Lake Riley Use Attainability Analysis

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Executive Summary

Overview

This report details the results of a Use Attainability Analysis (UAA) of Lake Riley. The UAA is a structured scientific assessment of the chemical, physical, and biological conditions in a water body. The analysis includes diagnosis of the causes of observed problems and prescription of alternative remedial measures (such as a diagnostic-feasibility study) that will result in the attainment of intended beneficial uses of Lake Riley. The analysis is based on historical water quality data, the results of an intensive 1997 through 1998 lake and watershed runoff water quality monitoring program, and computer simulations of watershed runoff, calibrated to the 1997 through 1998 data set. Computer simulations estimated watershed runoff under existing and proposed future land use conditions and under varying climatic conditions.

Riley-Purgatory-Bluff Creek Watershed District Water Quality Goals

The approved *Riley-Purgatory-Bluff Creek Watershed District Water Management Plan,* 1996, articulated five specific goals for Lake Riley. These goals address recreation, water quality, aquatic communities, water quantity, and wildlife. Wherever possible, Riley-Purgatory-Bluff Creek Watershed District (RPBCWD) goals for Lake Riley have been quantified using a standardized lake rating system termed Carlson's Trophic State Index (TSI). This rating system considers the lake's total phosphorus, chlorophyll *a*, and Secchi disc transparency measurements to assign it a water quality index number that reflects its general level of fertility. The resulting index values generally range between 0 and 100, with increasing values indicating more fertile conditions.

Total phosphorus, chlorophyll *a*, and Secchi disc transparency are key water quality parameters upon which TSI statistics are computed, for the following reasons:

- Phosphorus generally controls the growth of algae in lake systems. Of all the substances needed for biological growth, phosphorus is typically the limiting nutrient.
- Chlorophyll *a* is the main pigment in algae. Therefore, the amount of chlorophyll *a* in the water indicates the abundance of algae present in the lake.
- Secchi disc transparency is a measure of water clarity and is inversely related to the abundance of algae.

Although any one or all three parameters can be used to compute TSI, water transparency is most often used, since people's perceptions of water clarity are most directly related to recreational use impairment. The TSI rating system is scaled to place a mesotrophic (medium fertility level) lake on the scale between 40 and 50, and high and low fertility lakes (eutrophic and oligotrophic) toward the high and low ends of the TSI range, respectively. Characteristics of lakes in different trophic status categories are listed below with their respective TSI ranges:

1. **Oligotrophic**—[$20 \leq$ TSI ≤ 38] clear, low productivity lakes, with total phosphorus concentrations less than or equal to 10 μg/L, chlorophyll *a* concentrations less than or equal to 2 μg/L, and Secchi disc transparencies greater than or equal to 4.6 meters (15 feet).
2. **Mesotrophic—**[$38 \leq$ TSI ≤ 50] intermediate productivity lakes, with 10 to 25 μg/L total phosphorus, 2 to 8 μg/L chlorophyll *a* concentrations, and Secchi disc measurements of 2 to 4.6 meters (6 to 15 feet).
3. **Eutrophic—**[$50 \leq$ TSI ≤ 62] high productivity lakes, with 25 to 57 μg/L total phosphorus, 8 to 26 μg/L chlorophyll *a* concentrations, and Secchi disc measurements of 0.85 to 2 meters (2.7 to 6 feet).
4. **Hypereutrophic—**[$62 \leq$ TSI] extremely productive lakes, with total phosphorus concentrations greater than 57 μg/L, chlorophyll *a* concentrations greater than 26 μg/L, and Secchi disc measurements less than 0.8 meters (less than 2.7 feet).

The RPBCWD goals for Lake Riley include the following:

1. The **Recreation Goal** is to provide water quality that: (1) fully supports swimming, applying the "MPCA Use Support Classification for Swimming Relative to Carlson's Trophic State Index by Ecoregion" (i.e., a Trophic State Index (TSI_{SD}) of 53 or lower) and, (2) achieves a water quality that fully supports the lake's MDNR ecological class 24 rating (i.e., a Trophic State Index (TSI_{SD}) of 56 or lower). The goal is attainable, but only with the implementation of lake and watershed management practices as described in this UAA.
2. The **Water Quality Goal** is a trophic state index score that meets or exceeds the necessary level to attain and maintain full support of swimming and fishing: A Trophic State Index (TSI_{SD}) of 53 or lower to fully support swimming and a Trophic State Index (TSI_{SD}) of 56 or lower to fully support the lake's fishery. This goal is also attainable, but only with the implementation of lake and watershed management practices discussed in this UAA.
3. The **Aquatic Communities Goal** is a water quality that fully supports fishing, according to the Minnesota Department of Natural Resources (MDNR) "Ecological Use Classification." This goal is attainable, but only with the implementation of lake and watershed management practices listed herein.
4. The **Water Quantity Goal** for Lake Riley is to manage surface water runoff from a regional flood, the critical 100-year frequency storm event. This goal has been achieved.
5. The **Wildlife Goal** for Lake Riley is to protect existing, beneficial wildlife uses. The wildlife goal has been achieved.

Water Quality Problem Assessment

An evaluation of 1971 through 1998 Lake Riley water quality data was completed to determine the lake's current water quality. Results of this evaluation indicate the lake's water quality has remained relatively stable over time. The lake's poor water quality is related to excessive inputs of phosphorus. Sources of phosphorus include: (1) runoff-borne phosphorus from its urbanized watershed; (2) Rice Marsh Lake internal loading (i.e., sediment phosphorus release and vegetation decay) conveyed to Lake Riley via Riley Creek; (3) Lake Riley internal loading (i.e., sediment phosphorus release); and (4) atmospheric deposition.

Historical Water Quality Trends

Trend analyses of 1974 through 1998 data indicate no significant change in the lake's water quality. The results of the regression analyses indicate that Secchi disc transparency has been declining at an average rate of 0.02 meters per year (less than 1 inch); chlorophyll *a* concentration in the epilimnion (upper 6 feet) has increased at the rate of 0.07 μg/L per year; total phosphorus concentration in the epilimnion has been decreasing at a rate of 1.2 μg/L per year. The changes in Secchi disc and total phosphorus are significantly different from zero, statistically, but the chlorophyll changes are not significant. Hence, the data indicate the lake's current water quality problems are unlikely to change unless management practices are implemented to improve the lake's water quality.

A comparison of baseline (i.e., 1971 to 1987) and current (1988 to 1998) trophic state index (TSI) values indicates that Lake Riley has been unable to fully support swimmable use during the baseline and current periods. All but two summer averages exceeded MPCA-criteria (i.e., TSI $\leq$53) for full support swimmable use. Lake Riley's water quality has failed to meet MDNR-criteria during 36 percent of the baseline period and during 80 percent of the current period.

Current Water Quality

The current water quality of Lake Riley is poor, and recreational activities are impaired by summer algal blooms. The 1997 through 1998 total phosphorus concentration data indicate the lake was hypereutrophic (very poor water quality) during the spring and fall periods and eutrophic (poor water quality) during the summer period. Chlorophyll measurements during 1997 through 1998 indicate the lake was hypereutrophic (very poor water quality) during the fall of 1997 and during most of the 1998 summer period. Chlorophyll values during the fall of 1997, May of 1998, and late-June through August of 1998 exceeded nuisance levels (>20 μg/L). Secchi disc measurements during 1997 through 1998 ranged from oligotrophic (excellent) to hypereutrophic (very poor). Excellent transparency was noted during the winter, good transparency was noted during early-May, very poor transparencies were noted during the late-summer period, and poor transparencies were noted at other times during the monitoring period. Hence, moderate to severe recreational-use impairment occurred during the summer (Osgood, 1989). The lake's recreational-use impairment appear to be largely determined by algal abundance.

Phosphorus Budget

Lake Riley's 5,213-acre watershed is comprised of a 178-acre isolated watershed, a 1,585-acre direct watershed, and a 3,450-acre indirect watershed. Computer simulations of runoff water quality indicate that the annual total phosphorus load to Lake Riley under existing land use conditions varies from 670 pounds under dry climatic conditions (i.e., 19 inches annual precipitation) to 1,655 pounds under wet climatic conditions (i.e., 41 inches annual precipitation; See Figure EX-1). The average rate of phosphorus loading to the 286-acre lake is 3 pounds of phosphorus per acre of lake per year, which is excessive and causes water quality problems ($L = 0.375\ g/m^2/yr$).

Computer simulations of runoff water quality indicate that an increased total phosphorus load will occur under proposed future land use conditions. Total phosphorus loads are estimated to vary from 785 pounds under dry climatic conditions (i.e., 19 inches of annual precipitation) to 1,849 pounds under wet climatic conditions (i.e., 41 inches annual precipitation; See Figure EX-2). The average rate of phosphorus loading to the 286-acre lake is estimated to be 4 pounds of phosphorus per acre of lake per year under proposed future land use conditions ($L = 0.438\ g/m^2/yr$).

Increased phosphorus loading under proposed future land use conditions includes phosphorus loading from the proposed Highway 312 project. Assuming no new ponds are constructed to treat highway runoff waters, Lake Riley total phosphorus loading increases are expected to range from 34 pounds under dry climatic conditions (i.e., 19 inches of annual precipitation) to 74 pounds under wet climatic conditions (i.e., 41 inches annual precipitation). The Highway 312 total phosphorus load represents 5 percent of the total future phosphorus load to Lake Riley under dry climatic conditions (i.e., 19 inches of annual precipitation) and 4 percent under wet climatic conditions (i.e., 41 inches annual precipitation). Assuming all highway runoff waters are treated by ponds meeting MPCA- and NURP-criteria, total phosphorus loading increases are expected to range from 16 pounds under average climatic conditions (i.e., 27 inches of annual precipitation) to 25 pounds under wet climatic conditions (i.e., 41 inches annual precipitation).

Lake Riley's annual phosphorus budget for an average precipitation year (i.e., 27 inches of precipitation) indicates approximately 58 percent of the lake's annual phosphorus load enters the lake from Riley Creek. Lake Riley's direct watershed contributes approximately 3 percent of the annual load to the creek, and approximately 55 percent of the lake's annual phosphorus load is the outflow from Rice Marsh Lake. Other watershed phosphorus sources each contribute from 0.2 to 10 percent of the lake's annual phosphorus load. Atmospheric deposition and the lake's internal load represent 7 and 8 percent of the annual phosphorus load, respectively (See Figure EX-3).

Total Phosphorus Loads to Lake Riley Under Varying Climatic Conditions Existing Watershed Land Use

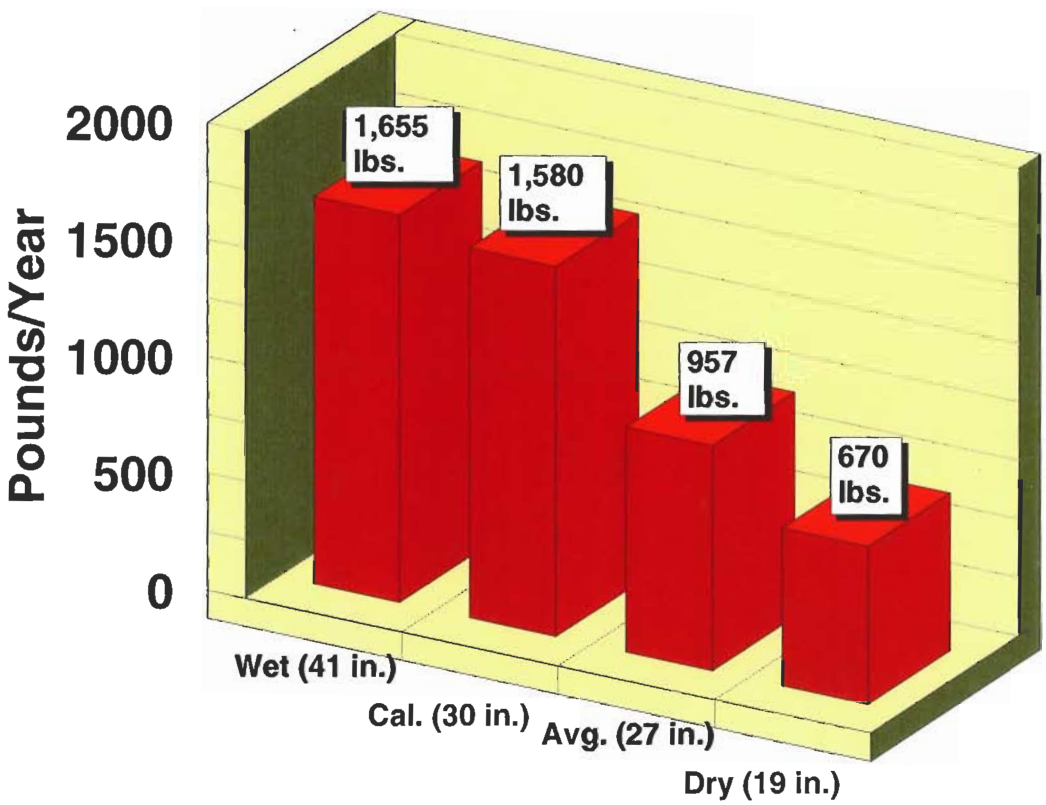


Figure EX-1

Total Phosphorus Loads to Lake Riley Under Varying Climatic Conditions Proposed Future Watershed Land Use

