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WATER QUALITY SURVEY OF 15 "VOLUNTEER-MONITORED" LAKES IN WASHINGTON STATE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

A 15 lake subset of the 90 "volunteer-monitored" lakes were sampled in June and September 1990 for conventional water quality parameters to assess each lake's current trophic status. Carlson's trophic state index (TSI) was used in the determination. This method yielded TSI values ranging from 31 to 63, 24 to 75, and 26 to 61 based on Secchi disc transparency, epilimnetic total phosphorus and epilimnetic chlorophyll-*a*, respectively. Eight of the 15 lakes had dissimilar TSI values based on the three index parameters. When TSI values were not similar, or there were anomalies based on other trophic state indicators, all factors were used for trophic state determination. Six lakes were classified oligotrophic to oligo-mesotrophic, three lakes were mesotrophic to meso-eutrophic and six lakes were eutrophic.

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INTRODUCTION

Most of Washington's natural lakes and drainage basins were formed during the glacial period (Goldman and Horne, 1983), and for that reason are roughly the same geologic age. Lakes begin oligotrophic, or low in nutrients and productivity. Additive nutrient inputs eventually create lakes that are eutrophic or high in nutrients and productivity. Eutrophication is a natural process in the life cycle of a lake. It happens at different speeds, depending on the rate nutrients are loaded. Cultural eutrophication is an acceleration of this natural process. People, through their use of land and water, increase rates of nutrient inputs. Washington's population growth and land-use changes have increased pressures on our lakes and have raised the potential for water quality deterioration.

The Washington State Lakes and Reservoir Water Quality Assessment Program began in 1989. This program is coordinated by the Ambient Monitoring Section of the Department of Ecology. It was developed to identify threatened lakes. The 1989 program consisted of three components: a volunteer lake monitoring program, a conventional parameter water quality study and a toxics study. The 1989 conventional parameter study (Brower and Kendra, 1990) surveyed 25 volunteer-monitored lakes. The toxics study (Johnson and Norton, 1990) surveyed chemical contaminants in fish tissue and sediments from 10 Washington lakes.

The 1990 program consists of 2 components: continuation of the volunteer lake monitoring program, and a conventional parameter water quality study of 15 of the volunteer-monitored lakes. Study objectives, lake selection criteria, and methods for the conventional parameter study were the same as the 1989 survey by Brower and Kendra (1990), excluding proximity to acid rain monitoring sites as a criterion for lake selection. This report completes the conventional water quality component for the 1990 program.

OBJECTIVES

The objectives of this study were to:

- Determine the trophic status of 15 publicly owned lakes.
- Assess the water quality of each lake.
- Provide assessment information needed to prioritize lake restoration activities.
- Provide assessment information to be incorporated into the 305(b) Statewide Water Quality Assessment.
- Validate results from the volunteer lake monitoring program.

LAKE SELECTION

An effort was made to represent lakes with varying size, depth, altitude, and geographic distribution. Priority selection was given to lakes based on the following criteria:

- Had not been studied or assessed within the last five years.
- Recreational importance.
- Organized public interest groups, such as lake associations, citizen volunteers, etc.
- Expressed interest by state and local water quality managers.
- Need of additional information for statewide assessment reports.

METHODS

Conventional water quality parameters were sampled at one site per lake, once in June, and again in September. Sampling was designed to characterize water quality prior to summer stratification (or as close to stratification as possible) and before fall turnover. Lakes were accessed by motor boat or john boat.

A Hydrolab Surveyor II water quality monitor was used to measure conductivity, dissolved oxygen, pH and temperature at 1-5 meter intervals from surface to bottom. Other field measurements included light transmission, measured with a Kahlsico irradiameter and Secchi disc transparency. Water column sampling occurred over the point of maximum depth. An exception was Davis Lake in June due to the inability to hold position in high winds, thus samples were taken adrift. Maximum depth was confirmed by echo sounding. Aeneas Lake, Leech Lake, Nunnally Lake, and Lake Kahlotus (September only), were accessed by john boat not equipped with echo sounding equipment. Depth at these lakes were confirmed by Hydrolab measurements.

Parametric coverage and analytical methodology are presented in Table 1. Representative samples of both the epilimnion and hypolimnion were taken from stratified lakes using a Kemmerer discrete sampler and composited individually. Stratification was determined in the field using the Hydrolab temperature profile. Samples collected from unstratified lakes were reported as epilimnetic concentrations. They were actually representative of the whole water column. Water color, estimated lakeside development, weather conditions and drainage basin anomalies were noted in field logs.

A cursory survey was made of aquatic macrophytes at each lake. Samples were collected, bagged, and kept on ice prior to identification. Macrophytes were identified using Hitchcock and Cronquist (1973), Tarver *et al.*, (1978) and Prescott (1980). Results are qualitative and not necessarily inclusive of all species present. Volunteer-monitor information supplemented macrophyte data in some cases.

Sub-surface algal samples were collected when blooms were observed or suspected. Samples were placed on ice in the field and refrigerated until identification was made using Smith (1950), Edmondson (1959) and Prescott (1962; 1978) as reference. Again, results are qualitative and not necessarily inclusive of all species present.

Water samples for laboratory analysis were placed on ice and shipped to Turnbull Ecological Laboratory at Eastern Washington University. Samples were received at the lab within 24 hours of collection, except for June samples from Big and Flowing Lakes, which were 2 days late due to bus delays. If analytical holding times were not met, samples were either not run or flagged in individual lake summaries. All sampling and analytical protocols conformed to standard procedures and methods of EPA (1983) and APHA *et al.*, (1985).

Table 1. Parametric Coverage and Analytical Methodology for Conventional Water Quality Monitoring in 15 Washington Lakes.

