# *Round Lake Use Attainability Analysis*

*Prepared for*
*Riley-Purgatory-Bluff Creek Watershed District*

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# Executive Summary

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

The main tools for this analysis are advanced water quality models whose predictions are calibrated to recently collected water quality data. These models predict the amount of pollutants that reach Round Lake and are calibrated to intensive data collection to assure accurate estimation. These models are used to analyze the effect of discharges from natural and stormwater conveyance systems, the critical analysis of this report.

The use attainability analysis provides the scientific foundation for a lake-specific best management plan that will maintain or attain the existing and potential beneficial uses of Round Lake.

The Recreation Goal is water quality that, 1) fully supports swimming, applying the "MPCA Use Support Classification for Swimming Relative to Carlson's Trophic State Index by Ecoregion" and, 2) achieves a sport fishery that includes a balance of predator fish (northern pike, bass) and planktivores (bluegills). This goal is attainable, but only with the implementation of additional lake and watershed management practices.

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. This goal is attainable, but only with the implementation of additional lake and watershed management practices.

The Aquatic Communities Goal is water quality that fully supports fishing, according to the Minnesota Department of Natural Resource (MDNR) "Ecological Use Classification" and achieves a balanced fishery. This goal is attainable, but only with the implementation of additional lake and watershed management practices.

The Water Quantity Goal is to manage surface water runoff from a regional flood, the critical 100-year frequency storm event. Construction of an outlet to Round Lake as part of the Eden Prairie Chain-of-Lakes Basic Water Management Project achieved this goal, now and in the future.

The wildlife goal for Round Lake is to protect existing, beneficial wildlife uses. The wildlife goal has been achieved, but the current wildlife use of the lake is impeding the achievement of the lake's recreation, water quality, and aquatic community goals. There is substantial use of Round Lake by waterfowl, particularly geese. This wildlife use is substantially degrading and impairing recreation and water quality due to excessive fecal coliform bacteria and is significantly contributing to degradations of aquatic communities due to excessive phosphorous. So long as this wildlife use continues unabated, it will impair other existing and potential beneficial uses, particularly those goals established for recreation and aquatic communities.

Without additionally treating discharges from natural and stormwater conveyance systems all goals for Round Lake will neither be maintained nor attained.

It has been determined that dry climatic conditions produce the greatest strain upon the water quality of Round Lake because the low lake level during dry conditions results in less dilution of watershed phosphorus loading. Hence, higher phosphorus concentrations result from watershed phosphorus loading during dry conditions. There are two recommended alternatives that will achieve all District goals. Assuming wet or average climatic conditions, which produce a lesser strain upon the water quality of the lake, one additional alternative will achieve all District goals. Consequently, a total of three recommended alternatives were considered to achieve all District goals. The water quality benefits and costs of the three alternatives are presented in Table EX-1. Alternatives 2 and 3 in Table EX-1 achieve all District goals under all climatic conditions, including dry conditions. Figure EX-1 compares the minimum and maximum costs of the three alternatives.

## Table EX-1 Benefits and Costs of Three Goal Achievement Alternatives

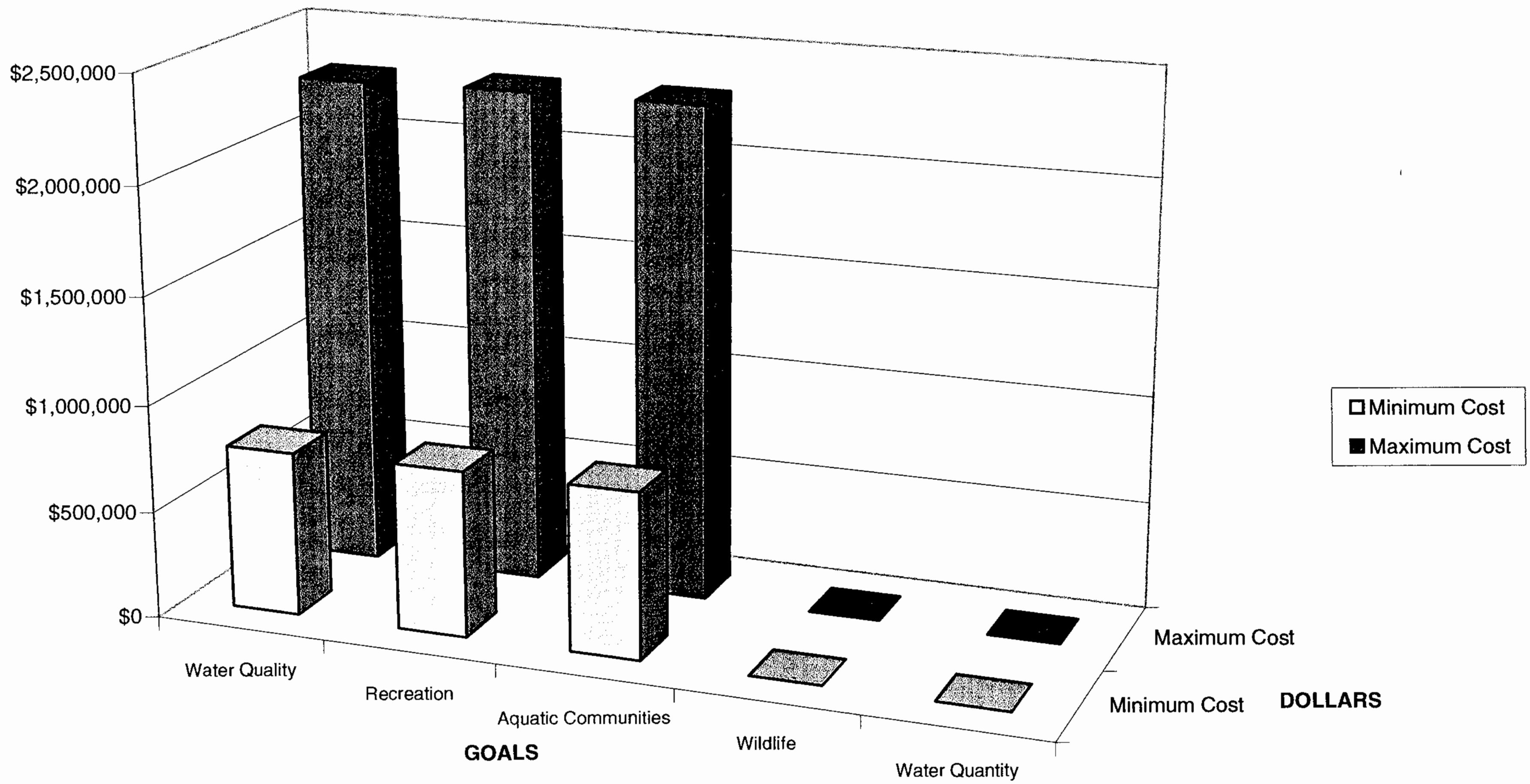
| Alternative | Trophic State Index (TSI) Value | | | | | Estimated Cost (Dollars) |
|---|---|---|---|---|---|---|
| | District Goal | Wet Year (1983, 41 inches of precipitation) | Model Calibration (1997, 34 inches of precipitation) | Average Year (1995, 27 inches of precipitation) | Dry Year (1988, 19 inches of precipitation) | |
| 1: Treat and Manage** | ≤ 53 | 51 | 51 | 52 | 56* | $775,100 |
| 2: Treat, Manage**, Upgrade, Add, and Reduce | ≤ 53 | 49 | 47 | 47 | 51 | $902,100 |
| 3: Treat, Manage**, Upgrade, Add, Reduce, and Store | ≤ 53 | 47 | 42 | 42 | 47 | $2,301,957 |

* Does not meet District Water Quality Goal.

** Manage includes alum treatment of lake, supplemental bluegill feeding, northern pike stocking, and management of curly leaf pondweed.

Given the goals for Round Lake, the alternative 2 option in Table EX-1 is recommended.

## ROUND LAKE
## Costs to Meet or Exceed Goals




"Minimum Cost" is the cost of the option that just meets each of the goals set for Round Lake.
"Maximum Cost" is the cost of the most expensive option analyzed in this study that exceeds each of the goals set for Round Lake.
Between these options are others that offer different degrees of success in meeting or exceeding the goals set for Round Lake.
**It is important to note that the infiltration costs for meeting the Water Quality, Recreation, and Aquatic Communities goal DOES NOT include the cost of land aquisition. If land acquisition is required, the estimated cost of purchasing land is estimated at $6,299,357.**

**Figure EX-1**

# Round Lake Use Attainability Analysis

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# 1.0 Surface Water Resources Data

The approved Riley-Purgatory-Bluff Creek Watershed District, Water Management Plan, 1996, inventoried and assessed Round Lake. The plan articulated five specific goals for Round Lake. 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 Round Lake contained in the approved Water Management Plan.

A use attainability analysis of Round Lake 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 Round Lake. 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.

An important component of the use attainability analysis is public participation. A technical advisory committee and/or citizens advisory committee will be formed to provide input on use attainment for Round Lake. In addition, citizens in the watershed will be notified of meetings through the District's published newsletter and they will be encouraged to become involved in the process.

## 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. Land uses in the Round Lake watershed have changed over time and lake water quality changes have been correlated with land use changes. Land use changes and current land uses in the Round Lake watershed are discussed in the following paragraphs.

Prior to settlement, the Round Lake watershed was primarily comprised of basswood, sugar maple, and oak. Early settlers and farmers removed the natural vegetation to provide tillable areas for corn, hay, and small grains. In the late-1800s, the Chicago, Milwaukee, St. Paul and Pacific Railroad was constructed through the northern one-half of the watershed. Based on conversations with area residents, it appears that in the 1940s a culvert beneath the tracks was blocked, thereby reducing the watershed area tributary to Round Lake from 501 acres to 356 acres (i.e., excluding the surface area of the lake). Also in the 1940s, a small business community was established along Highway 5, and the land along the east side of the lake was purchased by the Minneapolis Gun Club. The Gun Club constructed several buildings and a small park, including an on-site disposal system for sanitary sewage and a drinking water well. At one time, an access road terminated along the northern side of the lake. A large eroded gully at the end of the road was used as a dumping area for junk automobiles, furniture, and other waste (Barr, 1979).

In 1968, Eden Prairie purchased land along Round Lake for the development of a city park. In 1970, work was completed on a beach and swimming area on the eastern side of the lake.

During the 1970s and 1980s, urban development of the Round Lake watershed occurred. The watershed was nearly fully developed by 1988. During the period 1992 through 1997, expansion of the Eden Prairie High School and some additional residential development occurred.

A preliminary watershed land use assessment was completed and included in the RPBC District Water Management Plan for the Round Lake watershed. The assessment indicated Round Lake's existing direct watershed was comprised of single family homes (289 acres), medium density residential (23 acres), parks and open areas (150 acres), and commercial land use (21 acres). City-owned property surrounds the lake.

The Hennepin Conservation District (HCD) completed a more detailed analysis of existing land uses within Hennepin County, including the Round Lake watershed. The results of the analysis were provided to the District for use in its Use Attainability Analysis of Round Lake (See Figure 1 and Table 1). Analysis results indicate that under existing watershed land use conditions, Round Lake's 444-acre watershed (including Round Lake) consists of:

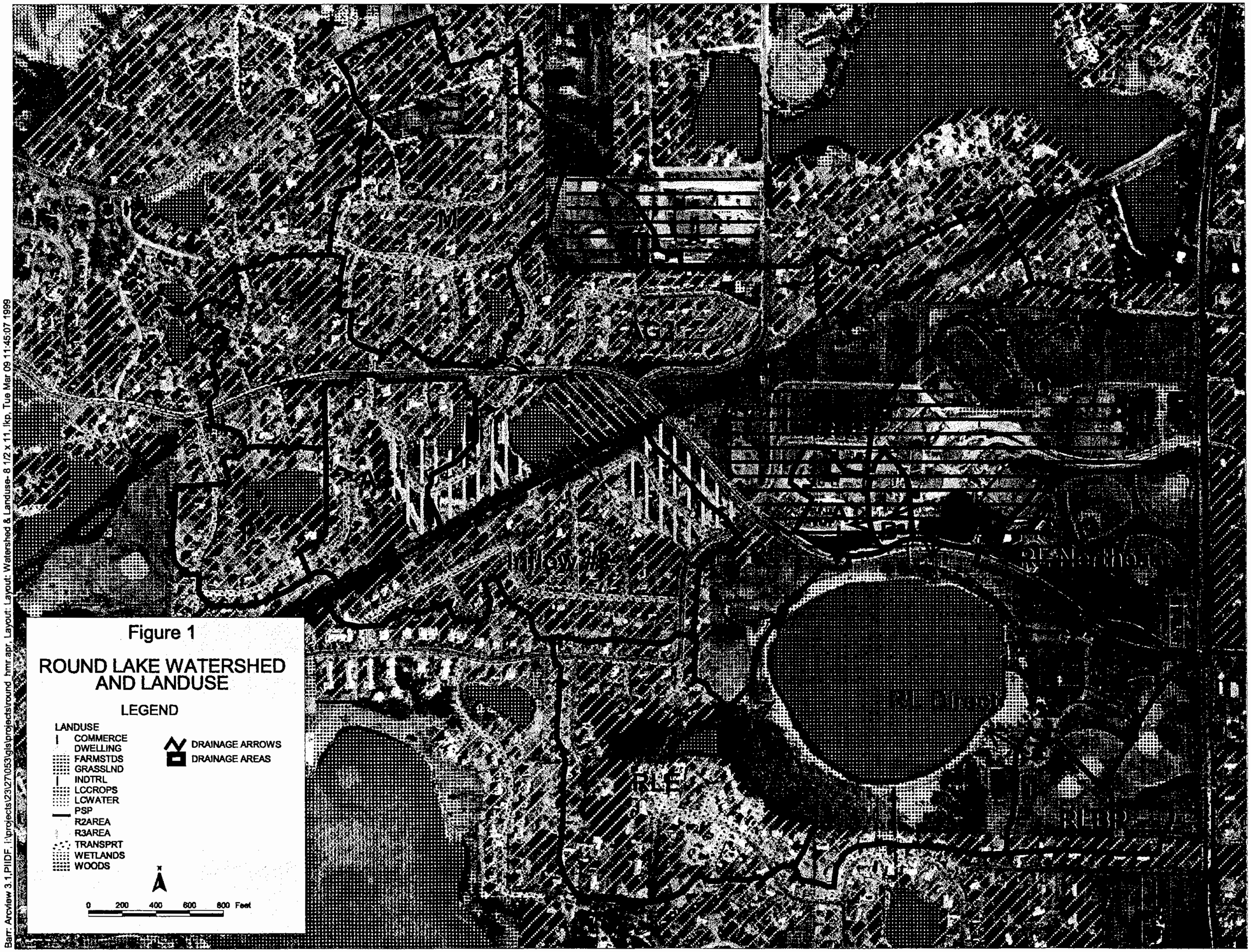


Figure 1
ROUND LAKE WATERSHED AND LANDUSE
LEGEND
LANDUSE
COMMERCE
DWELLING
FARMSTDS
GRASSLND
INDTRL
LCCROPS
LCWATER
PSP
R2AREA
R3AREA
TRANSPRT
WETLANDS
WOODS
DRAINAGE ARROWS
DRAINAGE AREAS
0 200 400 600 800 Feet
RLE
RLBP

- Single Family Homes (Dwelling)—158 acres
- Medium Density Residential (R2, from 2 through 4 families)—4 acres
- High Density Residential (R3, greater than 4 families)—9 acres
- Roads (Transport)—59 acres
- Commerce—2 acres
- Public Sector (PSP, includes high school)—64 acres
- Grassland—88 acres
- Woods—18 acres
- Water—42 acres

**Table 1 Round Lake Watershed Land Uses (Existing Watershed Conditions)**

| Watershed | Dwelling (acres) | R2 (acres) | R3 (acres) | Transport (acres) | Commerce (acres) | PSP (acres) | Grassland (acres) | Woods (acres) | Water (acres) |
|---|---|---|---|---|---|---|---|---|---|
| A | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 1 |
| AG1 | 11 | 0 | 3 | 4 | 0 | 0 | 0 | 0 | 1 |
| AG2 | 34 | 4 | 0 | 18 | 0 | 6 | 3 | 0 | 2 |
| B | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| C | 0 | 0 | 0 | 1 | 0 | 23 | 23 | 0 | 2 |
| Inflow #2 | 24 | 0 | 4 | 9 | 0 | 0 | 1 | 0 | 0 |
| M | 34 | 0 | 0 | 9 | 0 | 1 | 2 | 0 | 1 |
| P | 12 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| RL Direct | 3 | 0 | 0 | 1 | 0 | 5 | 21 | 14 | 32 |
| RL Northeast | 0 | 0 | 0 | 3 | 2 | 8 | 13 | 0 | 0 |
| RLBP | 2 | 0 | 0 | 0 | 0 | 1 | 7 | 0 | 0 |
| RLE | 27 | 0 | 0 | 6 | 0 | 0 | 0 | 4 | 1 |
| RLP | 11 | 0 | 2 | 6 | 0 | 12 | 18 | 0 | 0 |
| **Total** | 158 | 4 | 9 | 59 | 2 | 64 | 88 | 18 | 42 |

## 1.2 Major Hydrologic Characteristics

Round Lake has a 444-acre watershed, a surface area of 32 acres, a maximum depth of approximately 36 feet, and a mean depth of 11 feet. The lake's volume, outflow volume, and hydrologic residence time vary with climatic conditions (See Table 2).

**Table 2 Round Lake Estimated Volume, Outflow Volume, and Hydrologic Residence Time During Varying Climatic Conditions**

| Climatic Condition (Water Year, Inches of Precipitation) | Estimated Lake Volume $m^3$ (Volume acre-ft) | Estimated Lake Outflow Volume $m_3$ (Volume acre-ft) | Estimated Hydrologic Residence Time (Years) |
|---|---|---|---|
| Dry Year (1988, 19 inches) | 378,341 (307) | 0 (0) | Not Available (i.e., if no outflow, it appears that the lake has an infinite residence time) |
| Average Year (1995, 27 inches) | 418,412 (339) | 27,600 (22) | 15.2 |
| Model Calibration Year (1997, 34 inches) | 418,412 (339) | 70,182 (57) | 6.0 |
| Wet Year (1983, 41 inches) | 418,856 (340) | 150,356,770 (121,909) | 0.003 |

Of the twelve lakes in the watershed District, Round Lake is the twelfth largest by surface area and the tenth largest by volume. Round Lake overflows to Mitchell Lake when the normal elevation exceed 879.9 MSL.

## 1.3 Water Quality

### 1.3.1 Data Collection

Water quality data were collected from Round Lake during the period 1972 through 1997. During the 1972 through 1994 period, the District has generally sampled lakes on a three year rotating basis. However, Round Lake was sampled annually from 1980 through 1988 to assess the impacts of fisheries management programs implemented during 1980 and 1985 (i.e., the lake received a chemical treatment and restocking of fish during 1980 and 1985).