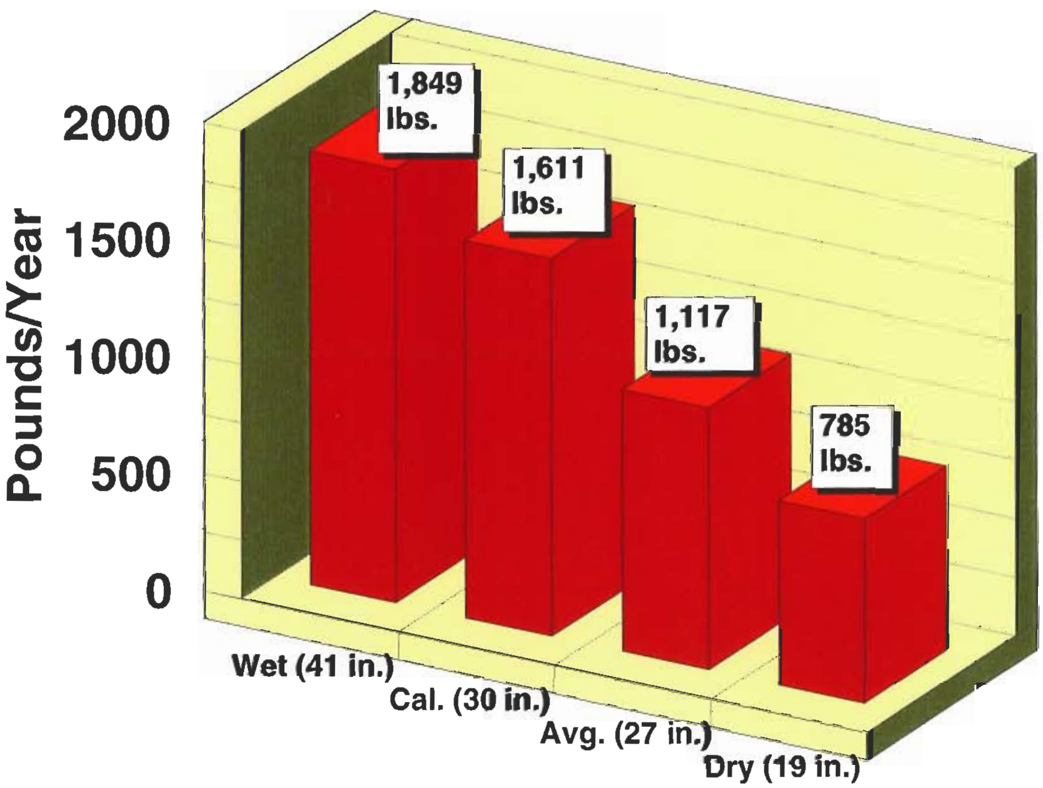
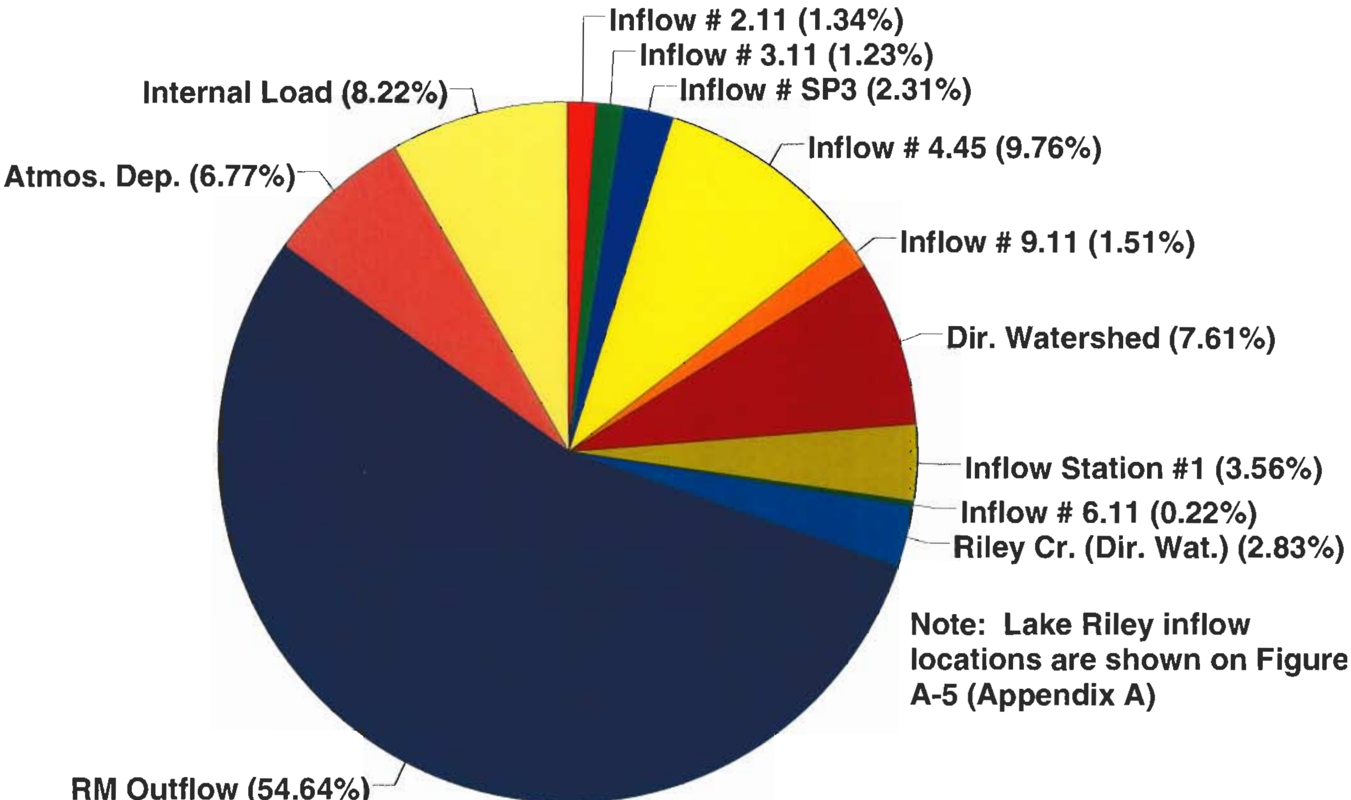


Figure EX-2

Lake Riley Phosphorus Budget: Sources
Average Precipitation Year (27 Inches)
Existing Watershed Landuse



Note: Lake Riley inflow locations are shown on Figure A-5 (Appendix A)

Figure EX-3

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Aquatic Plants

Macrophyte (i.e., aquatic plant) surveys performed during 1998 determined that one undesirable non-native macrophyte species was present in Lake Riley. Eurasian watermilfoil typically follows an aggressive growth pattern and eliminates native species from a lake. Eurasian watermilfoil was found throughout Lake Riley. However, because most portions of the lake contain only two plant species, eradication of Eurasian watermilfoil would eliminate needed fisheries habitat. Consequently, preservation of this species is recommended.

Recommended Goal Achievement Alternatives

Two different lake improvement alternatives will achieve or exceed District goals for Lake Riley. The two alternatives are:

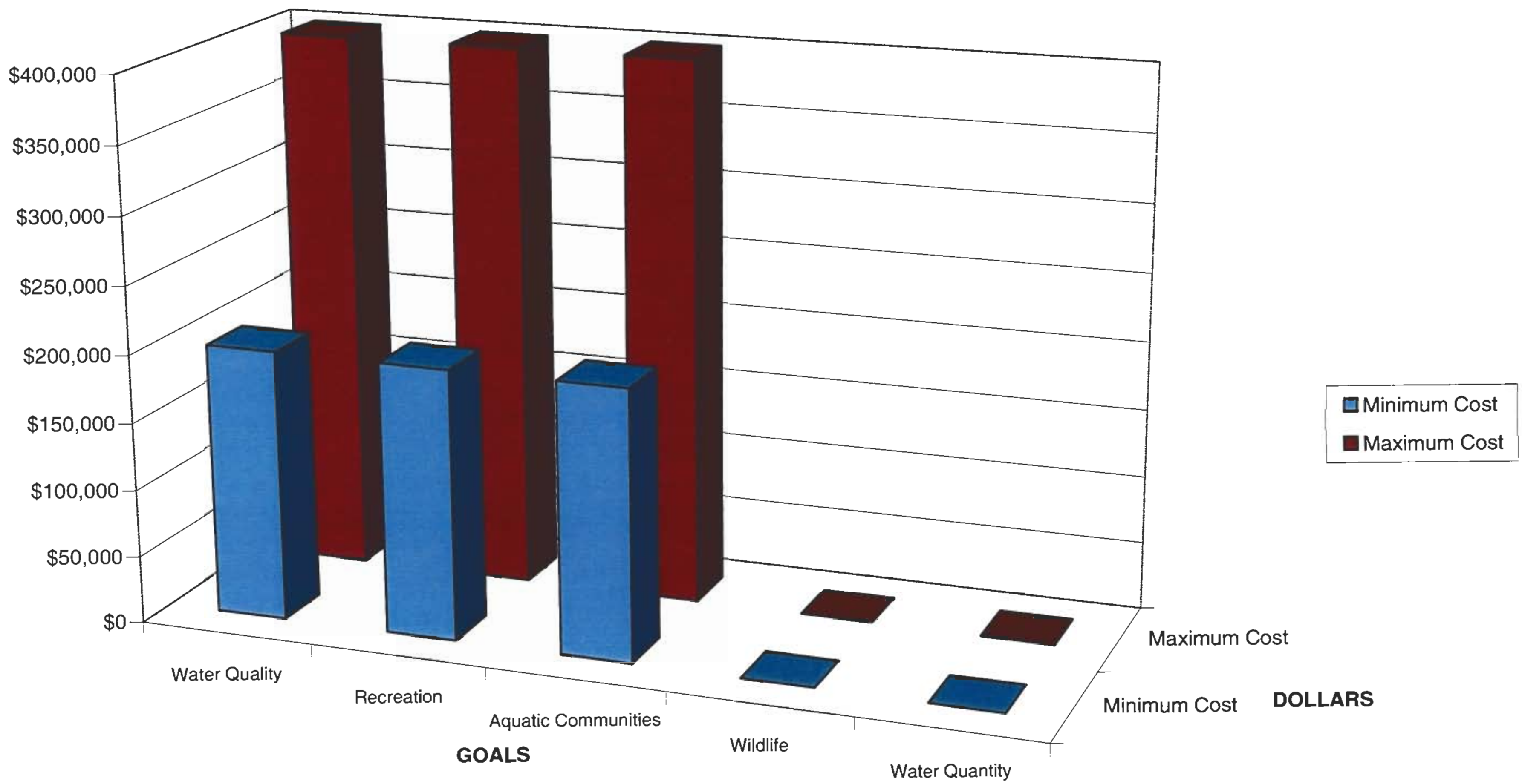
- **Manage Rice Marsh Lake** (treat Rice Marsh Lake with alum and lime slurry)
- **Manage Rice Marsh Lake** (treat Rice Marsh Lake with alum and lime slurry); **Manage Lake Riley** (treat Lake Riley with alum); and **Treat Highway Runoff** (treat Highway 312 runoff with four or five ponds meeting MPCA- and NURP-criteria)

The two alternatives were evaluated to compare cost and benefit differences (See Table EX-1). Figure EX-4 compares the minimum and maximum costs of the two alternatives.

Treatment of Rice Marsh Lake with a mixture of alum and lime slurry is expected to achieve the District's water quality goals for Lake Riley and is recommended. In addition, treatment of Lake Riley with alum is recommended to expedite goal achievement. Displacement of the higher phosphorus waters within Lake Riley with lower phosphorus waters from Rice Marsh Lake following its treatment may take several years. Hence, treatment of Lake Riley with alum is recommended to achieve rapid water quality improvement and rapid goal achievement. An alum treatment of Lake Riley will also remove the lake's internal phosphorus load for approximately 10 years, further improving the lake's water quality.

Treatment of runoff waters from proposed Highway 312 by 4 or 5 ponds meeting MPCA- and NURP-criteria will minimize phosphorus loading increases to Lake Riley. Treatment of runoff waters will facilitate goal attainment by the two lake improvement alternatives discussed in the previous paragraph.

Lake Riley
Costs to Meet or Exceed Goals



"Minimum Cost" is the cost of the option that just meets each of the goals set for Lake Riley under most climatic conditions.
"Maximum Cost" is the cost of the most expensive option analyzed in this study that meets or exceeds each of the goals set for Lake Riley under all climatic conditions.

Figure EX-4

Table EX-1 Benefits and Costs of Two Goal Achievement Alternatives

Treatment and Management Activities	Trophic State Index (TSI_{SD}) Value				
	District Goal	Wet year (1983) (41 inches of precipitation)	Average Year (1995) (27 inches of precipitation)	Dry Year (1988) (19 inches of precipitation)	Estimated Cost (Dollars)
Existing Watershed Land Uses					
Manage Rice Marsh Lake	≤53	43	46	45	$200,000
Manage Rice Marsh Lake and Lake Riley, Treat Highway Runoff	≤53	39	39	38	$400,000
Proposed Future Land Uses					
Manage Rice Marsh Lake	≤53	46	48	49	$200,000
Manage Rice Marsh Lake and Lake Riley, Treat Highway Runoff	≤53	40	39	44	$400,000

Selected Implementation Plan

The selected implementation plan is Manage Rice Marsh Lake and Lake Riley, Treat Highway Runoff (treat Rice Marsh Lake with alum and lime slurry; treat Lake Riley with alum; and treat proposed Highway 312 runoff waters with four or five ponds meeting MPCA- and NURP-criteria). The selected plan provides the greatest benefit to Lake Riley and is expected to result in rapid goal achievement.

Treatment of Rice Marsh Lake with alum/lime slurry will include:

- Collection and analysis of Rice Marsh Lake sediment cores to determine the extractable phosphorus content of the upper 5 centimeters of lake sediment.
- Lab experiments to determine the alum and lime slurry dose required to reduce Rice Marsh Lake internal loading to less than 10 percent of current levels.
- Treatment of Rice Marsh Lake with selected dose of alum/lime slurry mixture.

Lake Riley will be treated with an alum dose that is based upon the extractable phosphorus content of the upper 5 centimeters of lake sediment. A sediment core sample will be collected from the center of Lake Riley. The upper 5 centimeters of the core will be analyzed for extractable phosphorus. Alum dosage will be based upon a ratio of approximately 100 parts aluminum to 1 part extractable phosphorus.

The proposed Highway 312 project will include the construction of 4 or 5 ponds meeting MPCA- and NURP-criteria to treat highway runoff waters.