Location	Parameter	Method Reference	Analytical Method
Surface -to- Bottom Profile	Temperature	--	Hydrolab Surveyor II
	pH	--	" "
	Conductivity	--	" "
	Dissolved oxygen	--	" "
	Light transmission	--	Irradiameter
	Secchi disc transparency	--	Secchi disc
Sub-surface Grab	Fecal coliform bacteria	SM-909C	Membrane Filter
Epilimnion Composite	Chlorophyll-*a*	SM-1002G	Trichromatic
	Turbidity	SM-214A	Nephelometer
Epilimnion and Hypolimnion Composites	Ammonia-N	SM-417C	Phenate
	Nitrate+Nitrite-N	SM-418C	Cadmium Reduction
	Total Nitrogen-N	D'Elia *et al.* 1977	Persulfate Digestion, Cadmium Reduction
	Orthophosphate-P	SM-424F	Ascorbic Acid
	Total Phosphorus-P	EPA-365.3	Persulfate Digestion, Ascorbic Acid

SM = APHA *et al.*, (1985)
D'Elia = D'Elia *et al.*, (1977)
EPA = EPA (1983)

QUALITY ASSURANCE

EPA standard reference materials (SRMs), lab check standards, field replicates, lab duplicates, matrix spikes, and lab blanks were routinely analyzed to assess sampling and analytical variability.

SRMs and lab check standards are samples with known concentrations with which results can be compared. This makes these data the most valuable quality control test for overall accuracy. Results of SRMs and lab check standards are contained in Appendix A.

SRMs WP987 and WP1188 were analyzed as a portion of the normal sample shipment. They have a certified nutrient concentration which was intended to fall within the expected ranges for lakes in the study. Results from SRMs compared well with certified values and were all within the 95 percent confidence interval. Lab check standards are internal lab standards used to verify calibration of analysis. Mean values from lab check standards were also in agreement with known concentrations.

Thirteen percent of the water quality samples from all lakes were replicated to assess field and sampling variability. Replicate pairs were compared by determining the relative percent difference (RPD), defined as the difference between two numbers, divided by their mean. Results are expressed in Figure 1 using box plots and the total data set is provided in Appendix B.

Box plots are used to graphically illustrate the distribution of a series of data points from a ranked set of data. The example at the top of Figure 1 provides a key to interpreting box plots.

RPD's for water quality parameters, in general were within acceptable limits. Two exceptions were pairs of ammonia and total nitrogen field replicates from Waitts Lake in September. The high RPD for the total nitrogen replicate is in part a result of ammonia variability. Ammonia exhibited higher variability than other constituents. Data for this parameter should therefore be considered less accurate. The appearance of high RPD's for some parameters in Figure 1 were largely an artifact of sample concentrations being near detection limits.

Routine comparisons of Hydrolab Surveyor II data to reference standards and independent instruments were also made. Hydrolab data were considered acceptable. Differences between Hydrolab pH values and standard buffer solution values never exceeded 0.2 units. Hydrolab dissolved oxygen values were not significantly different ($P < 0.05$) than values from azide-modified Winkler titrations, and differences were never greater than 0.2 mg/L. RPD for conductivity was never greater than 1.4 percent as verified by a reference standard. Pre and post calibration was performed prior to and after each sampling week, in addition to daily calibration checks. Comparison data are contained in Appendix C.

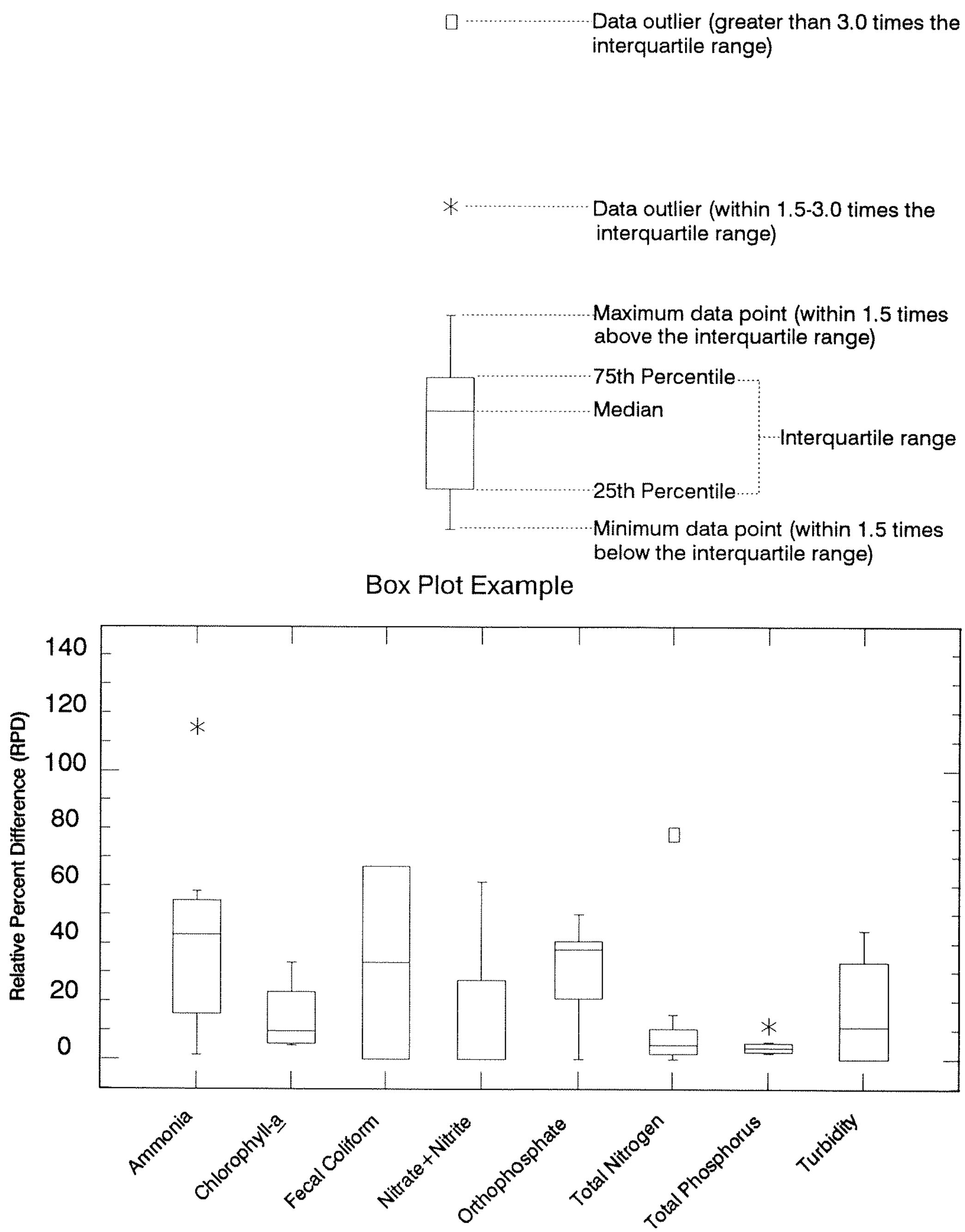


Figure 1. Comparison of field replicate samples taken from 15 Washington lakes in June and September, 1990.

