King County Lake Monitoring Report

Lake Stewardship Program

Volunteer Lake Monitoring Results for the Water Year 2002

King County

December 2003

King County Lake Monitoring Report

Volunteer Lake Monitoring Results for Water Year 2001–2002

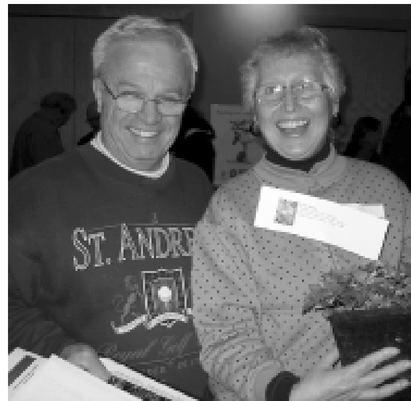

December 2003

King County
Department of Natural Resources and Parks
Water and Land Resources Division
Lake Stewardship Program
King Street Center
201 South Jackson, Suite 600
Seattle, WA 98104
(206) 296-6519 TTY Relay: 711
http://dnr.metrokc.gov/wlr/waterres/smlakes/

Text will be made available in large print, Braille, or audiotape as requested. TTY Relay: 711 or King County Information (206) 296-0100

2002 Participating Volunteers

Many individuals have contributed to the collection of lake volunteer monitoring data. Special thanks to our dedicated volunteers, many of whom have participated for several years. The success of this program is dependent upon their diligent and dedicated efforts.



Alice	Level I: Cheri Enevold Level II: Jenny Emsky
Allen	Levels I & II: David and Betty Burton
Ames	Levels I & II: Bob Young
Angle	Level I: Diane & Alden Chace Level II: Edward & Jeannie Montry
Beaver 1	Level II: Donna Carlson
Beaver 2	Level I: Al & Shirley Jokisch, Ray Petit Level II: Larry Miller
Bitter	Level II: Tom Hollowed
Boren	Level I: Mary Alice & Eric Root Level II: Ray Clark
Burien	Level II: Steve Locher
Cottage	Levels I & II: Ed Grubbs Backup Volunteers: Stafford Miller & Ann Whitney
Desire	Level I: Ed & Min Merrill Level II: Jan Falkenhagen
Easter	Level I: Mayetta E. Tiffany
Fivemile	Level I: Theresa & Larry Gunn Level II: Janet Gillies
Francis	Levels I & II: Brian & Eirica Moriarty
Geneva	Level I: Sue Yunker Jones & Thomas Jones Level II: Bruce Harpham & Laura Stiles

2002 Participating Volunteers (continued)

Grass	Levels I & II: Kathryn Howard
Haller	Levels I & II: Rud Okeson Backup Volunteers: Rick Ehle & Barbara Gross
Horseshoe	Level II: Eric Olsgaard Backup Volunteer: Frank Douglas
Jones	Level II: Dale & Linda Anson
Joy	Levels I & II: Bob & Sam Charles
Kathleen	Level I: Steve Thomas Levels I & II: Keith Lanan
Killarney	Level I: Kenna Patrick Level II: Craig Rice
Langlois	Levels I & II: Jasper Scott
Leota	Level I: David Mangels Level II: Rick Sampson
Lucerne	Level II: Milo Dullum & Barbara Winter
Marcel	Levels I & II: Chuck Willis Backup Volunteer: Andy Wones
Margaret	Levels I & II: Douglas Johnston Backup Volunteer: Meredith Mitchell
McDonald	Level I: Jeff & Suzanne Lowry Level II: Darcey Hauff & Trina Hernandez
Meridian	Level I: Kathe Dizard Level II: Al Flores
Mirror	Levels I & II: Bob Roper Backup Volunteers: John & Pat Hardman
Morton	Level I: Marty & Sandy Landers Level II: Paul & Laura Mueller

