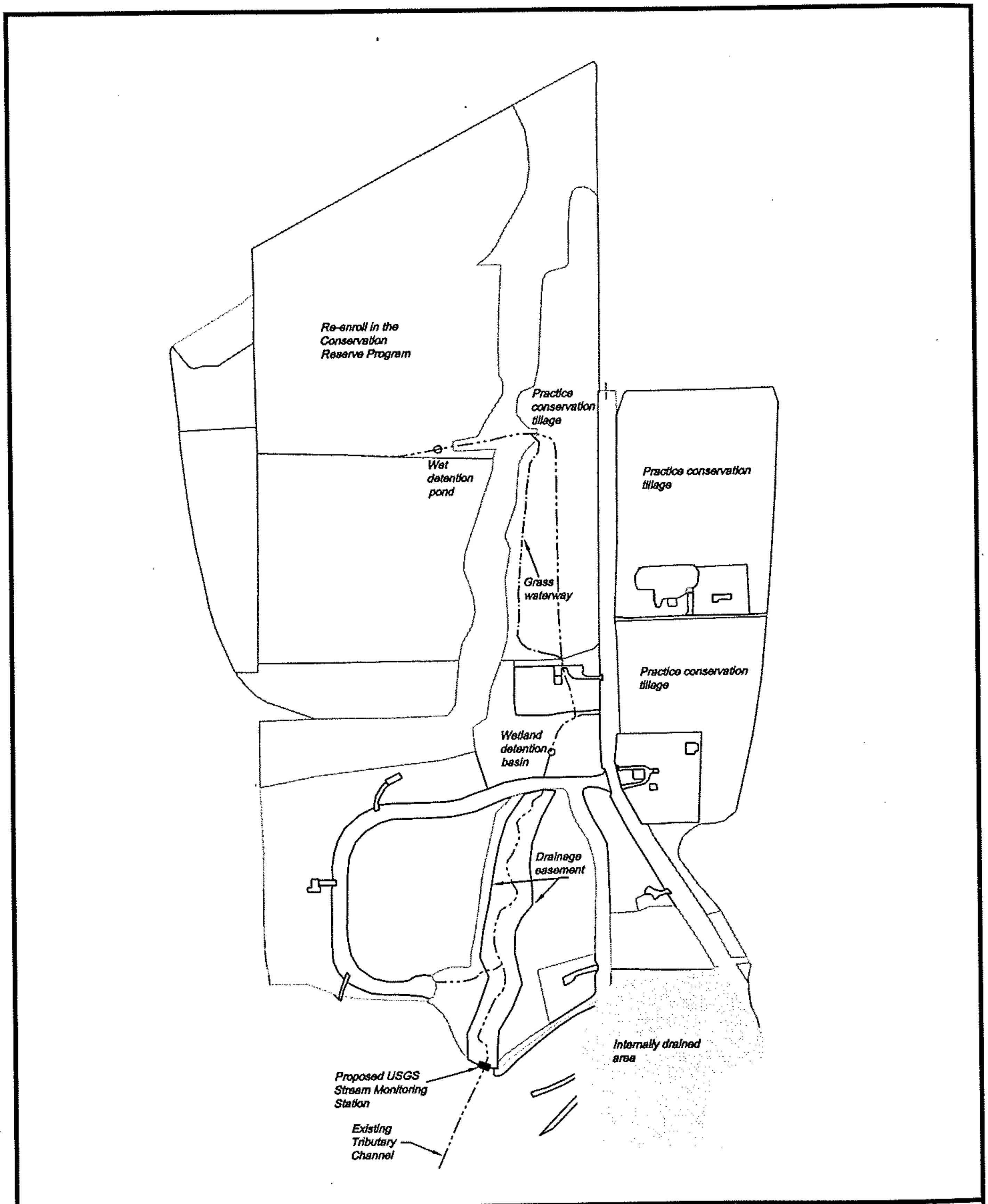
First Priority - The first priority is the construction of a wetland/detention facility on lot 1 in the Gladhurst Subdivision (see Figure 2). A problem with this recommendation is that the lot has recently been sold. Therefore it is recommended that the Lake District identify who the new owner of the lot is and see it they are aware the ephemeral stream runs through the center of the lot. The plat map shows a drainage easement close to the east side of the property, whereas, the actual waterway is further to the west. If the new owners are not aware of the waterway, they may be willing to re-sell the lot. Remax Realty stated that the lot sold for $39,000. The cost of this recommendation, if the land is available, is $65,000 for the construction of the pond, and approximately $42,000 for the land, for a total of $105,000.

Second Priority - The second priority would be to install a grass waterway along the west side of agricultural field west of HWY 12 (see Figure 2). This was a suggestion by Brian Semeta from the WCLC. Additional field survey would be required to identify the exact location of the waterway to fit it into the site's contours. To protect the waterway during heavy rainfall a detention facility should be constructed upstream of a steep section of field to allow the runoff to be safely metered. Cost of this recommendation is $2,000 for 1,000-feet of waterway, and $20,000 for the construction of the detention pond, for a total cost of $22,000.

Table 5 - Summary of Water Quality Management Alternatives

Alternative	Total Suspended Sediment (lbs/yr)											
	North Watershed					South Watershed						
	Residential/ open space	Residential/ open space (treated)	Ag	Total	% Reduction	Residential/ open space	Residential/ open space (treated)	Ag	Total	% Reduction	Total	% Reduction
Existing	10,257	--	504,000	514,257	0	4,993	--	158,000	162,993	0	677,250	0
Wet detention basin in residential area	5,334	492	50,400	56,226	89	999	399	15,800	17,198	89	73,424	89
(North Watershed(1.7 ac) and South Watershed (0.7 ac))												
Wet detention basin on Agricultural field	5,334	492	50,400	56,226	89	4,294	70	15,800	20,164	88	76,390	89
(South Watershed (0.5 ac), and North Watershed as above)												
Conservation cover on ag fields	10,257	--	36,000	46,257	91	4,993	--	4,000	8,993	94	55,250	92
Residue Management on agricultural fields	10,257	--	200,000	210,257	59	4,993	--	58,000	62,993	61	273,250	60
Contour farming on agricultural fields	10,257	--	164,000	174,257	66	4,993	--	54,000	58,993	64	233,250	66
Contour strips on agricultural fields	10,257	--	130,000	140,257	73	4,993	--	40,000	44,993	72	185,250	73

Alternative	Total Phosphorus (lbs/yr)											
	North Watershed					South Watershed						
	Residential/ open space	Residential/ open space (treated)	Ag	Total	% Reduction	Residential/ open space	Residential/ open space (treated)	Ag	Total	% Reduction	Total	% Reduction
Existing	21	--	252	273	0	24	--	79	103	0	376	0
Wet detention basin in residential area	11	5	113	129	53	5	9	36	49	52	178	53
(North Watershed(1.7 ac) and South Watershed (0.7 ac))												
Wet detention basin on Agricultural field	11	5	113	129	53	21	2	36	58	44	187	50
(South Watershed (0.5 ac), and North Watershed as above)												
Conservation cover on ag fields	21	--	18	39	86	24	--	2	26	75	65	83
Residue Management on agricultural fields	21	--	100	121	56	24	--	29	53	49	174	54
Contour farming on agricultural fields	21	--	82	103	62	24	--	27	51	50	154	59
Contour strips on agricultural fields	21	--	65	86	68	24	--	20	44	57	130	65

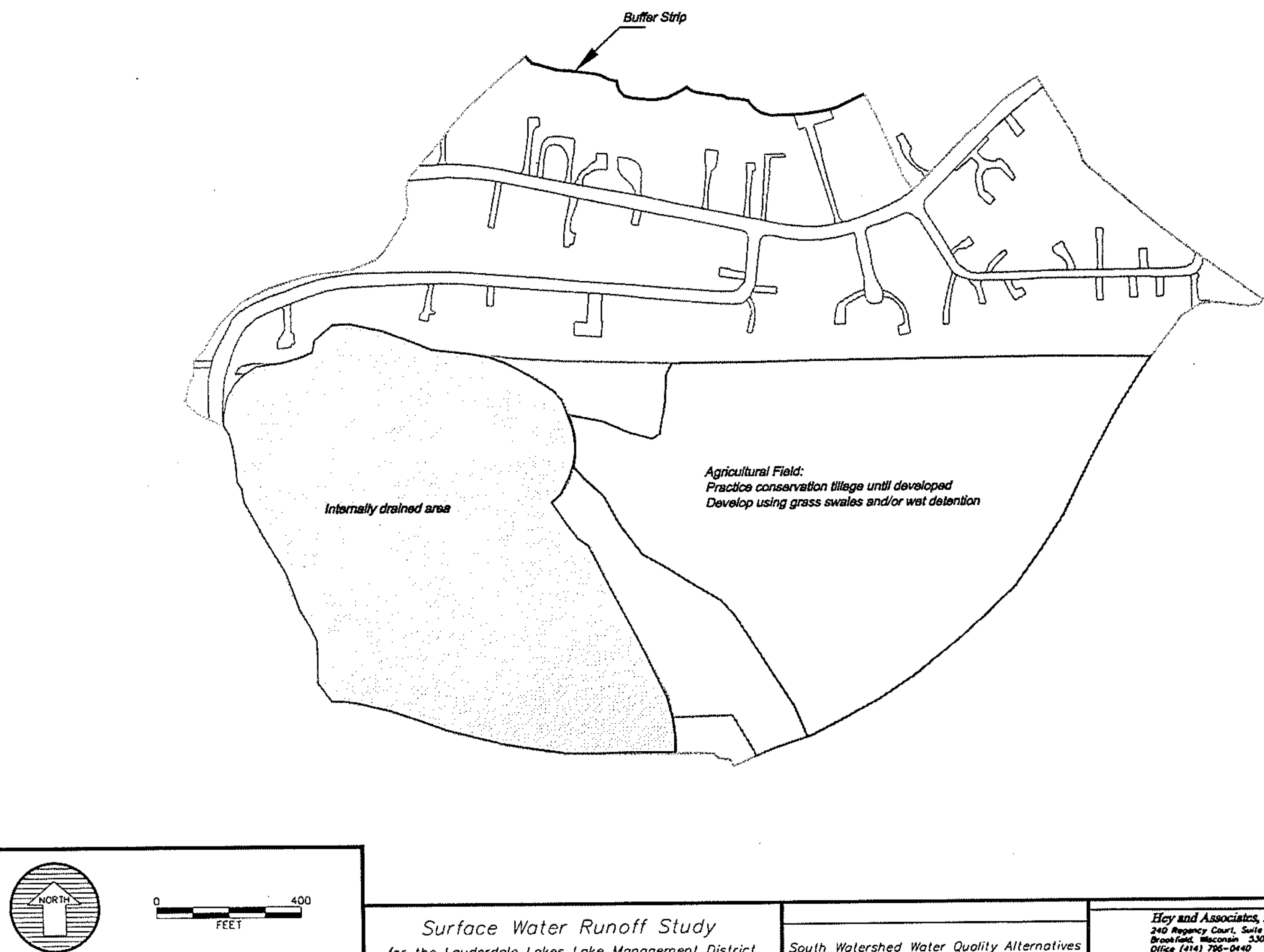


North Watershed Water Quality Alternatives

FIGURE NO. 2

Surface Water Runoff Study
for the Lauderdale Lakes Lake Management District

Hey and Associates, Inc.
240 Regency Court, Suite 201
Brookfield, Wisconsin 53045
Office (414) 796-0440
Fax (414) 796-0445



Surface Water Runoff Study

for the Lauderdale Lakes Lake Management District

South Watershed Water Quality Alternatives

Hey and Associates, Inc.
240 Regency Court, Suite 201
Brookfield, Wisconsin 53045
Office (414) 796-0440
Fax (414) 796-0445

3

Third Priority- The Third priority is to initiate conversation with the landowners of the two agricultural field East of HWY 12 and 8 regarding the use of conservation tillage (Figure 2). A letter has recently been sent by the Walworth County Land Conservation Department asking these landowners if they would be interested in being contacted with more information. Cost share incentives from the priority watershed project may be available for these properties.

Fourth Priority - The forth priority is to obtain conservation easements on the residential lots along the ravine area.

Fifth Priority - The last priority is to follow through on the re-enrollment of agricultural field located at the north side of the watershed in the conservation reserve program (Figure 2). WCLC stated that this landowner was interested in re-enrollment.

Additional recommendations based on field observations are to rake the leaves out of the downstream end of the tributary. When the site was visited the channel had many leaves in it which would be washed directly into the lake during a large rainfall event. An additional source of sediment is the unpaved road in the Gladhurst subdivision. During large rainfall events sediment may wash directly into the tributary. It may be desirable to pave this roadway.

SOUTH WATERSHED

As discussed above the South Watershed maybe in a period of land use transition. The agricultural field in the watershed has recently been sold for potential development. Therefore, the following recommendations will be prioritized based on the sequencing of the potential land use changes.

First Priority - The first priority is to discuss with the current owner of the agricultural area if they would manage the field in conservation tillage until such time it is developed. Conservation tillage, or residue management, would reduce sediment loadings from the watershed by 61% and phosphorus by 49%. Currently the Sugar/Honey Creek Priority Watershed Project is providing an incentive to eligible farmers of approximately $18.50 per acre to implement residue management. Due to its relatively flat topography, the field would not be eligible for cost share funds from the watershed project. Using the state incentive cost, placement of the watershed's portion of the agricultural field in residue management is estimated at $415.00 per year and would need to be implemented by the lake management district. Contacts with the landowner should be coordinated with the Walworth County Land Conservation Department.

Second Priority – The second priority is to begin discussions with Walworth County, Town of Sugar Creek and the land developer of the proposed new development to identify development standards and stormwater treatment practices that will protect the quality of the lake. The lake management district should contact the county and township stating their concerns and interest in participating in the planning discussions with the developer.

Third Priority – The third priority is to begin a public education program on proper lawn care. Educational materials are available from the WDNR and University of Wisconsin. Additional material is located in Appendix D of this report.

Fourth Priority- The fourth priority is to begin a public education program on the establishment of lake side buffers. An educational brochure on the benefits lake side buffers should be developed and distributed to each lake resident.

TABLE 6
Summary of Recommendations

Recommendation	Cost	Schedule	Implementing Body
North Watershed			
1. Wet detention facility	$105,000	Spring 1999	Lauderdale Lake Management District
2. Grassed waterway/detention basin	$2,000	Spring 1999	WCLD and landowner
3. Conservation easements	$20,000	Fall 1998	Lauderdale Lake Management District
4. Conservation tillage	$1,350/yr	Spring 1999	Lauderdale Lake Management District, WCLD and landowner
South Watershed			
1. Conservation tillage	$415/yr	Spring 1999	Lauderdale Lake Management District, WCLD and landowner
2. Zoning restrictions and stormwater management requirements on new residential development.	$0	When development is proposed	Walworth County and Town of LaGrange.
3. Education program on lawn care	-	Spring 1998	Lauderdale Lake Management District
4. Education program on establishment of lake buffer strips	-	Summer 1998	Lauderdale Lake Management District

FUTURE WATERSHED MONITORING

Success of the watershed nonpoint source program can only truly be determined through runoff monitoring. It is recommended that a monitoring station be established on the North Watershed to document changes over time and to help refine implementation of the watershed project. To establish a monitoring recommendation Bob Wakeman (WDNR) and representatives from the U.S. Geological Survey; Herb Garn and Bill Rose were contacted. From these meetings it was determined that the North tributary could be continuously monitored for flow and pollutants. A monitoring station could be established at a driveway culvert just upstream from Green Lake as shown on Figure 3. The monitoring station should monitor steam flows, and sediment and phosphorus loadings. It was determined that it would not be feasible to monitor the south tributary. The cost of monitoring the North Tributary for a five-year period is estimated at $66,793.

To complement the runoff monitoring it is important to have good rainfall and climatic data. Therefore it is recommended that the Lauderdale Lake Management District install a weather station on the golf course. This station would serve to collect local temperature and precipitation records. This data will be useful while analyzing any flow or water quality data collected on the lake or in the various tributaries to predict trends.

As identified in the introduction to this report, 75% of the surface runoff that enters Lauderdale Lakes comes from sheet flow. Much of the sheet flow is directly off residential lawns adjacent to the lake. To better understand the significance of the lawns as a pollution source it is recommended that a study of lawn runoff be conducted. The study should document typical pollutant export and the impacts of various management activities. The USGS has estimated the cost of a two year lawn study to be $30,204.

FUNDING SOURCES

Potential funding sources for implementation of the above recommendations are available from two state and two federal funding programs, the Lauderdale Lakes Management District, and private landowners. Table 7 summarizes the potentially eligible activities under each of the potential state and federal funding sources.

TABLE 7
Potential State and Federal Funding Sources and Eligible Activities

Program	Cost Share Rate	Eligible Activities in Plan
Wisconsin Nonpoint Source Priority Watershed Program	50 to 100%	Wet detention facility, grassed waterway, conservation tillage, and conservation easements.
Wisconsin Lake Protection Grant Program	75%	Wet detention facility, grassed waterway, conservation tillage, conservation easements, public education, and ordinance development.
USDA Conservation Reserve Program	100%	Conservation Cover
U. S. Geological Survey Cooperative Program Matching Funds	30%	Watershed and lake monitoring

The Wisconsin Nonpoint Source Priority Watershed Program is administered through the Sugar/ Honey Creeks Priority Watershed project. For Calendar year 1998, the priority watershed program is out of money and is not signing up any new landowners to participate in the grant program. Money may be available in calendar year 1999.

Table 8 outlines the recommended funding sources for implementation of this plan.

TABLE 8
Recommended Funding Sources

Recommendation	Cost	Funding Source
North Watershed		
1. Wet detention facility	$105,000.	Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District
2. Grassed waterway/detention basin	$2,000	Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District
3. Conservation easements	$20,000	Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District
4. Conservation tillage	$1,350/yr	Wisconsin Nonpoint Source Priority Watershed Program
5. Watershed Monitoring (5-year period)	$66,793	U. S. Geological Survey Cooperative Program Matching Funds, Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District
South Watershed		
1. Conservation tillage	$415/yr	Lauderdale Lakes Management District
2. Zoning restrictions and stormwater management requirements on new residential development.	$0	N/A
3. Education program on lawn care	-	Lauderdale Lakes Management District
4. Education program on establishment of lake buffer strips	-	Lauderdale Lakes Management District
Lake Watershed Wide		
1. Lawn runoff study	$30,204	U. S. Geological Survey Cooperative Program Matching Funds, Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District

watershed program is out of money and is not signing up any new landowners to participate in the grant program. Money may be available in calendar year 1999.

Table 8 outlines the recommended funding sources for implementation of this plan.

TABLE 8
Recommended Funding Sources

Recommendation	Cost	Funding Source
North Watershed		
1. Wet detention facility	$105,000.	Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District
2. Grassed waterway/detention basin	$2,000	Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District
3. Conservation easements	$20,000	Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District
4. Conservation tillage	$1,350/yr	Wisconsin Nonpoint Source Priority Watershed Program
5. Watershed Monitoring (5-year period)	$66,793	U. S. Geological Survey Cooperative Program Matching Funds, Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District
South Watershed		
1. Conservation tillage	$415/yr	Lauderdale Lakes Management District
2. Zoning restrictions and stormwater management requirements on new residential development.	$0	N/A
3. Education program on lawn care	-	Lauderdale Lakes Management District
4. Education program on establishment of lake buffer strips	-	Lauderdale Lakes Management District
Lake Watershed Wide		
1. Lawn runoff study	$30,204	U. S. Geological Survey Cooperative Program Matching Funds, Wisconsin Lake Protection Grant Program and Lauderdale Lakes Management District

PERMITS

Implementation of the above plan may require the acquisition of regulatory permits. The following is an overview of activities and the associated permit that may be required.

TABLE 9
Activities that May Require Regulatory Permits

Recommendation	Permit	Regulatory Agency
North Watershed		
1. Wet detention facility	Chapter 30	Wisconsin Department of Natural Resources
2. Grassed waterway/detention basin	Erosion Control	Walworth County
South Watershed		
None		

REFERENCES

Garn, H.S. and D.L. Olson, T.L. Seidel, W.J. Rose, 1996, Hydrology and Water Quality of Lauderdale Lakes, Walworth County, Wisconsin, 1993-94. U.S. Geological Survey Water-Resources Investigations Report 96-4235.

Novotony, Vladimir, and Harvey Olem, 1994, Water Quality Prevention, Identification, and Management of Diffuse Pollution, Van Nostrand Reinhold, New York.

Pitt, R. E., and John Vorhees, 1997, Source Loading and Management Model (SLAMM) V 7.0. Wisconsin Department of Natural Resources, Madison, WI.

Roehl, J.W. (1962). *Sediment Source Areas, Delivery Ratios and Influencing Morphological Factors*, Publ. No. 59, Internat. Assoc. Hydrol. Sci., pp. 202-213.

Shen, Hsieh Wen and Julien, Pierre Y., 1993, Handbook of Hydrology, Chapter 12, Erosion and Sediment Transport , McGraw Hill, Inc.

Smith, R.A. & Associates, Inc. (1988). Evaluation of Detention and Stream Buffers to Protect Fox Lake, Dodge County from Uncontrolled Upland Erosion,unpublished.

USDA, Soil Survey of Walworth County, U. S. Department of Agricultural, 1971.

Walworth County, Wisconsin, 1996, Land Atlas & Plat Book, 18th Edition, Rockford Map Publishers, Inc., Rockford, Illinois.

WDNR, WDATCP, and Walworth County Land Conservation Department, 1997. Nonpoint Source Control Plan for the Sugar/Honey Creeks Priority Watershed Project, Wisconsin Department of Natural Resources, Madison, WI.

Wischmeier, W.H., and D.D. Smith, "Predicting Rainfall Erosion Losses – A Guide to Conservation Planning," USDA Agriculture Handbook 537, 1978.

APPENDIX A

Results of SLAMM Modeling

NORTH WATERSHED

```
Data File:   North Watershed
Rain File:   RAIN81.RAN
Date: 04-08-1998   Time: 23:01:25
Site description:  Lauderdale Lakes Site 1, 120 acres trib. to NE corner of Green Lake

Total Area, with Drainage and Outfall Controls - Runoff Volume (cu. ft)
Start      Rain      Total     Total     Catch-    Total      Rv     Total     Calculat
d Peak        Flushing  Detention Basin
Date       Total     Without   With      basin     With              Losses    CN
  Reduction  Ratio      Outlet Structure
           (inches)  Drainage  Drainage  Volume    Outfall           (in) *
  Factor                Failed (land use #-
                     Controls  Controls  % Full    Controls
                        source area #)
Summary for Runoff Producing Events
Number of Runoff Prod-
   ucing Rains:           76        44        44        44        44
Minimum:     0.03         91        47       0.0        47      0.00      0.03      71.1
Maximum:     1.85      64554     51256       0.0     51256      0.16      1.64      98.5
Average:     0.40       9932     12855       0.0     12855      0.09      0.36
Total:      30.36     754816    565607              565607

    *  Total losses are summarized for all events, not for runoff producing events alon
e.
*****************************************************************

Total Area, with Drainage and Outfall Controls - Concentration of PARTICULATE SOLIDS
(mg/L)
Start      Rain      Total     Total     Catch-    Total    Flow-wtd
Date       Total     Without   With      basin     With     Min. Part.
           (inches)  Drainage  Drainage  Volume    Outfall  Size
                     Controls  Controls  % Full    Controls Controlled
Summary for Runoff Producing Events
```

Number of Runoff Producing Rains:		76	44	44	44	
Minimum:	0.03	261	0	0.0	0	
Maximum:	1.85	8720	839	0.0	839	
Fl Wt Ave:	0.40	327	291	0.0	291	

****

Total Area, with Drainage and Outfall Controls - Yield of PARTICULATE SOLIDS (lbs)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	44	44	44	
Minimum:	0.03	22	2	0.0	2	
Maximum:	1.85	1053	833	0.0	833	
Fl Wt Ave:	0.40	527	463	0.0	463	
Total:	30.36	15397	10257		10257	

****

==

==

==

==

Total Area, with Drainage and Outfall Controls - Concentration of TOTAL SOLIDS (mg/L)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	44	44	44	

Minimum:	0.03	447	0	0.0	0	
Maximum:	1.85	9578	1400	0.0	1400	
Fl Wt Ave:	0.40	841	813	0.0	813	

****

Total Area, with Drainage and Outfall Controls - Yield of TOTAL SOLIDS (lbs)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	44	44	44	
Minimum:	0.03	23	3	0.0	3	
Maximum:	1.85	3354	2478	0.0	2478	
Fl Wt Ave:	0.40	1453	1269	0.0	1269	
Total:	30.36	39616	28677		28677	

****

===

Total Area, with Drainage and Outfall Controls - Concentration of PARTICULATE PHOSPHORUS (micrograms/L)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	44	44	44	
Minimum:	0.03	102	0	0.0	0	
Maximum:	1.85	21225	818	0.0	818	
Fl Wt Ave:	0.40	324	297	0.0	297	

****

Total Area, with Drainage and Outfall Controls - Yield of PARTICULATE PHOSPHORUS (lbs)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	44	44	44	
Minimum:	0.03	6.95E-03	5.55E-04	0.0	5.55E-04	
Maximum:	1.85	2	1	0.0	1	
Fl Wt Ave:	0.40	6.09E-01	5.10E-01	0.0	5.10E-01	
Total:	30.36	15	10		10	

****

==

==

Total Area, with Drainage and Outfall Controls - Concentration of TOTAL PHOSPHORUS (micrograms/L)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	44	44	44	
Minimum:	0.03	327	0	0.0	0	
Maximum:	1.85	21534	1131	0.0	1131	
Fl Wt Ave:	0.40	641	608	0.0	608	

****

Total Area, with Drainage and Outfall Controls - Yield of TOTAL PHOSPHORUS (lbs)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	44	44	44	
Minimum:	0.03	1.23E-02	1.62E-03	0.0	1.62E-03	
Maximum:	1.85	3	2	0.0	2	
Fl Wt Ave:	0.40	1	1	0.0	1	
Total:	30.36	30	21		21	

****

===

==

SOUTH WATERSHED

Data File: South Watershed
Rain File: RAIN81.RAN
Date: 04-06-1998 Time: 22:24:33
Site description: Lauderdale Lakes Site 2

Residential Areas - Runoff Volume (cu. ft)

Start Date	Rain Total (inches)	Roofs 1	Drive-ways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals	Rv	Total Losses (in.) *	Calculated CN
Summary for Runoff Producing Events									
Minimum:	0.03	0.00E+00	0.00E+00	42	0.00E+00	42	0.01	0.03	73.7
Maximum:	1.85	1573	1418	10842	22250	36084	0.15	1.57	98.8
Average:	0.40	222	200	1870	3140	5433	0.10	0.36	
Total:	30.36	16878	15214	142140	238674	412906			

Open Space Areas - Runoff Volume (cu. ft)

Start Date	Rain Total (inches)	Undevel-oped Area Area	Land Use Totals	Rv	Total Losses (in.) *	Calculated CN
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	0.00	0.03	70.8
Maximum:	1.85	3856	3856	0.11	1.65	98.5
Average:	0.40	544	544	0.07	0.37	
Total:	30.36	41364	41364			

Total Area, with Drainage and Outfall Controls - Runoff Volume (cu. ft)

```
Start     Rain      Total     Total     Catch-    Total      Rv      Total     Calculat
d Peak       Flushing  Detention Basin
Date      Total     Without   With      basin     With               Losses    CN
  Reduction  Ratio     Outlet Structure
          (inches)  Drainage  Drainage  Volume    Outfall            (in) *
  Factor               Failed (land use #-
                    Controls  Controls  % Full    Controls
                       source area #)
Summary for Runoff Producing Events
Number of Runoff Prod-
   ucing Rains:         76        34        34        34        34
Minimum:     0.03       42        80       0.0        80      0.00      0.03      67.3
Maximum:     1.85    39940     31058       0.0     31058      0.13      1.72      98.5
Average:     0.40     5977      8886       0.0      8886      0.07      0.37
Total:      30.36   454270    302135              302135

    *  Total losses are summarized for all events, not for runoff producing events alon
e.
*****************************************************************

Residential Areas - Concentration of PARTICULATE SOLIDS  (mg/L)
Start     Rain      Roofs 1   Drive-    Street    Small          Land
Date      Total               ways 1    Area 1    Lndscaped      Use
          (inches)                                Area 1       Totals
Summary for Runoff Producing Events
Minimum:     0.03       23       120       176       108       124
Maximum:     1.85       23       120     19234       108     19234
Fl Wt Ave:  0.40        23       120       982       108       406

Open Space Areas - Concentration of PARTICULATE SOLIDS  (mg/L)
Start     Rain      Undevel-      Land
Date      Total     oped Area     Use
          (inches)  Area        Totals
```

Summary for Runoff Producing Events

Minimum:	0.03	500	0.00E+00
Maximum:	1.85	500	500
Fl Wt Ave:	0.40	500	500

Total Area, with Drainage and Outfall Controls - Concentration of PARTICULATE SOLIDS (mg/L)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	34	34	34	
Minimum:	0.03	161	0	0.0	0	
Maximum:	1.85	19234	2109	0.0	2109	
Fl Wt Ave:	0.40	414	265	0.0	265	

****

Residential Areas - Yield of PARTICULATE SOLIDS (lbs)

Start Date	Rain Total (inches)	Roofs 1	Drive-ways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	47	0.00E+00	47
Maximum:	1.85	2	11	165	150	303
Fl Wt Ave:	0.40	1	5	133	78	213
Total:	30.36	24	114	8705	1608	10451

Open Space Areas - Yield of PARTICULATE SOLIDS (lbs)

Start Date	Rain Total	Undevel-oped Area	Land Use

	(inches)	Area	Totals
Summary for Runoff Producing Events			
Minimum:	0.03	0.00E+00	0.00E+00
Maximum:	1.85	120	120
Fl Wt Ave:	0.40	62	62
Total:	30.36	1290	1290

Total Area, with Drainage and Outfall Controls - Yield of PARTICULATE SOLIDS (lbs)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	34	34	34	
Minimum:	0.03	47	10	0.0	10	
Maximum:	1.85	417	375	0.0	375	
Fl Wt Ave:	0.40	273	220	0.0	220	
Total:	30.36	11741	4993		4993	

****

Residential Areas - Source Area Percentage Contribution to Total Runoff Volume

Start Date	Rain Total (inches)	Roofs 1	Drive-ways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	26	0.00E+00	90
Maximum:	1.85	4	4	100	57	100
Average:	0.40	2	2	68	25	96

Open Space Areas - Source Area Percentage Contribution to Total Runoff Volume

Start	Rain	Undevel-	Land

Date	Total (inches)	oped Area Area	Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	0.00E+00	0.00E+00
Maximum:	1.85	10	10
Average:	0.40	4	4

Residential Areas - Source Area Percentage Contribution to PARTICULATE SOLIDS

Start Date	Rain Total (inches)	Roofs 1	Drive-ways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	28	0.00E+00	70
Maximum:	1.85	5.71E-01	3	100	38	100
Fl Wt Ave:	0.40	3.86E-01	2	60	26	81

Open Space Areas - Source Area Percentage Contribution to PARTICULATE SOLIDS

Start Date	Rain Total (inches)	Undevel-oped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	0.00E+00	0.00E+00
Maximum:	1.85	30	30
Fl Wt Ave:	0.40	21	21

===
===
===
===

Residential Areas - Concentration of TOTAL SOLIDS (mg/L)

Start Date	Rain Total (inches)	Roofs 1	Drive-ways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals

Summary for Runoff Producing Events						
Minimum:	0.03	26	138	259	214	294
Maximum:	1.85	351	1073	19361	7063	19361
Fl Wt Ave:	0.40	105	304	1114	1051	1007

Open Space Areas - Concentration of TOTAL SOLIDS (mg/L)

Start Date	Rain Total (inches)	Undevel- oped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	579	0.00E+00
Maximum:	1.85	4132	4132
Fl Wt Ave:	0.40	1063	1063

Total Area, with Drainage and Outfall Controls - Concentration of TOTAL SOLIDS (mg/L)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch- basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Prod- ucing Rains:		76	34	34	34	
Minimum:	0.03	370	0	0.0	0	
Maximum:	1.85	19361	4200	0.0	4200	
Fl Wt Ave:	0.40	1012	819	0.0	819	

****

Residential Areas - Yield of TOTAL SOLIDS (lbs)

Start Date	Rain Total (inches)	Roofs 1	Drive- ways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	48	0.00E+00	48

Maximum:	1.85	12	24	251	6785	7031
Fl Wt Ave:	0.40	5	14	170	804	942
Total:	30.36	110	288	9884	15654	25936

Open Space Areas - Yield of TOTAL SOLIDS (lbs)

Start Date	Rain Total (inches)	Undevel- oped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	0.00E+00	0.00E+00
Maximum:	1.85	259	259
Fl Wt Ave:	0.40	124	124
Total:	30.36	2745	2745

Total Area, with Drainage and Outfall Controls - Yield of TOTAL SOLIDS (lbs)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch- basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Prod- ucing Rains:		76	34	34	34	
Minimum:	0.03	48	12	0.0	12	
Maximum:	1.85	7179	4404	0.0	4404	
Fl Wt Ave:	0.40	1065	750	0.0	750	
Total:	30.36	28681	15443		15443	

****

Residential Areas - Source Area Percentage Contribution to TOTAL SOLIDS

Start Date	Rain Total	Roofs 1	Drive- ways 1	Street Area 1	Small Lndscaped	Land Use

	Rain Total (inches)				Area 1	Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	3	0.00E+00	67
Maximum:	1.85	2	5	100	95	100
Fl Wt Ave:	0.40	6.89E-01	2	39	53	85

Open Space Areas - Source Area Percentage Contribution to TOTAL SOLIDS

Start Date	Rain Total (inches)	Undevel-oped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	0.00E+00	0.00E+00
Maximum:	1.85	33	33
Fl Wt Ave:	0.40	16	16

==

Residential Areas - Concentration of PARTICULATE PHOSPHORUS (micrograms/L)

Start Date	Rain Total (inches)	Roofs 1	Drive-ways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	13	83	38	112	117
Maximum:	1.85	306	2139	41600	4098	41600
Fl Wt Ave:	0.40	112	423	774	988	858

Open Space Areas - Concentration of PARTICULATE PHOSPHORUS (micrograms/L)

Start Date	Rain Total (inches)	Undevel-oped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	33	0.00E+00
Maximum:	1.85	1073	1073

Fl Wt Ave:	0.40	321	321

Total Area, with Drainage and Outfall Controls - Concentration of PARTICULATE PHOSPHORUS (micrograms/L)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	34	34	34	
Minimum:	0.03	136	0	0.0	0	
Maximum:	1.85	41600	2657	0.0	2657	
Fl Wt Ave:	0.40	809	726	0.0	726	

****

Residential Areas - Yield of PARTICULATE PHOSPHORUS (lbs)

Start Date	Rain Total (inches)	Roofs 1	Driveways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	8.09E-03	0.00E+00	8.09E-03
Maximum:	1.85	1.73E-02	4.96E-02	8.50E-01	3	3
Fl Wt Ave:	0.40	5.21E-03	1.74E-02	9.78E-02	7.16E-01	7.88E-01
Total:	30.36	1.18E-01	4.02E-01	7	15	22

Open Space Areas - Yield of PARTICULATE PHOSPHORUS (lbs)

Start Date	Rain Total (inches)	Undeveloped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	0.00E+00	0.00E+00

Maximum:	1.85	1.08E-01	1.08E-01
Fl Wt Ave:	0.40	3.37E-02	3.37E-02
Total:	30.36	8.27E-01	8.27E-01

Total Area, with Drainage and Outfall Controls - Yield of PARTICULATE PHOSPHORUS (lbs)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	34	34	34	
Minimum:	0.03	8.09E-03	3.49E-03	0.0	3.49E-03	
Maximum:	1.85	3	3	0.0	3	
Fl Wt Ave:	0.40	8.24E-01	6.96E-01	0.0	6.96E-01	
Total:	30.36	23	14		14	

****

Residential Areas - Source Area Percentage Contribution to PARTICULATE PHOSPHORUS

Start Date	Rain Total (inches)	Roofs 1	Driveways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	2	0.00E+00	77
Maximum:	1.85	3	11	100	96	100
Fl Wt Ave:	0.40	7.79E-01	3	31	70	94

Open Space Areas - Source Area Percentage Contribution to PARTICULATE PHOSPHORUS

Start Date	Rain Total (inches)	Undeveloped Area Area	Land Use Totals

Summary for Runoff Producing Events

Minimum:	0.03	0.00E+00	0.00E+00
Maximum:	1.85	23	23
Fl Wt Ave:	0.40	6	6

==
==
==
==

Residential Areas - Concentration of TOTAL PHOSPHORUS (micrograms/L)

Start Date	Rain Total (inches)	Roofs 1	Drive-ways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	43	175	157	371	362
Maximum:	1.85	516	2201	41709	4950	41709
Fl Wt Ave:	0.40	171	641	972	1838	1428

Open Space Areas - Concentration of TOTAL PHOSPHORUS (micrograms/L)

Start Date	Rain Total (inches)	Undevel-oped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	117	0.00E+00
Maximum:	1.85	1811	1811
Fl Wt Ave:	0.40	627	627

Total Area, with Drainage and Outfall Controls - Concentration of TOTAL PHOSPHORUS (m
icrograms/L)

Start Date	Rain Total (inches)	Total Without Drainage Controls	Total With Drainage Controls	Catch-basin Volume % Full	Total With Outfall Controls	Flow-wtd Min. Part. Size Controlled

Summary for Runoff Producing Events

Number of Runoff Producing Rains:		76	34	34	34
Minimum:	0.03	402	0	0.0	0
Maximum:	1.85	41709	3140	0.0	3140
Fl Wt Ave:	0.40	1355	1274	0.0	1274

****

Residential Areas - Yield of TOTAL PHOSPHORUS (lbs)

Start Date	Rain Total (inches)	Roofs 1	Driveways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	8.87E-03	0.00E+00	8.87E-03
Maximum:	1.85	1.89E-02	8.74E-02	8.52E-01	4	4
Fl Wt Ave:	0.40	7.77E-03	2.97E-02	1.56E-01	1	1
Total:	30.36	1.80E-01	6.09E-01	9	27	37

Open Space Areas - Yield of TOTAL PHOSPHORUS (lbs)

Start Date	Rain Total (inches)	Undeveloped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	0.00E+00	0.00E+00
Maximum:	1.85	2.40E-01	2.40E-01
Fl Wt Ave:	0.40	7.38E-02	7.38E-02
Total:	30.36	2	2

Total Area, with Drainage and Outfall Controls - Yield of TOTAL PHOSPHORUS (lbs)

Start Date	Rain Total	Total Without	Total With	Catch-basin	Total With	Flow-wtd Min. Part.

	(inches)	Drainage Controls	Drainage Controls	Volume % Full	Outfall Controls	Size Controlled
Summary for Runoff Producing Events						
Number of Runoff Producing Rains:		76	34	34	34	
Minimum:	0.03	8.87E-03	5.09E-03	0.0	5.09E-03	
Maximum:	1.85	4	3	0.0	3	
Fl Wt Ave:	0.40	2	1	0.0	1	
Total:	30.36	38	24		24	

****

Residential Areas - Source Area Percentage Contribution to TOTAL PHOSPHORUS

Start Date	Rain Total (inches)	Roofs 1	Driveways 1	Street Area 1	Small Lndscaped Area 1	Land Use Totals
Summary for Runoff Producing Events						
Minimum:	0.03	0.00E+00	0.00E+00	3	0.00E+00	81
Maximum:	1.85	2	10	100	96	100
Fl Wt Ave:	0.40	5.67E-01	2	27	75	94

Open Space Areas - Source Area Percentage Contribution to TOTAL PHOSPHORUS

Start Date	Rain Total (inches)	Undeveloped Area Area	Land Use Totals
Summary for Runoff Producing Events			
Minimum:	0.03	0.00E+00	0.00E+00
Maximum:	1.85	19	19
Fl Wt Ave:	0.40	6	6

===

===

APPENDIX B

UNIVERSAL SOIL LOSS EQUATION RESULTS

Lauderdale Lakes USLE Computations

A = R K LS C P

A = Annual loss of soil, tons/acre
R = Runoff/rainfall indes, 140 for Lauderdale Lakes
K = Soil erodibility factor
LS = Topographic factor, L for slope length and S for percent slope
C = Cropping-management factor
P = Conservation practice factor

Existing Conditions:

Source	Area (acres)	K	Slope %	Length (ft)	LS	C[1]	P	A (tons/ac/yr)	Total Loss (tons/yr)	Sediment Delivery Ratio (%)	Sediment Delivered (tons/yr)	Total Phosphorus (lbs/yr)
Site 1, Area 1	1.78	0.35	11.0	200	2.25	0.01	1.0	1.1	2	50	1	1
Site 1, Area 2	4.48	0.37	4.0	250	0.57	0.41	1.0	12.1	54	50	27	27
Site 1, Area 3	22.24	0.36	9.0	250	1.85	0.01	1.0	0.9	21	50	10	10
Site 1, Area 4	14.19	0.37	4.0	250	0.57	0.41	1.0	12.0	171	50	85	85
Site 1, Area 5	3.46	0.35	6.0	250	1.1	0.01	1.0	0.5	2	50	1	1
Site 1, Area 6	10.31	0.37	5.0	250	0.85	0.41	1.0	18.1	186	50	93	93
Site 1, Area 7	9.82	0.37	1.0	250	0.14	0.41	1.0	3.0	29	50	15	15
Site 1, Area 8	6.96	0.37	2.0	250	0.27	0.41	1.0	5.7	40	50	20	20
Total Site 1	73.24								505		252	252
Site 2, Area 1	22.43	0.37	2.0	250	0.27	0.41	1.0	5.7	128	62	79	79
Total Site 2	22.43								128		79	79

[1] Fall Moldboard Plow - clean tillage

Site 1 **Eight areas totaling 73.24 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope
1	MxD2	0.69	0.32	0.22		12-20	16	11.04	
	MpC2	0.87	0.37	0.32		6-12	9	7.83	
	MpB	0.22	0.37	0.08	0.35	2-6	4	0.88	11.1
2	MpC2	0.03	0.37	0.01		6-12	9	0.27	
	MpB	4.45	0.37	1.65	0.37	2-6	4	17.8	4.0
3	MpB	6.89	0.37	2.55		2-6	4	27.56	
	MpC2	11.64	0.37	4.31		6-12	9	104.76	
	MxD2	1.9	0.32	0.61		12-20	16	30.4	
	MwD2	1.81	0.32	0.58	0.36	12-20	16	28.96	8.6
4	MpB	13.47	0.37	4.98		2-6	4	53.88	
	MxD2	0.35	0.32	0.11		12-20	16	5.6	
	MxC2	0.37	0.32	0.12	0.37	6-12	9	3.33	4.4
5	MpB	2.2	0.37	0.81		2-6	4	8.8	
	MxC2	1.09	0.32	0.35		6-12	9	9.81	
	MxD2	0.17	0.32	0.05	0.35	12-20	16	2.72	6.2
6	FsB	7.87	0.37	2.91		2-6	4	31.48	
	FsC2	1.52	0.37	0.56		6-12	9	13.68	
	MpB	0.92	0.37	0.34	0.37	2-6	4	3.68	4.7
7	FsA	8.94	0.37	3.31		0-2	1	8.94	
	FsB	0.88	0.37	0.33	0.37	2-6	4	3.52	1.3
8	FsA	3.62	0.37	1.34		0-2	1	3.62	
	FsB	3.34	0.37	1.24	0.37	2-6	4	13.36	2.4
Total		73.24							Override with above numbers, from field recon.

Site 2 **One area totaling 22.43 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope
1	SeA	15.7	0.37	5.81		0-2	4	62.8	
	SeB	3.6	0.37	1.33		2-6	4	14.4	
	JuA	0.9	0.37	0.33		1-3	2	1.8	
	FsB	1	0.37	0.37		2-6	4	4	
	ClC2	1.23	0.32	0.39	0.37	6-12	9	11.07	4.2
Total		22.43							Override with 2.0, from field recon.

Lauderdale Lakes USLE Computations

A = R K LS C P

A = Annual loss of soil, tons/acre
R = Runoff/rainfall indes, 140 for Lauderdale Lakes
K = Soil erodibility factor
LS = Topographic factor, L for slope length and S for percent slope
C = Cropping-management factor
P = Conservation practice factor

Residue Management (no till and strip till):

Source	Area (acres)	K	Slope %	Length (ft)	LS	C[1]	P	A (tons/ac/yr)	Total Loss (tons/yr)	Sediment Delivery Ratio (%)	Sediment Delivered (tons/yr)	Total Phosphorus (lbs/yr)
Site 1, Area 1	1.78	0.35	11.0	200	2.25	0.01	1.0	1.1	2	50	1	1
Site 1, Area 2	4.48	0.37	4.0	250	0.57	0.15	1.0	4.4	20	50	10	10
Site 1, Area 3	22.24	0.36	9.0	250	1.85	0.01	1.0	0.9	21	50	10	10
Site 1, Area 4	14.19	0.37	4.0	250	0.57	0.15	1.0	4.4	62	50	31	31
Site 1, Area 5	3.46	0.35	6.0	250	1.1	0.01	1.0	0.5	2	50	1	1
Site 1, Area 6	10.31	0.37	5.0	250	0.85	0.15	1.0	6.6	68	50	34	34
Site 1, Area 7	9.82	0.37	1.0	250	0.14	0.15	1.0	1.1	11	50	5	5
Site 1, Area 8	6.96	0.37	2.0	250	0.27	0.15	1.0	2.1	15	50	7	7
Total Site 1	73.24								200		100	100
Site 2, Area 1	22.43	0.37	2.0	250	0.27	0.15	1.0	2.1	47	62	29	29
Total Site 2	22.43								47		29	29

[1] No-till, 35% of ground cover after planting

Site 1 **Eight areas totaling 73.24 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope	
1	MxD2	0.69	0.32	0.22		12-20	16	11.04		
	MpC2	0.87	0.37	0.32		6-12	9	7.83		
	MpB	0.22	0.37	0.08	0.35	2-6	4	0.88	11.1	
2	MpC2	0.03	0.37	0.01		6-12	9	0.27		
	MpB	4.45	0.37	1.65	0.37	2-6	4	17.8	4.0	
3	MpB	6.89	0.37	2.55		2-6	4	27.56		
	MpC2	11.64	0.37	4.31		6-12	9	104.76		
	MxD2	1.9	0.32	0.61		12-20	16	30.4		
	MwD2	1.81	0.32	0.58	0.36	12-20	16	28.96	8.6	
4	MpB	13.47	0.37	4.98		2-6	4	53.88		
	MxD2	0.35	0.32	0.11		12-20	16	5.6		
	MxC2	0.37	0.32	0.12	0.37	6-12	9	3.33	4.4	
5	MpB	2.2	0.37	0.81		2-6	4	8.8		
	MxC2	1.09	0.32	0.35		6-12	9	9.81		
	MxD2	0.17	0.32	0.05	0.35	12-20	16	2.72	6.2	
6	FsB	7.87	0.37	2.91		2-6	4	31.48		
	FsC2	1.52	0.37	0.56		6-12	9	13.68		
	MpB	0.92	0.37	0.34	0.37	2-6	4	3.68	4.7	
7	FsA	8.94	0.37	3.31		0-2	1	8.94		
	FsB	0.88	0.37	0.33	0.37	2-6	4	3.52	1.3	
8	FsA	3.62	0.37	1.34		0-2	1	3.62		
	FsB	3.34	0.37	1.24	0.37	2-6	4	13.36	2.4	
Total		73.24							Override with above numbers, from field recon.	

Site 2 **One area totaling 22.43 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope	
1	SeA	15.7	0.37	5.81		0-2	4	62.8		
	SeB	3.6	0.37	1.33		2-6	4	14.4		
	JuA	0.9	0.37	0.33		1-3	2	1.8		
	FsB	1	0.37	0.37		2-6	4	4		
	ClC2	1.23	0.32	0.39	0.37	6-12	9	11.07	4.2	
Total		22.43							Override with 2.0, from field recon.	

Lauderdale Lakes USLE Computations

$A = R\ K\ LS\ C\ P$

A = Annual loss of soil, tons/acre
R = Runoff/rainfall indes, 140 for Lauderdale Lakes
K = Soil erodibility factor
LS = Topographic factor, L for slope length and S for percent slope
C = Cropping-management factor
P = Conservation practice factor

Contour Farming:

Source	Area (acres)	K	Slope %	Length (ft)	LS	C[1]	P	A (tons/ac/yr)	Total Loss (tons/yr)	Sediment Delivery Ratio (%)	Sediment Delivered (tons/yr)	Total Phosphorus (lbs/yr)
Site 1, Area 1	1.78	0.35	11.0	200	2.25	0.01	1.0	1.1	2	50	1	1
Site 1, Area 2	4.48	0.37	4.0	250	0.57	0.23	0.5	3.4	15	50	8	8
Site 1, Area 3	22.24	0.36	9.0	250	1.85	0.01	1.0	0.9	21	50	10	10
Site 1, Area 4	14.19	0.37	4.0	250	0.57	0.23	0.5	3.4	48	50	24	24
Site 1, Area 5	3.46	0.35	6.0	250	1.1	0.01	1.0	0.5	2	50	1	1
Site 1, Area 6	10.31	0.37	5.0	250	0.85	0.23	0.5	5.1	52	50	26	26
Site 1, Area 7	9.82	0.37	1.0	250	0.14	0.23	0.6	1.0	10	50	5	5
Site 1, Area 8	6.96	0.37	2.0	250	0.27	0.23	0.6	1.9	13	50	7	7
Total Site 1	73.24								163		82	82
Site 2, Area 1	22.43	0.37	2.0	250	0.27	0.23	0.6	1.9	43	62	27	27
Total Site 2	22.43								43		27	27

[1] Till Plant Contour Rows, 30% of ground cover after planting

Site 1 **Eight areas totaling 73.24 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope
1	MxD2	0.69	0.32	0.22		12-20	16	11.04	
	MpC2	0.87	0.37	0.32		6-12	9	7.83	
	MpB	0.22	0.37	0.08	0.35	2-6	4	0.88	11.1
2	MpC2	0.03	0.37	0.01		6-12	9	0.27	
	MpB	4.45	0.37	1.65	0.37	2-6	4	17.8	4.0
3	MpB	6.89	0.37	2.55		2-6	4	27.56	
	MpC2	11.64	0.37	4.31		6-12	9	104.76	
	MxD2	1.9	0.32	0.61		12-20	16	30.4	
	MwD2	1.81	0.32	0.58	0.36	12-20	16	28.96	8.6
4	MpB	13.47	0.37	4.98		2-6	4	53.88	
	MxD2	0.35	0.32	0.11		12-20	16	5.6	
	MxC2	0.37	0.32	0.12	0.37	6-12	9	3.33	4.4
5	MpB	2.2	0.37	0.81		2-6	4	8.8	
	MxC2	1.09	0.32	0.35		6-12	9	9.81	
	MxD2	0.17	0.32	0.05	0.35	12-20	16	2.72	6.2
6	FsB	7.87	0.37	2.91		2-6	4	31.48	
	FsC2	1.52	0.37	0.56		6-12	9	13.68	
	MpB	0.92	0.37	0.34	0.37	2-6	4	3.68	4.7
7	FsA	8.94	0.37	3.31		0-2	1	8.94	
	FsB	0.88	0.37	0.33	0.37	2-6	4	3.52	1.3
8	FsA	3.62	0.37	1.34		0-2	1	3.62	
	FsB	3.34	0.37	1.24	0.37	2-6	4	13.36	2.4
Total		73.24							Override with above numbers, from field recon.