During October 1996 through September 1997, 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

During 1969 to 1970, the water quality of Round lake was determined by the City of Eden Prairie to be satisfactory for all recreational uses (swimming, boating, and fishing). The lake's excellent water quality was confirmed by a District water quality study during 1972 (Barr, 1973a and 1973b). By 1974, the lake's water quality had deteriorated to a point where swimming was no longer enjoyable because of excessive weed growth in the swimming area. Specifically, aquatic weeds were washing up onto the beach, and rooted aquatic plants were abundant enough to deter swimming. In 1975, algal blooms, described as looking like spilled green paint, also became a problem for swimmers (Conversation with City of Eden Prairie Staff Cited in Barr, 1979). Eutrophic changes in Round Lake's water quality were verified by the 1975 Riley-Purgatory Creek Watershed District's water quality inventory of the District's 12 lakes (Barr, 1976). Specifically, a comparison of 1975 and 1972 study results found:

- A 250-percent increase in total phosphorus concentration (the nutrient controlling the lake's algal growth)
- A threefold increase in the average chlorophyll concentration (an indicator of algal abundance)
- A 50-percent decrease in water transparency

Between 1975 and 1977, the lake's water quality appeared to worsen. This perception was accentuated by a winterkill in 1976 through 1977 when many dead bass and sunfish washed ashore following the spring thaw.

A comparison of baseline and current water quality was completed to evaluate the significance of the perceived degradation in the lake's water quality. Data collected during the 1972 through 1997 monitoring period were evaluated. Baseline quality of the lake was determined by evaluating the average summer conditions during the period 1972 through 1987 (Table 3). Current water quality (i.e., 1988 through 1997) was compared to baseline averages to evaluate water quality changes (Table 3).

**Table 3 A Comparison of Baseline Quality of Round Lake With Current Conditions Based on Summer (June through August) Averages**

| Chlorophyll *a* (µg/L) | | Total Phosphorus (mg/L) | | Secchi Disc (m) | |
|---|---|---|---|---|---|
| **Baseline (1972-1987)** | **Current (1988-1997)** | **Baseline (1972-1987)** | **Current (1988-1997)** | **Baseline (1972-1987)** | **Current (1988-1997)** |
| Range: 4.7-30.0 | Range: 9.2-35.7 | Range: 0.020-0.099 | Range: 0.056-0.088 | Range: 1.8-5.0 | Range: 1.0-2.3 |
| Mean: 12.6 | Mean: 21.6 | Mean: 0.046 | Mean: 0.070 | Mean: 3.0 | Mean: 1.4 |
| 1972: 5.2 | 1988: 22.4 | 1972: 0.020 | 1988: 0.088 | 1972: 5.0 | 1988: 1.1 |
| 1975: 17.2 | 1991: 35.7 | 1975: 0.072 | 1991: 0.074 | 1975: 2.4 | 1991: 1.0 |
| 1978: 15.1 | 1993: 9.2 | 1978: 0.043 | 1993: 0.056 | 1978: 2.0 | 1993: 2.3 |
| 1980: 11.3 | 1997: 19.0 | 1980: 0.049 | 1997: 0.060 | 1980: 2.1 | 1997: 1.3 |
| 1981: 4.7 | | 1981: 0.041 | | 1981: 4.6 | |
| 1982: 6.6 | | 1982: 0.028 | | 1982: 4.4 | |
| 1983: 13.8 | | 1983: 0.042 | | 1983: 2.6 | |
| 1984: 9.6 | | 1984: 0.038 | | 1984: 3.0 | |
| 1985: 11.4 | | 1985: 0.041 | | 1985: 2.4 | |
| 1986: 13.6 | | 1986: 0.034 | | 1986: 2.9 | |
| 1987: 30.0 | | 1987: 0.099 | | 1987: 1.8 | |

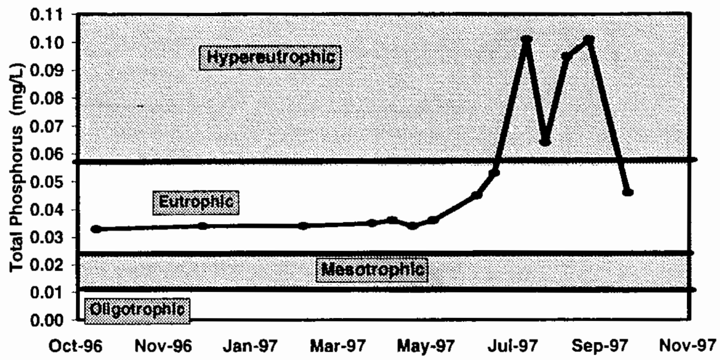
A comparison of baseline and current water quality indicates the lake's water quality has declined significantly. Chlorophyll *a* (means of summer averages) concentrations noted a 70 percent increase from baseline to current; total phosphorus (means of summer averages) concentrations increased by approximately 50 percent from baseline to current; and Secchi disc transparencies decreased by more than 50 percent from baseline to current. The comparison of baseline and current water quality conditions confirm the perceptions that the lake's water quality has generally degraded during the 1972 through 1997 period.

An evaluation of 1996 through 1997 Round Lake water quality data was completed to evaluate the extent of present water quality degradation. 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 measurements to assign the lake to a water quality category that best describes its water quality. Water quality categories include oligotrophic (i.e., excellent water quality), mesotrophic (i.e., good water quality), eutrophic (poor water quality), and hypereutrophic (very poor water quality). Total phosphorus, chlorophyll *a*, and Secchi disc transparency were used as the key water quality indicators to determine the lake's current 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 2 summarizes the seasonal changes in concentrations of total phosphorus and chlorophyll *a*, and Secchi disc transparencies for Round Lake during 1996 through 1997. The data are compared with a standardized lake rating system.

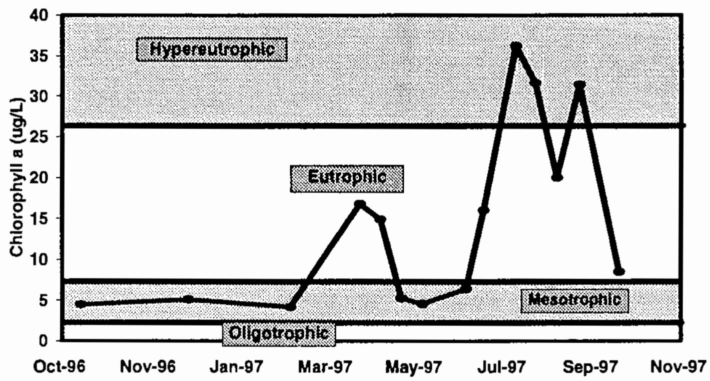
Total phosphorus data collected from Round Lake during 1996 through 1997 were within the eutrophic (i.e., poor water quality) category during fall through early-summer and were within the hypereutrophic (i.e., very poor water quality) category during the middle- and late-summer period. The data indicate the lake's water quality is poorest when the lake's use for swimming and other recreational uses is highest. Because phosphorus has been shown to most often limit the growth of algae, the phosphorus-rich lake waters indicate the lake has the potential for abundant algal growth throughout the summer period. Algal growth is a concern because abundant algal growth degrades the lake's water quality and interferes with the use of the lake for swimming and other recreational activities. The 1997 Round Lake average summer total phosphorus concentration (i.e., 0-2-meter depth) was 0.060 mg/L. This concentration is considered the upper limit for a lake to be considered swimmable (MPCA 1997) and indicates the lake experiences frequent nuisance algal blooms. As phosphorus concentrations increase from 0.030 mg/L to 0.060 mg/L, the frequency of nuisance algal blooms (greater than 20 µg/L chlorophyll *a*) generally increase from 5 percent of the summer to about 70 percent of the summer. The increased frequency of nuisance algal blooms and reduced Secchi transparency results in a high percentage of the summer (26-50 percent) perceived as "impaired swimming" (Heiskary and Wilson 1990).

Chlorophyll *a* measurements (i.e., 0-2 meters) from Round Lake during 1997 were in the mesotrophic (good water quality) category during the early-summer and were in the eutrophic (poor water quality) to hypereutrophic (very poor water quality) categories during the remaining portion of the summer. The data indicate nuisance algal blooms (greater than 20 µg/L chlorophyll *a*) occurred throughout August resulting in severe impairment for swimming.

**Round Lake: Epilimnetic (0-2 Meters)**
**Total Phosphorus Concentration**




**Round Lake: 1996-1997 Epilimnetic**
**Chlorophyll Concentrations**




**Round Lake: 1996-1997 Secchi Disc**
**Transparencies**

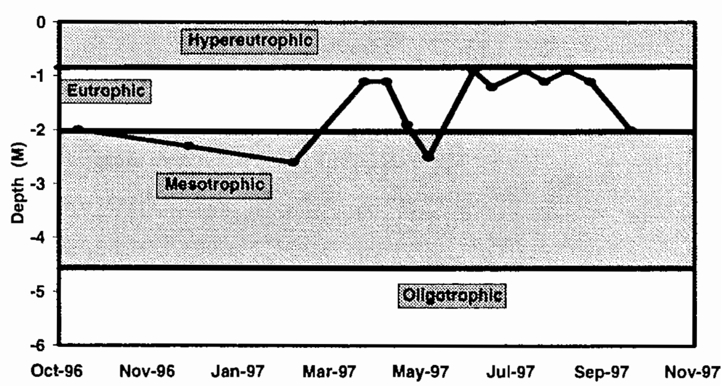



**Figure 2**
**Seasonal Changes in Concentrations of Total Phosphorus and Chlorophyll a and Secchi Disc Transparencies**

The 1997 Secchi disc measurements in Round Lake were in the mesotrophic (good water quality) category during the early summer and were in the eutrophic (poor water quality) category during the remainder of the summer. The data indicate the lake's water transparency is largely determined by algal abundance. Round Lake Secchi disc measurements during the 1997 summer period ranged from 0.9 to 2.5 meters. The data indicate that minimal recreational use-impairment occurs during the early-summer and moderate to severe recreational use-impairment (primarily swimming) occurs during the remaining portion of the summer.

## 1.4 Ecosystem Data

### 1.4.1 Aquatic Ecosystems

The Round Lake ecosystem is a determining factor in the achievement or non achievement of Round Lake'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 Round Lake and their interaction with the environment in which they live and with each other. The interdependency of the ecosystem is best illustrated by the food chain (See Figure 3). The food chain 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 bluegill 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. 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 Round Lake ecosystem is typical for a eutrophic (poor water quality), temperate lake in this region.

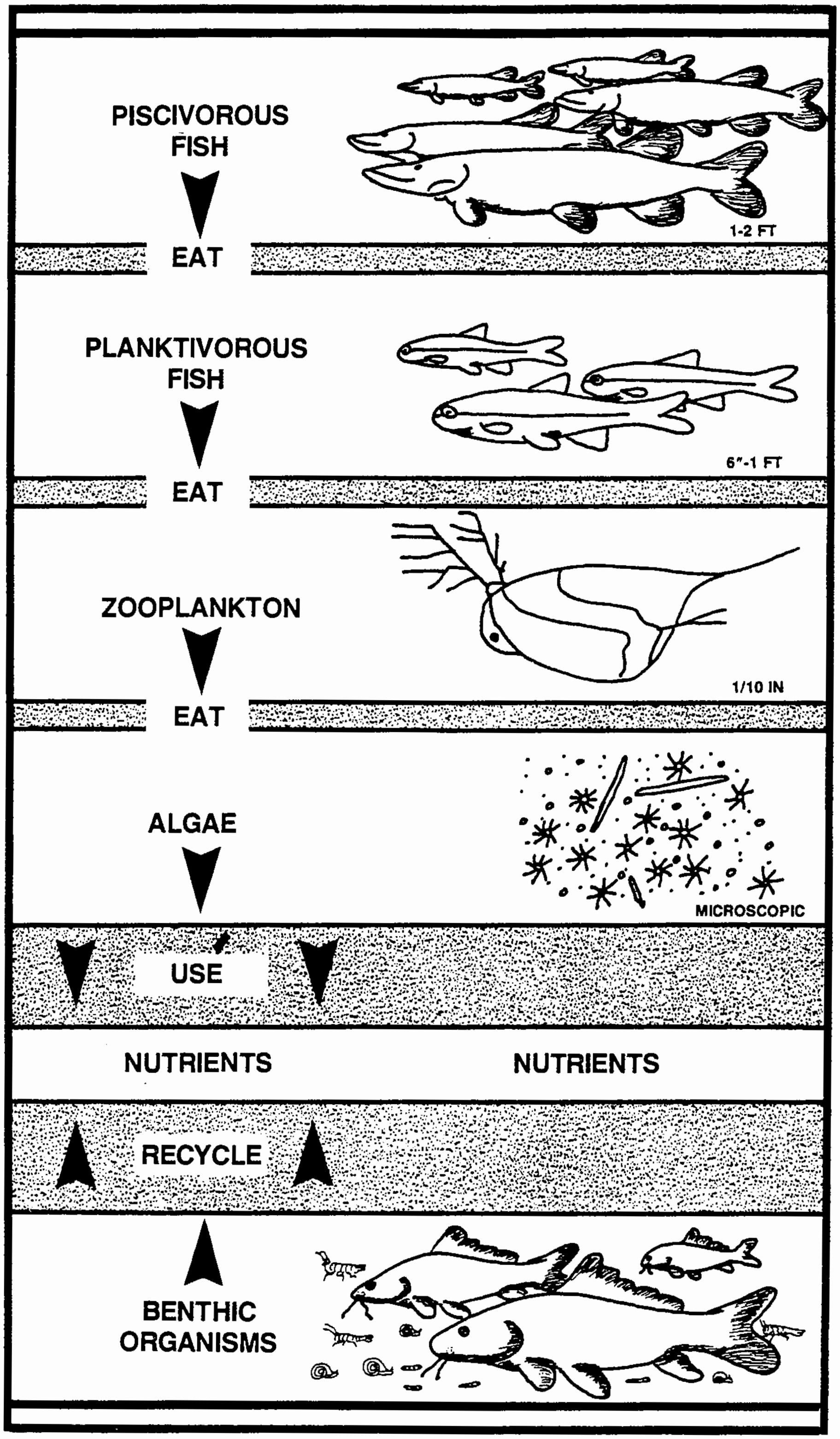



Figure 3
THE FOOD WEB

### 1.4.2 Phytoplankton

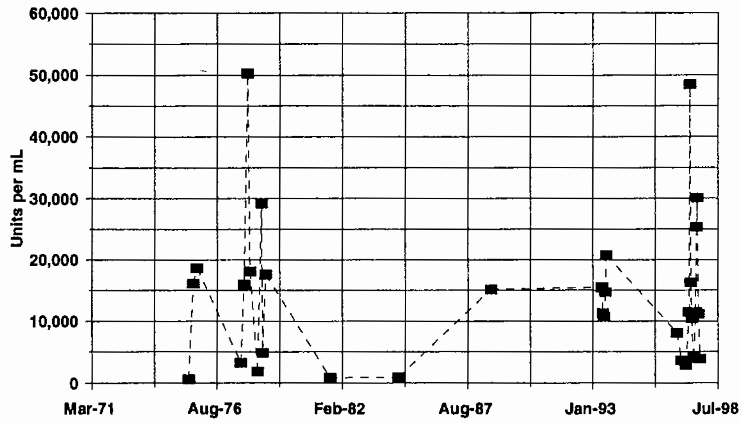
The phytoplankton species in Round Lake form the base of the lake's food web and directly impact the lake's fish production. Phytoplankton, also called algae, are small aquatic plants naturally present in all lakes. They derive energy from sunlight (through photosynthesis) and from dissolved-nutrients 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.

The 1997 phytoplankton data confirmed the presence of nuisance algal blooms throughout the summer period. Phytoplankton levels in 1997 were similar to levels observed during 1977, when the highest phytoplankton levels to date were measured (See Figure 4). The excess numbers of phytoplankton cause them to be out of balance with the other organisms in the lake's food web (See Figure 3). Blue-green and green algae were generally the dominant types of phytoplankton observed in 1997. Green algae are edible to zooplankton and serve as a valuable food source. Blue-green algae are considered a nuisance type of algae because they:

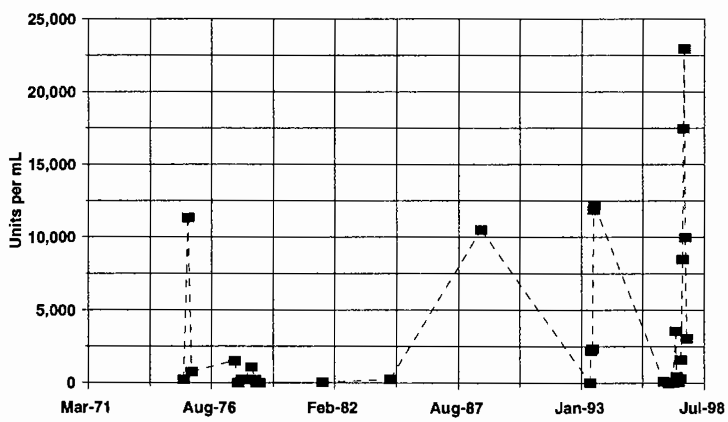
- are generally inedible to fish, waterfowl, and most zooplankters;
- float at the lake surface in expansive algal blooms;
- may be toxic to animals when occurring in large blooms;
- and since they are most likely to be present during the summer months, they can disrupt lake recreation.

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

## 1975-1997 Round Lake Phytoplankton




## Round Lake Phytoplankton
## 1975-1997 Blue-Green Algae




## Round Lake Phytoplankton
## 1975-1997 Green Algae

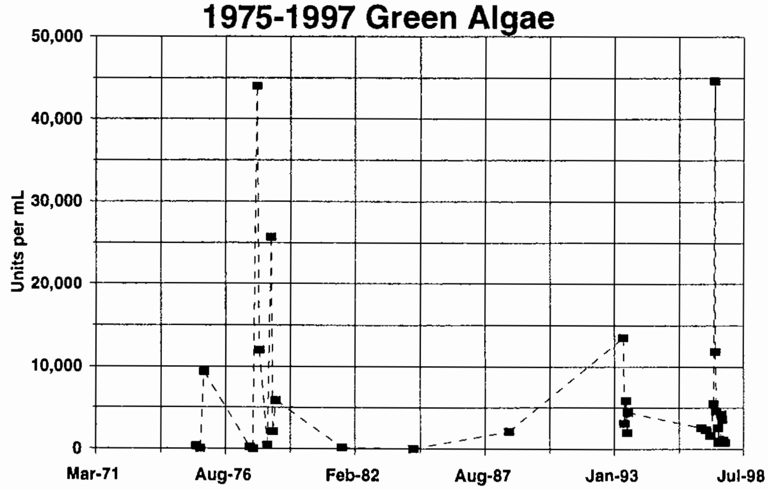


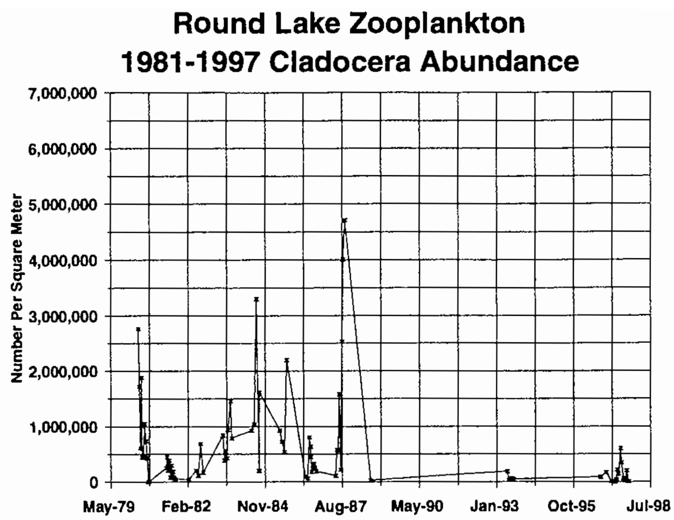

**Figure 4**

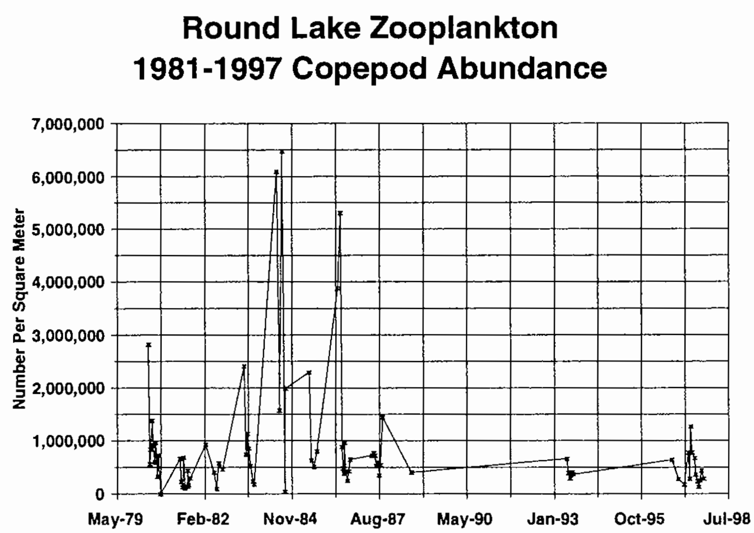
### 1.4.3 Zooplankton

Zooplankton are the second step in the Round Lake 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.

