1997 Lake Water Quality Study

Crane Lake, Lost Lake, and Westwood Lake

Prepared for

Bassett Creek Water Management Commission

March 1998

1997 Lake Water Quality Study
Crane Lake, Lost Lake, and Westwood Lake

Prepared for
Bassett Creek Water Management Commission

Table of Contents

List of Tables

List of Figures

List of Appendices

Table of Contents (Continued)

Executive Summary

Since 1970, when the Bassett Creek Water Management Commission (Commission) was formed, water quality conditions in the ten major lakes have been periodically monitored. The objective of the lake monitoring program is to detect changes or trends in water quality over time, thereby determining the effect of changing land use patterns in the watershed and the effectiveness of the Commission's efforts to prevent water quality degradation in the lakes.

This report presents the results of water quality monitoring in 1997 of Crane Lake (formerly Dayton Pond), Lost Lake, and Westwood Lake. The lakes were monitored for water quality and biota. The latter include macrophytes (i.e., aquatic vascular plants), phytoplankton, and zooplankton. Three primary indicators of water quality are total phosphorus concentration, chlorophyll *a* concentration, and Secchi disc transparency; additional water quality measurements are included in an appendix. Monitoring results are summarized by lake using a narrative description of the results, accompanied by a one page graphical summary of the data.

The conclusions from the water quality monitoring are as follows:

Crane Lake

- Crane Lake is a shallow wetland-type of lake that appears to have a relatively simple chemical, physical, and biological structure.

- Classified as a Level II water body, Crane Lake's water quality goals were achieved in the first half of the growing season, but not in late August, when elevated phosphorus levels appeared to contribute to high algal biomass and reduced water transparency.
- Crane Lake generally had better water quality in 1997, based on phosphorus and chlorophyll *a*, than it had in the 1970s and 1980s.

Lost Lake

- Lost Lake is a hypereutrophic lake, with extremely high concentrations of phosphorus and algal biomass.
- Lost Lake has been classified by the Commission as a Level II water body, but the 1997 data indicate the lake is far from achieving the water quality goals. Achieving the goals will require large reductions in phosphorus concentrations. Means of achieving those reductions were described in the lake's watershed managment plan (Barr 1995b).
- The sparse historical database for water quality in Lost Lake (1972, 1977, 1982 and 1993) indicates the lake has been hypereutrophic for at least 25 years, and does not appear to have changed significantly in more recent years.

Westwood Lake

- Westwood Lake is a eutrophic lake that generally meets the Level II water quality goals for chlorophyll *a* and total phosphorus concentrations, but not the goal for Secchi disc transparency.
- Invasion by the exotic macrophyte species, curlyleaf pondweed and purple loosestrife are a concern for Westwood Lake, because they often displace native species.

- Westwood Lake has better water quality in 1997 than it had in 1977, and is slightly better than it was in 1993; in 1977, the lake did not meet Level II water quality goals for summer means of total phosphorus, chlorophyll *a*, and Secchi disc transparency, but it did meet them in 1993 and 1997.

Introduction

Since 1970, when the Bassett Creek Water Management Commission (Commission) was formed, water quality conditions in the ten major lakes have been periodically monitored. The Commission's policy is to preserve water quality conditions, and to improve them where possible. Nonpoint source pollution—pollutants transported by stormwater runoff—is the predominant cause of lake water quality degradation. The objective of the lake monitoring program is to detect changes or trends in water quality over time, thereby determining the effect of changing land use patterns in the watershed and the effectiveness of the Commission's efforts to prevent water quality degradation in the lakes.