2002 Participating Volunteers (continued)

Neilson	Levels I & II: Kevin & Kurtis Schultz
North	Levels I & II: Robin & Tim Cook, Chuck Gibson, Debra Hansen, Wendy Honey & Lynn Naumann
Paradise	Levels I & II: Shirley Egerdahl Backup Volunteers: Kay Doolittle & Nancy Doolittle
Pine	Levels I & II: Kate Bradley
Pipe	Level I: Ralph Beede Level II: Bob Brenner
Ravensdale	Level II: Kim Madison
Retreat	Level II: Jason McKinney
Sammamish	Level I: Bruce & Becky Beaulaurier, Joanna Buehler, Pam Monger, Reid Brockway, Mike Schmidt & Cecily Way
Sawyer	Level I: John Davies Level II: Glenn Ross Backup Volunteer: Wilmur Davis
Shadow	Level I: Billy Aliment; Level II: Jake Finlinson
Shady	Levels I & II: Ray Konecke
Spring	Level I: Bob Keller Level II: Caren Adams Backup Volunteer: Ted Barnes
Star	Level II: Mark Baughman
Steel	Levels I & II: Susan Pearson
Trout	Levels I & II: Brenda & Jim Sherwood
Twelve	Levels I & II: Jan Delacy & Libby Moscardini; Backup Volunteers: Cathy & Dean Voelker

2002 Participating Volunteers (continued)

Walsh — Level II: Tina Miller
Backup Volunteer: Harry Morgan

Welcome — Levels I & II: Dave Hadley

Wilderness — Levels I & II: Ray Petit
Backup Volunter: John Vasboe

Contributors

Special thanks to the staff involved in the administration, training, volunteer coordination, and equipment management of the lake volunteer monitoring program. Staff efforts include data reduction and management; laboratory analysis, quality assurance and data verification; data analysis; technical writing; and report production. The following individuals contributed significantly to the volunteer monitoring program and production of this report:

Data Analysis
Sally Abella
Curtis Clement
Beth Cullen
Katie Sauter Messick
Michael "Murph" Murphy

Graphics
Sally Abella
Curtis Clement
Beth Cullen
Katie Sauter Messick
Michael "Murph" Murphy

Laboratory Analysis
Mary Silva, Laboratory Project Manager
Sample Management Personnel
Conventionals Chemistry and
Microbiology Staff at the Environmental Lab

Report Layout and Production Management
Saffa Bardaro

Technical Writing and Editing
Sally Abella
Saffa Bardaro
Beth Cullen
Donna Kalka
Katie Sauter Messick
Michael "Murph" Murphy

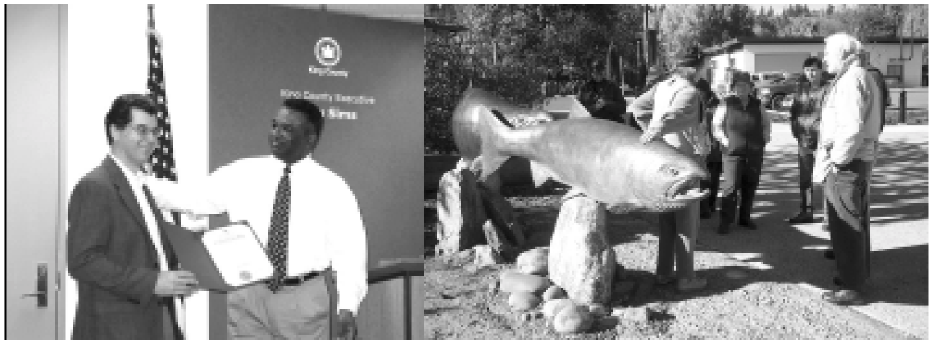
Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Figures and Tables

Figures and Tables (continued)



Executive Summary

Purpose of the Program

The Lake Stewardship Program focuses on small lakes in King County, collaborating with volunteer monitors to build a database of reliable environmental information on individual lakes and to document trends as well as unusual events or situations. The intent of this annual report is to provide citizens, scientists, managers, and other interested individuals with current information on water quality and water level fluctuations for the monitored bodies of water. The data is available for assessment purposes and for use in addressing general questions regarding characteristics of specific lakes. The information presented in the report can help with guidance of protective management and stewardship activities at participating lakes. However, the data and accompanying analysis are not detailed enough to substitute for more specific limnological studies that may be needed to produce specific management recommendations for restoration activities on particular lakes.

Monitoring Program

Two levels of participation are offered to citizen volunteers. The Level I program measures daily precipitation and water levels of the lakes, in addition to surface water temperatures, and Secchi depths. The Level II program includes the collection of water samples for laboratory analysis of total phosphorus, total nitrogen, chlorophyll *a*, and phytoplankton, as well as the measurement of water temperatures and Secchi depths.