The 1997 Round Lake zooplankton community noted low numbers of cladocera and copepoda (See Figure 5). The current low levels are believed to result from predation by the lake's bluegill community. The current zooplankton community in Round Lake provides food for the lake's fishery, but has little predatory impact on the lake's algal community. The rotifers and copepods in Round Lake graze primarily on extremely small particles of plant matter and do not significantly affect the lake's water quality. However, the cladocera graze primarily on algae and can improve water quality if present in abundance.

The lake's low algal population observed in 1981 are the apparent result of large numbers of cladocera observed in Round Lake. The abundance of cladocera followed the completion of a Round Lake fish management project completed by the Minnesota Department of Natural Resources (MDNR) in 1980. Grazing by the cladocera decreased the number of algae and improved water transparency within the lake. The low numbers of large bodied zooplankton observed during 1997, however, indicate algal reduction from grazing is currently negligible. The low numbers of large bodied zooplankton observed during 1997 indicate they are out of balance with the other organisms in the lake's food web (See Figure 3).


Round Lake Zooplankton
1981-1997 Cladocera Abundance
Number Per Square Meter
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
May-79
Feb-82
Nov-84
Aug-87
May-90
Jan-93
Oct-95
Jul-98


Round Lake Zooplankton
1981-1997 Copepod Abundance
Number Per Square Meter
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
May-79
Feb-82
Nov-84
Aug-87
May-90
Jan-93
Oct-95
Jul-98

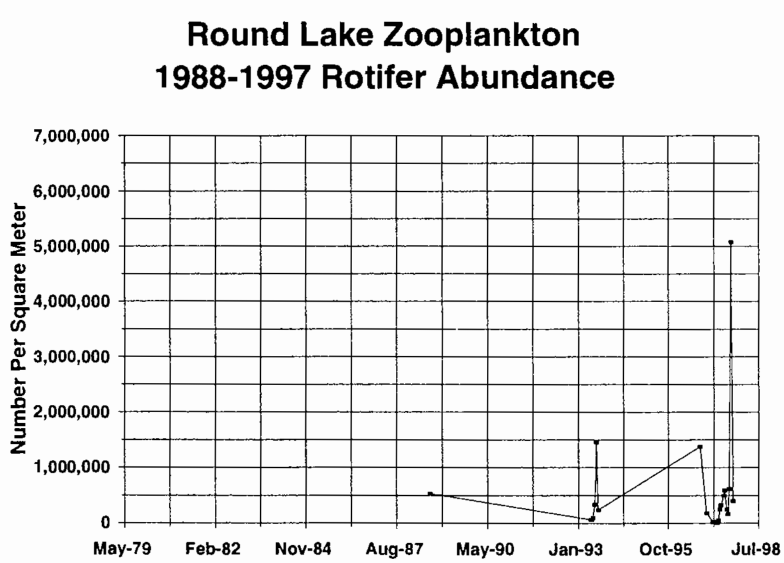

Round Lake Zooplankton
1988-1997 Rotifer Abundance
Number Per Square Meter
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
May-79
Feb-82
Nov-84
Aug-87
May-90
Jan-93
Oct-95
Jul-98

Figure 5

### 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

Surveys of the aquatic plant community in Round Lake were completed by the District during June and August of 1993 and 1997. Survey results are presented in Appendix E.

During 1993, macrophytes were identified to a relative depth of 11 feet. Water lilies covered the west side of the lake in June, but receded somewhat in August. The submerged plants were dominated by a dense growth of curly leaf pondweed (*Potamogeton crispus*) in June. Curly leaf pondweed is an undesirable non native species. It frequently replaces native species in lakes and exhibits a dense growth that may interfere with the recreational use of a lake. A dense growth also creates a refuge for small fish making it difficult for larger fish, such as bass, to find and capture the small fish they need for food. Curly leaf pondweed died back later in the summer and was replaced by northern watermilfoil (*Myriophyllum sibericum*). Northern water milfoil, a species native to this region, is often confused with the related undesirable non native Eurasian watermilfoil. Northern water milfoil is a desirable species that provides beneficial habitat for the lake's fishery.

During 1997, macrophytes were identified to a relative depth of 10 feet. Water lilies covered the west side of the lake during June and August. The submerged plants were dominated by a dense growth of curly leaf pondweed, a non native plant, and coontail (*Ceratophyllum demersum*), a native plant. A sparse growth of the undesirable non native plant Eurasian watermilfoil (*Myriophyllum spicatum*) was found near the both ramp (i.e., on the north side of the lake and between the boat ramp and the beach). Non native plants typically follow an aggressive growth pattern and eliminate native species from a lake. Also, non native plants generally produce a dense canopy of vegetation at the water surface. Such a growth pattern interferes with lake use by boaters and swimmers. Management to control the non native Eurasian watermilfoil and curly leaf pondweed is often necessary to protect the native plant community and provide a reasonable recreational use of the lake.

## 1.5 Water Based Recreation

Round Lake is used for all types of recreational activities, including swimming. The municipal swimming and boat access in Round Lake Park located along the east shore is owned and maintained by the City of Eden Prairie. A creel survey in 1991 identified fishing as a popular recreational activity on Round Lake. Recreational boating (canoeing, sailing, etc.) has also been popular on the lake, despite its relatively small size.

## 1.6 Fish and Wildlife Habitat

During 1992, the MDNR classified Round Lake and other Minnesota lakes relative to fisheries. According to its ecological classification, Round Lake is a Class 30 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 $TSI_{SD}$ of approximately 53. Currently, the lake's water quality corresponds to a $TSI_{SD}$ of 56. According to its classification, Round Lake's primary fish species are northern pike, bluegill, and carp. Northern pike is a tertiary consumer or predator fish and bluegill is a secondary consumer or planktivore (See Figure 3). Neither northern pike or carp were observed in the most recent fisheries survey (i.e., 1994). The predominant fish observed in 1994 were largemouth bass, a predator fish, and bluegill, a planktivore.

Prior to the MDNR classification of Round Lake as a Class 30 Lake, Round Lake was classified by the MDNR as a Centrarchid lake. A Centrarchid lake is a bass and panfish lake and is managed for these species. This means that the primary predator species is largemouth bass and the primary prey species is bluegill sunfish.

Fish species currently noted in Round Lake include largemouth bass, tiger muskellunge, walleye, bluegill, black crappie, hybrid sunfish, pumpkinseed sunfish, and black bullhead. The MDNR uses a natural management approach for the bass, walleye, and panfish populations in Round Lake. However, the MDNR has stocked the lake with a number of sport fish in previous years:

- 1981, adult largemouth bass
- 1983, hybrid (tiger) muskellunge
- 1985, largemouth bass, bluegill, walleye, adult rainbow, and book trout
- 1986, adult brook trout, walleye fry and fingerling, adult bluegill, and largemouth bass fry
- 1988, hybrid muskellunge fingerlings

Changes in the lake's water quality and its fisheries occurred during the period 1976 through 1997. Water quality degradation during this period resulted in increased total phosphorus and chlorophyll *a* concentrations. As the lake increased in fertility, it was able to support increased numbers of bluegills. However, the macrophyte growth associated with the lake's increased fertility prevented bass and other predators from controlling the bluegill fishery, hence keeping it in balance. As shown in Figure 6, the number of bluegills in Round Lake has increased approximately eight-fold during the 1976 through 1997 period. The current Round Lake fishery is comprised of excessive numbers of "stunted bluegills" (i.e., approximately 5 to 7 inches in length and average weight of 0.1 pound). The fish are stunted because the current available food source in the lake is unable to support the large bluegill fishery and enable them to grow to a normal size. Consequently, nearly all bluegills exhibit below normal growth.

Changes in the fertility of Round Lake also resulted in changes in the balance between predator (i.e, larger fish such as northern pike that eat panfish) and planktivore (i.e., panfish such as bluegills that eat zooplankton) communities. As shown in Figure 7, only predator fish were noted in samples collected during a 1962 fish survey. Fisheries surveys during 1976 through 1980 noted that predator fish were nearly absent from the samples. Consequently the samples were comprised almost solely of bluegills.

During 1981 through 1982 following completion of a fish management project during 1980, the fish community was comprised of 80 to 90 percent predators and 10 to 20 percent planktivores. However, during 1984 and 1985, the community again was primarily comprised of planktivores (i.e., bluegills) and predators were nearly absent. A fish management project during 1985 was less successful than the 1980 project and predator fish comprised less than 20 percent of the total catch during the 1986 survey. Predator fish declined during 1987 and reached a nearly negligible level by 1988. Predator fish have remained at a negligible level from 1988 through the present.

It should be noted that the fish collection method used for the fishery surveys, trapnetting, is ineffective in sampling bass, a predator fish found in Round Lake. Therefore, the lake's bass community is not considered in the comparison. In 1994, the Minnesota Department of Natural Resources (MDNR) sampled bass via electroshocking and concluded the lake currently has a good bass fishery. However, as shown in Figure 6, the bass are unable to control the excessive increases in the lake's bluegill fishery. If the bass captured by electroshocking were added to the fish captured by trapnetting, predators would comprise 12 percent and planktivores 88 percent of the fisheries community. Consequently, the lake's fishery notes an imbalance between the predators

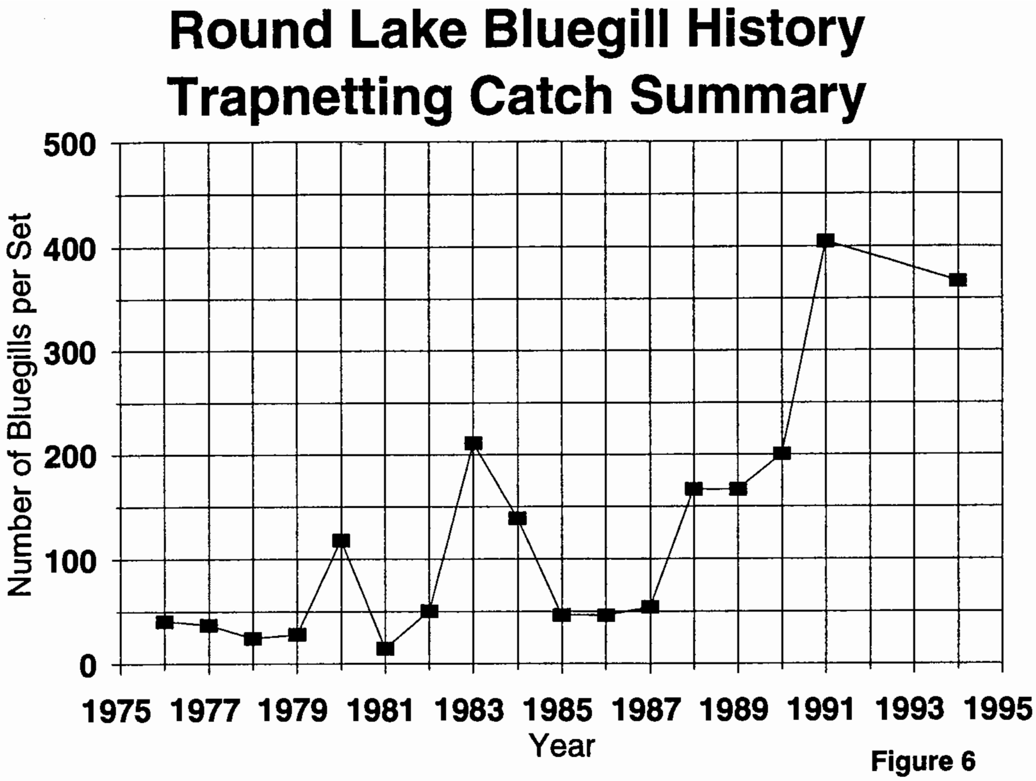



Figure 6

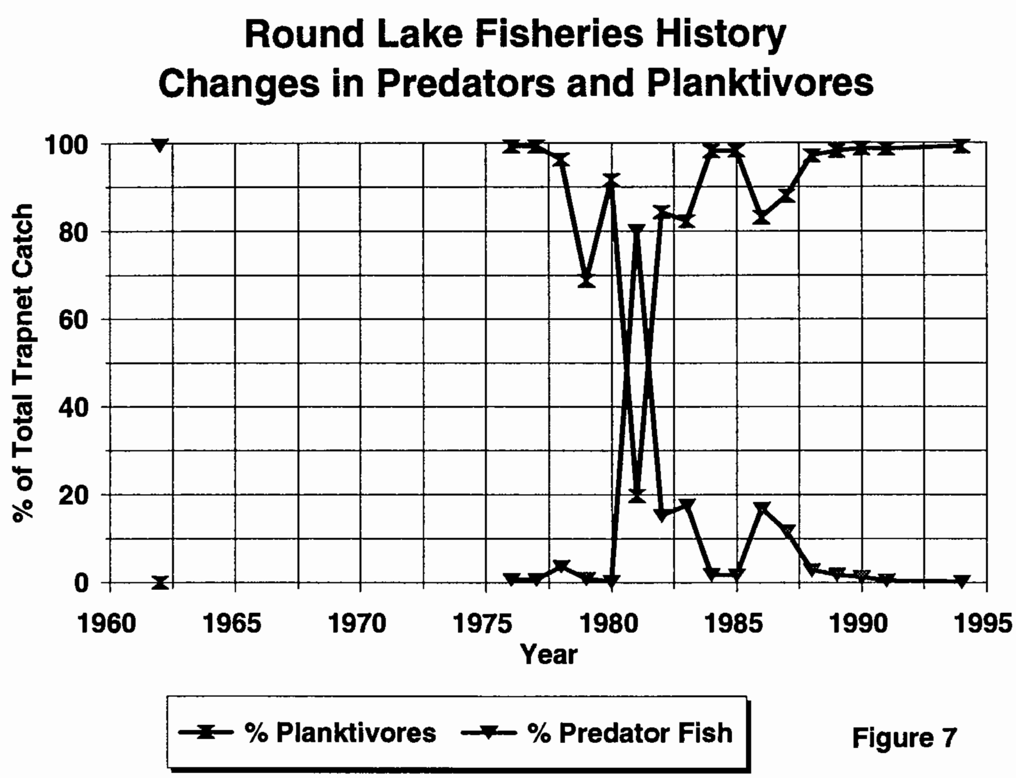



Figure 7

and planktivores resulting from the excess numbers of "stunted bluegills" in the lake. Figure 8 illustrates the change in the lake's fish community from the observed 1981 balanced community, following a fish management project, to the imbalanced community observed in 1994.

Threats to the lake's fishery habitat include oxygen depletion leading to winter fish kills. Aeration has successfully continued every winter for the past 17 years to prevent winterkill.

Round Lake provides habitat for seasonal waterfowl, such as ducks and geese. There is especially abundant waterfowl habitat on the western part of the lake, which has a dense macrophyte growth.

## 1.7 Discharges

### 1.7.1 Natural Conveyance Systems

The natural inflow to Round Lake is stormwater runoff from its direct watershed (i.e., RL Northeast, RLBP, and RL Direct on Figure 1) and groundwater discharge. There are no streams or rivers that convey flow to Round Lake.

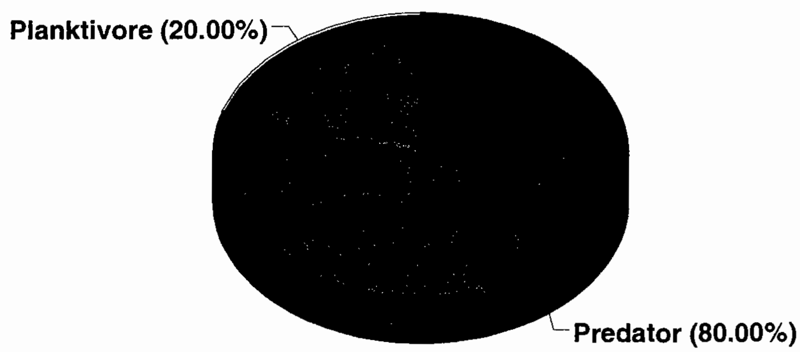
### 1.7.2 Stormwater Conveyance Systems

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

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.

## 1981 Round Lake Fishery -- Balanced




## 1994 Round Lake Fishery -- Unbalanced

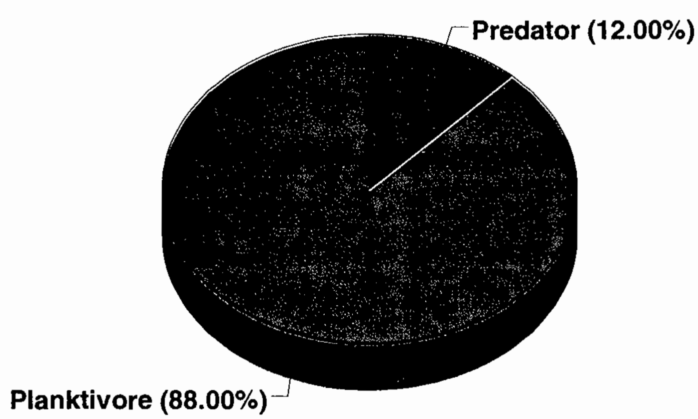



Figure 8

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.

Nine wet detention basins are within the Round Lake watershed to remove pollutants from stormwater runoff. The detention basin locations are shown on Figure 1. Table 4 presents basin details.