In 1991, the Commission established an annual lake water quality monitoring program that generally followed the recommendations of the Metropolitan Council (Osgood, 1989a) for a "Level 1, Survey and Surveillance" data collection effort. The lake sampling program generally involves monitoring of ten lakes on a three-year rotating basis, three or four lakes per year. Major lakes include the following water bodies, with prior monitoring years indicated parenthetically:

- Crane (1977, 1982, 1993, 1997)
- Lost (1977, 1982, 1993, 1997)
- Medicine (1977, 1982, 1983, 1984, 1988, 1994[1])
- Northwood (1977, 1982, 1992, 1994, 1996)
- Parker's (1977, 1982, 1992, 1996)
- Sunset Hill (Cavanaugh) (1977, 1982, 1994)

[1]Monitoring performed jointly with Suburban Hennepin Regional Park District

- Sweeney (1977, 1982, 1985, 1992, 1996)
- Twin (1977, 1982, 1992, 1996)
- Westwood (1977, 1982, 1993, 1997)
- Wirth (1977, 1982)

In addition, the lake sampling program has included the following ponds (and year sampled):

- Courtland, East Ring, and West Ring Ponds (1993)
- Grimes Pond (1996)
- North Rice and South Rice Ponds (1994)

This report presents the results of water quality monitoring in 1997 of Crane, Lost, and Westwood Lakes (Figure 1). The lakes were monitored for water quality (Appendix A) and biota (Appendix B). The latter included macrophytes (i.e., aquatic vascular plants), phytoplankton, and zooplankton. Monitoring results are summarized by lake as a narrative description of the results accompanied by a one page graphical summary of the data. More detailed results are tabulated and mapped in the appendices of the report.

The discussion of water quality conditions focuses on the three principal water quality indicators: total phosphorus and chlorophyll *a* concentrations, and Secchi disc transparency. Phosphorus is a nutrient that usually controls the growth of algae. Chlorophyll *a* is the primary photosynthetic pigment in lake algae; therefore, the concentration in a lake water sample 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.

The water quality conditions were classified as to trophic state, based on the total phosphorus concentration, chlorophyll *a* concentration, and Secchi disc transparency (Table 1). The most desirable lakes in the Twin

Cities Metropolitan Area generally are in the mesotrophic range of water quality, but most of the lakes are in the eutrophic to hypereutrophic range.

Table 1 **Trophic State Classifications for Total Phosphorus, Chlorophyll *a*, and Secchi Disc Transparency**

Lake Classification	Total Phosphorus	Chlorophyll *a*	Secchi Disc Transparency
Oligotrophic (nutrient poor)	less than 10 µg/L	less than 2 µg/L	greater than 15 ft (4.6 m)
Mesotrophic (moderate nutrient levels)	10 µg/L - 24 µg/L	2 µg/L - 7.5 µg/L	15 ft - 6.6 ft (4.6 m - 2.0 m)
Eutrophic (nutrient rich)	24 µg/L - 57 µg/L	7.5 µg/L - 26 µg/L	6.6 ft - 2.8 ft (2.0 m - 0.85 m)
Hypereutrophic (extremely nutrient rich)	greater than 57 µg/L	greater than 26 µg/L	less than 2.8 ft (0.85 m)

In addition to classifying the lakes according to trophic state, the Recreational Suitability Index (RSI) was calculated for each lake. The RSI is an index of recreational impairment in a lake caused by degraded water clarity (i.e. Secchi disc transparency). The index represents degrees of use-impairment and parallels an index of physical condition (Table 2). Secchi disc transparency data were used to calculate the RSI, which was originally based on empirical relationships developed by Osgood (1989a) using data from lakes in the Twin Cities metro area.

Table 2 **Recreational Suitability Index Compared to a Physical Condition Index**

Scale	Recreational Suitability Index	Physical Condition Index
1	Beautiful, could not be better	Crystal clear
2	Very minor aesthetic problems	Not quite crystal clear; some algae visible

3	Swimming and aesthetic enjoyment slightly impaired	Definite color caused by algae
4	Desire to swim and level of enjoyment substantially reduced	High algal levels, with limited clarity and/or mild odor apparent
5	Swimming and aesthetic enjoyment nearly impossible because of algae	Severely high algal levels; includes massive floating scums, strong foul odor, or fish-kill

Source: Osgood,1989b

The Commission established water quality goals for the lakes in a 1993 Water Quality Management Plan and adopted as policy in 1994. The Commission's water quality management policy divided water bodies located in Bassett Creek watershed into four management categories. The categories are based on desired water quality goals and recreational uses. The categories include:

1. **Level I** — Fully support all water-based recreational activities, including swimming, scuba diving, and snorkeling.
2. **Level II** — Appropriate for all recreational uses except full body contact activities; recreational activities for these water bodies include sail boating, water skiing, motor boating, canoeing, wind surfing, and jet skiing.
3. **Level III** — Support fishing, aesthetic viewing activities and observing wildlife.
4. **Level IV** — Generally intended for runoff management (i.e., stormwater detention) and have no significant recreational values.