Site 2 **One area totaling 22.43 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope
1	SeA	15.7	0.37	5.81		0-2	4	62.8	
	SeB	3.6	0.37	1.33		2-6	4	14.4	
	JuA	0.9	0.37	0.33		1-3	2	1.8	
	FsB	1	0.37	0.37		2-6	4	4	
	ClC2	1.23	0.32	0.39	0.37	6-12	9	11.07	4.2
Total		22.43							Override with 2.0, from field recon.

Lauderdale Lakes USLE Computations

A = R K LS C P

A = Annual loss of soil, tons/acre
R = Runoff/rainfall indes, 140 for Lauderdale Lakes
K = Soil erodibility factor
LS = Topographic factor, L for slope length and S for percent slope
C = Cropping-management factor
P = Conservation practice factor

Contour Strips:

Source	Area (acres)	K	Slope %	Length (ft)	LS	C[1]	P[2]	A (tons/ac/yr)	Total Loss (tons/yr)	Sediment Delivery Ratio (%)	Sediment Delivered (tons/yr)	Total Phosphorus (lbs/yr)
Site 1, Area 1	1.78	0.35	11.0	200	2.25	0.01	1.00	1.1	2	50	1	1
Site 1, Area 2	4.48	0.37	4.0	250	0.57	0.23	0.38	2.6	12	50	6	6
Site 1, Area 3	22.24	0.36	9.0	250	1.85	0.01	1.00	0.9	21	50	10	10
Site 1, Area 4	14.19	0.37	4.0	250	0.57	0.23	0.38	2.6	36	50	18	18
Site 1, Area 5	3.46	0.35	6.0	250	1.1	0.01	1.00	0.5	2	50	1	1
Site 1, Area 6	10.31	0.37	5.0	250	0.85	0.23	0.38	3.8	40	50	20	20
Site 1, Area 7	9.82	0.37	1.0	250	0.14	0.23	0.45	0.8	7	50	4	4
Site 1, Area 8	6.96	0.37	2.0	250	0.27	0.23	0.45	1.4	10	50	5	5
Total Site 1	73.24								130		65	65
Site 2, Area 1	22.43	0.37	2.0	250	0.27	0.23	0.45	1.4	32	62	20	20
Total Site 2	22.43								32		20	20

[1] Till Plant Contour Rows, 30% of ground cover after planting
[2] Option B, for rotations with 1/2 row crop, 1/4 close grown crop, and 1/4 Meadow.

Site 1 **Eight areas totaling 73.24 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope
1	MxD2	0.69	0.32	0.22		12-20	16	11.04	
	MpC2	0.87	0.37	0.32		6-12	9	7.83	
	MpB	0.22	0.37	0.08	0.35	2-6	4	0.88	11.1
2	MpC2	0.03	0.37	0.01		6-12	9	0.27	
	MpB	4.45	0.37	1.65	0.37	2-6	4	17.8	4.0
3	MpB	6.89	0.37	2.55		2-6	4	27.56	
	MpC2	11.64	0.37	4.31		6-12	9	104.76	
	MxD2	1.9	0.32	0.61		12-20	16	30.4	
	MwD2	1.81	0.32	0.58	0.36	12-20	16	28.96	8.6
4	MpB	13.47	0.37	4.98		2-6	4	53.88	
	MxD2	0.35	0.32	0.11		12-20	16	5.6	
	MxC2	0.37	0.32	0.12	0.37	6-12	9	3.33	4.4
5	MpB	2.2	0.37	0.81		2-6	4	8.8	
	MxC2	1.09	0.32	0.35		6-12	9	9.81	
	MxD2	0.17	0.32	0.05	0.35	12-20	16	2.72	6.2
6	FsB	7.87	0.37	2.91		2-6	4	31.48	
	FsC2	1.52	0.37	0.56		6-12	9	13.68	
	MpB	0.92	0.37	0.34	0.37	2-6	4	3.68	4.7
7	FsA	8.94	0.37	3.31		0-2	1	8.94	
	FsB	0.88	0.37	0.33	0.37	2-6	4	3.52	1.3
8	FsA	3.62	0.37	1.34		0-2	1	3.62	
	FsB	3.34	0.37	1.24	0.37	2-6	4	13.36	2.4
Total		73.24							Override with above numbers, from field recon.

Site 2 **One area totaling 22.43 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope
1	SeA	15.7	0.37	5.81		0-2	4	62.8	
	SeB	3.6	0.37	1.33		2-6	4	14.4	
	JuA	0.9	0.37	0.33		1-3	2	1.8	
	FsB	1	0.37	0.37		2-6	4	4	
	ClC2	1.23	0.32	0.39	0.37	6-12	9	11.07	4.2
Total		22.43							Override with 2.0, from field recon.

Lauderdale Lakes USLE Computations

A = R K LS C P

A = Annual loss of soil, tons/acre
R = Runoff/rainfall indes, 140 for Lauderdale Lakes
K = Soil erodibility factor
LS = Topographic factor, L for slope length and S for percent slope
C = Cropping-management factor
P = Conservation practice factor

Conservation Cover:

Source	Area (acres)	K	Slope %	Length (ft)	LS	C[1]	P	A (tons/ac/yr)	Total Loss (tons/yr)	Sediment Delivery Ratio (%)	Sediment Delivered (tons/yr)	Total Phosphorus (lbs/yr)
Site 1, Area 1	1.78	0.35	11.0	200	2.25	0.01	1.0	1.1	2	50	1	1
Site 1, Area 2	4.48	0.37	4.0	250	0.57	0.01	1.0	0.3	1	50	1	1
Site 1, Area 3	22.24	0.36	9.0	250	1.85	0.01	1.0	0.9	21	50	10	10
Site 1, Area 4	14.19	0.37	4.0	250	0.57	0.01	1.0	0.3	4	50	2	2
Site 1, Area 5	3.46	0.35	6.0	250	1.1	0.01	1.0	0.5	2	50	1	1
Site 1, Area 6	10.31	0.37	5.0	250	0.85	0.01	1.0	0.4	5	50	2	2
Site 1, Area 7	9.82	0.37	1.0	250	0.14	0.01	1.0	0.1	1	50	0	0
Site 1, Area 8	6.96	0.37	2.0	250	0.27	0.01	1.0	0.1	1	50	0	0
Total Site 1	73.24								36		18	18
Site 2, Area 1	22.43	0.37	2.0	250	0.27	0.01	1.0	0.1	3	62	2	2
Total Site 2	22.43								3		2	2

Site 1 **Eight areas totaling 73.24 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope
1	MxD2	0.69	0.32	0.22		12-20	16	11.04	
	MpC2	0.87	0.37	0.32		6-12	9	7.83	
	MpB	0.22	0.37	0.08	0.35	2-6	4	0.88	11.1
2	MpC2	0.03	0.37	0.01		6-12	9	0.27	
	MpB	4.45	0.37	1.65	0.37	2-6	4	17.8	4.0
3	MpB	6.89	0.37	2.55		2-6	4	27.56	
	MpC2	11.64	0.37	4.31		6-12	9	104.76	
	MxD2	1.9	0.32	0.61		12-20	16	30.4	
	MwD2	1.81	0.32	0.58	0.36	12-20	16	28.96	8.6
4	MpB	13.47	0.37	4.98		2-6	4	53.88	
	MxD2	0.35	0.32	0.11		12-20	16	5.6	
	MxC2	0.37	0.32	0.12	0.37	6-12	9	3.33	4.4
5	MpB	2.2	0.37	0.81		2-6	4	8.8	
	MxC2	1.09	0.32	0.35		6-12	9	9.81	
	MxD2	0.17	0.32	0.05	0.35	12-20	16	2.72	6.2
6	FsB	7.87	0.37	2.91		2-6	4	31.48	
	FsC2	1.52	0.37	0.56		6-12	9	13.68	
	MpB	0.92	0.37	0.34	0.37	2-6	4	3.68	4.7
7	FsA	8.94	0.37	3.31		0-2	1	8.94	
	FsB	0.88	0.37	0.33	0.37	2-6	4	3.52	1.3
8	FsA	3.62	0.37	1.34		0-2	1	3.62	
	FsB	3.34	0.37	1.24	0.37	2-6	4	13.36	2.4
Total		73.24							Override with above numbers, from field recon.

Site 2 **One area totaling 22.43 acres**

Area	Soil Type	Acres	K	Acres * K	Average K	Slope (%)	Average Slope (%)	Slope * Acres	Ave Slope
1	SeA	15.7	0.37	5.81		0-2	4	62.8	
	SeB	3.6	0.37	1.33		2-6	4	14.4	
	JuA	0.9	0.37	0.33		1-3	2	1.8	
	FsB	1	0.37	0.37		2-6	4	4	
	ClC2	1.23	0.32	0.39	0.37	6-12	9	11.07	4.2
Total		22.43							Override with 2.0, from field recon.

APPENDIX B

WATER QUALITY MODELING RESULTS

APPENDIX D

WATERSHED PROTECTION ACTIVITIES FOR PRIVATE LANDOWNERS

WATERSHED PROTECTION ACTIVITIES FOR PRIVATE LANDOWNERS

As documented in a recent report by the U. S. Geological Survey, Lauderdale Lakes have good water quality. However, the lakes are close to its carrying capacity with regards to nitrogen and phosphorus inputs. To maintain Lauderdale Lakes in their current high quality, management of the watershed is needed. The following is an overview of what you can do as a lake resident to prevent pollution from entering the lake from you property.

PROPERTY MANAGEMENT

Every home and yard requires some maintenance to keep it functioning well and looking good. A lakefront property requires the same maintenance as any other home plus some additional steps to keep the lake in good shape. This section presents ideas for both lakefront property owners and backlot property owners as to what they can do to protect Long Lake.

Septic Maintenance

Maintain your septic system frequently. Check for surface oozing or excessive plant and algae growth in the water at your beach. One sign of a leaking septic system is Cladaphora algae, which grows long, feathery, and green—attaching to rocks and dock posts. The septic tank may need pumping out every year or two to keep it in satisfactory operation. If the system is 20 years old or more, the drain field may need relocation. The Lauderdale Lake Management District has a program that requires landowners to have their septic system pumped every two years. To learn more about the District's program contact them at (414) ____-______ for more information.

Lawn Care/Greenbelts and Buffer Strips

Establish **greenbelts,** or **buffer strips** of shrubs and trees along the water instead of lawns. These trap sediments containing nutrients more effectively than a lawn. The following plants are adapted to lakeside situations:

Shrubs	**Trees**
red-stemmed dogwood	*river birch*
elderberry	tamarack
buttonwood	*sycamore*
Wisconsin Holly (protected)	*red maple*
tag alder	*white cedar*

Plant a few trees. They lock up a large amount of nutrients in the wood. Use shrubs for most of the buffer strip to allow a good view of the water. Evergreen plants loose fewer leaves and twigs and provides less debris to fall into the water and contribute nutrients as the organic matter decomposes.

If the lakefront vegetation has not been cleared, do not remove it and *avoid planting a* lawn. Leave the existing vegetation to act as a buffer. If there is no view of the water, thin the vegetation by removing a few branches or trees. Do not disturb the ground under the trees.

Often, planting a lawn under trees or removing the shrubs or ferns under trees lead to their eventual death.

Fertilizer Application

Get a soil test done before you buy fertilizer for your lawn to determine if you need to fertilize, and with what ingredients. The Cooperative Extension agent in your county, or the Soil Conservation District staff can explain how to test your soil. Most lawns in Wisconsin do not generally need additional phosphorus, one of the typical ingredients in packaged lawn fertilizer.

You may not need to fertilize as much as you have in the past. Nitrogen is the nutrient most responsible for producing a dark green lawn, but darkness of color also depends upon the type of grass in the lawn. A coarse fescue can naturally be a light green compared to some varieties of Kentucky blue grass.

Which is more important, fewer aquatic plants, or a dark green lawn? If maintaining dark green lawns around the lake also provides more nutrient for aquatic plants and algae, the dark green lawn becomes a nuisance. When the lawn slopes *steeply* toward the lake, do not use a fertilizer containing phosphorus. When the lawn slopes gently toward the lake, or is flat, use a fertilizer without phosphorus in the 30 feet of lawn along the water, or do not fertilize this strip at all.

The fertilizer bag label shows the percentage of the fertilizer contents. A 25-10-3 fertilizer is 25% nitrogen, 10% phosphorus, and 3% potassium. If a bag of fertilizer weighs 50 pounds, and is 25% nitrogen, then the bag contains 12.5 pounds of nitrogen. In this bag there is also 5 pounds of phosphorus. Urea is a 45-0-0 fertilizer, with nearly half of it nitrogen. If you applied the fertilizer in three applications from mid-spring to mid-summer, apply it at a rate of three pounds per 1000 square feet of lawn. This will achieve a total application of 4 pounds nitrogen for the season.

Four to six pounds of nitrogen per 1000 square feet of lawn per year is adequate. However, applying that much nitrogen in one application is too much. Nitrogen fertilizer should **not** be applied in the late fall to lawns near a waterbody. The grasses are not taking up the nutrient at that time, and the nitrogen will seep down to the groundwater or wash off the surface.

Lawn fertilizers without phosphorus, other than urea, are available to professional turf managers and may be obtained through some retailers in an order for many homeowners.

Protect Wetlands

If there is a wetland on your property, leave it alone. The wetland filters sediments out of storm water flowing toward the lake, it is habitat for wildlife and food chain animals, and it stores floodwaters during storms. Filling a wetland with soil kills plants and animals and stops the beneficial functions. Do not dump waste paint cans, oil, and other household products because toxic chemicals can enter the groundwater and wash into the lake. Do not dump kitchen garbage, leaves, and lawn clippings into the wetland because these release nutrients when they decompose.

No Dumping in the Lake

Keep organic matter out of the lake. Do not rake leaves or lawn clippings into the lake for disposal. Do not burn leaves along the shore. It may seem safe because the water is near, but the ashes contain nutrients that easily wash into the water. The best disposal of leaves and other organic matter is to compost them away from the lake. Use the compost in flower and vegetable beds, potted plants, or give it to neighbors who garden. As an alternative to allowing organic matter to decompose in a pile on the ground, plans for building and using a simple structure to hold organic matter for composting are available from the Cooperative Extension Service. Gardening catalogues also sell pre-fabricated compost drums and bins.

Do Not Feed Waterfowl

Ducks, geese, and swans can deposit many pounds of nutrient-rich manure on the shore and in the shallow water. Feeding them encourages waterfowl to stay at one location along the shore. The result is a greater plant and algae growth and a beach or shore that is too messy to walk along. It may also result in swimmers' itch.

Aquatic Plant Control

Aquatic Plants are limited on Long Lake, homeowners having a problem with aquatic plants should control them with caution. Plants can be harvested, killed by chemicals, or smothered by special plastic sheets when the proper permits have been obtained from the DNR.

Harvesting aquatic plants can be done by the homeowner to make swimming more pleasant or to clear a path for boats. Special plant cutting rakes are available to do the job by hand. Repeated removal of the stems and leaves deprives the root system of food, and can ultimately reduce the number of plants. Trampling the plants when they are small has a similar effect.

Remove the cut plants from the shore area to reduce the smell so that nutrients do not re-enter the lake from the decomposing weeds and feed more plant growth.

Chemical herbicides can be used to kill aquatic plants in much the same way that lawn plants are killed. The use of herbicides to control aquatic plants is controversial. An advantage to using chemicals is that the process does not involve any backbreaking work or barges with large equipment. Disadvantages include the potential to kill wetland plants, shoreline plants, fish, and beneficial aquatic plants. Herbicides can be dangerous to the person doing the application. Chemical control can also lead to algae blooms when the plants die in the water, releasing nutrients. Herbicide applications in the water requires a permit.

Selection and Protection of a Building Site

If you are about to build on a lakefront property or are going to do a major upgrading of a small or unwinterized lakefront cottage, the following guidelines are important for maintaining water quality. If you are contemplating the purchase of a lakefront lot, try to choose a wide lot. Wide lots allow the most opportunity to employ measures to protect water quality, and there will likely be less impact on the lake from your neighbors if lot widths are large.

Protect Existing Vegetation

Many new lakefront building lots are covered with trees and shrubs. *Keep as much existing vegetation as possible.* This vegetation acts as a sediment filter, it allows less runoff than a lawn, it provides a different visual character than a house in the city, and it is less expensive and time consuming to maintain.

If a flat space is necessary for entertaining or doing some work outside, build a patio or a deck. A small lawn is useful for this purpose, but requires a mower and space to store it.

Protecting existing vegetation involves more effort than simply not cutting it down. The backhoes and bulldozers that dig foundations, drainfields and wells, and grades the driveway must keep off the root area of trees that are intended to be saved. The root area of a tree covers all the ground under the spread of the branches and often out beyond the branch tips for many additional feet. Do not allow any earth to be piled for any length of time on the roots of trees to be saved. Do not store paints, stains, roofing tars, adhesives, mortar, or lumber on the roots of trees or near the water. Inform the contractor of these standards, and fence off the trees and shrubs to be saved. A consulting arborist or a landscape architect can help decide what vegetation is appropriate to save and what protection methods to use. Once trees are damaged, it may be impossible to save them—although the trees may take three to six years to die. Saving vegetation on a 50 foot wide lot can be very difficult because the construction equipment requires some maneuvering space, and building materials need to be stockpiled on the lot. If you highly value natural vegetation, choose a larger lot.

Build Away from the Water's Edge

Build the house and place the driveway as far from the water as is possible. A large setback protects water quality by providing more land surface for sediments to filter out of runoff. If the lot has a ridge that divides drainage toward and away from the water, build on the area that drains away from the water.

Many lakes in Wisconsin have wetlands surrounding much of the shoreline, or in such close proximity that lots are not deep. In these situations it may be impossible to build on the lot without causing harm to the water. Careful thinning of vegetation can provide views of the water. Selecting an appropriate house shape, height, and window placement can also contribute to good views.

Direct Runoff Away from the Lake

When final grading for the driveway is to begin, have the ground surface sloped so that runoff flows away from the lake and away from the septic drain field. Runoff will pick up sediments from the roof and flush them into the eaves and through the downspouts. Sediments from the driveway and the ground are also picked up. It is important to keep these sediments out of the lake and to keep stormwater from flooding the septic system drainfield. A flooded drainfield can cease to bind nutrients to the soil and can supply nutrients and bacteria to the groundwater and surface water. If the lot slopes steeply toward the lake, give the yard some side slope and direct runoff into a vegetation buffer strip at the edge and front of the property.

If extensive grading of the yard is necessary to re-direct runoff, and the result would destroy a large amount of existing vegetation, leave the vegetation intact. Water from the downspout can be directed into a dry well or a vegetation buffer. Slope the driveway toward a vegetation buffer planted alongside.

Protect Wetlands When Building

If there are wetlands on the property, there are three things to do to protect them. First, do not plan to dredge a channel in the wetland to make a deeper access for a boat. This is harmful to wetland functions, and you will probably not get a permit. If you do so without a permit you can be taken to court and be ordered to repair the damage. Second, do not fill the wetland to build a house. This is also harmful to wetland functions. You may see the harm in turbid water, fewer fish, more aquatic plants, and higher spring floods. Third, do not change the amount of runoff that flows into the wetlands. The wetland plant and animal community is balanced and depends upon a certain water supply, although one that probably fluctuates. Blocking surface flow or directing more water into the wetland could kill many of the plants and animals by either drying the wetlands or flooding it more than the amount to which those particular plants are adapted.

Shore Protection

Shoreline erosion is a concern to many lakefront property owners because it can be unsightly. In some severe situations, it represents a loss of property. Concrete and wood bulkheads and revetments out of rock riprap are built in an attempt to prevent the loss. Because these require excavation into the bottomland and the erection of a permanent structure there, a permit from the DNR is required under Wisconsin Statue Chapter 30.

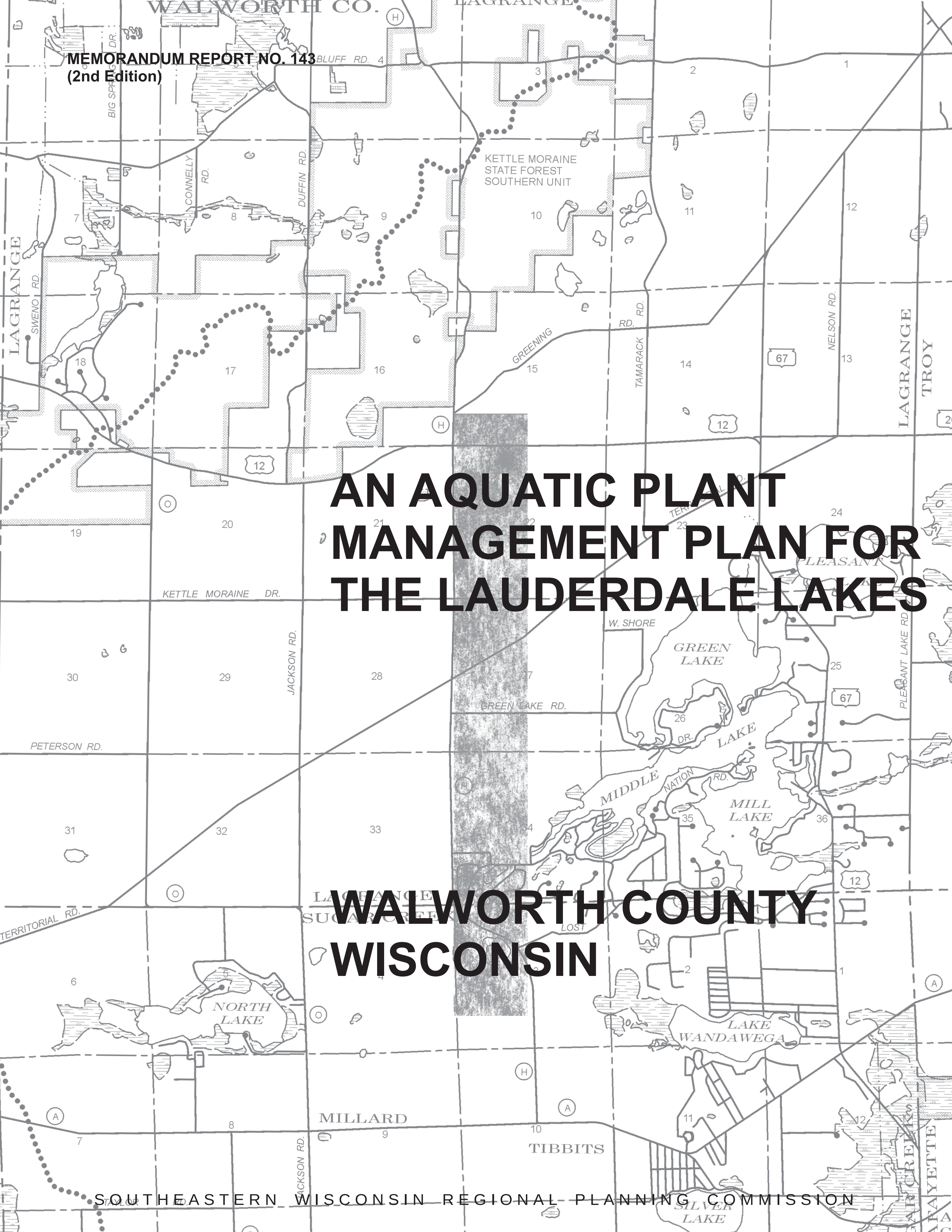
Department of Natural Resources or local Land Conservation Department technicians will be able to give you advice on planning the best type of structure to do the job. These agencies will also advise on the best planting stock and seed to use following construction.

Rock riprap is one of the most effective and permanent erosion control measures available. This material is generally maintenance free, visually acceptable, and provides fisheries' benefits of cover and food production in addition to erosion control. Do not use broken concrete or other unsightly or hazardous material.

Rock riprap is a blanket of various size rocks placed along the edge of an eroding bank. The rock "blanket" should extend the full length of the eroded area and beyond to insure adequate protection of the bank. Although there are other types of bank stabilization structures to do the job, they are more complex than rock riprap.

Southeastern Wisconsin Regional Planning Commission An Aquatic Plant Management Plan for the Lauderdale Lakes Report (2010)

MEMORANDUM REPORT NO. 143
(2nd Edition)



AN AQUATIC PLANT MANAGEMENT PLAN FOR THE LAUDERDALE LAKES

WALWORTH COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due to Dr. Jeffrey A. Thornton, CLM, PH, and Dr. Thomas M. Slawski, SEWRPC Principal Planners; Ms. Sara W. Teske, SEWRPC Research Analyst; Mr. Edward J. Schmidt, SEWRPC GIS Planning Specialist; and, Mr. Michael A. Borst, SEWRPC Research Aide, for their contributions to the conduct of this study and preparation of this report.

MEMORANDUM REPORT
NUMBER 143, 2nd Edition

AN AQUATIC PLANT MANAGEMENT PLAN FOR THE LAUDERDALE LAKES

WALWORTH COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin 53187-1607
www.sewrpc.org

July 2010

$10.00

(This Page Left Blank Intentionally)

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

(This Page Left Blank Intentionally)

Chapter I

INTRODUCTION

The Lauderdale Lakes, located in the Towns of LaGrange and Sugar Creek, both in Walworth County, Wisconsin, are an 841-acre, multiple-lake system comprised of three waterbodies: Green Lake, Middle Lake, and Mill Lake. These Lakes together form the headwaters of Honey Creek, a tributary stream to the Fox River. The Lakes are located within U.S. Public Land Survey Township 4 North, Range 16 East, Sections 25 and 26, and 34 through 36, in the Town of LaGrange; and, Township 3 North Range 16 East, Sections 1 and 2, in the Town of Sugar Creek, both in north-central Walworth County.

The Lauderdale Lakes system is a heavily used, recreational water resource, and the central feature of a residential community situated within easy reach of the Milwaukee metropolitan area. The lake system is a popular year-round residential area, and also is a popular destination for weekend recreational users. Several camps are located along the lakeshores, providing a water-oriented get-away for city dwellers particularly during the summer months. In recent years, the lake residents have become increasingly concerned about present and future impacts of development and increasing recreational use on the Lakes and their ecosystems. These concerns have related to a perceived decrease in water clarity, increase in growths of aquatic plants and the spread of nonnative aquatic plant species, contamination of the lake waters by nonpoint source pollutants, user-related aesthetic degradation, and surface water use conflicts. Seeking to improve the usability of the Lakes and to prevent the deterioration of its natural assets and recreational potential, residents have created a number of civic organizations, including the Lauderdale Lakes Improvement Association, Inc. (LLIA) and the Lauderdale Lakes Conservancy, now the Kettle Moraine Land Trust (KMLT). In addition, residents have formed a Chapter 33, *Wisconsin Statutes*, public inland lake protection and rehabilitation district, the Lauderdale Lakes Lake Management District (LLLMD), which continues to undertake annual programs of lake and aquatic plant management in the basin. Collectively, these organizations form the Lauderdale Lakes Partnership, described more fully at the end of this chapter.

BACKGROUND

The Lauderdale Lakes have been the subject of earlier lake management-related investigations, including a 2001 study conducted jointly by the LLLMD, the Wisconsin Department of Natural Resources (WDNR), and the Southeastern Wisconsin Regional Planning Commission (SEWRPC);[1] a WDNR *Lake Use Report* published in

[1]*SEWRPC Memorandum Report No. 143,* An Aquatic Plant Management Plan for the Lauderdale Lakes, *Walworth County, Wisconsin,* August 2001.

1969;[2] and, a nonpoint source pollution abatement planning program, documented in a WDNR Priority Watershed Plan for the Honey-Sugar Creeks watershed.[3] Collectively, these plans have formed the foundation for specific lake-oriented interventions by the community, including installation of stormwater management facilities at strategic locations around the Lakes, ongoing water quality monitoring programs, and an active program of aquatic plant management. In addition, the KMLT, in partnership with the other lake organizations and local communities, have purchased a number of critical wetland systems around the Lakes, placed these areas into conservancy zoning, and undertaken onsite remediation of the riparian vegetation within the sites.

With respect to the aquatic plant communities in the Lakes, the LLLMD has pursued an active program of aquatic plant management, seeking to moderate the impacts of nonnative species in the Lakes, while promoting the growths of native aquatic plants. A healthy native aquatic plant community in the Lakes provides the basis for the continued recreational use of the Lakes, including a healthy lake fishery and adequate open water areas for recreational boating and associated activities. To this end, the Regional Planning Commission assisted the LLLMD in developing an aquatic plant management strategy and plan for the Lakes during 2001.[4] This plan refines the issues of concern, evaluates the range of potential remedial options, provides information on the condition of the aquatic plant communities in the Lauderdale Lakes during 2008, includes relevant tributary area and waterbody data, and provides recommendations for the ongoing management of aquatic plants within the Lauderdale Lakes.

Specifically, this report represents part of the ongoing commitment of the Lauderdale Lakes community, through the LLLMD and its sister agencies and organizations, to sound planning with respect to the Lakes. The report sets forth inventories of the aquatic plant communities present within the Lauderdale Lakes during July and August of 2008. These inventories were prepared by SEWRPC in cooperation with the LLLMD, and include the results of field surveys conducted by the SEWRPC staff. The aquatic plant surveys were conducted using the modified Jesson and Lound transect method developed by the WDNR,[5] which, when used over a number of years, allows quantitative assessment of the effectivity of the management measures employed.[6] This planning program was funded by the LLLMD.

The scope of this report is limited to a consideration of the current water quality conditions and aquatic plant communities present within the Lauderdale Lakes, the documentation of historical changes in the plant communities based upon currently existing data and information, and the refinement of those management measures which can be effective in the control of aquatic plant growth in the Lake. Recommendations are made with respect to the potential management measures proposed to be implemented by the LLLMD, in cooperation with the Towns of LaGrange and Sugar Creek and the various other lake management and conservation organizations—the Lauderdale Lakes Partnership—serving the Lauderdale Lakes community.

---

[2]*Wisconsin Department of Natural Resources Publication Lake Use Report Nos. FX-17, FX-18, and FX-20,* The Lauderdale Lakes, Walworth County, Wisconsin, *1969.*

[3]*Wisconsin Department of Natural Resources Publication No. WT-478-97,* Nonpoint Source Control Plan for the Sugar/Honey Creek Priority Watershed Project, *February 1997.*

[4]*SEWRPC Memorandum Report No. 143,* op. cit.

[5]*R. Jesson, and R. Lound, Minnesota Department of Conservation Game Investigational Report No. 6,* An Evaluation of a Survey Technique for Submerged Aquatic Plants, *1962.*

[6]*Memorandum from Stan Nichols, to J. Bode, J. Leverence, S. Borman, S. Engel, and D. Helsel, entitled "Analysis of Macrophyte Data for Ambient Lakes-Dutch Hollow and Redstone Lakes example," Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, February 4, 1994.*

AQUATIC PLANT MANAGEMENT PROGRAM GOALS AND OBJECTIVES

The aquatic plant management goals and objectives for the Lauderdale Lakes were developed in consultation with the LLLMD and the Lauderdale Lakes Partnership. The agreed-upon goals and objectives are to:

1. Protect and maintain public health, and promote public comfort, convenience, necessity, and welfare, in concert with the natural resource, through the environmentally sound management of native vegetation, fishes, and wildlife populations in and around the Lauderdale Lakes;

2. Effectively control the quantity and density of aquatic plant growths in portions of the Lauderdale Lakes basins to better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the natural resource value of the waterbody;

3. Effectively maintain the water quality of the Lauderdale Lakes to better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the resource value of the waterbody; and,

4. Promote a quality, water-based experience for residents and visitors to the Lauderdale Lakes consistent with the policies and objectives of the WDNR as set forth in the regional water quality management plan.[7] The inventory and aquatic plant management plan elements presented in this report conform to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes.*[8] Implementation of the recommended actions set forth herein should continue to serve as an important step in achieving the stated lake use objectives over time.

THE LAUDERDALE LAKES PARTNERSHIP

The Lauderdale Lakes community has a long history of active involvement in lake management. From the early days of the Lauderdale Lakes Improvement Association in the late 1800s to the recent formation of the Kettle Moraine Land Trust in 2000, the Lauderdale Lakes community has evidenced a commitment to sound lake management and community development, with the protection of the Lakes and their natural resources forming the primary institutional objectives of the community. With the formation of the public inland lake protection and rehabilitation district in 1991, the three community institutions focused on the management of the Lauderdale Lakes have worked cooperatively with local, county, and State government to minimize the potentially deleterious impacts of human development on the Lakes, while simultaneously promoting the safe recreational use of these waterbodies for a wide range of recreational purposes, including both active and passive recreational pursuits, such as boating, angling, and scenic viewing. By creating an innovative public-private partnership for lake management, the Lauderdale Lakes Partnership continues to play an active role in the management of the Lakes and their natural resources, based on the relative strengths of each of the partner organizations, as summarized below.

---

[7] *SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, *June 1979, as amended; see also SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[8] *This plan has been prepared pursuant to the standards and requirements set forth in the following chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 103, "Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants Introduction, Manual removal and Mechanical Control Regulations."*

Lauderdale Lakes Improvement Association, Inc.

The Lauderdale Lakes Improvement Association, Inc., was formed in 1892 to encourage and assist in the general work of protecting and improving the Lauderdale Lakes, and their banks and shores in the Towns of LaGrange and Sugar Creek.[9] The Association was empowered to purchase, own, and sell personal property, and make contracts for dredging, weed cutting and clearing, and any and all other work which may be incidental to its general purposes. It also was empowered to aid in and attend to the restocking of the Lakes with fishes from time-to-time as may be necessary; to attend to and assist in the prosecution of any persons engaged in illegal activities on or about the Lauderdale Lakes; and prosecute or defend actions in its corporate name in the several Courts of State of Wisconsin or the United States, especially in response to actions affecting the physical conditions of the Lakes and their riparian properties that might alter or change conditions in the Lakes. In general, the Association shall have all the powers incidental to associations of like character organized under the laws of the State of Wisconsin. To this end, the Association has a number of standing committees, including communications, membership, planning and zoning, property, water quality, fish, and water safety.

Lauderdale Lakes Lake Management District

The Lauderdale Lakes Lake Management District was created in 1991 pursuant to Chapter 33 of the *Wisconsin Statutes* to undertake projects relating to environmental lake protection, lake management, and other statutory responsibilities related to the Lakes, including enhancement of the recreational use of the Lakes and conservation projects within the Lauderdale Lakes watershed.[10] Since its inception, the District has undertaken a number of lake improvement projects under its own auspices and in partnership with the other lake-oriented organizations serving the Lauderdale Lakes community, including the Lauderdale Lakes Improvement Association and the Kettle Moraine Land Trust. In 1996, the LLLMD purchased the Lauderdale Lakes Country Club, a nine-hole golf course, to maintain the property in open space use. The Lake District continues to operate this property as a daily fee public golf course, and has enrolled the course in the Audubon Society Cooperative Sanctuary Program. During 2000, the LLLMD purchased a lot in the Gladhurst subdivision on the north side of Green Lake for the purpose of reducing nonpoint pollution loads to the Lakes. A large detention pond was constructed on this site to capture surface runoff water allowing it to gradually perk into the pond instead of running into the Lake through an established tributary. The District also has entered into agreements with several farmers in its drainage area to reduce sediment- and nutrient-loads entering the Lakes, and has purchased a six-acre wetland adjoining the golf course property with about 700 feet of shoreline, to preserve and protect the SEWRPC-delineated primary environmental corridor. This shoreland area provides both habitat and a filter strip for stormwater runoff. In 2003, the District implemented a wetland restoration project in the shoreland wetlands adjacent to Don Jean Bay in Mill Lake to stabilize eroding shorelands and provide additional habitat. The LLLMD operates a water safety patrol in cooperation with the Town of LaGrange.

Kettle Moraine Land Trust

Founded in 2000 through the efforts of the Lauderdale Lakes Improvement Association, the Kettle Moraine Land Trust, formerly the Lauderdale Lakes Conservancy, serves to promote resource conservation and preserve important lands by building partnerships throughout Walworth County. Beginning with the acceptance of the title to the 35-acre Island Woods, the Land Trust has a history of active participation in advocating responsible stewardship of important lands in the Lauderdale Lakes area, as well as countywide. The Land Trust has played a key role in a number of significant contributions to the protection of the natural heritage of the area, including sponsoring workshops on conservation subdivisions, and assisting in the addition of two sensitive area sites to the WDNR report for the Lauderdale Lakes. Since its inception, the KMLT has accepted a conservation easement for the Lauderdale Lakes Country Club, protecting 57 acres of open space, over 1,500 feet of shoreline, and six acres of wetlands; purchased a five-acre marsh with over 1,000 feet of shoreline as an addition to the

[9] *Lauderdale Lakes Improvement Association website, http://www.llia.org/index.php.*

[10] *Lauderdale Lakes Lake Management District website, http://lllmd.org/index.htm.*

Island Woods site; donated a Conservation Easement on Island Woods to the Lauderdale Lakes Improvement Association and the Lauderdale Lakes Lake Management District; constructed a public overlook on the southern edge of the Island Woods preserve; accepted the North Lake Conservation Easement donation of 14 lakefront lots; worked with the Town of LaGrange to pass a mandatory Conservation Subdivision Ordinance; and, received the 2007 Wisconsin Lake Stewardship Award as part of the Lauderdale Lakes Partnership.[11] This Partnership includes both the LLIA and LLLMD.

[11]*Kettle Moraine Land Trust website,* http://www.kmlandtrust.org/history.htm*.*

(This Page Left Blank Intentionally)

Chapter II

INVENTORY FINDINGS

INTRODUCTION

The Lauderdale Lakes are located in the Towns of LaGrange and Sugar Creek, Walworth County, Wisconsin, as shown on Map 1. The Lakes are comprised of three natural basins linked as a result of the impoundment of the outlet to Mill Lake, which forms the headwaters of Honey Creek. The Lakes have a combined surface area of 841 acres, and include the 311-acre spring-fed Green Lake, the 259-acre flow-through Middle Lake, and the 271-acre drained Mill Lake. The Lauderdale Lakes are a heavily used, recreational water resource, forming the centerpiece of a large residential community comprised of both year-round and seasonal residents. The Lakes, situated within easy reach of the Milwaukee metropolitan area, also are a popular destination for weekend recreational users who utilize the public recreational boating access sites on the Lakes. These sites are located on the southwestern shore of Green Lake, the southwestern shore of Middle Lake, and the eastern shore of Mill Lake at Sterlingworth Bay. In addition, private access to the Lakes is provided at four sites on the Lakes: Lutherdale Lutheran Bible Camp on Green Lake, Lauderdale Landings on Middle Lake, and Sterlingworth Inn and Lauderdale Lakes Marina on Mill Lake. The Lauderdale Lakes Lake Management District also owns the municipal golf course located on the eastern shores of Mill Lake.

WATERBODY CHARACTERISTICS

Hydrographical characteristics of the Lauderdale Lakes system are set forth in Table 1. As mentioned above, the Lakes consist of three natural basins, each oriented in approximately a northeast-southwest orientation: Green Lake has a surface area of 311 acres and a maximum depth of approximately 55 feet; Middle Lake has a surface area of 259 acres and a maximum depth of 42 feet; and, Mill Lake has a surface area of 271 acres and a maximum depth of 44 feet. The bathymetries of the three lake basins are shown on Maps 2 through 4, respectively.

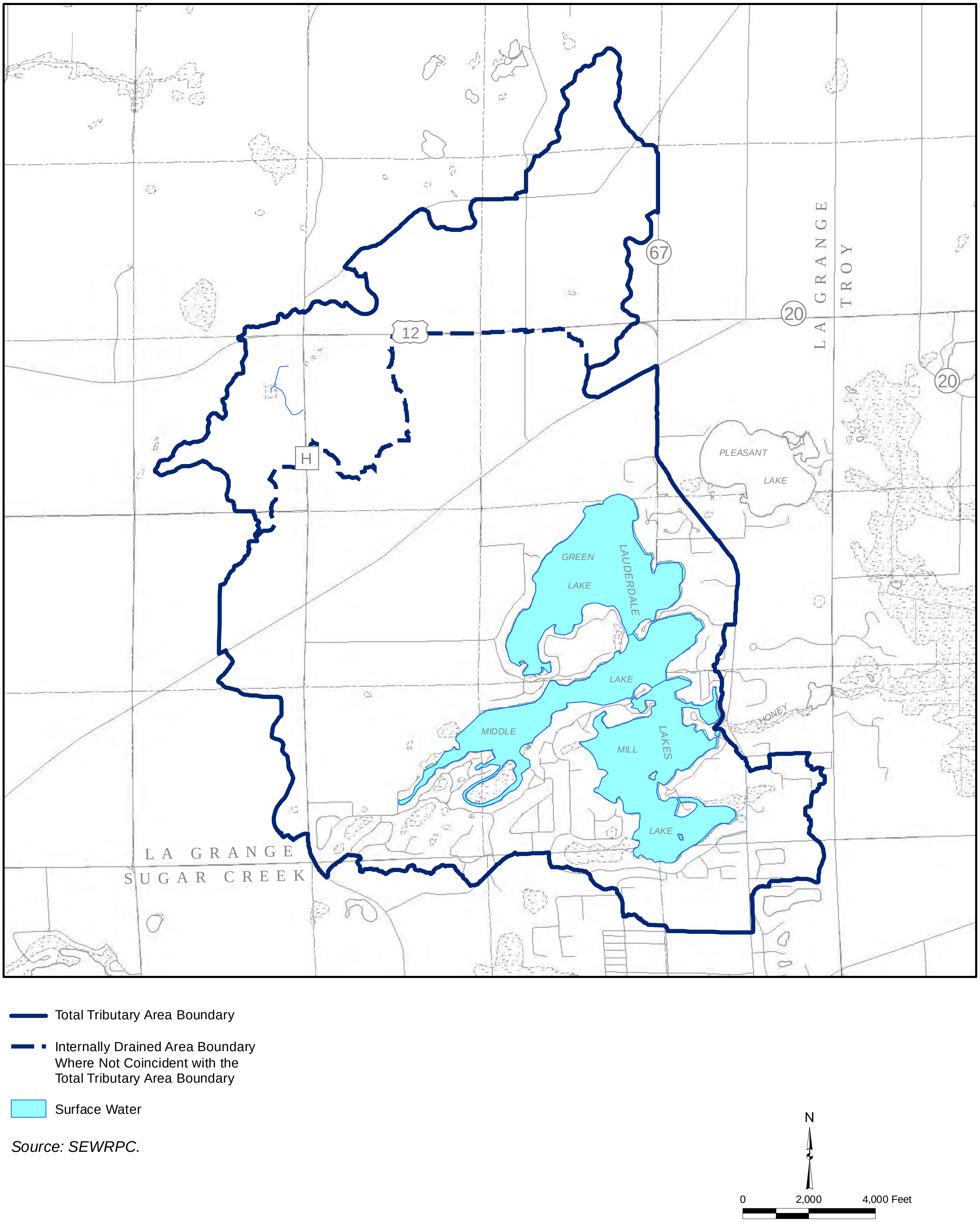
As a whole, the Lauderdale Lakes system has a surface area of 841 acres, a total volume of 11,560 acre-feet, a mean depth of 14.3 feet, and a shoreline 14.7 miles in total length. The system has a shoreline development factor (SDF) of 3.6, indicating that, due to its many irregularities, bays, and points, the shoreline is about three and one-half times longer than that of a perfectly circular lake of the same area. By contrast, nearby Pleasant Lake has a development factor of about 1.6, reflecting that Lake's more-circular shape.[1] Shoreline development factor is often related to the level of biological activity in a lake: the greater a lake's SDF (due to greater shoreline contour

---

[1]*See SEWRPC Memorandum Report No. 174,* An Aquatic Plant Management Plan for Pleasant Lake, Walworth County, Wisconsin, *December 2009.*

Map 1

LOCATION MAP OF THE LAUDERDALE LAKES



Source: SEWRPC.

Table 1

HYDROLOGY AND MORPHOMETRY OF THE LAUDERDALE LAKES

Parameter	Measurement
Lauderdale Lakes System	
Surface Area	841 acres
Total Tributary Area[a]	6,435 acres
Lake Volume	11,560 acre-feet
Shoreline Length	14.7 miles
Shoreline Development Factor[b]	3.6
Maximum Depth	55 feet
Mean Depth	14.3 feet
General Orientation	N-S
Green Lake	
Surface Area	311 acres
Maximum Depth	55 feet
Middle Lake	
Surface Area	259 acres
Maximum Depth	42 feet
Mill Lake	
Surface Area	271 acres
Maximum Depth	44 feet

[a]*The total tributary area for the Lauderdale Lakes was recorded in the earlier SEWRPC report as 6,217 acres. The current measurement is based on elevation refinements made possible through Commission digital terrain modeling analysis and includes the 1,547-acre internally drained area located in the northern portion of the total tributary area.*

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

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

irregularity), the greater is the likelihood of the lake to contain shallow, nearshore areas—the places usually containing habitat more suitable for plant and animal life. In other words, lakes with highly irregular shorelines usually provide more shallow-water, nearshore areas (or "littoral zone" areas) suitable for plant and animal life. With a development factor of 3.6, one of the higher development factors in the area, the Lauderdale Lakes would be expected, therefore, to have a fairly high level of biological activity compared to most other lakes in the area.

Biological activity in a lake can also be influenced by other physical factors, such as bottom sediment composition and lake-basin contours. A preponderance of soft bottom sediments and flatness of bottom contour are conditions consistent with lakes of high biological activity. As shown on Map 2, the northern shoreline of Green Lake and the majority of its northwestern shoreline, as well as its southern shoreline along the main point, are areas of hard lake bottom sediment types, such as rock, sand, and gravel, and are also areas of relatively steeply sloped bottom contours; whereas, the shallower bays in the southwestern and southeastern corners of Green Lake are comprised mainly of soft sediments with much flatter bottom contours. In Middle Lake, as shown on Map 3, rock and gravel bottom sediments along with somewhat steeply sloped bottom contours typify the nearshore areas around most of the main lake basin at the eastern half of the Lake; the western half of the Lake exists as an elongated bay comprised of an expansive area of soft bottom sediments and flat bottom contour. Mill Lake, as shown on Map 4, is largely a lake of flat bottom contours and vast expanses of soft bottom sediments in the southern half of the Lake, although, sand and gravel do appear along much of the shoreline that rings the single main basin in the northern half of the Lake.

TRIBUTARY AREA AND LAND USE CHARACTERISTICS

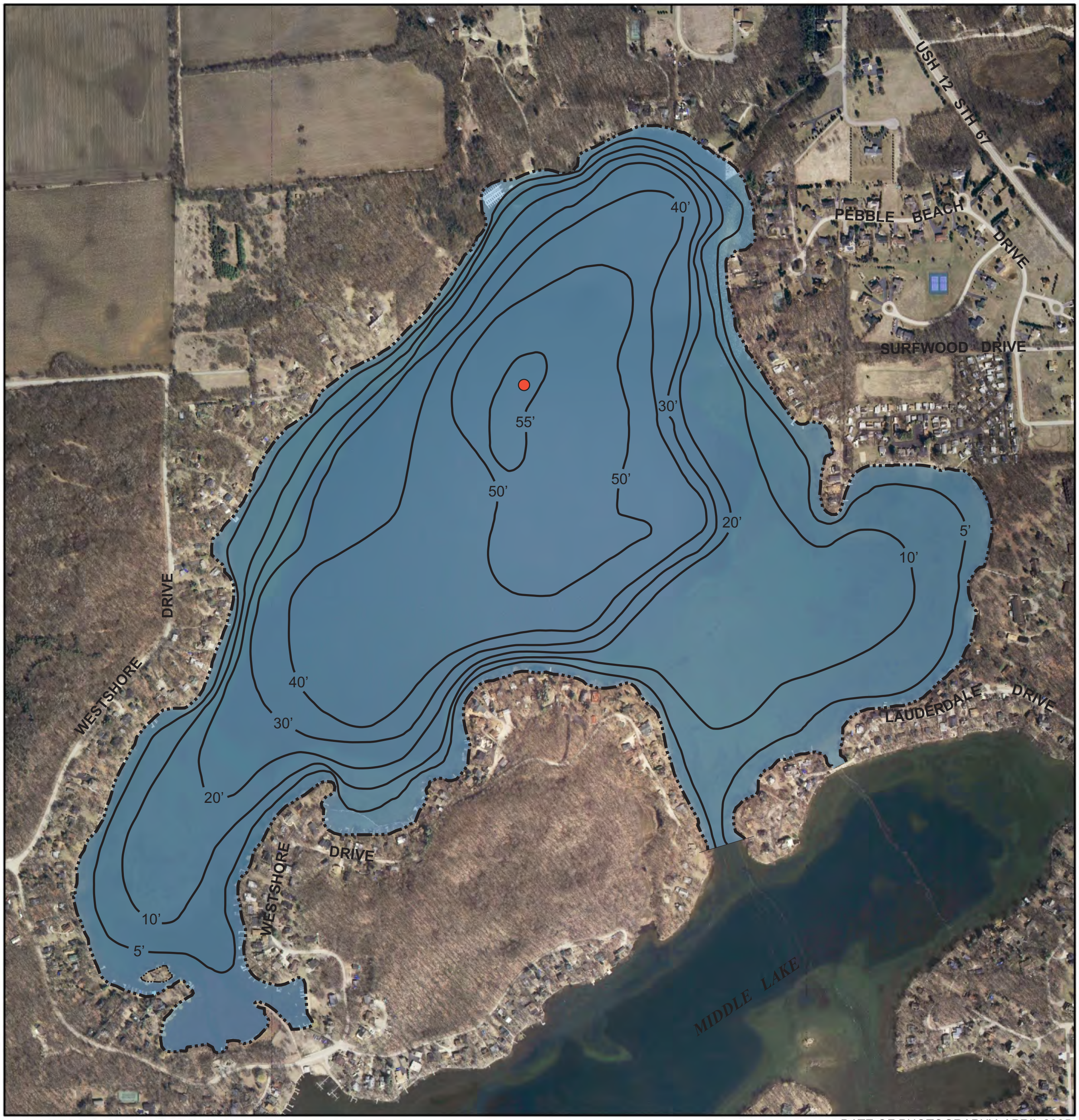
As shown on Map 5, the area tributary to the Lauderdale Lakes is situated mostly within the Town of LaGrange, with a small portion of the extreme southern edge of the tributary area being situated in the Town of Sugar Creek, both in Walworth County. This area, which drains directly to the Lauderdale Lakes system, is approximately 6,435 acres, or about 10.1 square miles, in areal extent. The Lake system and its tributary area are situated in the north-central portion of Walworth County.