Lake Riley Use Attainability Analysis

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1.0 Surface Water Resources Data

The approved Riley-Purgatory-Bluff Creek Watershed District, *Riley-Purgatory-Bluff Creek Watershed District Water Management Plan*, 1996, (Water Management Plan) inventoried and assessed Lake Riley. The plan articulated five specific goals for Lake Riley. These goals address recreation, aquatic communities, water quality, water quantity, and wildlife. This report: (1) evaluates the existing and potential beneficial uses intended in these goals; (2) contains an analysis of the factors that potentially impair or limit those beneficial uses, particularly problems identified in the inventory and assessment; and (3) expands upon specific aspects of the inventory and assessment of Lake Riley contained in the approved Water Management Plan.

A use attainability analysis of Lake Riley was completed to provide the scientific foundation for a lake-specific best management plan that will maintain or attain the existing and potential beneficial uses of Lake Riley. A use attainability analysis evaluates existing and potential beneficial uses of a water resource. "Use attainment" refers to the designated beneficial uses, such as swimming and fishing. Factors that potentially impair or limit existing beneficial uses, including problems identified in the inventory and assessment, are investigated in the use attainability analysis. Lake analyses rely on previously collected field data and continue with watershed evaluations using water quality modeling.

The main tool for the technical analysis is an advanced water quality model that predicts the amount of pollutants that reach a lake via stormwater runoff. Calibrating the model to a lake requires an accurate measurement of land use and stormwater inputs. Impacts of upland detention and treatment of stormwater are included in the model.

1.1 Land Use

All land use practices within a lake's watershed impact the lake and determine its water quality. Impacts result from the export of sediment and nutrients, primarily phosphorus, to a lake from its watershed. Each land use contributes a different quantity of phosphorus to the lake, thereby affecting the lake's water quality differently. Current and proposed future land uses in the Lake Riley watershed are discussed in the following paragraphs.

Lake Riley's 5,213-acre watershed is comprised of a 178-acre isolated watershed, a 1,585-acre direct watershed and a 3,450-acre indirect watershed. The water surface area of Lakes Riley, Lucy, Ann, Susan, and Rice Marsh are included in the watershed areas. Runoff from the lake's indirect watershed is treated by an upstream lake prior to draining to Lake Riley. Runoff from the lake's direct watershed drains directly to Lake Riley. The lake's isolated watershed retains all runoff waters and, hence, does not drain to the lake.

A preliminary watershed land use assessment was completed and included in the RPBCWD Water Management Plan for the Lake Riley watershed. The assessment indicated Lake Riley's existing direct watershed was comprised of 818 acres, excluding the lake. The assessment indicated land use within the direct watershed included 449 acres of low density residential, 1 acre of commercial, 82 acres of agricultural, and 286 acres of parks and open spaces.

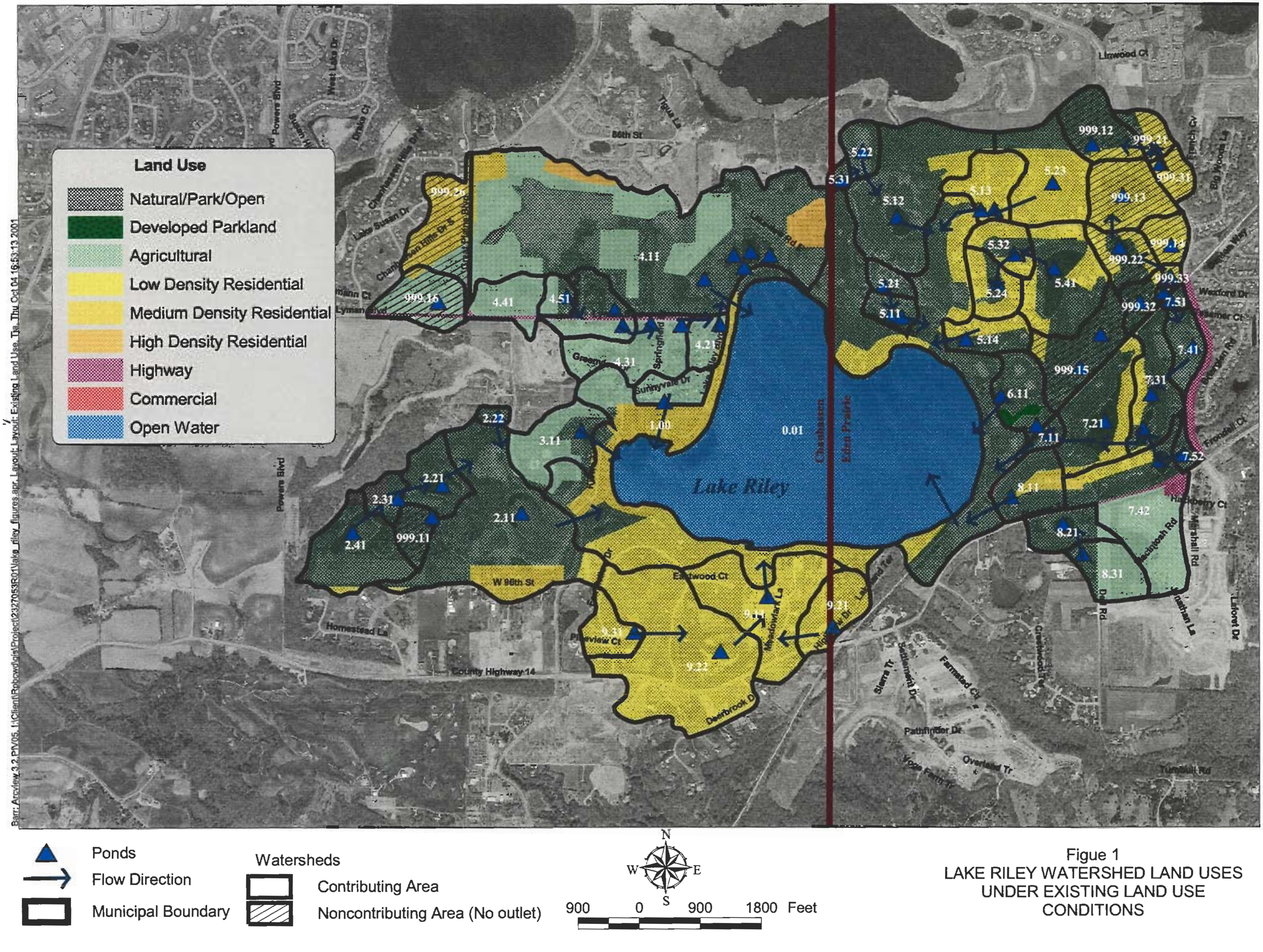
The Riley UAA included a more detailed land use analysis. Land use information was obtained from the cities of Chanhassen and Eden Prairie and updated using aerial photography. 1997 land use was selected for existing conditions to correspond with the time period selected for the intensive lake and watershed data collection program (i.e., October 1997 through October 1998). Hence, 1997 aerial photographs were used to update existing land use conditions. 2000 aerial photographs and land use information from the cities of Chanhassen and Eden Prairie were used to update proposed future land use conditions. The results of the land use analysis are summarized in Tables 1 and 2. Table 1 presents land uses under existing land use conditions and Table 2 presents land uses under proposed future conditions. Land uses in the lake's direct and indirect watersheds are presented separately. The lake's indirect watershed is further separated into subwatersheds that correspond with the individual upstream lakes (i.e., Lucy, Ann, Susan, and Rice Marsh). Maps presenting land uses in Lake Riley's direct watershed under existing and proposed future land use conditions are found in Figures 1 and 2. Maps presenting land uses for the Lake Lucy and Lake Ann subwatersheds are found in *Lake Lucy and Lake Ann Use Attainability Analysis* (Barr 1999). Maps presenting land uses for the Lake Susan and Rice Marsh Lake subwatersheds are found in *Susan and Rice Marsh Lake Use Attainability Analysis* (Barr 1999).

Table 1 Lake Riley Watershed Land Uses Under Existing Land Use Conditions

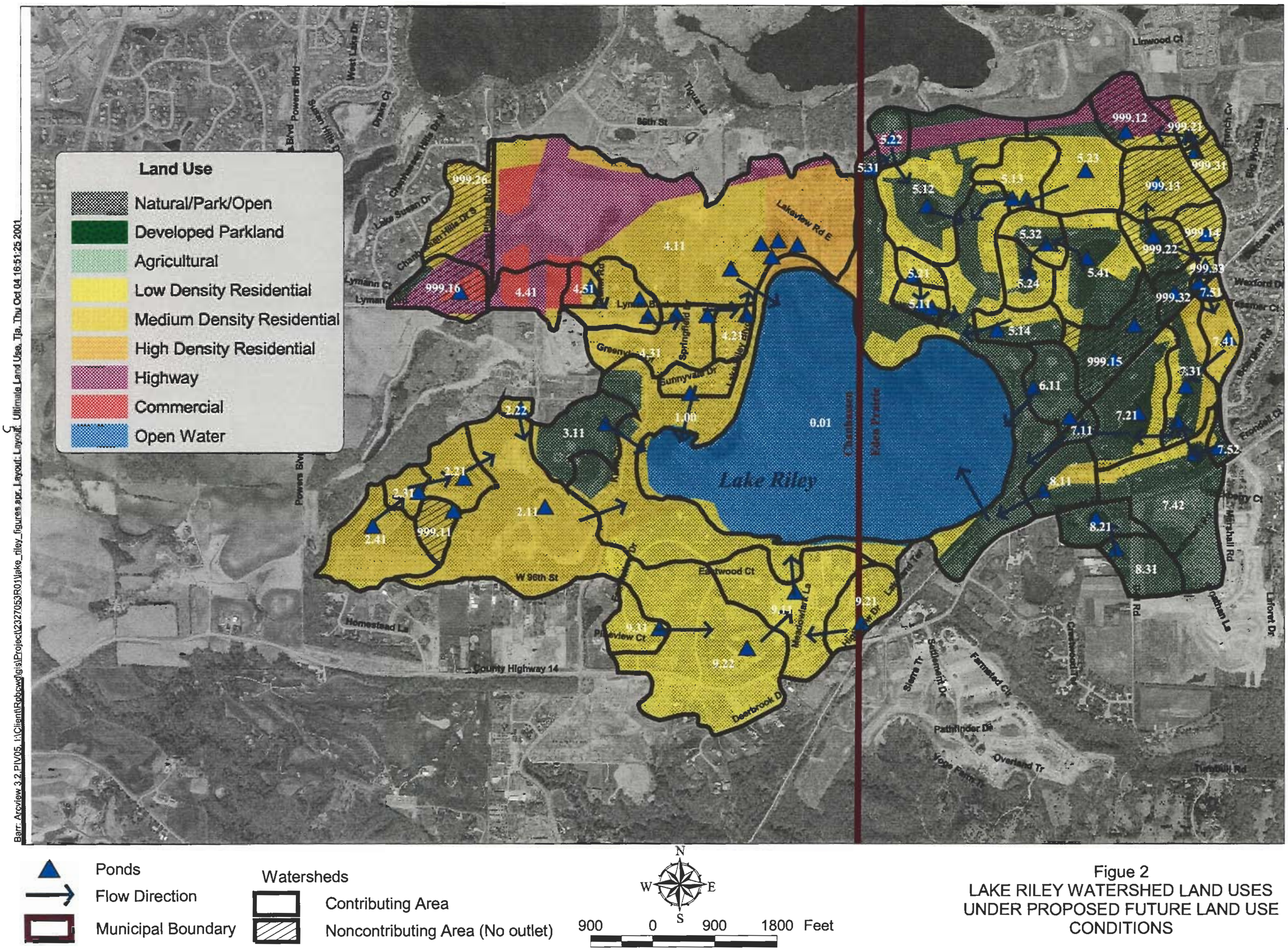
Land Use Type	Lake Riley Direct Watershed		Lake Riley Indirect Watershed			
	Non-Contributing	Contributing	Lake Lucy Subwatershed	Lake Ann Subwatershed	Lake Susan Subwatershed	Rice Marsh Lake Subwatershed
Very Low Density Residential (<1 house per acre)			156		40	35
Low Density Residential 1 to 4 houses per acre)	64	345	301	6	32	63
Medium Density Residential (4 to 8 houses per acre)	23	62			194	165
High Density Residential (> 8 houses per acre)		14			51	53
Developed Parkland		2				
Natural/Park/Open	66	638	264	119	512	257
Agricultural	22	209			84	69
Institutional				5	3	37
Industrial					197	13
Commercial					49	139
Highway	3	15			25	22
Wetland			184	8		
Open Water		300	88	117	81	81
Total	**178**	**1,585**	**993**	**255**	**1,268**	**934**

Table 2 Lake Riley Watershed Land Uses Under Proposed Future Land Use Conditions

Land Use Type	Lake Riley Direct Watershed		Lake Riley Indirect Watershed			
	Non-Contributing	Contributing	Lake Lucy Subwatershed	Lake Ann Subwatershed	Lake Susan Subwatershed	Rice Marsh Lake Subwatershed
Very Low Density Residential (<1 house per acre)			57		30	29
Low Density Residential 1 to 4 houses per acre)	64	385	614	59	25	69
Medium Density Residential (4 to 8 houses per acre)	34	381	4	12	357	201
High Density Residential (> 8 houses per acre)		55			106	47
Natural/Park/Open	42	351	46	54	286	218
Agricultural						0
Institutional				5	3	37
Industrial					299	18
Commercial	5	24			49	168
Highway	34	90			32	66
Wetland			184	8		
Open Water		297	88	117	81	81
Total	**178**	**1,584**	**993**	**255**	**1,268**	**934**



Figue 1
LAKE RILEY WATERSHED LAND USES
UNDER EXISTING LAND USE
CONDITIONS



Figue 2
LAKE RILEY WATERSHED LAND USES
UNDER PROPOSED FUTURE LAND USE
CONDITIONS

1.2 Major Hydrologic Characteristics

Lake Riley has a surface area of 286 acres at normal water surface elevation (i.e., 864.5 feet), a maximum depth of approximately 50 feet, a mean depth of approximately 23 feet. The lake's volume, outflow volume, and hydrologic residence time vary with climatic conditions (See Table 3).