Specific water quality goals were assigned to each level, and are described in the following summaries of water quality in Crane, Lost, and Westwood lakes.

Reserved for:

Figure 1 Location of Lakes and Ponds in the Bassett Creek Watershed

Crane Lake

Site Description

Crane Lake (also known as Dayton Pond) and its watershed are located entirely within the city limits of Minnetonka, Minnesota. The lake has a surface area of 30 acres (12 hectares), a maximum depth of 5 feet (1.5 meters), and an estimated mean depth of 3.3 feet (1.0 meters). Crane Lake is surrounded by a cattail marsh which provides excellent waterfowl habitat, but restricts recreation. The lake is bordered by residential areas to the south and east, by Highway 394 to the north, and by Ridgedale Center to the west. The Crane Lake watershed has a total area of 353 acres (131 hectares)(excluding the landlocked and lake surface areas) and is nearly fully developed. The remaining undeveloped land is located southwest of the lake.

Crane Lake is classified as a Level III water body, which means water bodies will support fishing, aesthetic viewing activities and observing wildlife. The specific water quality goals related to Level III water bodies include:

- Maximum total phosphorus of 75 μg/L
- Maximum chlorophyll *a* concentration of 40 μg/L
- Minimum Secchi disc transparency depth of 0.9 meters (about three feet).

The lake has typically met the Commission's water quality goals.

A watershed and lake management plan was completed for Crane Lake in 1995 by the Commission (Barr 1995a).

Water Quality Data

Crane Lake was sampled six times in 1997 at one sampling station in the deepest part of the lake. Total phosphorus concentrations, chlorophyll *a* concentrations, and Secchi disc transparencies during 1997 are graphically summarized in Figure 2. These data, along with other water quality data (e.g., temperature, dissolved oxygen, and specific electrical conductivity) are tabulated in Appendix A. The average summer concentration (shown on the graphs) were for June, July, and August. Total phosphorus and Secchi disc transparency summer averages indicted hypereutrophic conditions. Chlorophyll *a* —an indicator of algal biomass—had a summer average that was in the upper range of the eutrophic conditions.

Recreational Suitability

Based on average summer Secchi disc transparency in Crane Lake, the recreational suitability index (RSI) was 5, which is the poorest ranking of this index. This low ranking indicates that swimming and aesthetic enjoyment are impaired because of high algal biomass.

Biota

There are three components of the biota in the lake that are discussed here: macrophytes (vascular aquatic plants), phytoplankton (algae), and zooplankton (micro-crustaceans). The results for 1997 are graphically summarized in Figure 2 and tabulated in Appendix B. Fisheries are not discussed in this report because they are managed by the Minnesota Department of Natural Resources.

Macrophytes

Vegetation was found throughout the lake. Submerged aquatic plants covered most of the lake's surface in June and in August. Cattails (*Typha spp.*) were present along the entire shore of the lake and floating islands were noted in the June survey. Several emergent and submerged species were present in the June survey and more submerged species were identified in the August survey. Among the additional species in the August survey, were sago pondweed (*Potamogeton pectinatus*) and bushy pondweed (*Najas spp.*), which are excellent food for waterfowl. Purple loosestrife (*Lythrum salicaria*) is an exotic emergent that has attractive flowers, but provides poorer wildlife habitat than native emergent species that it displaces, such as cattails (*Typha spp.*).

Phytoplankton

Phytoplankton concentration was highest on August 6, consisting primarily of bluegreen algae and is indicative of an algal bloom. Bluegreen algae also were predominant on August 20, but the total numbers had greatly diminished, yet the chlorophyll *a* concentration was at its highest value. This apparent lack of agreement between phytoplankton numbers and chlorophyll *a* concentration could have been caused by a change in the “packaging” or biovolumes of the algal cells. The bluegreen algae can form “flakes” that consist of many individual algal cells.