Precipitation was just above the 50-year average in water year 2002 for the Sea-Tac weather station. Records of rainfall were kept for at least part of the year at 38 lakes, including Lake Sammamish. Of these, 23 were sufficient to estimate yearly accumulation totals. Water level data were collected for 38 lakes, of which 28 had enough data to evaluate seasonal variation and response to large-scale rainfall events. Most lakes followed a pattern of annual high winter levels, dropping through the summer to a minimum stand in early autumn, but there are several exceptions to this pattern. Many showed quick response times to large storm events in the wet season.

Water quality was rated by trophic state or degree of biological activity (Carlson 1977). Lakes were classified into three levels from low to high productivity: oligotrophic, mesotrophic and eutrophic. In 2002, all of the 48 lakes with level II monitors had sufficient data to rate their trophic states. Of these, eleven lakes were rated oligotrophic, nine were borderline oligotrophic to mesotrophic, eighteen were mesotrophic, six were borderline mesotrophic to eutrophic, and four were eutrophic. Details on each lake participating in Level II monitoring can be found in Chapters 3 through 5. While many lakes have retained the same rating over the years, there appear to be more declines in productivity than increases over the last five years, thus suggesting a possible overall gain in water quality on a countywide basis.

Detailed phytoplankton analyses were completed for the third year, adding an additional source of information to the database and providing another way to assess the health and character of the ecosystems and water quality of the monitored lakes.

Program Thanks and Outlook

We want to emphasize our gratitude for the invaluable work done by the more than 100 volunteer lake monitors. They braved the cold, rain, and winds of our climate (as well as the treat of unexpected sunshine on occasion) to measure the properties of their lakes. These volunteers deserve to have great weather whenever they go out to sample, whether we can arrange that or not!

A rough calculation of how much it would cost King County to pay staff to do all the work on lakes done by volunteer monitors is estimated to be in the range of $600,000. Thus, volunteer efforts are essential to the scope and success of this program; it simply could not be done without their hard work and dedication.

The Lake Stewardship Program at King County has undergone many changes over the past several years, and more changes may occur as King County restructures its budget and evaluates the services it provides. However, we are committed to keeping the primary goals of the program constant: to monitor as many small lakes in the county as possible within our allotted budget; to summarize all findings for use by citizens, groups and jurisdictions in planning for lake protection and stewardship; and to provide technical support and limnological advice in response to requests from as many groups and individuals as we can accommodate.

Heartfelt thanks to all our volunteers, and a happy welcome to all who would like to help out in the future.

CHAPTER 1 Introduction

Purpose of Report

This report is the eighth in a series that summarizes data collected by volunteer lake monitors annually. This volume, covering water year 2002 (October 2001 through September 2002) and extending into October 2002 for water quality measurements, provides citizens, scientists, lake managers, and other interested individuals with current information on King County lake water quality and physical conditions for lakes monitored by participating citizens.

For many lakes, these data represent the only available source of information for assessing current water quality and addressing questions regarding the characteristics of a particular lake. The information in this report may help to guide lake protection and stewardship activities in King County and can be used to suggest further work that could be done to address specific questions about a lake's conditions. These data and the accompanying analyses cannot substitute for detailed limnological studies that may be necessary to produce management recommendations and restoration plans for individual lakes.

The Lake Monitoring Program

Why Monitor?

The collection of data on lakes varies from one program to another, depending on the objectives of the program. For the King County Lake Stewardship Program, the objectives of data collection include: (1) gathering baseline data and assessing long-term trends; (2) defining seasonal and water column variability; (3) identifying potential problems, proposing possible management solutions when feasible, or pinpointing additional studies to be made; (4) educating lake residents, lake users, and policy makers regarding lake water quality and its protection; and (5) providing a foundation of knowledge that can be used for long-term stewardship of King County lakes.

Every lake is a unique body of water, reflecting the characteristics and hydrology of its watershed. Water quality is affected by the sources and relative quantity of water inflows and by the amounts and types of nutrients originating from the watershed, in particular nitrogen and phosphorus. For example, when the surface area of a lake represents a relatively large percentage of the total watershed, much of the precipitation falling in the basin goes directly into the lake, not passing first through soils, wetlands or constructed drainage systems. Thus, in this case relatively pure water makes up a significant proportion of the total input to the lake. In other cases where direct precipitation makes up a smaller proportion of the water input, land use practices throughout the watershed become very important influences on conditions as well as changes within lakes.