Table 3 Lake Riley Estimated Volume, Outflow Volume, and Hydrologic Residence Time During Varying Climatic Conditions (Existing Watershed Landuse)

Climatic Condition (Water Year, Inches of Precipitation)	Estimated Lake Volume in m^3 (Estimated Lake Volume in acre-ft)	Estimated Lake Outflow in m^3 (Volume in acre-feet)	Estimated Hydrologic Residence Time (Years)
Wet Year (1983, 41 inches)	7,918,890 (6,419)	5,624,040 (4,559)	1.4
Model Calibration Year (1998, 30 inches)	7,918,890 (6,419)	4,054,810 (3,287)	2.0
Average Year (1995, 27 inches)	7,918,273 (6,419)	2,936,165 (2,380)	2.7
Dry Year (1988, 19 inches)	7,537,866 (6,110	1,733,371 (1,405)	4.3

Of the twelve major lakes in the District, Lake Riley is ranked first in surface area and volume.

Riley Creek enters Lake Riley in the northeast side of the lake and continues at the outlet, in the southeast side of the lake. Riley Creek begins at Lake Lucy, inlets to and from Lake Ann, Lake Susan, then flows through Rice Marsh Lake before entering Lake Riley.

1.3 Water Quality

1.3.1 Data Collection

Water quality data were collected from Lake Riley during the period 1971 through 1998. During 1971 through 1994, the District has generally sampled lakes on a three year rotating basis. Hence, Lake Riley has been sampled by the District during 1971, 1975, 1978, 1981, 1984, 1988, 1991, and 1994. Because Lake Riley has been designated as a Priority Lake by the Metropolitan Council, the lake has been monitored by the Metropolitan Council during 1980, 1982, 1985, 1986, and 1987.

During October of 1997 through September of 1998, an intensive data collection program was completed to evaluate current water quality conditions and to calibrate the water quality models used in the Use Attainability Analysis. The intensive data collection program involved more frequent lake sampling and the collection of samples at additional depths from lake surface to lake bottom than previous programs. The data collection program also involved inflow sample collection and continuous flow monitoring from two locations.

1.3.2 Baseline/Current Water Quality

A comparison of baseline and current water quality was completed to determine whether changes in the lake's water quality occurred during the 1971 through 1998 monitoring period. Baseline quality of the lake was determined by evaluating the average summer conditions during the period 1971 through 1987 (Table 4). Current water quality (i.e., 1988 through 1998) was compared to baseline averages to evaluate water quality changes (Table 4).

Table 4 A Comparison of Baseline Quality of Lake Riley With Current Conditions Based on Summer (June through August) Averages

Total Phosphorus (μg/L)		Chlorophyll *a* (μg/L)		Secchi Disc (m)	
Baseline (1971-1987)	**Current (1988-1998)**	**Baseline (1971-1987)**	**Current (1988-1998)**	**Baseline (1971-1987)**	**Current (1988-1998)**
Range: 0.037 to 0.075	Range: 0.035 to 0.051	Range: 16.6 to 47	Range: 24.5 to 36.5	Range: 0.9 to 2.2	Range: 0.9 to 1.4
Mean: 0.055	Mean: 0.042	Mean: 32.6	Mean: 29.5	Mean: 1.5	Mean: 1.2
1971: 0.047	1988: 0.035	1971: 24.6	1988: 24.5	1971: 0.9	1988: 1.2
1972: 0.066	1990: –	1972: 20.6	1990: 36.5	1972: 1.4	1990: 1.1
1975: 0.058	1991: 0.043	1975: 38.0	1991: 30.0	19.75: 1.2	1991: 1.4
1978: 0.075	1994: 0.051	1978: 21.5	1994: 26.4	1978: 2.2	1994: 1.2
1980: 0.060	1998: 0.038	1980: 34.0	1998: 30.1	1980: 1.0	1998: 0.9
1981: 0.059		1981: 25.2		1981: 2.1	
1982: 0.038		1982: 16.6		1982: 1.8	
1984: 0.051		1984: 39.7		1984: 1.0	
1985: 0.057		1985: 47.0		1985: 1.7	
1986: 0.037		1986: 44.9		1986: 1.5	
1987: 0.053		1987: 46.8		1987: 1.3	

A comparison of baseline and current water quality indicates the lake's total phosphorus, chlorophyll, and Secchi disc values have remained relatively stable. A comparison of ranges indicates current values are within the baseline range of values. Baseline values, however, note a somewhat wider range of values. The narrower range of values under current conditions has resulted in a lower mean value for the current period than for the baseline period. Hence, a comparison of means for the baseline and current periods indicates total phosphorus (means of summer averages) concentrations have decreased by about 24 percent; chlorophyll *a* (means of summer averages) have decreased by about 10 percent; Secchi disc transparency values have decreased by about 20 percent. Although current data comprise a narrower range of values than baseline data, the lake's overall water quality has been relatively stable.

Baseline and current water quality were evaluated based upon a standardized lake rating system. The rating system is scaled to place ranges of phosphorus, chlorophyll, and Secchi disc values within four water quality categories: Oligotrophic (clear, low productivity lakes with excellent water quality), Mesotrophic (intermediate productivity lakes with good water quality), Eutrophic (high productivity lakes with poor water quality) and Hypereutrophic (extremely productive lakes with very poor water quality). Based upon this rating system, baseline and current summer average total phosphorus and chlorophyll values have been within the eutrophic or hypereutrophic water quality categories. Secchi disc summer average values have generally been within the eutrophic trophic water quality category. Although summer average baseline Secchi disc values measured during 1978 and 1981 were within the mesotrophic (good) water quality category, summer average Secchi disc values measured during all other years during the 1971 through 1998 period were within the eutrophic (poor) category. Hence, the data indicate that while fluctuations occurred during the monitoring period, the lake's water transparency has generally been poor.

An evaluation of 1997 through 1998 Lake Riley water quality data was completed to examine the lake's present water quality. The evaluation was based upon a standardized lake rating system. The rating system uses the lake's total phosphorus, chlorophyll *a*, and Secchi disc transparency as the key water quality indicators to determine the lake's present water quality for the following reasons. Phosphorus generally controls the growth of algae in lake systems. Of all the substances needed for biological growth, phosphorus is generally the one present in limited quantity. Consequently, when phosphorus is added to a system, it enhances algal growth. Chlorophyll *a* is the main pigment in algae; therefore, the concentration of chlorophyll *a* in the water indicates the amount of algae present in the lake. Secchi disc transparency is a measure of water clarity, and is inversely related to algal abundance. Water clarity determines recreational use-impairment. Figure 3 summarizes the seasonal changes in concentrations of total phosphorus and chlorophyll *a*, and Secchi disc transparencies for Lake Riley during 1997 through 1998. The data are compared with a standardized lake rating system.

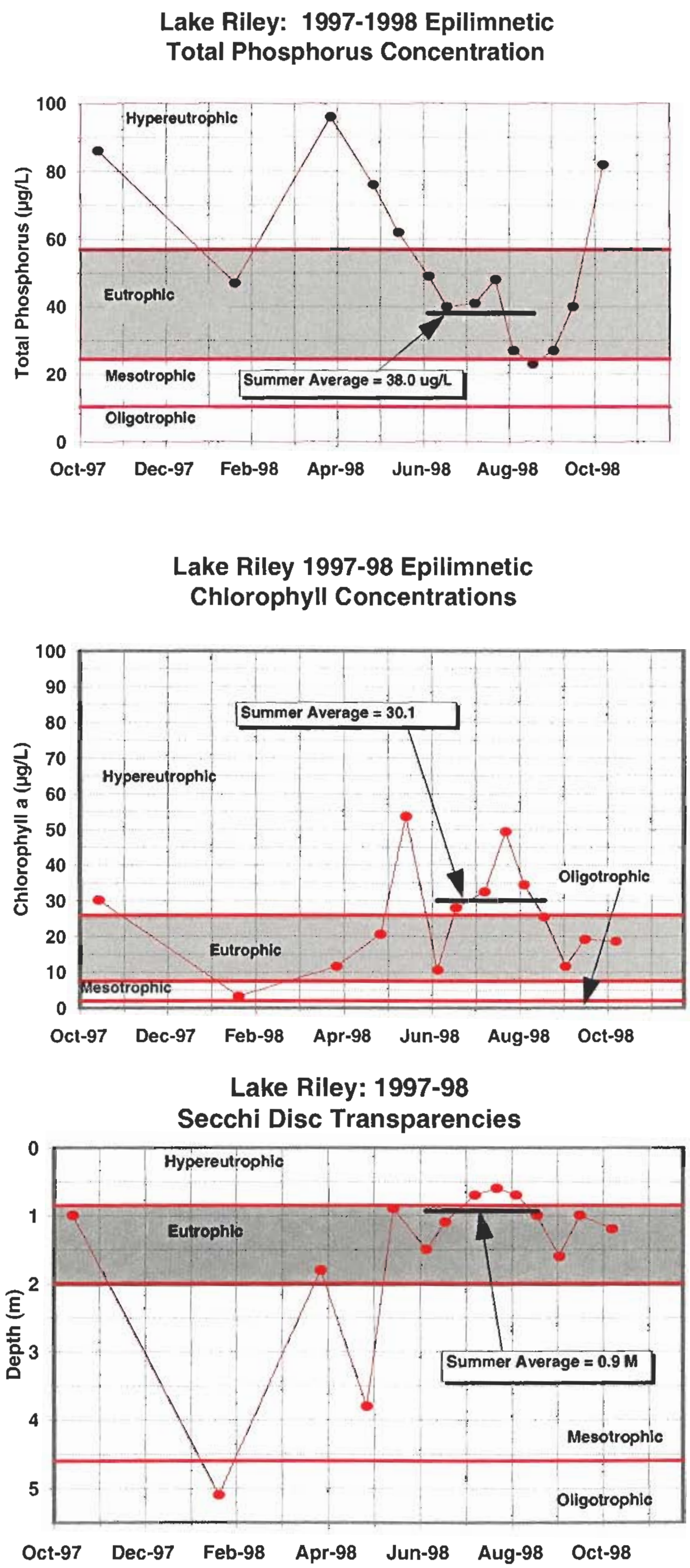


Figure 3
Seasonal Changes in Concentrations of
Total Phosphorus and Chlorophyll a Concentrations
and Secchi Disc Transparencies

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Total phosphorus data collected from Lake Riley during 1997 through 1998 indicate the lake may experience nuisance algal blooms during the summer. The data were in the hypereutrophic (very poor water quality) category during the spring and fall periods and were generally in the eutrophic (poor water quality) during the summer period. The lake's phosphorus level declined during the late-summer and a late-August measurement in the mesotrophic (good water quality) category was noted. The data indicate the lake's water quality fluctuates during the summer, but has the potential for being poor when the lake's use for swimming and other recreational use is highest. The 1998 Lake Riley average summer total phosphorus concentration (measured at the 0- to 2-meter depth) was 38 μg/L. This average is within the eutrophic (poor water quality) category.

The 1997 through 1998 Lake Riley chlorophyll *a* measurements (i.e., measured at 0-2 meters) generally exceeded nuisance levels. Measurements were lowest during the winter period and were highest during the summer period. The winter measurement was within the mesotrophic (good water quality) category. Measurements were in the hypereutrophic (very poor water quality) category during the fall of 1997 and during most of the summer period. Measurements were in the eutrophic (poor water quality) category during the spring, late-summer, and fall of 1998. Chlorophyll values during the fall of 1997, May of 1998, and late-June through August of 1998 exceeded nuisance levels (>20 μg/L).

The 1997 through 1998 Secchi disc measurements in Lake Riley ranged from the oligotrophic (excellent) to hypereutrophic (very poor) categories, but were generally within the eutrophic (poor water quality) category. Excellent transparency was noted during the winter, good transparency was noted during early-May, and very poor water transparencies were noted during the late-summer period. Poor water transparencies were noted at other times during the monitoring period. The data indicate Lake Riley Secchi disc measurements ranged from 0.6 to 1.5 meters during the summer period. Hence, moderate to severe recreational-use impairment occurred during the summer (Osgood, 1989). The lake's poor water transparency and resultant recreational-use impairment appear to be largely determined by algal abundance.

1.4 Ecosystem Data

1.4.1 Aquatic Ecosystems

The Lake Riley ecosystem is a determining factor in the achievement or non achievement of Lake Riley's recreation, aquatic communities, and water quality goals. Hence, the use attainability analysis included an evaluation of ecosystem data. Ecosystem describes the community of living things within Lake Riley and their interaction with the environment in which they live with each other. The interdependency of the ecosystem is best illustrated by the food web. The food web begins with the primary producers, which are green plants, such as phytoplankton (algae) and macrophytes (aquatic weeds). They take in carbon dioxide and water and use the sun's energy to produce their own food. Next in the chain are the primary consumers or herbivores, which eat plants. The most populous of these consumers are the zooplankton, which prey upon algae (phytoplankton). Succeeding the primary consumers are the secondary consumers or planktivores, which include sunfish and crappies. The diet of these fish includes zooplankton and other primary consumers. Tertiary consumers or predator fish occupy the next level of the food chain. This group includes bass and northern pike, which consume crappies and bluegill sunfish. At the top of the food chain are omnivores, such as humans, which eat bass and northern pike. A less visible component of the food chain, the decomposers, include bacteria living at the lake bottom, which break down dead and decaying organisms into nutrients and other essential elements (See Figure 4). All life in a food chain is interdependent. If any one group becomes unbalanced, all life in the food chain is adversely impacted. An aquatic ecosystem is managed to maintain balance between the phytoplankton, zooplankton, small fish (crappies and bluegill sunfish), and large fish (bass and northern pike).

The Lake Riley ecosystem is typical for a eutrophic (poor quality), temperate lake in this region.

1.4.2 Phytoplankton

The phytoplankton species in Lake Riley form the base of the lake's food web and directly impact the lake's fish production. Phytoplankton, also called algae, are small aquatic plants naturally present in all lakes. They derive energy from sunlight (through photosynthesis) and from dissolved-nutrients found in lake water. They provide food for several types of animals, including zooplankton, which are in turn eaten by fish. A phytoplankton population in balance with the lake's zooplankton population is ideal for fish production. An inadequate phytoplankton population reduces the lake's zooplankton population and adversely impacts the lake's fishery. Excess phytoplankton, however, reduce water clarity and reduced water clarity can interfere with the recreational usage of a lake.