Population

The population and the numbers of households and housing units within the Lauderdale Lakes tributary area have all generally shown a relatively steady increase since 1960, as documented in Table 2. The greatest increases in population occurred between 1970 and 1980 when the number of people increased by nearly 96 percent, increasing from 696 persons to 1,361 persons. The numbers of households also increased during this period by

Map 2

BATHYMETRIC MAP OF GREEN LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

— 20' — WATER DEPTH CONTOUR IN FEET

● MONITORING SITE

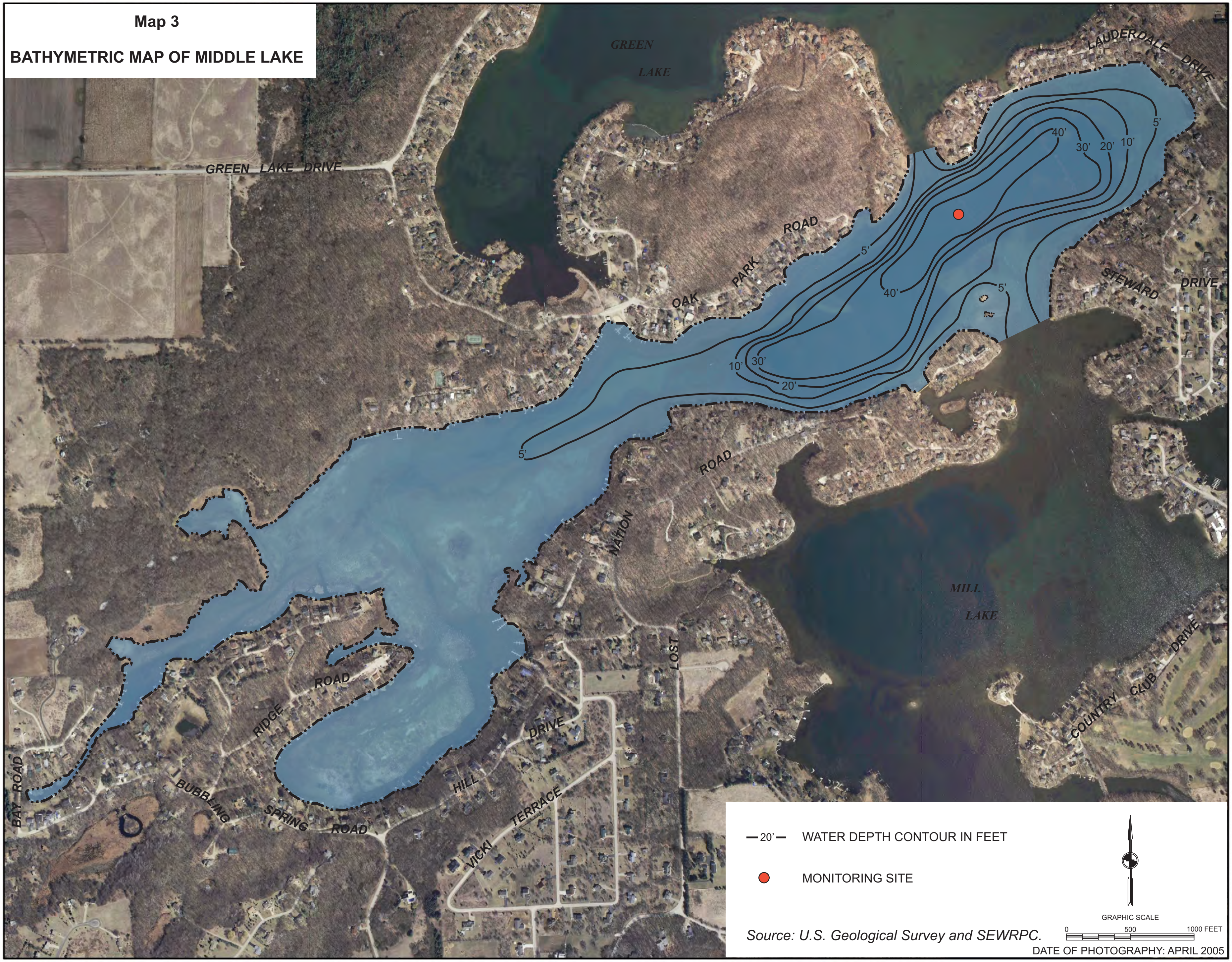
Source: U.S. Geological Survey and SEWRPC.

GRAPHIC SCALE

0 450 900 FEET

Map 3

BATHYMETRIC MAP OF MIDDLE LAKE

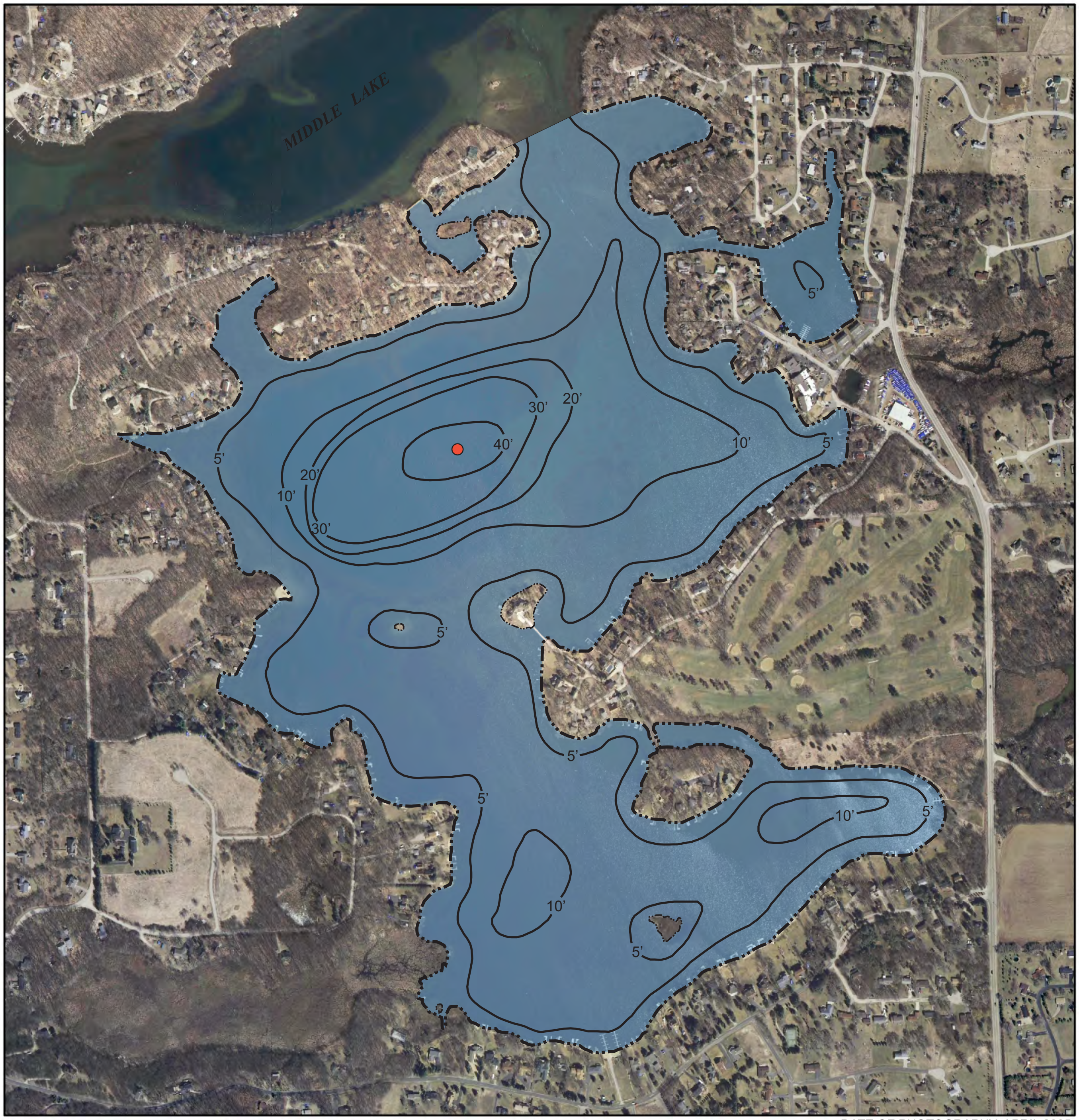


Source: U.S. Geological Survey and SEWRPC.

DATE OF PHOTOGRAPHY: APRIL 2005

Map 4

BATHYMETRIC MAP OF MILL LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

20' WATER DEPTH CONTOUR IN FEET

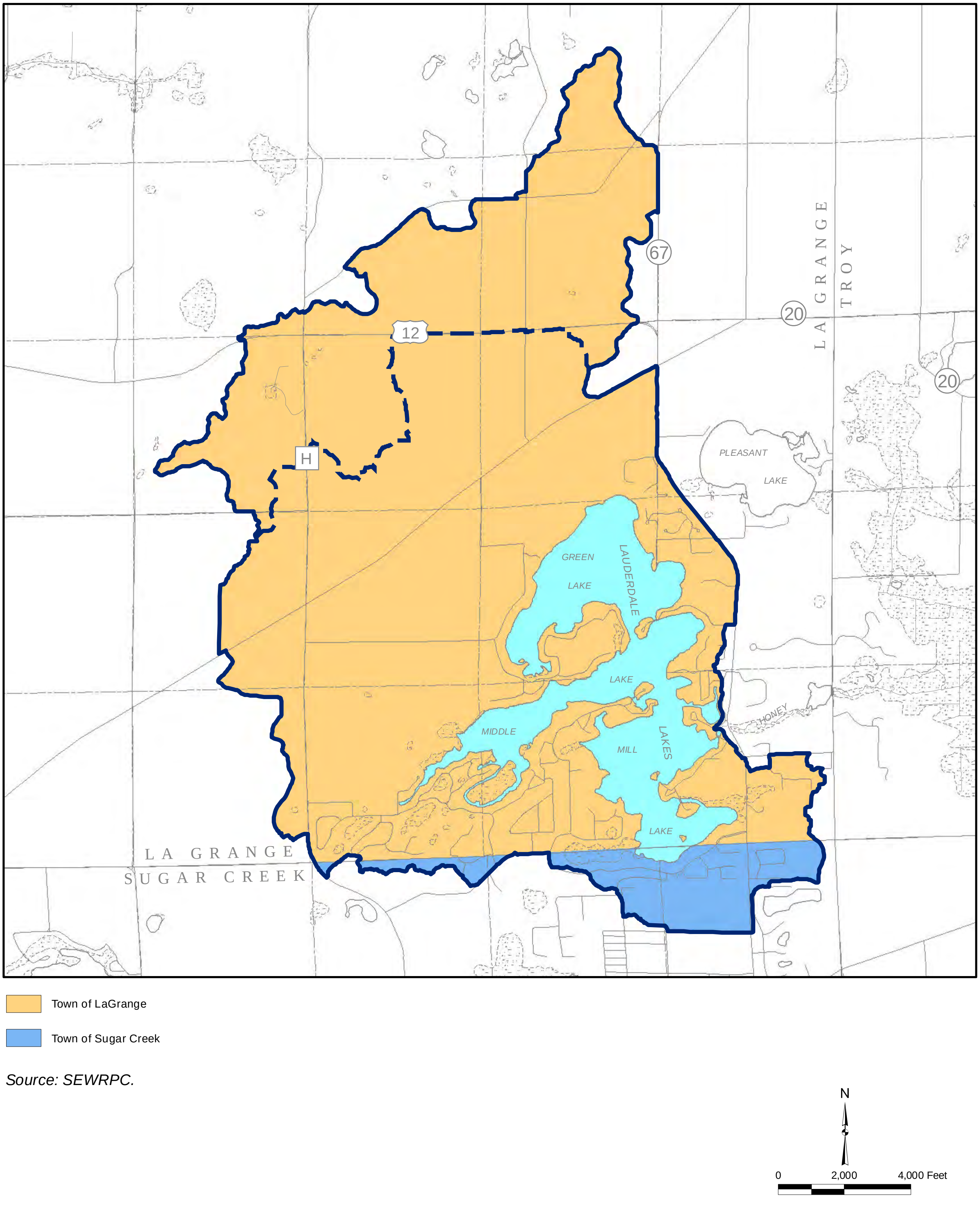
MONITORING SITE

Source: U.S. Geological Survey and SEWRPC.

GRAPHIC SCALE
0 450 900 FEET

Map 5

CIVIL DIVISION BOUNDARIES WITHIN THE LAUDERDALE LAKES TRIBUTARY AREA



Source: SEWRPC.

Table 2

POPULATION AND HOUSEHOLDS WITHIN THE AREA TRIBUTARY TO THE LAUDERDALE LAKES: 1960-2000

Year	Total Tributary Area			
	Population	Households	Housing Units (year-round)	Housing Units (seasonal)
1960	436	111	507	N/A
1970	696	229	661	N/A
1980	1,361	476	981	323
1990	1,276	469	1,257	757
2000	1,936	742	1,491	735

NOTE: 1970 total housing units is an estimate.

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

nearly 108 percent, from 229 households to 476 households. After a slight decline in both population and the numbers of households between 1980 and 1990, further increases in numbers occurred between 1990 and 2000—the population gained almost 52 percent, increasing from 1,276 to 1,936 individuals; the numbers of households increased almost 60 percent, from 469 to 742 households.

The numbers and types of housing units, as shown in Table 2, reflect the popularity of the Lauderdale Lakes as a recreational destination for seasonal, as well as year-round residents. In 1980, there were about 323 seasonal housing units compared with the 981 year-round housing units in the Lauderdale Lakes tributary area. Seasonal housing units comprised nearly one-third of the total number of housing units. In 1990, the numbers of seasonal housing units increased slightly, comprising about two-fifths of all housing units. However, by 2000, the numbers of seasonal housing units had diminished slightly, forming about one-third of all housing units. It would be expected that the majority of these seasonal housing units would be concentrated in close proximity to the Lakes themselves.

Land Uses

The land uses within the total area tributary to the Lauderdale Lakes are primarily rural, with agricultural uses being the dominant rural land use. The shoreline of the Lakes, however, is largely developed for residential uses. Wetland areas are located along the western shores of Middle and Mill Lakes, with several isolated woodland areas being located along the southern shoreline of Green Lake and the northern shoreline areas of Middle Lake. Map 6 shows the existing land uses within the tributary area as of 2000; those uses also are summarized in Table 3.

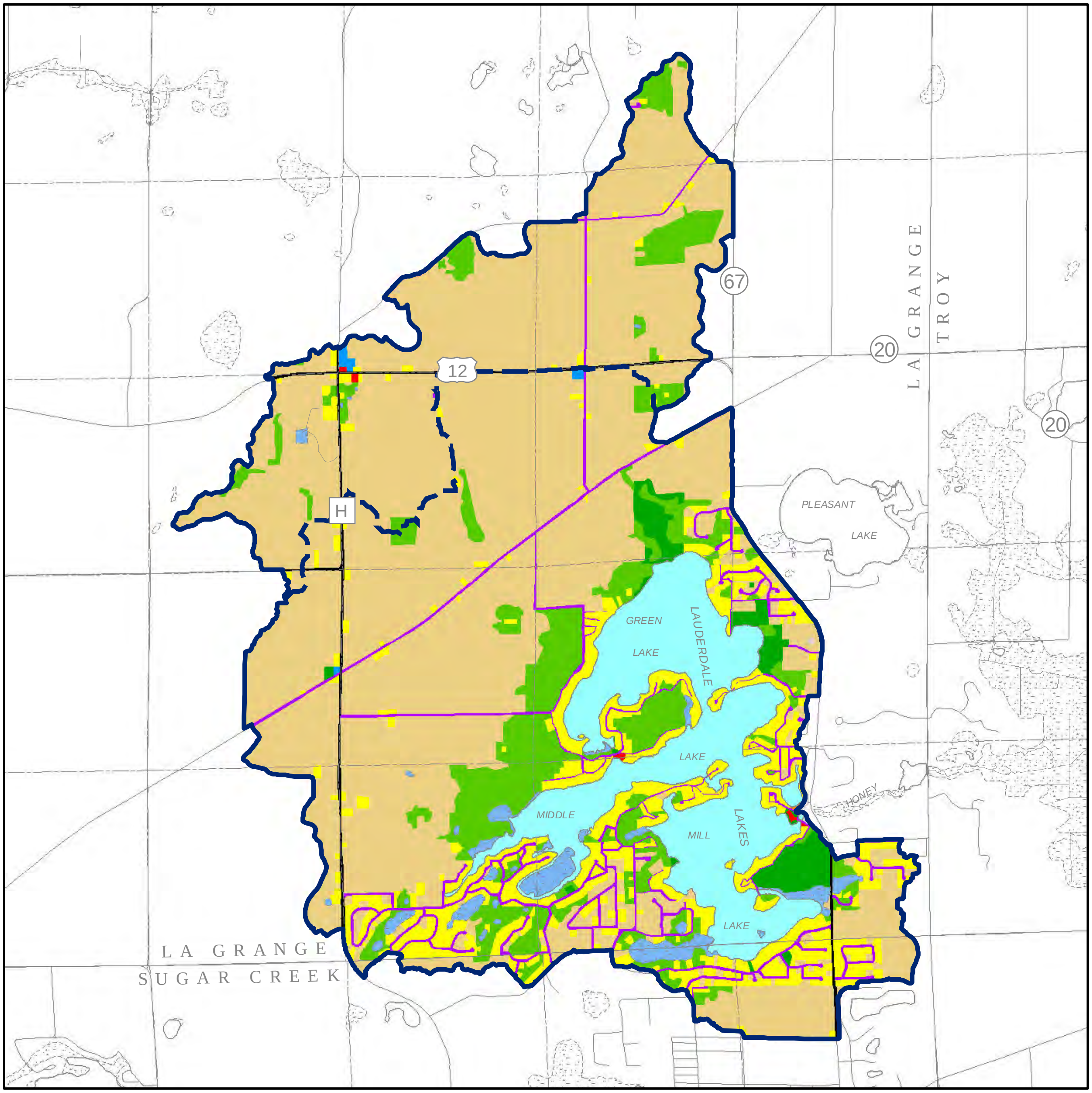
Future changes in land use within the area tributary to the Lakes may include limited further urban development, infilling of already platted lots, and possible redevelopment of existing properties. Under proposed year 2035 conditions, as shown on Map 7 and summarized in Table 3, urban land uses are expected to further increase, from about 18 percent of the land coverage in 2000 to about 24 percent of the land coverage in 2035. Agricultural uses are anticipated to decrease from about 83 percent of the land coverage in the year 2000, to about 77 percent of the land coverage under planned year 2035 conditions. These land use changes have the potential to modify the nature and delivery of nonpoint source contaminants to the Lakes, with concomitant impacts on the aquatic plant communities within the waterbody.

SHORELINE PROTECTION STRUCTURES

Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with lake access and use. Wind-wave erosion, ice movement, and motorized boat traffic usually cause such erosion. About

Map 6

EXISTING LAND USE WITHIN THE LAUDERDALE LAKES TRIBUTARY AREA: 2000



SINGLE-FAMILY RESIDENTIAL

MULTI-FAMILY RESIDENTIAL

COMMERCIAL

INDUSTRIAL

TRANSPORTATION, COMMUNICATIONS, AND UTILITIES

GOVERNMENT AND INSTITUTIONAL

RECREATION

WETLANDS

WOODLANDS

SURFACE WATER

AGRICULTURAL, UNUSED, AND OTHER OPEN LANDS

EXTRACTIVE AND LANDFILL

N

0 2,000 4,000 Feet

Source: SEWRPC.

Table 3

EXISTING AND PLANNED LAND USE WITHIN THE TOTAL AREA TRIBUTARY TO THE LAUDERDALE LAKES: 2000 AND 2035

Land Use Categories[a]	2000 Acres	2000 Percent of Tributary Area	2035 Acres	2035 Percent of Tributary Area
Urban				
Residential	708	11.0	950	14.8
Commercial	4	0.1	26	0.4
Industrial	1	<0.1	1	<0.1
Governmental and Institutional	7	0.1	7	0.1
Transportation, Communication, and Utilities	285	4.4	291	4.5
Recreational	120	1.9	241	3.7
Subtotal	1,125	17.5	1,516	23.5
Rural				
Agricultural and Other Open Lands	3,730	57.9	3,347	52.1
Wetlands	110	1.7	110	1.7
Woodlands	674	10.5	666	10.3
Surface Water	796	12.4	796	12.4
Extractive	- -	- -	- -	- -
Landfill	- -	- -	- -	- -
Subtotal	5,310	82.5	4,919	76.5
Total	6,435	100.0	6,435	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

70 percent of the shoreline of the Lauderdale Lakes is developed. A survey of the shorelines of the Lauderdale Lakes, conducted by Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff for the previous SEWRPC report, identified the shoreline, at that time, as having a combination of riprap, bulkhead, and natural shoreline, with small scattered areas of beach; no obvious erosion-related problems were encountered. During the current study period, few significant changes in the shoreline protection techniques were observed since the previous report, with the primary methods of shoreline protection utilized being riprap, bulkhead, and naturalized shoreline, with a few small beaches, as shown on Maps 8 through 10. There were no severe erosion-related problems observed during the 2008 survey.

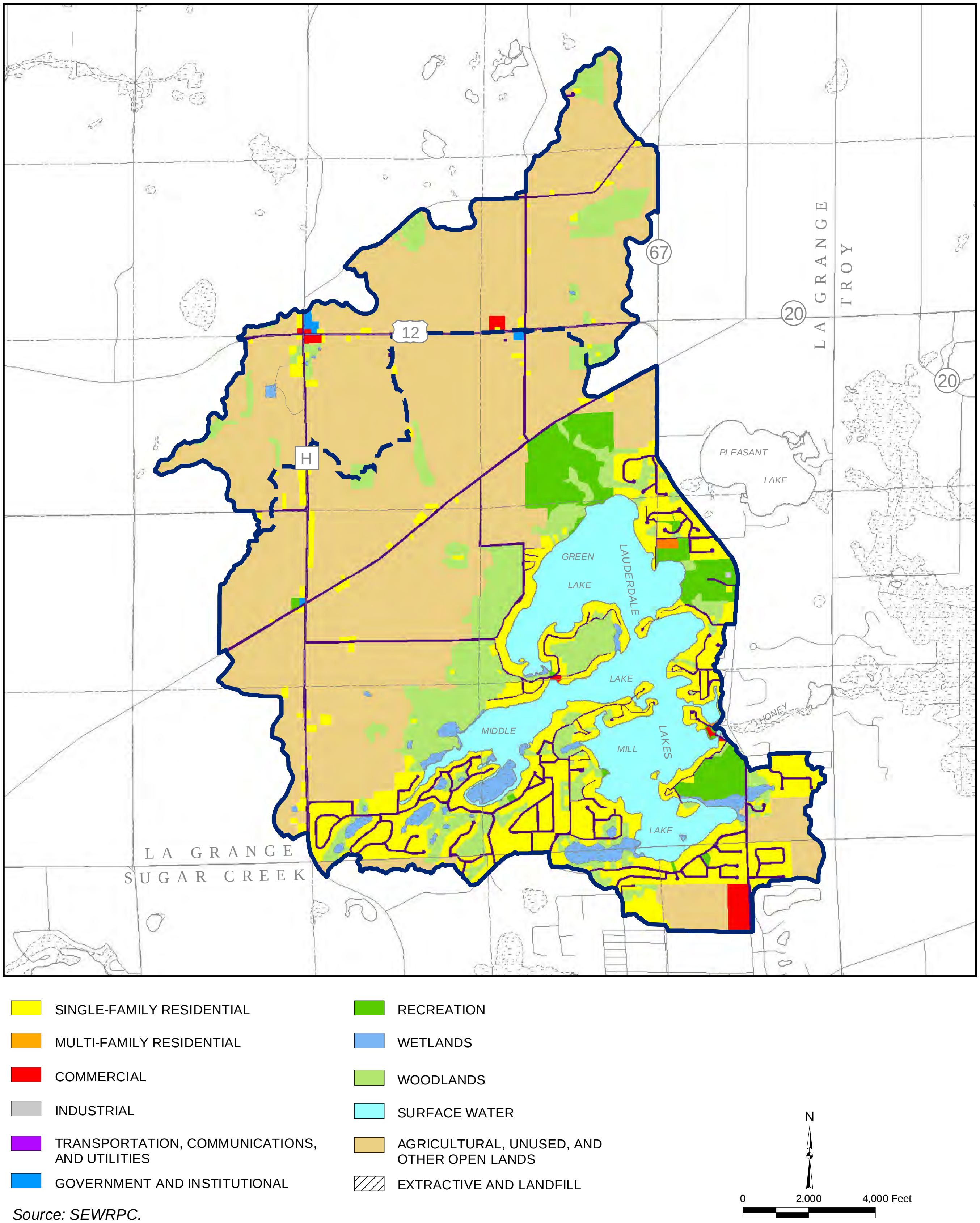
WATER QUALITY

Water quality data for the Lauderdale Lakes were collected in 1966 by the Wisconsin Department of Natural Resources (WDNR) and was presented in the WDNR Lake Use Report of 1969.[2] Additional data were acquired between September 1973 and February 1975, under the National Eutrophication Survey (NES) program of the U.S. Environmental Protection Agency (USEPA), and between November 1993 and October 1999, under the Trophic State Index (TSI) monitoring program of the U.S. Geological Survey (USGS). These data were used to

[2]*Wisconsin Department of Natural Resources Publication Lake Use Report Nos. FX-17, FX-18, and FX-20,* The Lauderdale Lakes, Walworth County, Wisconsin, *1969.*

Map 7

PLANNED LAND USE WITHIN THE LAUDERDALE LAKES TRIBUTARY AREA: 2035



Source: SEWRPC.

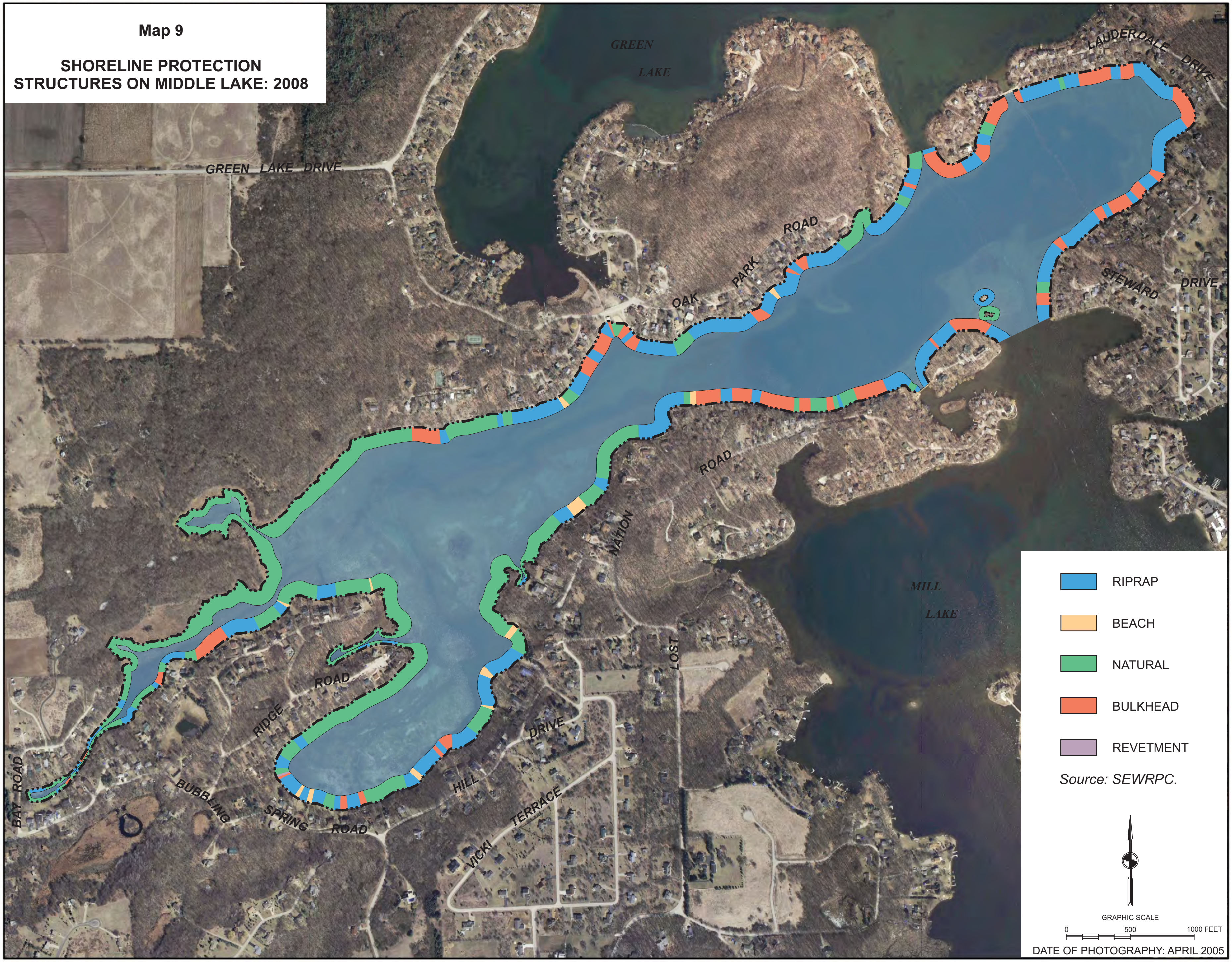
Map 8

SHORELINE PROTECTION STRUCTURES ON GREEN LAKE: 2008

Source: SEWRPC.

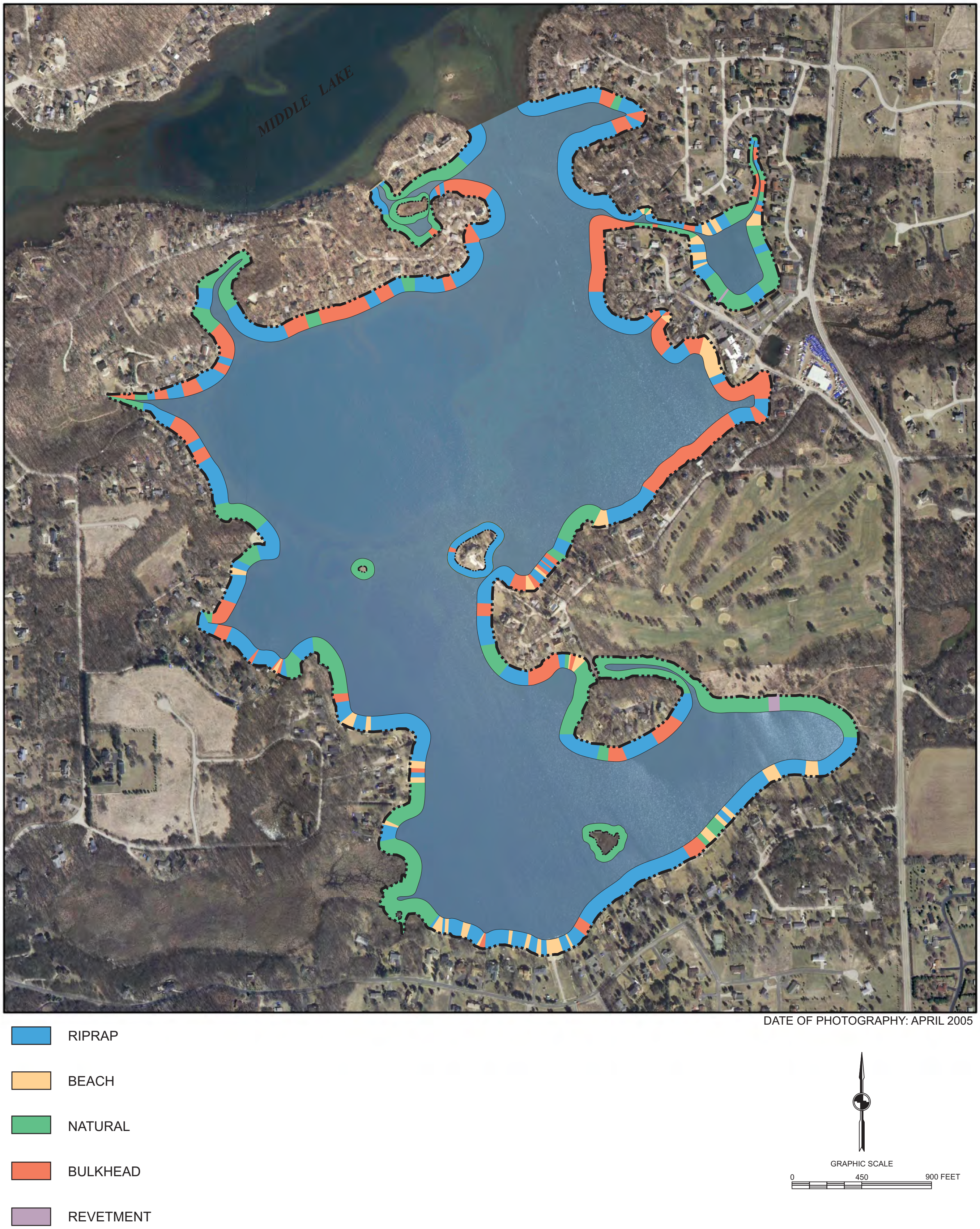
Map 9

SHORELINE PROTECTION STRUCTURES ON MIDDLE LAKE: 2008



Map 10

SHORELINE PROTECTION STRUCTURES ON MILL LAKE: 2008



Source: SEWRPC.

Table 4

WATER QUALITY CONDITIONS IN THE LAUDERDALE LAKES BY MAJOR BASIN: 2006-2009

Water Quality Parameter	Green Lake	Middle Lake	Mill Lake
Secchi-Disk Transparency (feet) Mean	6.5-26.0 14.7	6.0-27.0 13.4	4.5-14.2 10.1
Chlorophyll-*a* (µg/l) Mean	1.8-4.6 3.0	2.2-5.1 4.0	3.8-9.9 3.9
Total Phosphorus (µg/l) Mean	7-13 10	9-16 13	6-23 16
Dissolved Oxygen At Surface (mg/l)	8.5-10.2	8.4-11.3	8.2-11.0
Dissolved Oxygen At Bottom (mg/l)	0.03-10.3	0.01-7.8	0.0-11.0
Water Temperature At Surface (°F)	43.0-78.9	42.0-80.5	43.0-80.1
Water Temperature At Bottom (°F)	40.8-69.0	43.0-54.3	42.0-55.3

Source: SEWRPC.

determine water quality conditions in the Lakes for the previous SEWRPC report.[3] Based upon those data, Green Lake and Middle Lake were rated as having very good water quality, while Mill Lake was considered to have very good to fair water quality.

More recently, data on Green Lake and Mill Lake have been acquired under the auspices of the University of Wisconsin-Extension (UWEX) Citizen Lake Monitoring Network (CLMN) program, formerly known as the WDNR Self-Help Monitoring Program, since March 2006, while the volunteer data collection effort on Middle Lake has been ongoing since May 1994. For the purposes of this plan, water quality data gathered between 2006 and 2009 have been used to characterize the water quality of the three lakes that comprise the Lauderdale Lakes. These water quality data are summarized in Table 4 and shown in Figure 1. Sampling locations used for data collection are shown on Maps 2 through 4.

Water Clarity

Water clarity, or transparency, is often used as an indication of water quality. Transparency can be affected by physical factors, such as water color and suspended particles, and by various biologic factors, including seasonal variations in planktonic algal populations living in the lake. Water clarity is measured typically with a Secchi disk, a black-and-white, eight-inch-diameter disk, which is lowered into the water until a depth is reached at which the disk is no longer visible. This depth is known as the "Secchi-disk reading." Such measurements comprise an important part of the aforementioned CLMN program in which citizen volunteers assist in lake water quality monitoring efforts.

Secchi-Disk Data

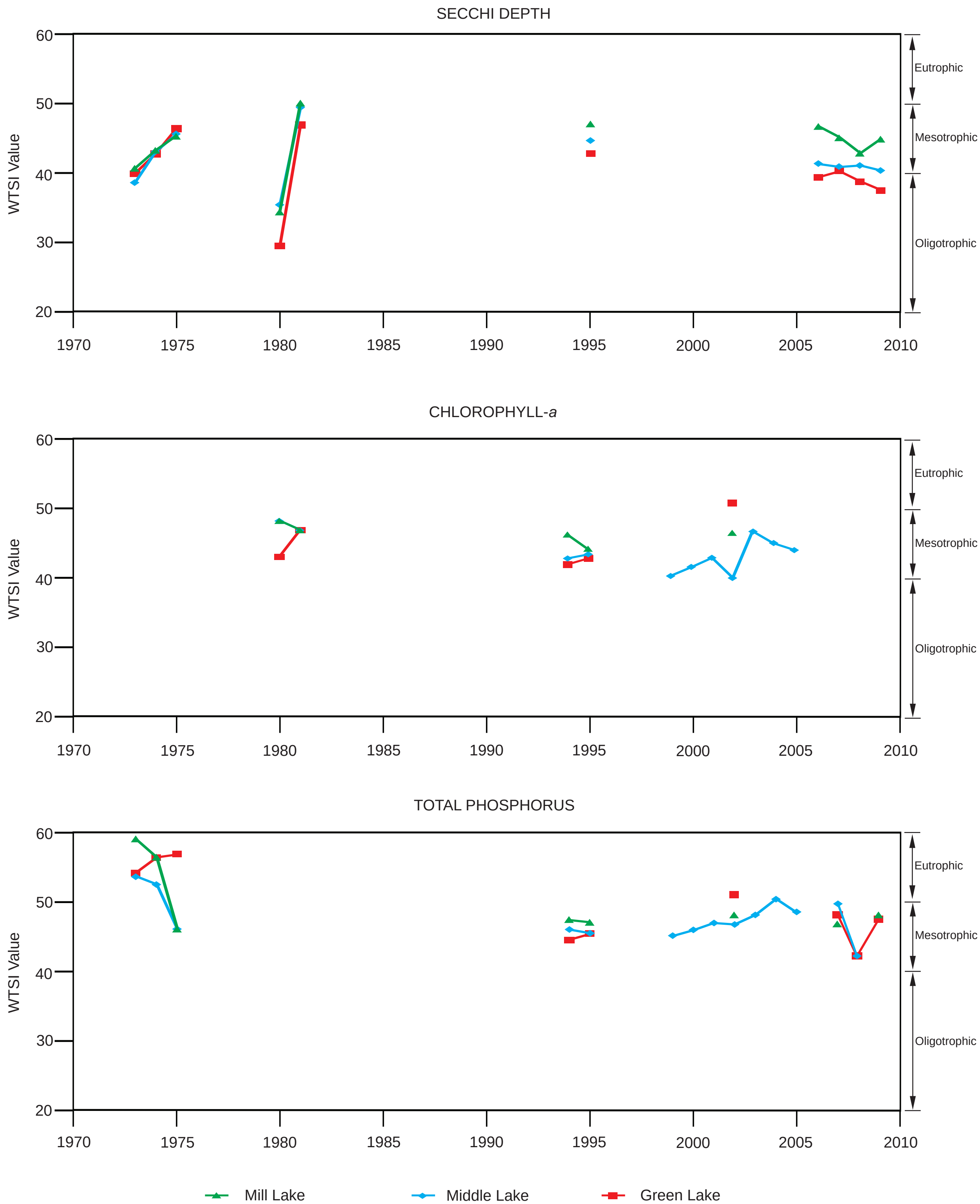
Historically, Secchi-disk transparencies in the three Lakes has ranged from 8.5 to 19.7 feet, with water clarity diminishing from North to South—Green Lake having the greatest water clarity, Middle Lake having an intermediate water clarity, and Mill Lake having the lowest water clarity. Water clarity in Green and Middle Lakes was indicative of very good water quality, while water clarity in Mill Lake was indicative of good water quality.

---

[3]*SEWRPC Memorandum Report No. 143*, An Aquatic Plant Management Plan for the Lauderdale Lakes, Walworth County, Wisconsin, *August 2001.*

Figure 1

TROPHIC STATE INDICES FOR THE LAUDERDALE LAKES: 1970-2010



Source: Citizen Lake Monitoring Network, WDNR Surface Water Information Management System, and SEWRPC.

During the current study, similar trends were observed, with water clarity ranging from 4.5 feet to 26.0 feet, with the deepest water clarity occurring in the deeper northernmost two lakes—Green Lake and Middle Lake—and slightly lower water clarity occurring in the shallower Mill Lake. The least clarity occurred during June and July 2007 in all three lakes.

The National Weather Service (NWS) reported that June 2007 and July 2007 averaged near or slightly below normal for precipitation in Milwaukee, with precipitation for the two month period totaling 5.04 inches, or 2.10 inches below normal. Temperatures were at or above normal during this period. Scattered severe thunderstorms occurred every day during the first six days of June 2007, while late-July 2007 and early-August 2007 were periods of record breaking precipitation totals over much of southern Wisconsin. Similar situations were reported during the summers of 2008, when the NWS reported a record monthly rainfall value of 12.27 inches of precipitation during June 2008, and 2009 when the NWS reported a record daily rainfall value of 2.25 inches on June 19, 2009. These data would suggest that the reduced Secchi-disk transparencies observed during these summers might have been related to exceptional weather conditions which resulted in the wash off of plant nutrients and particulate matter, among other contaminants, from the land surface around the Lakes. Reported summer chlorophyll-*a* concentrations during these years were generally equal to or exceeding those previously reported from the Lakes. The highest chlorophyll-*a* concentrations coincided with the lowest Secchi-disk transparency values.

Remote Sensing Water Clarity Data

In addition to in-lake direct measurements of water clarity using a Secchi disk, the transparencies of many Wisconsin lakes have been measured using remote sensing technology. The Environmental Remote Sensing Center (ERSC), established in 1970 on the University of Wisconsin-Madison campus, was one of the first remote sensing facilities in the United States. Using data gathered by satellite remote sensing over a three-year period, the ERSC generated a map based on a mosaic of satellite images showing the estimated water clarity of the largest 8,000 lakes in Wisconsin. The WDNR, through its volunteer Self-Help Monitoring Program (now the CLMN), was able to gather water clarity measurements from about 800 lakes, or about 10 percent of Wisconsin's largest lakes. Of these, the satellite remote sensing technology utilized by ERSC was able to accurately estimate clarity, providing a basis for extrapolating water clarity estimates to the remaining 90 percent of lakes. Measurements collected through the ERSC remote sensing program from 1999 through 2005, estimated the average water clarity of Green Lake to be 8.2 feet, a value indicative of generally good water quality; Middle Lake was estimated to have an average water clarity of 5.4 feet, indicative of generally fair water quality; and Mill lake was estimated to have an average water clarity of 4.3 feet, indicative of poor water quality. Such data are lower than the in-lake measured transparencies observed during the previous study period; however, the trend of declining transparency from north to south within the Lauderdale Lakes is essentially consistent with the abovementioned Self-Help Monitoring Program and CLMN Secchi-disk measurements during the current study period.

Zebra Mussel Impacts

The Lauderdale Lakes are listed by the WDNR as having an established population of zebra mussels (*Dreissena polymorpha*) since 1998. Zebra mussels, a nonnative species of shellfish with known negative impacts on native benthic organism populations, are having a varied impact on the inland lakes of the Upper Midwest, disrupting the food chain by removing significant amounts of bacteria and smaller phytoplankton which serve as food for a variety of other aquatic organisms, including larval and juvenile fishes and many forms of zooplankton. As a result of the filter feeding proclivities of these animals, many lakes have experienced improved water clarity. This improved water clarity, in turn, has led to increased growths of rooted aquatic plants, including Eurasian water milfoil. Curiously, within the Southeastern Wisconsin Region, and specifically within the Lauderdale Lakes, zebra mussels have been observed attaching themselves to the stalks of the Eurasian water milfoil plants, dragging the stems out of the zone of light penetration due to the weight of the zebra mussel shells, and interfering with the competitive strategy of the Eurasian water milfoil plants. This has contributed to improved growths of native aquatic plants in some cases, and to the growths of filamentous algae too large to be ingested by the zebra mussels in others. Regardless as to the seeming beneficial impacts of these animals, the overall effect is that, as zebra mussels and other invasive species spread to inland lakes and rivers, so do the environmental, aesthetic, and economic costs to water users.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. Generally, dissolved oxygen levels are higher at the surface of a lake, where there is an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels are usually lowest near the bottom of a lake, where decomposer organisms and chemical oxidation processes utilize oxygen in the decay process.

When a lake becomes stratified—that is, when a thermal gradient (called a "thermocline") or chemical gradient ("chemocline") of sufficient intensity produces a barrier separating upper waters, called the epilimnion, from lower waters, known as the hypolimnion—the surface supply of oxygen to the hypolimnion is cut off. Eventually, if there is not enough dissolved oxygen to meet the demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced to zero, a condition known as anoxia or anaerobiasis.

Where oxygen levels are depleted in the hypolimnion, fish tend to move upward, nearer to the surface of the lake, where higher dissolved oxygen concentrations exist. This migration, when combined with temperature, can select against some fish species that prefer the cooler water temperatures that generally prevail in the lower portions of the lake. When there is insufficient oxygen at these depths, these fish are susceptible to summerkills, or, alternatively, are driven into the warmer water portions of the lake where their condition and competitive success may be severely impaired. Additionally, this condition, common to many shallow lakes in Wisconsin, can lead to winter fish kills if oxygen stores are not sufficient to meet the total demand.

Information on dissolved oxygen levels during 1966 was presented in the earlier WDNR lake use report.[4] Due to the presence of deep water in all three basins, all three Lakes were found to be stratified by mid-summer, with thermoclines developing at a depth of about 18 feet in Green and Middle Lakes, and at a depth of about 12 feet in Mill Lake. Water samples taken at that time indicated that during the summer, all three Lakes had sufficient oxygen to support fish and other aquatic life in Green Lake to a depth of about 35 feet, Middle Lake to a depth of about 28 feet, and Mill Lake to a depth of about 23 feet. In Green Lake, the deep thermoclinal maximum of oxygen was attributed to the transparency of the Lake's waters; increased transparency allowing deeper light penetration with subsequent higher levels of oxygen-producing photosynthesis at those depths. Data also indicted that all three Lakes did become anoxic—depleted of oxygen—at bottom depths during summer. Winter levels of dissolved oxygen were not presented as part of the 1969 WDNR report.

Dissolved oxygen levels presented in the previous SEWRPC report [5] were collected by the USGS for the period from November 1993 through August 1999 for Middle Lake, and for the period from November 1993 through November 1994 for Green and Mill Lakes.[6] At that time, the Green Lake data indicated the establishment of a thermocline at a depth of 25 to 35 feet by July with anoxia in bottom waters of that Lake from July through November; oxygen levels near the surface remained mostly within the range of about 8.0 to 9.0 milligrams per liter (mg/l) throughout the sampling period. In Middle Lake, thermal stratification took place by early July with the thermocline becoming established at depths of 25 to 35 feet and, as summer progressed, gradually moving higher in the water column to depths in the 15 to 25 foot range by late summer; anoxic conditions became evident

---

[4]*Wisconsin Department of Natural Resources Publication Lake Use Report Nos. FX-17, FX-18, and FX-20,* op. cit.

[5]*SEWRPC Memorandum Report No. 143,* op. cit.

[6]*U.S. Geological Survey Open-File Reports No. 95-190 through 00-89,* Water Quality and Lake-Stage Data for Wisconsin Lakes, Water Years 1994 through 1999*, published annually from 1995 through 2000.*

in bottom waters by early-July and persisted until mid-October. Year 1999 data for Middle Lake showed a similar pattern. Surface waters in Middle Lake showed good levels of dissolved oxygen throughout the sampling periods both in 1994 and in 1999. In Mill Lake, stratification occurred by early June at a depth of 25 to 35 feet, gradually moving higher in the water column to a depth of 12 to 20 feet by the end of August; anoxic conditions in the bottom waters persisted from early July to mid-October, although surface waters in the Lake showed good oxygen levels throughout the sampling period.

During the current study, dissolved oxygen data were acquired from the three Lakes since June 2007, with data being available through the WDNR Surface Water Information Management System (SWIMS) through October 2009. These data reflect a similar seasonal pattern as previously reported, with the onset of dissolved oxygen concentration stratification at the 40 feet depth in Middle Lake at the end of June 2007, when dissolved oxygen concentrations of less than 5.0 mg/l were observed. This oxycline, or zone of transition from dissolved oxygen concentrations greater than 5.0 mg/l to concentrations approaching zero, moved upwards during the summer and the volume of the hypolimnion increased with the 5.0 mg/l dissolved oxygen concentration level occurring at about 20 feet depth by the end of July. This oxycline remained at this level through early September. During 2008, Middle Lake was well mixed during April, but stratification began to occur at the end of May. By July 2008, the oxycline was again at about 20 feet. During 2009, an oxycline appeared as early as late-March and persisted through mid-October. A similar seasonal pattern was observed in Green Lake, although the oxycline occurred at depths of below 40 feet in June 2007, with the greatest extent of hypolimnetic deoxygenation including depths below 30 feet. During 2008, deoxygenation of the hypolimnion occurred only in late-June and at depths below 25 feet. The distribution of dissolved oxygen in Green Lake during 2009 was similar to that observed in 2007. Mill Lake was stratified with respect to dissolved oxygen concentrations, with dissolved oxygen concentrations of less than 5.0 mg/l occurring at depths below 35 feet in June 2007. In later summer of that year, Mill Lake was deoxygenated below 20 feet in depth. During 2008, deoxygenation was first observed during late-May with the extent of the hypolimnion including lake waters at depths of 20 feet and greater by late-June 2008. These conditions persisted through late-October. Dissolved oxygen concentrations in Mill Lake during 2009 followed a similar pattern. Surface water dissolved oxygen concentrations ranged from about 8.0 mg/l to about 10.0 mg/l in the upper waters, or epilimnion, of the Lakes.

In addition to the biological consequences of deoxygenation, the lack of dissolved oxygen at depth can enhance the development of chemoclines, or chemical gradients, with an inverse relationship to the dissolved oxygen concentration. For example, the sediment-water exchange of elements, such as phosphorus, iron, and manganese, is increased under anaerobic conditions, resulting in increased hypolimnetic concentrations of these elements. Under anaerobic conditions, changes in iron and manganese oxidation states enable the release of phosphorus from the iron and manganese complexes to which they were bound under aerobic conditions. This “internal loading” can affect water quality significantly if these nutrients and salts are mixed into the epilimnion, especially during early summer, when these nutrients can become available for algal and rooted aquatic plant growth. Water quality data presented in the previous SEWRPC report showed good agreement between predicted and observed levels of phosphorus in the Lauderdale Lakes; such agreement would suggest that the estimated phosphorus load was a reasonable representation of the loads actually entering the Lakes, and that other pollution sources, including internal, atmospheric, groundwater, and onsite sewage disposal system sources, were relatively small compared to the loading from external sources. For the current reporting period, CLMN data reported for the period from 2006 through 2009 are consistent with these observations.

Chlorophyll-*a*

Chlorophyll-*a* is the major photosynthetic (“green”) pigment in algae. The amount of chlorophyll-*a* present in the water is an indication of the biomass or amount of algae in the water. The mean chlorophyll-*a* concentration for lakes in the Southeastern Wisconsin Region is about 43.3 micrograms per liter (μg/l), with a median concentration of about 9.9 µg/l.[7] Chlorophyll-*a* levels above about 10 µg/l generally result in a green coloration of the water that may be severe enough to impair recreational activities, such as swimming or waterskiing.[8]

Although chlorophyll-*a* measurements were not presented in the initial WDNR report,[9] for the previous SEWRPC report,[10] measurements for Green Lake averaged 3.18 milligrams per cubic meter (mg/m^3 = µg/l) annually, averaged 2.95 µg/l annually for Middle Lake, and averaged 4.94 µg/l annually in Mill Lake. Such concentrations were not indicative of water quality problems in any of the three Lakes.