Water chemistry and physical characteristics in lakes vary seasonally as well as by depth at certain times of the year. The most dynamic period for lakes is during the "growing season" of mid-spring through early autumn when lake dwelling organisms are most active. To maximize information obtained for the effort, the Volunteer Monitoring Program offers two different programs: Level I monitors collect data all year on precipitation, lake level, surface water temperature, and water clarity. Level II monitors measure temperature and clarity, and also collect samples for water chemistry from May through October. Level II sampling also coincides with much of the primary recreational period for lakes in the Pacific Northwest.

Most of the more than 700 lakes and ponds in King County have never been monitored and only a few have long monitoring records. In 2002, the Lake Stewardship Program staff worked with volunteer monitors in the collection of Level I data on 38 lakes and Level II data on 48 lakes. Volunteers on 37 lakes completed five or more years of continuous water quality monitoring, thus building a solid body of information for use in the future.

During the summer, water chemistry and temperature vary with depth in most lakes. On two dates in water year 2002, Level II samples were collected from the surface, middle, and one meter above the bottom in the deepest part of the lake to define changes found in the vertical profiles of the parameters.

Water Quality

Lake Classification and Eutrophication

Lakes can be classified by measurements of potential and actual biological activity, also known as "trophic state." Lakes with high concentrations of nutrients and algae, generally accompanied by low water transparencies, are termed eutrophic or highly productive. Lakes with low concentrations of nutrients and algae, most often accompanied by high transparencies, are categorized as oligotrophic or low in productivity. Lakes intermediate between eutrophic and oligotrophic are termed mesotrophic. A commonly used index of water quality for lakes is the Trophic State Index (TSI) originally developed by Robert Carlson (1977), which separates lakes into the three categories by scoring water clarity and concentrations of phosphorus and chlorophyll *a*, relating them to a scale based on the amount of phytoplankton biovolume present. This index and its application to King County lakes are discussed further in Chapter 5.

Each lake's productivity is influenced by a variety of natural factors, including watershed size and geology, lake depth and surface area, climate, catastrophic events such as earthquakes and volcanic eruptions, and the quality and quantity of water entering and leaving the lake. Lakes may be naturally eutrophic, mesotrophic, or oligotrophic based on the original character and stability of the surrounding watershed.

Increases in a lake's biological activity over time ("eutrophication") may occur naturally in some lakes, but can be hastened by human activities in others. Natural eutrophication occurs on a time scale of hundreds to thousands of years and is generally not observable in a lifetime. At any particular point in time, lakes in a region may naturally exhibit a variety of degrees of productivity without human-induced (cultural) impacts. However, the effects of human-induced eutrophication can be seen in as little as a decade, speeding up substantially what is often a very slow natural process.

Land use activities, including home building, commercial and industrial development, agriculture, forestry, resource extraction, landscaping, gardening, and animal keeping all have the potential to contribute nutrients into surface and ground waters and change sediment movements. Increases in impervious surfaces associated with land development also result in distinct changes in surface water runoff patterns. This surface water, as it enters lakes and streams, can increase biological productivity by increasing concentrations of nutrients that stimulate plant growth. Additional sediment input associated with increased surface water runoff can also impact lakes in various other ways.

Lakes in various trophic states can also be characterized by the frequency of algal blooms and the type of algae present. Large amounts of algae can affect swimming, fishing, boating, wildlife, aesthetics, and other uses. Eutrophic lakes, for example, may have frequent nuisance algal blooms dominated by bluegreen algae (cyanobacteria). These blooms can form surface scums, give off noxious odors, and may occasionally produce toxins that have direct health impacts on animals as well as people. (See Chapter 4 for further discussion on algae commonly found in freshwater).

Excessive growth of rooted aquatic plants can also impact boating, fishing, and swimming. A lake need not be eutrophic to support a large amount of aquatic plant life. Many aquatic plants are rooted in the sediments, from which they draw nutrients. One very important factor is the depth to which light can penetrate in the lake as well as how much of the lake bottom is within that depth range. Clear lakes with large areas of shallow water can support more aquatic plant growth than deep or colored water lakes.