During 1997 through 1998, Lake Riley noted a diverse phytoplankton population (Figure 5). Blue-green algae dominated the phytoplankton community during the fall of 1997 and during May through September of 1998. Blue-green algae and cryptomonads comprised the phytoplankton community during winter (i.e., January 1998). The spring phytoplankton community (i.e., March 31) was dominated by green algae and cryptomonads.

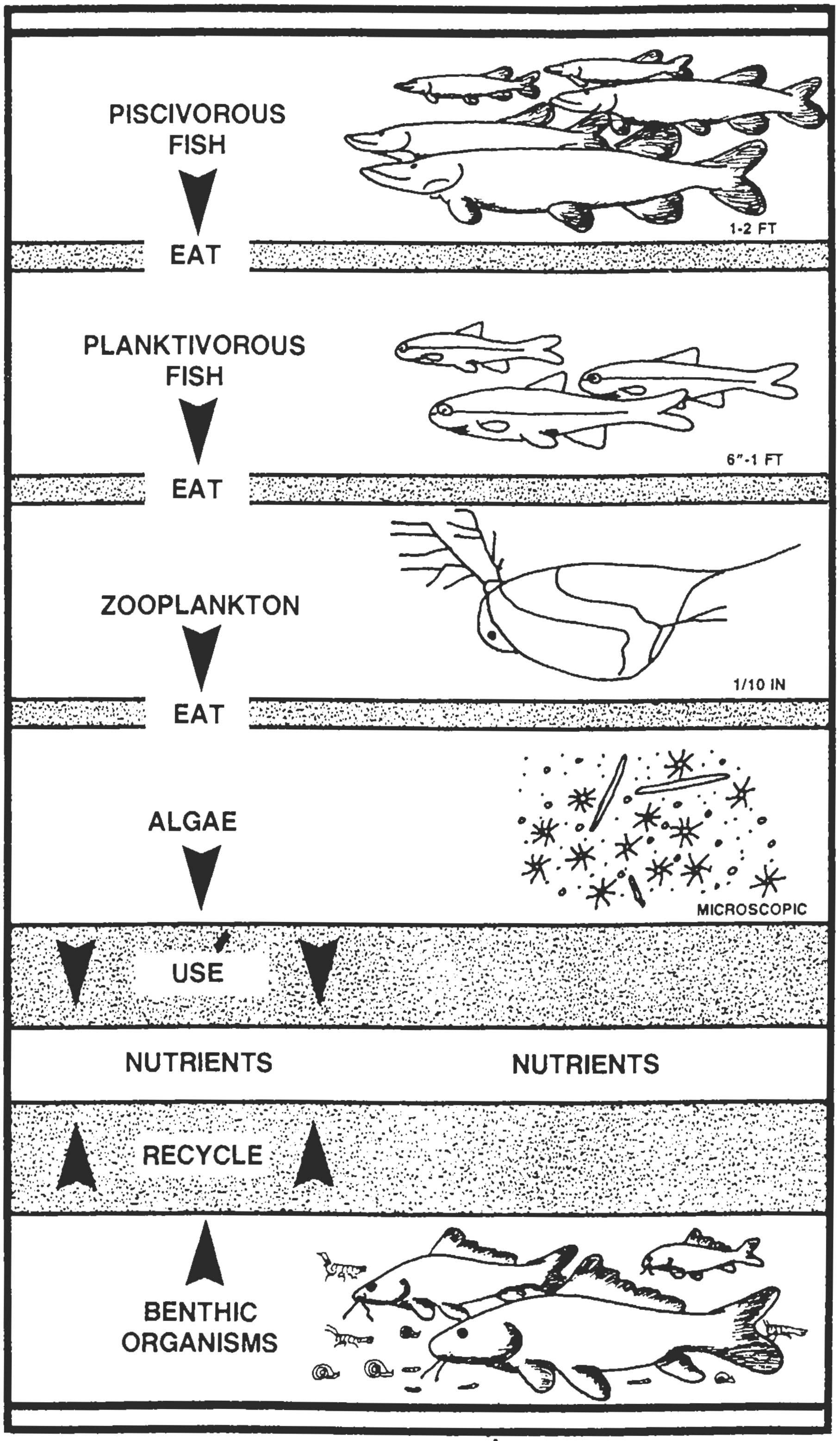

Figure 4
THE FOOD WEB

1997-1998 Lake Riley Phytoplankton Summary by Division

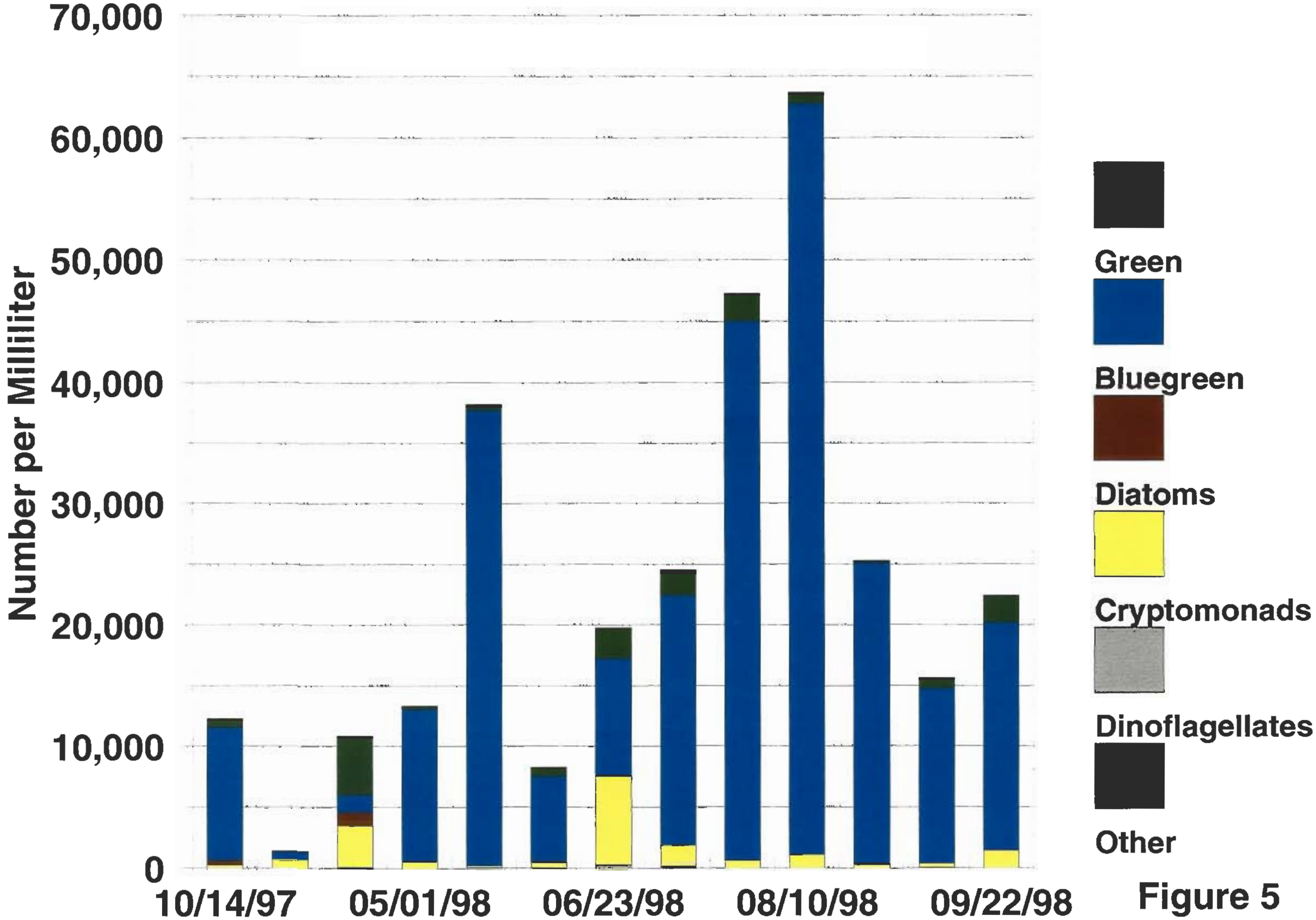

Figure 5

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The quantity of algae in a lake or algal volume is a function of the number of individual algae in the lake and the size of each individual. Algal sizes vary greatly. Green algae, cryptomonads, and diatoms are small in size and represent very low algal volumes. Blue-green algae are generally larger in size and, consequently, represent relatively high volumes. Lake Riley noted highest numbers of algae during the summer period when blue-green algae predominated. Consequently, the lake noted highest algal volumes during the summer period (See Figure 6). The excess numbers and high volumes of phytoplankton during the summer period caused them to be out of balance with the other organisms in the lake's food web (See Figure 7).

Dominance by blue-green algae during the summer period was unfavorable for the following reasons:

- Blue-green algae are inedible to fish, waterfowl, and most zooplankters and, hence, not subject to biological control;
- Blue-green algae float at the lake surface in expansive algal blooms;
- Blue-green algae may be toxic to animals when occurring in large blooms;
- Blue-green algae disrupt lake recreation during the summer period.

Blue-green algal growth is stimulated by excess phosphorus loads. The growing conditions in July and August are particularly favorable to blue-green algae, and they have a competitive advantage over the other algal species during this time. A reduction in phosphorus loads is required for a reduction in blue-green algal growth.

1.4.3 Zooplankton

Zooplankton are the second step in the Lake Riley food web, and are considered vital to its fishery. They are microscopic animals that feed on particulate matter, including algae, and are, in turn, eaten by fish. Protection or enhancement of the lake's zooplankton community through judicious management practices affords protection to the lake's fishery.

Healthy zooplankton communities are characterized by balanced densities (number per meter squared) of the three major groups of zooplankton: cladocera, copepods, and rotifers. Fish predation, however, may alter community structure and reduce the numbers of larger-bodied zooplankters (i.e., larger bodied cladocera).