Zooplankton

Generally a healthy zooplankton community will have balanced densities (number per square meter) of the three major groups: cladocera, copepods, and rotifers. The zooplankton community in Crane Lake consisted predominately of rotifers and fewer copepods. Cladoceran species were few in number and richness, and no cladocera were found in the July 15, 1997, sample. Thus, Lost Lake generally appears to have a poorly developed zooplankton community and is not likely to support a very diverse fish population.

Conclusions

- Crane Lake is a shallow wetland-type of lake that appears to have a relatively simple chemical, physical, and biological structure
- Water quality goals for Crane Lake were achieved in the first half of the growing season, but were exceeded in late August, when elevated phosphorus levels appeared to contribute to high algal biomass and reduced water transparency
- Crane Lake generally had better water quality in 1997, based on phosphorus and chlorophyll *a*, than it had in the 1970s and 1980s.

Reserved for:

Figure 2Crane Lake

Lost Lake

Site Description

Lost Lake is located in a northeastern section of the City of Plymouth (Figure 1). It has a water surface area of approximately 22 acres (8.9 hectares), a maximum depth of 6.5 feet (2.0 meters), and a mean depth of 3.5 feet (1.1 meters). Lost Lake's watershed area is about 39 acres (15.8 hectares), excluding the lake's water surface area.

The lake is classified by the DNR as a type V wetland, which typically have water depths less than 10 feet, may contain submergent vegetation (e.g., pondweeds), and may be fringed by emergent vegetation (e.g., cattails). Lost Lake's shoreline is developed with single family homes, except for a short stretch of the north shore that abuts Old Rockford Road.

The Commission classifies Lost Lake as a Level II water body—appropriate for all recreational uses except full body contact activities. The water goals for Level II water bodies are

- Maximum total phosphorus concentration of 45 µg/L
- Maximum chlorophyll *a* concentration of 20 µg/L
- Minimum Secchi disc transparency of 1.4 meters (about 4.5 feet).

Water quality in Lost Lake has typically not met these goals.

A watershed and lake management plan was completed for Lost Lake in 1996 by the Commission (Barr 1996).

Water Quality Data

Lost Lake was sampled six times in 1997 at one sampling station in the central area of the lake. Total phosphorus concentrations, chlorophyll *a* concentrations, and Secchi disc transparencies during 1997 are graphically summarized in Figure 3. These data, along with other water quality data (e.g., temperature, dissolved oxygen, and specific electrical conductivity) are tabulated in Appendix A.

As is typical for shallow lakes, Lost Lake did not stratify, except in July. Temperature and dissolved oxygen remained nearly uniform throughout the water column for five of the six sample periods. In July the water column was stratified and dissolved oxygen was less than 1.0 mg/L at 1.5 m and probably absent near the lake sediments. By the next sample collection on August 6, the dissolved oxygen ranged from 6.0 mg/L at the top to 5.5 mg/L at the bottom and temperature was uniform from top to bottom. An unusual feature of Lost Lake's dissolved oxygen concentration was the very high concentrations measured on April 22, 1997. Dissolved oxygen was probably supersaturated at that time and pH also was unusually high. These high values are most likely caused by a high rate of algal growth — "primary productivity" — as indicated in the very high concentrations of phytoplankton (Figure 3).

Total phosphorus concentrations in Lost Lake were extremely high, averaging 174 μg/L during the summer months (June, July, and August). The highest phosphorus concentration at the surface in 1997 was 216 μg/L was collected on the August 20. These were reflected in extremely high chlorophyll *a* concentrations. Chlorophyll *a* concentrations were relatively low in the July and September samples, which might have been caused by algicide treatment in the lake. Total phosphorus and chlorophyll *a* concentrations clearly demonstrate hypereutrophic conditions. Secchi disc transparency indicated water clarity was greater than would be expected from the high chlorophyll *a* concentrations. This was most likely because the phytoplankton consisted primarily of bluegreen algae that form "colonies" or "flakes." The chlorophyll is then concentrated in these colonies rather than more diffusely spread throughout the water in smaller algal cells. Light is able to penetrate deeper among the colonies, giving a higher Secchi disc reading, despite appearing very green with algae. The high chlorophyll *a* and total phosphorus concentrations in Lost Lake are well above the Level II water quality goals set for the lake, although, compared to historical data from Lost Lake, the concentrations are typical (Barr 1996).