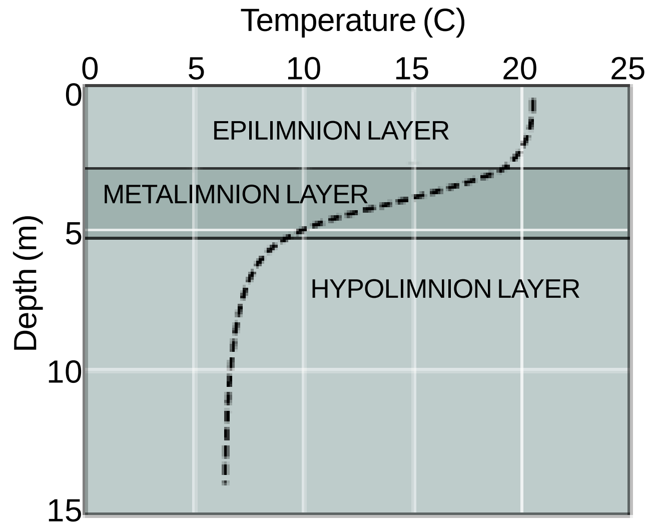


Figure 1-1: Typical Summer Temperature Profile

Seasonal Patterns in Water Quality

Lakes are complex ecosystems with many kinds of living organisms interacting with each other and their environment. External factors such as solar radiation, wind, air temperature and water inflows combine with internal forces such as evaporation rates, currents, nutrient release from sediments, nutrient uptake by algae, and plant-animal interactions to produce an intricate web of relationships.

An annual process known as thermal stratification occurs when the water column, warmed by sunshine at the surface, separates into layers divided by temperature difference (Fig. 1-1). In late fall and winter, water temperatures are essentially uniform from top to bottom and water circulates evenly through the volume of the lake. As spring begins, the surface water warms faster than heat can conduct downward through the water column. This is aided by the density differences of water at differing temperatures. Cool water is denser than warm, so it tends to remain at the bottom. Eventually, the thermal differences stabilize into three layers: the upper warm epilimnion, the lower cool hypolimnion, and the zone of rapid temperature change in between them, termed the metalimnion.

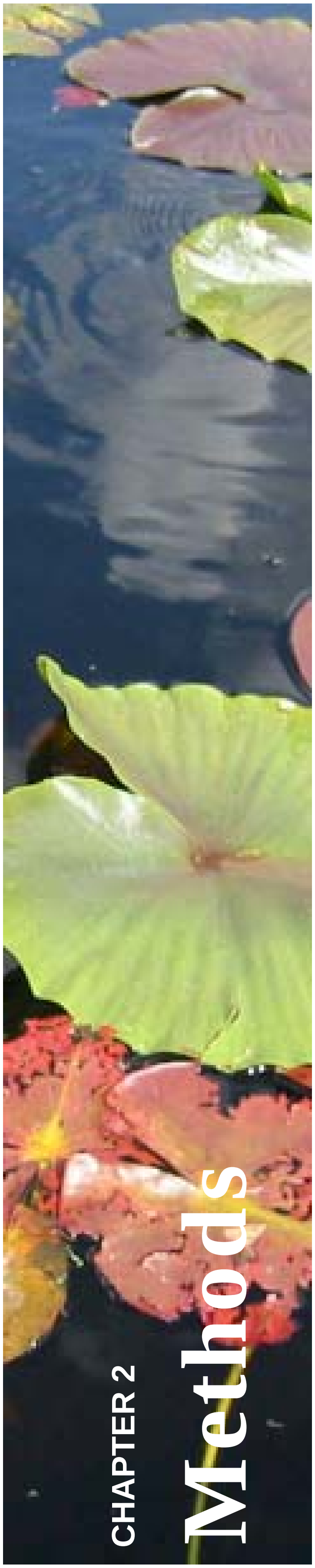
Water does not readily move across the boundaries due to the density differences, and as a result overall water chemistry changes in each layer through the summer. The changes are related to the biological activities and physical processes taking place at each level. The epilimnion stays warm, and algae continue to grow and reproduce until the nutrient supply is depleted. A hiatus in algal increase then occurs until cool air temperatures in the autumn cause the sharply defined thermal layers to begin mixing together, circulating the nutrients previously held in the hypolimnion back up to water near the surface. This sometimes stimulates an autumn burst of algal growth, but this is generally short-lived, eventually slowed down by the onset of colder weather and shorter days.

The amount of oxygen contained in the hypolimnion is affected by thermal stratification and productivity level of the lake. Oxygen enters the waters of a lake by mixing into the surface water from the air, given off as a by-product of photosynthesis by algae, and contained in water flowing into the lake. It disperses through water movements and diffusion.