SUMMARY

Summary of Trophic State Index

The traditional terms oligotrophic, mesotrophic and eutrophic are ambiguous and relate to a lake's nutrient content and productivity. In lake management these terms have questionable significance and are inadequate for management decisions. It has been argued that a quantitative classification is necessary to manage lakes effectively, determine their recreational potential, estimate their sensitivity to degradation and determine needs for restoration based on trophic indices (Shapiro, 1975). A numerical scale developed by Carlson (1977) to establish trophic classifications for Minnesota lakes has found broad geographical applicability. It was developed to communicate more effectively to the public, the current status and future condition (after restoration) of lakes. His system, called a trophic state index (TSI), both defines and determines trophic status in lakes.

Carlson's index ranges numerically from 0 to 100, although greater values are possible. The complete scale and associated parameters are included in Table 2. The 0 point on the scale is equal to a Secchi disc depth (SD) of 64 m, while an index value of 100 corresponds to a SD reading of 6.4 cm. Each 10 unit increase in TSI reflects a halving of Secchi disc depth. Lakes with higher TSI values are considered more eutrophic than lakes with lower values. In addition to TSI_{SD}, two other TSI's were developed by regression of Secchi disc against epilimnetic chlorophyll-*a* and total phosphorus data.

Carlson's (1977) TSI values are calculated from Secchi disc depth, epilimnetic total phosphorus and chlorophyll-*a* as follows:

$$TSI_{SD} = 10\left(6 - \frac{\ln SD}{0.693}\right)$$

$$TSI_{TP} = 10\left(6 - \frac{\ln \frac{48}{TP}}{0.693}\right)$$

$$TSI_{Chl} = 10\left(\frac{6 - 2.04 - 0.68 \ln Chl}{0.693}\right)$$

where SD = Secchi disc depth, in meters

TP = total phosphorus concentration of epilimnion, in μg-P/L (micrograms of phosphorus per liter), and

Chl = chlorophyll-*a* concentration of epilimnion, in μg chl-*a*/L (micrograms of chlorophyll-*a* per liter).

Ideally, all index parameters should predict the same trophic state, however this is not always the case. In this study, 8 of 15 lakes had some divergence. It has been pointed out that dissimilar TSI values don't necessarily mean index values are wrong, but may indicate certain facts about an individual lake's behavior (Shapiro, 1975). For example, if TSI_{TP} is higher than TSI_{Chl} or TSI_{SD}, it may indicate the lake is not phosphorus limited, or that algal populations may have been reduced by grazing of herbivorous zooplankton or outcompeted by dense macrophyte growth. It should be noted that the TSI is only an index. For the purpose of classification, Carlson (1977) suggests priority be given to TSI_{Chl} in summer and TSI_{TP} during the remaining seasons. These priorities should result in about the same TSI for all times of the year. TSI values for the 15 lakes from this study are contained in Figure 2, Table 3 and the individual lake data sheets in the Results and Discussion section.

Table 2. Trophic State Index (TSI) and Associated Parameters (Carlson, 1977).

TSI	Secchi disc (m)	Epilimnetic phosphorus (μg/L)	Epilimnetic Chlorophyll-*a* (μg/L)
0	64	0.7	0.04
10	32	1.5	0.12
20	16	3	0.34
30	8	6	0.94
40	4	12	2.6
50	2	24	6.4
60	1	48	20
70	0.5	96	56
80	0.25	192	154
90	0.12	384	427
100	0.06	768	1,183

To compare TSI values with traditional lake classifications, Carlson (1979) suggests limits on TSI values that correspond to the terms "oligotrophic" and "eutrophic". He took an average of the trophic limit values suggested by several authors, and found a TSI of 41 as the upper limit of oligotrophy and a TSI value of 51 as the lower limit of eutrophy. These values should however be considered only an estimate of the likely trophic levels of individual lakes.

A disadvantage to Carlson's index is the use of phytoplankton biomass (as measured by chlorophyll-*a*) as a single priority index during summer. This raises questions in situations where a lake exhibits a dense macrophyte and/or periphyton growth, but low phytoplankton population. This would lead to a misclassification of a less eutrophic state. However, this disadvantage is overshadowed by the method's simplicity; its ability to use historical data, small data sets and volunteer-monitor data; and its value as a lake management tool. There are also