1997-1998 Lake Riley Phytoplankton Biovolume Data Summary

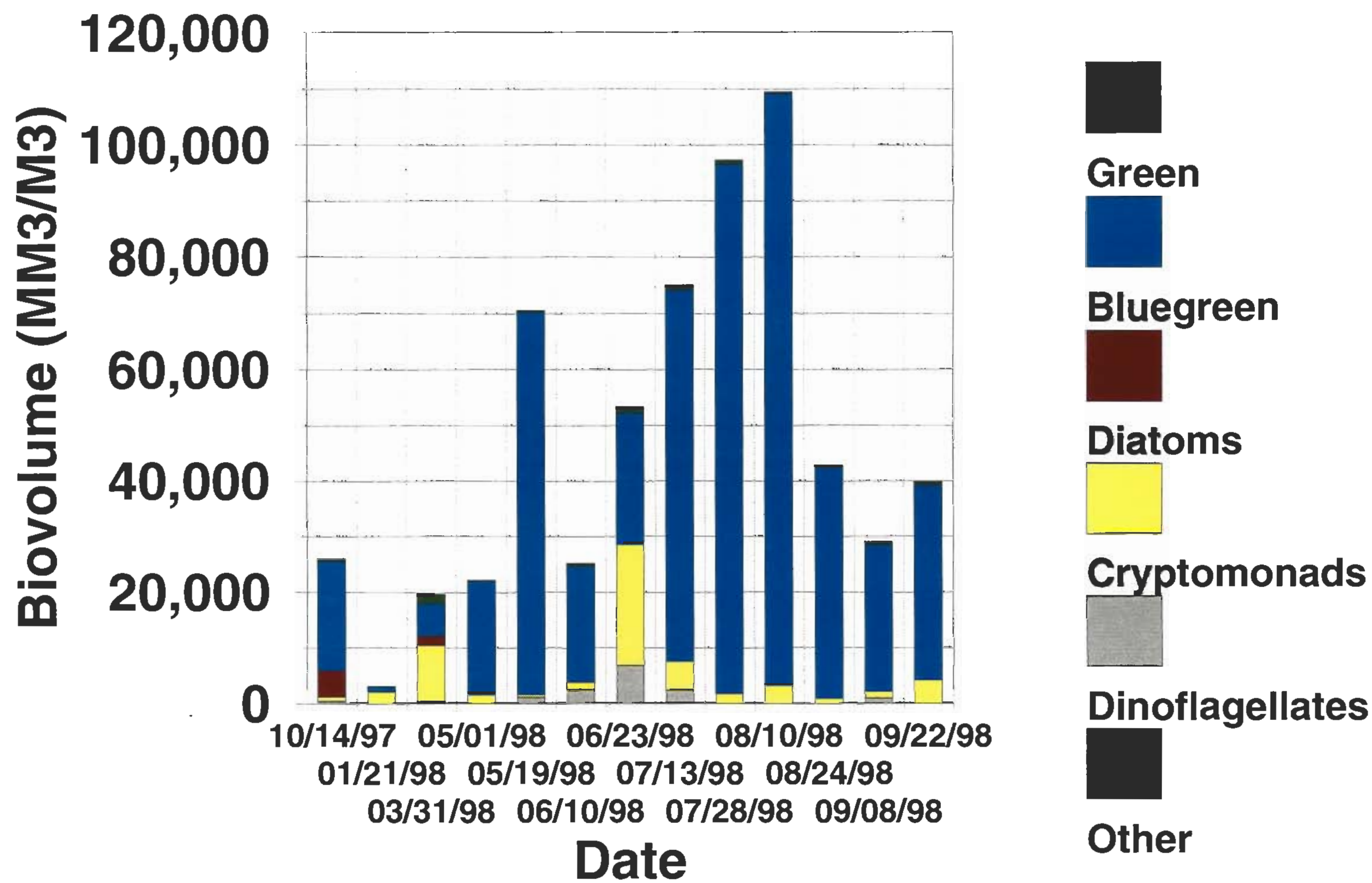

Figure 6

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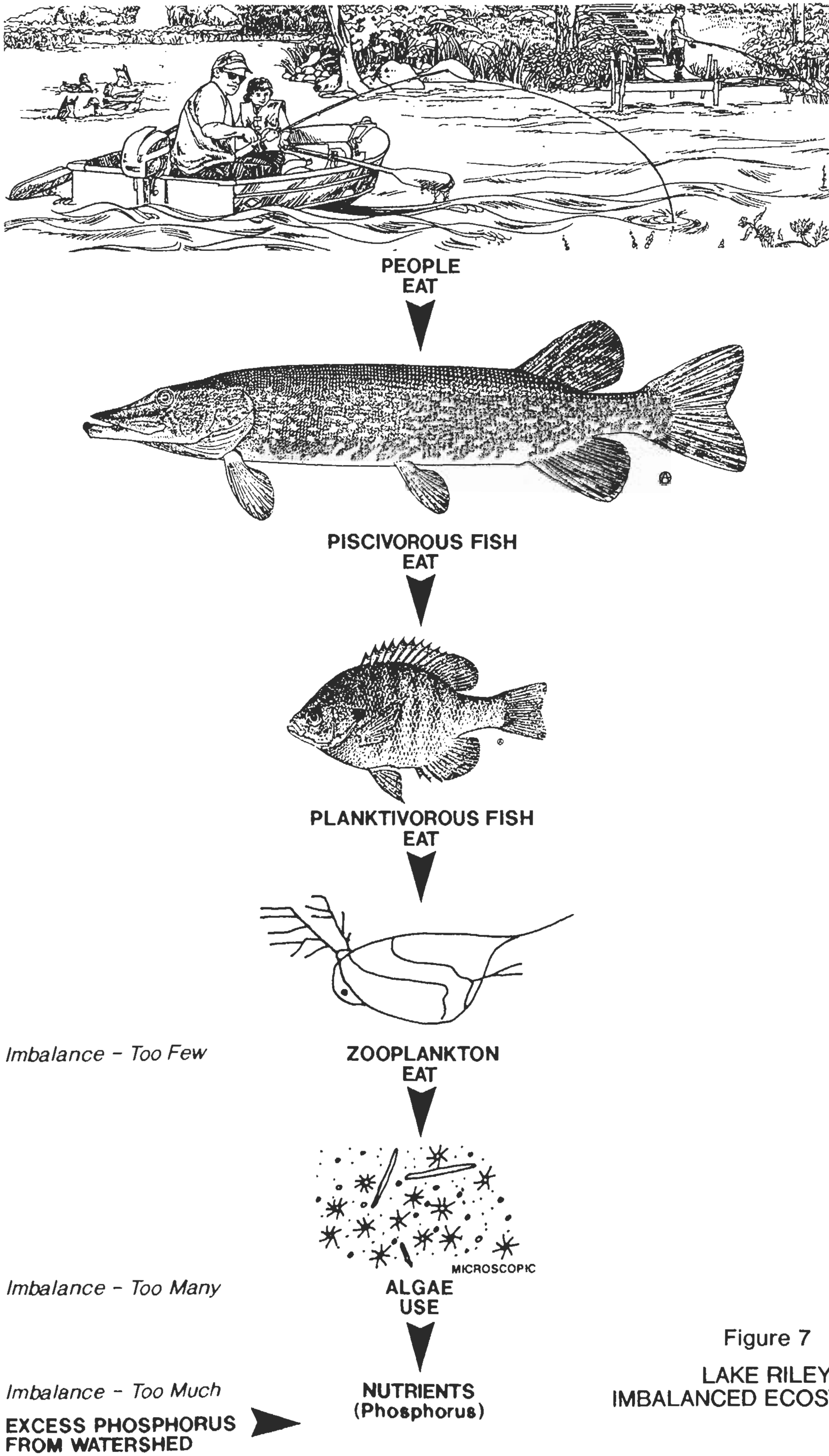

Figure 7

LAKE RILEY
IMBALANCED ECOSYSTEM

Although the three groups were represented during the 1997 through 1998 period, the zooplankton community in Lake Riley was dominated by small-bodied zooplankters (Figure 8). Large-bodied zooplankters comprised less than 10 percent of the zooplankton community during most sample events. Exceptions occurred on May 19 (14 percent), August 24 (19 percent) and September 8 (25 percent). Fish predation of the larger-bodied zooplankters likely resulted in dominance by smaller-bodied zooplankters throughout the sample period.

The low numbers of large-bodied zooplankters have minimized biological control of the lake's phytoplankton. Highest daily grazing by cladocera was estimated to be 17 percent of the lake's upper 2 meters during early-May, when increased numbers of cladocera were noted. Daily grazing by cladocera during the late-May through September period, when low numbers of cladocera were noted, was more than an order of magnitude lower, ranging from 0.4 to 1.9 percent of the lake's upper 2 meters. The low numbers of large cladocera generally noted during 1998 indicate they are out of balance with the other organisms in the lake's food web (See Figure 7).

1.4.4 Macrophytes

Aquatic plants are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. Typical functions of a lake's macrophyte community include:

- Provide habitat for fish, insects, and small invertebrates
- Provide food for waterfowl, fish, and wildlife
- Produce oxygen
- Provide spawning areas for fish in early-spring
- Help stabilize marshy borders and protect shorelines from wave erosion
- Provide nesting sites for waterfowl and marsh birds

Lake Riley's macrophytes were surveyed on June 18 (Figure 9) and August 17, 1998 (Figure 10). Macrophytes cover the littoral area of Lake Riley, except at the swimming beach. Macrophytes were identified to a maximum depth of 8 feet. During 1998, five individual species were identified during the June and August surveys.

1998 Lake Riley Zooplankton Summary by Division

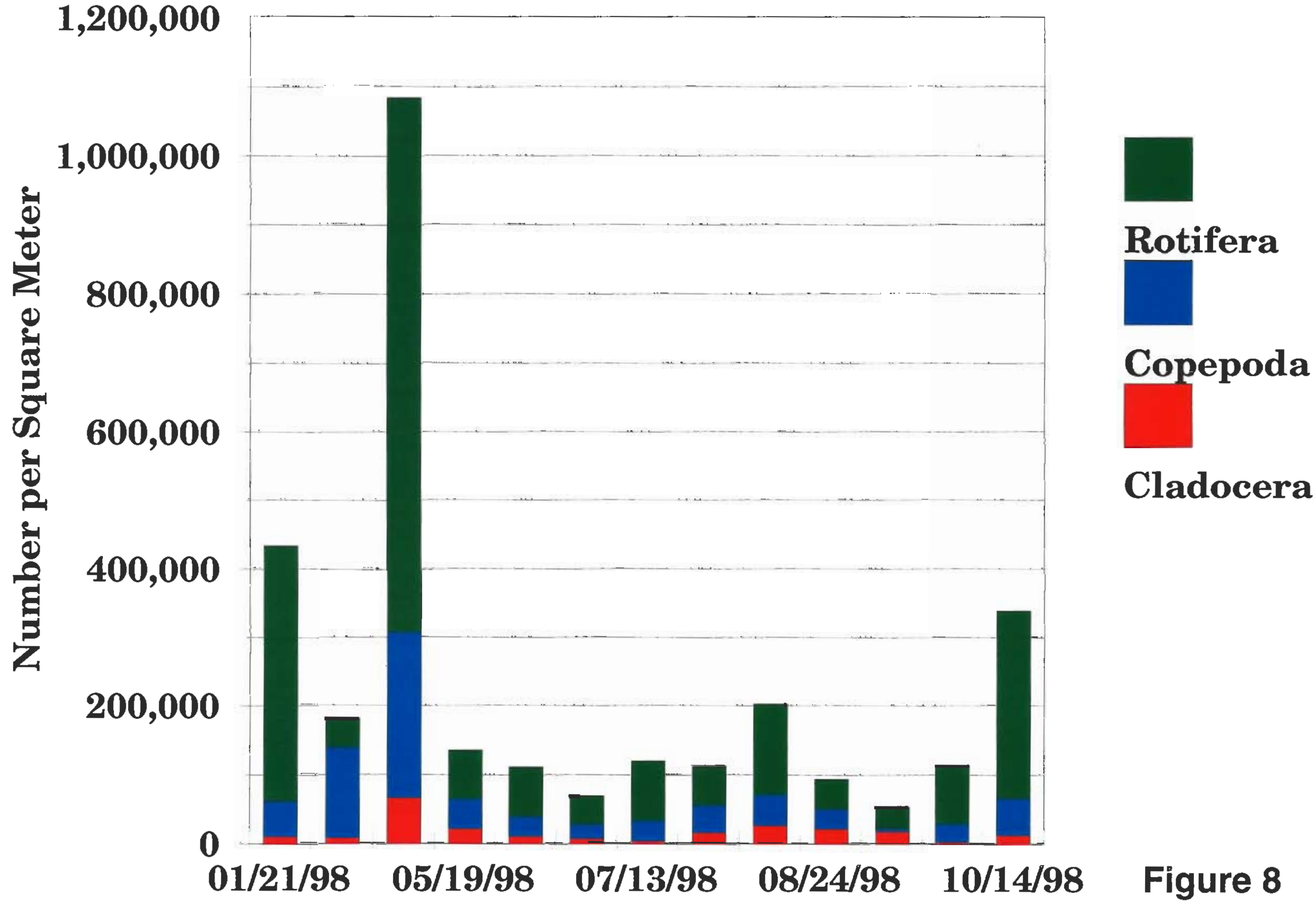

Figure 8

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LAKE RILEY MACROPHYTE SURVEY
JUNE 18, 1998

- No Macrophytes Found in Water > 8.0'
- Algae Was Found in Light Density Mats Around the Lake. Plant Density is greatest near shore
- Portions of the Lake Shore appear to have been Treated with a Herbicide
- Macrophyte Densities Estimated As Follows:1= light; 2= moderate; 3= heavy
- Aquatic Vegetation:

	Common Name	Scientific Name
Submerged Aquatic Plants:	Eurasian watermilfoil	*Myriophyllum spicatum*
	Sago Pondweed	*Potamogeton pectinatus*
	Coontail	*Ceratophyllum demersum*
	Curly Leaf Pondweed	*Potamogeton crispus*
Floating Leaf:	White Waterlily	*Nymphaea tuberosa*
Emergent:		
No Aquatic Vegetation Found:		

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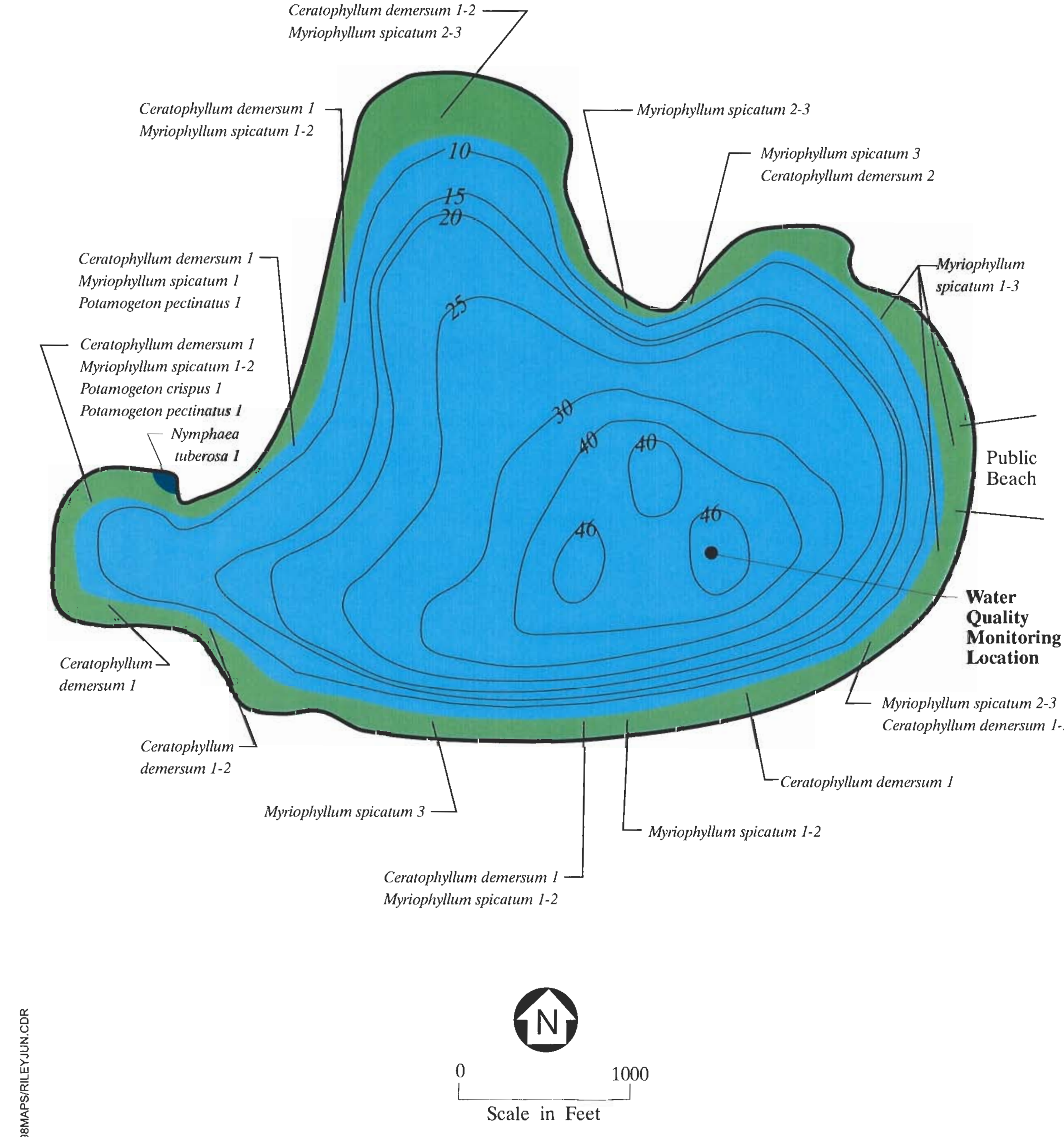