Once thermal stratification is established, oxygen is no longer supplied to the hypolimnion as the lower water is cut off from contact with the atmosphere. There still is a demand for oxygen from the animals that live in deep waters such as fish, as well as from the bacterial decomposers that break down the organic material that has sunk, (e.g.: algal remains and organic detritus). If a lake is eutrophic, the algal remains will stimulate massive decomposition activity, and oxygen concentrations in the water may get very low and may even be totally used up by the bacteria before the end of summer. If this happens, it can have an enormous impact on fish such as salmonids, who need cool temperatures and prefer the safety of deep water, but who may be forced upwards by the lack of available oxygen. Warm surface water temperatures can force some fish into the depths between warm surface water and oxygen deprived bottom water. This area narrows through the summer, sometimes leading to die-offs. Heat and oxygen stressed fish are also more susceptible to disease.

Very low oxygen concentrations also have an impact on nutrient availability in future seasons. In the absence of oxygen, a chemical reaction in the sediments facilitates the release of more phosphorus back into the water column than would otherwise occur if oxygen levels remained high. This means that more phosphorus is available in the water for algal growth in the next growing season, and the lake is likely to be even more productive than before.

The Lake Stewardship Volunteer Monitoring Program has focused on the monitoring of water chemistry in the upper water layers during the growing season in order to characterize lake trophic state. As funds have allowed, additional sampling has been performed to characterize the water chemistry of the deeper lake layers. This vertical sampling has provided some data that is useful in understanding the general nutrient cycling and water column relationships in individual lakes.



CHAPTER 2
Methods

Introduction

Volunteer monitors sampled 50 lakes for the Lake Stewardship Program in water year 2002 (see Chapter 3, Table 3-1). Aside from Lake Sammamish, lakes sampled ranged in surface area from 10 acres to 279 acres and in maximum depth from seven feet to 98 feet (see Chapter 3, Table 3-2). Lake Sammamish has a maximum depth of 105 feet and a surface area of 4,893 acres. These lakes spanned all trophic classifications and degrees of urbanization in their watersheds.

The Lake Stewardship Volunteer Monitoring Program is split into two levels of data collection: Level I and Level II. The Level I participants measure precipitation, lake level, surface water temperature, and clarity (Secchi depth). The Level II participants collect water samples for water quality analysis, while also measuring water temperature and clarity.

Level I Data Collection

Level I data collection occurs daily and weekly, and is compiled by the water year which begins in October and ends in September. The water year differs from the calendar year because it is based on annual precipitation and hydrologic patterns.

In water year 2002, 38 lakes participated in the Level I program (see Chapter 3, Table 3-1). For many lakes, volunteers were able to collect data for the entire year. For several lakes, volunteers were not able to complete this commitment or were recruited later in the year, so the data are incomplete. Gaps and anomalies are noted by lake in Chapter 3 and in Appendix A.

Lake level and precipitation measurements were recorded daily by volunteers. Lake level was recorded from a gauge (a porcelain glazed aluminum metric ruler) attached permanently to a rigid dock or other fixed structure in the lake, usually near the volunteer's home. Precipitation was collected in a plastic rain gauge installed in an area exposed to direct rainfall and away from overhanging objects such as trees or buildings.