**Table 4 Round Lake Watershed Detention Ponds**

| Pond* | Dead Storage Surface Area (acres) | Dead Storage Volume (acre-feet) | Dead Storage Average Depth (feet) | Live Storage Surface Area (acres) | Live Storage Volume (acre-feet) | Outlet Diameter (inches) |
|---|---|---|---|---|---|---|
| Muirfield (M) | 0.7 | 1.9 | 2.6 | 1.4 | 3.9 | 24 |
| Paulsens (P) | 1.8 | 3.1 | 1.7 | 3.3 | 11.5 | 12 |
| Apple Grove 1 (AG1) | 0.6 | 1.8 | 2.9 | 0.7 | 2.6 | 12 |
| Apple Grove 2 (AG2) | 2.0 | 6.6 | 3.3 | 2.3 | 11.3 | 36 |
| Round Lake Pond (RLP) | 0.4 | 0.5 | 1.3 | 1.0 | 2.0 | 12-Foot Weir |
| Round Lake Estates (RLE) | 0.7 | 1.1 | 1.5 | 1.0 | 5.6 | 15 |
| Eden Prairie High School Basin A (A) | 0.7 | 2.8 | 4.2 | 1.0 | 3.2 | 15 |
| Eden Prairie High School Basin B (B) | 0.3 | 1.0 | 3.7 | 0.3 | 0.6 | 15 |
| Eden Prairie High School Basin C (C) | 1.6 | 9.3 | 5.9 | 2.2 | 8.6 | 12 |

*Pond names are the names of the development for which a permit for construction of the pond was issued.

Stormwater is conveyed to Round Lake via four stormwater conveyance systems. The storm sewer inflows to Round Lake are shown on Figure 9 and discussed below:

- **A**—Stormwater runoff from the Eden Prairie High school is treated in detention Basins A and B. Outflow from Basin B flows into Basin A and outflow from Basin A is conveyed to Round Lake via a storm sewer.

- **C**—Stormwater runoff from the Eden Prairie High school is treated in detention Basin C. The outflow from Basin C is conveyed to Round Lake via a storm sewer.

- **RLE**—Stormwater runoff from subwatershed RLE (i.e., Round Lake Estates development) is treated in detention Basin RLE. Outflow from RLE is conveyed to Round Lake via a storm sewer.

- **RLP**—Stormwater runoff from the remaining portion of the Round Lake watershed (i.e., subwatersheds M, P, AG1, AG2, Inflow #2, and RLP) is conveyed to detention basin RLP.

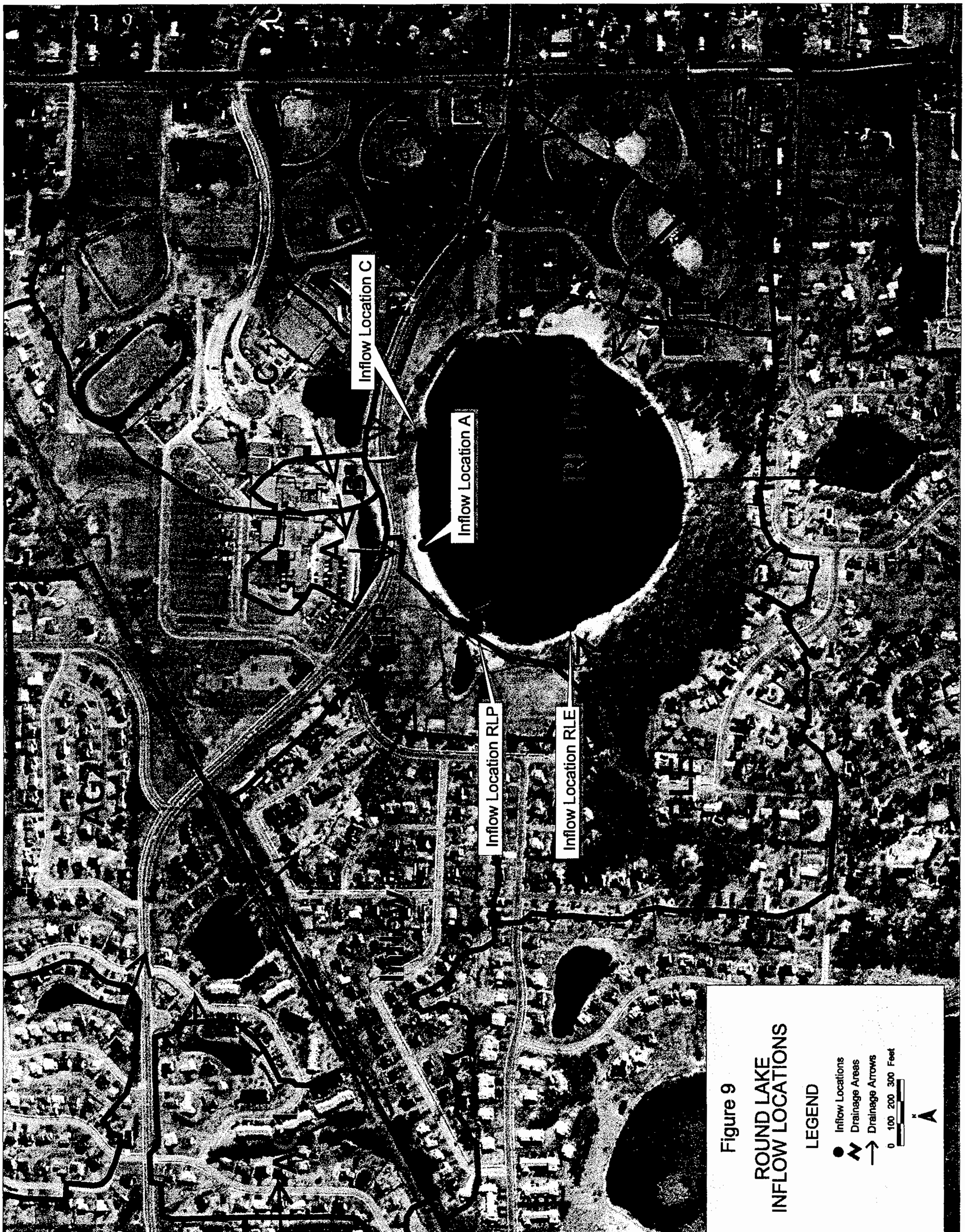
Stormwater runoff from subwatersheds M, P, AG1, and AG2 discharges through upland detention basin treatment prior to discharge to detention Basin RLP for additional treatment. Outflow from RLP is conveyed to Round Lake via a storm sewer.

### 1.7.3 Public Ditch Systems

There are no public ditch systems that affect Round Lake.

## 1.8 Appropriations

There are no known water appropriations from Round Lake.


Inflow Location C
Inflow Location A
Inflow Location RLP
Inflow Location RLE
Figure 9
ROUND LAKE
INFLOW LOCATIONS
LEGEND
Inflow Locations
Drainage Areas
Drainage Arrows
0 100 200 300 Feet
N
Barr: Arcview 3.1, PIIDF, I:\projects\23\27\053\gis\projects\round_hmr.apr, Layout: Layout: Inflow Locations - 8 1/2 x 11, lkp, Tue Mar 09 11:48:09 1999

# 2.0 Assessment of Round Lake Problems

## 2.1 Appropriations

There are no known water appropriations from Round Lake.

## 2.2 Discharges

Round Lake's current water quality results from the discharge of excess phosphorus to the lake. A detailed analysis of discharges was completed to determine phosphorus sources and management opportunities to reduce the amount of phosphorus added to the lake. Since phosphorus typically moves either in water as soluble phosphorus dissolved in the water or attached to sediments carried by water, the determination of the volume of water discharged to Round Lake annually was an important step in defining the amount of phosphorus discharged to the lake. During development of the District Water Management Plan, literature export rate coefficients were used to estimate the annual water and phosphorus loads to the lake. The District Plan recommended using the water quality model XP-SWMM, XP-Stormwater and Waste Water Model, in the completion of the Use Attainability Analysis to provide a more precise estimate of water and phosphorus loads. Because the P8 model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds; IEP, Inc., 1990) provides more accurate predictions of phosphorus loads to a lake than the XP-SWMM model, the P8 model was selected instead of the XP-SWMM model. The Use Attainability Analysis used the P8 model to estimate the volume of water and phosphorus mass entering the lake. An intensive inflow monitoring program collected flow information and total phosphorus concentration information from two inflow locations throughout the 1997 water year. The data were used to calibrate the P8 model to ensure accurate predictions of annual water and phosphorus loads. Details of phosphorus discharges to the lake and management opportunities follow.

### 2.2.1 Natural Conveyance Systems

The direct watershed to Round Lake contributes stormwater runoff to the lake via overland flow along the south and east sides of the lake. Runoff from the direct watershed does not receive treatment before entering the lake. The annual amount of phosphorus added to Round Lake from its direct watershed was estimated for four climatic conditions, previously shown to affect the lake's volume, outflow volume, and hydrologic residence time (See Section 1.2 Major Hydrologic Characteristics):

- Wet year—an annual precipitation of 41 inches, the amount of precipitation occurring during the 1983 water year

- Model calibration year—an annual precipitation of 34 inches, the amount of precipitation occurring during the 1997 water year (The model calibration year is the year in which data were collected from the lake and from represented inflow locations. The data were used to calibrate the P8 model and in-lake model.)

- Average year—an annual precipitation of 27 inches, the amount of precipitation occurring during the 1995 water year

- Dry year—an annual precipitation of 19 inches, the amount of precipitation occurring during the 1988 water year

The amount of phosphorus added to the lake from the direct watershed under these climatic conditions is estimated to range from 28 to 68 pounds per year. This amount represents between 21 to 23 percent of the lake's annual load (See Table 5). During wet climatic conditions, the percentage of phosphorus added to the lake from the direct watershed is less than the percentage added to the lake under other climatic conditions. This is a result of the stormwater conveyance system adding a higher proportion of phosphorus during wet climatic conditions than other conditions. Consequently, the direct watershed contribution declines and the stormwater conveyance system contribution increases under wet conditions.

**Table 5 Total Phosphorus Loads from Round Lake Direct Watershed Under Varying Climatic Conditions**

| Climatic Condition (inches of precipitation) | Annual Total Phosphorus Load From Direct Watershed (Pounds) | % of Total Annual Round Lake Total Phosphorus Load |
|---|---|---|
| Wet (41") | 68 | 21 |
| Model Calibration (34") | 49 | 23 |
| Average (27") | 36 | 22 |
| Dry (19") | 28 | 22 |

An assessment of the direct watershed natural conveyance system indicates a portion of the water could be treated and, consequently, the phosphorus load could be reduced. A basin could be added to treat the runoff from subwatershed RLNE (See Figure 1). In addition, the volume of runoff to the lake could be reduced by retaining additional water in infiltration devices. Reduced runoff volume would result in reduced phosphorus loads to the lake.

- **Add**—Modeling simulations were completed to determine the reduction in annual phosphorus loading to Round Lake if a basin were added to treat runoff from subwatershed RLNE. Assuming the pond was designed to meet Minnesota Pollution Control Agency (MPCA) and Nationwide Urban Runoff Program (NURP) criteria, the amount of phosphorus added to the lake from the direct watershed would be reduced by 10 to 15 pounds of phosphorus annually under varying climatic conditions. With this reduction, the amount of phosphorus entering the lake from the direct watershed represents about 16 percent to 18 percent of the lake's annual load (See Table 6). Design and construction of treatment pond RLNE is estimated to cost approximately $30,000.

**Table 6 Total Phosphorus Loads from Round Lake Direct Watershed Under Varying Climatic Conditions After Adding Treatment Pond RLNE**

| Climatic Condition (inches of precipitation) | Annual Total Phosphorus Load From Direct Watershed with Added Pond to Treat Runoff From RLNE (Pounds) | % of Total Annual Round Lake Total Phosphorus Load |
|---|---|---|
| Wet (41") | 56 | 18 |
| Model Calibration (34") | 34 | 17 |
| Average (27") | 23 | 15 |
| Dry (19") | 18 | 15 |

- **Store**—Diverting a portion of the lake's watershed runoff into retention areas where the runoff can seep into the ground (infiltration) will reduce the phosphorus load conveyed to the lake by the natural conveyance system. Infiltration facilities include infiltration basins, infiltration trenches, dry wells, porous pavement, swales with check dams, and bioretention areas (infiltration areas with vegetation designed to enhance infiltration). Model simulation was completed to estimate the removal effectiveness of infiltration. It was assumed that an additional 0.4 inches of storage over the entire direct watershed would be provided through infiltration. With the additional storage, the amount of phosphorus added to the lake from the direct watershed would range from 17 to 52 pounds, a reduction of from 11 to 16 pounds of phosphorus annually, under varying climatic conditions. With this reduction, the amount of phosphorus entering the lake from the direct watershed represents about 13 percent to 16 percent of the lake's annual load (See Table 7). Design and construction of infiltration basins in the direct watershed only would cost approximately $203,000.

**Table 7 Total Phosphorus Loads from Round Lake Direct Watershed After Infiltration of an Additional 0.4 Inches of Runoff**

| Climatic Condition (inches of precipitation) | Annual Total Phosphorus Load From Direct Watershed with Added Infiltration of 0.4 Inches (Pounds) | % of Total Annual Round Lake Total Phosphorus Load |
|---|---|---|
| Wet (41") | 52 | 16 |
| Model Calibration (34") | 34 | 16 |
| Average (27") | 24 | 15 |
| Dry (19") | 17 | 13 |

## 2.2.2 Stormwater Conveyance Systems

Stormwater conveyance systems, storm sewers, add the major portion of the phosphorus load to Round Lake. Existing storm sewers are located on the north and west sides of the lake. The annual phosphorus load added to Round Lake from storm sewers was estimated to range from 68 to 231 pounds per year for wet, dry, average, and model calibration year climatic conditions (i.e., the four climatic conditions described in Section 1.2 Major Hydrologic Characteristics). This amount represents from 53 to 70 percent of the lake's annual load (See Table 8).

**Table 8 Total Phosphorus Loads from Round Lake Stormwater Conveyance Systems Under Varying Climatic Conditions**

| Climatic Condition (inches of precipitation) | Annual Total Phosphorus Load From Stormwater Conveyance Systems (Pounds) | % of Round Lake Annual Total Phosphorus Load |
|---|---|---|
| Wet (41") | 231 | 70 |
| Model Calibration (34") | 135 | 63 |
| Average (27") | 96 | 59 |
| Dry (19") | 68 | 53 |

Four storm sewer systems discharge into Round Lake (See Figure 9). Each system adds a different amount of phosphorus to the lake based on the size of the watershed, the land uses within the watershed, and the stormwater treatment that occurs prior to discharge to the lake. All stormwater conveyed to Round Lake via storm sewers is treated by at least one detention/water quality basin before it is discharged to the lake. As shown in Table 9, inflow locations RLE, A, and C each contribute less than 6 percent of the annual load and each receive runoff from 2 to 11 percent of the lake's watershed. Collectively, these three subwatersheds comprise 22 percent of the lake's watershed (See Figure 1) and collectively add from 4 to 10 percent of the lake's annual total phosphorus load. The storm sewer outlet from pond RLP is estimated to add from 63 to 199 pounds of phosphorus per year to Round Lake which comprises from 49 to 60 percent of the lake's annual phosphorus load.

**Table 9 A Comparison of Total Phosphorus Loads from Four Round Lake Stormwater Conveyance Systems Under Varying Climatic Conditions**

| Stormwater Conveyance System* | Annual Total Phosphorus Load in Pounds | | | |
|---|---|---|---|---|
| | Wet (41") | Model Calibration (34") | Average (27") | Dry (19") |
| RLE | 19 | 8 | 5 | 5 |
| RLP | 199 | 125 | 89 | 63 |
| A | 1 | 0 | 0 | 0 |
| C | 12 | 2 | 2 | 0 |
| Total Annual Load from Stormwater Conveyance Systems | 231 | 135 | 96 | 68 |

* The systems are named from the detention basin whose outlet conveys the stormwater to the lake (See Figure 9).

Collectively, the four Round Lake storm sewers add excess quantities of phosphorus to the lake each year despite the treatment of stormwater runoff by nine detention basins in the lake's watershed. The treatment effectiveness of the nine detention basins was estimated under wet, dry, average, and model calibration precipitation conditions. Under average precipitation conditions, all basins except RLP (See Figure 1) removed at least 60 percent of the phosphorus load (See Table 10). Basin RLP removed 16 percent of the phosphorus load under average precipitation conditions. Under wet conditions, all basins except RLP removed at least 47 percent of the phosphorus load and basin RLP removed 10 percent of the phosphorus load. Under dry conditions, all basins removed at least 63 percent of the phosphorus load except basin RLP which removed 18 percent.

**Table 10 Total Phosphorus Removal Efficiency of Round Lake Watershed Detention Ponds**

| Stormwater Conveyance System* | Pond Name | Total Phosphorus Removal Efficiency (% Removed) | | | |
|---|---|---|---|---|---|
| | | Wet ('83) 41" pptn. | Dry ('88) 19" pptn. | Avg. ('95) 27" pptn. | Model Calibration ('97) 34" pptn. |
| RLP | M | 49 | 63 | 61 | 54 |
| | P | 73 | 94 | 88 | 80 |
| | AG1 | 49 | 75 | 67 | 56 |
| | AG2 | 47 | 64 | 60 | 52 |
| | RLP | 10 | 18 | 16 | 13 |
| RLE | RLE | 64 | 76 | 79 | 69 |
| A | A | 89 | 97 | 97 | 96 |
| | B | 85 | 97 | 95 | 88 |
| C | C | 72 | 95 | 96 | 88 |

* The systems are named from the detention basin whose outlet conveys the stormwater to the lake (See Figure 9).

Many of the detention basins in the lake's watershed were constructed prior to the establishment of current MPCA and NURP criteria. An assessment of the nine detention basins in the lake's watershed was completed to determine whether the ponds currently meet the minimum criteria established by the MPCA (i.e., Protecting Water Quality in Urban Areas, 1989) and NURP criteria (i.e., based upon results from the Nationwide Urban Runoff Program). Current criteria by the MPCA and NURP require a minimum permanent pool or dead storage volume for each pond based upon its watershed size. As discussed previously, the treatment effectiveness of a pond is directly related to its dead storage volume. Pond surveys were completed during 1997 through 1998 to estimate current dead storage volume for all ponds except A, B, and C. Recent development plans were used to estimate the dead storage volumes of these three basins. As shown in Table 11, all ponds with the exception of M, RLP, and RLE currently meet MPCA/NURP criteria. Upgrading ponds M, RLP, and RLE to meet MPCA/NURP criteria would result in improved treatment effectiveness and reduced phosphorus loading to Round Lake. The reduced phosphorus load from the upgrade alone would be insufficient, but necessary, to meet District goals.

**Table 11** **Round Lake Watershed Ponds: A Comparison with MPCA/NURP Criteria**

| Pond | Current Dead Storage Volume (acre-feet) | Dead Storage Volume Required by MPCA/NURP Criteria (acre-feet) |
|---|---|---|
| **M** | **1.9** | **3.9** |
| P | 3.1 | 1.1 |
| AG1 | 1.8 | 1.7 |
| AG2 | 6.6 | 5.7 |
| **RLP** | **0.5** | **4.2** |
| **RLE** | **1.1** | **2.6** |
| A | 2.8 | 0.5 |
| B | 1.0 | 0.3 |
| C | 9.3 | 3.3 |

An assessment of the particulate and soluble portions of the watershed phosphorus load was completed to evaluate the feasibility of reducing the phosphorus load by upgrading detention basins RLP, RLE, and M. Detention basins remove particulate phosphorus through the settling of particulate material. Soluble or dissolved phosphorus is primarily removed by algal growth in ponds, however, because detention basins generally detain water for relatively short periods of time, these basins remove a small percentage of dissolved phosphorus.