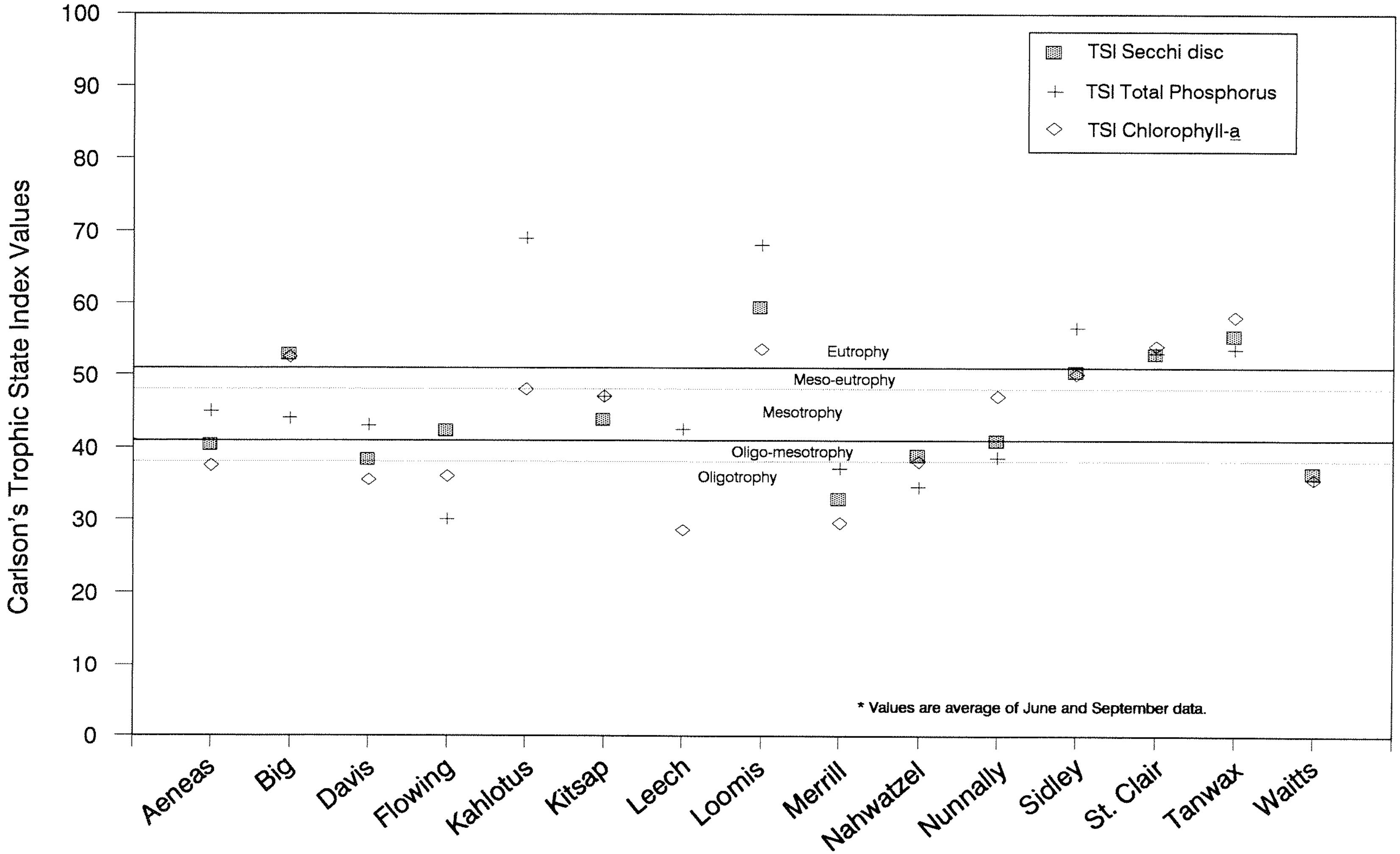


Figure 2. Classification of 15 Washington lakes based on Carlson's (1977) Trophic State Index.

Table 3. Trophic State Index (TSI) Values for 15 Washington Lakes.

	Spring			Fall			
Lake(County)	TSI SD	TSI TP	TSI Chl	TSI SD	TSI TP	TSI Chl	Trophic State
Aeneas (Okanogan)	35	40	27	46	50	48	Oligo-mesotrophic■
Big (Skagit)	57	32	50	49	56	55	Eutrophic
Davis (Pend Oreille)	42	44	41	35	42	30	Oligotrophic
Flowing (Snohomish)	44	24	33	41	36	39	Oligotrophic
Kahlotus (Franklin)	♦	63	44	♦	75	52	Eutrophic■
Kitsap (Kitsap)	37	40	43	51	54	51	Mesotrophic
Leech (Yakima)	♦	36	26	♦	49	31	Mesotrophic■
Loomis (Pacific)	56	62	46	63	74	61	Eutrophic
Merrill (Cowlitz)	35	37	31	31	37	28	Oligotrophic
Nahwatzel (Mason)	39	32	38	39	37	38	Oligo-mesotrophic■
Nunnally (Grant)	48	34	52	34	43	42	Mesotrophic
Sidley (Okanogan)	44	54	43	57	59	57	Eutrophic■
St. Clair (Thurston)	54	55	55	52	51	53	Eutrophic
Tanwax (Pierce)	56	53	57	55	54	59	Eutrophic
Waitts (Stevens)	39	37	36	31	34	35	Oligo-mesotrophic■

■ Explanation of inconsistent trophic classification contained in individual lake summaries under Results and Discussion.

♦ Secchi disc was visible to the lake bottom.

weaknesses associated with assessments based on small data sets. As in this survey, a trophic status determination based on one June and one September sample could be misleading due to levels of chlorophyll-*a* varying greatly throughout the growing season. Obviously, the larger the data set the greater degree of confidence one would have in the results. This should not however, minimize the usefulness of assessments based on Carlson's TSI.

General Summary

Nutrients, chlorophyll-*a*, fecal coliform, turbidity, Secchi disc, and conductivity from all lakes were ranked for comparison. Ranking was done by giving the lake with the highest value a one, second highest a two, and so on. It is a relative system that compares individual lakes to other lakes within the survey. In general, the lower the ranking number the more eutrophic the lake is. An exception is specific conductance, which measures the ability of a solution to carry an electrical current. The higher the specific conductance the better the solution is at conducting electricity. Secchi disc is also a special case where high values indicate high transparency, which in turn indicates a less productive or eutrophic lake. Table 4a ranks data from June and 4b ranks data from September. Secchi disc ranking was reversed in the tables to be consistent with other parameters (i.e. the lower the ranking number, the more eutrophic the water may be). Secchi disc measurements from June and September were not included in the ranking from Kahlotus and Leech Lakes due to a lack of water column depth. Three June orthophosphate values (St. Clair, Nunnally, and Kitsap Lakes) and one September (Merrill Lake) were excluded from all tables. This was due to orthophosphate concentrations exceeding corresponding total phosphorus concentrations. Orthophosphate is a fraction of the total phosphorus determination. Significant findings from the ranking system are discussed in the individual lake results.

Nitrogen and phosphorus are nutrients that are needed for growth of algae. Algae can have many effects on a lake's character. In lake management nitrogen and phosphorus are of primary significance because they are considered the most important growth limiting nutrients to plants (i.e. they are in the least supply compared to demand). Within the data tables of the individual lake summaries is a reference to the nitrogen/phosphorus ratio (TN:TP). This number is an indicator of the nutrient that is most limiting to algal growth. Freshwater habitats are generally thought to be nitrogen limited when the TN:TP ratio is less than 10:1 and phosphorus limited when the TN:TP ratio is greater than 17:1. When the TN:TP ratio is between 10:1 and 17:1 nitrogen and/or phosphorus may be limiting to growth (Forsberg, 1980). There is some debate as to where to set these limits, but these are generally accepted by most investigators.