Figure 2-1: Lake locations for western King County

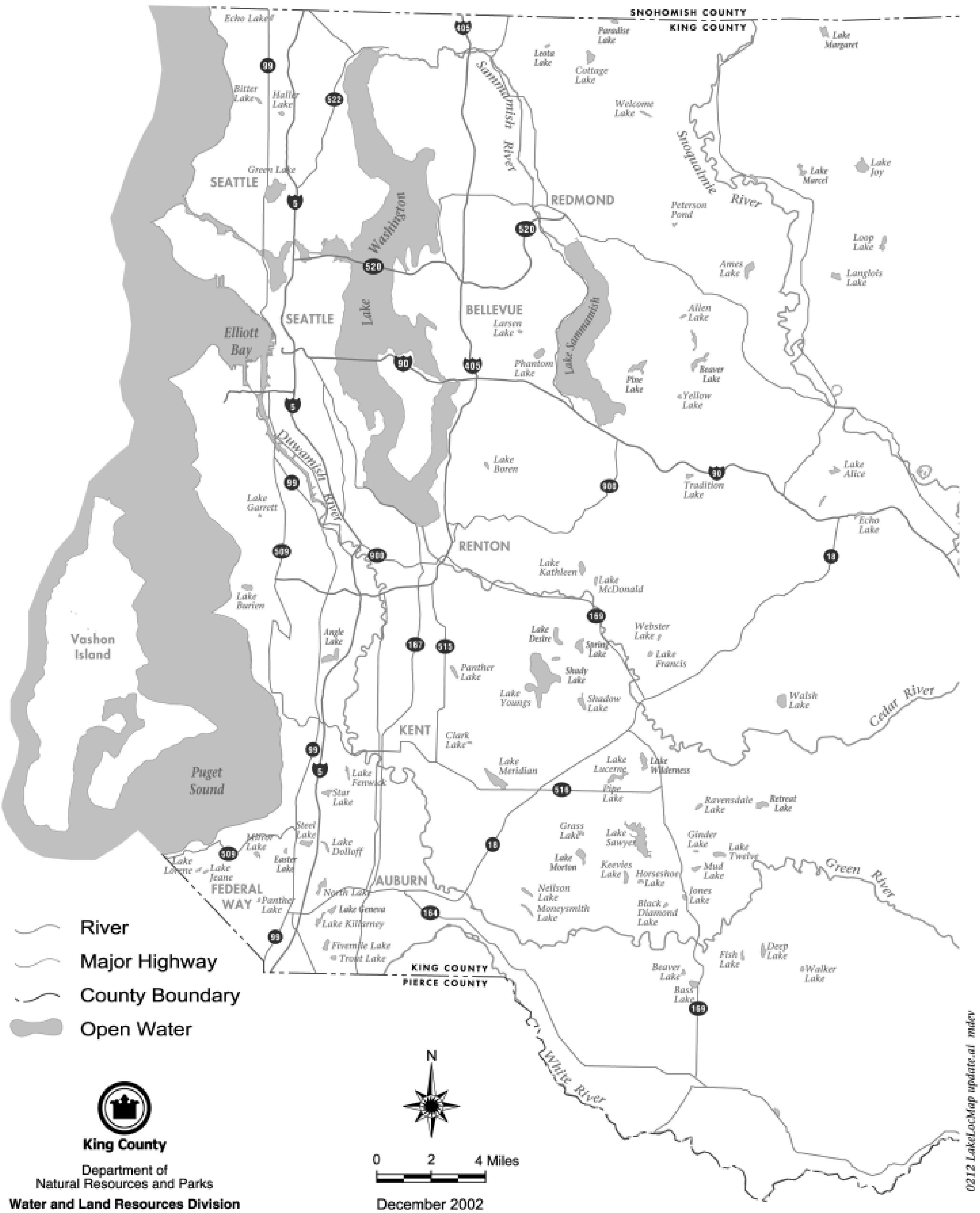


Figure 2-2: How lake samples are collected and processed

STEP 1: Sampling
Volunteer lake monitors collect observational data and water quality samples on an assigned day. They use prelabeled, clean bottles provided by the Lake Stewardship Program.

STEP 2: Pick-Up
Lake Stewardship Program staff pick up samples and data sheets from volunteers' homes and leave new bottles for the next sample date. Phytoplankton samples are preserved at the time of pick up and samples are kept cool and protected. Any unusual conditions are noted.

STEP 3: Environmental Lab Analysis
Data sheets and water samples for chemistry analysis are delivered and logged into the King County Environmental Laboratory. Sample dates and times are checked for consistency. Any unusual conditions are noted.

STEP 4:
Phytoplankton Sample Analysis
Phytoplankton samples are mailed to Water Environmental Services, Inc., a consulting group, that then identifies algae in each sample, measures cell sizes and estimates numbers. The data are summarized and sent to the county to be entered into spreadsheets for analysis and graphing. The consultant cleans the sample bottles and returns them to King County for re-use.

STEP 5: Quality Control
The lab chemistry staff follow strict protocol for sample holding times and quality assurance of chemical analysis. Staff include "blanks," "standards," and "spikes," — predetermined sample values — in all batches being analyzed to test reliability of the chemical analyses and ensure quality.

STEP 6: Data Entry & Storage
After lab analysis, all sample values are examined for consistency. Once its quality is assured, data are entered into a King County database for further analysis. The time between receiving samples and database entry is less than 30 days. Excess water samples are frozen and kept for 90 days, for further analysis as needed.

STEP 7: Data Review
Using the King County database, Lake Stewardship Program staff review data for entry errors and internal consistency on a lake-by-lake basis. Anomalies are discussed with the Environmental Lab and if necessary, samples are re-analyzed.