Recreational Suitability

Based on average summer Secchi disc transparency in Lost Lake, the recreational suitability index (RSI) was 4, which indicates that recreational activity is substantially reduced because of algae levels.

Biota

There are three components of the biota in the lake that are discussed here: macrophytes (vascular aquatic plants), phytoplankton (algae), and zooplankton (micro-crustaceans). They are graphically summarized in Figure 3 and tabulated in Appendix B. Fisheries are managed by the Minnesota Department of Natural Resources, and are not discussed in this report.

Macrophytes

Lost Lake had very few aquatic vascular plants (Figure 3). There were no submerged species collected in the June survey and only one submerged species (*Potamogeton foliosus*) identified in the August survey. Small patches of emergent species were identified around the perimeter of the lake. Included among the emergents was purple loosestrife (*Lythrum salicaria*), which is considered a nuisance exotic species because it usually replaces other emergents species that provide better wildlife habitat. The blue flag iris (*Iris versicolor*) is an unusual species for lakes in this region; it was found Lost Lake during both the June and August surveys.

Phytoplankton

Phytoplankton (algae) were sampled and quantified five times from July through early September. Concentrations of phytoplankton were extremely high throughout the sampling period in 1997. The highest concentration was on June 18, which is earlier in the growing season than is typically seen in lakes. Green algae made up a significant portion of the phytoplankton community on June 18, but after that bluegreen algae predominated. When phosphorus concentrations are very high as they are in Lost Lake, phosphorus may no longer limit the growth of the algae and instead nitrogen can become limiting. The bluegreen algae have a competitive advantage compared to other algal taxa in their ability to fix nitrogen (i.e., converts nitrogen gas to ammonia).

Zooplankton

Zooplankton were sampled and quantified five times from July through early September. The zooplankton community was lacking in diversity and consisted of only a few species of rotifers and copepods. A healthier community should include more cladoceran species, which filter the water and remove algae. Surprisingly, no cladocera were found in the August 20 and September 3, 1997 samples. It is unusual not to find any cladocera in a summer sample. Another unusual feature of the Lost Lake zooplankton were the two cladocera species, *Alona sp.* and *Simocephalus sp.*, identified in the June, July, and early August samples. They are littoral species that live near or attached to aquatic plants. This would not be surprising in a lake covered with macrophytes, but Lost Lake had extensive open water in the June macrophyte survey.

Conclusions

- Lost Lake is a hypereutrophic lake, with extremely high concentrations of phosphorus and algal biomass
- Lost Lake has been classified by the Commission as a class II water body, but the water quality indicate the lake is far from achieving the water quality goals. Achieving the goals will require large reductions in phosphorus concentrations. Means of achieving those reductions were described in the lake's watershed managment plan (Barr 1995b).
- The sparse historical database for water quality in Lost Lake (1972, 1977, 1982 and 1993) indicates the lake has been hypereutrophic for at least 25 years, and does not appear to have changed significantly in more recent years.

Reserved for:

Figure 3Lost Lake

Westwood Lake

Site Description

Westwood Lake is located southwest of the interchange of Highways 394 and 169, in St. Louis Park (Figure 1). It has an open water surface area of approximately 38 acres (15 hectares) and a maximum depth of 5 feet (1.5 meters). The lake is encircled by a cattail marsh. Westwood Lake's watershed area is about 305 acres (123.4 hectares), excluding the lake's water surface and landlocked areas. Most of the watershed lies within the city of St. Louis Park; areas north of the lake and west of Highway 169 lie within the cities of Golden Valley and Minnetonka, respectively.