The results of nutrient determinations are summarized in Table 5. Results of epilimnetic and hypolimnetic composites for each lake are contained in the individual lake results.

Physical characteristics of a lake and its surrounding area can have a significant influence on the lake's trophic state. Physical data for each lake is included within the individual lake summaries. Survey design included lakes with various sizes, depths, altitudes, and geographic distribution. Surveyed lakes ranged in size from 41 acres (Leech Lake) to 520 acres (Big Lake). The remaining 13 lakes were between 60 and 490 acres.

Mean depths (calculated by dividing a lake's volume by its area) ranged from 5 feet (Loomis Lake) to 83 feet (Davis Lake). Eight lakes had a mean depth of less than 20 feet. Five lakes

Table 4a. Comparative Ranking of Chemical and Physical Parameters for 15 Washington Lakes in June 1990. Highest value is ranked one. Values with the same rank are equal.

Lake (County)	Total Nitrogen E	Total Nitrogen H	Orthophos-phate-P E	Orthophos-phate-P H	Total Phosphorus E	Total Phosphorus H	Nitrate+ Nitrite E	Nitrate+ Nitrite H	Ammo-nia-N E	Ammo-nia-N H	Turbi-dity E	Chloro-phyll-*a* E	Fecal Coliform (Surface)	Secchi Disc■	Specific Conductance
Aeneas (Okanogan)	10	4	7	2	7	2	8	9	9	1	10	14	7	9	4
Big (Skagit)	5	7	-	-	11	10	2	1	4	4	1	4	3	1	10
Davis (Pend Oreille)	11	12	4	8	6	12	4	4	10	11	7	9	1	6	9
Flowing (Snohomish)	7	10	-	-	12	8	1	2	2	5	5	12	7	5	12
Kahlotus (Franklin)	1	2	1	5	1	5	6	6	7	14	6	6	7	-	2
Kitsap (Kitsap)	12	11	-	7	7	11	8	9	6	7	7	7	7	8	8
Leech (Yakima)	14	14	6	9	9	12	8	7	5	12	9	15	7	-	13
Loomis (Pacific)	9	8	2	6	2	6	8	9	4	10	3	5	6	2	6
Merrill (Cowlitz)	15	15	6	11	8	13	8	8	6	8	8	13	7	9	14
Nahwatzel (Mason)	13	13	5	9	11	12	8	9	3	9	7	10	5	7	15
Nunnally (Grant)	6	9	-	-	10	9	5	5	7	6	5	3	7	4	3
Sidley (Okanogan)	2	3	6	10	4	7	8	9	8	13	8	8	6	5	1
St. Clair (Thurston)	3	1	-	1	3	1	3	3	1	-	2	2	2	3	7
Tanwax (Pierce)	4	6	3	3	5	3	8	9	3	3	4	1	4	2	11
Waitts (Stevens)	8	5	5	4	8	4	7	8	11	2	8	11	7	7	5
Range	15	15	7	11	12	13	8	9	11	14	10	15	7	9	15

■ Secchi disc ranking is arranged in reverse order to be consistent with other parameters.
"E" Epilimnion composite.
"H" Hypolimnion composite.
"-" No data.

Table 4b. Comparative Ranking of Chemical and Physical Parameters for 15 Washington Lakes in September 1990. Highest value is ranked one. Values with the same rank are equal.

Lake (County)	Total Nitrogen E	Total Nitrogen H	Ortho-phosphate-P E	Ortho-phosphate-P H	Total Phosphorus E	Total Phosphorus H	Nitrate+ Nitrite E	Nitrate+ Nitrite H	Ammo-nia-N E	Ammo-nia-N H	Turbi-dity E	Chloro-phyll-*a* E	Fecal Coliform (Surface)	Secchi Disc■	Specific Conductance
Aeneas (Okanogan)	7	2	12	1	7	1	6	5	9	1	7	8	5	7	3
Big (Skagit)	11	-	10	-	4	-	4	-	6	-	2	4	5	6	10
Davis (Pend Oreille)	13	6	9	4	10	7	6	3	11	6	11	14	5	10	9
Flowing (Snohomish)	9	5	13	5	12	6	6	2	10	4	10	10	2	8	13
Kahlotus (Franklin)	1	-	2	-	1	-	6	-	6	-	5	6	5	-	2
Kitsap (Kitsap)	10	-	7	-	5	-	6	-	7	-	8	7	4	5	8
Leech (Yakima)	12	-	8	-	8	-	5	-	6	-	11	13	5	-	12
Loomis (Pacific)	3	-	1	-	2	-	2	-	5	-	1	1	3	1	6
Merrill (Cowlitz)	15	7	-	5	11	5	6	4	12	7	12	15	5	12	14
Nahwatzel (Mason)	14	-	13	-	11	-	6	-	9	-	11	11	4	9	15
Nunnally (Grant)	6	-	5	-	9	-	1	-	2	-	9	9	5	11	4
Sidley (Okanogan)	2	-	3	-	3	-	6	-	4	2	4	3	4	2	1
St. Clair (Thurston)	5	1	4	2	6	2	3	1	1	-	6	5	2	4	7
Tanwax (Pierce)	4	4	6	3	5	4	6	5	3	5	3	2	1	3	11
Waitts (Stevens)	8	3	11	3	13	3	6	5	8	3	12	12	5	12	5
Range	15	7	13	5	13	7	6	5	12	7	12	15	5	12	15

■ Secchi disc ranking is arranged in reverse order to be consistent with other parameters.
"E" Epilimnion composite.
"H" Hypolimnion composite.
"-" No data (Epilimnion concentrations represent whole lake. See Methods Section).

Table 5. Summary Statistics for Nutrients from 15 Washington Lakes in June and September 1990.