During the current study period, chlorophyll-*a* concentrations in the Lakes ranged between 2.0 µg/l and about 10 µg/l, with the higher concentrations occurring in Mill Lake; in Green Lake and Middle Lake, the maximum concentrations of chlorophyll-*a* were less than about 5.0 µg/l. These suggest that the Lakes are not subject to regular algal blooms.

Nutrient Characteristics

Aquatic plants and algae require such nutrients as phosphorus and nitrogen for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations that exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, plant growth is limited by the amount of the nutrient that is available in the least quantity relative to all of the others. The ratio (N:P) of total nitrogen (N) to total phosphorus (P) in lake water indicates which nutrient is the factor most likely to be limiting aquatic plant growth in a lake.[11] Where the N:P ratio is greater than 14:1, phosphorus is most likely to be the limiting nutrient. If the ratio is less than 10:1, nitrogen is most likely to be the limiting nutrient.

During the study period for the previous SEWRPC report,[12] the N:P ratio was always 16:1 or greater, indicating plant growth at that time was consistently limited by phosphorus, which is common in most inland lakes in Wisconsin. Nitrogen data were not available for the current study period.

Total phosphorus concentrations include the phosphorus contained in plant and animal fragments suspended in the lake water, phosphorus bound to sediment particles, and phosphorus dissolved in the water column, and is, therefore, usually considered a good indicator of nutrient status in a lake.

For lakes, the guideline value set forth in the adopted regional water quality management plan is 20 µg/l of total phosphorus or less during spring turnover. This is the level considered as necessary to limit algal and aquatic plant growths to levels consistent with recreational water use objectives, as well as water use objectives for maintaining

---

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

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

[9] *Wisconsin Department of Natural Resources Publication Lake Use Report Nos. FX-17, 18 and 20,* op. cit.

[10] *SEWRPC Memorandum Report No. 143,* op. cit.

[11] *M.O. Allum, R.E. Gessner, and T.H. Gakstatter, U.S. Environmental Protection Agency Working Paper No. 900,* An Evaluation of the National Eutrophication Data, *1976.*

[12] *SEWRPC Memorandum Report No. 143,* op. cit.

a warmwater fishery and other aquatic life. In the Lauderdale Lakes, as described in the Priority Watershed Plan,[13] the 1995 spring total phosphorus concentrations ranged narrowly from 20 μg/l to 23 μg/l; the summer phosphorus concentrations ranged from 7.0 μg/l to 13 μg/l.

Total phosphorus concentrations since that time have been about the same as the 1995 summer average. In Green Lake, total phosphorus concentrations reported by the CLMN ranged from 7.0 μg/l to 13 μg/l; in Middle Lake, the total phosphorus concentrations ranged from 9.0 μg/l to 16 μg/l; and in Mill Lake, the total phosphorus concentrations ranged from 6.0 μg/l to 22 μg/l, during the period from March 2006 through November 2009. These levels generally were found to be below the levels necessary to support nuisance algae blooms, although total phosphorus concentrations in excess of 20 μg/l are considered to be above the level necessary to sustain algal blooms in lakes.[14]

Seasonal gradients of phosphorus concentrations between the epilimnion and hypolimnion of a lake reflect the biogeochemistry of this growth element. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed. Phosphorus from these organisms is then either stored in the bottom sediments or rereleased into the water column. Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates, predominantly, in the lake sediments. As aforestated, if the bottom waters become depleted of oxygen during stratification, certain chemical changes occur, including the change in the oxidation state of iron from the insoluble Fe^{3+} state to the more soluble Fe^{2+} state. The effect of these chemical changes is that phosphorus becomes soluble and is more readily released from the sediments in a process known as *internal loading*. This process also occurs under aerobic conditions, but generally at a slower rate than under anaerobic conditions. As the waters mix, this phosphorus may be widely dispersed throughout the lake waterbody and become available for algal growth.

Although the significant concentration gradients between surface and bottom concentrations of total phosphorus observed in all three Lakes during the previous study, concurrent with the onset of anoxic conditions in the hypolimnion, might be construed as indicative of internal loading, the absence of accompanying increases in levels of chlorophyll-*a* or marked decreases in water transparency would tend to favor the view that such hypolimnetic phosphorus releases are not dispersing to any significant degree in the water column and are not, therefore, practically contributing to increased plant growth in the Lakes, thereby supporting the notion that total phosphorus levels in the Lakes are likely the result of external, not internal, sources.

Should any such loading occur, the magnitude of the release and its subsequent effects in contributing to algal growth in the surface waters of the Lakes may be moderated by a number of circumstances, including the rates of mixing during the spring and fall overturn events. Slow mixing generally results in any phosphorus released into the bottom waters of the Lakes being reprecipitated and unavailable to aquatic plants.[15]

---

[13]*Wisconsin Department of Natural Resources Publication No. WT-478-97,* Nonpoint Source Control Plan for the Sugar/Honey Creek Priority Watershed Project*, February 1997.*

[14]*During 2007 and 2008, surface water total phosphorus concentrations in Mill Lake exceeded the 20 μg/l threshold during mid-summer. These periods were coincident with the occurrence of chlorophyll-*a *concentrations in approaching 10 μg/l, which is considered to be the level at which most observers will report a greenish coloration of the water.*

[15]*See, for example, R.D. Robarts, P.J. Ashton, J.A. Thornton, H.J. Taussig, and L.M. Sephton, "Overturn in a hypertrophic, warm, monomictic impoundment (Hartbeespoort Dam, South Africa),"* Hydrobiologia*, Volume 97, 1982, pp. 209-224.*

POLLUTION LOADINGS AND SOURCES

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the area tributary to a lake. These loads are transported to the lake through the atmosphere, across the land surface, and by way of inflowing streams. Pollutants transported by the atmosphere are deposited onto the surface of the lake as dry fallout and direct precipitation. Pollutants transported across the land surface enter the lake directly as surface runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams also enter a lake as surface water inflows.

In drained lakes, like the Lauderdale Lakes system, pollutant loadings transported by inflowing streams, by precipitation falling directly onto the Lakes' surfaces and runoff from the tributary areas immediately surrounding the Lakes, in the absence of identifiable or point source discharges from industries or wastewater treatment facilities, comprise the principal routes by which contaminants enter the waterbodies.[16] Currently, there are no significant point source discharges of pollutants into the Lauderdale Lakes. For this reason, the discussion that follows is based upon nonpoint source pollutant loadings to the Lakes.

Nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities; and rural sources, such as runoff from agricultural lands and onsite sewage disposal systems.

Nonpoint source phosphorus, suspended solids, and urban-derived metals inputs to the Lauderdale Lakes were estimated using the Wisconsin Lake Model Spreadsheet (WILMS version 3.3),[17] and the unit area load-based models developed for use within the Southeastern Wisconsin Region.[18]

Phosphorus Loadings

During the current study, as shown in Table 5, existing year 2000 phosphorus loads to the Lauderdale Lakes were identified and quantified using SEWRPC land use inventory data.[19] It was estimated that, under year 2000 conditions, the total phosphorus load to the Lauderdale Lakes was 2,690 pounds. Of the annual total phosphorus load, it was estimated that 2,085 pounds per year, or about 77 percent of the total loading, were contributed by runoff from rural lands, mostly agricultural, and 500 pounds per year, or about 19 percent, were contributed by runoff from urban lands, mostly from residential sources. About 105 pounds, or about 4 percent, were contributed by direct precipitation onto the lake surface.

Phosphorus release from the lake bottom sediments, or internal loading, as discussed above, does not appear to have been a contributing factor to the total phosphorus loading to the Lakes.

---

[16]*Sven-Olof Ryding and Walter Rast*, The Control of Eutrophication of Lakes and Reservoirs, *Unesco Man and the Biosphere Series, Volume 1, Parthenon Press, Carnforth, 1989; Jeffrey A. Thornton, Walter Rast, Marjorie M. Holland, Geza Jolankai, and Sven-Olof Ryding,* The Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems, *Unesco Man and the Biosphere Series, Volume 23, Parthenon Press, Carnforth, 1999.*

[17]*John C. Panuska and Jeff C. Kreider, Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-94,* Wisconsin Lake Modeling Suite Program Documentation and User's Manual, Version 3.3 for Windows, *August 2002.*

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

[19]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

Table 5

ESTIMATED ANNUAL POLLUTANT LOADINGS TO THE LAUDERDALE LAKES BY LAND USE CATEGORY: 2000

Land Use Category	Pollutant Loads Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential[a]	6.6	135.8	0.0	1.5
Commercial	0.8	2.4	0.4	3.0
Industrial	0.4	1.2	0.2	1.5
Governmental	<0.1	0.3	0.0	0.0
Transportation	62.3	329.4	17.1	24.8
Recreational	1.4	32.4	0.0	0.0
Subtotal	71.5	501.5	17.7	30.8
Rural				
Agricultural	538.6	2,058.8	- -	- -
Wetlands	0.2	4.2	- -	- -
Woodlands	1.0	21.7	- -	- -
Water	74.8	103.5	- -	- -
Subtotal	614.6	2,188.2	- -	- -
Total	686.1	2,689.7	17.7	30.8

[a]*Includes the contribution from onsite sewage disposal systems. The contribution from onsite sewage disposal systems, based upon the* per capita *phosphorus contribution contained within wastewater estimated within the WILMS model, could range from approximately 25.5 pounds per year to as much as about 681.5 pounds per year, depending upon soil type, system condition, and system locations. For purposes of this analysis, 25.5 pounds per year were used as that value provided the loading that was best correlated to the measured in-lake phosphorus concentration.*

Source: SEWRPC.

Under 2035 conditions, as set forth in the adopted regional land use plan,[20] the annual total phosphorus load to the Lakes is anticipated to diminish as agricultural activities within the area tributary to the Lauderdale Lakes are replaced by urban residential land uses. Table 6 shows the estimated phosphorus loads to the Lauderdale Lakes under planned year 2035 conditions. The most likely annual total phosphorus load to the Lakes under the planned conditions is estimated to be 2,475 pounds.[21] Of the forecast total annual phosphorus load to the Lauderdale Lakes, 1,760 pounds per year, or about 71 percent of the total loading, are estimated to be contributed by runoff from rural land, and 610 pounds per year, or about 25 percent, from urban land. About 105 pounds, or about 4 percent, are expected to be contributed by direct precipitation onto the lake surface. Thus, it may be anticipated that not only will the amount of the phosphorus load decrease, but that the distribution of the sources of the phosphorus load to the Lakes may change, with the amount of phosphorus being contributed from urban sources experiencing an increase from 19 percent of the total in 2000 to about 25 percent of the total in 2035, while the amount of phosphorus from rural sources will decrease from 77 percent of the total in 2000 to about 71 percent of the total in 2035.

[20]Ibid.

[21]*Wisconsin Department of Natural Resources Publication No. WT-478-97,* Nonpoint Source Control Plan for the Sugar-Honey Creeks Priority Watershed Project, *February 1997, set a phosphorus load reduction goal of 14 percent of the then-estimated total annual phosphorus load of 1,880 pounds per year estimated to be entering the Lauderdale Lakes.*

Table 6

ESTIMATED ANNUAL POLLUTANT LOADINGS TO THE LAUDERDALE LAKES BY LAND USE CATEGORY: 2035

Land Use Category	Pollutant Loads			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential[a]	8.9	184.2	0.0	1.6
Commercial	7.0	21.6	4.0	3.0
Industrial	0.4	1.2	0.2	1.5
Governmental	<0.1	0.3	0.0	0.0
Transportation	63.9	337.5	17.5	24.8
Recreational	2.9	65.1	0.0	0.0
Subtotal	83.1	609.9	21.7	30.9
Rural				
Agricultural	453.8	1,734.6	- -	- -
Wetlands	0.2	4.2	- -	- -
Woodlands	1.0	21.4	- -	- -
Water	74.8	103.5	- -	- -
Subtotal	529.8	1,863.7	- -	- -
Total	612.9	2,473.6	21.7	30.9

[a]*Includes the contribution from onsite sewage disposal systems. The contribution from onsite sewage disposal systems, based upon the* per capita *phosphorus contribution contained within wastewater estimated within the WILMS model, could range from approximately 25.5 pounds per year to as much as about 681.5 pounds per year, depending upon soil type, system condition, and system locations. For purposes of this analysis, 25.5 pounds per year were used as that value provided the loading that was best correlated to the measured in-lake phosphorus concentration.*

Source: SEWRPC.

While the trends forecast for year 2035 land use conditions may be offset by the increasing utilization of agro-chemicals in urban landscaping, the stormwater management requirements set forth in Chapter NR 151 of the *Wisconsin Administrative Code*, and the limits established by the Wisconsin Legislature on the use and sale of fertilizer containing phosphorus in turf fertilizers to be used in urban areas pursuant to 2009 Wisconsin Act 9 and on the amount of phosphorus in certain cleaning agents pursuant to 2009 Wisconsin Act 63, may be expected to further decrease the phosphorus loads to Honey Creek and its Lakes.

Sediment Loadings

For the current study period, the estimated sediment loadings to the Lauderdale Lakes under existing year 2000 conditions are shown in Table 5. Based upon estimated sediment loadings from various classes of land usage within the tributary area, as shown in Table 5, a total annual sediment loading of 685 tons was estimated to be contributed to the Lauderdale Lakes.[22] Of the likely annual sediment load, it was estimated that 540 tons per year, or about 79 percent of the total loading, were contributed by runoff from rural lands, mostly from agricultural sources, and 70 tons, or about 10 percent, contributed by urban lands. Approximately 75 tons, or about 11 percent of the annual sediment load, were contributed by atmospheric deposition onto the lake surface.

---

[22]*Wisconsin Department of Natural Resources Publication No. WT-478-97,* Nonpoint Source Control Plan for the Sugar-Honey Creeks Priority Watershed Project, *February 1997, set a sediment load reduction goal of 30 percent of the then-estimated total annual sediment load of 2,605 tons per year estimated to be entering the Lauderdale Lakes.*

Under 2035 conditions, as set forth in the adopted regional land use plan and as shown in Table 6, the annual sediment load to the Lakes is anticipated to diminish. The most likely annual sediment load to the Lakes under buildout conditions is estimated to be 610 tons. Of the forecast sediment load anticipated for the Lauderdale Lakes, about 455 tons of sediment are estimated to be contributed to the Lakes from rural sources and 80 tons from urban sources. Approximately 75 tons of sediment per year are estimated to continue to be contributed by direct precipitation onto the lake surface.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[23] The majority of these metals become associated with sediment particles[24] and, consequently, are likely to be encapsulated into the bottom sediments of a lake.

The estimated loadings of copper and zinc likely to be contributed to the Lauderdale Lakes under existing year 2000 and forecast year 2035 land use conditions are shown in Tables 5 and 6, respectively. In 2000, 18 pounds of copper and 31 pounds of zinc were estimated to be contributed annually to the Lauderdale Lakes, all from urban lands. Under planned year 2035 conditions, as set forth in the adopted regional land use plan,[25] the annual zinc loads to the Lakes are anticipated to remain about the same as those estimated under existing year 2000 conditions. The copper load is anticipated to increase slightly to about 22 pounds per year as a consequence of ongoing urban-density development in the watershed.

TROPHIC STATUS

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

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

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

Eutrophic lakes are nutrient-rich lakes. These lakes often exhibit excessive aquatic macrophyte growths and/or experience frequent algae blooms. If the lakes are shallow, fish winterkills may be common. While portions of such lakes are not ideal for swimming and boating, eutrophic lakes may support very productive fisheries. Although some eutrophic lakes are present in the Region, severely eutrophic lakes are rare, especially since the regionwide implementation of recommendations put forth in the regional water quality management plan. Severely enriched lakes are sometimes referred to as being hypertrophic.

---

[23]*Jeffrey A. Thornton, et al.,* op. cit.

[24]*Werner Stumm and James J. Morgan,* Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters, *Wiley-Interscience, New York, 1970.*

[25]*SEWRPC Planning Report No. 48,* op. cit.

Several numeric "scales," based on one or more water quality indicators, have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale used is appropriate for the lake to which it is applies. In this case, two indices appropriate for Wisconsin lakes have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[26] and the Carlson Trophic State Index (TSI),[27] with a variation known as the Wisconsin Trophic State Index value (WTSI).[28] The WTSI is a refinement of the Carlson TSI and is designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes; it has been adopted by the WDNR for use in lake management investigations.

During the previous study period, Secchi-disk transparency conditions resulted in a WTSI value of about 40 for Green Lake, of about 42 for Middle Lake, and of about 45 for Mill Lake. Data at the time suggested that water quality in each of the three individual Lake systems had remained relatively stable over the approximately 20-year period since 1980. All three values indicated that the Lauderdale Lakes were mesotrophic waterbodies.

During the current study period, Secchi-disk transparency conditions resulted in a WTSI value of about 39 for Green Lake, of about 40 for Middle Lake, and of about 45 for Mill Lake. Data at the time suggested that water quality in each of the three individual Lake systems had remained relatively stable over the approximately 20-year period since 1980. All three values indicated that the Lauderdale Lakes were mesotrophic waterbodies.

Based upon data gathered during the aforementioned ERSC satellite remote sensing study, Green Lake was estimated to have a TSI value of 51 while Middle and Mill Lakes both had an estimated TSI value of 55. A value above 50 is generally indicative of the enriched conditions associated with slightly eutrophic lakes. These values are slightly higher than those calculated from the Secchi-disk transparency values obtained under the auspices of the CLMN program, but are consistent in placing the Lauderdale Lakes at the point of transition between mesotrophic and eutrophic states.

AQUATIC PLANTS: DISTRIBUTION AND MANAGEMENT AREAS

Previous surveys and inventories of the aquatic macrophyte communities in the Lauderdale Lakes were conducted in 1967 and 1999, the latter of which formed the basis for the current aquatic plant management plan for the Lauderdale Lakes.[29] The implementation of this plan resulted in a study, conducted by SEWRPC staff during July of 2003, of the response of the aquatic plant flora in Sterlingworth Bay to the removal of the Eurasian water milfoil canopy with an aquatic plant harvester. The current study builds from these foundational aquatic plant surveys. Conducted by SEWRPC staff during July of 2008, the results of this aquatic plant survey are shown in Tables 7 through 9, and on Maps 11 through 13.

---

[26]*H. Olem and G. Flock, U.S. Environmental Protection Agency Report EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition*, Walworth, D.C., August 1990.*

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

[28]*See R.A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes,"* Research and Management Findings*, Wisconsin Department of Natural Resources Publication No. PUBL-RS-735 93, May 1993.*

[29]*SEWRPC Memorandum Report No. 143,* op. cit.*; see also Wisconsin Department of Natural Resources Publication Lake Use Report Nos. FX-17, 18 and 20,* op. cit.

Table 7

AQUATIC PLANT SPECIES OBSERVED IN LAUDERDALE LAKES—GREEN LAKE: JULY 2008

Aquatic Plant Species	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Ceratophyllum demersum (coontail)	7	6.6	1.4	9.4
Chara vulgaris (muskgrass)	78	73.6	2.9	213.2
Elodea canadensis (waterweed)	11	10.4	1.9	19.8
Myriophyllum sibiricum (northern water milfoil)	8	7.5	1.0	7.5
Myriophyllum spicatum (Eurasian water milfoil)	37	34.9	2.2	76.4
Najas flexilis (bushy pondweed)	21	19.8	1.8	34.9
Najas marina (spiny naiad)	9	8.5	1.3	11.3
Nuphar advena (yellow water lily)	5	4.7	2.6	12.3
Nymphaea odorata (white water lily)	4	3.8	2.0	7.5
Potamogeton crispus (curly-leaf pondweed)	7	6.6	1.3	8.5
Potamogeton gramineus (variable pondweed)	22	20.8	1.5	31.1
Potamogeton foliosis (leafy pondweed)	3	2.8	1.7	4.7
Potamogeton illinoensis (Illinois pondweed)	3	2.8	2.3	6.6
Potamogeton natans (floating-leaf pondweed)	3	2.8	2.3	6.6
Potamogeton pectinatus (Sago pondweed)	32	30.2	1.9	57.5
Potamogeton pusillus (small pondweed)	1	0.9	1.0	0.9
Potamogeton richardsonii (clasping-leaf pondweed)	1	0.9	2.0	1.9
Potamogeton zosteriformis (flat-stem pondweed)	5	4.7	1.4	6.6
Utricularia spp. (bladderwort)	4	3.8	1.0	3.8
Vallisneria americana (wild celery/eel-grass)	53	50.0	2.7	135.8
Zosterella dubia (water stargrass)	3	2.8	1.0	2.8

NOTE: Sampling occurred at 106 sampling sites along 28 transects.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

[b]*The average density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the relative frequency of occurrence and the average density, expressed as a percentage. This number provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

During the 1967 study, at least 23 different aquatic plant genera were observed, evidence of the exceptional diversity of the aquatic plant communities in the Lakes at that time. Eel-grass, or wild celery, (*Vallisneria americana*) and muskgrass (*Chara vulgaris*) were the dominant species around the deep basins; coontail (*Ceratophyllum demersum*), water milfoil (*Myriophyllum* sp.) and muskgrass were the dominant species in the larger, shallower bays. Pondweeds (*Potamogeton* spp.) were observed scattered throughout the Lakes, while water lilies, pond lilies, and cattails were abundant in the large bays. Overall, the Lakes contained a good diversity of aquatic species with little or no reported problems from algal blooms.

During the previous SEWRPC aquatic plant survey of 1999, the Lauderdale Lakes continued to exhibit this exceptional diversity, with up to 25 species of aquatic plants being recorded during that survey. The aquatic plant communities in each of the three Lakes were discussed separately:

- Green Lake, which contained some 18 different aquatic plant species, had a high floral diversity. Eurasian water milfoil (*Myriophyllum spicatum*) was the dominant species of submergent aquatic plant in this Lake, particularly in areas where silty or sand-silt sediments were present. Muskgrass,

Table 8

AQUATIC PLANT SPECIES OBSERVED IN LAUDERDALE LAKES—MIDDLE LAKE: JULY 2008

Aquatic Plant Species	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Ceratophyllum demersum (coontail)	3	3.6	1.3	4.8
Chara vulgaris (muskgrass)	55	66.3	3.1	206.0
Elodea canadensis (waterweed)	8	9.6	1.6	15.7
Myriophyllum sibiricum (northern water milfoil)	13	15.7	1.5	24.1
Myriophyllum spicatum (Eurasian water milfoil)	15	18.1	1.4	25.3
Najas flexilis (bushy pondweed)	16	19.3	2.0	38.6
Najas marina (spiny naiad)	19	22.9	1.9	43.4
Nuphar advena (yellow water lily)	15	18.1	1.9	34.9
Nymphaea odorata (white water lily)	9	10.8	1.9	20.5
Potamogeton crispus (curly-leaf pondweed)	7	8.4	2.1	18.1
Potamogeton gramineus (variable pondweed)	11	13.3	1.3	16.9
Potamogeton foliosis (leafy pondweed)	2	2.4	1.0	2.4
Potamogeton illinoensis (Illinois pondweed)	3	3.6	1.0	3.6
Potamogeton nodosus (long-leaf pondweed)	1	1.2	1.0	1.2
Potamogeton pectinatus (Sago pondweed)	8	9.6	1.1	10.8
Potamogeton zosteriformis (flat-stem pondweed)	5	6.0	2.2	13.3
Scirpus acutus (hardstem bulrush)	7	8.4	2.7	22.9
Sparganium minima (small bur reed)	3	3.6	2.0	7.2
Utricularia spp. (bladderwort)	13	15.7	1.2	18.1
Vallisneria americana (wild celery/eel-grass)	27	32.5	2.1	68.7

NOTE: Sampling occurred at 83 sampling sites along 25 transects.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

[b]*The average density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the relative frequency of occurrence and the average density, expressed as a percentage. This number provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

eel-grass, spiny naiad (*Najas marina*), and bushy pondweed (*Najas flexilis*) were also present in significant numbers.

- Middle Lake contained 25 different aquatic plant species and had the best floral diversity of the three Lakes. The dominant species was muskgrass, although other species present in significant numbers included bushy pondweed, Eurasian water milfoil, spiny naiad, and eel-grass. As was the case in Green Lake, Eurasian water milfoil was widespread in areas where soft or organic bottom sediments dominated, such as in the western portions of Middle Lake that had been wetland prior to construction of the dam impounding the Lauderdale Lakes.

- Mill Lake contained 21 different aquatic plant species with Eurasian water milfoil found in the highest densities of all the Lauderdale Lakes. This is not surprising considering the generally widespread dominance of soft bottom sediments especially in the southern half of the Lake. Other plant species present in Mill Lake in fairly significant numbers included muskgrass, bushy pondweed, and eel-grass.

Table 9

AQUATIC PLANT SPECIES OBSERVED IN LAUDERDALE LAKES—MILL LAKE: JULY 2008

Aquatic Plant Species	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Ceratophyllum demersum (coontail)	14	13.9	2.5	34.7
Chara vulgaris (muskgrass)	54	53.5	3.2	169.3
Elodea canadensis (waterweed)	24	23.8	2.3	53.5
Lemna spp. (duckweed)	1	1.0	1.0	1.0
Myriophyllum sibiricum (northern water milfoil)	15	14.9	1.9	28.7
Myriophyllum spicatum (Eurasian water milfoil)	48	47.5	2.8	130.7
Najas flexilis (bushy pondweed)	31	3.7	2.5	75.2
Najas marina (spiny naiad)	2	2.0	2.5	5.0
Nitella spp. (stonewort)	4	4.0	1.8	6.9
Nuphar advena (yellow water lily)	1	1.0	4.0	4.0
Nymphaea odorata (white water lily)	3	3.0	2.3	6.9
Potamogeton amplifolius (large-leaf pondweed)	1	1.0	2.0	2.0
Potamogeton crispus (curly-leaf pondweed)	4	4.0	1.8	6.9
Potamogeton gramineus (variable pondweed)	9	8.9	1.2	10.9
Potamogeton foliosis (leafy pondweed)	3	3.0	0.7	2.0
Potamogeton nodosus (long-leaf pondweed)	1	1.0	0.0	0.0
Potamogeton pectinatus (Sago pondweed)	18	17.8	1.9	34.7
Potamogeton pusillus (small pondweed)	2	2.0	1.0	2.0
Potamogeton zosteriformis (flat-stem pondweed)	5	5.0	1.2	5.9
Utricularia spp. (bladderwort)	14	13.9	1.4	18.8
Vallisneria americana (wild celery/eel-grass)	41	40.6	2.2	89.1
Zosterella dubia (water stargrass)	5	5.0	1.8	8.9

NOTE: Sampling occurred at 101 sampling sites along 25 transects.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

[b]*The average density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the relative frequency of occurrence and the average density, expressed as a percentage. This number provides an indication of the dominance of a species within a community.*

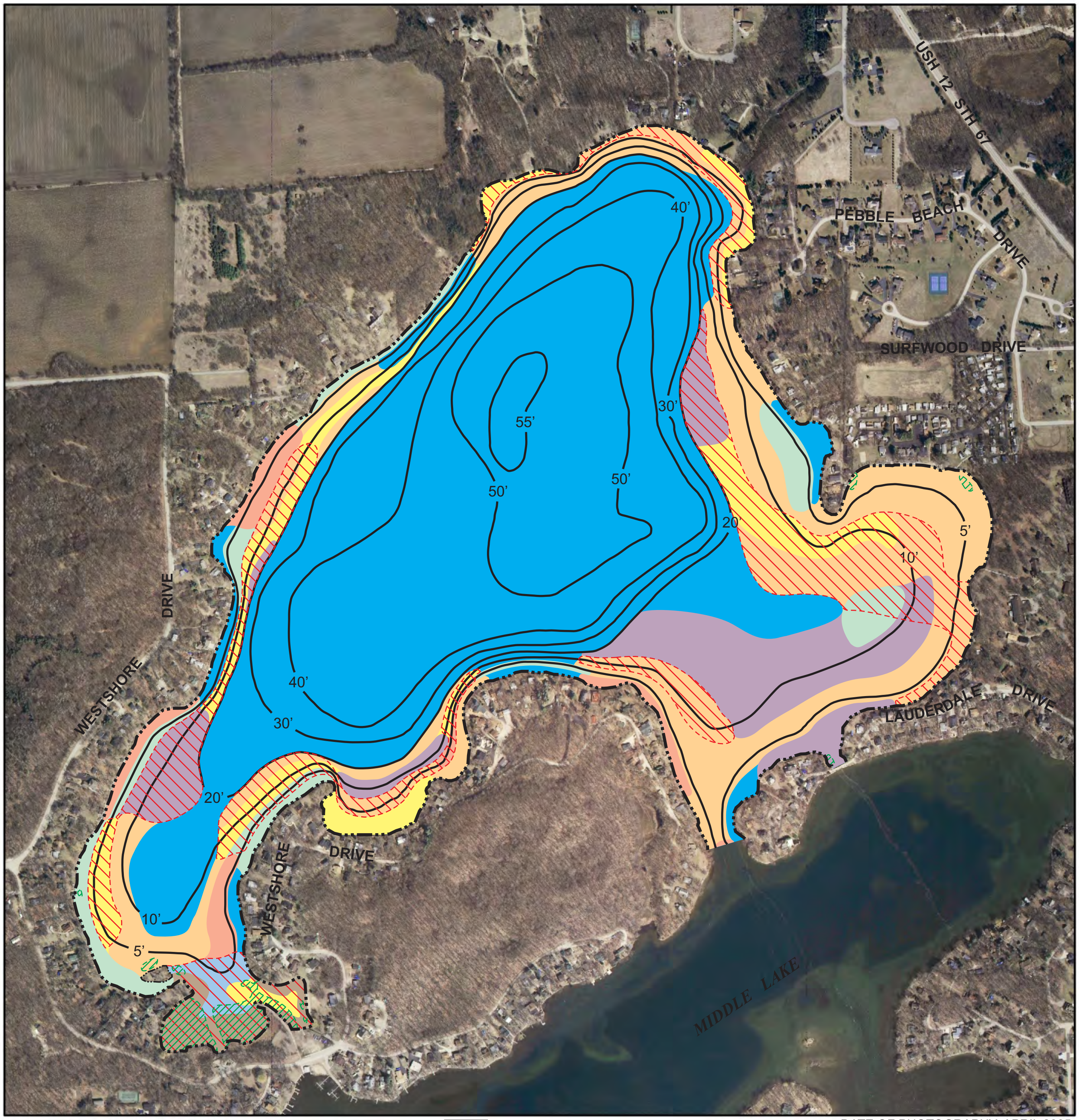
Source: SEWRPC.

During the current study, slightly fewer species of aquatic plants were found in Green Lake, as shown in Table 7. Of the 19 submergent aquatic plant species observed during 2008, the dominant species was muskgrass. Other species present in significant numbers included eel-grass, Eurasian water milfoil, and Sago pondweed (*Potamogeton pectinatus*). In Middle Lake during 2008, 18 species of submergent aquatic plant species were observed, as shown in Table 8. The dominant species in Middle Lake was muskgrass, with eel-grass and spiny naiad also present in significant numbers. This muskgrass-dominated aquatic plant community was repeated in Mill Lake during 2008, although Eurasian water milfoil was nearly as abundant as muskgrass and eel-grass was present in significant numbers, as shown in Table 9. There were some 20 submergent aquatic plant species observed in Mill Lake during the 2008 survey.

During 2008, Green Lake, Middle Lake, and Mill Lake all contained a variety of pondweeds, ranging from nine different pondweed species in Green Lake, to seven species in Middle Lake, to eight species in Mill Lake. The presence of such a diverse community of pondweed is generally considered to be indicative of a healthy lake and good habitat for fishes and aquatic life.

Map 11

AQUATIC PLANT COMMUNITY DISTRIBUTION IN GREEN LAKE: 2008



20' WATER DEPTH CONTOUR IN FEET

OPEN WATER

WATER LILIES

EURASIAN WATER MILFOIL

MUSKGRASS, WILD CELERY, BUSHY PONDWEED, AND BLADDERWORT

MUSKGRASS, WILD CELERY, AND VARIABLE PONDWEED

MUSKGRASS, WILD CELERY, VARIABLE PONDWEED, AND SAGO PONDWEED

MUSKGRASS, WILD CELERY, BUSHY PONDWEED, WATERWEED, NATIVE MILFOIL, CURLY-LEAF PONDWEED, AND COONTAIL

MUSKGRASS, WILD CELERY, BUSHY PONDWEED, WATERWEED, AND NATIVE MILFOIL

MUSKGRASS, WILD CELERY, AND SAGO PONDWEED

MUSKGRASS, WILD CELERY, BUSHY PONDWEED, WATERWEED, AND COONTAIL

DATE OF PHOTOGRAPHY: APRIL 2005

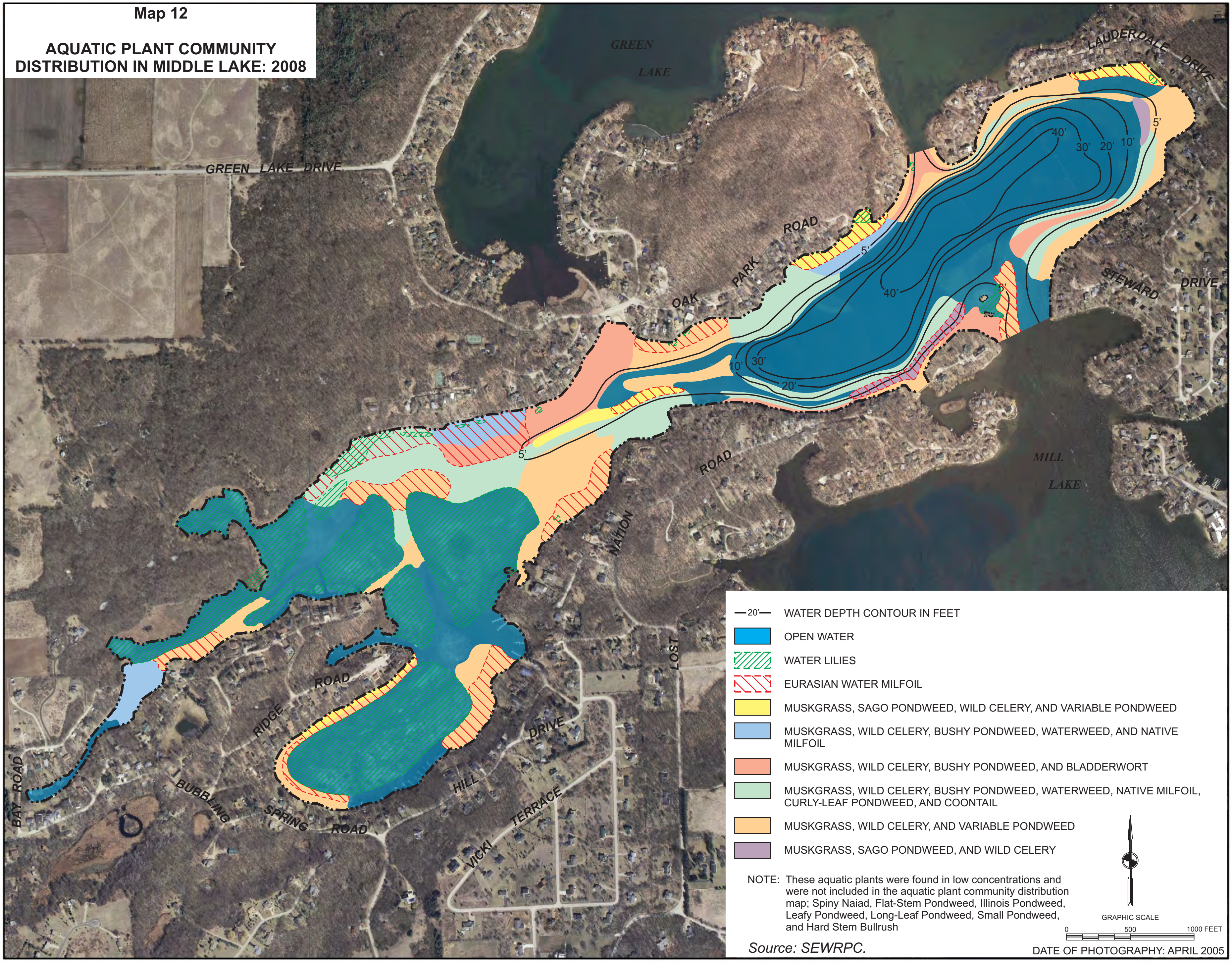
GRAPHIC SCALE
0 450 900 FEET

NOTE: These aquatic plants were found in low concentrations and were not included in the aquatic plant community distribution map; Spiny Naiad, Flat-Stem Pondweed, Water Star Grass, Leafy Pondweed, Floating-Leaf Pondweed, Clasping-Leaf Pondweed, Illinois Pondweed, and Small Pondweed.

Source: SEWRPC.

Map 12

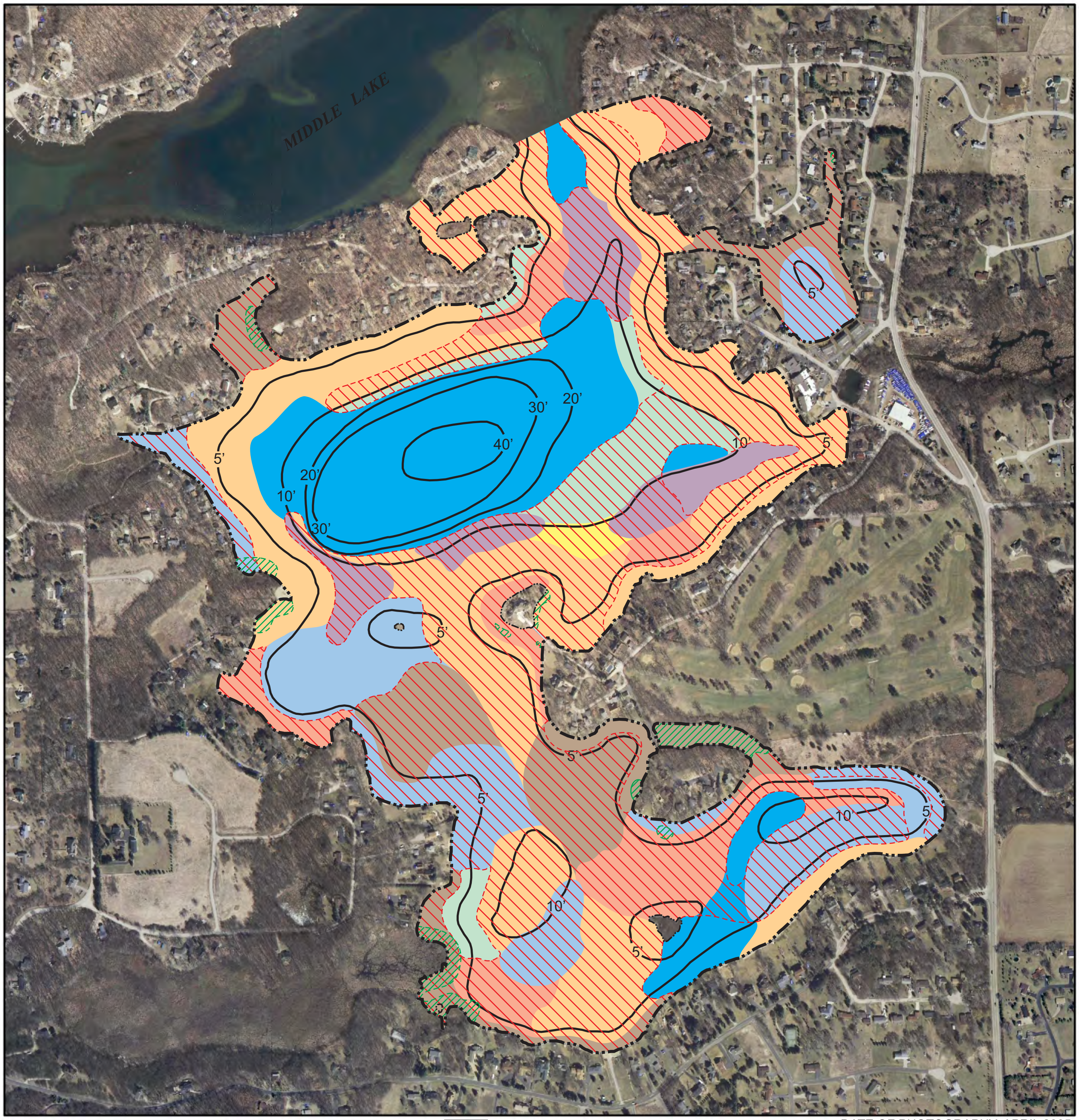
AQUATIC PLANT COMMUNITY DISTRIBUTION IN MIDDLE LAKE: 2008



Source: SEWRPC.

Map 13

AQUATIC PLANT COMMUNITY DISTRIBUTION IN MILL LAKE: 2008



DATE OF PHOTOGRAPHY: APRIL 2005

- 20' — WATER DEPTH CONTOUR IN FEET
- OPEN WATER
- WATER LILIES
- EURASIAN WATER MILFOIL
- MUSKGRASS, WILD CELERY, BUSHY PONDWEED, AND BLADDERWORT
- MUSKGRASS, WILD CELERY, AND VARIABLE PONDWEED
- MUSKGRASS, WILD CELERY, VARIABLE PONDWEED, AND SAGO PONDWEED
- MUSKGRASS, WILD CELERY, BUSHY PONDWEED, WATERWEED, NATIVE MILFOIL, CURLY-LEAF PONDWEED, AND COONTAIL
- MUSKGRASS, WILD CELERY, BUSHY PONDWEED, WATERWEED, AND NATIVE MILFOIL
- MUSKGRASS, WILD CELERY, AND SAGO PONDWEED
- MUSKGRASS, WILD CELERY, BUSHY PONDWEED, WATERWEED, AND COONTAIL

GRAPHIC SCALE

0 450 900 FEET

NOTE: These aquatic plants were found in low concentrations and were not included in the aquatic plant community distribution map; Spiny Naiad, Flat-Stem Pondweed, Water Star Grass, Leafy Pondweed, Long-Leaf Pondweed, Nitella, Small Pondweed, and Large Leaf Pondweed.

Source: SEWRPC.

The ecological significance of each plant species reported from the 2008 SEWRPC aquatic plant survey of the Lauderdale Lakes is set forth in Table 10. Representative illustrations of these aquatic plants can be found in Appendix A.

Aquatic Plant Diversity in the Lauderdale Lakes

A critical key to the ability of an ecosystem, such as a lake, to maintain its ecological integrity is through *biological diversity*. Conserving the biological diversity, or biodiversity, of an ecosystem helps not only to sustain the system, but preserves a spectrum of options for future decisions regarding the management of that system. During 2008, the aquatic plant communities in the Lauderdale Lakes demonstrated significant biodiversity: Green Lake with 19 species, Middle Lake with 18 different species, and Mill Lake with 20 different species of submersed aquatic plants. This numerical diversity is largely unchanged from that reported during the initial planning program. In Green Lake, the frequencies of occurrence of a number of the native aquatic plant species, specifically chara, elodea, and variable pondweed, have increased while the frequency of occurrence of the nonnative Eurasian water milfoil has decreased, as shown in Table 11, indicating the conduct of an effective aquatic plant management program in this Lake. In Middle Lake, similar changes in the frequencies of occurrence of the submergent aquatic plants can be noted, as shown in Table 12, with the frequencies of occurrence of Eurasian water milfoil decreasing relative to native species such as chara, elodea, and pondweed species. In Mill Lake, this shift is less pronounced, although the frequency of occurrence of the nonnative Eurasian water milfoil has also decreased relative to the frequency of occurrence of the native elodea, as shown in Table 13.

The distribution of this aquatic plant diversity, both in terms of the areal extent of the aquatic plant communities observed during 1999 and during 2008 in Mill Lake, is largely unchanged, although the aquatic plant communities identified during the latter survey would indicate greater diversity of species. Comparison of Map 10 of the initial aquatic plant management plan for the Lauderdale Lakes with Map 8 of this plan is indicative of the success achieved in managing the nonnative aquatic plant community of this Lake. The aquatic plant distribution in Middle Lake also illustrates this trend; comparison of Map 9 of the initial aquatic plant management plan for the Lauderdale Lakes with Map 9 of this plan indicates a reduction in the areal extent of the Eurasian water milfoil communities, as well as the expansion of the floating-leafed water lily communities. In Green Lake, a similar trend can be seen through comparison of Map 10 of this plan with Map 8 of the initial aquatic plant management plan; however, in Green Lake the Eurasian water milfoil community appears to have spread further along the southern shoreline of the Lake.

Aquatic Plant Species of Special Significance

Native Aquatic Plants

There were two native plant species observed in the 2008 and earlier surveys of the Lakes that are considered to be of exceptionally high-ecological value, muskgrass and large-leaf pondweed (*Potamogeton amplifolius*). Muskgrass is a favorite waterfowl food source and, as an effective bottom sediment stabilizer, benefits water quality. Its prevalence in the plant communities of a lake may be a significant contributing factor to establishing and maintaining good water quality of a lake and, consequently, in establishing water quality conditions that assist native plant species to successfully compete with nonnative species. Large-leaf pondweed, also known as musky weed or bass weed, is another native species of high-ecological value in natural communities. This plant was observed in Mill Lake during the 2008 and earlier surveys. Large-leaf pondweed, as anglers well know, has a reputation as a highly valuable contributor to fish habitat.

Nonnative Species

During the 2008 and earlier aquatic plant surveys of the Lauderdale Lakes, several nonnative aquatic plant species of special significance were observed. Two of these species, Eurasian water milfoil and curly-leaf pondweed (*Potamogeton crispus*), are considered to be detrimental to the ecological health of the Lakes and are declared nuisance species identified in Chapter NR 109 of the *Wisconsin Administrative Code*.

Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one known to be exotic or nonnative. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can inhibit its

Table 10

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN THE LAUDERDALE LAKES: 2008

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish and supports insects; valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass; stabilizes bottom sediments; has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed)	Provides shelter and support for insects which are valuable as fish food
Lemna spp. (duckweed)	Small duckweed is prized for its nutritional value as food for waterfowl; extensive rafts of duckweed can provide shelter for fish and even inhibit mosquito reproduction
Myriophyllum sibiricum (northern water milfoil)	Provides food for waterfowl; insect habitat and foraging opportunities for fish
Myriophyllum spicatum (Eurasian water milfoil)	None known; nonnative
Najas flexilis (bushy pondweed)	Stems, foliage, and seeds important wildfowl food; produces good food and shelter for fish
Najas marina (spiny naiad)	Valued as a food source for a wide variety of waterfowl; also important to muskrats and marsh birds as a food source
Nitella spp. (stonewort)	Valued as an indirect food source for waterfowl, as it harbors a myriad of insects and invertebrates that serve as food for ducks and geese
Nuphar advena (yellow water lily)	Seeds provide food for waterfowl; leaves, stems, and flowers are food for deer; rhizomes are food source for muskrats and beaver; leaves provide shelter and shade for fish and habitat for invertebrates
Nymphaea odorata (white water lily)	Seeds provide food for waterfowl; leaves, stems, and flowers are food for deer; rhizomes are food source for muskrats and beaver; leaves provide shelter and shade for fish and habitat for invertebrates
Potamogeton amplifolius (large-leaf pondweed)	Offers shade, shelter, and foraging for fish; valuable food for waterfowl
Potamogeton crispus (curly-leaf pondweed)	Nonnative
Potamogeton foliosis (leafy pondweed)	Provides food for geese and ducks; food for muskrat, beaver, and deer; good surface area for insects; cover for juvenile fish
Potamogeton gramineus (variable pondweed)	Provides habitat for fish and food for waterfowl, muskrat, beaver, and deer
Potamogeton illinoensis (Illinois pondweed)	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton natans (floating-leaf pondweed)	Provides food for waterfowl, muskrat, beaver, and deer; good fish habitat
Potamogeton nodosus (long-leaf pondweed)	Fruit is food source for waterfowl; habitat and foraging opportunities for fish
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton pusillus (small pondweed)	Provides food for ducks, geese, muskrat, beaver, and deer; provides food and shelter for fish

Table 10 (continued)

Aquatic Plant Species Present	Ecological Significance
Potamogeton richardsonii (clasping-leaf pondweed)	Provides food, shelter, and shade for some fish; food for some wildfowl; and food for muskrat; provides shelter and support for insects, which are valuable as fish food
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks
Scirpus acutus (hardstem bulrush)	Provides habitat and shelter for fish; food for waterfowl; nesting materials for marsh birds
Sparganium minima (small bur reed)	Helps anchor bottom sediment; provides nesting sites for waterfowl and birds; food source for muskrat and deer
Utricularia spp. (bladderwort)	Provides cover and foraging for fish
Vallisneria americana (wild celery/eel-grass)	Provides good shade and shelter; supports insects; valuable fish food
Zosterella dubia (water stargrass)	Provides food and shelter for fish; locally important food for waterfowl

NOTE: Information obtained from *A Manual of Aquatic Plants* by Norman C. Fassett, University of Wisconsin Press; *Guide to Wisconsin Aquatic Plants*, Wisconsin Department of Natural Resources; and, *Through the Looking Glass...A Field Guide to Aquatic Plants*, Wisconsin Lakes Partnership, University of Wisconsin-Extension.

Source: SEWRPC.

Table 11

FREQUENCY OF OCCURRENCE[a] OF SUBMERGED AQUATIC PLANT SPECIES OBSERVED IN THE LAUDERDALE LAKES—GREEN LAKE: 1999 AND 2008

Aquatic Plant Species	1999	2008
Ceratophyllum demersum (coontail)	4.2	6.6
Chara vulgaris (muskgrass)	47.4	73.6
Elodea canadensis (waterweed)	4.2	10.4
Myriophyllum sibiricum (northern water milfoil)	1.1	7.5
Myriophyllum spicatum (Eurasian water milfoil)	58.9	34.9
Najas flexilis (bushy pondweed)	41.1	19.8
Najas marina (spiny naiad)	51.6	8.5
Potamogeton crispus (curly-leaf pondweed)	1.1	6.6
Potamogeton foliosis (leafy pondweed)	3.2	2.8
Potamogeton gramineus (variable pondweed)	- -	20.8
Potamogeton illinoensis (Illinois pondweed)	3.2	2.8
Potamogeton natans (floating-leaf pondweed)	- -	2.8
Potamogeton pectinatus (Sago pondweed)	32.6	30.2
Potamogeton pusillus (small pondweed)	- -	0.9
Potamogeton richardsonii (clasping-leaf pondweed)	- -	0.9
Potamogeton spp.	24.2	- -
Potamogeton zosteriformis (flat-stem pondweed)	8.4	4.7
Utricularia spp. (bladderwort)	- -	3.8
Vallisneria americana (wild celery/eel-grass)	51.6	50.0
Zosterella dubia (water stargrass)	7.4	2.8

NOTE: Sampling occurred at 106 sampling sites along 28 transects in 2008 and at 95 sampling sites in 1999.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

Source: SEWRPC.