The Commission classifies Westwood Lake as a Level II water body—appropriate for all recreational uses except full body contact activities. . The water goals for Level II water bodies are

- Maximum total phosphorus concentration of 45 µg/L
- Maximum chlorophyll *a* concentration of 20 µg/L
- Minimum Secchi disc transparency of 1.4 meters (about 4.5 feet).

Westwood Lake did not meet the Commission's water quality goals during 1972, 1977, and 1982, but did meet goals for phosphorus and chlorophyll *a* in 1993.

A watershed and lake management plan was completed for Westwood Lake in 1995 by the Commission (Barr 1995b).

Water Quality Data

Westwood Lake was sampled six times in 1997 at one sampling station in the deepest part of the lake. Total phosphorus concentrations, chlorophyll *a* concentrations, and Secchi disk transparencies during 1997 are graphically summarized in Figure 4. These data, along with other water quality data (e.g., temperature, dissolved oxygen, and specific electrical conductivity) are tabulated in Appendix A.

Temperature and dissolved oxygen concentration generally were uniform throughout the water column on all sampling dates. The lowest dissolved oxygen was 2.5 mg/L measured at 1.0 m on August 6.
Total phosphorus had an average summer concentration (June, July, and August) of 36 µg/L. The highest value for 1997 in the 0 to 1 m composite was 65 µg/L measured on August 6. Chlorophyll *a* also was at its highest on August 6 (19 µg/L), but remained below the maximum chlorophyll *a* water quality goal of 20 µg/L. Historically, Westwood Lake has had summer mean total phosphorus concentrations as high as 340 µg/L (1977) and as low as 45 µg/L (1993). Summer mean chlorophyll *a* was nearly 50 µg/L in 1982, but only 10 µg/L in 1993. These values, along with the 1997 summer mean values suggest that Westwood Lake water quality have improved over the last 20 years.

Recreational Suitability

Based on average summer Secchi disc transparency in Westwood Lake, the recreational suitability index (RSI) was 4, which indicates that recreational activity is substantially reduced because of algae levels.

Biota

There are three components of the biota in the lake that are discussed here: macrophytes (vascular aquatic plants), phytoplankton (algae), and zooplankton (micro-crustaceans). They are graphically summarized in Figure 4 and tabulated in Appendix B. Fisheries are not discussed in this report because they are managed by the Minnesota Department of Natural Resources.

Macrophytes

Submerged aquatic plants were found throughout Westwood Lake. A dense area of *Potamogeton pusillus* was identified in the center of the lake. Curlyleaf pondweed (*Potamogeton crispus*) was found at light densities at various locations throughout the lake. The perimeter of the lake is filled with cattails (*Typha spp.*) and sporadic growths of the nuisance exotic species, purple loosestrife (*Lythrum salicaria*).

Phytoplankton

Phytoplankton (algae) were sampled and quantified five times from July through early September. The peak phytoplankton concentration on August 6 corresponded to peak levels of phosphorus and chlorophyll *a*. On other sample dates the phytoplankton community was at a low density and consisted primarily of green and cryptomonad algae, whereas on August 6, bluegreen algae were predominant and green algae remained at levels found on other dates.

Zooplankton

Zooplankton were sampled and quantified five times from July through early September. The zooplankton community consisted primarily of rotifer and copepod species. Cladoceran species that appeared in the first three samples included littoral species that are rarely found in zooplankton samples collected in the open water of lakes. Littoral species live among the macrophytes, but were found in the center of the lake because the lake is covered with macrophytes.

Conclusions

- Westwood Lake is a eutrophic lake that generally meets the Level II water quality goals for chlorophyll *a* and total phosphorus concentrations, but not the goal for Secchi disc transparency
- Invasion by the exotic species, curlyleaf pondweed and purple loosestrife are a concern for Westwood Lake, because they often displace native species.
- Westwood Lake has better water quality in 1997 than it had in 1977, and is slightly better than it was in 1993; in 1977, the lake did not meet Level II water quality goals for summer means of total phosphorus, chlorophyll *a*, and Secchi disc transparency, but it did meet them in 1993 and 1997.