An assessment of the percentage of the particulate and dissolved portions of the annual watershed phosphorus load to Round Lake was completed for the period of May through September, 1997. During this period, the soluble fraction of the watershed phosphorus load ranged from 10 percent to 68 percent and was, on average, 35 percent (See Figures 10 and 11). The particulate phosphorus load therefore was, on average, 65 percent. The assessment results indicate that an upgrade of watershed basins RLE, M, and RLP would likely reduce the particulate phosphorus load but have relatively little effectiveness on soluble phosphorus reduction.

An additional assessment of the dissolved portion of the lake's annual watershed phosphorus load was completed to determine the need for additional treatment measures to reduce the dissolved phosphorus load to the lake. The results of the previous assessment were extrapolated to wet, dry, and average climatic conditions. The soluble fraction of the watershed load was assumed, on average, 35 percent of the annual watershed phosphorus load. The annual dissolved phosphorus load to Round Lake from its watershed was therefore estimated to range from 24 pounds under dry conditions to 81 pounds under wet conditions. Of this total, approximately 90 percent is estimated to enter the lake from pond RLP. Upgrading the watershed detention basins, particularly pond

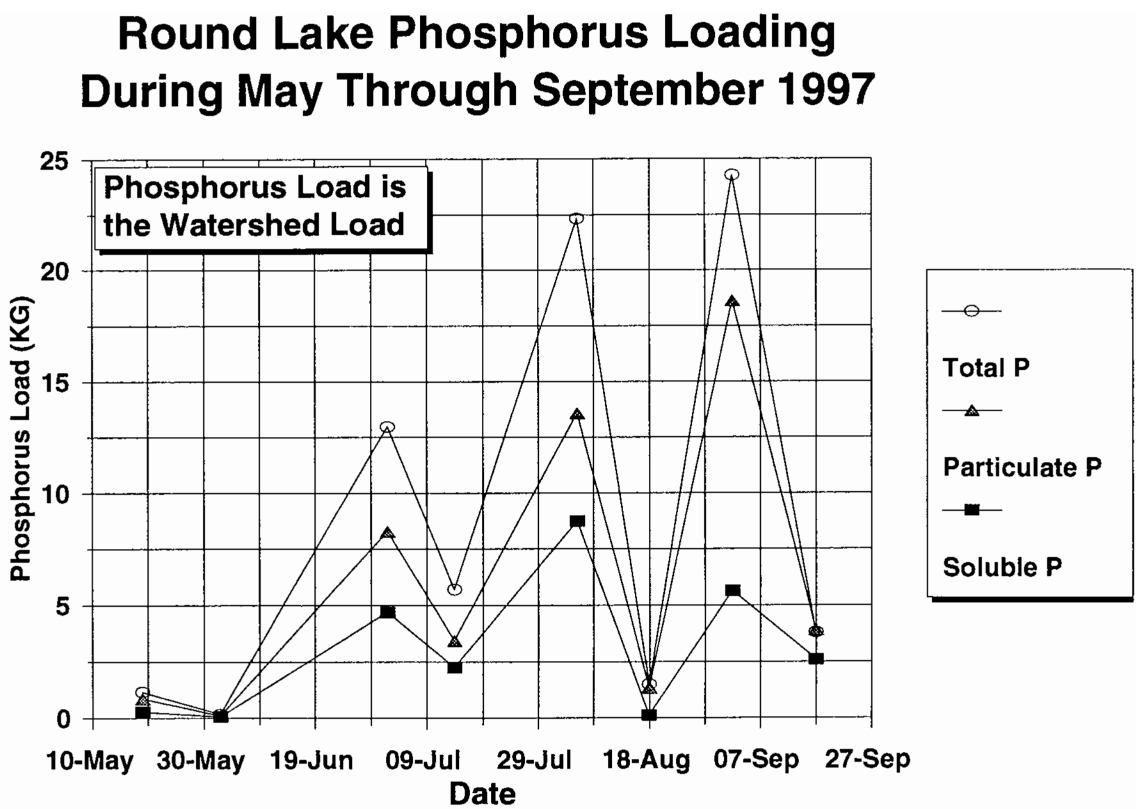



Figure 10

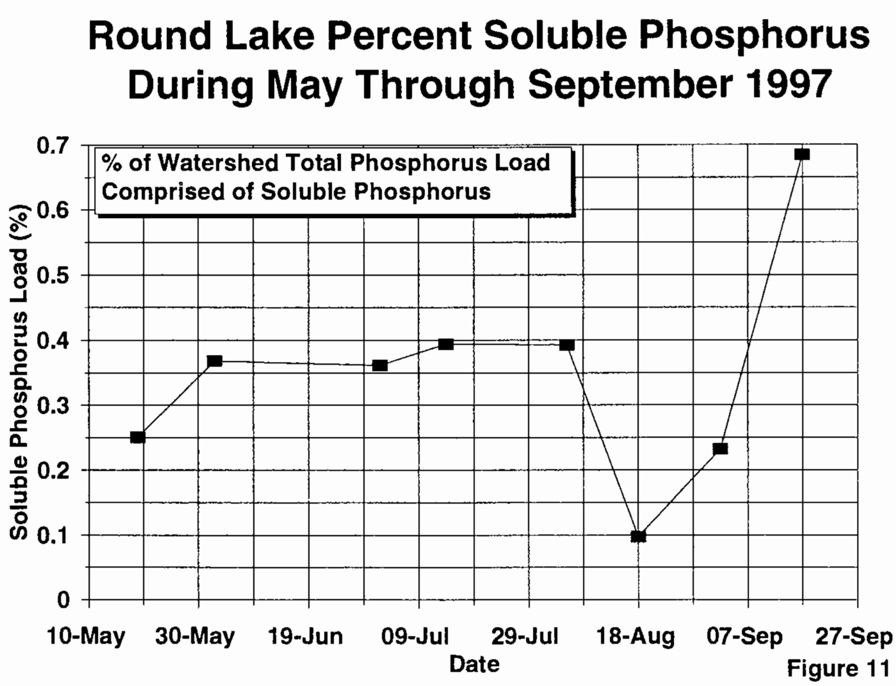



Figure 11

RLP, would only address a portion of the lake's watershed phosphorus loading problem. Additional treatment of runoff waters to remove dissolved phosphorus is needed to address the remaining portion of the lake's phosphorus loading problem.

The phosphorus load to Round Lake may be reduced substantially by management practices such as upgrading detention basins, treating surface runoff with alum, and retaining water in infiltration basins. Details of these management practices follow.

- **Upgrade**—Model simulations were completed to estimate the reduction in phosphorus loading to Round Lake if treatment basins M, RLP, and RLE were upgraded to meet MPCA and NURP dead storage criteria. Following the upgrade of the basins, the amount of phosphorus added to the lake from the stormwater conveyance systems would range from 46 to 187 pounds or a reduction of 22 to 44 pounds of phosphorus annually (See Table 11). Upgrading these treatment basins is estimated to cost approximately $96,000.

**Table 11 Phosphorus Loading Reduction from Upgrade of Ponds M, RLP, and RLE to MPCA/NURP Criteria**

| Climatic Condition | Annual Total Phosphorus Load From Stormwater Conveyance Systems Under Current Conditions: lbs | Annual Total Phosphorus Load From Stormwater Conveyance Systems Following Upgrade of Ponds M, RLP, and RLE: lbs |
|---|---|---|
| Wet (41" of precipitation) | 231 | 187 |
| Model Calibration (34" of precipitation) | 135 | 103 |
| Average (27" of precipitation) | 96 | 72 |
| Dry (19" of precipitation) | 68 | 46 |

- **Treat**—Treatment of runoff waters entering pond RLP with alum would substantially reduce the phosphorus load to Round Lake. Alum (aluminum sulfate) is commonly used as a flocculent in water treatment plants and as an in-lake treatment for phosphorus removal. To treat the inflow to pond RLP, alum would be injected to all surface water flowing into the pond. The treated water would flow into the pond and the alum floc (i.e., large flakes that look similar to Ivory detergent flakes) would settle out. Dissolved phosphorus in the water would attach to the floc, and the floc would sweep particulate phosphorus out of the water as it settles to the pond bottom. Alum treatment has been shown to remove approximately 80 to 90 percent of the soluble and particulate phosphorus from inflows. Model simulations were completed to estimate the removal effectiveness of alum treatment of pond RLP inflow waters. A conservative estimate of 80 percent total phosphorus removal of pond RLP inflow waters was assumed for the evaluation. With alum treatment of RLP inflow waters, the total amount of phosphorus added to the lake from the stormwater conveyance systems would range from 20 to 79 pounds per year, a reduction of 48 to 152 pounds of phosphorus annually (See Table 12), under varying climatic conditions. Design and construction of an alum treatment facility is estimated to cost approximately $760,000. In addition, annual maintenance costs for the facility are expected to range from $10,000 to $25,000. A MDNR permit will be required for operation of the alum treatment facility and annual monitoring to determine permit compliance will be required. Monitoring costs will depend upon permit requirements.

**Table 12 Phosphorus Loading Reduction from Treatment of Inflow Waters to Pond RLP**

| Climatic Condition | Annual Total Phosphorus Load From Stormwater Conveyance Systems Under Current Conditions: lbs | Annual Total Phosphorus Load From Stormwater Conveyance Systems Following Alum Treatment of Inflow Waters to Pond RLP: lbs |
|---|---|---|
| Wet (41" of precipitation) | 231 | 79 |
| Model Calibration (34" of precipitation) | 135 | 42 |
| Average (27" of precipitation) | 96 | 29 |
| Dry (19" of precipitation) | 68 | 20 |

- **Store**—Diverting a portion of the lake's watershed runoff into retention areas where the runoff can seep into the ground (infiltration) will reduce the phosphorus load conveyed to the lake by the stormwater conveyance systems. Infiltration facilities include infiltration basins, infiltration trenches, dry wells, porous pavement, swales with check dams, and bioretention areas (infiltration areas with vegetation designed to enhance infiltration). Model simulation was completed to estimate the removal effectiveness of infiltration. It was assumed that an additional 0.4 inches of storage over the entire watershed would be provided through infiltration. The amount of phosphorus added to the lake from stormwater conveyance systems with the additional storage would range from 37 to 169 pounds, a reduction of from 31 to 62 pounds of phosphorus annually (See Table 13), under varying climatic conditions. Design and construction of infiltration basins over the entire Round Lake watershed is estimated to cost $1,400,000. This cost assumes no land acquisition costs or anticipated annual maintenance costs.

**Table 13** **Phosphorus Loading Reduction with Infiltration throughout the Watershed**

| Climatic Condition | Annual Total Phosphorus Load From Stormwater Conveyance Systems Under Current Conditions: lbs | Annual Total Phosphorus Load From Stormwater Conveyance Systems Following Watershed Wide Infiltration |
|---|---|---|
| Wet (41" of precipitation) | 231 | 169 |
| Model Calibration (34" of precipitation) | 135 | 87 |
| Average (27" of precipitation) | 96 | 54 |
| Dry (19" of precipitation) | 68 | 37 |

### 2.2.3 Public Ditch Systems

There are no known public ditch systems affecting Round Lake.

## 2.3 Fish and Wildlife Habitat

The current habitat for Round Lake does not meet the MDNR-criteria for the lake's fishery. The MDNR has established criteria for the support of the lake's fishery, based upon its classification as a Class 30 lake. The MDNR-criteria for Round Lake is an average $TSI_{SD}$ of 53. As shown in Table 14, the lake's $TSI_{SD}$ ranges from 56 to 63 under varying climatic conditions. Unless the water quality is improved to meet MDNR-criteria for Round Lake, the lake will continue to exhibit an impaired habitat for its fishery.

**Table 14** **Round Lake Trophic State Index Secchi Disc Values Under Varying Climatic Conditions***

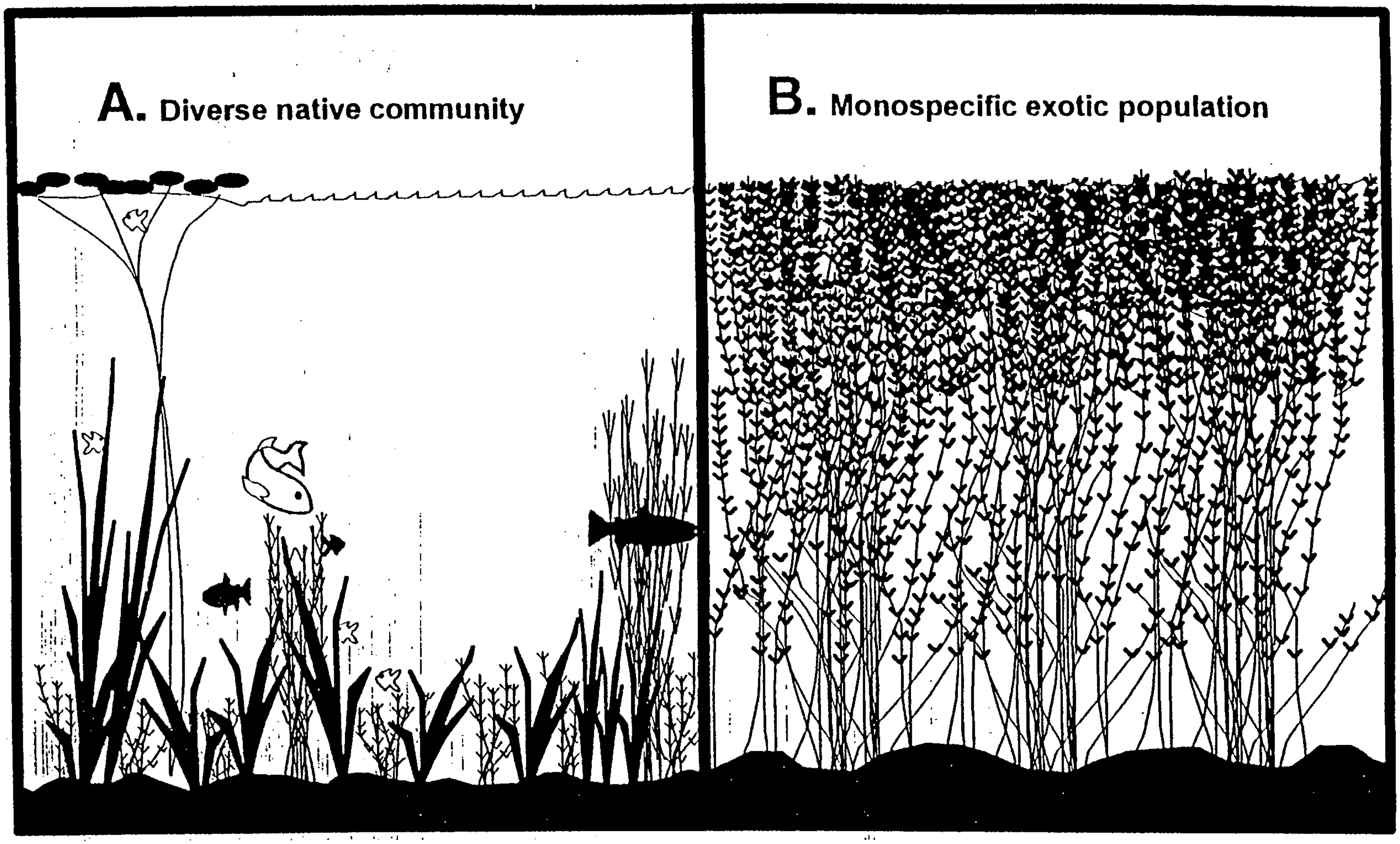
| Parameter | District Goal | Trophic State Index (TSI) Value | | | |
|---|---|---|---|---|---|
| | | Wet Year (1983, 41") | Dry Year (1988, 19") | Average Year (1995, 27") | Model Calibration Year (1997, 34") |
| Secchi disc | $\leq 53$ | 60 | 63 | 59 | 56 |

* Trophic State Index Values are based upon the average summer Secchi disc transparency estimated by models and by relationships established by the MPCA.

An additional habitat problem includes a macrophyte refuge for small fish that prevents control of the bluegill community by predators such as bass. Currently, curly leaf pondweed and coontail exhibit a dense growth that creates a refuge for bluegills and smaller fish making it difficult for larger fish, such as bass, to capture the smaller fish they need for food. The refuge from predation, together with the lake's fertility, results in a bluegill population explosion. The current bluegill community is comprised of "stunted bluegills", exhibiting below normal growth. The lake does not have sufficient food to support the current bluegill community and, consequently, all fish are of below normal size and grow at a below normal rate. The dense macrophyte growth creates habitat problems for the lake's fishery.

Undesirable non native macrophyte species currently found in Round Lake may cause additional habitat problems for the lake's fishery in the future. Curly leaf pondweed and Eurasian watermilfoil are non native species currently found in Round Lake. These species typically follow an aggressive growth pattern and eliminate native species from a lake. Eurasian watermilfoil was first noted in Round Lake during 1997. Because it was recently introduced to the lake, its growth was confined to a relatively small area and only sparse growth was noted during the 1997 survey. This species may exhibit an aggressive growth pattern and a widespread dense growth may occur in the future. Curly leaf pondweed currently exhibits a dense growth and is one of the two dominant species in the lake. If the two species follow an aggressive growth pattern and eliminate native species, the refuge for smaller fish may increase and cover a larger portion of the lake. As previously stated, increases in the small fish refuge would result in greater difficulties by bass and predator fish to obtain needed food. As shown in Figure 12A, a diverse native community provides greater opportunities for predation of smaller fish than a dense growth by non native species (also called exotic species) shown in Figure 12B. Declines in native species reduce available habitat for invertebrates and other food organisms for small fish. Reduced habitat may result in reduced food production. Hence, aggressive growth by curly leaf pondweed and Eurasian watermilfoil may result in increased numbers of bluegills and a reduction in food to support the bluegill community. Whereas management of these species may protect and/or improve the lake's fishery habitat.

- **Manage**—Early spring treatment of the lake's curly leaf pondweed community is recommended to encourage the growth of more desirable native species. An experimental treatment on selected portions of the littoral area should first occur (i.e., about 3 acres). Treatment of a larger portion of the littoral area may be possible if the experimental treatment proves successful. Treatment should consist of application of the chemical Reward during mid-May. Curly leaf pondweed grows during the winter and has a competitive advantage over native species that grow from seed during the spring. Reduction of curly leaf pondweed in mid-May would encourage the growth of native species that typically begin their growth at a later time. An experimental project on Big Lake near Osceola, Wisconsin, noted the reduction of curly leaf pondweed following Reward treatment during May and noted the subsequent growth of Robbin's pondweed, a desirable native species (Rudolph, Personal Communication, 1998). The




Source: Smart et al., 1996

**Figure 12A and 12B**

SUBMERSED AQUATIC PLANT COMMUNITIES

District should work with MDNR staff to identify areas of the lake that would receive the greatest benefit from treatment and the resultant improved fisheries habitat. Currently, MDNR rules restrict treatment to no more than 15% of the vegetated area (i.e., 3 acres). The rules are predicated upon a treatment purpose of controlling all vegetation in the treated area during the growing season. However, the proposed curly leaf pondweed treatment would specifically target the elimination of an undesirable non native species to encourage the growth of native vegetation. Discussion with the MDNR should occur to determine the area of the lake they would permit to be treated for this purpose. The estimated treatment cost will depend upon the area selected for treatment. If 5 acres are treated, treatment costs are estimated at $4,000. A MDNR permit would be required.