Table 12

FREQUENCY OF OCCURRENCE[a] OF SUBMERGED AQUATIC PLANT SPECIES OBSERVED IN THE LAUDERDALE LAKES—MIDDLE LAKE: 1999 AND 2008

Aquatic Plant Species	1999	2008
Ceratophyllum demersum (coontail)	1.9	3.6
Chara vulgaris (muskgrass)	61.1	66.3
Elodea canadensis (waterweed)	3.7	9.6
Myriophyllum sibiricum (northern water milfoil)	9.3	15.7
Myriophyllum spicatum (Eurasian water milfoil)	29.6	18.1
Najas flexilis (bushy pondweed)	42.6	19.3
Najas marina (spiny naiad)	55.6	22.9
Potamogeton crispus (curly-leaf pondweed)	5.6	8.4
Potamogeton foliosis (leafy pondweed)	- -	2.4
Potamogeton gramineus (variable pondweed)	- -	13.3
Potamogeton illinoensis (Illinois pondweed)	11.1	3.6
Potamogeton natans (floating-leaf pondweed)	3.7	- -
Potamogeton nodosus (long-leaf pondweed)	- -	1.2
Potamogeton pectinatus (Sago pondweed)	18.5	9.6
Potamogeton spp.	13.0	- -
Potamogeton zosteriformis (flat-stem pondweed)	11.1	6.0
Utricularia spp. (bladderwort)	18.5	15.7
Vallisneria americana (wild celery/eel-grass)	40.7	32.5
Zosterella dubia (water stargrass)	1.9	- -

NOTE: Sampling occurred at 106 sampling sites along 28 transects in 2008 and at 95 sampling sites in 1999.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

Source: SEWRPC.

growth, which can be explosive under suitable conditions. The plant exhibits this characteristic growth pattern in lakes with organic-rich sediments, or where the lake bottom has been disturbed. It frequently has been reported as a colonizing species following dredging, unless its growth is anticipated and controlled. Eurasian water milfoil populations can displace native plant species and interfere with the aesthetic and recreational use of the waterbodies. This plant has been known to cause severe recreational use problems in lakes within the Southeastern Wisconsin Region.

Eurasian water milfoil reproduces by the rooting of plant fragments. Consequently, some recreational uses of lakes can result in the expansion of Eurasian water milfoil communities, especially when boat propellers fragment Eurasian water milfoil plants. These fragments, as well as fragments that occur for other reasons, such as wind-induced turbulence or fragmentation of the plant by fishes, are able to generate new root systems, allowing the plant to colonize new sites. The fragments also can cling to boats, trailers, motors, and/or bait buckets, and can stay alive for weeks contributing to the transfer of milfoil to other lakes. For this reason, it is very important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies.

Curly-leaf pondweed is a plant that thrives in cool water and exhibits a peculiar split-season growth cycle that helps give it a competitive advantage over native plants and makes management of this species difficult. In late summer, the plant produces specialized over-wintering structures, or "turions." In late summer, the main body of the plant dies off and drops to the bottom where the turions lie dormant until the cooler fall water temperatures trigger the turions to germinate. Over the winter, the turions produce winter foliage that thrives under the ice. In

Table 13

FREQUENCY OF OCCURRENCE[a] OF SUBMERGED AQUATIC PLANT SPECIES OBSERVED IN THE LAUDERDALE LAKES—MILL LAKE: 1999 AND 2008

Aquatic Plant Species	1999	2008
Ceratophyllum demersum (coontail)	35.7	13.9
Chara vulgaris (muskgrass)	70.0	53.5
Elodea canadensis (waterweed)	11.4	23.8
Myriophyllum sibiricum (northern water milfoil)	1.4	14.9
Myriophyllum spicatum (Eurasian water milfoil)	87.1	47.5
Najas flexilis (bushy pondweed)	47.1	3.7
Najas marina (spiny naiad)	32.9	2.0
Nitella spp. (stonewort)	- -	4.0
Potamogeton amplifolius	1.4	1.0
Potamogeton crispus (curly-leaf pondweed)	11.4	4.0
Potamogeton foliosis (leafy pondweed)	4.3	3.0
Potamogeton gramineus (variable pondweed)	- -	8.9
Potamogeton illinoensis (Illinois pondweed)	4.3	- -
Potamogeton natans (floating-leaf pondweed)	5.7	- -
Potamogeton nodosus (long-leaf pondweed)	- -	1.0
Potamogeton pectinatus (Sago pondweed)	38.6	17.8
Potamogeton pusillus (small pondweed)	- -	2.0
Potamogeton spp.	17.1	- -
Potamogeton zosteriformis (flat-stem pondweed)	14.3	5.0
Utricularia spp. (bladderwort)	17.1	13.9
Vallisneria americana (wild celery/eel-grass)	55.7	40.6
Zosterella dubia (water stargrass)	1.4	5.0

NOTE: Sampling occurred at 106 sampling sites along 28 transects in 2008 and at 95 sampling sites in 1999.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

Source: SEWRPC.

spring, when water temperatures begin to rise again, the plant has a head start on the growth of native plants and quickly grows to full size, producing flowers and fruit earlier than its native competitors. Because it can grow in more turbid waters than many native plants, protecting or improving water quality is an effective method of control of this species; clearer waters in a Lake can help native plants compete more effectively with curly-leaf pondweed.

Changes in the Lauderdale Lakes Aquatic Plant Communities

Aquatic plant communities do undergo cyclical and periodic changes, which reflect, in part, changing climatic conditions on an interannual scale, as well as, in part, the evolution of the aquatic plant community in response to changing hydroclimate conditions in the Lakes—these latter factors include changes in long-term nutrient loading, sedimentation rates, and recreational use patterns, for example. Interannual changes occur over a period of three to seven years and may be temporary. Evolutionary changes occur over a decadal period or longer, and are longer-lasting. Also, some species, such as the pondweeds, exhibit distinct seasonality, with individual species having well-defined growing periods that reflect water temperature, insolation, and other factors. It is not unusual to see a succession of pondweeds occurring in a lake during the course of the spring, summer, and autumn.

Changes in the Eurasian water milfoil population of a lake, in contrast, may reflect the results of aquatic management practices and/or be a reflection of the periodicity naturally experienced by this species. This periodicity has been observed throughout southeastern Wisconsin, and potentially reflects the influences of a combination of stressors. These stressors include biological factors, such as the activities of naturally occurring Eurasian water milfoil weevils, as well as climatic and limnological factors, such as insolation, water temperature, and lake circulation patterns.

Tables 11 through 13 present data comparing the frequencies of occurrence of aquatic plant species in each of the Lauderdale Lakes in 1999 with those from the same lakes reported during 2008. These data represent a 10-year period of record, although the two surveys conducted during this period may be insufficient to distinguish interannual changes from longer-term trends. For this reason, more frequent surveys at approximately three- to five-year intervals, based upon a consistent methodology, are generally suggested to statistically discern interannual variability from longer-term changes in species abundance or community composition. Use of the modified Jesson and Lound transect method, as promulgated by the WDNR, in successive aquatic plant surveys at this interval, would allow the statistical evaluation of changes in the aquatic plant community within the Lakes.[30]

Past and Present Aquatic Plant Management Practices

An aquatic plant management program has been carried out on the Lauderdale Lakes in a documented manner since 1950. Records of aquatic plant management efforts were first maintained by the WDNR beginning in 1950. Prior to 1950, aquatic plant management interventions are likely, but were not recorded. Currently, all forms of aquatic plant management are subject to permitting by the WDNR pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*.

Since 1950, and prior to the development of the first aquatic plant management plan for the Lakes,[31] the aquatic plant management activities in the Lauderdale Lakes could be characterized as primarily a chemical control program designed to minimize nuisance growths of aquatic macrophytes and algae. A cumulative summary of the chemical applications to the Lauderdale Lakes for a range of commonly used herbicides is shown in Table 14 for the period between 1950 and 1996. Cumulative totals for each of the major chemical herbicides applied to the individual lakes in the Lauderdale chain for the period from 1950 through 1996 are set forth in Table 15. As shown in Tables 14 and 15, 19,306 pounds of sodium arsenite were applied to the Lauderdale Lakes between 1950 and 1969.

Sodium arsenite was typically sprayed onto the surface of a lake within an area of up to 200 feet from the shoreline. Treatments typically occurred between mid-June and mid-July. The amount of sodium arsenite used was calculated to result in a concentration of about 10 milligrams per liter (mg/l) of sodium arsenite in the treated lake water, or about 5.0 mg/l of elemental arsenic. The sodium arsenite typically remained in the water column for less than 120 days. Although the arsenic residue was naturally converted from a highly toxic form to a less toxic and less biologically active form, much of the arsenic residue was deposited in the lake sediments.

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

---

[30]*Memo from Stan Nichols, to J. Bode, J. Leverence, S. Borman, S. Engel, D., Helsel, entitled "Analysis of Macrophyte Data for Ambient Lakes-Dutch Hollow and Redstone Lakes example," Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, February 4, 1994.*

[31]*Integrated Lakes Management,* Lauderdale Lakes Aquatic Plant Distribution, *July 1989.*

Table 14

TOTAL CHEMICAL CONTROLS ON THE LAUDERDALE CHAIN OF LAKES: 1950-2008

		Algae Control			Macrophyte Control					
Year	Total Acres Treated	Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine Plus (gallons)	Sodium Arsenite (pounds)	2,4-D (gallons)	2,4,5-TP (gallons)	2,4,5-T (gallons)	Diquat (gallons)	Endothall/ Aquathol (gallons)
1950-1969	- -	15,181.0	- -	- -	20,566	80.0	92.6	52.0	78.0	9.0 + 48.4 lbs.
1970	9.0	- -	- -	- -	- -	- -	- -	- -	15.0	10.0 + 300.0 lbs.
1971	3.4	- -	- -	- -	- -	- -	- -	- -	- -	67.0
1972	- -	- -	- -	- -	- -	- -	- -	- -	6.0	41.0
1973	- -	- -	- -	- -	- -	- -	- -	- -	18.0	8.0
1974	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1975	- -	- -	- -	- -	- -	4.0	- -	- -	- -	8.0
1976	N/A	- -	- -	- -	- -	- -	- -	- -	- -	- -
1977	- -	- -	- -	- -	- -	- -	- -	- -	- -	22.0
1978	N/A	- -	- -	5.0	- -	- -	- -	- -	- -	- -
1979	- -	- -	- -	5.0	- -	- -	- -	- -	2.0	10.0 + 100.0 lbs.
1980	- -	100.0	- -	- -	- -	48.0	- -	- -	4.0	9.0 + 50.0 lbs.
1981	- -	8.0	- -	- -	- -	- -	- -	- -	5.5	12.0 + 160.0 lbs.
1982	- -	30.0	- -	- -	- -	- -	- -	- -	4.0	28.0
1983	N/A	- -	- -	- -	- -	- -	- -	- -	- -	- -
1984	3.8	36.0	- -	- -	- -	13.5	- -	- -	1.0	10.0
1985	- -	- -	- -	- -	- -	13.0	- -	- -	1.0	14.0
1986	8.2	3.0	- -	- -	- -	41.0	- -	- -	1.5	61.7 lbs.
1987	14.4	0.5	- -	- -	- -	21.0	- -	- -	0.5	3.5
1988	12.3	- -	- -	- -	- -	22.0	- -	- -	- -	1.5
1989	N/A	- -	- -	- -	- -	- -	- -	- -	- -	- -
1990	6.0	- -	- -	- -	- -	14.0	- -	- -	- -	- -
1991	N/A	- -	- -	- -	- -	6.0	- -	- -	- -	- -
1992	0.9	- -	- -	- -	- -	2.5	- -	- -	- -	- -
1993-2001	N/A	- -	- -	- -	- -	- -	- -	- -	- -	- -
2002[a]	1.3	2.7 gal.	- -	- -	- -	- -	- -	- -	2.7	2.7 + 10.0 lbs.
2003	1.0	1.3 gal.	- -	- -	- -	- -	- -	- -	1.3	1.0
2004	3.4	- -	- -	- -	- -	2.5 + 138 lbs.	- -	- -	- -	- -
2005	0.4	- -	- -	- -	- -	- -	- -	- -	0.8	1.0
2006	0.3	1.0 gal.	- -	- -	- -	- -	- -	- -	0.5	1.7
2007	0.9	2.0 gal.	- -	- -	- -	- -	- -	- -	1.5	2.5
2008	0.3	2.0 gal.	- -	- -	- -	- -	- -	- -	0.6	2.5
Total	- -	15,358.5 + 9.0 gal.	- -	10.0	20,566	267.5 + 138 lbs.	92.6	52.0	143.9	264.4 + 730.1 lbs.

NOTE: N/A = Records are not available or no chemical applications were reported as made during this year.

[a]*In 2002, 0.7 gallon of Aquashade was applied.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

In recent years, the aquatic plant management program conducted on the Lauderdale Lakes has been modified to include an emphasis on aquatic plant harvesting as the major element of the aquatic plant management strategy. Applications of aquatic herbicides have been limited to primarily individual applications around piers and docks, and focused on the treatment of nuisance growths of Eurasian water milfoil and curly-leaf pondweed. Contrasting Table 14 with Table 15 shows the magnitude of this shift in emphasis from the use of chemical control measures to harvesting of aquatic plants. During the period since 1996, herbicide use has been greatly reduced, with application of those herbicides—2,4-D, diquat, and endothal—having effectiveness in reducing growths of the nonnative aquatic plant species found within the Lauderdale Lakes, accounting for the majority of the applications of aquatic chemicals, the balance being accounted for through the application of copper compounds to control algal growths in the Lakes. Table 16 illustrates this shift in aquatic plant management practices, and documents the mass of aquatic vegetation removed from the Lakes since 2002 by means of mechanical harvesting.

Table 15

CHEMICAL CONTROL OF AQUATIC PLANTS IN INDIVIDUAL LAUDERDALE LAKES: 1950-1996

	Algae Control			Macrophyte Control				
Lake	Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine Plus (gallons)	Sodium Arsenite (pounds)	2,4-D (gallons)	Diquat (gallons)	Silvex (gallons)	Endothall/ Aquathol (gallons)
Green Lake	2,506	- -	- -	1,260	2.0	6.0	- -	20.0
Middle Lake	2,574	- -	5.0	- -	30.5	9.5	- -	55.0 + 20.0 lbs.
Mill Lake	2,525	- -	- -	- -	4.0	8.0	- -	39.0 + 305.0 lbs.
Lauderdale Lakes (unspecified)	7,754	- -	5.0	19,306	228.5	113.0	92.6	139.0 + 395.1 lbs.
Total	15,359	- -	10.0	20,566	265.0	136.5	92.6	253 + 720.1 lbs.

NOTE: Data for individual annual chemical application amounts, by lake, are presented in Tables 10, 11 and 12 of SEWRPC Memorandum Report No. 143.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 16

AQUATIC PLANT MATERIAL MECHANICALLY HARVESTED IN LAUDERDALE LAKES

Year	Acres Harvested	Tons of Plant Material Removed	Primary Plant Types Harvested
2002	200	620	Eurasian water milfoil, native milfoil, *vallisneria*, and *chara*
2003	200	387	Eurasian water milfoil, native milfoil, *vallisneria*, and *chara*
2004	200	401	Eurasian water milfoil, native milfoil, *vallisneria*, and *chara*
2005	200	347	Eurasian water milfoil, native milfoil, *vallisneria*, and *chara*
2006	200	406	Eurasian water milfoil, native milfoil, *vallisneria*, and *chara*
2007	200	362	Eurasian water milfoil, native milfoil, *vallisneria*, and *chara*
2008	200	352	Eurasian water milfoil, native milfoil, *vallisneria*, and *chara*

Source: Wisconsin Department of Natural Resources and SEWRPC.

FISHERIES

Fish Community Composition

At the time of the 1969 WDNR report,[32] the Lauderdale Lakes were considered to have one of the best fish populations in Walworth County. Based on a 1966 fisheries survey, panfish were noted to be abundant, with largemouth bass being the principal game species present in the Lakes. Northern pike were considered to be of

[32]*Wisconsin Department of Natural Resources Publication Lake Use Report No. FX-17, 18 and 20,* op. cit.

secondary importance, and walleye, although able to reproduce naturally, were found to be present only as a small population. Spawning areas for largemouth bass were widespread throughout the Lauderdale Lakes system, while walleye spawning areas were assumed to be confined mostly to the gravelly east shores of the deeper basins. Areas suitable for northern pike spawning were found in the large bays on the western end of Middle Lake and the southern end of Mill Lake. Although present, roughfish—such as carp, longnose gar, and dogfish—were not considered to be a problem.

WDNR fish surveys conducted in 1978, 1998 and 1999,[33] summarized in the previous SEWRPC report,[34] noted 19 species of fishes. Bluegill being considered to be very abundant, largemouth bass abundant, and rock bass, pumpkinseed, and black crappie common. Walleye and northern pike were noted to be present within the system.

During the spring of 2008, the WDNR conducted additional fisheries surveys of the Lauderdale Lakes.[35] The surveys incorporated both fyke netting and electrofishing. These surveys indicated that the Lauderdale Lakes support naturally reproducing gamefish populations of largemouth bass and northern pike; populations of smallmouth bass and walleye are maintained primarily through stocking. The Lakes also supported naturally reproducing populations of numerous panfish species, including bluegill, yellow perch, rock bass, pumpkinseed, and black crappie.[36]

The 2008 netting survey documented largemouth bass as the most abundant gamefish, comprising over 69 percent of the sample. Very low numbers of legal-sized largemouth bass were recorded, however, probably due to harvesting pressure from anglers. The second most abundant gamefish was walleye, comprising about 15 percent of the sample and reflecting an excellent size structure with over 82 percent of the walleye being of legal size, compared to only about 3.5 percent of the bass population being of legal size. Northern pike was the next most abundant gamefish, comprising about 15 percent of the sample. Nearly 30 percent of the northern pike population was of legal size and the data seemed to indicate a balanced population.

The 2008 electrofishing survey also was dominated by largemouth bass, although the majority of fish captured during this survey also were less than the legal length.[37] Smallmouth bass of legal size comprised about 10 percent of the smallmouth bass population noted in this survey, and the overall size distribution of smallmouth bass seemed to indicate a population in balance. Panfish surveyed included bluegill, rock bass, yellow perch, pumpkinseed, and black crappie; the dominant panfish were bluegill, with more than half of those sampled being considered quality fish of seven inches or more in length.

The diverse fish population of the Lauderdale Lakes also contains the lake chubsucker (*Erimyzon sucetta*), a State Species of Special Concern. Special Concern species are “those in which reduced abundance or distribution is suspected, but not yet proven.” The main purpose of this category is to focus attention on certain species before

---

[33]*D.E. Welch and R. Dauffenbach,* Fisheries Survey Report for the Lauderdale Lakes (WBIC 0755500), Walworth County, *Wisconsin Department of Natural Resources, 2000.*

[34]*SEWRPC Memorandum Report No. 143,* op. cit.

[35]*D.E. Welch, personal communication.*

[36]Ibid.

[37]Ibid.

Table 17

FISH STOCKED INTO LAUDERDALE LAKES

Year	Species Stocked	Number	Average Fish Length (inches)
2002	Smallmouth bass	9,674	3.25
2003	Smallmouth bass	4,950	3.30
2004	Smallmouth bass	13,940	4.00

Source: Wisconsin Department of Natural Resources and SEWRPC.

they become threatened or endangered."[38] The lake chubsucker is a preferred food for largemouth bass. Habitat necessary for supporting this fish is found in Middle Lake, Mill Lake, and in the upper reaches of Honey Creek immediately downstream of the Lauderdale Lakes outlet.

Fisheries Management

Stocking of the Lauderdale Lakes with largemouth bass, bluegill, and several other species, was fairly regular during the period from 1937 through 1946. After 1946, annual stocking of walleye and sometimes northern pike was carried out between 1948 and 1965. This became intermittent between 1973 through 1998. Since 2002, smallmouth bass have been stocked into the Lauderdale Lakes, as shown in Table 17.

WILDLIFE

With respect to wildlife, and given the urbanization of land uses present around the shorelands of the Lakes, most of the wildlife remaining are urban-tolerant species. Smaller animals and waterfowl that would be expected to inhabit the lakeshore areas include muskrats, beaver, grey and fox squirrels, and cottontail rabbits, which are likely to be the most abundant and widely distributed fur-bearing mammals in the immediate riparian areas, and larger mammals, such as the whitetail deer, which are likely to be confined to the larger wooded areas and the open meadows found within the tributary area to the Lakes. The remaining undeveloped areas provide the best-quality cover for many wildlife species.

The Lauderdale Lakes tributary area supports a significant population of waterfowl including mallards, wood duck, and blue-winged teal. During the migration seasons a greater variety of waterfowl may be present and in greater numbers.

Amphibians and reptiles are vital components of the Lauderdale Lakes ecosystem, and include frogs, toads, and salamanders, and turtles and snakes, respectively. About 14 species of amphibians and 16 species of reptiles would normally be expected to be present in the Lauderdale Lakes area.

WDNR-DESIGNATED SENSITIVE AREAS

Within or immediately adjacent to bodies of water, the WDNR identifies sites that have special importance biologically, historically, geologically, ecologically, or even archaeologically. Such areas are defined as "areas of aquatic vegetation identified by the Department as offering critical or unique fish and wildlife habitat, including seasonal or life-stage requirements, or offering water quality or erosion control benefits of the body of water" and, after comprehensive examination and study is completed by WDNR staff from many different disciplines and

---

[38]*Wisconsin Department of Natural Resources,* Lauderdale Lakes (Walworth County, Wisconsin) Integrated Sensitive Area Report; *this report appears as* Appendix B *attached hereto.*

fields of study, are identified as Sensitive Areas pursuant to Chapter NR 107 of the *Wisconsin Administrative Code*. Chapter NR 107 authorizes the Department of Natural Resources to restrict chemical treatment of aquatic plants in Sensitive Areas on lakes and requires that alternatives to chemical treatment of aquatic plants be evaluated.

As reported in the previous SEWRPC plan, the WDNR surveyed the Lauderdale Lakes in 1990 to evaluate potential sensitive areas, identifying and designating five such areas. In 2004, the WDNR surveyed two additional sensitive sites in the Lauderdale Lakes area; the draft 2004 WDNR report and management recommendations for these seven areas in the Lauderdale Lakes basin are appended hereto as Appendix B. It is of note that Eurasian water milfoil was present in all but one of these sensitive areas.

SEWRPC-IDENTIFIED CRITICAL SPECIES HABITAT

SEWRPC has identified natural areas and critical species habitat areas within the Southeastern Wisconsin Region.[39] In the tributary area to the Lauderdale Lakes, the lakeshores, located within the environmental corridor network delineated by the Regional Planning Commission as part of its regional land use planning duties, should be candidates for immediate protection through proper zoning or through public ownership. Of the areas not already publicly owned, the remaining areas of natural shoreline (natural shoreline constitutes about 30 percent of the shoreline) and riparian wetland areas are perhaps the most sensitive areas in need of greatest protection. In this regard, two natural areas that contain intact native plant and animal communities of local significance have been identified, and are shown on Map 14. These natural areas, designated as NA-3 areas of local significance, include:

1. <u>Island Woods</u>: A privately owned, 46-acre, good-quality dry-mesic woods on rough terrain located within a primary environmental corridor on the peninsula separating Green and Middle Lakes; and,

2. <u>Baywood Road Sedge Meadow</u>: a privately owned 29-acre, good-quality sedge meadow and shallow marsh complex containing a strong influx of calciphilic species located within the primary environmental corridor in the western near-shore area at the southern end of Mill Lake.

In addition to the abovelisted sites, the tributary area to the Lauderdale Lakes contains several other sites, as well as several species, of special significance. The Lauderdale Lakes Woods contain two plant species of concern: *Aster furcatus*, or the forked aster which produces white blossoms (unusual for asters) and is found in less than 50 known locations across six Midwestern states—about a dozen of which are located in southeastern Wisconsin, and *Eupatorium sessilifolium*, or woodland boneset, an uncommon savannah species more often found in southwestern Wisconsin. Green Lake and Middle Lake both have a rating of AQ-3, designating them as aquatic areas of local significance due to their good water quality, fish diversity and natural habitat. Mill Lake has received a rating of AQ-2 as an aquatic area of countywide or regional significance, due, primarily, to its good overall fishery and habitat supporting “special concern” species lake chubsucker, as described above. Honey Creek, in its upper reaches, is also rated AQ-3 due to its habitat supporting the lake chubsucker.

RECREATIONAL USES AND FACILITIES

As set forth in the regional water quality management plan, the Lauderdale Lakes are multi-purpose waterbodies serving a variety of recreational uses in addition to being a year-round visual amenity.[40] Active recreational uses

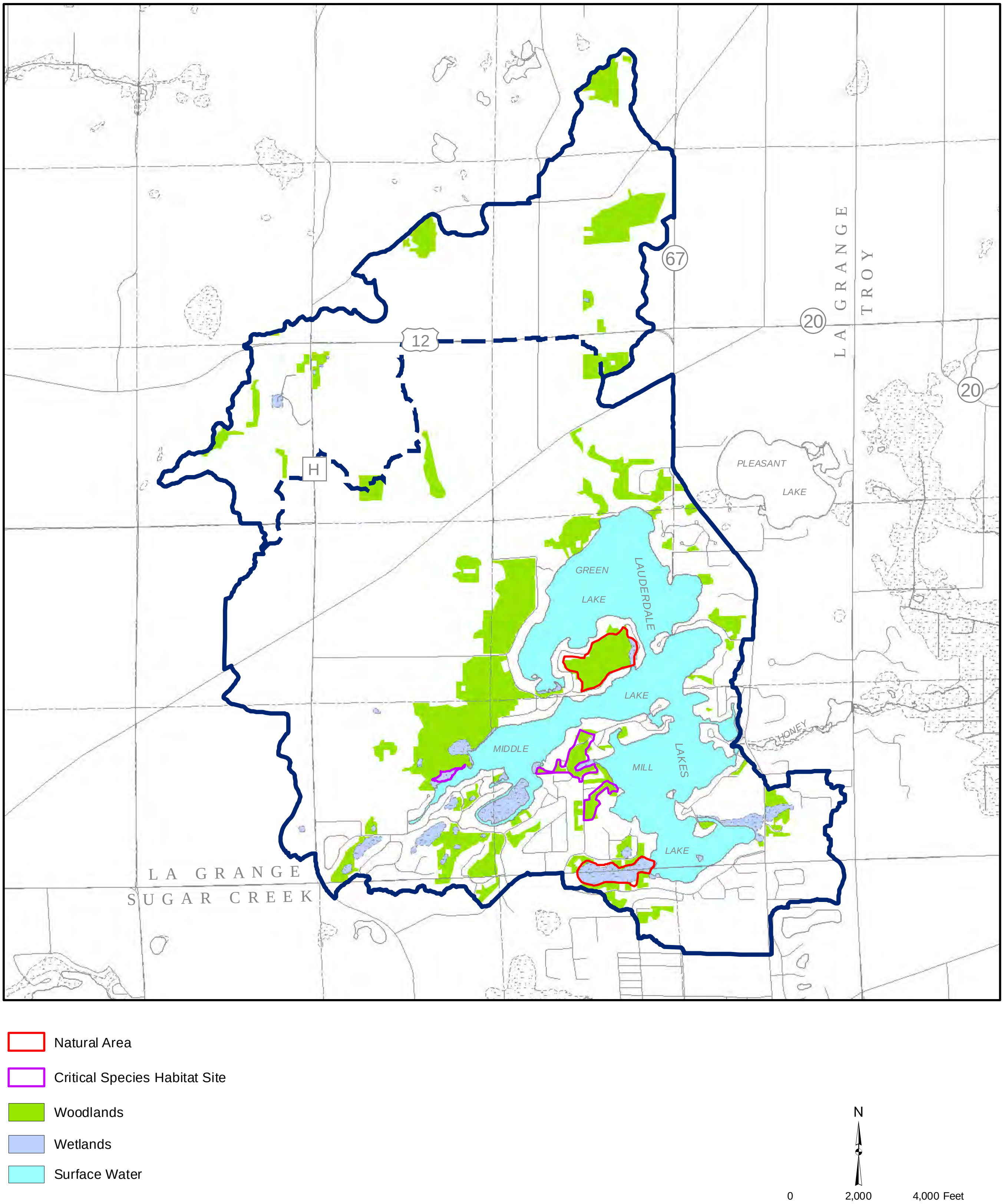
---

[39]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997.*

[40]*SEWRPC Planning Report No. 30,* op.cit. *See also SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

Map 14

WETLANDS, WOODLANDS, AND NATURAL AREAS WITHIN THE LAUDERDALE LAKES TRIBUTARY AREA



Source: SEWRPC.

include boating, waterskiing, swimming, and fishing during the summer months; and cross-country skiing, snowmobiling, and ice-fishing during the winter; popular passive recreational uses include walking, bird watching, and picnicking. The Lakes experience intense recreational boating use during open-water periods, especially on weekends. In an intensive statewide survey of boating pressure on Wisconsin's lakes and rivers conducted in 1989 by the WDNR, the Lauderdale Lakes were reported to be eighth most-visited site in the then-WDNR Southeast District.[41] Public access to the Lakes is provided through three sites located on the western shores of Green and Middle Lakes and on the eastern shore of Middle Lake. The Lakes are deemed to have adequate public access as defined in Chapter NR 1 of the *Wisconsin Administrative Code,* which establishes quantitative standards for determining the adequacy of public recreation boating access, setting maximum and minimum standards based upon available parking facilities for car-top and car-trailer units.

Surveys of watercraft docked or moored on the Lauderdale Lakes were conducted by SEWRPC staff in 1999, as part of the initial planning project, and again in 2008 for the current study. The types of watercraft found on the Lakes included fishing boats, pontoon boats, paddleboats, canoes, sailboats, rowboats, and personal watercraft ("jetskis"®).

During the current study, a total of 2,151 watercraft were observed either moored in the water or stored on land in the shoreland areas around the Lakes, as shown in Table 18. Of these watercraft, 635 were observed to be moored or stored around Green Lake, 728 around Middle Lake, and 788 around Mill Lake. This total represents an increase of about 15 percent over the total number of watercraft inventoried during 1999. Comparison of the categories of watercraft observed during the two surveys showed the rankings of the three most numerous types of watercraft—in order: powerboats, pontoon boats, personal watercraft—to be the same in 2008 as it was in 1999, although some differences were observed in the other categories, most notably a decrease in the proportion of fishing boats between 1999 and 2008.

The types of watercraft docked or moored on a lake, as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the lake, the lake residents. In a similar survey conducted on nearby Lake Wandawega during 2007,[42] only about 15 percent of watercraft were motorized, with pontoon boats comprising the single largest category of motorized watercraft, while the 2008 survey of the Lauderdale Lakes showed motorized watercraft accounted for about 73 percent of all watercraft, with powerboats comprising the single largest category of motorized watercraft. This would indicate that recreational high-speed boating is a major active recreational use of the Lauderdale Lakes. Of the nonmotorized watercraft observed on the Lauderdale Lakes during 2008, paddleboats and kayaks represented the most common types on the Lake, with canoes and rowboats also observed in good numbers. At times, especially on Sunday mornings, sailboats are the principal recreation watercraft to be observed on Green Lake.

To assess the degree of recreational boat use on a lake, it has been estimated that, in southeastern Wisconsin, the number of watercraft operating on a lake at any given time is between 2 percent and 5 percent of the total number of watercraft docked and moored. On the Lauderdale Lakes system as a whole, this would amount to somewhere between 43 and 108 boats of all kinds, about 71 percent of which would be capable of high-speed operation. Individually, on Green Lake, this would amount to between 13 and 32 watercraft of all kinds, 76 percent of which would be capable of high speed; on Middle Lake, between 15 and 36 watercraft, 62 percent capable of high speed; and, on Mill Lake, between 16 and 39 watercraft of all kinds, with 75 percent capable of high speed. Based on the

[41]*Wisconsin Department of Natural Resources,* http://digital.library.wisc.edu/1711.dl/EcoNatRes.DNRBull174*; the WDNR Southeast District encompassed Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Walworth, Washington, and Waukesha Counties. This same region now forms the WDNR Southeast Region.*

[42]*See SEWRPC Memorandum Report No. 175,* An Aquatic Plant Management Plan for Lake Wandawega, Walworth County, Wisconsin*, April 2009.*

Table 18

WATERCRAFT DOCKED OR MOORED ON THE LAUDERDALE LAKES: 2008[a]

Type of Watercraft—Green Lake									
Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Paddleboat	Rowboat	Total
220	17	144	109	45	24	30	25	21	635

Type of Watercraft—Middle Lake									
Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Paddleboat	Rowboat	Total
170	33	160	102	44	24	68	80	47	728

Type of Watercraft—Mill Lake									
Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Paddleboat	Rowboat	Total
245	32	214	117	27	29	28	61	35	788

Type of Watercraft—Total for All Lakes									
Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Paddleboat	Rowboat	Total
635	82	518	328	116	77	126	166	103	2,151

[a]*Including trailered watercraft and watercraft on land observable during survey.*

Source: SEWRPC.

number of watercraft docked or moored around the Lakes, it would appear that Mill Lake would be likely to have the greatest number of high-speed boats operating at any given time, although with the high degree of mobility exercised by watercraft of all types in navigating from one lake to the next in the Lauderdale Lakes system, it is difficult to predict with any degree of reliability which Lake might have the greatest high-speed boat traffic at any one time. Nevertheless, based upon the observed watercraft usage in the Lauderdale Lakes, as set forth in Table 18, it would appear that the density of usage of watercraft on the Lakes is consistent with the lower numbers of watercraft.

There is a range of opinion on the issue of what constitutes optimal boating density, or number of acres of open water in which to operate a boat on a lake. In this regard, an average area of about 16 acres per powerboat or sailboat was, at one time, considered suitable for the safe and enjoyable use of a boat on a lake. Over time, motorized watercrafts of all kinds have steadily increased in power and speed. For safe waterskiing and fast boating, the regional park and open space plan suggested an area of 40 acres per boat as the minimum area necessary for safe operations.[43] Chapter NR 1 of the *Wisconsin Administrative Code* has established recreational boating standards that suggest densities of between 25 acres and 35 acres per watercraft as being appropriate for lakes with a surface area equal to that of the Lauderdale Lakes. Using these standards, estimates of the densities of

[43]*See SEWRPC Planning Report No. 27,* A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000, *November 1977.*

high-speed boats on the Lauderdale Lakes, based on the percentages of watercraft docked or moored around the Lakes, would produce boating densities ranging between about one-boat-per 13 acres to about one-boat-per 31 acres on Green Lake; one-boat-per 11 acres to one-boat-per 29 acres on Middle Lake; and, one-boat-per nine acres to one-boat-per 23 acres on Mill Lake. When taken as a whole, the Lauderdale Lakes system, based on percentages of watercraft docked or moored, is capable of producing high-speed boating densities that range between 11 acres-per-boat to 28 acres-per-boat.

Another way to assess the degree of recreational boat use on a lake is through direct counts of boats actually in use on a lake at a given time. During 2009, surveys to assess the types of watercraft in use on a typical summer weekday and a typical summer weekend day were conducted by SEWRPC staff. The results of these surveys are shown in Table 19. As shown in the table, powerboats were the most popular watercraft in use on the Lakes during weekdays and weekends. Based on counts of boats observed to be actually in use, the density of high-speed watercraft on Green Lake ranged from a low of about one-boat-per 52 acres on a weekday morning to a high of about one boat-per 13 acres on a weekend afternoon; on Middle Lake, the range was from one-boat-per 52 acres on a weekday morning to one-boat-per 22 acres on a weekend afternoon; and on Mill Lake, the range was from one-boat-per 68 acres on a weekday morning to one-boat-per 14 acres on a weekend afternoon. For the Lauderdale Lakes system as a whole, the values ranged from one high-speed boat per 60 acres on a weekday morning to one-boat-per 15 acres on a weekend afternoon. Such densities reflect the intense weekend recreational use the Lakes experience, a situation not uncommon on many of the lakes in the Region. The densities observed on the Lauderdale Lakes on weekdays and weekend mornings are generally within those considered appropriate for the conduct of safe high-speed boating activities; however, the higher degree of boating activity that often occurs on the Lakes during holidays and weekend afternoons may produce high-speed boating densities that temporarily exceed the standards.

Table 20 shows the numbers of people engaged in the various types of recreational activities on and around the Lauderdale Lakes during a typical summer weekday and a typical summer weekend in 2009. The most popular weekday and weekend recreational activities on the Lakes, both as a whole and individually, were pleasure boating and waterskiing/tubing, swimming, fishing from boats, and operating personal watercraft were also popular activities. Sailing was also a popular activity mostly during those limited predetermined times and events, such as noted above; kayaking was a fairly popular activity, as well.

LOCAL ORDINANCES

As shown in Table 21, the Towns of LaGrange and Sugar Creek have each adopted the Walworth County ordinances in regard to general zoning and subdivision control ordinances, floodland zoning, shoreland or shoreland-wetland zoning; the Town of LaGrange has adopted its own construction site erosion control/storm-water management control ordinances, while the Town of Sugar Creek has adopted the Walworth County ordinances in this regard. Recreational boating activities on the Lauderdale Lakes are currently regulated through Town ordinances as appended hereto in Appendix C.

Table 19

WATERCRAFT IN USE ON THE LAUDERDALE LAKES: SUMMER 2009

Green Lake									
Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddleboat	Total
Wednesday, July 29									
8:30 a.m. to 9:30 a.m.	3	1	4	0	0	0	0	0	8
2:30 p.m. to 3:30 p.m.	6	6	1	1	0	5	0	1	20
Sunday, August 2									
8:30 a.m. to 9:30 a.m.	2	4	11	1	13	0	0	0	31
12:30 p.m. to 1:30 p.m.	16	4	2	6	3	0	0	0	31

Middle Lake									
Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddleboat	Total
Wednesday, July 29									
8:30 a.m. to 9:30 a.m.	2	2	1	0	0	0	0	0	5
2:30 p.m. to 3:30 p.m.	3	3	0	1	1	0	0	0	8
Sunday, August 2									
8:30 a.m. to 9:30 a.m.	5	2	3	1	1	4	0	0	16
12:30 p.m. to 1:30 p.m.	6	6	0	0	5	0	0	0	17

Mill Lake									
Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddleboat	Total
Wednesday, July 29									
8:30 a.m. to 9:30 a.m.	3	0	1	0	0	0	0	0	4
2:30 p.m. to 3:30 p.m.	6	2	1	0	0	0	0	0	9
Sunday, August 2									
8:30 a.m. to 9:30 a.m.	11	3	2	0	1	1	0	0	18
12:30 p.m. to 1:30 p.m.	8	6	1	4	3	1	0	0	23

Total for All Lakes									
Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddleboat	Total
Wednesday, July 29									
8:30 a.m. to 9:30 a.m.	8	3	6	0	0	0	0	0	17
2:30 p.m. to 3:30 p.m.	15	11	2	2	1	5	0	1	37
Sunday, August 2									
8:30 a.m. to 9:30 a.m.	18	9	16	2	15	5	0	0	65
12:30 p.m. to 1:30 p.m.	30	16	3	10	11	1	0	0	71

Source: SEWRPC.

Table 20

PARTICIPANTS ENGAGED IN WATER-BASED RECREATION IN/ON THE LAUDERDALE LAKES: SUMMER 2009

Green Lake										
Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Wednesday, July 29										
8:30 a.m. to 9:30 a.m.	1	3	5	0	0	0	6	0	0	15
2:30 p.m. to 3:30 p.m.	0	32	11	0	1	21	4	21	0	90
Total for the Day	1	35	16	0	1	21	10	21	0	105
Percent	1	33	15	0	1	20	10	20	0	100
Sunday, August 2										
8:30 a.m. to 9:30 a.m.	1	11	3	13	1	0	25	0	8	62
12:30 p.m. to 1:30 p.m.	0	25	25	3	8	9	8	0	0	78
Total for the Day	1	36	28	16	9	9	33	0	8	140
Percent	1	26	20	11	6	6	24	0	6	100

Middle Lake										
Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Wednesday, July 29										
8:30 a.m. to 9:30 a.m.	1	0	5	0	0	0	6	0	0	12
2:30 p.m. to 3:30 p.m.	1	12	10	1	0	0	0	0	0	24
Total for the Day	2	12	15	1	0	0	6	0	0	36
Percent	5	33	42	2	0	0	18	0	0	100
Sunday, August 2										
8:30 a.m. to 9:30 a.m.	4	21	3	1	1	0	12	4	0	46
12:30 p.m. to 1:30 p.m.	0	20	15	5	0	12	0	0	0	52
Total for the Day	4	41	18	6	1	12	12	4	0	98
Percent	4	42	19	6	1	12	12	4	0	100

Mill Lake										
Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Wednesday, July 29										
8:30 a.m. to 9:30 a.m.	0	3	8	0	0	0	2	0	0	13
2:30 p.m. to 3:30 p.m.	0	0	31	0	0	4	1	0	0	36
Total for the Day	0	3	39	0	0	4	3	0	0	49
Percent	0	6	80	0	0	8	6	0	0	100
Sunday, August 2										
8:30 a.m. to 9:30 a.m.	4	13	28	1	0	0	10	1	0	57
12:30 p.m. to 1:30 p.m.	25	17	13	3	4	12	3	1	0	78
Total for the Day	29	30	41	4	4	12	13	2	0	135
Percent	22	23	30	3	3	9	9	1	0	100

Table 20 (continued)

Total for All Lakes										
Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Wednesday, July 29										
8:30 a.m. to 9:30 a.m.	2	6	18	0	0	0	14	0	0	40
2:30 p.m. to 3:30 p.m.	1	44	52	1	1	25	5	21	0	150
Total for the Day	3	50	70	1	1	25	19	21	0	190
Percent	2	26	36	1	1	13	10	11	0	100
Sunday, August 2										
8:30 a.m. to 9:30 a.m.	9	45	34	15	2	0	47	5	8	165
12:30 p.m. to 1:30 p.m.	25	62	53	11	12	33	11	1	0	208
Total for the Day	34	107	87	26	14	33	58	6	8	373
Percent	9	29	23	7	4	9	16	1	2	100

Source: SEWRPC.

Table 21

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO THE LAUDERDALE LAKES IN WALWORTH COUNTY BY CIVIL DIVISION: 2003

	Type of Ordinance				
Community	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Walworth County................	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Adopted	Adopted
Town of LaGrange	County ordinance	County	County	County and Town	Adopted
Town of Sugar Creek	County ordinance	County	County	County and Town	County

Source: SEWRPC.

Chapter III

ALTERNATIVE AND RECOMMENDED AQUATIC PLANT MANAGEMENT PRACTICES

INTRODUCTION

The Lauderdale Lakes generally contain a robust and fairly diverse aquatic plant community capable of supporting a warmwater fishery, albeit with some areas that suffer impairment of recreational boating opportunities and other lake-oriented activities due to an overabundance of aquatic macrophytes. For example, in those areas of the Lakes where Eurasian water milfoil (*Myriophyllum spicatum*) is abundant, certain recreational uses are limited, the aesthetic quality of the Lakes is impaired, and in-lake habitat degraded. The plant primarily interferes with recreational boating activities, by encumbering propellers, clogging cooling water intakes, snagging paddles, and slowing sailboats by wrapping around keels and control surfaces. The plant also causes concern among swimmers who can become entangled within the plant stalks. Thus, without control measures, these areas can become problematic to navigation, fishing, and swimming. Native aquatic plants, generally found at slightly deeper depths, pose fewer potential problems for navigation, swimming, and fisheries, and generally have attributes that sustain a healthy fishery. Many native aquatic plants provide fish habitat and food resources, and offer shelter for juvenile fishes and young-of-the-year fish.

In this chapter, alternative and recommended actions for the management of aquatic plants in the Lauderdale Lakes are presented. These measures are focused primarily on those measures which can be implemented by the Lauderdale Lakes Lake Management District (LLLMD), with lesser emphasis given to those measures which are applicable to other agencies having jurisdiction, or other organizations having interests, within the area tributary to the Lakes. To this end, the Lauderdale Lakes Partnership—comprised of the LLLMD, the Lauderdale Lakes Improvement Association (LLIA), and Kettle Moraine Land Trust (KMLT)—should continue to promote collective and cooperative community involvement and action in lake management and monitoring activities.

AQUATIC PLANT MANAGEMENT MEASURES

As stated in Chapter II of this report, recent aquatic plant management activities in the Lauderdale Lakes can be categorized as being primarily based on mechanical harvesting. In addition, individual householders on the Lauderdale Lakes have been known to engage in manual harvesting in the vicinities of their piers and docks. This approach provides for maximum impact of the harvesting operations.

The shoreland and aquatic macrophyte management elements of this plan consider alternative management measures consistent with the provisions of Chapters NR 103, NR 107, and NR 109 of the *Wisconsin Administrative Code*. Further, the alternative aquatic plant management measures are consistent with the requirements of

Chapter NR 7 of the *Wisconsin Administrative Code*, and with the public recreational boating access requirements relating to the eligibility under the State cost-share grant programs, set forth under Chapter NR 1 of the *Wisconsin Administrative Code*.

Array of Management Measures

Aquatic plant management measures can be classed into four groups: ***physical measures***, which include lake bottom coverings and water level management; ***biological measures***, which include the use of various organisms, including herbivorous insects and plantings of aquatic plants; ***manual*** and ***mechanical measures***, which include harvesting and removal of aquatic plants; and, ***chemical measures***, which include the use of aquatic herbicides. All control measures are stringently regulated and require a State of Wisconsin permit; chemical controls are regulated under Chapter NR 107 of the *Wisconsin Administrative Code,* and all other aquatic plant management practices are regulated under Chapter NR 109 of the *Wisconsin Administrative Code*. Placement of bottom covers, a physical measure, also requires a Wisconsin Department of Natural Resources (WDNR) permit under Chapter 30 of the *Wisconsin Statutes*. Costs range from minimal for manual removal of plants using rakes and hand-pulling, to upwards of $75,000 for the purchase of a mechanical plant harvester, for which the operational costs can approach $2,500 to $25,000 per year depending on staffing and operation policies.

Physical Measures

Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. Synthetic materials, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years. However, such materials, known as bottom screens or barriers, generally have to be placed and removed annually. Such barriers also are susceptible to disturbance by watercraft propellers or the build-up of gasses from decaying plant biomass trapped under the barriers. In the case of the Lauderdale Lakes, the need to encourage native aquatic plant growth while simultaneously controlling the growth of Eurasian water milfoil, suggests that the placement of lake bottom covers as a method to control aquatic plant growth does not appear to be warranted. Thus, such measures are not considered viable for the Lauderdale Lakes.

Biological Measures

Biological controls offer an alternative approach to controlling nuisance plants, particularly purple loosestrife (*Lythrum salicaria*), an invasive shoreland wetland plant, and Eurasian water milfoil. Classical biological control techniques have been successfully used to control both nuisance plants with herbivorous insects.[1] Recent evidence shows that *Galerucella pucilla* and *Galerucella calmariensis,* both beetle species, and *Hylobius transversovittatus* and *Nanophyes brevis*, both weevil species, have potential as biological control agents for purple loosestrife.[2] Extensive field trials conducted by the WDNR in the Southeastern Wisconsin Region since 1999 have indicated that these insects can provide effective management of large infestations of purple loosestrife. In contrast, the few studies of Eurasian water milfoil control utilizing *Eurhychiopsis lecontei*, an aquatic weevil species, have resulted in variable levels of control, with little control being achieved on those lakes having extensive motorized boating traffic. Thus, while the use of insects as a means of shoreland wetland plant management is considered to be viable, the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control, is not considered a viable option for use on the Lauderdale Lakes at this time.

---

[1]*B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* LakeLine*, Vol. 17, No. 3, September 1997, pp. 20-21, 34-3. See also, C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities*, 1984, pp. 659-696; and C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology*, John Wiley, New York, New York, USA.*

[2]*Sally P. Sheldon, "The Potential for Biological Control of Eurasian Water Milfoil (*Myriophyllum spicatum*) 1990-1995 Final Report," Department of Biology Middlebury College, February 1995.*

The use of grass carp, *Ctenopharyngodon idella*, an alternative biological control used elsewhere in the United States, is not permitted in Wisconsin. This voracious herbivore has been shown to denude lakes and ponds of aquatic vegetation, exposing lake bottom sediments to wind erosion and increasing turbidity in lakes and ponds, and enhancing the likelihood of occurrence of nuisance algal blooms.[3]

A variation on the theme of biological control is the introduction of aquatic plants into a waterbody as a means of encouraging or stimulating the growth of desirable native aquatic plant species in a lake. While few projects of this nature have been undertaken in the Southeastern Wisconsin Region, the Lac La Belle Management District, in partnership with the WDNR and University of Wisconsin-Milwaukee, did attempt to supplement the aquatic plant community of that lake by selectively planting pondweeds (*Potamogeton* spp.).[4] Several hundred pondweeds were transplanted into Lac La Belle, and, while there is some evidence that a few of these transplants were successful, the net outcome of the project was disappointing. Few of the introduced plants were observed in subsequent years.[5] Given the extensive and diverse aquatic plant community present in the Lauderdale Lakes, supplemental plantings are not considered to be a viable aquatic plant management option.

Manual and Mechanical Measures

The physical removal of specific types of vegetation by selective harvesting of plants provides a highly selective means of controlling the growths of nuisance aquatic plant species, including purple loosestrife and Eurasian water milfoil. Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, manual harvesting of aquatic plants within a 30-foot-wide corridor outside of a WDNR-designated sensitive area along a shoreline would be allowed without a WDNR permit, provided the plant material is removed from the lake. Any other manual harvesting, including manual harvesting within a WDNR-designated sensitive area, would require a State permit, unless employed in the control of designated nonnative invasive species, such as Eurasian water milfoil or curly-leaf pondweed.

Aquatic macrophytes also may be harvested mechanically with specialized equipment consisting of a cutting apparatus, which cuts up to about five feet below the water surface, and a conveyor system that picks up the cut plants. Mechanical harvesting can be a practical and efficient means of controlling plant growth as it removes the plant biomass and nutrients from a lake. Mechanical harvesting is particularly effective as a measure to control large-scale growths of aquatic plants. Narrow channels can be harvested to provide navigational access and “cruising lanes” for predator fish to migrate into the macrophyte beds to feed on smaller fish. The harvesting of water lilies and other emergent native plants should be avoided.