Figure 9

LAKE RILEY MACROPHYTE SURVEY
JUNE 18, 1998

LAKE RILEY MACROPHYTE SURVEY
AUGUST 17, 1998

- No Macrophytes Found in Water > 8.0'
- Algae Was Found in Light Density Mats Around the Lake. Plant Density is greatest near shore
- Macrophyte Densities Estimated As Follows: 1= light; 2= moderate; 3= heavy
- Aquatic Vegetation:

		Common Name	Scientific Name
Submerged Aquatic Plants:	(green)	Eurasian watermilfoil	*Myriophyllum spicatum*
		Sago Pondweed	*Potamogeton pectinatus*
		Coontail	*Ceratophyllum demersum*
		Curly Leaf Pondweed	*Potamogeton crispus*
Floating Leaf:	(dark blue)	White Waterlily	*Nymphaea tuberosa*
Emergent:	(orange)		
No Aquatic Vegetation Found:	(light blue)		

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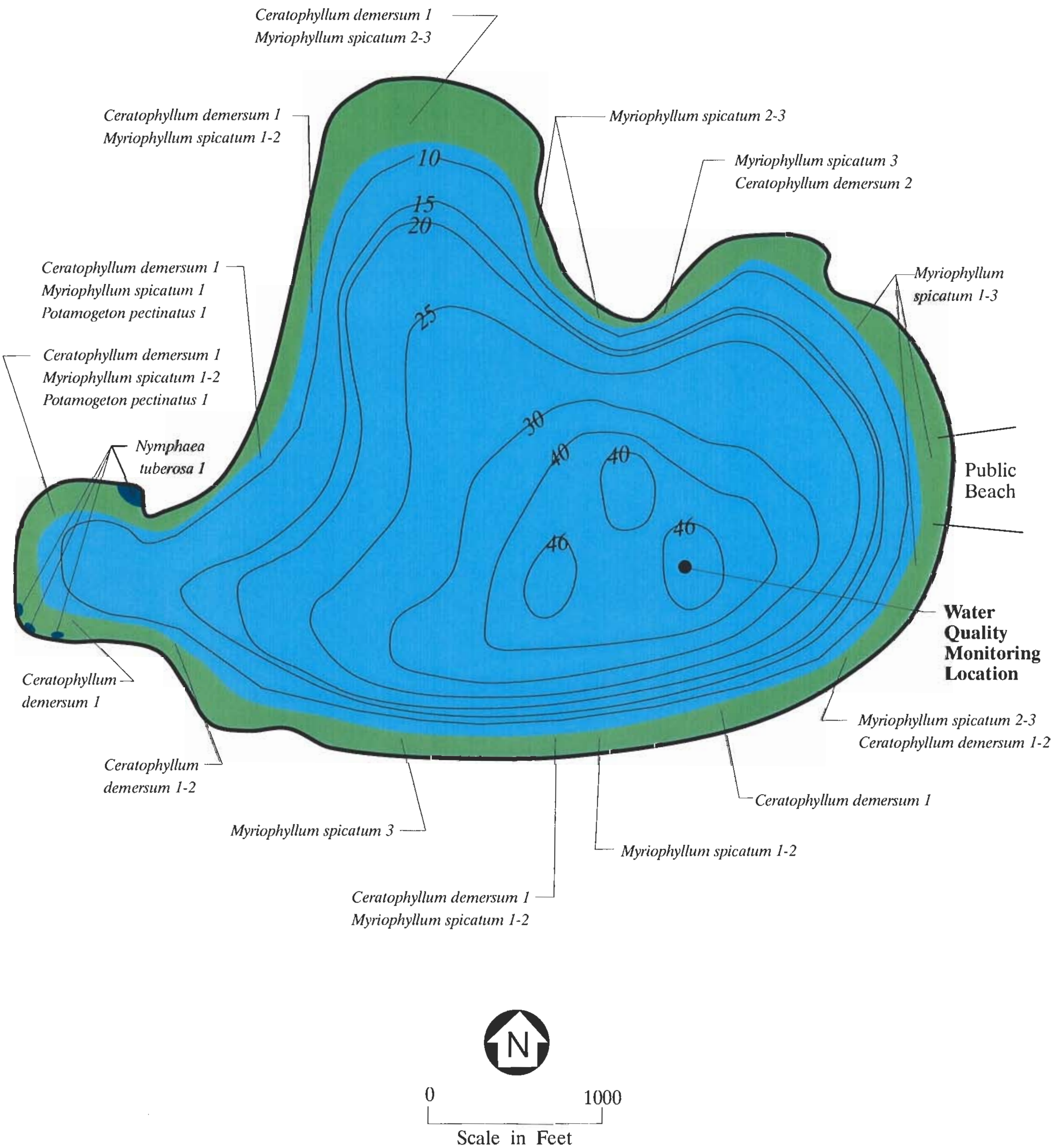


Figure 10

LAKE RILEY MACROPHYTE SURVEY
AUGUST 17, 1998

Lake Riley noted one nuisance exotic (non-native) plant during 1998, Eurasian watermilfoil. Eurasian watermilfoil is a particularly problematic exotic plant in North America due to its ability to reproduce from fragments and spread rapidly, its high growth rate in a range of temperature and environmental conditions, and its tendency to reach the surface and form extensive mats of plant at the surface, which can allow it to shade and outcompete native vegetation (Madsen et al. 1991; Valley and Newman 1998). Eurasian watermilfoil was found throughout Lake Riley. However, because most portions of the lake contain only two plant species, eradication of Eurasian watermilfoil would eliminate needed fisheries habitat. Consequently, preservation of this species is recommended.

1.5 Water Based Recreation

Lake Riley is used for all types of recreational activities, including swimming. The municipal swimming beach and boat access for Lake Riley, located along the east shore, are owned and maintained by the City of Eden Prairie. A creel survey in 1980 identified fishing as a popular recreational activity on Lake Riley. Recreational boating (runabouts, canoeing, sailing, etc.) has also been popular on the lake (MDNR, 1980).

1.6 Fish and Wildlife Habitat

During 1992, the MDNR classified Lake Riley and other Minnesota lakes relative to fisheries. According to its ecological classification, Lake Riley is a Class 24 lake, which signifies a good permanent fish lake (Schupp, 1992). The MDNR has indicated that the average water quality for its ecological class is a TSI_{SD} (Trophic State Index in terms of Secchi disc transparency) of approximately 56 or lower (i.e., a summer average Secchi disc transparency of about 4 feet or greater). The recommendation is based upon the water quality needs of the fishery found in a Class 24 lake. Currently, the lake's water quality does not meet this recommendation based upon the 1998 data. The lake's current water quality corresponds to a TSI_{SD} of 62 (a summer average Secchi disc of approximately 3 feet). Lake Riley's water quality during 1971 through 1998 has not met the MDNR recommendation during approximately 37 percent of the monitoring period (n=16). Years in which the lake's water quality failed to meet the MDNR recommendation include 1971, 1975, 1980, 1984, 1987, 1991, and 1998.

According to its classification, Lake Riley's primary fish species are northern pike, carp, and bluegill. Northern pike is a tertiary consumer or predator fish and bluegill is a secondary consumer or planktivore (See Figure 4). Carp is considered a benthic or bottom feeding fish.

The lake's current fishery is comprised of panfish species, gamefish species, rough fish species, and other fish species. Species captured during the MDNR 1995 and 1999 fisheries surveys include:

- **Panfish**—black crappie, bluegill, hybrid sunfish, and pumpkinseed sunfish
- **Gamefish**—largemouth bass, northern pike, yellow perch, and walleye
- **Rough fish**—black bullhead, brown bullhead, yellow bullhead, and common carp
- **Other fish**—golden shiner, fathead minnow, white sucker, and spottail shiner

Fisheries survey results indicated Lake Riley exhibited a typical largemouth bass-bluegill-northern pike fishery during 1995 and 1999.

During 1995, northern pike were sampled in relatively high numbers. Approximately one of every six northern pike sampled was 28 inches or longer. Although largemouth bass are reported to be abundant, high numbers were not captured in the survey. Walleye were present even though they have never been stocked. It is suspected that walleye are migrating down Riley Creek from Lake Susan where fry have been stocked on a regular basis. Bluegill, pumpkinseed sunfish, and black crappie were abundant in the trap net samples with some quality size fish present in the population. Almost 1/3 of the bluegill captured were 7.0 inches or longer. Although three species of bullhead were present in the lake, black bullhead were the most abundant. Carp and white sucker were also present in above average abundance (MDNR 1996).

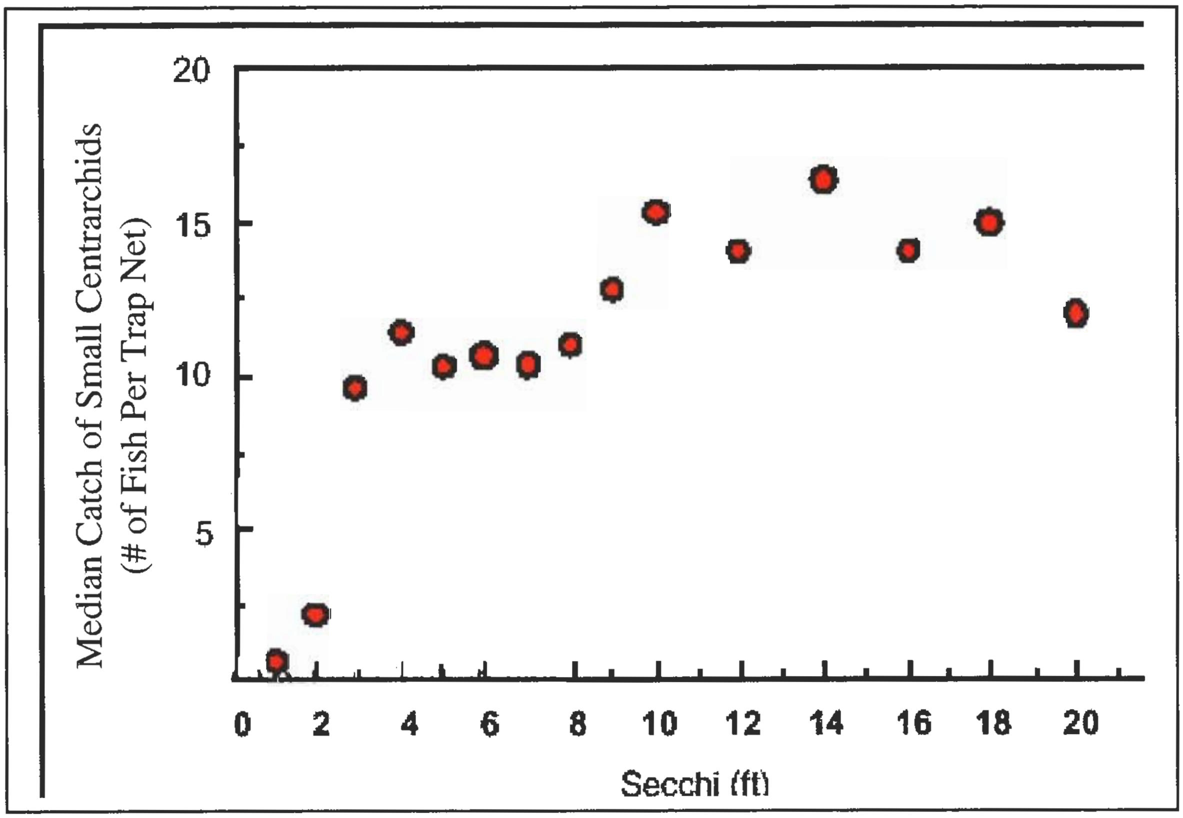
A comparison of 1995 and 1999 fishery survey results indicated fluctuations occurred among some of the lake's fish species. The lake's fishery, however, was relatively similar during 1995 and 1999.

During 1999, northern pike were very abundant and over half of the fish handled during the survey exceeded 25 inches in length. Electrofishing, a sampling method more suited for largemouth bass, captured 23 individuals. Largemouth bass averaged 10 inches in length. Bluegills were very abundant and nearly 20 percent were larger than 7 inches. Walleyes were present in good numbers and averaged 16 inches in length. Yellow perch were abundant, but averaged only about 6.6 inches in length. Carp and bullheads were present in abundant numbers. White sucker and yellow bullhead were also present, but in much lower numbers.

Improvement of the lake's water quality is important for the maintenance of the lake's fishery. MDNR evaluated data from its data warehouse to determine whether a relationship between water transparency and fishery quality occurred. The evaluation included the trap net data collected in Minnesota lakes since 1980 in 6,109 fisheries surveys. The evaluation indicated that improved Secchi disc water transparency resulted in improved fishery. Fewer rough fish and increased numbers of small Centrarchids (i.e., bluegills, green sunfish, hybrid sunfish, and pumpkinseeds) occurred with increased Secchi disc transparency (shown in Figure 11). The evaluation also indicated that below a Secchi disc transparency of 3 feet, the lakes' fishery "crashed" resulting in extremely low numbers of small Centrarchids and a value of 0 for the proportion of small Centrarchids (i.e., virtually all fish were rough fish) (also shown in Figure 11). During 1998, the lake's average summer Secchi disc water transparency was 2.9 feet. The data indicate improvement of Lake Riley's current transparency is necessary to maintain the lake's fishery. Should the lake's average summer Secchi disc transparency remain below 3 feet, the lake could experience a significant loss of small Centrarchids and a significant increase in rough fish. A reduction in the lake's total phosphorus concentration is required to increase the lake's Secchi disc transparency..

Lake Riley provides habitat for seasonal waterfowl, such as ducks and geese.