- **Manage**—The District should work with MDNR staff to determine the best management approach for the lake's Eurasian watermilfoil growth. The current growth does not create adverse habitat for the lake's fishery. However, because of the potential for problems, working with MDNR staff to identify the best management approach for the Eurasian watermilfoil is recommended.

The lake currently exhibits excellent wildlife habitat, though with undesirable effects upon fisheries, recreation, and water quality. The resident population of geese currently loads problematic quantities of bacteria and phosphorus to the lake. It is estimated that the geese discharge approximately 16 pounds of phosphorus annually (i.e., assume discharge occurs during the April through October period) to the lake. In 1997, the annual phosphorus load from geese was estimated to comprise 8 percent of the annual phosphorus load to the lake. While the annual phosphorus load from geese contributes to the lake's problem of excess phosphorus, bacteria from geese presents an even more serious problem to the lake. During 1997 and 1998, the Round Lake Beach was closed to the public during the late-summer period when public use of the lake was high because fecal coliform bacteria levels within the lake were at an unsafe level for body contact. Bacteria from geese loaded to the lake are the likely cause of the beach closures. Unless the numbers of geese in the Round Lake Park area are reduced, future beach closures due to unsafe bacteria levels are likely to occur and likely when the public demand for use of the lake is highest.

- **Reduce**—It is recommended that the District and City of Eden Prairie work with the University of Minnesota to study the lake's resident geese community and formulate an effective long-term goose management plan. Prior to the completion of a long-term plan, the District and City of Eden prairie may try one or more of the following management techniques. (1) A "no feeding" ordinance is a good first step to dissuading geese. Preventing supplemental food to encourage the geese to stay may help encourage them to disperse. (2) Contracting with dog services to patrol the park and scare flocking geese away from the lake. Border collies, traditionally used to herd sheep, have been trained to chase geese from golf course greens and fairways. (3) Goose repellants have been used to reduce geese. The odor and taste of the repellant lead the birds to seek greener pastures elsewhere if other nearby grazing areas are available. Only one repellant is registered for use on turf and lawns (ReJex-iT). It needs to be carefully sprayed at a set concentration to avoid burning out the lawn. Confirmation that the repellant does not adversely affect people must occur prior to use on park grasses, however. The repellant usually lasts only 14 days and is washed off whenever it rains. (4) Scare techniques have been used to reduce geese. These techniques are particularly effective in the spring. Mylar helium balloons painted with eye spots can be tethered at desired locations. They scare geese because they look like large predators. Half-inch strips of flashing mylar tape or ribbon can also persuade geese to move onto other nearby mown grass. Both the rattling sound and the light flashes frighten geese. Such tape is available through garden centers, feed co-ops, and mail order catalogs. (5) Vegetative or fence barriers have been used to reduce geese. Dense hedges or a 50- to 100-foot strip of stiff grasses or shrubs at least 3 feet high will dissuade use by geese. Landscaping with trees, shrubs, and hedges make lakeside areas less attractive to geese. Consequently, landscaping around the beach area and along the lake's shoreline could dissuade geese from entering the lake. Shoreline areas, not including the beach, could use increased height of existing vegetation to dissuade geese. Artificial barrier fencing at least 30 inches high with a minimum 3 x 3 inch mesh will dissuade geese (Sperling, 1998). The beach area could be fenced and the public could enter and exit the beach area via gates. Alternatively, an attractive "hedge" fence could be placed around the beach and gates installed at desired locations to allow entrance and exit from the beach.

## 2.4 Water-Based Recreation

Recreation uses of Round Lake currently include swimming, fishing, canoeing, paddle boating, and aesthetic viewing. However, swimming is its primary recreation use. The MPCA has established water quality criteria to determine whether a lake has the water quality required to fully support a swimmable use. According to MPCA-criteria, lakes fully supporting the swimmable use should exhibit "impaired swimming" conditions less than 10 percent of the time and in terms of physical condition should exhibit "high algal levels" less than 10 percent of the time. To put this criteria in measurable terms, the MPCA has specified that lakes with an average Trophic State Index (TSI) $\leq$ 53 are classified as fully supporting swimmable and aesthetic uses. The trophic state index is calculated from total phosphorus, chlorophyll *a*, and Secchi disc transparency data from a lake

(Carlson 1977). When the MPCA criteria for fully swimmable and aesthetic uses are compared to a standardized lake rating system, a TSI $\leq$ 53 would correspond to oligotrophic (excellent water quality), mesotrophic (good water quality), and mildly eutrophic (poor water quality) conditions. An evaluation of estimated Round Lake TSI under wet, dry, average and model calibration year (i.e., water year 1997) climatic conditions indicates the lake is currently unable to fully support swimmable use under virtually all climatic conditions (see Table 15). Consequently, the lake exhibits "impaired swimming conditions" under virtually all climatic conditions.

**Table 15 Round Lake Trophic State Index Values Under Varying Climatic Conditions***

| | Trophic State Index (TSI) Value | | | | |
|---|---|---|---|---|---|
| **Parameter** | **District Goal** | **Wet Year (1983, 41")** | **Model Calibration Year (1997, 34")** | **Average Year (1995, 27")** | **Dry Year (1988, 19")** |
| Total Phosphorus | $\leq$53 | 66 | 63 | 65 | 69 |
| Chlorophyll *a* | $\leq$53 | 65 | 59 | 64 | 68 |
| Secchi disc | $\leq$53 | 60 | 56 | 59 | 63 |
| Average TSI | $\leq$53 | 64 | 59 | 63 | 67 |

*Trophic State Index Values are based upon the average summer epilimnetic total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency predicted by the in-lake phosphorus model and by the relationships between phosphorus/chlorophyll and chlorophyll/Secchi disc established by the MPCA.

Round Lake can achieve the water quality needed to fully support swimming by reducing phosphorus loads to the lake. Phosphorus reduction can be attained by implementing the management practices discussed in Section 2.2.1 Natural Conveyance Systems and Section 2.2.2 Stormwater Conveyance Systems (add, treat, and store management practices). Phosphorus reduction is expected to reduce the phytoplankton population and hence improve the lake's water quality. In addition, the following management practice is recommended to achieve the District's recreation goal.

- **Manage**—Treatment of the lake with alum is recommended to remove excess phosphorus currently present in the lake. Although reduction of phosphorus loading to the lake will reduce its phosphorus concentration over the long-term, residual effects of the current phosphorus load may delay the anticipated reduction for several years. As shown in Table 2, the hydrologic residence time of Round Lake varies with climatic conditions, ranging from 1 day to an infinite number of years. On average, the lake notes a 15 year hydrologic residence time. This means that some of the current high phosphorus waters may reside in the lake for several years after completion of watershed management practices. An alum treatment of the lake would quickly remove current high levels of phosphorus, resulting in low phosphorus concentrations following treatment. Watershed management practices would then protect the improved water quality through reduced phosphorus loading to the lake. An alum treatment of the lake is estimated to cost $6,500.

## 2.5 Ecosystem Data

The Round Lake ecosystem is a determining factor in the achievement or non achievement of Round Lake's recreation, aquatic communities, and water quality goals. An imbalance in the lake's ecosystem adversely impacts the lake's fish community, water based recreation, and water quality thereby preventing goal achievement. The ecosystem consists of phytoplankton (small aquatic plants), zooplankton (small animals), fish, and macrophytes (large aquatic plants).

An imbalanced phytoplankton community in Round Lake results in nuisance algal blooms throughout the summer, but particularly during the late summer period. The profuse phytoplankton cause the lake to have a reduced water transparency and an objectionable green appearance. Water quality degradation and "impaired swimming conditions" result from the overabundant phytoplankton community. As shown in Table 15, current phytoplankton levels in the lake result in non compliance with MPCA criteria for full swimmable use. Current phytoplankton levels also result in non compliance with MDNR criteria for the lake's fishery (See Table 14). Hence, profuse phytoplankton prevent achievement of the lake's recreation, aquatic communities, and water quality goals. The excess phytoplankton are caused by overabundant phosphorus loading to the lake (imbalanced nutrients). A reduction in the lake's phosphorus load will reduce the phytoplankton to acceptable levels.

The lake's problem of excessive phytoplankton is exacerbated by the lack of natural control by the zooplankton community. The current unbalanced levels of zooplankton in Round Lake noted low levels of cladocera and copepoda. The zooplankton community provides food for the lake's fishery, but has little impact on the lake's water quality. Zooplankton eat algae and, if present in large numbers and size, can improve the lake's water quality. Increased numbers of large zooplankton (primarily cladocera, a type of zooplankton) would help reduce the lake's phytoplankton and improve the lake's water quality.

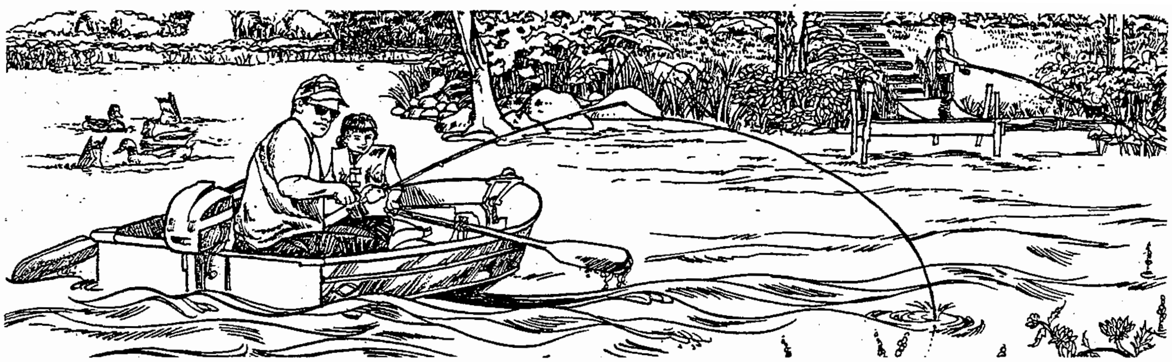
An unbalanced bluegill community is the assumed cause of the low numbers of zooplankton. Bluegills eat zooplankton and, hence, the number of bluegills in the lake determine the number of zooplankton. An uncontrolled increase in the number of bluegills has occurred in Round Lake since 1988. Currently, the lake's available food source is unable to allow the bluegill fishery to grow to a normal size. Consequently, nearly all bluegills exhibit below normal growth. The bluegill grazing pressure on the zooplankton community has reduced their numbers (zooplankton) to low levels. The low numbers of zooplankton limit the available food for bluegills and concurrently prevent control of the lake's phytoplankton community.

The lake's predator fish (e.g., northern pike) are unbalanced and have been at a negligible level since 1988. The MDNR indicates the lake notes a good bass fishery (Ellison, 1999), however, the large number of bluegills in the lake creates an imbalance between the lake's predators and planktivores (bluegills). The bass and other predators are unable to control the lake's bluegill fishery. In addition, the bluegills are too small to be removed by fishermen. Consequently, they continue to exhibit explosive growth.

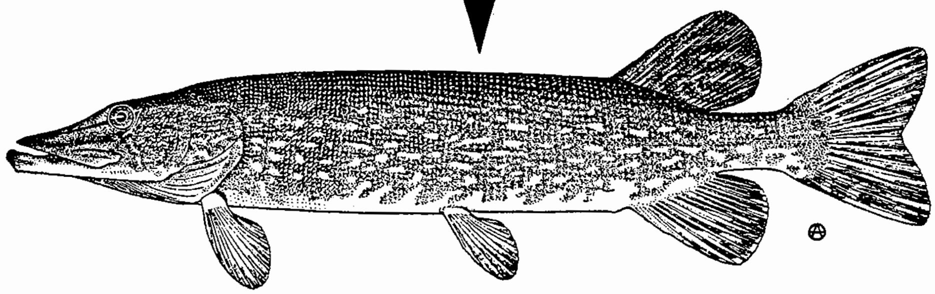
The lake's ecosystem is currently imbalanced (See Figure 13). Excess nutrients have resulted in excess phytoplankton, thus causing an imbalance. The bluegill population explosion has resulted in an imbalance in the planktivore community, which in turn has reduced the zooplankton community to negligible levels. An imbalance in the zooplankton is also observed. Lastly, fishing pressure on the lake's sportfish has reduced the predator fish to negligible levels, creating an imbalance. This imbalance, together with the lake's dense macrophyte growth, prevents the predator fish from controlling growth of the bluegill community. The unbalanced ecosystem prevents attainment of the lake's aquatic communities goal.

Balance to the lake's ecosystem may be restored by reducing phosphorus loads to the lake and management of the lake's fisheries. Phosphorus reduction can be attained by implementing the management practices discussed in Section 2.2.1 Natural Conveyance Systems and Section 2.2.2.

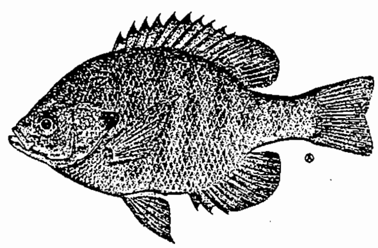
- **Manage**—Supplemental feeding of the lake's bluegill community is recommended. Automatic feeders containing bluegill food could be placed at specified locations in the lake's littoral area. It is estimated that approximately one summer of supplemental feeding would enable significant numbers of the current bluegill community to grow to a "catchable and keepable size." Fishermen are then expected to remove bluegills and fishing pressure is expected to restore balance to the bluegill community. Annual feeding of bluegills during June through mid-September is recommended to sustain a good bluegill fishery and ensure that fishing pressure keeps the bluegill community in balance. A special feed would be used that contained 0.5 percent phosphorus to prevent a net increase in phosphorus to the lake. Bluegill



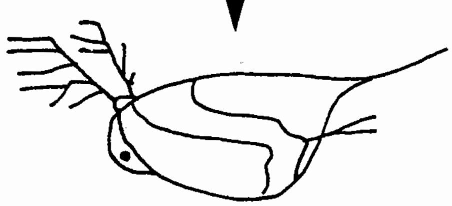
*Imbalance – Too Many* **PEOPLE EAT**



*Imbalance – Too Few* **PISCIVOROUS FISH EAT**



*Imbalance – Too Many* **PLANKTIVOROUS FISH EAT**



*Imbalance – Too Few* **ZOOPLANKTON EAT**

**MICROSCOPIC**

*Imbalance – Too Many* **ALGAE USE**

*Imbalance – Too Much* **NUTRIENTS (Phosphorus)**

**EXCESS PHOSPHORUS FROM WATERSHED** ➤

Figure 13

ROUND LAKE IMBALANCED ECOSYSTEM

removal is estimated to remove as much phosphorus as added by the feed. The initial cost of the bluegill feeding program is $4,200. The cost includes $3,100 for the purchase of feeders, $1,000 for fish feed, and about $100 for miscellaneous costs. Annual supplemental feeding of the bluegill community is estimated to cost $1,100. A MDNR permit is required for supplemental feeding of bluegills. In addition to supplemental feeding, the MDNR has recommended the installation of a second fishing pier to facilitate bluegill harvest. The estimated cost of the pier is $43,000.

- **Manage**—Annual (or as needed) stocking of northern pike is recommended to restore balance to the predator fish community. Additional numbers of northern pike will enhance the lake's fishery, help control the bluegill community (i.e., northern pike eat bluegills), and help restore balance to the lake's ecosystem. Annual stocking of northern pike is estimated to cost $400. Alternatively, a walleye stocking program could be used to restore balance to the predator fish community. The cost of the walleye stocking program would also be $400. The MDNR has recommended northern pike rather than walleye because northern pike are expected to have a better survival and growth rate in Round Lake (Ellison, Personal Communication, 1999). A MDNR permit would be required for annual stocking.

## 2.6 Water Quality

### 2.6.1 Baseline/Current Analysis

Water quality degradation in Round Lake during the 1972 through 1975 period created efforts beginning in 1977 to assess the lake's water quality problems and identify solutions. A study was conducted from September 1977 to March 1979. Study results indicated:

- The principal sources of phosphorus (a nutrient that stimulates algal blooms) were non-point sources (e.g., lawns, street, litter and debris) in the lake's watershed. Annual phosphorus loading to the lake was estimated to be 130 pounds.

- The lake's deterioration in water quality was accompanied by an increase in the ratio of chlorophyll to phosphorus. This finding implied that food chain organisms that feed on algae were not effectively controlling the algae during these months. Specifically, it was observed that microorganisms that feed on algae (i.e., zooplankton) were not abundant in Round Lake during the late-summer. The unbalanced zooplankton community provided an opportunity for algae to increase to nuisance levels.

- The fish population in Round Lake was dominated by species that feed on zooplankton. Specifically, it was observed that crappie and sunfish (bluegill sunfish) populations increased substantially during 1972 through 1979. It appeared that the abundance of these two species created an imbalance in the lake's ecosystem. Their preference for feeding on zooplankton was limiting the zooplankton population, thus creating favorable conditions for algal blooms to occur.

The study recommended a restructuring of the lake's fish population to restore balance to the lake's ecosystem. The balanced ecosystem would favor the survival of zooplankton organisms. Specifically, it was recommended that the sunfish and crappie population be reduced by introducing predator fish or by chemical control. Restocking the lake with a more diversified fish population was also recommended. The study further recommended the construction of treatment basins to treat watershed runoff and reduce phosphorus loading to the lake (Barr 1979).

During the fall of 1980, the lake was treated with rotenone to eliminate the existing fish population. The lake was then restocked with channel catfish, walleye, largemouth bass, and bluegill. By returning the fish population to one high in predators (i.e., large fish that eat smaller fish) as opposed to one high in planktivores (i.e., fish that eat zooplankton) it was hoped that the lake's water quality would improve. In 1981 and 1982, improved lake water quality was noted with fewer algae and greater transparency as a result of the large population of *Daphnia*, an herbivorous zooplankter, that developed. However, the number of planktivorous fish in the lake increased during the 1982 through 1985 period and water quality degradation occurred. During 1985, the lake was again treated with rotenone and restocked with a fish population similar to the 1980 restocking. In 1986, Rainbow trout, a planktivore (i.e., eat zooplankton) were stocked to provide fishing while the bass grew to catchable size. The rotenone treatment in fall 1985 was followed by a resurgence of *Daphnia pulex* to concentrations as great or greater than those found in 1982, and *Daphnia galeata* became even more abundant than earlier. However, the 1986 chlorophyll concentrations and transparency did not improve as expected. One possible explanation for the disappointing response is that Rainbow trout fed on the larger-bodied *Daphnia*, leaving only smaller-bodied individuals to control the algae. Despite their abundance, it appeared that the *Daphnia* were unable to control the algae because they were too small. The rainbow trout disappeared from Round Lake by 1987 (Limnological Research Center, 1981, 1982, 1983, 1984, 1986, 1988).

Efforts to halt the water quality degradation of the lake by restoring balance to a portion of the lake's ecosystem were unsuccessful. The lack of success occurred because excess phosphorus loaded to the lake from its watershed caused the lake's ecosystem to remain unbalanced. Excess nutrients resulted in water quality degradation, which in turn fueled explosive phytoplankton and bluegill growth. A comparison of baseline (1972 through 1987) and current (1988 through 1997) water quality confirms the significant degradation in water quality that has occurred in Round Lake (See Table 3). Average summer total phosphorus concentrations increased by approximately 50 percent from baseline to current; chlorophyll *a* concentrations increased by 70 percent from baseline to current; and Secchi disc transparencies decreased by more than 50 percent from baseline to current. The comparison of baseline and current water quality conditions confirm the perceived degradation of the lake's water quality since 1972.