Parameter (units mg/L)	June Range	June Mean*	June SD	September■ Range	September■ Mean	September■ SD
Ammonia N						
Epilimnion	<0.003 - 0.034	0.012 ±	0.008	<0.003 - 0.036	0.013 ±	0.010
Hypolimnion	0.005 - 0.719	0.12 ±	0.23	0.016 - 1.130	0.30 ±	1.43
Nitrate+Nitrite N						
Epilimnion	<0.006 - 0.230	0.041 ±	0.078	<0.006 - 0.332	0.043 ±	0.100
Hypolimnion	<0.006 - 0.290	0.058 ±	0.100	<0.006 - 0.351	0.090 ±	0.140
Total Nitrogen						
Epilimnion	0.048 - 2.110	0.53 ±	0.55	0.120 - 2.740	0.68 ±	0.70
Hypolimnion	0.059 - 4.000	0.89 ±	1.03	0.080 - 1.570	0.78 ±	0.62
Orthophosphate						
Epilimnion	0.002 - 0.035	0.010 ±	0.011	0.004 - 0.054	0.015 ±	0.014
Hypolimnion	0.002 - 1.187	0.14 ±	0.33	0.006 - 0.336	0.090 ±	0.130
Total Phosphorus						
Epilimnion	0.004 - 0.061	0.020 ±	0.018	0.008 - 0.140	0.037 ±	0.042
Hypolimnion	0.007 - 1.330	0.14 ±	0.33	0.008 - 0.370	0.10 ±	0.14

* Values that were undetected were assumed to equal one half the method detection limit.
■ September hypolimnion calculations were based on 7 samples.

had mean depths from 20 to 40 feet. Maximum depths ranged from 7.5 feet (Leech Lake) to 150 feet (Davis Lake).

Lake elevations ranged from 17 feet (Loomis Lake) to 4,412 feet (Leech Lake). In general, lakes east of the Cascade range are at higher elevations than those west. Lakes west of the Cascades ranged from 17 feet (Loomis Lake) to 1,541 feet (Merrill Lake). Lakes east of the Cascades ranged from 530 feet (Nunnally Lake) to 3,660 feet (Sidley Lake). Leech Lake at 4,412 feet is located at the crest of White Pass in the Cascades. Sixty percent of the lakes were below 1,000 feet in elevation.

Ecoregions are geographic areas that are similar in land surface form, potential natural vegetation, land use, and soils (Omernik *et al.*, 1986). Eight ecoregions have been identified within Washington State, five of them are represented in this study. Distribution of survey lakes by ecoregion is shown in Figure 3.

Human activity accelerates the natural process of eutrophication. How land is used around a lake and within the drainage basin has direct and indirect impacts on the lake's trophic state. Data on residential development and land use were taken from Department of Ecology publications by Bortleson *et al.*, (1976a,b,c,d), Dion *et al.*, (1976a,b,c) and Sumioka and Dion (1985), to give an idea of the likelihood of nutrient loading and provide a means for comparison between lakes. Residential development of the shoreline ranged from 0 (Kahlotus and Leech Lakes) to 70 and 75 percent (Tanwax and Kitsap Lakes, respectively). Eight lakes had 0 to 49 percent development and seven lakes had 50 to 75 percent of the shoreline developed.

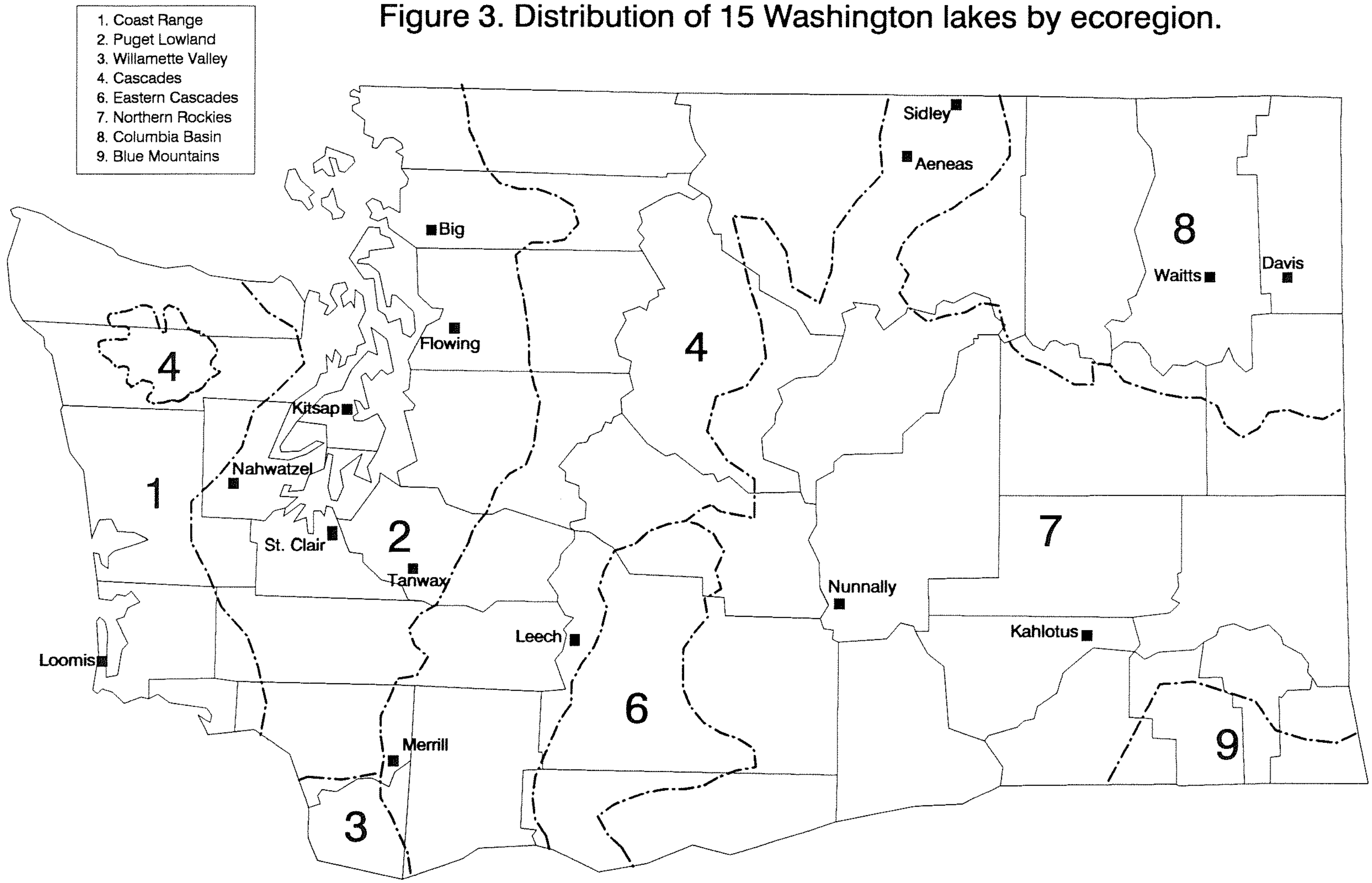
Residential development within drainage basins ranged from 0 (Leech and Sidley Lakes) to 19 percent (Flowing Lake). Eight lakes had less than 1 percent, five lakes had from 1 to 10 percent, and two lakes had between 11 and 19 percent of their drainage basins developed.