Reserved for:

Figure 4Westwood Lake

References

Barr Engineering Company. 1993a. Draft Bassett Creek Water Quality Management Plan. Prepared for the Bassett Creek Water Management Commission

Barr Engineering Company. 1995a. Crane Lake Watershed and Lake Management Plan. Prepared for the Bassett Creek Water Management Commission.

Barr Engineering Company. 1995b. Westwood Lake Watershed and Lake Management Plan. Prepared for the Bassett Creek Water Management Commission.

Barr Engineering Company. 1996. Lost Lake Watershed and Lake Management Plan. Prepared for the Bassett Creek Water Management Commission.

Osgood, R.A. 1989a. An Evaluation of Lake and Stream Monitoring Programs in the Twin Cities Metropolitan Area. Metropolitan Council Publication No. 590-89-128

Osgood, R.A. 1989b. A 1989 Study of the Water Quality of 20 Metropolitan Area Lakes. Metropolitan Council, St. Paul, MN. Publication No. 590-89-129. 12 pp.

Osgood, R.A. 1989c. Assessment of Lake Use-Impairment in the Twin Cities Metropolitan Area. Metropolitan Council Publication No. 590-89-130.

Appendix A: Lake Water Quality Data for 1997

Appendix B: Macrophyte Surveys; Phytoplankton and Zooplankton Analyses for 1997

Appendix C: Field and Laboratory Methods

Sample Collection

The epilimnetic sample at each lake's central sampling site was collected with a 0-to-2-meter integrated composite sampler. Additional samples were collected for total phosphorus from 2 meters below the surface to ½-meter above the lake bottom, at approximately 3-meter depth intervals.

Phytoplankton samples were collected as subsamples from the epilimnetic composite sample. Zooplankton samples were collected with a Wisconsin-type net towed from just above the lake bottom to the surface.

At every sample site the following parameters were measured at one-meter depth intervals:

- Water temperature
- Dissolved oxygen concentration
- Specific electrical conductivity

Secchi disc transparencies were also measured at each site.

Macrophytes were surveyed and mapped twice in each lake using a transect method.

Chemical Analyses

Procedures for the chemical analyses are presented in the accompanying table.

Procedures for Chemical Analysis Performed on Water Samples

Analysis	Procedure	Reference
Total Phosphorus	Persulfate digestion, manual ascorbic acid	Standard Methods, 16th Edition, 1985, 424 C.III, 424F, and Eisenreich, et al., Environmental Letters 9(1), 43-53 (1975)
Ortho Phosphorus	Manual ascorbic acid	Standard Methods, 16th Edition, 1985, 424F(1985) and Eisenreich, et al., Environmental Letters 9(1), 43-53 (1975)
Nitrite + Nitrate Nitrogen	Colorimetric	Lachat Instruments Quik Chem Method No. 10-107-04-1-C and Standard Methods, 16th Edition, 1985, 418C and 418F
Ammonia Nitrogen	Automated	Standard Methods, 16th Edition, 1985, 417C and 417G and Manual of Analytical Methods, Water Chemistry Unit, Laboratory of Hygiene, Madison, Wisconsin
Total Kjeldahl Nitrogen	Semi-automated	Jirka, et al., Environ. Science and Technology 10:1038-1044, (1976) and Standard Methods, 15th Edition, 1980, 424E
Chlorophyll a	Spectrophotometric	Standard Methods, 16th Edition, 1985, 1002G
pH	Potentiometric measurement, glass electrode	Standard Methods, 16th Edition, 1985, 423
Specific Conductance	Wheatstone bridge	Standard Methods, 16th Edition, 1985, 205
Temperature	Thermometric	Standard Methods, 16th Edition, 1985, 212
Dissolved Oxygen	Electrode	Standard Methods, 16th Edition, 1985, 421F
Phytoplankton Identification and Enumeration	Inverted microscope	Standard Methods, 16th Edition, 1985, 1002F (2-d), 1002H (2)
Zooplankton Identification and Enumeration	Sedgewick Rafter	Standard Methods, 16th Edition, 1985, 1002F (7)
Transparency	Secchi disc	