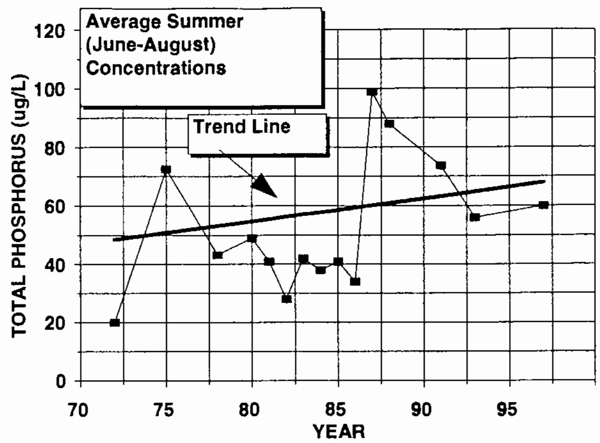
### 2.6.2 Historical Water Quality—Trend Analysis

A trend analysis of Round Lake was completed to determine if the lake had experienced significant degradation or improvement during the years for which water quality data are available. The results of the trend analysis show a significant degradation in the lake's water quality has occurred. The analysis was based upon Secchi disc transparency, total phosphorus, and chlorophyll *a* observations collected since 1972 (i.e., 15 years of data). Standard statistical methods (i.e., linear regression and analysis of variance) were used to complete the analysis. Plots of the three water quality variables and the fitted regression lines are shown in Figure 14.

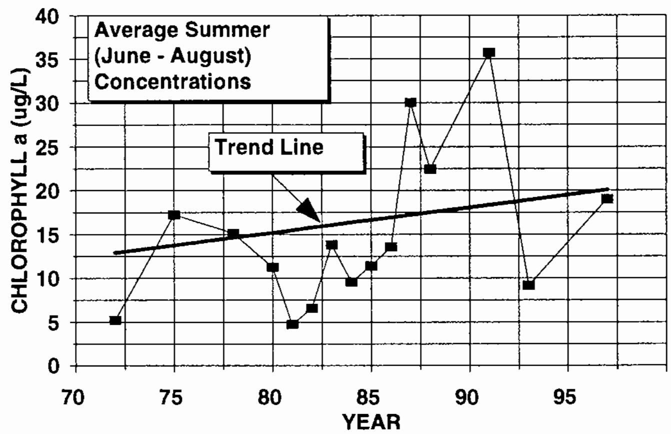
Two criteria must be met to conclude the lake's water quality has significantly improved or declined. First, the trend in a variable was considered significant if the slope of the regression was statistically significant at the 95 percent confidence level. Second, a conclusion of degraded water quality requires concurrent increases in total phosphorus and chlorophyll *a* concentrations, and decreases in Secchi disc transparencies; a conclusion of improvement requires the inverse relationship. The results for the three variables fit these criteria, showing that the water quality of Round Lake has continued to decline over time.

The results of the regressions indicate that Secchi disc transparency has been declining at an average rate of 0.07 meters per year (0.2 feet or approximately 3 inches); chlorophyll *a* concentration in the epilimnion (upper 6 feet) has increased at the rate of 0.3 µg/L per year; and total phosphorus concentration in the epilimnion (upper 6 feet) has been increasing at the rate of 0.8 µg/L per year. Slightly improved water quality was noted during 1993, but additional deterioration of water quality noted in 1997 confirmed the trend of degrading lake water quality. The results of the trend analysis indicate continued decline in Round Lake water quality can be expected to occur unless management practices to stop the decline are identified and implemented.

## ROUND LAKE
## TOTAL PHOSPHORUS - 1972 THROUGH 1997




## ROUND LAKE
## CHLOROPHYLL a - 1972 THROUGH 1997




## ROUND LAKE
## SECCHI DISC - 1972 THROUGH 1997

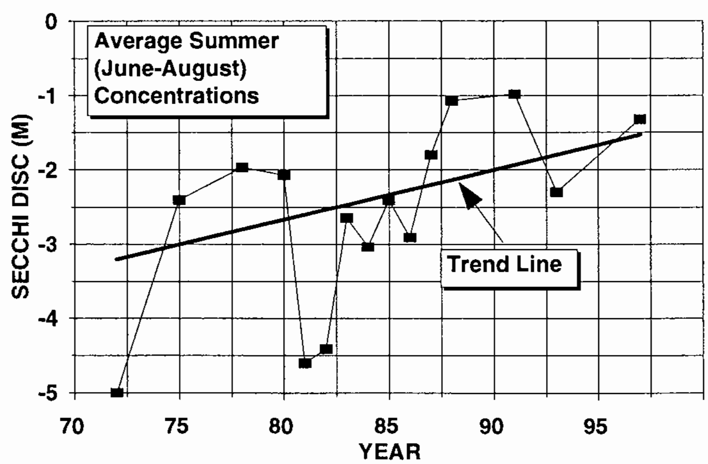



**Figure 14**
**Round Lake Trend Analysis -- 1972-1997**
**Total Phosphorus and Chlorophyll a Concentrations and Secchi Disc Transparencies**

### 2.6.3 Water Quality Modeling Analysis

During preparation of the District water management plan, the Dillon and Rigler model was used to estimate lake water quality conditions. During completion of the use attainability analysis, It was determined that the Dillon and Rigler model was inappropriate for estimation of Round Lake water quality. The intensive water quality data collection program and the P8 modeling results provided additional information not available during plan preparation. The additional information indicated the outflow volume from the lake was much lower than the outflow volume predicted by the Dillon and Rigler model. Also, the Dillon and Rigler model predicted a lower settling rate of the phosphorus added to the lake from its watershed than actually occurred in the lake. The Dillon and Rigler model estimated a greater phosphorus retention than actually occurred in the lake. The Vollenweider (1976) steady state mass balance model was found to be an appropriate model to predict the lake's water quality. The use attainability analysis used the Vollenweider model to estimate the average summer total phosphorus concentrations in the upper six feet of Round Lake under wet, dry, average, and model calibration year (1997) conditions. MPCA relationships were used to estimate the corresponding values for chlorophyll *a* and Secchi disc transparency (Heiskary and Wilson 1990).

The modeling analysis indicates the lake currently has poor or very poor water quality under virtually all climatic conditions. A comparison of the lake's modeled total phosphorus concentrations under wet, dry, average, and model calibration year (1997) climatic conditions with a standardized lake rating system indicates the average summer values were within the hypereutrophic category (i.e., very poor water quality, See Figure 15). The lake's modeled summer average chlorophyll *a* concentrations and Secchi disc transparencies were within the eutrophic (poor water quality) or hypereutrophic (very poor water quality) categories (See Figures 16 and 17). The modeling analysis confirms that the lake is currently unable to meet the District water quality goal under virtually all climatic conditions (See Table 15).

The lake's water quality can be improved by reducing phosphorus loaded to the lake from its watershed. Phosphorus reduction can be attained by implementing the management practices discussed in Section 2.2.1 Natural Conveyance Systems and Section 2.2.2 Stormwater Conveyance Systems (add, treat, and store management practices). Alum treatment of the lake, discussed in Section 2.4 Water Based Recreation, will remove excess phosphorus loads currently present in the lake.

## Round Lake Avg. Summer [TP] Under Varying Climatic Conditions

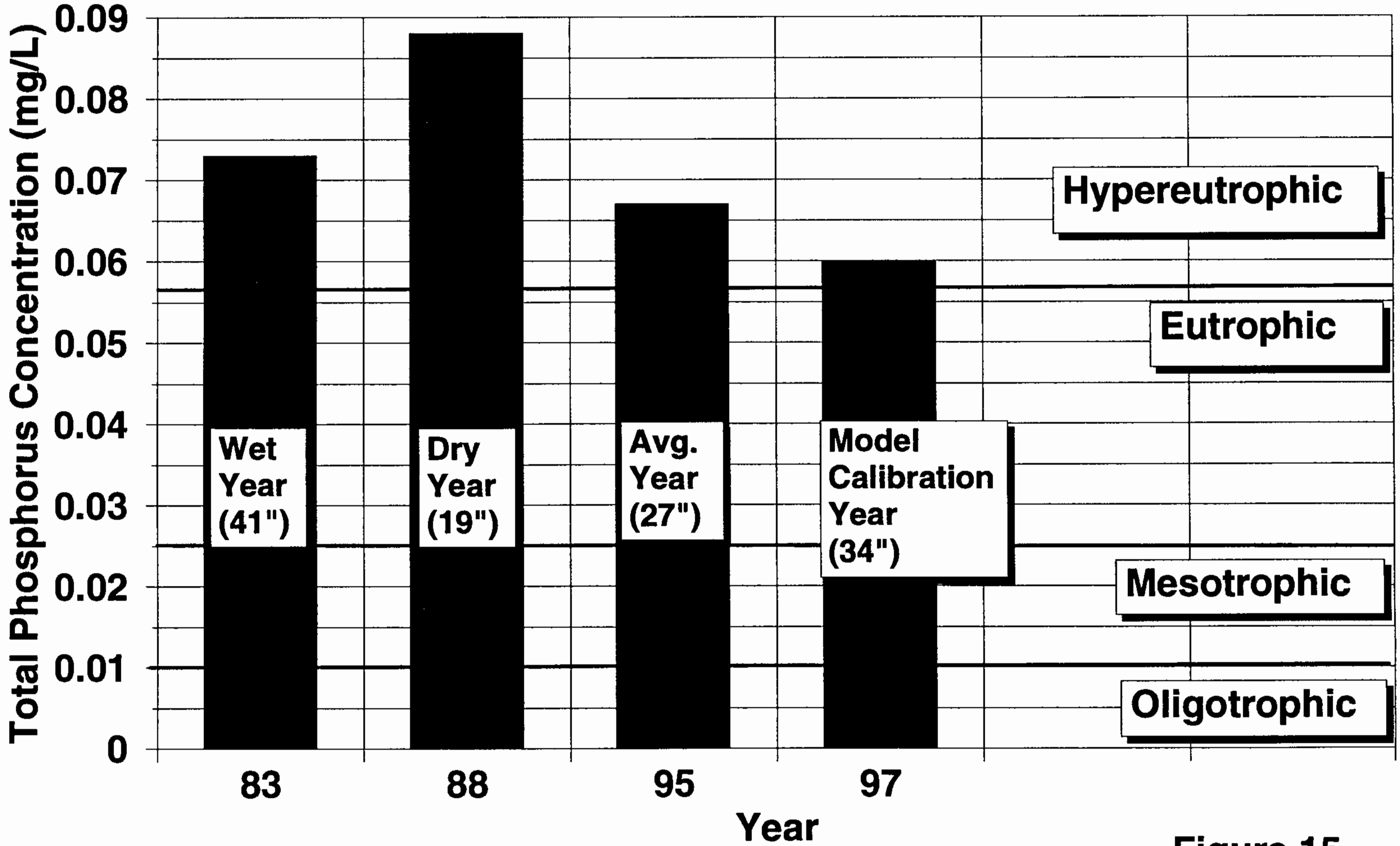



Figure 15

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## Round Lake Avg. Summer Chlorophyll a Under Varying Climatic Conditions

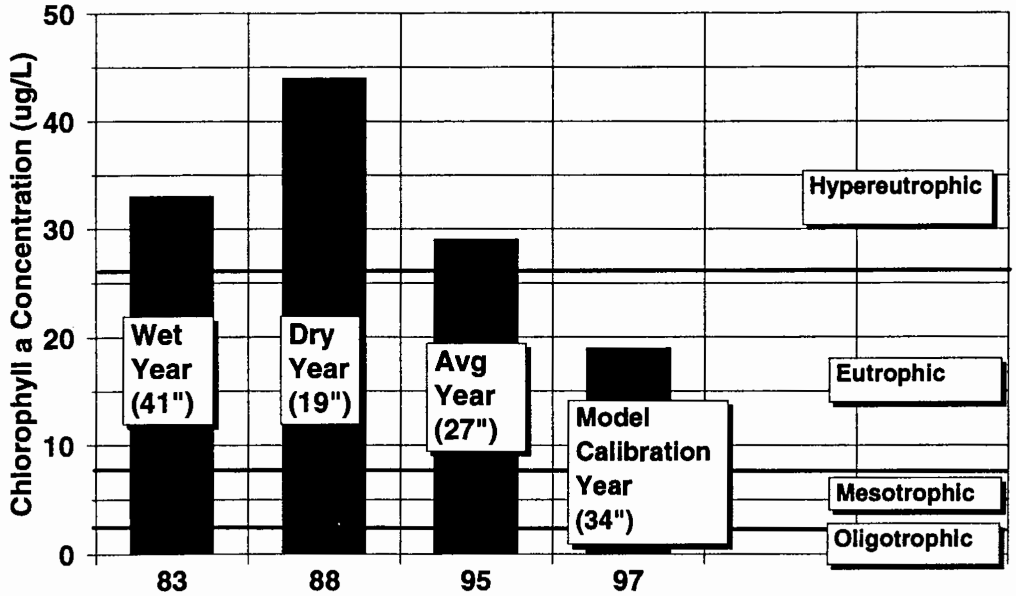


Figure 16

## Round Lake Avg. Summer Secchi Disc Under Varying Climatic Conditions

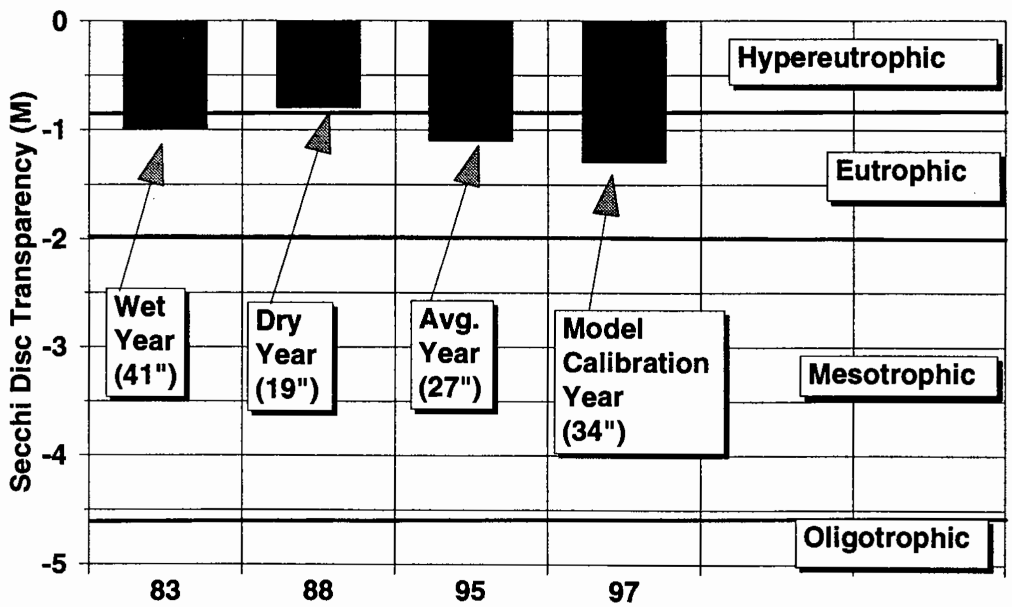


Figure 17



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## 2.7 Major Hydrologic Characteristics

The major hydrologic characteristics of the lake have changed from the pre-development period. Change continued throughout the development of the watershed. The watershed is currently fully developed and the major hydrologic characteristics are now stabilized.

## 2.8 Land Use Assessment

Land use in the watershed has changed from the predevelopment period. The watershed's land use changed from wooded to agriculture to urbanized. The watershed land use is currently complete. However, future redevelopment within the watershed could result in density increases and increased phosphorus loading to the lake. Increased density in residential development and increased commercial development are both possible in the future. Proposed land use changes within the lake's watershed should be analyzed to determine whether increased phosphorus loading to the lake would result from the changes. Management practices to prevent phosphorus loading increases should be required of land use changes to prevent degradation of the lake's water quality.

- **Store**—Infiltration basins may be required of developments to prevent increased phosphorus loading to the lake.

- **Add**—Detention basins may be required of developments to remove phosphorus from runoff waters.

# 3.0 Round Lake Goals

The approved water management plan of the Riley-Purgatory-Bluff Creek Watershed District articulated five specific goals for Round Lake. These goals address recreation, aquatic communities, water quality, water quantity, and wildlife. A discussion of the goals follows.

## 3.1 Water Quantity Goal

The water quantity goal for Round Lake is to provide sufficient water storage during a regional flood. Construction of an outlet from Round Lake to Mitchell Lake as part of the Eden Prairie Chain-of-Lakes Basic Management Project achieved this goal, now and in the future. Hence, the water quantity goal has been achieved and no action is required.

## 3.2 Water Quality Goal

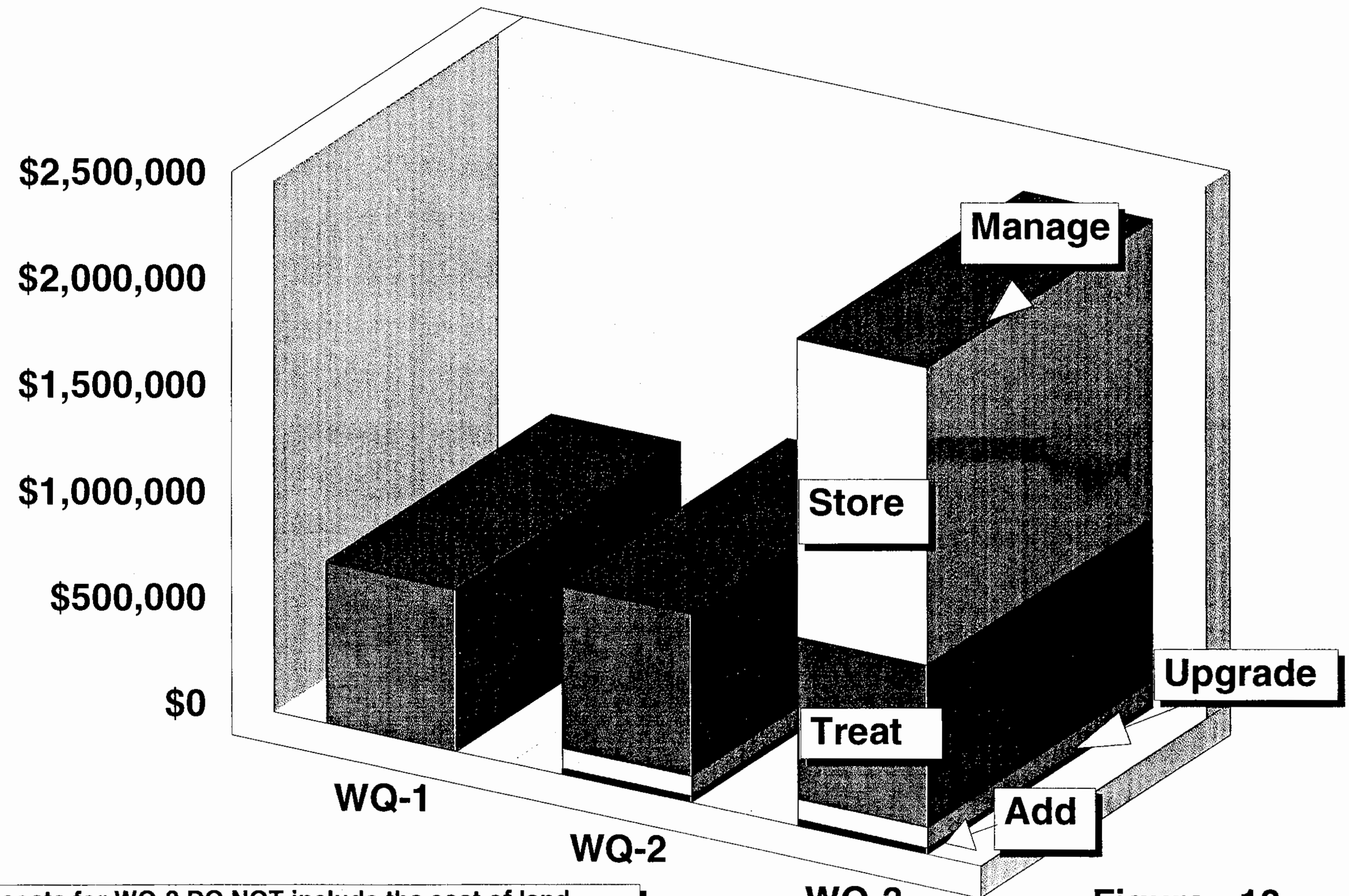
The water quality goal of Round Lake is predicated upon the lake's recreation goal. The goal is to achieve a water quality that will fully support the lake's swimmable use. The specific District goal is to achieve and maintain a $TSI_{SD} \leq 53$.