STEP 8: Data Reporting
At the end of the season, sample values are finalized for the year. Graphs are made of the data parameters and compared with previous years, with the results published herein. The King County Lake Monitoring Report is distributed to volunteers, libraries, scientists, government and environmental agencies and other stakeholders interested in the water quality of King County's small lakes.

Water clarity (Secchi depth) and surface water temperature were measured weekly. Secchi depth generally was measured over the lake's deepest point (Wolcott 1961, USGS 1976). The method involves lowering an eight-inch disk painted with alternating black and white quadrants over the shaded side of the boat until the disk disappears from view, then lifting it until it reappears again. The depths at each point are noted and, if different, are averaged.

Volunteers measured water temperature at the same location as Secchi depth. The method called for submerging a Celsius thermometer in the water to about one meter below the water surface for two minutes, then bringing it to the surface and reading the temperature to the nearest 0.5 degrees. Further details on Level I volunteer monitoring sampling methods are supplied in the *Lake Stewardship Program Volunteer Lake Monitor 2002 Sampling Manual* (King County 2002).

Daily data are reported by summation (precipitation) or averaged (water level) into weekly values where complete, while the parameters measured weekly are reported directly (Appendix A). All original data are available upon request to King County Water and Land Resources Division.

Level II Data Collection

Level II volunteer monitoring activities were performed every two weeks from April through October on a predetermined schedule. While water was collected at one meter depth on every sampling date, volunteers also collected deeper samples twice during the period, usually at mid-depth as well as at one meter from the lake bottom.

In water year 2002, 48 lakes participated in the Level II program (see Chapter 3, Table 3-1). For most lakes, volunteers were able to collect data for the entire period (May through October). Gaps and anomalies are noted by lake in both Chapter 3 and Appendix B.

Volunteers anchored at a specified location, generally over the lake's deepest point. For each date, volunteers recorded the time and weather, adding observations on unusual conditions or activities on the lake. Secchi depth was measured using the same methods as described for Level I. Water samples were collected using a Van Dorn vertical water sampler at one meter. Temperature was read from a thermometer installed inside the sampler, after which water was saved in special containers for further analysis, generally for total phosphorus, total nitrogen, chlorophyll *a*, and phytoplankton. On two dates, an additional small amount of water was collected for water color and pH analyses.

On dates where vertical profiles were sampled, samples were taken at one meter, mid-depth, and one meter from the lake bottom. Temperature was measured at each depth using the thermometer mounted inside the sampler, and water samples for total phosphorus and total nitrogen were collected at all three depths. Chlorophyll *a* and phytoplankton analyses were collected for the one meter and mid-depth samples only.

The water samples were analyzed at the King County Environmental Laboratory for total phosphorus, total nitrogen, and chlorophyll *a*, using standard protocols and quality assurance and quality control procedures. Phytoplankton (algae) identifications and enumerations were carried out by a private consultant to the Lake Stewardship Program.

Physical and chemical values for each date are detailed in Appendix B. Phytoplankton data for individual dates are available upon request. Further details on Level II volunteer monitoring sampling methods are described in the *Lake Stewardship Program Volunteer Lake Monitor 2002 Sampling Manual* (King County 2002).

Data Analysis

Minimum, maximum, and average values for temperature and Secchi depth were determined for the Level I volunteer monitoring data (Appendix A). Annual lake level range and total precipitation were determined for each participating lake with complete data sets. The data are illustrated in charts for each individual lake (Chapter 3).

For Level II water quality measurements, the minimum, maximum, and average values were determined for the sampling period (Appendix B). The values found throughout the sample season are charted for each lake, with total nitrogen and total phosphorus on the same chart for comparison (Chapter 3).

The Trophic State Index or TSI (Carlson 1977) and the nitrogen to phosphorus ratios were calculated for Level II volunteer monitoring data. TSI values are derived from a regression that compares values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to the algal biovolume of a suite of lakes and assigns a number from a scale of 0 to 100 based on the relationships found. This scale can be used to compare water quality over time and between lakes (see discussion in Chapters 1 and 5). If nutrient limitation of algal growth is likely to occur, the nitrogen to phosphorus ratio may be used to identify the nutrient that is in shortest supply. Generally lakes with an N:P ratio of less than 20 may be experiencing limitations by both nitrogen and phosphorus at times during the growing season. The results of these analyses for the lakes are presented in both Chapter 3 and Chapter 5.