“Clear cutting” aquatic plants and denuding the lake bottom of flora, using either manual or mechanical harvesting, should be avoided. However, top cutting of plants, such as Eurasian water milfoil, using mechanical harvesters, as shown in Figure 2, has proven to be beneficial in some lakes as a means of minimizing the

---

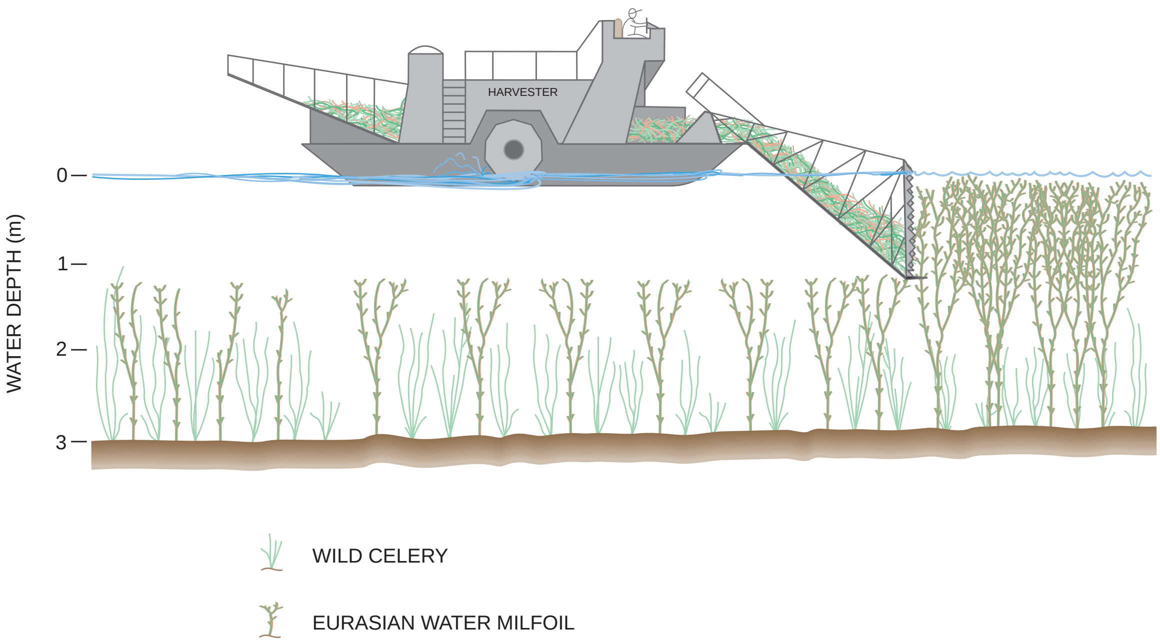
[3]*C. Holdren, W. Jones and J. Taggart,* Managing Lakes and Reservoirs, *Third Edition, North American Lake Management Society, Terrene Institute, and U.S. Environmental Protection Agency, 2001.*

[4]*Donald H. Les and Glenn Guntenpergen, “Laboratory Growth Experiments for Selected Aquatic Plants, Final Report, July 1989-June 1990 (Year 1),” Report to the Wisconsin Department of Natural Resources, June 1990; Wisconsin Department of Natural Resources, “Environmental Assessment: Improvement of the Water Quality and Fisheries Habitat of LacLaBelle [sic] and the Lower Oconomowoc River,” s.d.*

[5]*At the 2003 annual meeting of the Lac La Belle Management District, a citizen reported observing a herbicide application in the vicinity of the planted area of the Lake. Such an application might explain the observed lack of success of this management measure. See SEWRPC Community Assistance Planning Report No. 47, 2nd Edition,* A Water Quality Management Plan for Lac La Belle, Waukesha County, Wisconsin, *May 2007.*

Figure 2

PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER



NOTE: Selective cutting or seasonal harvesting can be done by aquatic plant harvesters. Removing the canopy of Eurasian water milfoil may allow native species to reemerge.

Source: Wisconsin Department of Natural Resources and SEWRPC.

competitive advantage of the Eurasian water milfoil plant and encouraging native aquatic plant growths.[6] This "top chopping" of Eurasian water milfoil is particularly recommended in those areas of the Lauderdale Lakes that have been shown to respond well to this method, as reported in an August 2002 Commission memorandum attached to this report as Appendix D.

In the shoreland area, where purple loosestrife may be expected to occur, bagging and cutting loosestrife plants prior to the application of chemical herbicides to the cut ends of the stems, can be an effective control measure for small infestations of this plant. Loosestrife management programs, however, should be followed by an annual monitoring and control program for up to 10 years following the initial control program to manage the regrowth of the plant from seeds. Manual removal of such plants is recommended for isolated stands of purple loosestrife when and where they occur.

In the nearshore area, specially designed rakes are available to assist in the manual removal of nuisance aquatic plants, such as Eurasian water milfoil. The use of such rakes also provides a safe and convenient method of controlling aquatic plants in deeper nearshore waters around piers and docks. The advantage of the rakes is that they are relatively inexpensive, easy and quick to use, and immediately remove the plant material from the lake,

---

[6]*See SEWRPC Memorandum Report No. 143,* An Aquatic Plant Management Plan for the Lauderdale Lakes, Walworth County, Wisconsin, *August 2001.*

without a waiting period. Removal of the plants from the lake avoids the accumulation of organic matter on the lake bottom, which adds to the nutrient pool that favors further plant growth. State permitting requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. Should the LLLMD acquire a number of these specially designed rakes, they could be made available for the riparian owners to use on a trial basis to test their operability before purchasing them.

Hand-pulling of stems, where they occur in isolated stands, provides an alternative means of controlling plants, such as Eurasian water milfoil, in a lake, and purple loosestrife, on the lakeshore. Because this is a more selective measure, the rakes being nonselective in their harvesting, manual removal of Eurasian water milfoil is considered a viable option in the Lauderdale Lakes, where practicable and feasible.

An advantage of mechanical aquatic plant harvesting is that the harvester typically leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms, and to stabilize the lake bottom sediments. Aquatic plant harvesting also has been shown to facilitate the growth of native aquatic plants in harvested areas by allowing light penetration to the lakebed. Many native aquatic plants are low-growing species that are less likely to interfere with human recreational and aesthetic uses of a lake. A disadvantage of mechanical harvesting is that the harvesting operation may cause fragmentation of plants and, thus, unintentionally facilitate the spread of some plants that utilize fragmentation as a means of propagation, namely Eurasian water milfoil. Harvesting may also disturb bottom sediments in shallower areas where such sediments are only loosely consolidated, thereby increasing turbidity and resulting in deleterious effects, including the smothering of fish breeding habitat and nesting sites. Disrupting the bottom sediments also could increase the risk that an exotic species, such as Eurasian water milfoil, may colonize the disturbed area since this is a species that tends to thrive under disturbed bottom conditions. To this end, most WDNR-issued permits do not allow harvesting in areas having a water depth of less than three feet. Nevertheless, if done correctly and carefully, harvesting has been shown to be of benefit in ultimately reducing the regrowth of nuisance plants when used under conditions suitable for this method of control. Both manual and mechanical harvesting techniques are considered to be viable options for control of aquatic plants in the Lauderdale Lakes.

Chemical Measures

Chemical treatment with herbicides is a short-term method of controlling heavy growths of nuisance aquatic plants. Chemicals are generally applied to the growing plants in either a liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophytes growth are the relatively low-cost and the ease, speed, and convenience of application. The disadvantages associated with chemical control include unknown long-term effects on fish, fish food sources, and humans; a risk of increased algal blooms due to the eradication of macrophyte competitors; an increase in organic matter in the sediments, possibly leading to increased plant growth, as well as anoxic conditions which can cause fishkills; adverse effects on desirable aquatic organisms; loss of desirable fish habitat and food sources; and, finally, a need to repeat the treatment the following summer due to existing seed banks and/or plant fragments. Widespread chemical treatments can also provide an advantage to less desirable, invasive, introduced plant species to the extent that such treatments may produce conditions in which nonnative species can outcompete the more beneficial, native aquatic plant species. Hence, this is seldom a feasible management option to be used on a large scale. Widespread chemical treatment, therefore, is not considered a viable option for the Lauderdale Lakes, although limited chemical control is often a viable technique for the control of the relatively small-scale infestations of aquatic plants, such as Eurasian water milfoil, or shoreland plants, such as purple loosestrife.

To minimize the possible impacts of deoxygenation, loss of desirable plant species, and contribution of organic matter to the sediments, early spring or late fall applications should be considered. Such applications also minimize the concentration and amount of chemicals used due to the facts that colder water temperatures enhance the herbicidal effects, while the application of chemical herbicides during periods when most native aquatic plants species are dormant limit the potential for collateral damage. Use of chemical herbicides in aquatic environments is stringently regulated and requires a WDNR permit and WDNR staff oversight during applications.

Use of early spring or late fall chemical controls,[7] especially in those shoreline areas where mechanical harvesting would not be deemed viable, targeting growths of Eurasian water milfoil and purple loosestrife in and around the Lakes, is considered a viable option for the Lauderdale Lakes. It should be noted, however, that the use of chemical herbicides within WDNR-delineated sensitive areas is prohibited by Town of LaGrange ordinance dated June 14, 2010.

Recommended Management Measures

The most-effective plans for managing aquatic plants rely on a combination of methods and techniques, such as those described above. Therefore, to enhance the recreational uses of the Lauderdale Lakes, while maintaining the quality and diversity of the biological communities, the following recommendations are made:

- Manual harvesting around piers and docks is the recommended means of controlling nonnative nuisance species of plants in those areas. In this regard, the LLLMD could consider purchasing several specialty rakes designed for the removal of vegetation from shoreline property and make these available to riparian owners. This would allow the riparian owners to use the rakes on a trial basis before purchasing their own. Although the rakes do not require a permit for use along a 30-foot-wide length of shoreline, State requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. Where feasible and practicable, hand-pulling of stems, where they occur in isolated stands, is also recommended as an alternative means of controlling Eurasian water milfoil and purple loosestrife. Manual control should target nonnative species.

- Mechanical harvesting should be considered as the primary method of aquatic plant management in the Lauderdale Lakes. Due to the nature of the dual approach to aquatic plant control employed on the Lakes, comprised of manual and mechanical harvesting, specific control measures are recommended to be applied in various areas of the Lake, as summarized below.

- Continued use of the District-owned property on Mill Lake, adjacent to the Lauderdale Lakes Country Club golf course, as the primary on-lake harvester mooring and servicing facility is recommended; repair or replacement of the board walk serving this area is recommended to minimize the impacts on the shoreland wetland system that the District has established on the dredge spoil deposited historically in this vicinity. Additional temporary mooring sites adjacent to the public recreational boating access sites on Green Lake and at the western extreme of Middle Lake are recommended for ongoing use during the limited periods, estimated to be 10 percent of the in-water period, that the harvesters are operating on those waterbodies.

- Through informational programming, riparian owners should be encouraged to monitor their shoreline areas, as well as open-water areas of the Lakes, for new growths of nonnative nuisance plants and report such growths immediately to the LLLMD so that a timely and effective response can be executed.

- It also is recommended that the LLLMD consider the conduct of in-lake aquatic plant surveys at about three- to five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of major areas of nuisance plant growth and areas chemically treated.

---

[7]*It should be noted that, at the time of writing, late fall herbicide treatments are considered to be experimental in Wisconsin and will not typically be permitted by the WDNR at this time, pending further research into the use of such treatments. It also is noted that many aquatic plants become dormant during the late fall and winter, die back, and do not meet the nuisance standards established pursuant to Chapter NR 107 of the* Wisconsin Administrative Code *as the basis for the application of aquatic herbicides. Consequently, late fall applications of herbicides are not recommended.*

- Additional periodic monitoring of the aquatic plant community is recommended for the early detection and control of future-designated nonnative species that may occur. Such control could be effected with the assistance of funds provided under the Chapter NR 198, aquatic invasive species control grant program, and should be undertaken as soon as possible once the presence of a nonnative, invasive species is observed and confirmed, reducing the risk of spread from waters where they are present and restoring native aquatic communities. Control of currently designated invasive species, designated pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, using appropriate control measures,[8] is recommended throughout the Lake.

- It is recommended that any use of chemical herbicides be limited to controlling nuisance growths of exotic species, particularly Eurasian water milfoil and purple loosestrife. It is recommended that chemical applications, if required, be made by licensed applicators in early spring, subject to State permitting requirements to maximize their effectiveness on nonnative plant species while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions. Such use should be evaluated annually and the herbicide applied only on an as-needed basis. Only herbicides that selectively control milfoil, such as 2,4-D, [9] should be used; for the control of purple loosestrife, the use of glyphosate[10] could be considered for application to the cut stems of the plants after the seed heads have been bagged and cut. Use of chemical herbicides within WDNR-delineated sensitive areas is prohibited by Town of LaGrange ordinance.

- The use of algicides, such as Cutrine Plus,[11] is not recommended because there are few significant, recurring filamentous algal or planktonic algal problems in the Lauderdale Lakes and valuable macroscopic algae, such as *Chara* and *Nitella*, are killed by this product. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners.

ANCILLARY PLAN RECOMMENDATIONS

Shoreline Protection

Shoreline protection measures refer to a group of management measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, or related action of the water. Currently, about 30 percent of the shoreline of the Lauderdale Lakes is in a natural state. To the extent practicable, continued use of vegetative shoreline protection is recommended. Where structural management measures were installed, most of the observed shoreline protection measures were in a good state of repair and no severe erosion-related problems were observed. Monitoring of shoreline vegetation for early detection and control of purple loosestrife, for example, and ongoing maintenance of shoreline protection structures is recommended.

---

[8]*Appropriate control measures include, but are not limited to, any permitted aquatic plant management measure, placement of signage, and use of buoys to isolate affected areas of the Lakes. Such measures as may be appropriate should be determined in consultation with WDNR staff and conducted in accordance with required permits under Chapters NR 107, NR 109, and NR 198, among others, of the* Wisconsin Administrative Code.

[9]*See Wisconsin Department of Natural Resources PUBL-WR-236 90,* Chemical Fact Sheet: 2,4-D*, May 1990.*

[10]*See Wisconsin Department of Natural Resources PUBL-WR-239 90,* Chemical Fact Sheet: Glyphosate*, May 1990.*

[11]*See Wisconsin Department of Natural Resources PUBL-WR-238 90,* Chemical Fact Sheet: Copper Compounds*, May 1990.*

Array of Management Measures

Shoreline Erosion Control

Five shoreline erosion control techniques were commonly observed to be used along the shorelines of the Lauderdale Lakes, 1) vegetative buffer strips, 2) riprap, 3) concrete and rock revetments, 4) wooden and concrete bulkheads, and 5) beach. Of these, revetments and bulkheads are strongly discouraged as these types of structures impede the movement of amphibians and inhibit the reproduction of other aquatic creatures that depend on the shore zone for breeding, feeding, and resting. Factors affecting the choice of method include cost; the shoreline bank height, vegetation, stability, and composition; the shoreline geometry and geographic orientation; the lake bottom contour and vegetation immediately adjacent to the stretch of shoreline under consideration; the proximity to boat channels; possible influence of adjacent structures in producing flank erosion; and the amount of open water (or "fetch") over which wind can act to produce wave action directly into the shoreline under consideration. A worksheet is provided as Table 1 of Section NR 328.08 of the *Wisconsin Administrative Code* in order to assist property owners who wish to install or modify existing shoreline protection structures.

Maintenance of vegetated buffer strips immediately adjacent to the Lakes is the simplest, least costly, and most natural method of reducing shoreline erosion. Along developed shorelines, this technique employs natural vegetation, rather than maintained lawns, in the first five to 10 feet landward from the shoreline and the establishment of emergent aquatic vegetation from the waterline out to two to six feet lakeward from the shoreline. The use of such natural shorescaping techniques is generally required pursuant to Chapter NR 328 of the *Wisconsin Administrative Code*, except in moderate- to high-energy shorelines where more-robust structural approaches may be required. Along undeveloped shorelines, the WDNR recommends shoreland buffers extend from the water's edge onto land at least 35 to 50 feet, contain three layers of flora—herbaceous, shrub, and tree—found along natural Wisconsin lakeshores. It also is recommended that these areas not be mowed except for a viewing access corridor.[12]

Desirable plant species that may be expected and encouraged to form an effective buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), common reed (*Phragmites communis*), water plantain (*Alisma plantago-aquatica*), bur reed (*Sparganium eurycarpum*), and blue flag (*Iris versicolor*) in the wetter areas; and jewelweed (*Impatiens biflora*), elderberry (*Sambucus canadensis*), giant goldenrod (*Solidago gigantea*), marsh aster (*Aster simplex*), red-stem aster (*Aster puniceus*), and white cedar (*Thuja occidentalis*) in the drier areas. In addition, trees and shrubs, such as silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), black willow (*Salix nigra*), and red-osier dogwood (*Cornus stolonifera*) could become established. These plants will develop a more extensive root system than lawn grass and the aboveground portion of the plants will protect the soil against the erosive forces of rainfall and wave action. A narrow path to the Lakes could be maintained as lake access for boating, swimming, fishing, and other activities. A vegetative buffer strip would also serve to trap nutrients and sediments washing into the Lakes via direct overland flow. This alternative would involve only minimal cost.

Rock riprap is a highly effective method of shoreline erosion control applicable to many types of erosion problems found along active shorelines, especially in areas with low banks and shallow water. Riprap is already in place along much of the shoreline of the Lauderdale Lakes. The technique involves the shaping of the shoreline slope, the placement of a porous filter material, such as sand, gravel, or pebbles, on the slope and the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of riprap structures are that they are highly flexible and not readily weakened by movements caused by settling or ice expansion, they can be constructed in stages, and they require little or no maintenance. The disadvantages are that they limit some uses of the immediate shoreline. The rough, irregular rock surfaces are unsuitable for walking;

---

[12]*Wisconsin Department of Natural Resources,* Delavan Lake (Walworth County, Wisconsin) Integrated Sensitive Area Report, 2007.

require a relatively large amount of filter material and rocks to be transported to the lakeshore; and can cause temporary disruptions and contribute sediment to the lake. If improperly constructed, they may fail because of washout of the filter material.

Vertical bulkheads and sloping revetments, which form barriers to wildlife and amphibians, are not recommended. Beaches, and the use of sand blankets for the control of aquatic plants within the shoreland zone, also are not recommended, although maintenance of existing beach areas is warranted, given the current intensity of use of these areas by the community.

Shoreline Protection in the Vicinity of the Aquatic Plant Harvester and Water Safety Patrol Dock

As noted above, the District's aquatic plant harvesting equipment is customarily moored at a pier on District-owned property on Mill Lake, adjacent to the Lauderdale Lakes Country Club golf course. This pier also is utilized by the LLLMD and Town of LaGrange water safety patrol, both for mooring of the patrol craft and for emergency access should it be necessary for the water safety patrol to render assistance to persons in distress. Access to the pier is across reclaimed land, in part comprised of dredge spoil from Mill Lake deposited historically in this vicinity. Portions of the access route are served by a board walk, ongoing repair or periodic replacement of which is recommended to minimize the impacts on the shoreland wetland system. In addition, connection of the pier area to the board walk to ensure all weather access to the water safety patrol pier and to minimize degradation of the shoreland wetland system established by the District along the portions of the shoreline adjacent to the water safety patrol and aquatic plant harvester docking area would benefit both the shoreland restoration efforts and public safety on the Lakes. A Chapter 30, *Wisconsin Statutes*, permit may be required for such a board walk.

Recommended Management Measures

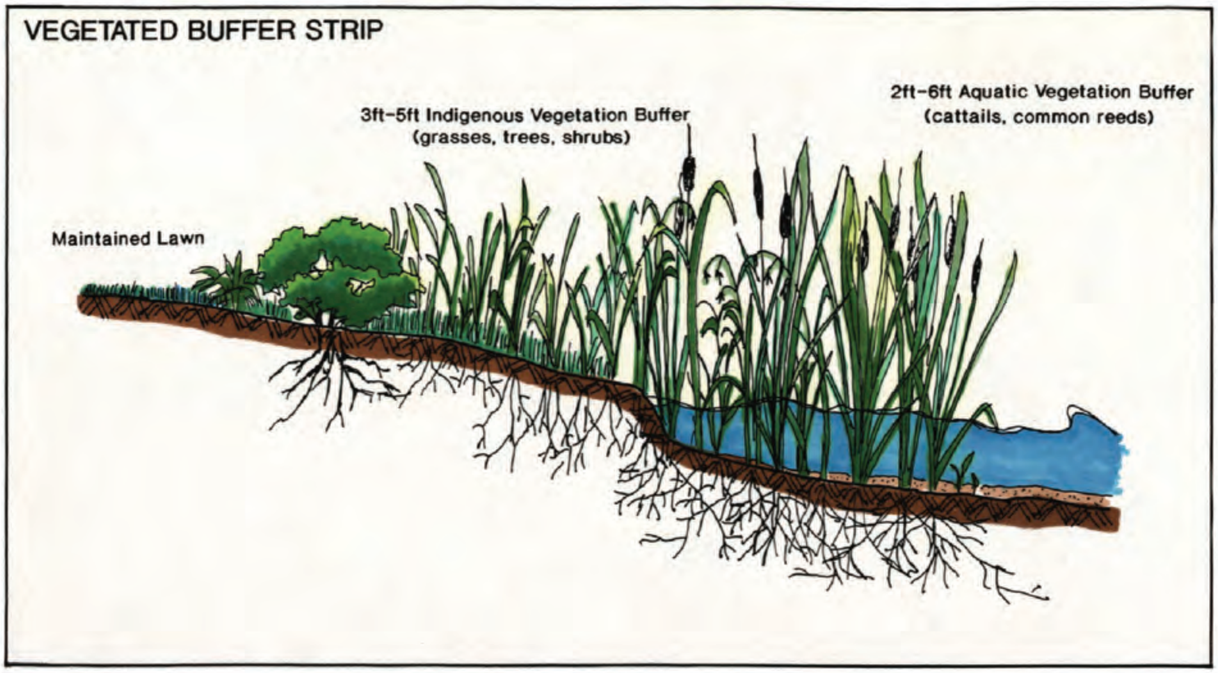
The use of vegetative buffer strips and riprap, as shown in Figure 3, is recommended. These alternatives were selected because they can be constructed, at least partially, by local residents; because most of the construction materials involved are readily available; because the measures would, in most cases, enable the continued use of the immediate shoreline; and because the measures are visually "natural" or "semi-natural" and should not significantly affect the aesthetic qualities of the lake shoreline. In those portions of the Lakes subject to direct action of wind waves and ice scour, the use of riprap would provide a more-robust means of stabilizing shorelines, while elsewhere along the lakeshores creation of vegetated buffer strips would provide, not only shoreline erosion protection, but also enhanced shoreland habitat for fish and wildlife. This is especially important for WDNR Sensitive Area Number 3, which contains one of the highest-quality shorelines in southeast Wisconsin.[13] It should be noted that the selection of appropriate shoreland protection structures is subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*.

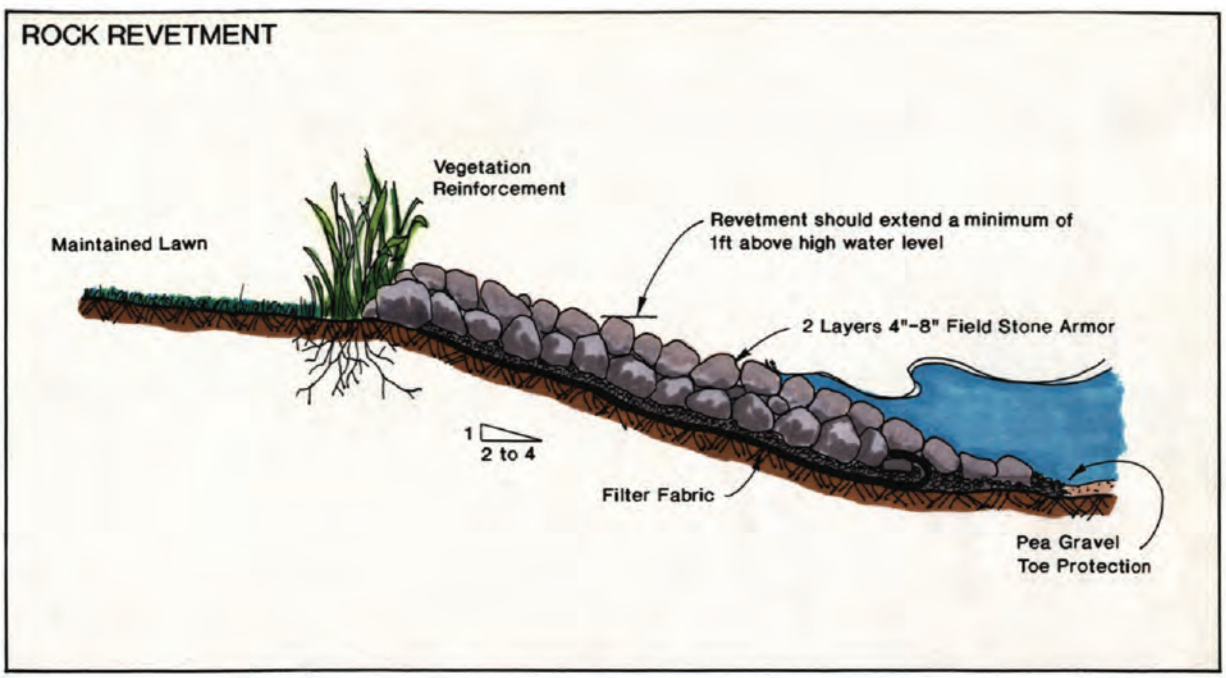
It is recommended that the LLLMD and Town of LaGrange consider placement of a board walk or elevated accessway to provide all-weather access to the water safety patrol pier and aquatic plant harvester dock on the District-owned property on Mill Lake, adjacent to the Lauderdale Lakes Country Club golf course, utilized for mooring of the aquatic plant harvesting equipment and for docking of the water safety patrol craft. Provision of such all weather access would contribute to public safety by minimizing the risk of emergency vehicles becoming mired in the wetland areas leading to the pier, and protect the shoreland wetland habitat that has been recreated by the LLLMD in this vicinity from unnecessary disturbance. To this end, it is recommended that any such accessway be sized to accommodate a light-duty vehicle, such as a golf cart, and provide for adequate area to allow this vehicle to turn around at the lakeward extent of the accessway. In addition, as it is likely that any such accessway would inevitably form part of a lakeshore trail system, also allowing pedestrians access to the shoreland area and connect to the lake access linking the shoreland (Walworth County Tax Key Parcel H LG 3600009) to USH 12

[13]*Wisconsin Department of Natural Resources,* Lauderdale Lakes (Walworth County, Wisconsin) Integrated Sensitive Area Report.

Figure 3

RECOMMENDED ALTERNATIVES FOR SHORELINE EROSION CONTROL





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

Source: SEWRPC.

along the northern perimeter of the subdivision identified as Strawberry Banke Plantation (specifically along the northern property line of Walworth County Tax Key Parcel H LG 3600009C), the provision of turn outs at intervals is recommended to allow emergency vehicles to pass pedestrians without fear of contact. Such turn outs could also form areas for placement of informational signage, in accordance with the public informational program recommended below.

Water Quality Management

Water quality is one of the key parameters used to determine the overall health of a waterbody. The importance of good water quality can hardly be underestimated, as it impacts nearly every facet of the natural balance and relationships that exist in a lake between the myriad of abiotic and biotic elements present. Because of the important role that water quality plays in the functioning of a lake ecosystem, careful monitoring of key water quality indicators represents a fundamental lake management tool.

Array of Management Measures

The University of Wisconsin-Extension (UWEX) operates the Citizen Lake Monitoring Network (CLMN), formerly the WDNR Self-Help Monitoring Program. Volunteers enrolled in this program gather data at regular intervals on water clarity using a Secchi disk. Because pollution tends to reduce water clarity, either by spurring algal growth or by introducing inorganic turbidity into a lake, Secchi-disk measurements are generally considered one of the key parameters in determining the overall quality of a lake’s water, as well as a lake’s trophic status. Secchi-disk measurement data are included in the WDNR lake data base. This lake water quality information is accessible on-line through the WDNR website for many lakes in Wisconsin. The UWEX also offers an Expanded Monitoring Program that involves the collection of data on several other key physical and chemical parameters in addition to the Secchi-disk measurements. Under this program, samples of lake water are collected by volunteers at regular intervals and analyzed by the State Laboratory of Hygiene. Data collection is more extensive and, consequently, places more of a burden on volunteers.

The basic UWEX CLMN program is available at no charge, but does require volunteers to be committed to taking Secchi-disk measurements at regular intervals throughout the spring, summer, and fall. The Expanded Self-Help Program requires additional commitment by volunteers to take a more-extensive array of measurements and samples for analysis, also on a regular basis. As with any volunteer-collected data, despite the implementation of standardized field protocols, individual variations in levels of expertise due to background and experiential differences, can lead to variations in data and measurements from lake-to-lake and from year-to-year for the same lake, especially when volunteer participation changes.

In addition to the UWEX volunteer-based CLMN program, the University of Wisconsin-Stevens Point (UWSP) Water and Environmental Analysis Laboratory (WEAL) offers several other water quality packages that can supplement the water clarity monitoring program. Under these programs, volunteers collect water samples and send them to the UWSP WEAL for analysis. The basic program includes the analysis of a spring overturn sample (once per year), while additional packages include the submission of multiple samples taken during the open water season. The UWSP turnover sampling program requires only a once-a-year sampling, thereby requiring a smaller time commitment by the volunteers, but there is a modest charge for the laboratory analysis, and because sampling is performed by volunteers, is subject to those variations identified above. Additionally, since samples need to be taken as closely as possible to the actual turnover period, which occurs only during a relatively short window of time, volunteers need to monitor lake conditions as closely as possible to be able to determine when the turnover period is occurring.

The U.S. Geological Survey (USGS) offers a more extensive water quality monitoring program under their Trophic State Index monitoring program. USGS field personnel conduct a series of approximately five monthly samplings beginning with the spring turnover. Samples are analyzed by the State Laboratory of Hygiene for an extensive array of physical and chemical parameters. The USGS program does not require volunteer sampling. All sampling and analysis is provided by USGS personnel using standardized field techniques and protocols. As a result, a more standardized set of data and measurements may be expected. However, the cost of the USGS program is significantly higher than the UWSP program, even with State cost-share availability.

The LLLMD has participated in all of these programs on an intermittent basis.

Recommended Management Measures

The WDNR offers Small Grant cost-share funding within the Chapter NR 190 Lake Management Planning Grant Program that can be applied for to defray the costs of laboratory analysis and sampling equipment. It is recommended that the LLLMD resume regular participation in the CLMN program sponsored by the UWEX. Data gathered as part of this program should be presented annually by the volunteers at meetings of the LLIA, where the citizen monitors could be given some recognition for their work. The Lake Coordinator of the WDNR, Southeast Region, could assist in enlisting more volunteers in this program. The information gained at first-hand by the public from participation in this program can increase the credibility of the proposed changes in the nature and intensity of use to which the Lakes are subjected.

It is further recommended that the LLLMD consider participating in one of the other more comprehensive water quality programs: the UWEX Expanded Self-Help Program on an annual basis, or either the UWSP WEAL lake sampling program or USGS program on a periodic basis at three- to five-year intervals. The use of either the UWSP or USGS programs would be especially valuable as a means to attain a comprehensive water quality determination on a periodic basis while maintaining yearly CLMN data.

Recreational Use Management

Current public recreational boating standards as set forth in Sections NR 1.91(4) and NR 1.91(5) of the *Wisconsin Administrative Code*, establish minimum and maximum standards for public boating access development, respectively, to qualify waters for resource enhancement services provided by the WDNR. As noted in Chapter II of this report, the Lakes are deemed to have adequate public access as defined in Chapter NR 1 of the *Wisconsin Administrative Code,* which establishes quantitative standards for determining the adequacy of public recreation boating access, setting maximum and minimum standards based upon available parking facilities for car-top and car-trailer units.

These sites should continue to be periodically monitored to ensure consistency with public recreational boating access standards.

Recommended Management Measures

In addition to the existing public recreational boating access, it is recommended that appropriate signage at the public recreational boating access site be provided to alert users of Eurasian water milfoil, zebra mussels, and other nonnative invasive species. Such information should also be included in the District's informational programming, consistent with the aquatic plant management measures set forth in this plan. The District should also consider participating in the UWEX Clean Boats-Clean Waters Program.

Continued operation of the joint water safety patrol, operated by the LLLMD and the Town of LaGrange, also is recommended.

Public Informational and Educational Programming

As part of the overall citizen informational and educational programming to be conducted in the Lauderdale Lakes community, residents and visitors in the vicinity of the Lakes should be made aware of the value of the ecologically significant areas in the overall structure and functioning of the ecosystems of the Lakes. Specifically, informational programming related to the protection of ecologically valuable areas in and around the Lakes should focus on the need to minimize the spread of nuisance aquatic invasive species, such as purple loosestrife and Eurasian water milfoil. To this end, the Lauderdale Lakes Partnership can play a major role in outreach to the Lakes community and beyond.

Recommended Management Measures

With respect to aquatic plants, distribution of posters and pamphlets, available from the UWEX and the WDNR, that provide information and illustrations of aquatic plants, their importance in providing habitat and food resources in aquatic environments, and the need to control the spread of undesirable and nuisance plant species is recommended. Currently, many lake residents seem to view all aquatic plants as "weeds" and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impact. Inclusion of specific public informational and educational programming within the lake-related activities of the Towns of LaGrange and Sugar Creek and the LLLMD is recommended. These programs should focus on the value and impacts of these plants on water quality, fish, and wildlife; and on alternative methods for controlling existing nuisance plants, including the positive and negative aspects of each method. These programs can be incorporated into the comprehensive informational and educational programs that also would include information on related topics, such as water quality, recreational use, fisheries, and onsite sewage disposal systems.

Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the lake management program, are available from UWEX, WDNR, Walworth County, and many Federal governmental agencies. These brochures could be provided to homeowners through local media, direct distribution, or targeted library/civic center displays. Alternately, they could be incorporated into the newsletters produced and distributed by the LLLMD and the Lauderdale Lakes Partnership. Many of the ideas contained in these publications can be integrated into ongoing, larger-scale activities, such as anti-littering campaigns, recycling drives, and similar pro-environment activities undertaken by the Partnership and other community organizations.

Other informational programming offered by the WDNR, Walworth County, and the UWEX Lakes Program, such as the Adopt-A-Lake program and Project WET (Water Education Training) curriculum, can contribute to an informed public, actively involved in the protection of ecologically valuable areas within the area tributary to the Lauderdale Lakes. Citizen monitoring and awareness of the positive value of native aquatic plant communities are important opportunities for public informational programming and participation that are recommended for the Lakes.

Continuing Education

As part of their commitment to the effective managing of the Lauderdale Lakes, the LLLMD commissioners, LLIA board members, and KMLT trustees should continue to avail themselves of opportunities to learn about current developments and issues involving lake management. There are numerous publications, writings, newsletters, seminars, and conventions available through governmental, educational and other organizations and agencies dealing with the subject of lake management. Walworth County, UWEX, the Wisconsin Association of Lakes (WAL), the North American Lake Management Society (NALMS), and WDNR, all produce written materials and conduct meetings and seminars dealing with lake management issues. Publications, such as *Lake Tides*, published by the Wisconsin Lakes Partnership, comprised of WDNR, UWEX, and WAL, and available from UWEX, are also readily available and deal with a wide range of lake-related topics. Additionally, the statewide Lakes Convention, held annually in Green Bay, Wisconsin, provides valuable opportunities to learn about important and timely developments in lake management and learn about lake issues from experts in their fields. Participation in such activities that will further understanding of lake management issues is deemed an important part of the lake management experience. In this regard, the participation of the LLLMD, LLIA, and KMLT officers as lecturers in sharing their collective expertise with other lake organizations from around Wisconsin is noted.

SUMMARY

This plan documents the findings and recommendations of a study of the aquatic plant community of the Lauderdale Lakes, requested by the LLLMD, and examines existing and anticipated conditions, potential aquatic plant management problems, and recreational use problems on the Lauderdale Lakes. The plan sets forth recommended actions and management measures for the resolution of those problems. The recommended plan is summarized in Table 22 and shown on Maps 15 through 17.

Table 22

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR THE LAUDERDALE LAKES

Plan Element	Subelement	Management Measures	Management Responsibility
Aquatic Plant Management Measures	Proactive measures	Conduct periodic in-lake reconnaissance surveys of aquatic plant communities and update aquatic plant management plan every three to five years	LLLMD
		Conduct additional periodic monitoring of the aquatic plant community for the early detection and control of future-designated nonnative species that may occur	WDNR, LLLMD, and private landowners
		Monitor invasive species populations; where they occur, remove isolated stands of purple loosestrife through bagging, cutting, and herbicide application onto cut stems	WDNR, LLLMD, KMLT, and private landowners
	Management actions	Mechanically harvest nuisance plants to maintain boating access, promote public safety, enhance angling opportunities, and encourage growth of native plants; consider "top chopping" of Eurasian water milfoil in areas designated by SEWRPC memorandum of 2002 to encourage native plant growth and biodiversity	WDNR and LLLMD
		Limited use of aquatic herbicides for control of nuisance nonnative aquatic plant growth where necessary; specifically target Eurasian water milfoil[a]	WDNR and private landowners
		Encourage growth of native plants in the Lauderdale Lakes through use of vegetated buffer strips and control of Eurasian water milfoil	Walworth County, UWEX, KMLT, and private landowners
		Manually harvest around piers and docks as necessary[b]	Private landowners
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials in Lakes	Private landowners
Ancillary Management Measures	Shoreline Protection Management	Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Walworth County, Towns of LaGrange and Sugar Creek, WDNR, and private landowners
	Water Quality Management	Continue participation in WDNR CLMN program; consider participation in WDNR Expanded Self-Help program; periodic participation in USGS TSI or similar programs	WDNR, CLMN/USGS, and LLLMD/LLIA
	Recreational Use Management	Maintain recreational boating access from the public access site pursuant to Chapter NR 7 guidelines	WDNR, Towns of LaGrange and Sugar Creek, and LLLMD
		Maintain signage at public access sites regarding invasive species and WDNR Clean Boats-Clean Waters Program; provide disposal containers for disposal of plant material removed from watercraft	WDNR, Towns of LaGrange and Sugar Creek, and LLLMD
	Public informational and educational programming	Continue to provide informational material and pamphlets on lake-related topics, especially the importance of aquatic plants and the protection of ecologically significant areas; consider offering public informational programming on topics of lake-oriented interest and education	Towns of LaGrange and Sugar Creek, WDNR, UWEX, LLLMD, LLIA, and KMLT
		Encourage inclusion of lake studies in environmental curricula (e.g., Pontoon Classroom, Project WET, Adopt-A-Lake)	Area school districts, UWEX, WDNR, LLIA, KMLT, and LLLMD
		Encourage riparian owners to monitor their shoreline areas, as well as open-water areas of the Lakes, for new growths of nonnative plants and report same immediately to LLLMD	LLLMD and LLIA

Table 22 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility
Ancillary Management Measures (continued)	Lake district board continuing education	Maintain awareness of current developments in the area of lake management through informative publications such as “Lake Tides” (available free through the Wisconsin Lakes Partnership) and attendance at lake education conventions, workshops, and seminars	LLLMD and LLIA

NOTE: The following abbreviations have been used:

CLMN = University of Wisconsin-Extension Citizen Lake Monitoring Network
KMLT = Kettle Moraine Land Trust
LLIA = Lauderdale Lakes Improvement Association
LLLMD = Lauderdale Lakes Lake Management District
TSI = Trophic State Index monitoring program
USGS = U.S. Geological Survey
UWEX = University of Wisconsin-Extension
WDNR = Wisconsin Department of Natural Resources

[a]*Use of aquatic herbicides requires a WDNR permit pursuant to Chapter NR 107 of the* Wisconsin Administrative Code*. Use of chemical herbicides within WDNR-delineated sensitive areas is prohibited by Town of LaGrange ordinance.*

[b]*Manual harvesting beyond a 30-linear-foot width of shoreline is subject to WDNR individual permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code*.*

Source: SEWRPC.

The Lauderdale Lakes were found to be mesotrophic lakes of average to slightly above average water quality. Preservation of environmental corridor lands, especially within the shoreland areas situated immediately adjacent to the Lakes, is recommended. Walworth County and the Towns of LaGrange and Sugar Creek, together with the LLLMD and its partner organizations in the Lauderdale Lakes Partnership, the Lauderdale Lakes Improvement Association and the Kettle Moraine Land Trust, should support appropriate land management practices designed to reduce nonpoint source pollutant discharges in stormwater runoff into the Lakes. Further, the Towns and LLLMD should promote appropriate shoreline management practices, including the use of riprap and vegetative buffer strips, where applicable.

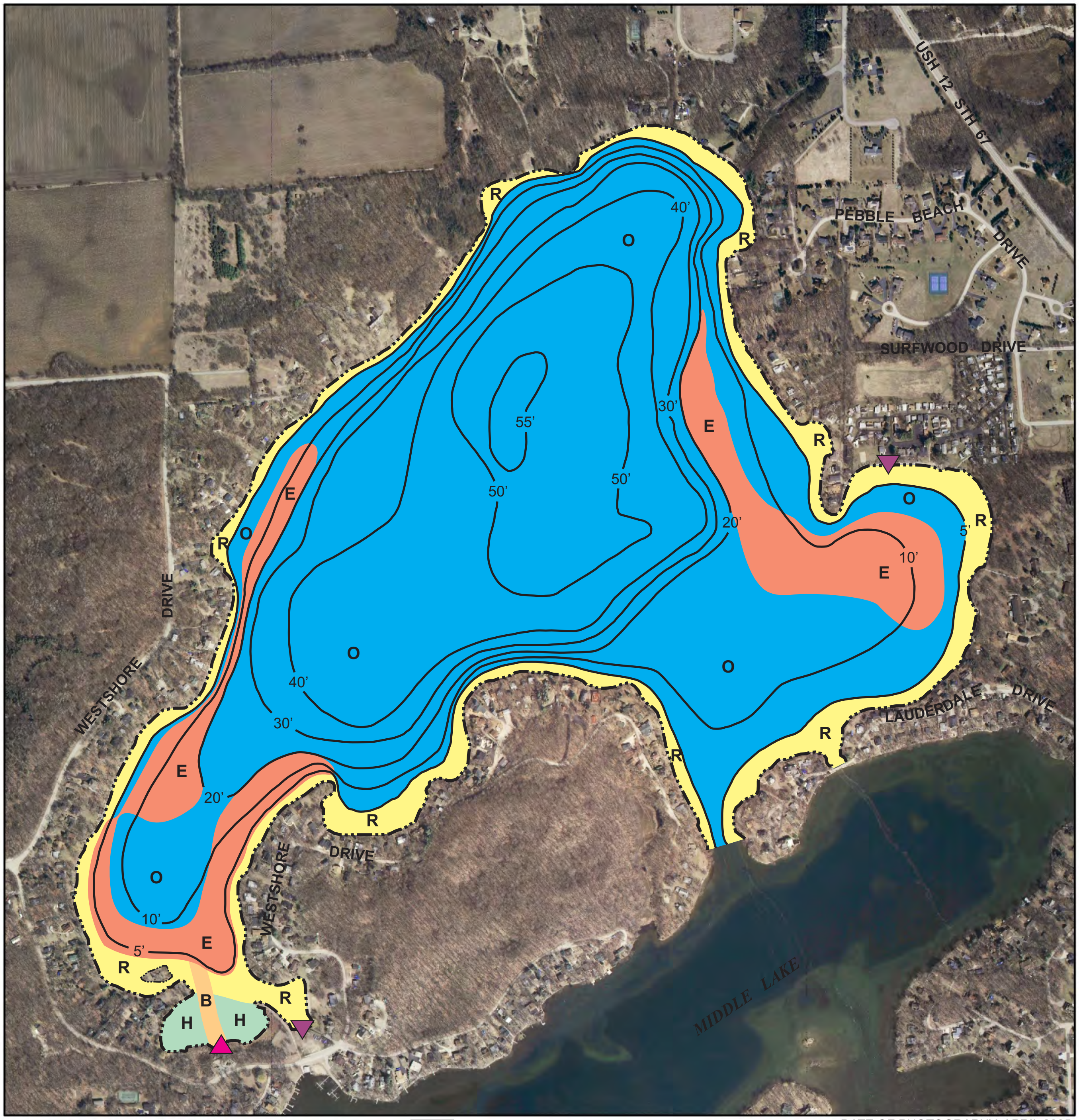
The shoreland protection and aquatic plant management elements of this plan recommend actions be taken that would reduce human impacts on ecologically valuable areas in and adjacent to the Lakes, encourage a biologically diverse community of native aquatic plants, and limit the spread of nonnative invasive plant species. The plan recommends the use of mechanical harvesting of nuisance plants in those areas where depth of water and bottom substrate are sufficient to support such activity, manual harvesting aquatic plants around piers and docks with subsequent removal of cut material from the Lakes, and monitoring of invasive species populations. The plan further recommends periodic in-lake aquatic plant surveys every three to five years to monitor changes in the aquatic plant community and assess effectiveness of aquatic plant management techniques.

The plan recommends regular participation in the UWEX CLMN volunteer water quality monitoring program with consideration of participation in the Expanded Self-Help Program, and periodic conduct of USGS, or equivalent, comprehensive water quality surveys. With regard to recreational uses of the Lauderdale Lakes, the plan recommends maintaining the public access sites in a manner consistent with Chapter NR 1 standards and Chapter NR 7 guidelines, as well as maintaining signage regarding aquatic and other invasive species.

Finally, the recommended plan includes continuation of an ongoing program of public information and education, focusing on providing riparian residents and lake users with an improved understanding of the lake ecosystem. For example, additional options regarding household chemical use, lawn and garden care, onsite sewage disposal

Map 15

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR GREEN LAKE



—20'— WATER DEPTH CONTOUR IN FEET

PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA

PRIVATE ACCESS SITE

H — WISCONSIN DEPARTMENT OF NATURAL RESOURCES DESIGNATED CHAPTER NR 107 ENVIRONMENTALLY SENSITIVE AREA
HARVESTING: ACCESS LANE ONLY
CHEMICALS: NONE

O — OPEN WATER AREA: NO CONTROL REQUIRED

B — BOATING ACCESS LANE: 15 FEET WIDE TO FIVE FOOT CONTOUR
HARVESTING: HIGH PRIORITY
CHEMICALS: NONE

R — RECREATIONAL AREA: MAINTAIN SHORELINE PROTECTION STRUCTURES AS NECESSARY
HARVESTING: LOW PRIORITY-SURFACE CUT FOR EURASIAN WATER MILFOIL CONTROL, MANUAL HARVEST NEAR SHORE
CHEMICALS: NONE

E — EURASIAN WATER MILFOIL MANAGEMENT AREA:
HARVESTING: MODERATE PRIORITY
CHEMICALS: NONE

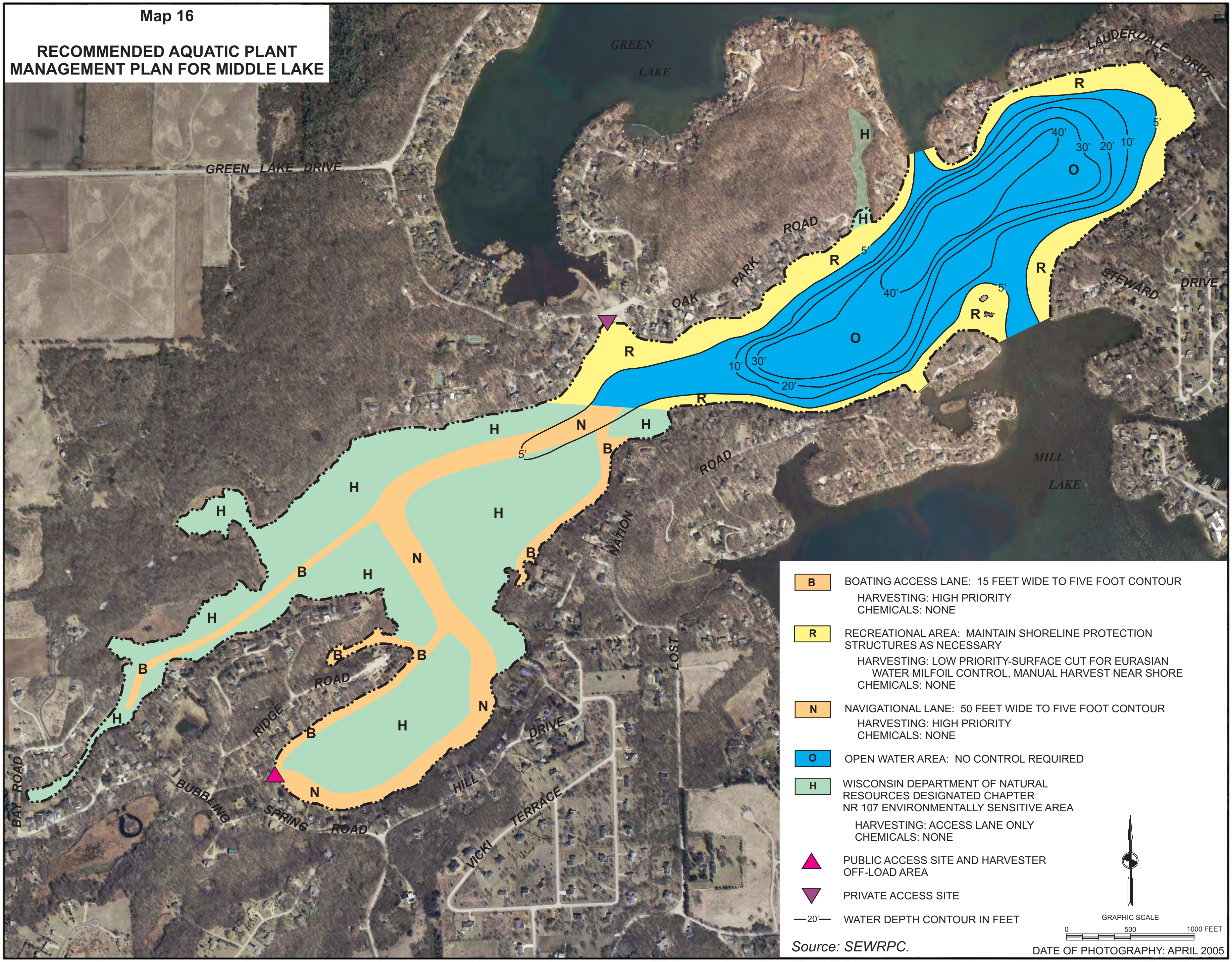
DATE OF PHOTOGRAPHY: APRIL 2005

GRAPHIC SCALE
0 450 900 FEET

Source: SEWRPC.

Map 16

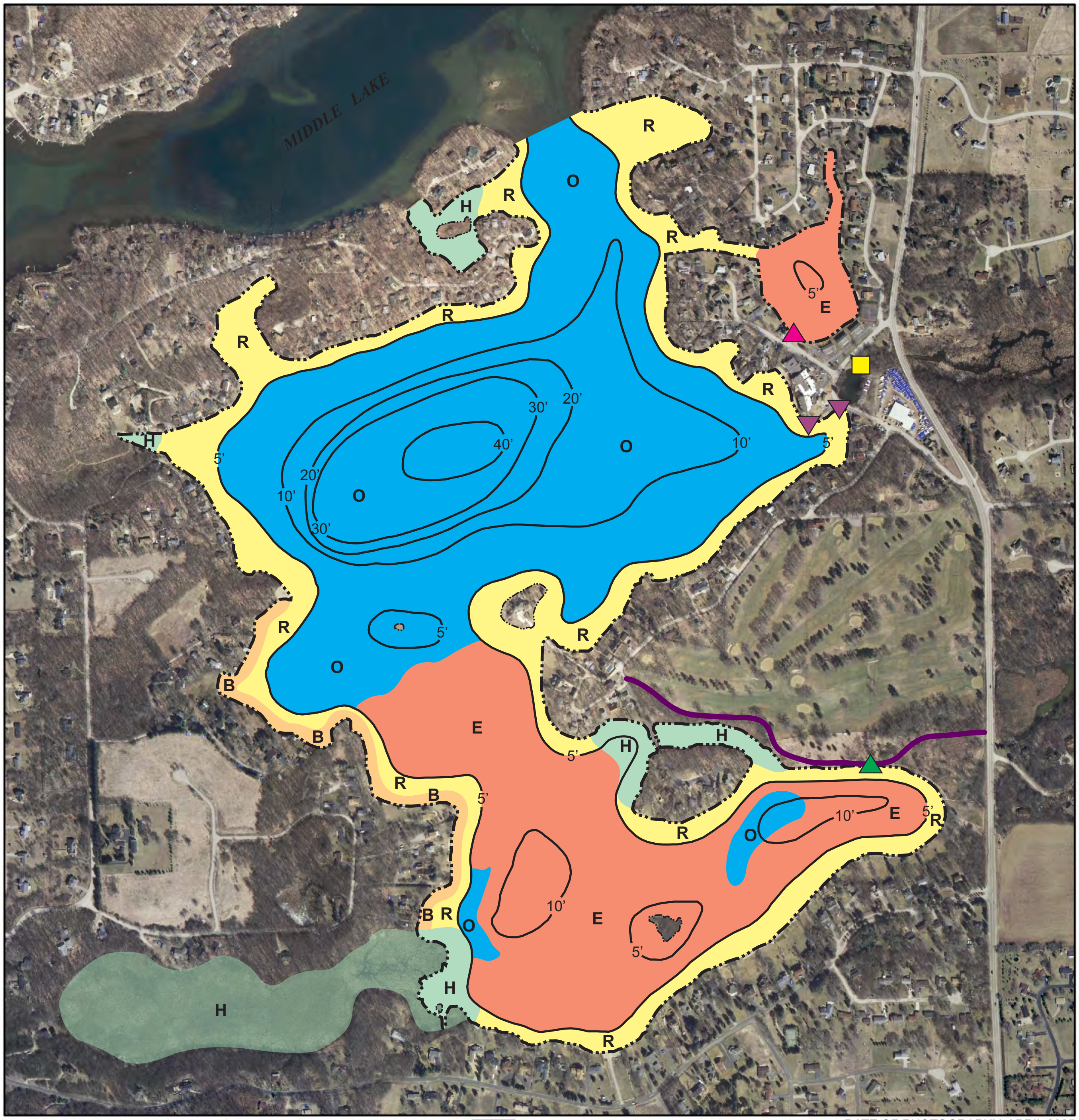
RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR MIDDLE LAKE



Source: SEWRPC.