The water quality goal has not been achieved, but can be achieved through the implementation of lake and watershed management practices. Three different alternatives will achieve or exceed the District goal water quality goal. Figure 18 compares costs of the three alternatives and Table 16 compares water quality benefits of the three alternatives under varying climatic conditions. The three alternatives are:

- **WQ-1—Treat** (alum treatment facility to treat inflows to RLP) and **Manage** (alum treatment of Round Lake)

- **WQ-2—Treat** (alum treatment facility to treat inflows to RLP), **Manage** (alum treatment of Round Lake), **Upgrade** (Upgrade RLE, M, and RLP to MPCA/NURP standards), **Add** (Add pond RLNE), and **Reduce** (Reduce the geese).

# Water Quality




The store costs for WQ-3 DO NOT include the cost of land aquisition. If land aquisition is required, the estimated cost of purchasing land is about $6,300,000.

Figure 18

- **WQ-3—Treat** (alum treatment facility to treat inflows to RLP), **Manage** (alum treatment of Round Lake), **Upgrade** (Upgrade RLE, M, and RLP to MPCA/NURP standards), **Add** (Add pond RLNE), **Reduce** (Reduce the geese), and **Store** (Store an additional 0.4 inches of runoff watershed wide in infiltration basins).

**Table 16 Benefits of Water Quality Management Alternatives**

| Alternative | Trophic State Index (TSI) Value | | | | |
|---|---|---|---|---|---|
| | District Goal | Wet Year (1983, 41") | Model Calibration (1997, 34") | Average Year (1995, 27") | Dry Year (1988, 19") |
| WQ-1: Treat and Manage** | ≤ 53 | 51 | 51 | 52 | **56*** |
| WQ-2: Treat, Manage**, Upgrade, Add, and Reduce | ≤ 53 | 49 | 47 | 47 | 51 |
| WQ-3: Treat, Manage**, Upgrade, Add, Reduce, and Store | ≤ 53 | 47 | 42 | 42 | 47 |

* Does not achieve District Water Quality Goal.
** Manage includes alum treatment of lake

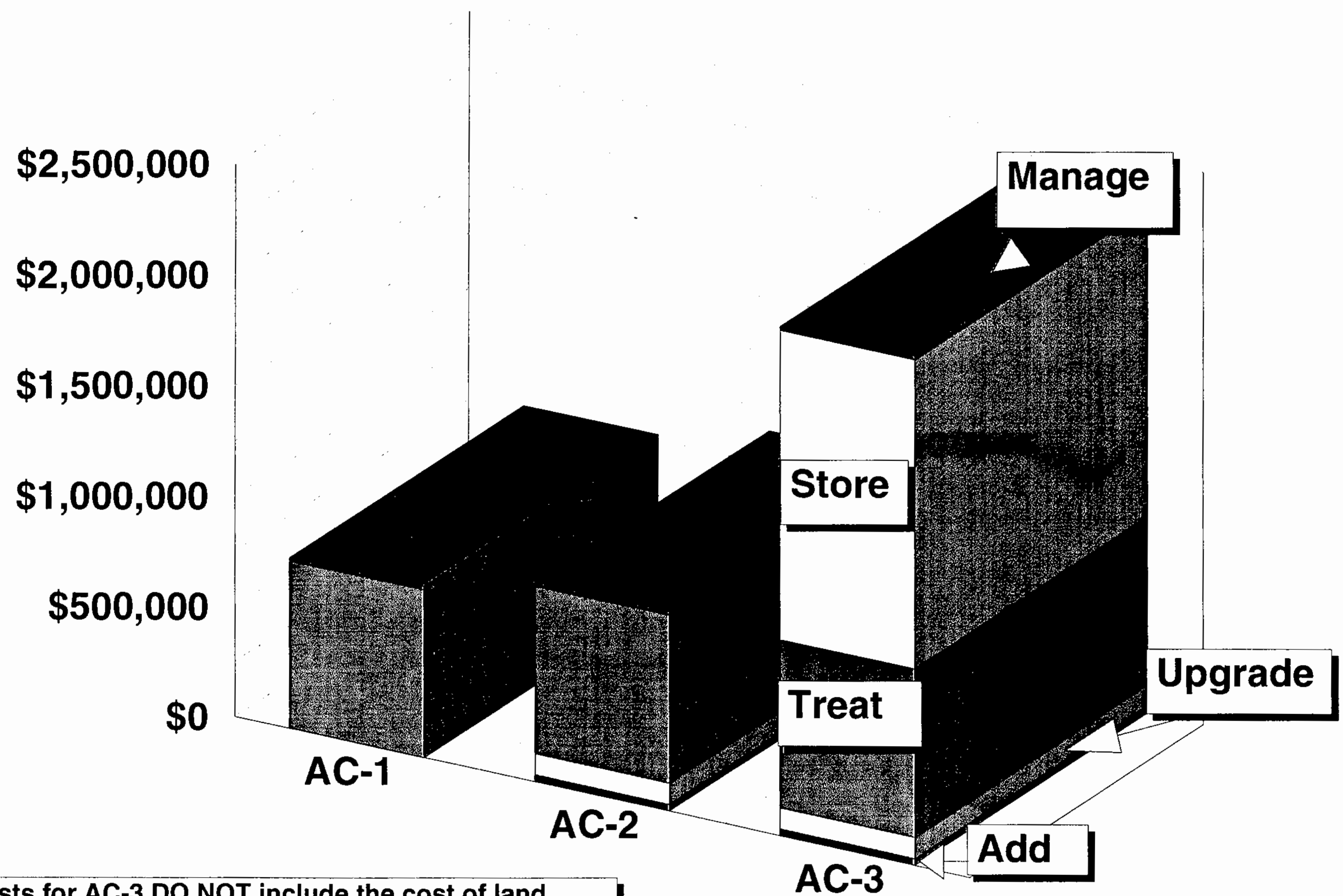
## 3.3 Aquatic Communities

The aquatic communities goal of Round Lake is to achieve a water quality that fully supports the lake's fisheries-use classification determined by the MDNR in accord with the MDNR *An Ecological Classification of Minnesota Lakes with Associated Fish Communities* and achieve a balanced ecosystem. Specifically, the goal is to achieve and maintain a $TSI_{SD}$ ≤53 and a balanced fishery. Management of Round Lake to achieve a balanced fishery includes achieving a balance of predator fish (e.g., northern pike, bass) and panfish (e.g., bluegills) of a desirable size for fishermen.

The aquatic communities goal has not been achieved, but can be achieved through the implementation of lake and watershed management practices. Three different alternatives will achieve or exceed the District goal water quality goal. Figure 19 compares costs of the three alternatives and Table 17 compares water quality benefits of the three alternatives under varying climatic conditions. The three alternatives are:

- **AC-1—Treat** (alum treatment facility to treat inflows to RLP) and **Manage** (alum treatment of Round Lake, supplemental feeding of bluegills, stocking of northern pike, and treatment of curly leaf pondweed)

# Aquatic Communities




The store costs for AC-3 DO NOT include the cost of land aquisition. If land aquisition is required, the estimated cost of purchasing land is about $6,300,000.

Figure 19

- **AC-2—Treat** (alum treatment facility to treat inflows to RLP), **Manage** (alum treatment of Round Lake, supplemental feeding of bluegills, stocking of northern pike, and treatment of curly leaf pondweed), **Upgrade** (Upgrade RLE, M, and RLP to MPCA/NURP standards), **Add** (Add pond RLNE), and **Reduce** (Reduce the geese).

- **AC-3—Treat** (alum treatment facility to treat inflows to RLP), **Manage** (alum treatment of Round Lake, supplemental feeding of bluegills, stocking of northern pike, and treatment of curly leaf pondweed), **Upgrade** (Upgrade RLE, M, and RLP to MPCA/NURP standards), **Add** (Add pond RLNE), **Reduce** (Reduce the geese), and **Store** (Store an additional 0.4 inches of runoff watershed wide in infiltration basins).

**Table 17 Benefits of Aquatic Communities and Recreation Alternatives**

| | Trophic State Index (TSI) Value | | | | |
|---|---|---|---|---|---|
| Alternative | District Goal | Wet Year (1983, 41") | Model Calibration (1997, 34") | Average Year (1995, 27") | Dry Year (1988, 19") |
| AC-1 and Rec-1: Treat and Manage** | $\leq$ 53 | 51 | 51 | 52 | **56*** |
| AC-2 and Rec-2: Treat, Manage**, Upgrade, Add, and Reduce | $\leq$ 53 | 49 | 47 | 47 | 51 |
| AC-3 and Rec-3: Treat, Manage**, Upgrade, Add, Reduce, and Store | $\leq$ 53 | 47 | 42 | 42 | 47 |

* Does not meet District Water Quality Goal.
** Manage includes alum treatment of lake, supplemental bluegill feeding, northern pike stocking, and management of curly leaf pondweed.

## 3.4 Recreation Goal

The recreation goal is to achieve a fully supporting use classification and to maintain a MDNR ecological class 30 rating, with a balanced predator/planktivore fishery. Goal details follow:

- Achieve a fully supporting use support classification in accord with the *MPCA Use Support Classification for Swimming Relative to Carlson's Trophic State Index by Ecoregion*. The specific District goal is to achieve and maintain a $TSI_{SD} \leq 53$. The recreation goal of Round Lake is based upon the *Minnesota Lake Water Quality Assessment Data: 1997— An Update to Data Presented in the Minnesota Lake Water Quality Assessment Report: 1990* (MPCA 1998). The MPCA has established criteria for the full support of swimming. The criteria are based upon a lake's water quality and its location. The MPCA has divided the state into four areas called ecoregions: Northern Lakes and Forests, North Central Hardwood Forests, Northern Glaciated Plains, and Western Corn Belt Plains. The MPCA then established phosphorus criteria (Heiskary and Walker, 1988) for full support of swimming in each ecoregion. The criteria were based upon a comparison of phosphorus concentrations and a standardized lake rating system (Carlson's TSI scale to establish a use support threshold for each ecoregion). Because the lakes in the Northern Lakes and Forests were of better water quality than lakes in other ecoregions, higher criteria were established for full support of swimming for this ecoregion. Phosphorus criteria for the Northern Lakes and Forests ecoregion is $P \leq 30$ µg/L and a $TSI_{SD} \leq 50$. Round Lake is in the North Central Hardwood Forests ecoregion. The phosphorus criteria level of full support of swimmable use for the North Central Hardwood Forest ecoregion is $P \leq 40$ µg/L and a $TSI_{SD} \leq 53$. The criteria ensures that conditions associated with "impaired swimming" would occur less than 10 percent of the summer. Phosphorus concentrations above criteria levels result in greater frequencies of nuisance algal blooms and increased frequencies of "impaired swimming." The upper threshold for partial support of swimmable use was set at 60 µg/L for the lake's ecoregion. As phosphorus concentrations increase from about 10 µg/L to 60 µg/L, summer mean chlorophyll concentrations increase from about 30 µg/L to 60 µg/L, and Secchi disc transparency decreases from about 1.7 meters to 0.8 meters. Over this range, the frequency of nuisance algal blooms (greater than 20 µg/L chlorophyll) increases from about 5 percent of the summer to about 70 percent of the summer (Heiskary and Wilson, 1990). The increased frequency of nuisance algal blooms and reduced Secchi transparency results in a high percentage of the summer (26 to 50 percent) perceived as "impaired swimming." Because the primary use of Round Lake is swimming, the District has established a water quality goal to insure the lake fully supports swimming. The goal is to achieve and maintain a $TSI_{SD} \leq 53$.

- Maintain a water quality that fully supports the lake's fisheries-use classification determined by the MDNR in accord with the MDNR *An Ecological Classification of Minnesota Lakes with Associated Fish Communities.* The specific District goal is to achieve and maintain a $TSI_{SD} \leq 53$.

- Achieve a sport fishery that includes a balance of predator fish and panfish of a desirable size for fishermen.

The recreation goal has not been achieved. The goal can be achieved through the implementation of lake and watershed management practices. Three different alternatives will achieve or exceed the District water quality goal. Figure 20 compares costs of the three alternatives and Table 17 compares water quality benefits of the three alternatives under varying climatic conditions. The three alternatives are:

- **REC-1—Treat** (alum treatment facility to treat inflows to RLP) and **Manage** (alum treatment of Round Lake, supplemental feeding of bluegills, stocking of northern pike, and treatment of curly leaf pondweed)

- **REC-2—Treat** (alum treatment facility to treat inflows to RLP), **Manage** (alum treatment of Round Lake, supplemental feeding of bluegills, stocking of northern pike, and treatment of curly leaf pondweed), **Upgrade** (Upgrade RLE, M, and RLP to MPCA/NURP standards), **Add** (Add pond RLNE), and **Reduce** (Reduce the geese).

- **REC-3—Treat** (alum treatment facility to treat inflows to RLP), **Manage** (alum treatment of Round Lake, supplemental feeding of bluegills, stocking of northern pike, and treatment of curly leaf pondweed**), Upgrade** (Upgrade RLE, M, and RLP to MPCA/NURP standards), **Add** (Add pond RLNE), **Reduce** (Reduce the geese), and **Store** (Store an additional 0.4 inches of runoff watershed wide in infiltration basins).

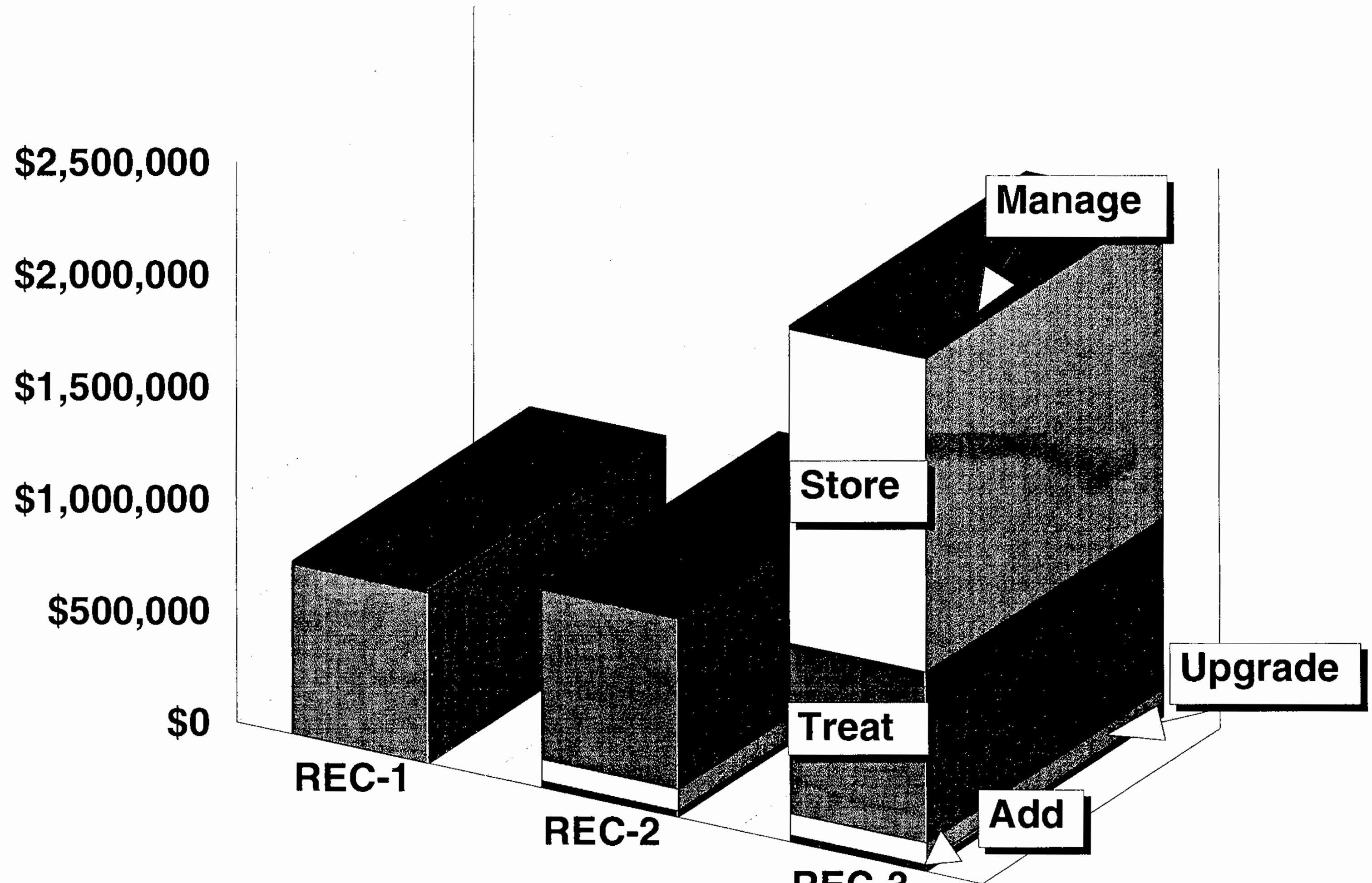
## 3.5 Wildlife Goal

The wildlife goal for Round Lake is to protect existing, beneficial wildlife uses. The wildlife goal has been achieved, but the current wildlife use of the lake is impeding the achievement of the lake's recreation, water quality, and aquatic communities goals.

## 3.6 Public Participation

The public participation goal is to encourage public participation as a part of the use attainability analysis. This goal will be achieved through a public meeting to obtain comments on the use attainability analysis.

# Recreation




The store costs for REC-3 DO NOT include the cost of land aquisition. If land aquisition is required, the estimated cost of purchasing land is about $6,300,000.

Figure 20

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# *Appendices*