Forest or unproductive land use within drainages ranged from 0 to 95 percent. This land use type includes public and private forest lands, tree farms, cleared or fallow non-producing land, meadows, wetlands and recreational areas (Sumioka and Dion, 1985). Eleven catchments had more than 50 percent of this land use type, with four of them greater than 90 percent. Davis (95%), Merrill (92%), and Nahwatzel (91%) Lakes had the highest amount of forest or unproductive land within their drainages. Although no data was available for Leech Lake, it would also be expected to have a very high percent forest. Ten lakes had agricultural land use (pasture or cropland) within their drainages, with four in excess of 50 percent. Kahlotus (100%), Nunnally (96%) and Aeneas (78%) Lakes had the highest amount of agriculture within their drainages.

Lake Specific Summary

The following lake reports contain a brief summary of findings, followed by a table of water quality data from epilimnion and hypolimnion regions which includes TSI values. It should be noted that near-bottom samples were taken in June even when stratification was not obvious.

Figure 3. Distribution of 15 Washington lakes by ecoregion.



Ecoregions After Omernick, J.M. and A.L. Gallant, 1986.

In September, epilimnion samples were used to represent whole water column concentrations in lakes that were not stratified.

The summaries also include a bathymetric map of each lake with water sampling locations noted. An exception is Leech Lake, which has a digitized outline from a United States Geological Survey (USGS) 7.5 minute map and an approximate depth based on field observations. Bathymetric maps were taken from Wolcott, (1973a,b), Bortleson *et al.*, (1976a,b,c,d), Dion *et al.*, (1976a,b,c) and Sumioka and Dion (1985). They are Washington Department of Game and USGS maps from the 1940's, 50's, 60's, and 70's. Maps were found to be generally accurate based on field measurements. Kahlotus Lake was an exception; it was redrawn using field measurements taken in 1990. Four graphs representing water column data for temperature, dissolved oxygen, pH, and percent light transmission accompany each lake report. The complete set of data for water column measurements is contained in Appendix D.

RESULTS AND DISCUSSION

AENEAS LAKE - OKANOGAN COUNTY

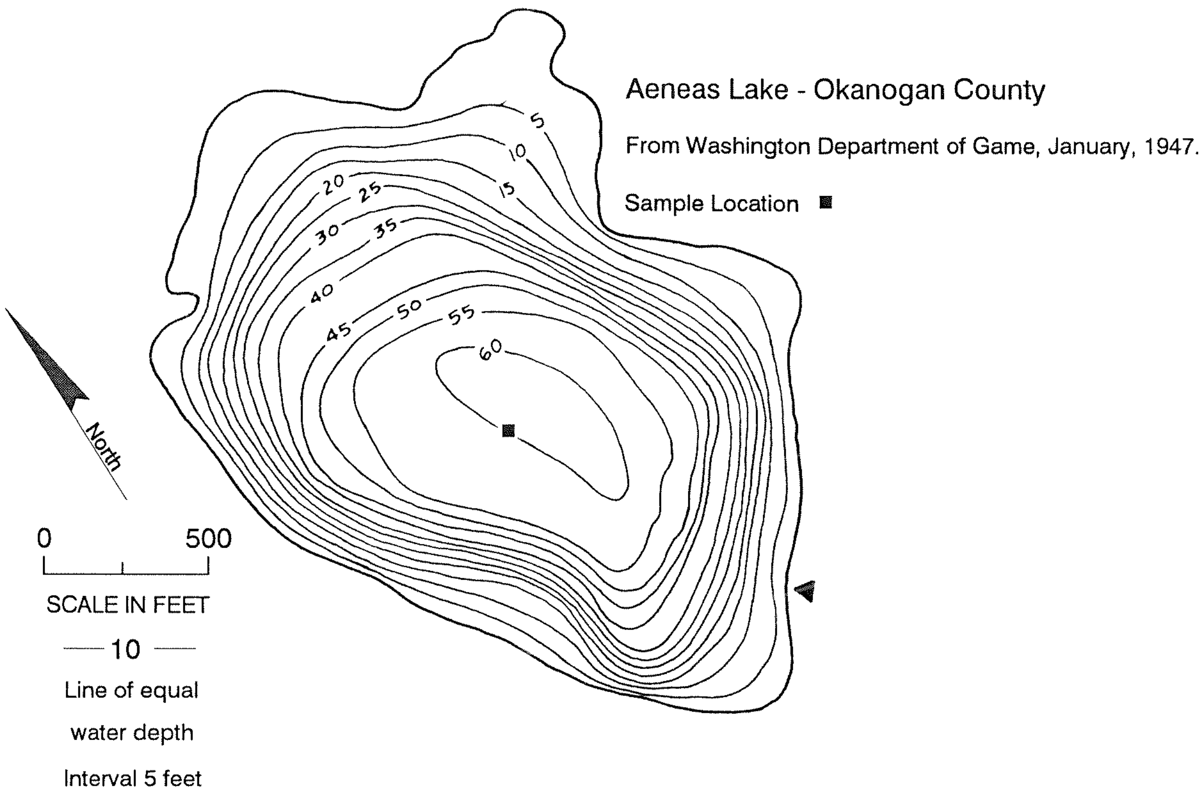
Aeneas Lake is located 3.7 miles southwest of Tonasket, Washington, within the Okanogan River Basin. It was one of the smallest lakes studied, covering 62 acres and draining 32.4 square miles. Aeneas has a mean depth of 29 feet and a maximum depth of 62 feet. Inflow is intermittent from Horse Springs Coulee and there is no visual outflow. There is very little residential development on the lake. Land use in the drainage basin is dominated by agriculture.