Map 17

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR MILL LAKE



—20'— WATER DEPTH CONTOUR IN FEET

PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA

PRIVATE ACCESS SITE

PUBLIC SAFETY ACCESS AND HARVESTER DOCKING SITE

WATER LEVEL CONTROL STRUCTURE

PROPOSED RECREATIONAL TRAIL AND BOARDWALK

H WISCONSIN DEPARTMENT OF NATURAL RESOURCES DESIGNATED CHAPTER NR 107 ENVIRONMENTALLY SENSITIVE AREA

HARVESTING: ACCESS LANE ONLY
CHEMICALS: NONE

B BOATING ACCESS LANE: 15 FEET WIDE TO FIVE FOOT CONTOUR

HARVESTING: HIGH PRIORITY
CHEMICALS: NONE

R RECREATIONAL AREA: MAINTAIN SHORELINE PROTECTION STRUCTURES AS NECESSARY

HARVESTING: LOW PRIORITY-SURFACE CUT FOR EURASIAN WATER MILFOIL CONTROL, MANUAL HARVEST NEAR SHORE
CHEMICALS: NONE

E EURASIAN WATER MILFOIL MANAGEMENT AREA:

HARVESTING: MODERATE PRIORITY
CHEMICALS: NONE

O OPEN WATER AREA: NO CONTROL REQUIRED

DATE OF PHOTOGRAPHY: APRIL 2005

GRAPHIC SCALE
0 450 900 FEET

Source: SEWRPC.

system operation and maintenance, shoreland protection and maintenance, and recreational use of the Lakes should be made available to riparian property owners, thereby providing riparian residents with alternatives to traditional activities. Additionally, LLLMD Commissioners, LLIA board members, and KMLT trustees are encouraged to maintain, broaden, and share their awareness of current developments in the area of lake management through participation in meetings, seminars, conventions, and other lake management-related events, and educational opportunities.

Adherence to the recommendations contained in this plan should provide the basis for a set of management actions that are aligned with the goals and objectives set forth in Chapter I of this report; reflective of the ongoing commitment by the Lauderdale Lakes community, through the LLLMD, the Lauderdale Lakes Partnership, and the Towns of LaGrange and Sugar Creek, to sound planning with respect to the Lakes; and, sensitive to current needs, as well as those in the immediate future.

(This Page Left Blank Intentionally)

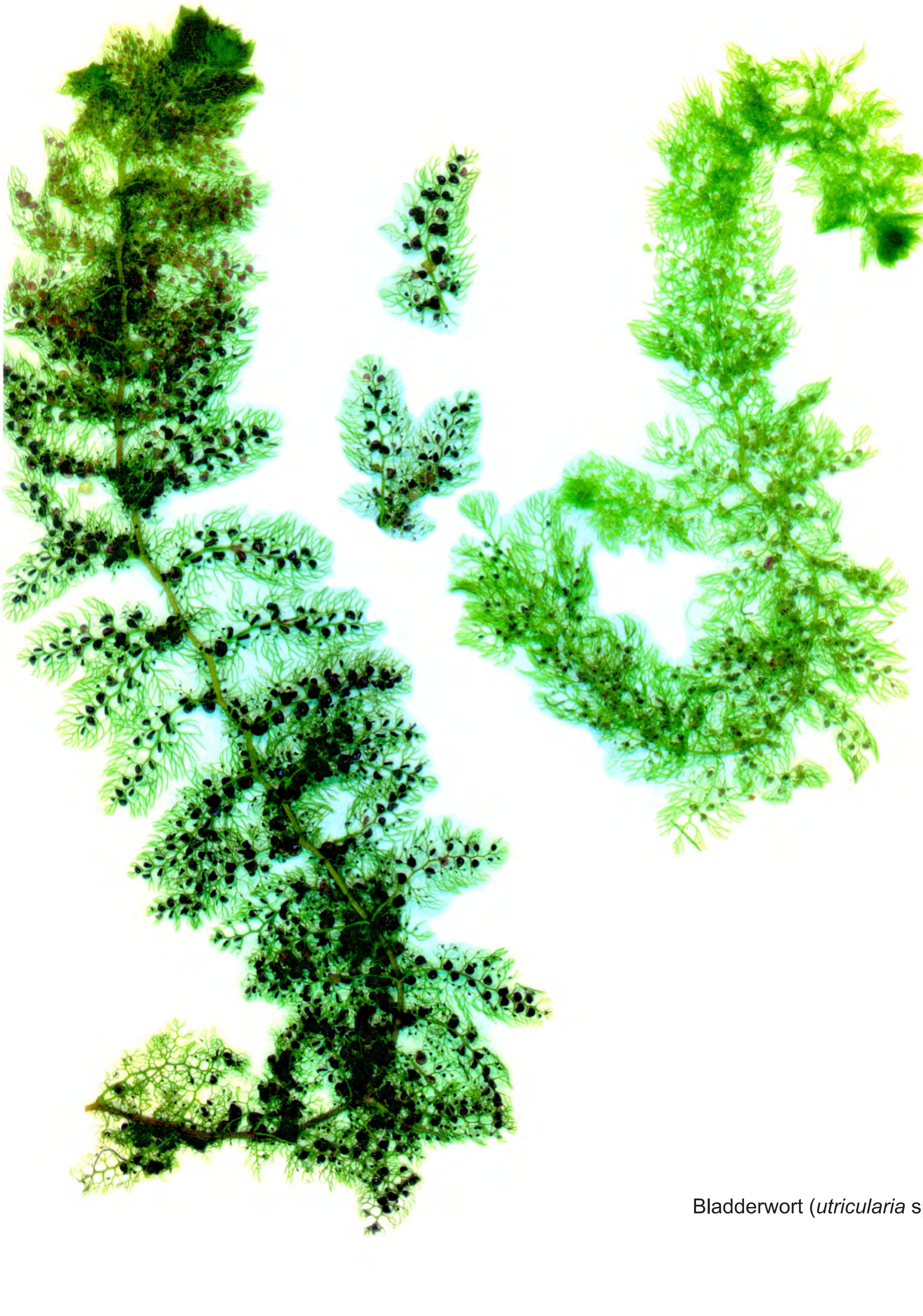
APPENDICES

(This Page Left Blank Intentionally)

Appendix A

REPRESENTATIVE ILLUSTRATIONS OF AQUATIC PLANTS FOUND IN THE LAUDERDALE LAKES

(This Page Left Blank Intentionally)



Bladderwort (*utricularia* sp.)

Bushy Pondweed (*najas flexilis*)

Clasping-Leaf Pondweed
(*potamogeton richardsonii*)

Coontail (*ceratophyllum demersum*)

Curly-Leaf Pondweed (*potamogeton crispus*)
Exotic Species (nonnative)

Eurasian Water Milfoil (*myriophyllum spicatum*)
Exotic Species (nonnative)

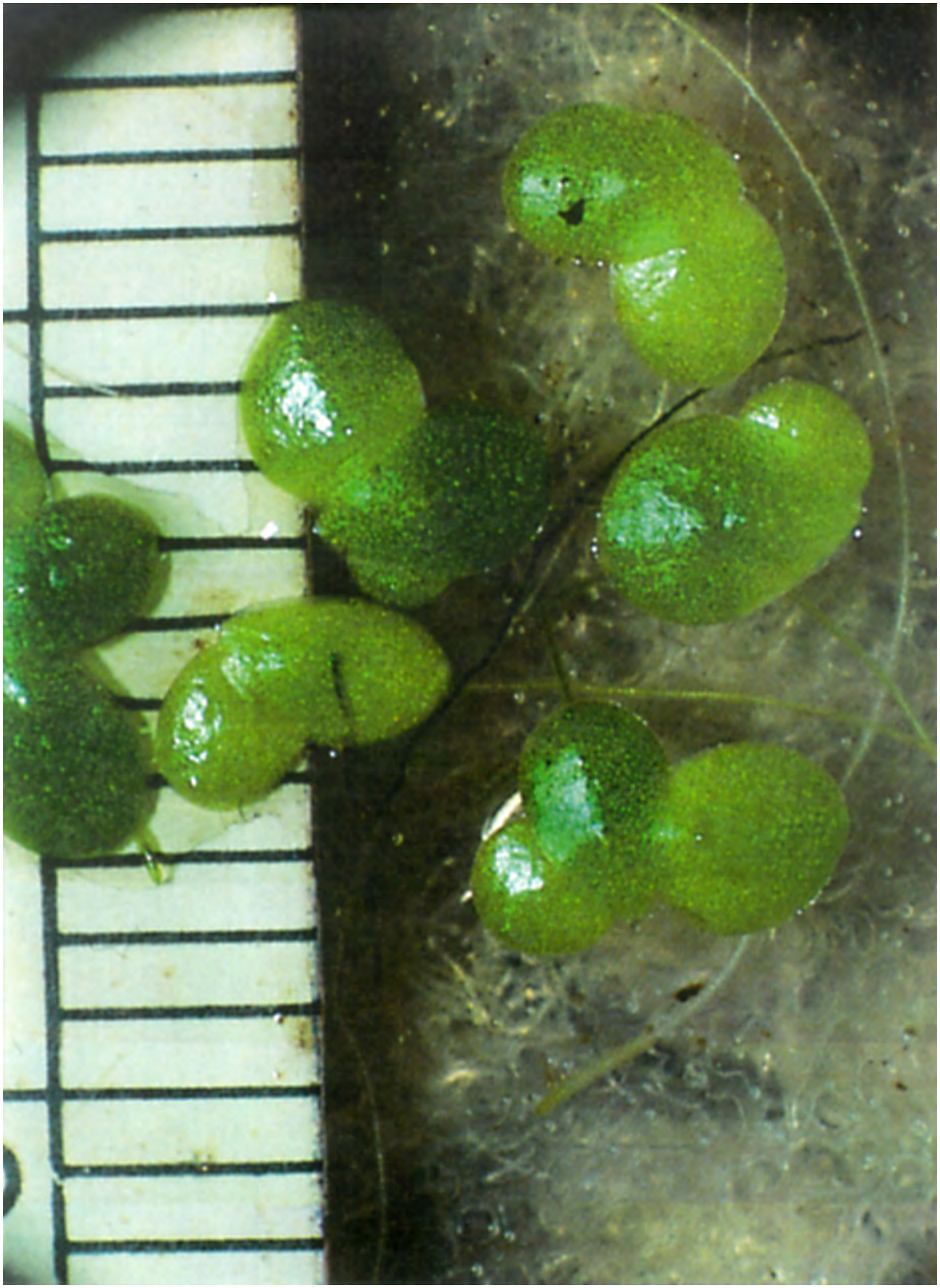
Flat-Stem Pondweed (*potamogeton zosteriformis*)

Floating-Leaf Pondweed (*potamogeton natans*)

Illinois Pondweed (*potamogeton illinoensis*)

Large-Leaf Pondweed (*potamogeton amplifolius*)

Leafy Pondweed (*potamofeton foliosus*)



Lesser Duckweed (*lemna minor*)

NOTE: Plant species in photograph are not shown proportionate to actual size

Source: Steve D. Eggers and Donald M. Reed, Wetland Plants and Plant Communities of Minnesota & Wisconsin*, 2nd Edition, 1997*

Long Leaved Pondweed
(*potamogeton nodosus*)

Muskgrass (*chara vulgaris*)

Native Water Milfoil (*myriophyllum* sp.)

Nitella (*nitella* spp.)

Sago Pondweed (*potamogeton pectinatus*)

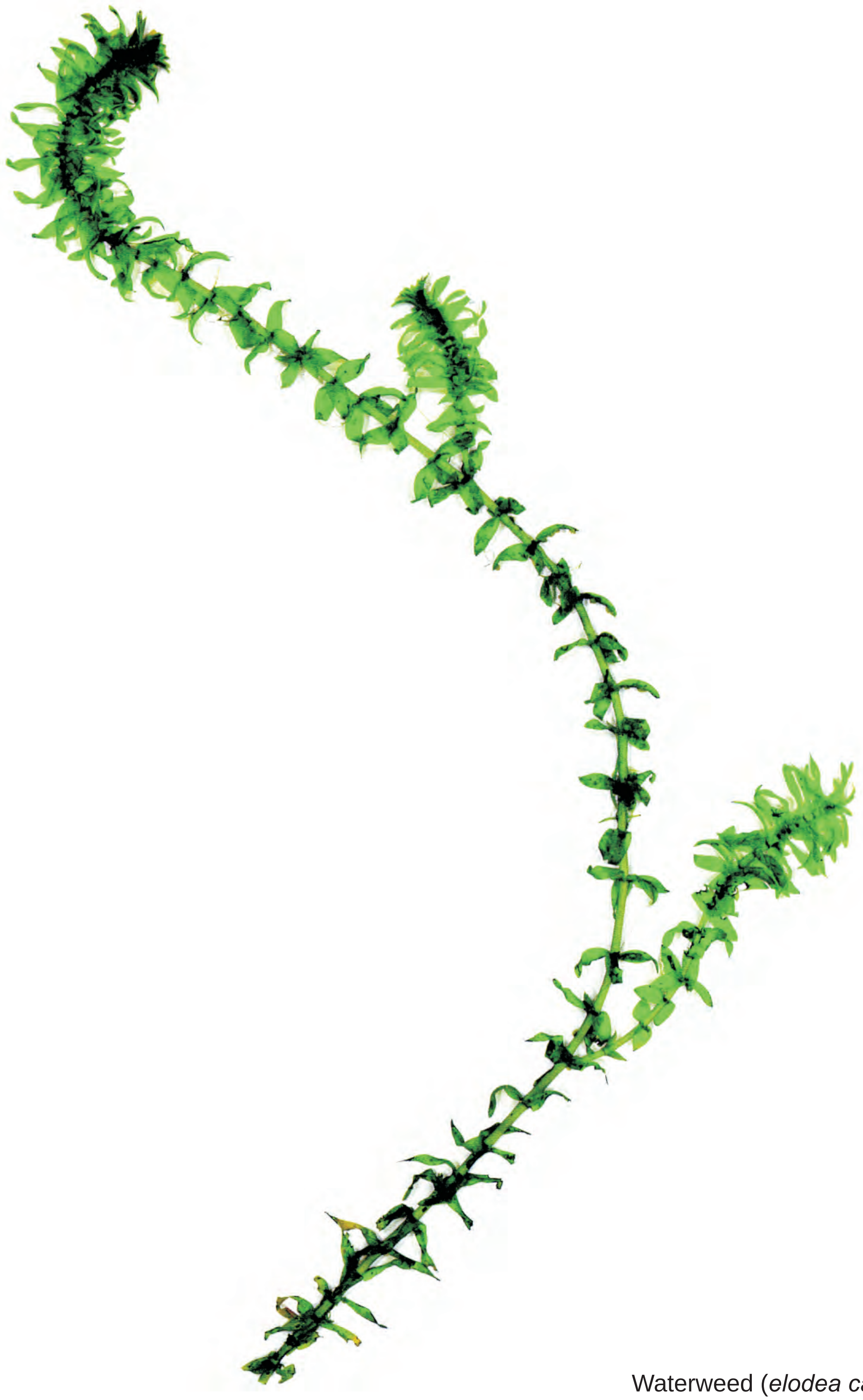
Small Bur Reed (*sparganium minimum*)

Small Pondweed (*potamogeton pusillus*)

Spiny Naiad (*najas marina*)

Variable Pondweed (*potamogeton gramineus*)

Water Stargrass (*zosterella dubia*)



Waterweed (*elodea canadensis*)

White Water Lily (*nymphaea odorata*)

Eel-Grass / Wild Celery (*valisneria americana*)

Yellow Water Lily (*nuphar variegatum*)

Appendix B

WISCONSIN DEPARTMENT OF NATURAL RESOURCES CHAPTER NR 107 SENSITIVE AREA REPORTS FOR THE LAUDERDALE LAKES

(This Page Left Blank Intentionally)

Lauderdale Lakes (Walworth County, Wisconsin)
Integrated Sensitive Area Report

Assessment Dates:	June 14, 1990 - Areas 1-5 July 7 and September 2, 2004 - Areas 6-7
Number of Sensitive Areas Surveyed:	7
Site Evaluators:	1990: Jerry Collins, Water Resources Specialist Doug Welch, Fisheries Biologist Bob Wakeman, Water Resource Manager Mark Anderson, Wildlife Biologist 2004: Pam Schense, Water Resources Specialist Doug Welch, Fisheries Biologist Heidi Bunk, Lakes Biologist Jim Jackley, Wildlife Biologist Dave Heilmeier, Town of LaGrange Scott Mason, Lauderdale Lakes Management District Rick Callaway, Town of LaGrange
Authors:	Pat Campfield, Water Resources Specialist Gabe Powers, Water Resources Specialist Heidi Bunk, Lakes Biologist

General Lake Information

The Lauderdale Lakes consist of a chain of three lakes - Green, Middle, and Mill Lakes - located in north-central Walworth County (Township 4 North, Range 16 East, Sections 25-26, 34-36 and Township 3 North, Range 16 East, Sections 1-2). The Lakes have a total surface area of 807 acres with maximum depths ranging from 42-55 feet. Middle and Mill Lakes are characterized as drainage lakes, fed primarily by groundwater, precipitation, and runoff. They have no major surface inlets. Green Lake is spring fed. Lake level of the Lauderdale Lakes is controlled by a dam and weir at a single surface-water outlet, Honey Creek.

The Lauderdale Lakes serve as "all sports" lakes, withstanding intense anthropogenic pressure. The shoreline is approximately 70 percent developed, including 1,010 houses. Three public boating access sites are located on the western shores of Green and Middle Lakes and the eastern shore of Mill Lake, meeting the requirement of "adequate public access" defined by NR 1.91(11), Wis. Adm. Code. There are five private recreational facilities offering boating access to the general public (SEWRPC 2001).

The Lakes have multiple recreational uses. These include fishing, water skiing, swimming, and small craft sailing in summer months and ice fishing, cross-country skiing, ice-skating, and hunting during winter. Throughout the year, the Lakes provide natural scenic beauty and opportunities for walking and jogging, bird watching, and picnicking.

Overall, the Lauderdale Lakes have a diverse fish population, including multiple “forage” and “non-game” fish species, and several "game" species. In a 1999 survey, the Wisconsin Department of Natural Resources observed 19 fish species: northern pike, grass pickerel, longnose gar, walleyed pike, largemouth bass, yellow perch, warmouth, bluegill, pumpkinseed, green sunfish, black crappie, rock bass, golden shiner, yellow bullhead, brown bullhead, bowfin, brook silverside, white sucker, and lake chubsucker (Welch 2000).

The lake chubsucker (*Erimyzon sucetta*) is listed as a State **species of special concern** (Lyons et al. 2000). Special Concern species are those in which reduced abundance or distribution is suspected but not yet proven. The main purpose of this category is to focus attention on certain species before they become threatened or endangered. *E. sucetta* relies on dense vegetation for cover throughout its life history. Large and small beds of aquatic moss and filamentous algae are preferred for spawning between late March and early July. Young lake chubsuckers feed on copepods, cladocerans (e.g., *Daphnia*), and midge larvae. Adult lake chubsuckers prey upon these same items, as well as algae, molluscs, and both larval and adult insects. It is a valuable forage fish and fry are a preferred food of largemouth bass (Becker, 1983). In areas where lake chubsucker habitat exists, preservation is highly recommended.

Fish habitat in the Lauderdale Lakes consists mostly of aquatic vegetation. Minimal woody debris, overhanging vegetation, and fallen timber exist along the lakeshore. The lack of natural fish habitat is due to the largely developed shoreline and associated “urbanized lakefront landscapes”. Remaining undeveloped shoreline provides critical habitat for fish, reptiles, amphibians, waterfowl, and small and large mammals.

Prime wildlife habitat exists on the Lauderdale Lakes where shoreline and waterfront areas remain natural or in areas where waterfront owners kept “natural corridors” in place. During urbanization of the Lakes, most developed properties retained some large trees, conserving the canopy. However, these owners also eliminated the sub-canopy and associated shrubbery. The sub-canopy provides important nesting, feeding, and cover habitat for multiple species. Consequently, most wildlife remaining in and around the Lauderdale Lakes are urban-tolerant species. The resident mammal population includes white-tailed deer, muskrats, cottontail rabbits, and some squirrels. Songbirds, wood ducks, mallards, and Canada geese are representative avian species. The remaining undeveloped areas associated with the Lakes provide the only balanced cover for a number of wildlife species.

The Lauderdale Lakes Lake Management District is the primary sponsor for aquatic plant management goals/plans on the lakes, currently controlling nuisance plants by harvesting and chemical treatment. In past aquatic plant studies of the entire Lauderdale Lakes chain, approximately 25 plant species were observed (SEWRPC 2001). In 1990, Department surveyors observed 10 native aquatic plant species in sensitive area 1, 8 native plant species in sensitive area 2, 18 native species in sensitive area 3, 13 native species in sensitive area 4, and 10 native species in sensitive area 5. In the 2004 survey, 10 native species occurred in sensitive area 6 and 12 native species in sensitive area 7. Three exotic species were observed in these sensitive areas. Eurasian watermilfoil (*Myriophyllum spicatum*) was observed in areas 1-6. Curly-leaf pondweed (*Potamogeton crispus*) was observed in sensitive areas 2-6, and purple loosestrife (*Lythrum salicaria*) was observed in sensitive areas 6-7.

Exotic Species

Southeastern Wisconsin lakes have been invaded by aquatic exotic species, most notably zebra mussels, Eurasian watermilfoil, and purple loosestrife. Most exotic species are introduced to a waterbody anthropogenically (e.g., transient boaters). The disturbance of lake substrate from human activity (boating, plant harvesting, chemical treatments, etc.) plays a significant role in the colonization and/or expansion of exotic species, particularly exotic plants.

Eurasian watermilfoil has established itself as one of the most common and abundant plants in the Lauderdale Lakes. It occurred in all but one of the sensitive areas. Eurasian watermilfoil is one of eight milfoil species currently found in Wisconsin. It is often misidentified as one of its seven native cousins, and vice versa. In many areas within the Lakes, this non-native milfoil has established large monocultures and out competed many native plants. These dense beds of milfoil not only impede the growth of native plant species but also inhibit fish movement and create navigational problems for boaters.

The regenerative ability of Eurasian milfoil is yet another obstacle when attempting to control this species. Fragments of Eurasian watermilfoil detached by harvesting, boating, and other recreational activities can float to non-colonized areas of the lake or downstream to additional lakes in the drainage system and create new colonies. Therefore, when controlling Eurasian watermilfoil, selective chemicals and harvesting, coupled with skimming, often produces the best results. In some lakes, biological agents such as the milfoil weevil have helped suppress milfoil populations. However, the most effective "treatment" of exotic milfoil is prevention through public education.

Curly-leaf pondweed is another submerged, exotic species found in the Lauderdale Lakes. Like Eurasian watermilfoil, curly-leaf grows into large, homogenous stands. It also crowds out native vegetation, creates navigational problems, and limits fish movement. Also, a unique life history characteristic of curly-leaf pondweed is that the plant dies off in mid-summer, increasing nutrient availability in the water column. This often contributes to summer algal blooms and decreasing water quality.

The unusual life cycle of curly-leaf pondweed makes management difficult. The plant germinates as temperatures decrease in Fall. Curly-leaf is highly tolerant of cold temperatures and reduced sunlight, continuing to grow under lake ice and snow cover. With ice-off and increasing water temperatures in the spring, the plant produces fruit, flowers, and buds (turions). Turions are the main reproductive mechanism of curly-leaf. To control the species in lakes, the plant must be combated before turions become viable. Most plant harvesters have not started cutting when curly-leaf is most susceptible and a small window of opportunity exists for chemical treatment. Therefore, <u>prevention</u> through public education is once again very important.

Purple loosestrife, a hardy perennial native to Europe, was desirable primarily as an ornamental plant but also marketed for bee keeping. It was transported in soil used as ballast during shipping. Since its introduction to North America in the early 1800s, purple loosestrife has become common in gardens and wetlands, and around lakes, rivers, and roadways. The species is highly invasive and thrives in disturbed areas. Monotypic stands of purple loosestrife out compete native plants, resulting in the destruction of food, cover, and nesting sites for wildlife and fish.

Purple loosestrife most often spreads when seeds adhere to animals. Humans should be aware of picking up seeds on clothing and equipment when in the vicinity of the plant. Loosestrife can be controlled manually, biologically, or with a broad-leaf herbicide. Young plants can be pulled, but adult plants have large root structures and must be excavated with a garden fork. Biological control is most effective on large stands of purple loosestrife. Five different insects are known to feed on this plant. Four of those have been used as control agents in the United States. Of the five species, *Galerucella pusilla* and *G. calmariensis* are leaf-eating beetles; *Nanophyes brevis* and *N. marmoratus* are flower-eating beetles; and *Hylobius trasversovittatus* is a root-boring weevil. Only *N. brevis* has not been released in the United States (WDNR 2003). Lastly and most importantly, <u>prevention</u> through public education plays an important role in the management of this species.

Shoreland Management

Wisconsin's Shoreland Management Program, a partnership between state and local governments, works to protect clean water, habitat for fish and wildlife, and natural scenic beauty. The program establishes minimum standards for lot sizes, structural setbacks, shoreland buffers, vegetation removal, and other activities within the shoreland zone. The shoreland zone includes land within 1000 feet of lakes, 300 feet of rivers, and floodplains. Current research shows that present standards are probably inadequate for the protection of water resources (Woodford and Meyer 2003, Garn 2002). Therefore, many communities have chosen to go beyond minimum standards to ensure protection of our natural resources. This report provides management guidelines for activities within the lake and in the immediate shoreland areas. Before any recommendations in this report are completed, please check with the Department of Natural Resources and local units of government for required approvals.

A vital step in protecting our water resources is to maintain effective vegetative buffers. A shoreland buffer should extend from the water onto the land at least 35 to 50 feet. Studies have shown that buffers less than 35 feet are not effective in reducing nutrient loading. Wider buffers of 50 feet or more can help provide important wildlife habitat for songbirds, turtles, frogs, and other animals, as well as filter pollutants from runoff. In general, no mowing should occur in the buffer area, except perhaps in a viewing access corridor. The plant composition of a buffer should match the flora found in natural Wisconsin lakeshores. A buffer should include three layers - herbaceous, shrub, and tree.

In addition, the reader also should investigate other innovative ways to reduce the impacts of runoff flowing into the lake while improving critical shoreline habitat (see A. Greene 2003). This may include the use of phosphorus-free fertilizers, installing rain gardens, setting the lawnmower at a higher mower height, decreasing the area of impervious surfaces, or restoring aquatic plant communities.

Introduction

Department personnel conducted Lauderdale Lakes sensitive area designation surveys on June 14, 1990 and July 7 and September 2, 2004, following the Wisconsin Department of Natural Resources' sensitive area survey protocol. This study utilized an integrated team of DNR resource managers with input from multiple disciplines: water regulation, water chemistry, fisheries, lake biology, and wildlife.

Sensitive areas are defined in Wisconsin Administrative Code NR 107.05 (3)(i)(1) as *areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or life stage requirements, or offering water quality or erosion control benefits to the body of water*. Department resource managers determined that five areas met this definition in 1990. Two additional areas were added in 2004 (Fig. 1). Their recommendations on future management of these areas are included below.

The companion document, *Guidelines for Protecting, Maintaining, and Understanding Lake Sensitive Areas*, provides additional information to help interpret lake sensitive area reports. This document is designed to help people understand the important factors that determine the health of a lake’s ecosystem. It discusses aquatic plant sensitive areas, shoreland use and lakeshore buffers, gravel and coarse rock rubble habitat, large woody cover, and various water regulation and zoning issues.

Overview of Sensitive Area Designations

Sensitive areas often have aquatic or wetland vegetation, terrestrial vegetation, gravel or rubble lake substrate, or areas that contain large woody cover (fallen trees or logs). These areas provide water quality benefits to the lake, reduce shoreline erosion, and provide habitat necessary for seasonal and/or life stage requirements of fish, invertebrates, and wildlife. A designated sensitive area alerts interested parties (i.e., DNR personnel, county zoning personnel, lake associations, etc.) that the area contains critical habitat vital to sustaining a healthy lake ecosystem or may feature an endangered plant or animal. Information presented in a sensitive area report may discourage certain permits from being approved within these sites.

Whole Lake Recommendations:

Several recommendations from Department staff pertain to the Lauderdale Lakes chain as a whole rather than to individual sensitive areas:

1. The aquatic plant community in the Lauderdale Lakes is not highly diverse outside of the sensitive areas. Native aquatic plant beds should be protected and maintained.
2. Prevent the spread of exotic species through sign postings, education, etc. and control exotic species where established.
3. Comply with State and Local Shoreland Zoning standards by maintaining no-cut buffers and setbacks, removing non-conforming structures, and limiting impervious surfaces.
4. Create shoreland buffers and maintain existing buffers, especially in areas not currently developed.
5. Monitor water quality for early detection of changes and possible degradation.

Resource Value of Sensitive Area Site 1 – Lauderdale Lakes

Sensitive area 1 is located on the southwest end of Green Lake and is unique to the Lauderdale Lakes (Fig. 2). Water lilies in the bay may shade out Eurasian watermilfoil. Eurasian watermilfoil only is present on the outer edge of the bay. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of the Lauderdale Lakes. The substrate in the bay is muck. This area has not been the target of plant control activities.

The bay acts as a sediment and nutrient trap for the lake, enhancing water quality. Aquatic vegetation (Table 1) helps control shoreline erosion. It also provides northern pike, largemouth bass, bluegill, and forage fish (suckers and minnows) with spawning, nursery, and foraging habitat (Table 2).

The extensive development of the Lauderdale Lakes area has reduced available wildlife habitat. However, ducks, herons, bittern, songbirds, muskrat, and opossum inhabit this portion of the lake the majority of the year.

Table 1. Plants observed in sensitive area 1.

	Emergent	Submergent	Free-floating	Exotic
PRESENT (0-25% Cover)	*Typha* (cattail) *Scirpus* (bulrush) *Carex* (sedges)	*Utricularia* (bladderwort) *Ceratophyllum* (coontail) *Stuckenia pectinata* (sago pondweed) *P. praelongus* (white-stemmed pondweed)	*Nymphaea odorata* (white water lily) *Nuphar advena* (yellow water lily) *Lemna* (duckweed)	*Myriophyllum spicatum* (Eurasian watermilfoil)
COMMON (26-50% Cover)				
ABUNDANT (51-75% Cover)				
DOMINANT (76-100% Cover)				

Table 2. Sensitive area 1 habitat (plants and substrates) utilized by resident fish species of the Lauderdale Lakes (1999 survey).

Fish Species	Spawning	Nursery	Feeding	Protective Cover
Northern Pike	cattail	cattail, water lily, coontail, milfoil, sago	water lily, coontail, milfoil, sago	water lily, coontail, milfoil, sago
Largemouth Bass	coontail, milfoil	cattail, water lily, coontail, milfoil, sago	water lily, coontail, milfoil, sago	water lily, coontail, milfoil, sago
Rock Bass	coarse sand or gravel	cattail, water lily, coontail, milfoil, sago	sago, milfoil	sago, milfoil
Bluegill and Pumpkinseed	sand/gravel	cattail, water lily, coontail, milfoil, sago, clasping leaf	water lily, coontail, milfoil, sago, clasping leaf	water lily, coontail, milfoil, sago, clasping leaf
Black Crappie	fine gravel and sand	water lily, coontail, milfoil, sago	sago, milfoil	sago, milfoil
Yellow Perch	cattail, coontail, milfoil, sago	water lily, coontail, milfoil, sago	sago, milfoil	sago, milfoil

* Shaded rows identify fish species found in the Lauderdale Lakes but not specifically observed in this SA.

Management Recommendations for Sensitive Area #1

1. No chemical treatment will be permitted.

2. Mechanical control allowed with the following condition:
   Restrict harvesting to a 25-foot wide navigational channel from the boat launch to open water.

3. None of the following in-lake activities allowed:
   - Filling
   - Aquatic plant screens
   - Wetland alterations
   - Boardwalks
   - Pea gravel/sand blankets

4. The following in-lake activities may allowed with conditions:
   - Dredging only in navigational channel from boat launch.

5. Strictly enforce shoreland and wetland ordinances.

6. Efforts should be undertaken to create and enforce ordinances, and educate developers on preventing erosion. A "No-Wake Zone" should be implemented.

Resource Value of Sensitive Area Site 2 – Lauderdale Lakes

Sensitive area 2 consists of a small bay on the north shore of Middle Lake that is dominated by *Decodon* (water willow) (Fig. 3). Its quiet water and proximity to upland areas are important to the Lakes. *Decodon* acts as a buffer for runoff entering the bay. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of the Lauderdale Lakes.

The bay acts as a sediment and nutrient trap for the lake, enhancing water quality. The substrate is primarily silt and muck in open water areas. Aquatic vegetation helps control shoreline erosion (Table 3). It also provides northern pike, largemouth bass, and bluegill with spawning, nursery, and foraging habitat (Table 4). The bay is often not navigable by boat.

This area is not critical to fisheries in the Lakes. It is extremely important to wildlife. The extensive development of the Lauderdale Lakes has reduced available wildlife habitat. However, herons, bittern, songbirds, muskrat, and opossum inhabit this portion of the lake during the majority of the year. The upland woods located west of the bay are valuable to migratory songbirds.

Table 3. Plants observed in sensitive area 2.

	Emergent	Submergent	Exotic	Algae
PRESENT (0-25% Cover)		*Vallisneria* (wild celery) *P. praelongus* (white-stemmed pondweed) *P. zosteriformis* (flat-stemmed pondweed) *Elodea* (waterweed)	*Myriophyllum spicatum* (Eurasian watermilfoil) *P. crispus* (curly-leaf pondweed)	filamentous algae
COMMON (26-50% Cover)		**Submergents** *Chara* (muskgrass)	**Free-floating** *Nuphar* (yellow water lily)	
ABUNDANT (51-75% Cover)				
DOMINANT (76-100% Cover)	*Decodon* (water willow)			

Table 4. Sensitive area 2 habitat (plants and substrates) utilized by resident fish species of the Lauderdale Lakes (1999 survey).

Fish Species	Spawning	Nursery	Feeding	Protective Cover
Northern Pike	*Chara*	water lily, *Chara*, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Largemouth Bass	milfoil	water lily, *Chara*, wild celery, milfoil	water lily, wild celery, milfoil	water lily, wild celery, milfoil
Rock Bass		water lily, *Chara*, wild celery, milfoil	milfoil	milfoil
Bluegill and Pumpkinseed		water lily, *Chara*, wild celery, milfoil	water lily, wild celery, milfoil	water lily, wild celery, milfoil
Black Crappie	*Chara*	water lily, *Chara*, wild celery, milfoil	milfoil	milfoil
Yellow Perch	milfoil	water lily, *Chara*, wild celery, milfoil	milfoil	milfoil

Management Recommendations for Sensitive Area # 2

1. No chemical treatment will be permitted.

2. No mechanical harvesting will be permitted.

3. None of the following in-lake activities allowed:

Filling	Pea Gravel/Sand Blankets
Aquatic plant screens	Dredging
Wetland alterations	Boardwalks

4. Strictly enforce shoreland and wetland ordinances.

5. Efforts should be undertaken to create and enforce ordinances, and educate developers on preventing erosion.

Resource Value of Sensitive Area Site 3 – Lauderdale Lakes

This is the largest of the sensitive areas on the Lakes, consisting of the western third of Middle Lake (Fig. 4). The area contains the greatest diversity of emergent, submergent, and floating plants within the Lakes, including wild rice. Water lilies, logs, stumps, and vegetation provide cover for fish. The abundance and diversity of native pondweed species (*Potamogeton* spp.) provide essential cover for a variety of fish species. This is excellent spawning and nursery habitat for largemouth bass, bluegill, and pumpkinseed. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of the Lauderdale Lakes.

The area acts as a sediment and nutrient trap for the lake, enhancing water quality. The substrate is sand, silt, and muck. The area is unique because it contains valuable spawning habitat for sunfish. Aquatic vegetation (Table 5) also provides northern pike, largemouth bass, bluegill, and forage fish with spawning, nursery, and foraging habitat (Table 6).

The extensive development of the Lauderdale Lakes has reduced available wildlife habitat. However, ducks, geese, herons, bittern, songbirds, muskrat, and opossum inhabit this portion of the lake during certain periods of the year. The boundaries of this sensitive area expanded between the study conducted in 1990 and the study conducted in 2004. The wild rice bed expanded to the north and the east. This change will affect 13 riparian landowners.

Table 5. Plants observed in sensitive area 3.

	Emergents	**Submergents**	**Free-floating**	**Algae**
PRESENT (0-25% Cover)	*Decodon* (water-willow) *Typha* (cattail) *Scirpus* (bulrush) *Carex* (sedges)	*Myriophyllum sibiricum* (northern watermilfoil) *Elodea* (waterweed), *Najas flexilis* (slender naiad) *Chara* (muskgrass) *Vallisneria* (wild celery) *Utricularia* (bladderwort)	*P. natans* (floating-leaf pondweed) *Nuphar advena* (yellow water lily) *Nymphaea* (white water lily) **Exotics** *Myriophyllum spicatum* (Eurasian watermilfoil) *P. crispus* (curly-leaf pondweed)	filamentous algae
COMMON (26-50% Cover)		*P. zosteriformis* (flat-stemmed pondweed) *Stuckenia pectinata* (sago pondweed) *P. illinoensis* (Illinois pondweed)		
ABUNDANT (51-75% Cover)	*Zizania* (wild rice)			
DOMINANT (76-100% Cover)				

Table 6: Sensitive area 3 habitat (plants and substrates) utilized by resident fish species of the Lauderdale Lakes (1999 survey).

Fish Species	Spawning	Nursery	Feeding	Protective Cover
Northern Pike	*Chara*	*Chara*, water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Largemouth Bass	milfoil sand	water lily, *Chara*, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds, woody debris	water lily, wild celery, milfoil, pondweeds, woody debris
Rock Bass		water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil
Bluegill and Pumpkinseed	sand	water lily, *Chara*, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Black Crappie	*Chara* sand	water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil, woody debris	pondweeds, milfoil, woody debris
Yellow Perch	woody debris, milfoil, pondweeds	water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil

Management Recommendations for Sensitive Area # 3

1. Chemical treatment is not permitted except to target an infestation of an exotic species such as purple loosestrife, Eurasian water milfoil or curly leaf pondweed.

2. Restrict mechanical harvesting to a navigational channel along the developed shoreline but only after spawning activities have finished.

3. A DNR permit should not be issued for any of the following:
   Filling
   Aquatic plant screens
   Dredging along the undeveloped area
   Wetland dredging, filling or cutting
   Boardwalks

4. The following in-lake activities may be allowed with conditions:
   Dredging a navigational channel along the currently developed shoreline
   Pea gravel/sand blankets along the currently developed shoreline

5. Maintain the “No-Wake Zone”.

6. Recommendations regarding **local zoning** along the currently <u>undeveloped</u> shoreline:
   - Strictly enforce shoreland and wetland ordinances
   - Restrict/limit subdivision of existing undeveloped parcels
   - Require a buffer/"no touch" zone for grading projects. This buffer/"no touch" zone should be at least 200 feet from the edge of the wetland back into the (landward) upland portion of parcels.
   - Require a buffer/"no touch" zone for grading projects located along steep slopes. The zone should extend at least 200 feet from the edge of a steep slope towards the landward side of the parcel.
   - Grading proposals should be strictly examined for superior erosion control and nutrient management plans.

Resource Value of Sensitive Area Site 4 – Lauderdale Lakes

This is a shallow (<5 feet) area adjacent to a wetland on the southwestern shore of Mill Lake (Fig. 5). Large-leaf pondweed is abundant here. The aquatic plant community is not unusually valuable, except for the large-leaf pondweed (Table. 7). However, the proximity of aquatic plants to the wetland improves the overall value of this area. See Appendix 1 for a complete list of aquatic plants found in the sensitive areas of the Lauderdale Lakes.

Northern pike use the area for spawning, while the large amount of cover provides shelter for waterfowl. Aquatic vegetation provides northern pike, largemouth bass, bluegill, and forage fish with spawning, nursery, and foraging habitat (Table 8).

The wetland provides a buffer for runoff entering the lake. It traps sediment and nutrients, enhancing water quality. Aquatic vegetation helps control shoreline erosion.

The extensive development of the Lauderdale Lakes has reduced available wildlife habitat. However, this area is locally important as fish and wildlife habitat. Herons, bittern, songbirds, muskrat, and opossum inhabit this portion Mill Lake during the majority of the year.

Table 7. Plants observed in sensitive area 4.

	Emergents	**Submergents**	**Free-floating**
PRESENT (0-25% Cover)	*Decodon* (water-willow) *Typha* (cattail) *Scirpus* (bulrush) *Carex* (sedges)	*Elodea* (waterweed), *Najas flexilis* (slender naiad) *Chara* (muskgrass) *Vallisneria* (wild celery) *P. zosteriformis* (flat-stemmed pondweed) *P. illinoensis* (Illinois pondweed)	*Nuphar advena* (yellow water lily) *Nymphaea* (white water lily) **Exotics** *Myriophyllum spicatum* (Eurasian watermilfoil) *P. crispus* (curly-leaf pondweed)
COMMON (26-50% Cover)			
ABUNDANT (51-75% Cover)		*P. amplifolius* (large-leaf pondweed)	
DOMINANT (76-100% Cover)			

Table 8: Sensitive area 4 habitat (plants and substrates) utilized by resident fish species of the Lauderdale Lakes (1999 survey).

Fish Species	Spawning	Nursery	Feeding	Protective Cover
Northern Pike	*Chara*	*Chara*, water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Largemouth Bass	milfoil	water lily, *Chara*, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Rock Bass		water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil
Bluegill and Pumpkinseed		water lily, *Chara*, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Black Crappie	*Chara*	water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil, woody debris
Yellow Perch	milfoil, pondweeds	water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil

Management Recommendations for Sensitive Area # 4

1. No chemical treatment permitted.

2. Restrict mechanical harvesting to a navigational channel extending from piers.

3. None of the following in-lake activities allowed:
   Filling
   Aquatic plant screens
   Wetland alterations
   Boardwalks
   Dredging
   Pea gravel/sand blankets

4. Strictly enforce shoreland and wetland ordinances.

5. Efforts should be undertaken to create and enforce ordinances, and educate developers on preventing erosion. A “No-Wake Zone” should be implemented.

Resource Value of Sensitive Area Site 5 – Lauderdale Lakes

This area of the Lauderdale Lakes is located between Treasure Island and the Lauderdale Country Club Golf Course (Fig. 6), in Don Jean Bay. The area has large beds of large-leaf pondweed. The pondweed bed on the extreme western shore of the island should be protected from any removal activities. There is good shoreline cover consisting of woody growth and the north side of the island is excellent for wildlife.

There is little water flow through the area and the substrate is soft muck/silt. The area acts as a sediment and nutrient trap for the lake, enhancing water quality.

Aquatic vegetation (Table 9) controls shoreline erosion and provides northern pike, largemouth bass, bluegill, and forage fish with spawning, nursery, and foraging habitat (Table 10). See Appendix 1 for a complete list of aquatic plants found in sensitive areas of the Lauderdale Lakes.

The extensive development of the Lauderdale Lakes has reduced available wildlife habitat. Ducks, geese, herons, bittern, songbirds, muskrat, and opossum inhabit this portion of Mill Lake during the majority of the year.

Table 9. Plants observed in sensitive area 5.

	Emergents	**Submergents**	**Free-floating**	**Algae**
PRESENT (0-25% Cover)	*Typha* (cattail)	*Elodea* (waterweed) *Najas flexilis* (slender naiad) *Chara* (muskgrass) *Vallisneria* (wild celery) *P. zosteriformis* (flat-stemmed pondweed)	*P. natans* (floating-leaf pondweed) *Nuphar advena* (yellow water lily) **Exotics** *Myriophyllum spicatum* (Eurasian watermilfoil) *P. crispus* (curly-leaf pondweed)	filamentous algae
COMMON (26-50% Cover)				
ABUNDANT (51-75% Cover)				
DOMINANT (76-100% Cover)		*P. amplifolius* (large-leaf pondweed)		

Table 10: Sensitive area 5 habitat (plants and substrates) utilized by resident fish species of the Lauderdale Lakes (1999 survey).

Fish Species	Spawning	Nursery	Feeding	Protective Cover
Northern Pike	*Chara*	*Chara*, water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Largemouth Bass	milfoil	water lily, *Chara*, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Rock Bass		water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil
Bluegill and Pumpkinseed		water lily, *Chara*, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds	water lily, wild celery, milfoil, pondweeds
Black Crappie	*Chara*	water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil
Yellow Perch	milfoil, pondweeds	water lily, *Chara*, wild celery, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil

Management Recommendations for Sensitive Area # 5

1. No chemical treatment permitted.

2. Restrict mechanical harvesting to a navigational channel extending from piers and only after spawning has ended. No large-leaf or floating-leaf pondweed may be harvested.

3. None of the following in-lake activities allowed:
   Filling/dredging
   Aquatic plant screens
   Wetland alterations
   Boardwalks
   Pea gravel/sand blankets

4. Strictly enforce shoreland and wetland ordinances.

5. Efforts should be undertaken to create and enforce ordinances, and educate developers on preventing erosion. A “No-Wake Zone” should be implemented.

Resource Value of Sensitive Area Site 6 – Lauderdale Lakes

Sensitive area 6 is located on the northwest corner of Mill Lake and is unique to the Lauderdale Lakes (Figure 7). The area consists of a shallow bay with abundant *Sagittaria* (arrowhead), an emergent plant providing cover for young fish and valuable food for migratory waterfowl. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of the Lauderdale Lakes.

The substrate is primarily silt and muck in open water areas with more detritus along the shoreline. The bay acts as a sediment and nutrient trap for the lake, enhancing water quality. Aquatic vegetation helps control shoreline erosion (Table 11). It also provides northern pike, largemouth bass, bluegill, yellow perch, and forage fish with spawning, nursery, and foraging habitat (Table 12). The area is not favorable to bluegill spawning due to the silt present. However, submergent vegetation provides excellent sites for northern pike and yellow perch to deposit eggs.

The extensive development of the Lauderdale Lakes has reduced available wildlife habitat. However, this sensitive area is extremely important for wildlife. Ducks, herons, bittern, songbirds, reptiles, frogs, muskrat, mink, shrews, and voles inhabit this portion of the lake during the majority of the year. The wetland is quite diverse, containing jewelweed, boneset, sedges, sweet flag iris, mannagrass, canada bluejoint grass, marsh fern, bulrushes, bidens, great blue lobelia, blue flag iris, marsh dock, willow, dogwood, cattails, mint, marsh milkweed, arrowhead and coreopsis.

Table 11. Plants observed in the open water area of sensitive area 6.

	Emergents	**Submergents**	**Free-floating**	**Exotics**
PRESENT (0-25% Cover)	*Alisma* (water plantain) *Scirpus* (bulrush) *Decodon* (water-willow)	*Ceratophyllum* (coontail) *P. richardsonii* (clasping-leaf pondweed)	*Lemna* (duckweed) *Nuphar advena* (yellow water lily) *Nymphaea odorata* (white water lily)	*Myriophyllum spicatum* (Eurasian watermilfoil) *P. crispus* (curly-leaf pondweed) *Lythrum* (purple loosestrife)
COMMON (26-50% Cover)	*Carex* (sedges) *Typha* (cattail) *Sagittaria* (arrowhead)	*Najas flexilis* (slender naiad) *Utricularia* (bladderwort) *Vallisneria* (wild celery)		**Algae** filamentous algae
ABUNDANT (51-75% Cover)		*Chara* (muskgrass)	*Spirodela* (large duckweed)	
DOMINANT (76-100% Cover)				

Table 12. Sensitive area 6 habitat (plants and substrates) utilized by resident fish species of the Lauderdale Lakes (1999 survey).

Fish Species	Spawning	Nursery	Feeding	Protective Cover
Northern Pike	cattail	cattail, water lily, *Chara*, wild celery, coontail, milfoil, pondweeds	water lily, wild celery, coontail, milfoil, pondweeds	water lily, wild celery, coontail, milfoil, pondweeds
Largemouth Bass	coontail, milfoil	cattail, water lily, *Chara*, wild celery, coontail, milfoil, pondweeds	water lily, wild celery, coontail, milfoil, pondweeds	water lily, wild celery, coontail, milfoil, pondweeds
Rock Bass		cattail, water lily, *Chara*, wild celery, coontail, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil
Bluegill and Pumpkinseed		cattail, water lily, *Chara*, wild celery, coontail, milfoil, pondweeds	water lily, wild celery, coontail, milfoil, pondweeds	water lily, wild celery, coontail, milfoil, pondweeds
Black Crappie		water lily, *Chara*, wild celery, coontail, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil
Yellow Perch	cattail, coontail, milfoil, pondweeds	water lily, *Chara*, wild celery, coontail, milfoil, pondweeds	pondweeds, milfoil	pondweeds, milfoil

Management Recommendations for Sensitive Area #6

1. No chemical treatment, mechanical harvesting, mowing, or clear-cutting permitted in the wetland. Submergent vegetation within the existing channel (open water area only) may be harvested.

2. A DNR permit should not be issued for any of the following:
   - Filling
   - Dredging
   - Aquatic plant screens
   - Pea gravel/sand blankets
   - Wetland alterations

3. No alteration of littoral zone unless the activity improves spawning habitat.

4. Boardwalks will be permitted on a case by case basis to provide open water access only for a riparian landowner.

5. Chemical treatment is not permitted except to target an infestation of an exotic species such as purple loosestrife, Eurasian water milfoil or curly leaf pondweed.