Fisheries Quality vs. Water Transparency



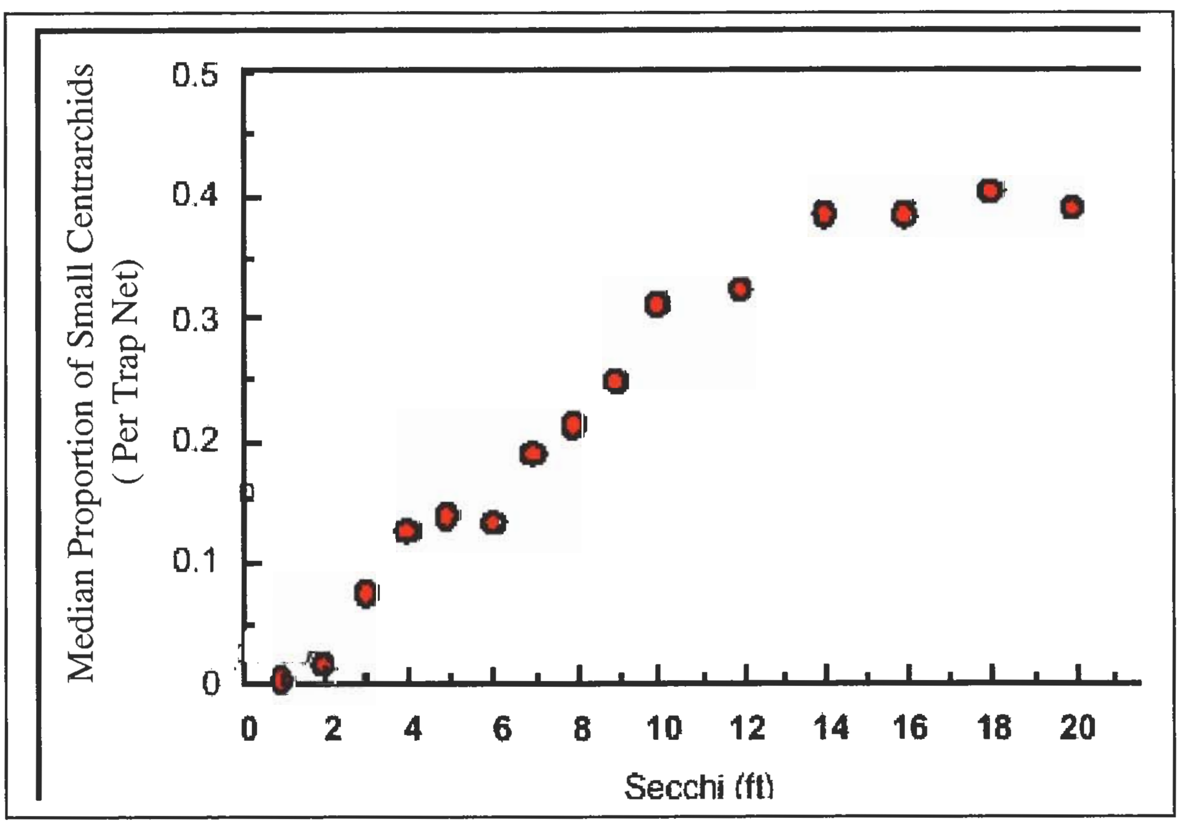


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Figure 11

1.7 Discharges

1.7.1 Natural Conveyance Systems

The natural inflow to Lake Riley is comprised of stormwater runoff from its direct watershed (i.e., 1.00 on Figure 12), groundwater discharge, and Riley Creek, which enters on the northeast side of the lake.

Riley Creek receives runoff from four conveyance systems in the lake's direct watershed and from the lake's large indirect watershed, comprised of the watershed tributary to Lakes Lucy, Ann, Susan, and Rice Marsh. Conveyance systems tributary to Lake Riley in its direct watershed include (See Figure 12):

- **Pond 5.12**—Stormwater runoff from subwatershed/detention pond 5.31 and from subwatershed 5.12 is conveyed to pond 5.12, which discharges to Riley Creek.
- **Pond 5.01**—Stormwater runoff from subwatersheds/detention ponds 5.21 and 5.11 and from subwatershed 5.01 is conveyed to pond 5.01, which discharges to Riley Creek.
- **Pond 5.03**—Stormwater runoff from subwatersheds/detention ponds 5.23 and 5.13 and from subwatershed 5.03 is conveyed to pond 5.03, which discharges to Riley Creek.
- **Pond 5.14**—Stormwater runoff from subwatersheds/detention ponds 5.41, 5.32 and 5.24, and from subwatershed 5.14 is conveyed to pond 5.14, which discharges to Riley Creek.

Wet detention ponds treat runoff prior to conveyance to Riley Creek. Wet detention ponds are found in the lake's direct and indirect watersheds.

Wet detention ponds consist of a permanent pool of water and have the capacity to hold runoff and release it at lower rates than incoming flows. Wet detention ponds are one of the most effective methods available for treatment of nutrient-rich runoff. Wet detention ponds are used to interrupt the transport phase of sediment and pollutants associated with it, such as trace metals, hydrocarbons, nutrients, and pesticides.

During a storm event, polluted-runoff enters the detention basin and displaces "clean water" until the plume of polluted-runoff reaches the basin's outlet structure. When the polluted-runoff reaches the basin outlet, it has been diluted by the water previously held in the basin. This dilution further reduces the pollutant concentration of the outflow. In addition, the course sediments being transported by the polluted runoff and the pollutants associated with these sediments are trapped in the detention basin.

As storm flows subside, finer sediments suspended in the basin's pool will have a relatively longer period of time to settle out. These finer sediments eventually trapped in the basin's permanent pool, will continue to settle until the next storm flow occurs. In addition to efficient settling, this long detention time allows some removal of dissolved nutrients through biological activity (Walker, 1987). These dissolved nutrients are mainly removed by algae and aquatic plants. After the algae die, the dead algae can settle to the bottom of the pond, carrying with them the dissolved nutrients that were consumed, to become part of the bottom sediments.

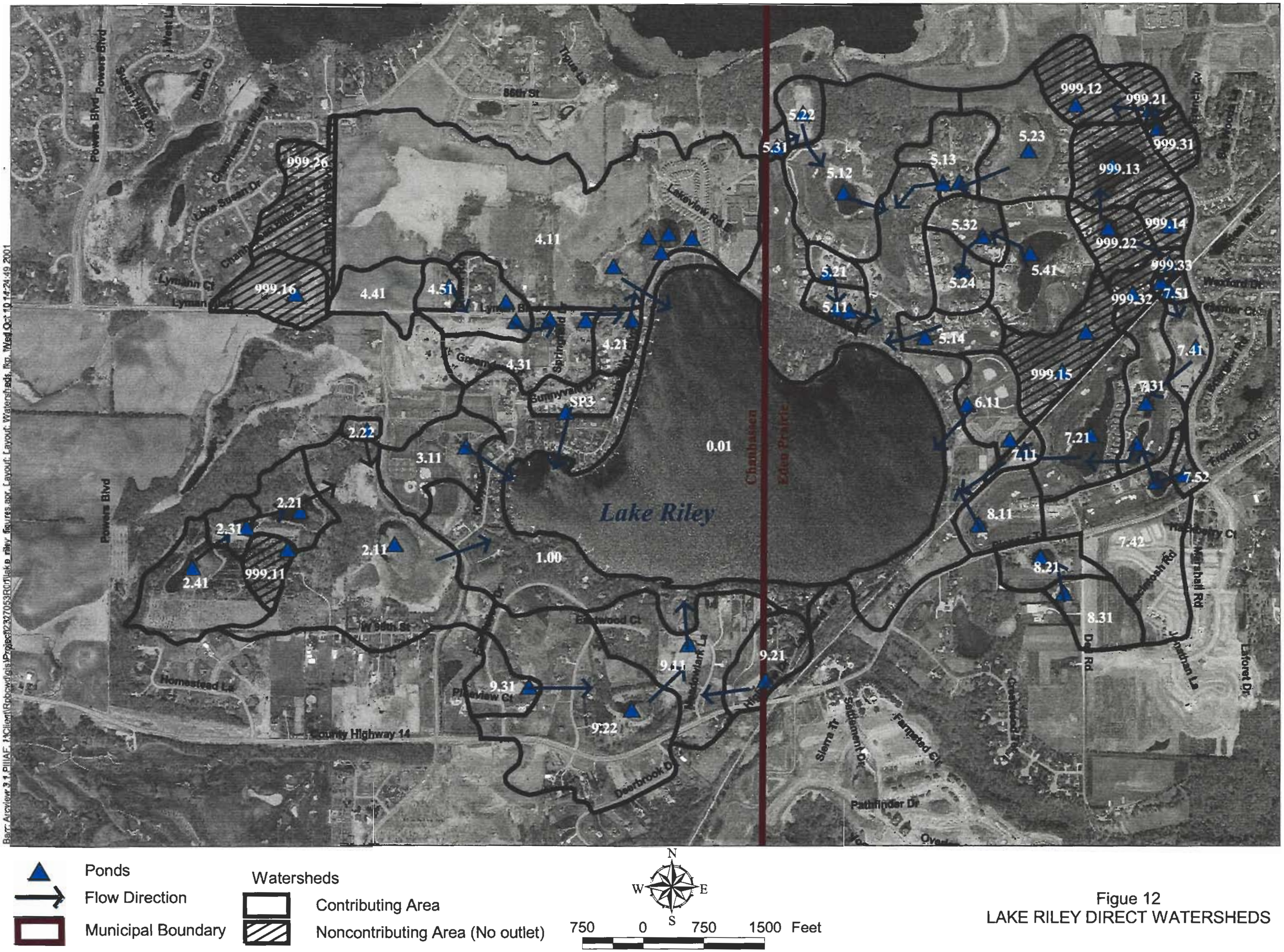
The wet detention process results in good pollutant removal from small storm events. Runoff from larger storms will experience pollutant removal, but not with the same high efficiency levels as the runoff from smaller storms. Studies have shown that because of the frequency distribution of storm events, good control for more frequent small storms (wet detention's strength) is very important to long-term pollutant removal.

A total of 101 wet detention ponds are found in the watershed tributary to Riley Creek. The ponds include 12 wet detention basins found within the lake's direct watershed and 89 wet detention basins found in the lake's indirect watershed. Wet detention basins in the lake's direct watershed are shown on Figure 12. Basin details are found in Appendix B. Eighty nine wet detention ponds in the lake's indirect watershed include:

- 10 ponds in the watershed tributary to Lake Ann
- 21 ponds in the watershed tributary to Lake Lucy
- 31 ponds in the watershed tributary to Lake Susan
- 27 ponds in the watershed tributary to Rice Marsh Lake

Wet detention basins within the Lake Riley indirect watershed are shown and discussed *in Lake Lucy and Lake Ann Use Attainability Analysis* (Barr, 1999) and *Susan and Rice Marsh Lake Use Attainability Analysis* (Barr, 1999).

Lakes Ann, Lucy, Susan, and Rice Marsh also serve as wet detention basins and remove pollutants.



Figue 12
LAKE RILEY DIRECT WATERSHEDS

1.7.2 Stormwater Conveyance Systems

The Lake Riley stormwater conveyance system is comprised of a network of storm sewers and wet detention ponds within the direct watershed tributary to the lake. The wet detention ponds provide water quality treatment of stormwater runoff. Storm sewers convey stormwater runoff to and from many of the wet detention ponds, and eventually convey the runoff to Lake Riley. Some wet detention ponds convey runoff to Lake Riley via overland flow.

Stormwater is conveyed to Lake Riley via seven stormwater conveyance systems located within the lake's direct watershed. The storm sewer inflows to Lake Riley are shown on Figure 12 and discussed below:

- **Pond 2.11**—Stormwater runoff from a conveyance system and a detention basin converge at pond 2.11, which discharges to Lake Riley. Pond 2.11 receives runoff from subwatersheds/detention basins 2.41, 2.31, 2.21 and 2.22 and from subwatershed 2.11.
- **Pond 3.11**—Stormwater runoff from subwatershed 3.11 is treated in detention pond 3.11 and conveyed to Lake Riley.
- **Pond SP3**—Stormwater runoff from subwatershed SP3 is treated in detention basin SP3 and conveyed to Lake Riley.
- **P445**—Stormwater runoff from two conveyance systems converge at stormsewer location P445. P445 discharges to Lake Riley. P445 receives runoff from subwatersheds/detention ponds 4.15, 4.14, 4.13, 4.12, 4.11, 4.51, SP4, 9999.42, 9999.43, and 4.21.
- **Pond 9.11**—Stormwater runoff from a conveyance system and a detention basin converge at pond 9.11, which discharges to Lake Riley. Pond 9.11 receives runoff from subwatersheds/detention basins 9.31, 9.22, and 9.21 and from subwatershed 9.11.
- **Pond 6.11**—Stormwater runoff from subwatershed 6.11 is treated in detention pond 6.11 and conveyed to Lake Riley.
- **St. 1**—Stormwater runoff from two conveyance systems converge upstream of stormsewer location St. 1, which discharges to Lake Riley. St. 1 receives runoff from subwatersheds/detention ponds 8.31, 8.21, 8.11, 7.52, 7.42, 7.31, 7.21, 7.11, and 7.01.

A total of 31 wet detention basins are found within the seven stormwater conveyance systems. Basin details are presented in Appendix B.

A total of 136 wet detention basins are found in the Lake Riley watershed, including four upstream lakes, 101 ponds tributary to Riley Creek, and 31 ponds in the lake's direct watershed. Wet detention basins tributary to Riley Creek are discussed in Section 1.7.1—Natural Conveyance Systems.

Extended dry ponds are stormwater detention ponds that are designed to temporarily hold stormwater for an extended period of time. Extended detention basins rely upon this detention time to allow physical settling of pollutants. They are different than wet detention ponds because they are dry most of the time, and hold water for a period of time after each rainstorm (they do not require dead storage). Because they do not have a permanent pool, their effectiveness in removing nutrients can be substantially lower than wet detention ponds. Eleven extended dry ponds are located within the Lake Riley direct watershed. Extended dry ponds convey water to a stormwater conveyance system via overland flow. Water is then conveyed to Lake Riley via its stormwater conveyance systems.

1.7.3 Public Ditch Systems

There are no public ditch systems that affect Lake Riley.

1.8 Appropriations

There are no known water appropriations from Lake Riley.