6. Efforts should be undertaken to create and enforce shoreland and wetland ordinances, as well as educate developers on preventing erosion during construction. A "No-Wake Zone" should be implemented.

Resource Value of Sensitive Area Site 7 – Lauderdale Lakes

Sensitive area 7 consists of a shallow, sinuous waterway surrounding an island located between Middle and Mill Lakes (Figure 8). The area has a diverse plant community, including several emergent wetland species (sedges, rushes, and asters). It is unique in that it lacks Eurasian watermilfoil, an exotic species common elsewhere in the Lakes. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of the Lauderdale Lakes.

The bottom is composed of a few inches of silt with firm substrate underneath. Aquatic vegetation helps control shoreline erosion (Table 13). It also provides northern pike, largemouth bass, bluegill, yellow perch, and forage fish with spawning, nursery, and foraging habitat (Table 14). Submergent vegetation provides excellent sites for northern pike and yellow perch to deposit eggs. Limited but valuable spawning habitat is available for bass, bluegill, and pumpkinseed in substrate uncovered by the thin layer of silt.

The extensive development of the Lauderdale Lakes has reduced available wildlife habitat. However, this sensitive area is extremely important for wildlife. Ducks, herons, bittern, songbirds, reptiles, frogs, muskrat, mink, shrews, voles, and beaver inhabit this portion of the lake during the majority of the year. The island contains a high diversity of wetland plants. Plants observed include marsh fern, mannagrass, canada bluejoint, cattail, bulrush, sedges, spike rush, sweet flag, arrowhead, bidens, great blue lobelia, blue flag iris, blue vervain, marsh milkweed, water willow, goldenrod, boneset, coreopsis, willow, dogwood, and white aster.

Table 13. Plants observed in the open water area of sensitive area 7.

	Emergents	**Submergents**	**Free-floating**	**Exotics**
PRESENT (0-25% Cover)		*Chara* (muskgrass)		*P. crispus* (curly-leaf pondweed)
COMMON (26-50% Cover)	*Scirpus* (bulrush) *Eleocharis* (spike-rush) *Aster* (aster) *Acorus* (sweet flag) *Sagittaria* (arrowhead) *Typha* (cattail)			
ABUNDANT (51-75% Cover)		*Vallisneria* (wild celery) *Najas flexilis* (slender naiad) *P. zosteriformis* (flat-stemmed pondweed)	*Nymphaea odorata* (white water lily)	
DOMINANT (76-100% Cover)	*Carex* (sedges)			

Table 14: Sensitive area 7 habitat (plants and substrates) utilized by resident fish species of the Lauderdale Lakes (1999 survey).

Fish Species	**Spawning**	**Nursery**	**Feeding**	**Protective Cover**
Northern Pike	*Chara*	*Chara*, water lily, wild celery, pondweeds	water lily, wild celery, pondweeds	water lily, wild celery, pondweeds
Largemouth Bass	hard substrate	water lily, *Chara*, wild celery, pondweeds	water lily, wild celery, pondweeds	water lily, wild celery, pondweeds
Rock Bass		water lily, *Chara*, wild celery, pondweeds	pondweeds	pondweeds
Bluegill and Pumpkinseed		water lily, *Chara*, wild celery, pondweeds	water lily, wild celery, pondweeds	water lily, wild celery, pondweeds
Black Crappie	*Chara*	water lily, *Chara*, wild celery, pondweeds	pondweeds	pondweeds, woody debris
Yellow Perch	pondweeds	water lily, *Chara*, wild celery, pondweeds	pondweeds	pondweeds

Management Recommendations for Sensitive Area #7

1. No mechanical harvesting, mowing, or clear-cutting permitted.

2. Chemical treatment is not permitted except to target an infestation of an exotic species such as purple loosestrife, Eurasian water milfoil or curly leaf pondweed.

3. A DNR permit should not be issued for any of the following:

Filling	Boardwalks
Aquatic plant screens	Dredging
Wetland alterations	Pea gravel/sand blankets

4. No alteration of littoral zone unless the activity improves spawning habitat.

5. Maintain the "No-Wake" boating zone.

6. Efforts should be undertaken to create and enforce shoreland and wetland ordinances, as well as educate developers on preventing erosion during construction.

Conclusion

Seven sensitive areas have been designated. Sensitive area number 3 contains one of the highest quality shorelines in southeast Wisconsin. Development along the shoreline of each of the seven sensitive areas sensitive should be carefully studied to prevent the further loss of habitat in the Lauderdale Lakes chain. This sensitive area report identifies characteristics and management recommendations for each of the seven areas.

In Wisconsin, lakes attract many users and water quality in these lakes affects many more. The Lauderdale Lakes attract a diversity of user groups, inevitably creating conflict. An integrated approach that includes the public and all of the Lakes' governing units is essential. The objective is to create and maintain a balance between recreational use and preservation of habitat, which is essential to the Lakes' health. Improving or at least maintaining water quality in Wisconsin lakes is critical. By protecting and restoring habitat these resources will continue to provide ecosystem functions and responsible recreational opportunities for years to come.

Works Cited

Becker, G.C., 1983. Fishes of Wisconsin, *The University of Wisconsin Press*.

Borman, S., R. Korth, and J. Temte, 1997. Through the Looking Glass: A Field Guide to Aquatic Plants, *Wisconsin Lakes Partnership*.

Chapter 30, Wisconsin State Statute.

Garn, H. S. Effects of Lawn Fertilizer on Nutrient Concentration in Runoff from Lakeshore Lawns, Lauderdale Lakes, Wisconsin. USGS Water-Resources Investigations Report 02-4130, July 2002.

Greene, A. 2003. A Homeowners Guide to Native Shoreline Buffers, *Walworth County Publication.*

Lyons, J., P.A. Cochran, and D. Fago, 2000. Wisconsin Fishes 2000: Status and Distribution, *University of Wisconsin Sea Grant Institute*.

NR 1, 107, 109, Wisconsin Administrative Code.

Purple Loosestrife: What You Should Know, What You Can Do, *WDNR*, PUB-WT-276 2003.

Southeast Wisconsin Regional Planning Commission, 2001. An Aquatic Plant Management Plan for the Lauderdale Lakes.

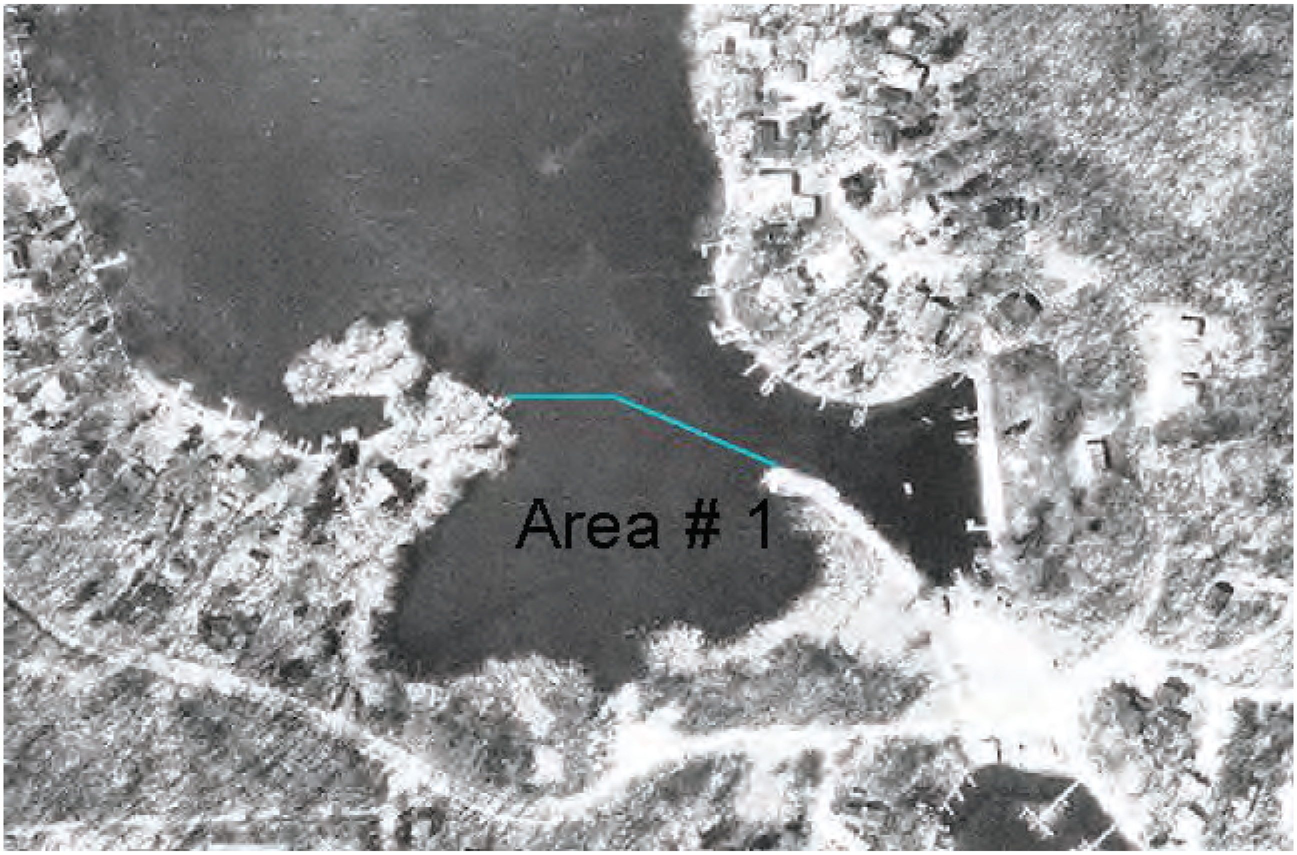
Welch, D.E. and R. Dauffenbach, 2000. Fisheries Survey Report for the Lauderdale Lakes (WBIC 0755500), Walworth County, *WDNR*.

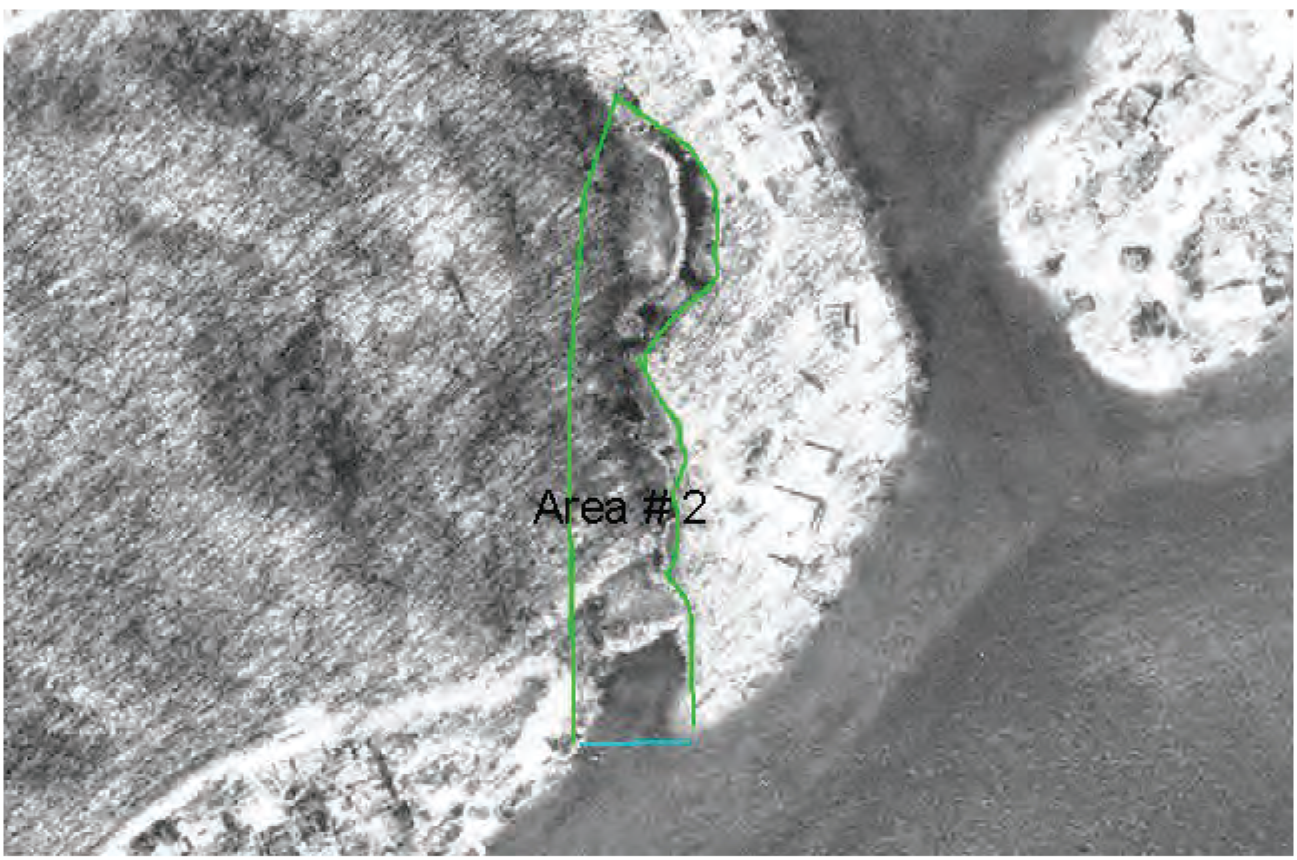
Woodford, J. E. and Meyer, M. W. Impact of Lakeshore Development on Green Frog Abundance. Biological Conservation 110 (2003), pp. 277-284

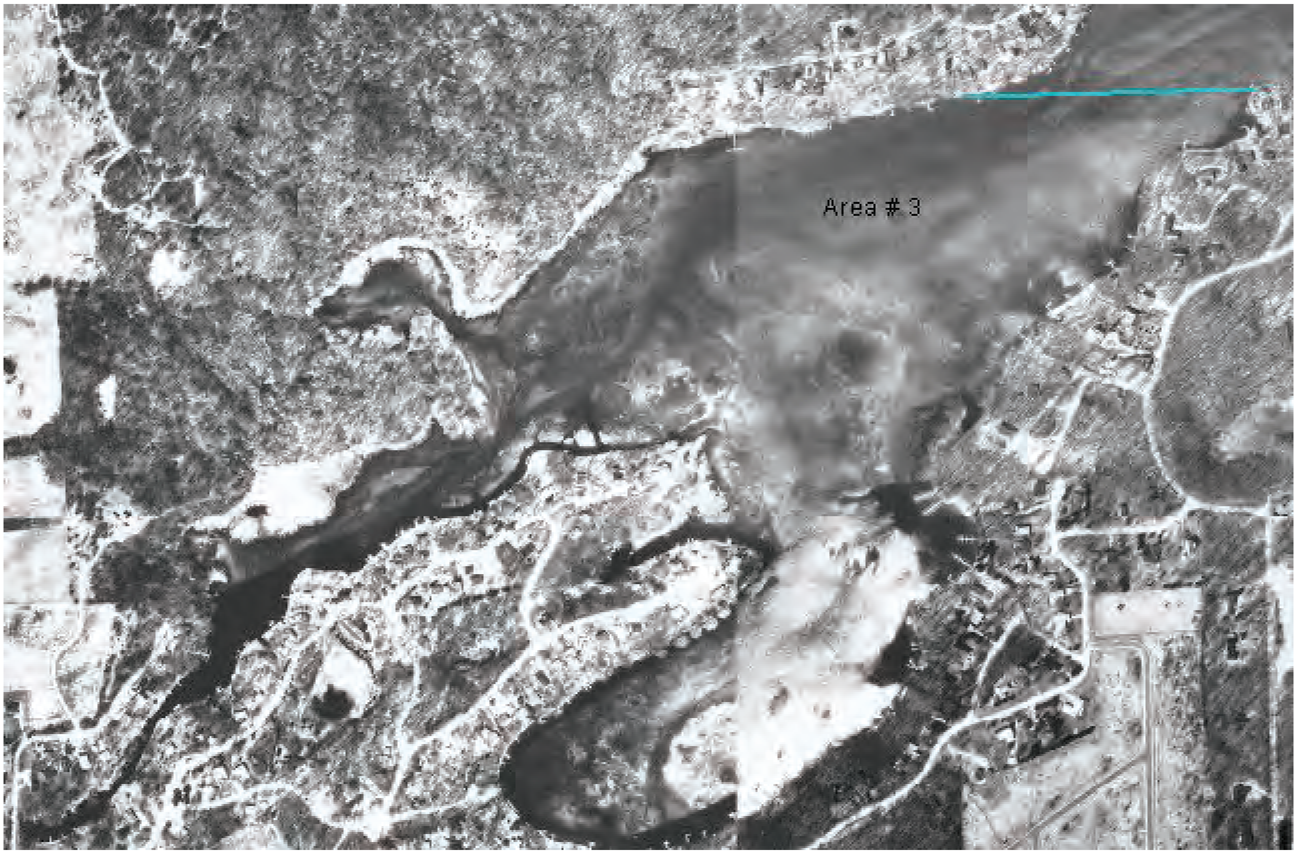
APPENDIX 1 - Aquatic plants within sensitive areas of the Lauderdale Lakes

Emergent	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 7**
Zizania (wild rice)			X				
Typha (cattail)	X		X	X	X	X	X
Scirpus (bulrush)	X		X	X		X	X
Eleocharis (spike-rush)							X
Carex (sedges)	X		X	X		X	X
Decodon (water-willow)		X	X	X		X	X
Alisma (water plantain)						X	
Sagittaria (arrowhead)						X	X
Acorus (sweet flag)						X	X
Aster (aster)						X	X
Thelypteris (marsh fern)						X	X
Glyceria (mannagrass)						X	X
Calamagrostis (Can. BG)						X	X
Bidens (Beggar Tick)						X	X
Lobelia (great blue)						X	X
Iris (Blue Flag)						X	X
Eupatorium (Boneset)						X	X
Mentha (mint)						X	
Asclepias (marsh milkweed)						X	X
Verbena (blue vervain)						X	X
Coreopsis						X	X
Impatiens (jewelweed)						X	
Rumex (marsh dock)						X	
Cornus (dogwood)						X	X
Solidago (goldenrod)							X

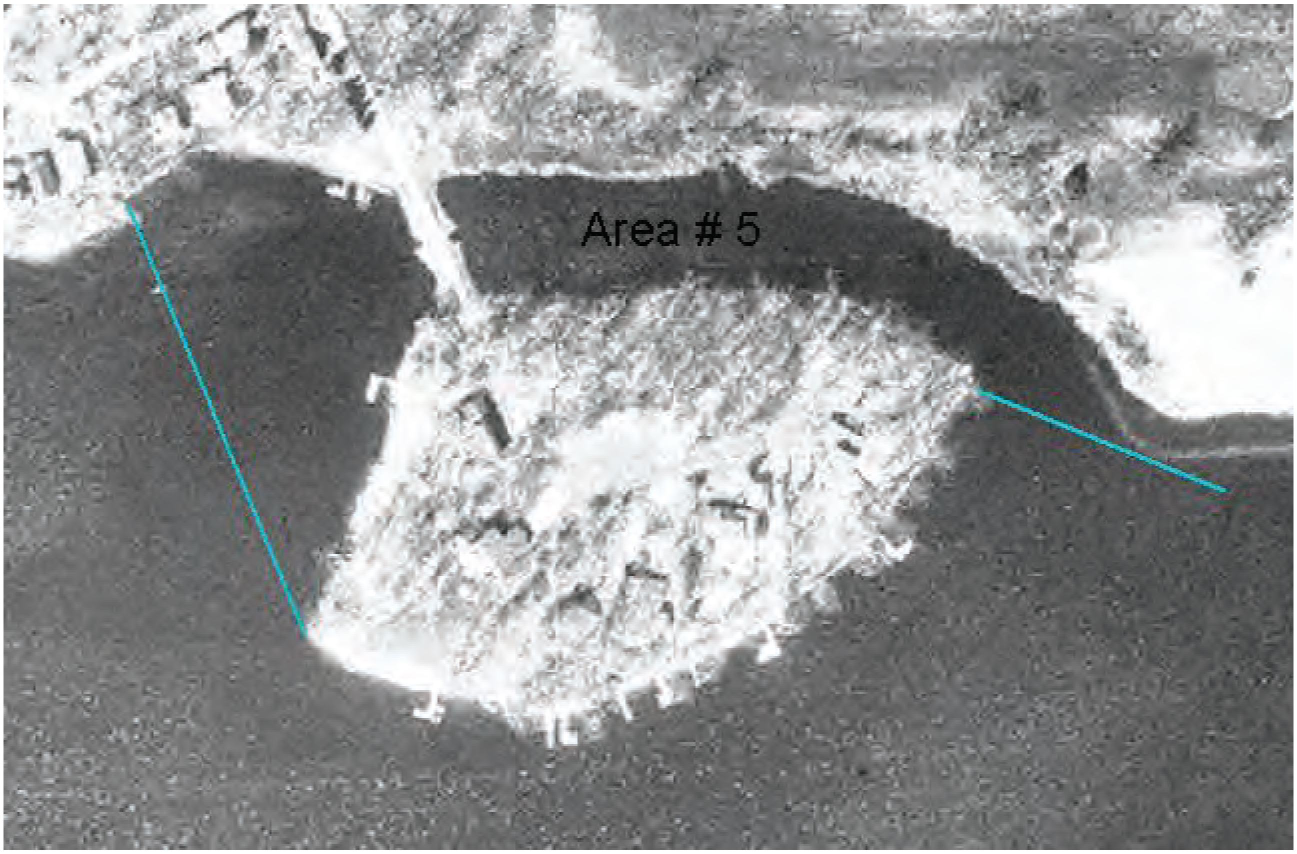
Submergent	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 7**
Myriophyllum sibiricum (northern watermilfoil)			X				
Chara (muskgrass)		X	X	X	X	X	X
Potamogeton amplifolius (large-leaf pondweed)				X	X		
Elodea (waterweed)		X	X	X	X		
Utricularia (bladderwort)	X		X			X	
Ceratophyllum (coontail)	X					X	
Stuckenia pectinata (sago pondweed)	X		X				
Vallisneria (wild celery)		X	X	X	X	X	X
P. zosteriformis (flat-stemmed pondweed)		X	X	X	X		X
P. illinoensis (Illinois pondweed)			X	X			
Najas flexilis (slender naiad)			X	X	X	X	X
P. praelongus (white-stemmed pondweed)	X	X					
P. richardsonii (clasping-leaf pondweed)						X	
Free-floating							
Nuphar advena (yellow water lily)		X	X	X	X	X	
Nymphaea odorata (white water lily)		X	X	X		X	X
P. natans (floating-leaf pondweed)			X		X		
Lemna (duckweed)						X	
Spirodela (large duckweed)						X	
Exotic							
Myriophyllum spicatum (Eurasian watermilfoil)	X	X	X	X	X	X	
P. crispus (curly-leaf pondweed)		X	X	X	X	X	X
Lythrum (purple loosestrife)						X	
Algae							
filamentous		X	X		X	X	

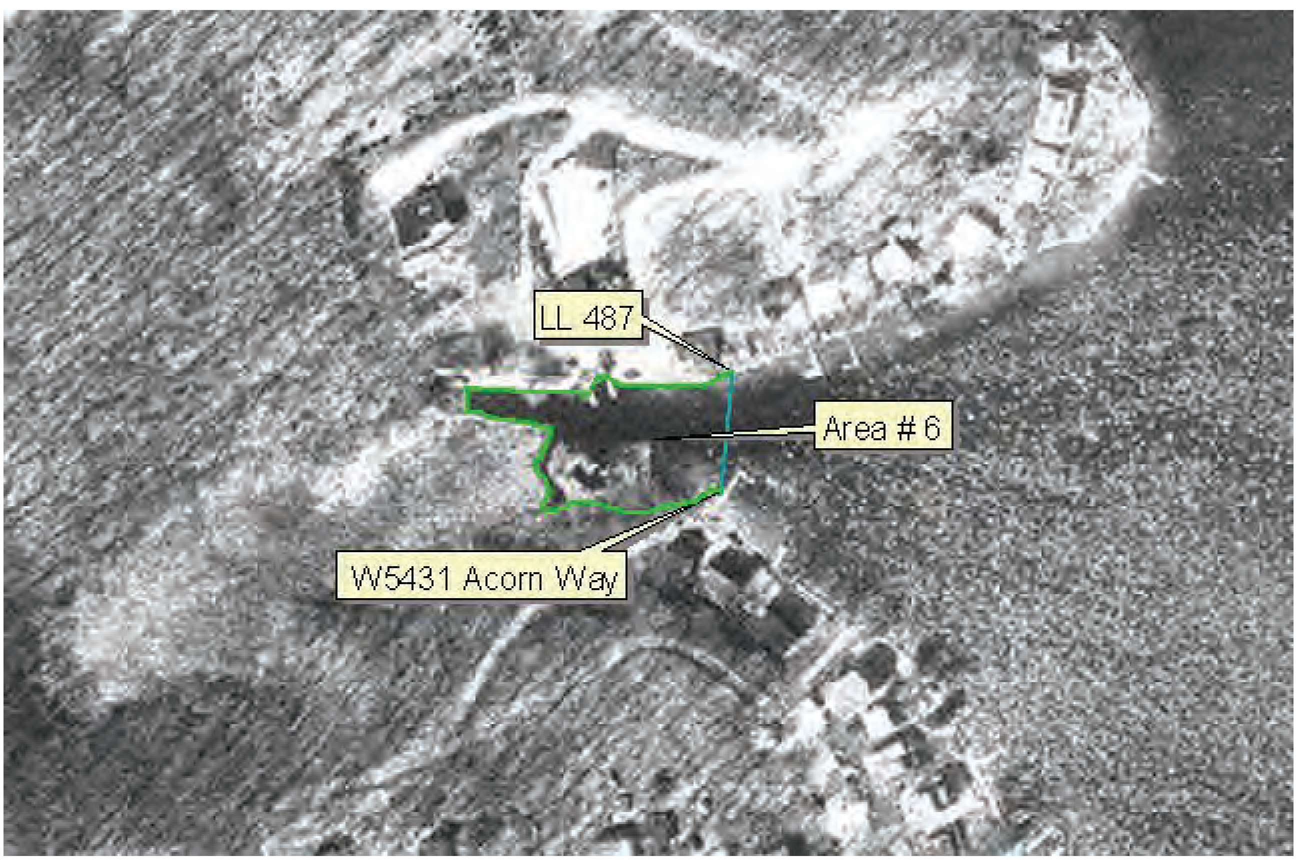

Area # 1


Area # 2


Area # 3


Area # 4


Area # 5


LL 487
Area # 6
W5431 Acorn Way


LL 535D (Brown House)
Area # 7
LL 528 (Green House)

(This Page Left Blank Intentionally)

Appendix C

TOWNS OF LA GRANGE AND SUGAR CREEK BOATING AND PIER ORDINANCES APPLICABLE TO THE LAUDERDALE LAKES

(This Page Left Blank Intentionally)

STATE OF WISCONSIN
TOWNS OF LAGRANGE & SUGAR CREEK
WALWORTH COUNTY

ORDINANCE NO. 2008-03
AN ORDINANCE TO REGULATE WHARFS, PIERS AND MOORING FACILITIES AND. ESTABLISH A PIERHEAD LINE FOR LAUDERDALE LAKES

WHEREAS, the placement of structures in and on Lauderdale Lakes may materially impact the health, safety and welfare of the public, environmental concerns relating to clean water, and aquatic habitat for fish and plant life, and recreational opportunities for all;

NOW, THEREFORE, the Town Boards of LaGrange and Sugar Creek enact this ordinance.

SECTION 1. DEFINITIONS
A. The definitions set forth in Section 30.01, Wis. Stats., as amended from time to time, are adopted by reference.

B. Mooring facility - means any allotted space, place or contrivance to which a single water craft is attached, secured or berthed, including, but not limited to, a mooring buoy, pier slip or shore station. By way of example, a pier of sufficient size to moor two (2) boats counts as two (2) mooring facilities.

C. Pier head line - means the distance into the water from the ordinary high water mark, as defined in NR 320.03(4), Wisconsin Administrative Code, in which area piers maybe allowed.

D.Raft - is any structure which floats on the water by means of inflation, barrels, logs, or similar means, and is not used for transportation.

SECTION II. PERMIT REQUIRED
No property owner, tenant, agent, business or person may do any of the following:0 construct;
• place;
• extend;
• enlarge;
• replace, except seasonal replacement; or
• repair an existing pier greater than 10% of its surface square feet in one year or more than 50% of the posts of a permanent pier in one year, a wharf, pier, or mooring facility in Lauderdale Lakes without obtaining a permit from the Town of LaGrange for the portion of the lakes in the Town of LaGrange and from the Town of Sugar Creek for the portion of the lakes in the Town of Sugar Creek.

• SECTION III. APPLICATION FOR PERMIT

Any person, firm, corporation or association desiring to erect, construct, place, extend or replace or repair to an extent defined in Section II any wharf, pier or mooring facility on or about the bed of Lauderdale Lakes along or beyond the shoreline as it exists or as it may have been determined and established by ordinance shall be required, regardless of other permits obtained, make and file a written application in the office of the Building Inspector of the Town of LaGrange or Town of Sugar Creek. The application shall contain the following information:

A. Describe the real estate, existing mooring facilities, and wharf, pier, mooring facility or extension thereof in detail;

B. The structures location in regard to the shoreline and pier head line;

C. Distances to all property lines of the abutting riparian lands;

D. Details of the dimensions and kinds of materials, together with drawings;

E. Any additional details and specifications that the Town Board may request;

F. The name, addresses of legal residence of riparian property, and signature of the riparian proprietor of the shoreline or easement holder who otherwise meets the criteria in Sec. 30.131, Stats., on whose behalf the application is made, and the name and post office address of the applicant, if different;

G. A fee in the amount established from time to time by the respective Town Board; and

H. In the case of repair or replacement of a legally nonconforming pier, the year the pier, wharf or mooring facility was originally placed in the water and the number of mooring facilities in existence as of May 16, 1981.

SECTION IV STANDARDS AND PROCEDURE FOR GRANTING PERMITS
There shall be two (2) procedures for obtaining a permit. All applicants shall submit an application to the Building Inspector which shall include photographs of the current shoreline showing all mooring facilities and drawings of the proposed construction and or modification of the all mooring facilities.

Procedure 1:
The Building Inspector is authorized to issue permits to riparian owners or easement holders which meet the following standards:

1. Meets the criteria in Sec. 30.131, Stats., for piers, wharfs, mooring facilities and shore stations.
2. Not longer than the established pier head line, (35ft);
3. No pier wider than 5 feet measured at its point of greatest width, except the pier or wharf may exceed 5 feet width for a triangle at an angle of an L or T shaped pier or wharf, no greater than 3 feet on any side of the triangle attached to the pier or wharf;
4. Constructed so as to allow the free movement of water underneath all parts of the structure extending beyond the natural shore;
5. Constructed in such manner as will not cause the formation of land on the lake bed;
6. No more than one mooring facility for each twenty-two (22) feet, or fraction thereof, of shoreline owned by the riparian owner;
7. No more than five (5) mooring facilities per lot regardless of the size of the riparian owner's shoreline;
8. Placed in a location not inconsistent with the pier planner used by the Department of Natural Resources, as amended from time to time;
9. No mooring facility shall be located closer than eight (8) feet to a lot line; and
10. Not in an environmentally sensitive: area delineated by the Department of Natural Resources.

The Building Inspector shall review the application and forward the application, together with an investigation and report, to the Town Board of LaGrange or Sugar Creek for all applications for piers, wharfs, mooring facilities, moorings, mooring buoys and mooring anchors which do not meet the standards established in Procedure 1 of this ordinance. Any application which does not meet the standards shall be forwarded to the Town Board which may grant or deny the permit pursuant to Procedure 2.

Procedure 2:
At a Town Board meeting, the Town Board may, after considering the application and all evidence presented, and hearing all parties desiring to be heard, grant a permit to riparian owners for piers, wharfs, mooring facilities, moorings, mooring buoys and mooring anchors meeting the following standards and considering the following factors:
1. The location, design and construction will not detrimentally impact the health, safety and welfare of the public which consideration shall include water quality, aquatic habitat and other environmental concerns, including factors considered by the DNR, and of the owners of the abutting riparian property. No new nor enhancement of

established piers, wharfs, mooring facilities, moorings, mooring buoys and mooring anchors shall be permitted in DNR defined environmentally sensitive areas.
2. The location, design and construction will not interfere with public rights in the waters or with the rights of neighboring riparian proprietors or occupants;
3. Constructed so as to allow the free movement of water underneath all parts of the structure extending beyond the natural shore;
4. Constructed in such manner as will not cause the formation of land on the lake bed;
5. No more than one mooring facility for each twenty-two (22) feet, or fraction thereof, of shoreline owned by the riparian owner; however, this is not a guarantee that a permit will be granted;
6. Placed in a location not inconsistent with the pier planner used by the Department of Natural Resources, as amended from time to time;
7. No mooring facility shall be located closer than eight (8) feet to the lot line; and
8. Additional Requirements for Mooring Buoys and Anchors:
a. No permit for placement of a mooring buoy or anchor shall be granted by the Town Board beyond 60 feet from the ordinary high water mark;
b. Mooring buoys shall extend eighteen (18) inches above the waterline, be white in color with a blue band clearly visible above the waterline, and be spherical or ovate in shape;
c. The painter or line between a mooring buoy and any watercraft attached to it shall not exceed ten (10) feet in length; and
d. Section 30.722(d) 1 through 4, Stats., are adopted by reference as though fully set forth herein and as amended from time to time.
9. For replacement or repair for which a permit is required for legally nonconforming piers, wharfs or mooring facilities, the Town Board shall grant permits authorizing structures for the number of mooring facilities in existence as of May, 1981 or grant permits to the extent reasonably possible, or grant permits consistent with the other standards in this ordinance.
D. All permits granted shall state the location and size of the allowed mooring facility, as well as the number of permitted watercraft.
E. The Town Board of the town in which the pier is located may grant variances from the terms of Section C. of this Ordinance for extraordinary circumstances when the riparian owner will suffer a hardship by literal application of the standards established in this ordinance when the hardship is not of the riparian owner’s own making.

SECTION V. MAINTENANCE

All wharfs, piers, and mooring facilities extending beyond the natural shore shall be so maintained as to prevent any part or parts thereof from floating or sinking into and obstructing the waters or impeding free navigation of Lauderdale Lakes.

SECTION VI. PREEXISTING PIERS, WHARFS AND MOORING FACILITIES
A. Any wharf, pier or mooring facility legally existing in place as of the date of adoption of this ordinance may be repaired during one year up to 10% of the square feet of the surface of the structure and, if permanent, up to 50% of the posts, so long as the size of the structure is not expanded.
B. In order to protect the legitimate rights of persons with preexisting piers, wharfs and mooring facilities, all persons with a wharf, pier or mooring facility legally in place as of July 10, 2006 shall provide the following information to the LaGrange Town Building inspector by September 1, 2007: Name of riparian owner, address of owner, address where pier is located, year pier first placed in Lauderdale Lakes, length of pier, width of pier and number of mooring facilities. All persons failing to file this information with the Town Building Inspector shall be deemed not to own a pier, wharf or mooring facility with rights as a preexisting pier, wharf or mooring facility and such structures shall conform to the standards established in this ordinance.

SECTION VII. PIERHEAD LINE REGULATED
A. Policy. The Towns of LaGrange and Sugar Creek, pursuant to Chapter 30 of the Wisconsin Statutes, are empowered to regulate wharfs and piers and to establish a pier head line. It is in the interest of the Towns of

LaGrange and Sugar Creek to preserve and protect the property within the Town of LaGrange and Sugar Creek at the same time as preserving and protecting public rights in navigable waters and non-uniformity with respect to wharfs and piers in Lauderdale Lakes can be detrimental to these interests. It is in the interest of the Towns of LaGrange and Sugar Creek and the public to establish uniform requirements for the establishment of piers and wharfs on Lauderdale Lakes, Walworth County, Wisconsin. To that end, a pier head line should be established.
B. Establishment of Pier head Line. There is established, in the Towns of LaGrange and Sugar Creek on Lauderdale Lakes, a pier head line. Such pier head line is established at a distance of thirty-five (35) feet channel ward from the ordinary high water mark of the shore. No pier or wharf shall be so placed or so constructed such that it extends a distance greater than the established pier head line channel ward from the ordinary high water mark of the shore from which such pier or. Wharf is constructed, unless the permit from the Town Board as required by Section IV.C. has been obtained. No pier or wharf may exist more than thirty- five (35) feet from the ordinary high water mark of the shore, except as hereinafter set forth. “Ordinary high water mark" is defined by NR 320.03(4), Wisconsin Administrative Code. Where the bank or shore, at any particular place, is of such a character that it is impossible or difficult to ascertain where the point of ordinary high water mark is, recourse may be had to other places on the shore of the lake to determine whether a given stage of water is above or below the ordinary high water mark. ' C. Prohibition and Exceptions. Any wharf or pier extending into navigable water beyond the limit set forth herein constitutes an unlawful obstruction of navigable water unless a permit for such wharf or pier has been obtained by the Town Board and pursuant to Section 30.12(2) of the Wisconsin Statutes, or is otherwise accepted.

SECTION VIIL RAFTS REQUIRED
A. Size Limitation. No person may use a raft greater than 200 square feet in surface area on Lauderdale Lakes unless that person proves that he/she owned the raft prior to September 30, 2000.
B. B. Reflectors. All rafts floating on Lauderdale Lakes shall have reflectors affixed to the outside perimeter.

SECTION IX. REMEDIES AND PENALTIES
A. All actions to recover forfeitures and penalty assessments under this ordinance are civil actions in the name of the Town of LaGrange or Town of Sugar Creek and shall be heard in Circuit Court for Walworth County.
B. Any person (riparian owner and / or contractor) violating any provisions of this ordinance relating to mooring facilities shall forfeit not less than $10 nor more than $200 for each day that a violation takes place or continues, plus costs and assessments. The cash deposit amount shall be $100 plus costs and assessments per day for each day that a violation takes place or continues.
C. Any permit issued which is contrary to any law or ordinance or rule, or regulation of. the Department of Natural Resources, or with which the applicant has not complied, shall be void and of no effect.
D. In the event a mooring facility for which a permit has been granted shall not be erected, constructed, placed, extended or maintained in accordance with the plans, specifications, details and drawings submitted, or not maintained in a safe condition, or in the event such mooring facility shall not be constructed within one (1) year from date permit was granted, or that it be used in a manner detrimental to the general public, or interfere with the rights of the neighboring riparian owners, then, in such event, the board may cancel and revoke the permit provided it shall first hold a meeting after fixing a time and place of hearing and shall cause a written notice thereof to be issued and delivered or mailed to the holder of such permit, and also to the owners of the neighboring abutting riparian lands, not less than five (5) days before the time fixed for hearing.
E. Every pier, wharf or mooring facility constructed, placed or extended, enlarged or replaced in violation of this ordinance is declared to be a public nuisance, and the construction thereof may be enjoined and the maintenance thereof may be abated by action at the suit of the Town.
F. The Building Inspector(s) of the Towns of LaGrange and Sugar Creek are authorized to issue citations for violations of this ordinance.

SECTION X. SEVERABILITY
The provisions of this ordinance shall be deemed severable and it is expressly declared that the Town Boards would have passed the other provisions of this ordinance irrespective as to whether or not one or more provisions may be declared invalid and any provision of this ordinance or the application thereof to any person or

circumstance is held invalid, the remainder of the ordinance and the application of such provisions, other persons or circumstances shall not be affected thereby.

SECTION XI. REPEAL OF CONFLICTING ORDINANCE
All ordinances and parts of ordinances in conflict with this ordinance heretofore enacted by the Towns of LaGrange and Sugar Creek, Walworth County, Wisconsin, are hereby repealed.

XII. EFFECTIVE DATE AND CLERK'S DUTY

A. This ordinance shall take effect and be in force from and after its passage and publication as provided by law and after review by the Department of Natural Resources.

B. The LaGrange Clerk is directed to file a signed copy of this ordinance with the Department of Natural Resources in Madison, Wisconsin.

Enacted by the Town Board of LaGrange this 9TH day of June, 2008.
Approved:
Frank Taylor
Mark Bromley
Donald Sukala
Richard Callaway
Jeff Schramm

ATTEST: Crystal Hoffinann, Town Clerk, LaGrange

Enacted by the Town Board of Sugar Creek this 18th day of August, 2008.
Approved:
Gary Wallem
Carl Rieken

ATTEST: Diane Boyd, Town Clerk, Sugar Creek

STATE OF WISCONSIN
TOWN OF LAGRANGE
WALWORTH COUNTY

ORDINANCE NO. 2007-003

AN ORDINANCE TO REGULATE USE OF THE TOWN'S PUBLIC BOAT LAUNCHES

The Town Board hereby enacts this Ordinance as follows:
SECTION 1. FEES FOR USE OF PUBLIC BOAT LAUNCH.
A. No person shall use or otherwise launch a watercraft at or on the public boat launches owned by the Town of LaGrange without prepayment of the following fees: Per day watercraft launch fee (entitling the holder to launch watercraft for one day); Per season fee (entitling unlimited launches from January 1 to December 31);

B. The amount of fees shall be established by the Town Board from time to time by motion.

SECTION 2. PAYMENT OF FEES AND DISPLAY OF PERMIT.

A. Fees shall be paid in advance. Upon payment the person shall receive a permit.

B. Fees may be paid as follows:
At the launch ramp; or
At the Town Hall either in person or by mail by sending a check or money order to the Town Clerk at P.O. Box 359, Whitewater WI 53190.
C. Every person or vehicle using the launch ramp shall either carry with them or display on the vehicle dashboard the permit that they receive when paying the fee.

SECTION 3. NO OVERNIGHT TIE UP. No person, firm or association shall tie a watercraft to a launch ramp owned by the Town of LaGrange at any time from 11 PM to 5AM the following day. This prohibition shall not apply to watercraft owned or operated by the Town of LaGrange, the Fire Department or the Lauderdale Lakes Lake Association.

SECTION 4. ITEMS ALLOWED ON RAMP. No person, firm or association shall place any thing on the launch ramp except watercrafts, motor vehicles and trailers.

SECTION 5. ENFORCEMENT. This ordinance may be enforced by the Walworth County Sheriff's Department and the Lake Patrol by issuing citations. Violations shall be punishable by a forfeiture in the amount of a minimum of $25 up to a maximum of $100. Each day of a violation takes place shall be a separate violation. Failure to pay the forfeiture may result in a jail term.

SECTION 6. SEVERABILITY AND REPEAL.
A. The provisions of this ordinance shall be deemed severable and it is expressly declared that the Town Board would have passed the other provisions of this ordinance irrespective as to whether or not one or more provisions may be declared invalid and any provision of this ordinance or the application thereof to any person or circumstance is held invalid, the remainder of the ordinance and the application of such provisions, other persons or circumstances shall not be affected thereby.

B. All ordinances and parts of ordinances in conflict with this ordinance heretofore enacted by the Town of LaGrange are hereby repealed.
Adopted on motion of Supervisor Bromley, seconded by Supervisor Schramm on the 9th day of April, 2007.

Approved:
Frank Taylor,Chairman
Mark Bromley, Supervisor
Don Sukala, Supervisor
Rick Callaway, Supervisor
Jeff Schramm, Supervisor

Attest:
Crystal Hoffmann, Clerk

(This Page Left Blank Intentionally)

Appendix D

EURASIAN WATER MILFOIL MANAGEMENT IN MILL LAKE: 2002

(This Page Left Blank Intentionally)

MEMORANDUM

TO: Peter M. van Kampen, Commissioner
Lauderdale Lakes Lake Management District

FROM: Jeffrey A. Thornton, Principal Planner (Environment)
Southeastern Wisconsin Regional Planning Commission

DATE: August 22, 2002

SUBJECT: EURASIAN WATER MILFOIL MANAGEMENT IN MILL LAKE: 2002

Background

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) prepared an aquatic plant management plan for the Lauderdale Lakes, published as SEWRPC Memorandum Plan No. 143, *An Aquatic Plant Management Plan for the Lauderdale Lakes, Walworth County, Wisconsin*, which was published by the Commission during August 2001. One recommendation of this plan related to the management of Eurasian water milfoil populations in the areas of Mill Lake known as Sterlingworth Bay and Don Jean Bay.

Eurasian Water Milfoil (Myriophyllum spicatum)

Eurasian water milfoil is a non-native, invasive plant that forms dense, single species stands in many inland lakes in Wisconsin. Since it was originally introduced into the state during the 1960s, the plant has spread rapidly to the point where it has been declared to be a nuisance species. Efforts are underway statewide to control the spread of this plant through informational signage, adoption of Chapter NR 109 of the Wisconsin Administrative Code which prohibits transference of the plant between lakes, and the application of aquatic plant management measures using a variety of techniques.

Strategy

One of the techniques proposed in the management plan to control Eurasian water milfoil was designed to remove the competitive advantage of the milfoil plant: its competitive advantage is to begin its active growth cycle at water temperatures of about 48 to 54°F—about 5°F cooler than most native plants begin growing—and then shoot straight to the lake surface, where it spreads out and captures the sunlight. This then limits the ability of the lower-growing, native aquatic plants to compete—which start to grow at about 56 to 58°F—given the limited availability of sunlight. To combat this advantage, modification of the harvesting program to cut the tops of the milfoil was recommended.

The Lauderdale Lakes Lake Management District implemented the "top-chopping" strategy during 2002. SEWRPC was asked to monitor the performance the technique in encouraging the growth of native plant populations, and discouraging the growth of Eurasian water milfoil. This assessment was made by comparing aquatic plant communities observed during 2002 to those recorded during the initial survey conducted in August 1999.

Results

Sterlingworth Bay

At the time of the initial survey, Sterlingworth Bay was dominated by Eurasian water milfoil. At the 5-feet depth, the only plants observed were Eurasian water milfoil and Chara or muskgrass, a macro-alga. Sparse growths of Robbins pondweed were also recorded. At the 1.5-feet depth, milfoil was also dominant, or most abundant, with coontail, eel grass and some few pondweeds also present.

During 2002, the aquatic plant community in the Bay remained diverse throughout the summer. The initial sampling was conducted at the end of Mar 2002, and sampling continued at approximately monthly intervals—immediately prior to harvesting—throughout the summer (one additional sampling in planned for mid-September 2002). Eurasian water milfoil remained abundant in the Bay, and, with the exception of late July, did not "top out" as harvesting was undertaken at approximately monthly intervals. (In late July, the harvester was delayed in cutting Sterlingworth Bay, with the result that the Eurasian water milfoil did reach the surface of the Bay—during 2003, it is recommended that harvesting be scheduled at no more than monthly intervals to limit the possibility of "topping out" occurring.)

Notwithstanding, during 2002, a diverse community of aquatic plants was also recorded from within the Bay. This result was quite different from that observed during the initial aquatic plant survey, when the Bay was close to being a mono-culture of milfoil. While some seasonality was observed in the plant community—certain species preferring cooler or warmer water temperatures, and so being reported during only parts of the summer, substantial numbers of pondweeds, Chara, eel grass, Elodea, and coontail were also observed consistently through the summer period. Muskgrass, eel grass, and Elodea were especially abundant, and these relatively low-growing, native plants generally cause few problems for recreational water users. Some patchiness was noted around the Bay, with this phenomenon seemingly related to the composition of the lake bottom sediments—the peaty soils of the southwestern portion of the Bay forming relatively poor rooting substrate for the aquatic plants, while the more mucky soils of the northeastern portion of the Bay supported the greatest diversity (and abundance) or aquatic plants.

Don Jean Bay

During the August 1999 survey, Don Jean Bay was also dominated by Eurasian water milfoil. Along the three sampling transects established on the western shoreline of the Bay, adjacent to the extensive wetland area, Eurasian water milfoil dominated the aquatic plant flora between the 1.5-feet depth and the 11-feet depth, decreasing in abundance from the shoreline to the deeper water area. Coontail was moderately abundant in these same area, with a few pondweeds were recorded, although these did not constitute a significant part of the aquatic plant community. The most diverse flora, or plant community, was observed along the southwestern shore of Don Jean Bay, where Eurasian water milfoil, eel grass, muskgrass, and a number of pondweeds were more equally distributed—Eurasian water milfoil, however, remained the most abundant plant.

During the 2002 surveys, Eurasian water milfoil remained abundant along this shoreline, although there was a consistent decline in Eurasian water milfoil abundance in later summer as the plant appeared to be dying back with the onset of autumn. The greatest diversity throughout the summer continued to be observed along the southwestern shoreline. Chara or muskgrass, Elodea, eel grass, coontail, and a variety of pondweeds were present throughout this portion of the Bay. Bushy pondweed was exceptionally abundant, increasing in abundance throughout the summer and competing during the later summer with Eurasian water milfoil for dominance.

Evaluation

Based on the four surveys already completed during the 2002 summer season, the adoption of the recommended “top chopping” strategy to combat the dominance and abundance of Eurasian water milfoil in portions of the Lauderdale Lakes appeared to be successful in maintain an increasingly diverse aquatic plant community within the areas where this strategy was applied. In Sterlingworth Bay, especially, the strategy appears to have enhanced the aquatic habitat available for fishes without seriously impairing recreational uses. That said, the “topping out” of the milfoil plants during late July was noted to have caused some concern, as reported to the field crews by local homeowners. For this reason, a more regular schedule of harvesting is recommended, as noted above.

It should also be noted that 2002 was a year in which Eurasian water milfoil growth was exceptionally abundant. The combination of a mild winter and long cool spring season proved to be an ideal combination that ensured continued, over-winter growth of Eurasian water milfoil in many of the Region’s lakes, while the absence of a spring “cold snap” allowed the plant to secure a dominant position within the aquatic plant community. In many of the Region’s lakes, the growths of aquatic plants were reported to have reached their highest levels in the last 25-years. With this in mind, the continued presence and abundance of native aquatic plants in Sterlingworth and Don Jean Bays demonstrates the effectivity of "top-chopping" as a Eurasian water milfoil control strategy.

Continued Vigilance Required

While the harvesting strategy adopted by the Lauderdale Lakes Lake Management District has proven effective during the 2002 summer season, the role of individuals remains an important part of the overall aquatic plant management strategy for the Lauderdale Lakes:

- help to prevent the spread of the plant by ensuring that boats, trailers, and other aquatic equipment are “weed-free” when removing these items from the Lake and when transporting such equipment between Lakes or locations on the Lake.
- help to limit the spread of the plant by removing plant fragments from along their shorelines—harvested plants make an excellent mulch.
- help to prevent the growth of the plant by limiting the application of garden chemicals and fertilizers to those needed for terrestrial plant growth—remember, what turns your lawn green, will also turn your lake green.
- help to prevent the fertilization of the Lake by having a soil test done to ensure that the nutrients applied to lawns and gardens are those required by the plants, and that these are applied in the quantities necessary for growth—over enthusiastic application of fertilizers means that the excess will simply run off into the lake.
- help to limit the run off of excess fertilizer and other household chemicals to the Lake by installing a buffer strip along the shoreline using native plants—these will add beauty to your property, reduce your maintenance time, and help to stabilize the shoreland area.

* * *

JAT
#74830 v1 - LAUDERDALE LAKE APM INTERIM REPORT