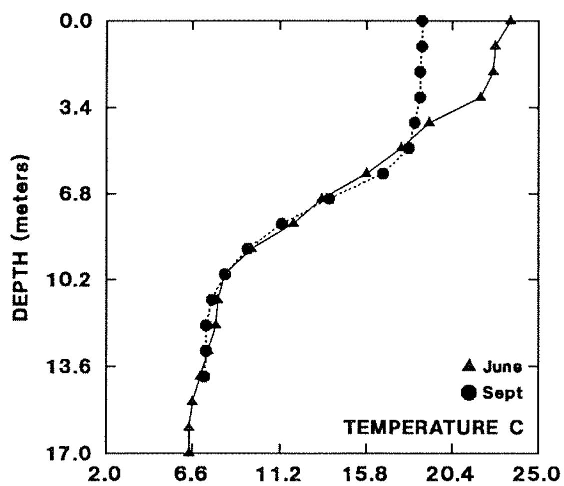
The chlorophyll-*a* TSI indicates Aeneas Lake is oligotrophic, however, for the following reasons an oligo-mesotrophic classification is estimated: indices were upper mesotrophic in September; high ammonia and anoxia in the hypolimnion in June and September; the presence of blue-green algae and hydrogen sulfide (hypolimnion) in September; and macrophyte development over the summer. It was stratified in both June and September. Relative to other lakes surveyed, Aeneas had mid-range nutrient concentrations in the epilimnion and high in the hypolimnion, with ammonia ranking the highest, on both sampling dates. The dissolved oxygen pulse at 2-5 meters in June was likely due to algal productivity. Anoxic conditions existed below 13 meters in June and below 8 meters in September. There was no surface algal bloom in June and only a few shoreline *Scirpus* were noted; in September, floating aggregate chunks of *Oscillatoria* were observed and most of the shoreline and bottom was covered with *Chara*. Water color was clear in June and moderately green in September.

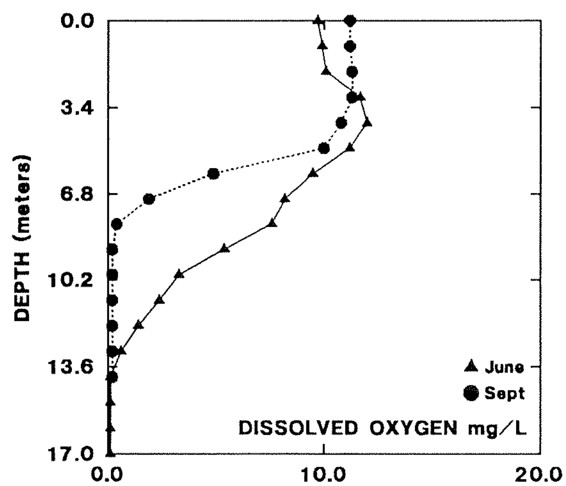
AENEAS LAKE - OKANOGAN COUNTY
1990 WATER QUALITY DATA

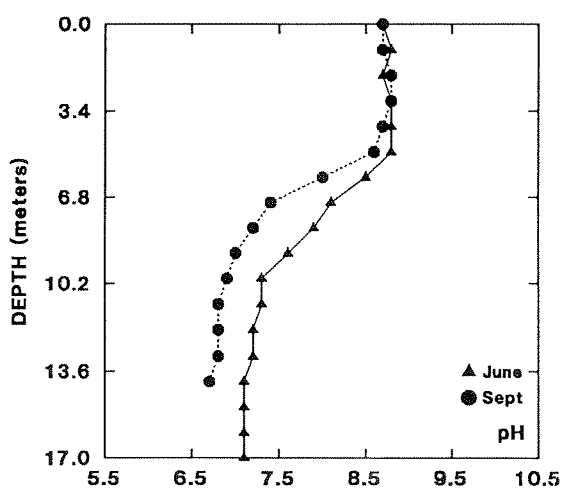
Parameter (mg/L unless noted)	June 6 E	June 6 H	Sept. 26 E	Sept. 26 H
Depth (m)(composite sample)	0,1.5,3	14,15.5,17	1,3,5	11,12,13
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006U	0.006U	0.006U	0.006U
Ammonia (NH_3-N)	0.004	0.719	0.006	1.130
Total Nitrogen (TN)	0.315	1.220	0.435●	1.510●
Orthophosphate (PO_4-P)	0.002	0.183	0.005	0.336
Total Phosphorus (TP)	0.012	0.215	0.024	0.370
Nitrogen/Phosphorus ratio (TN/TP)	26.3	5.7	18.1	4.1
Specific Conductance (umhos/cm)	285	438	305	443
Turbidity (NTU)	0.50	-	1.7	-
Chlorophyll-*a* (μg/L)	0.7	-	6.0	-
Secchi disc (m)	5.5		2.6	
Fecal Coliform (#/100 mL)	0		0	
Predominant Algae	-		*Oscillatoria, Anabaena*	
Macrophytes present	*Chara, Ceratophyllum demersum, Potamogeton pectinatus, P. illinoisensis, Scirpus*			
Trophic State Index				
TSI_{SD}	35		46	
TSI_{TP}	40		50	
TSI_{Chl}	27		48	

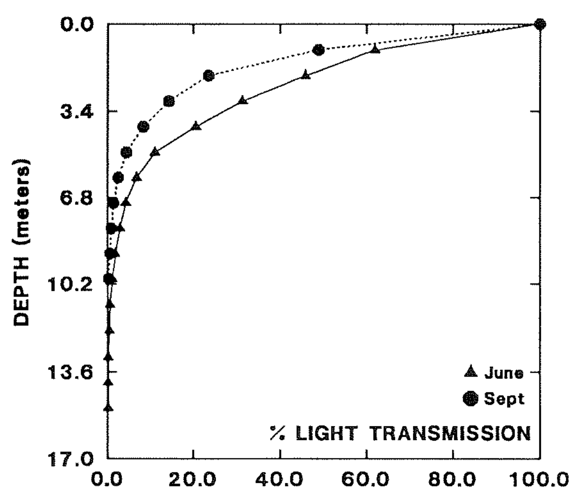
U Analyte was not found at the method detection limit shown.
● Sample was filtered in the lab; result may or may not be biased low.


Aeneas Lake - Okanogan County
From Washington Department of Game, January, 1947.
Sample Location
North
0
500
SCALE IN FEET
10
Line of equal water depth
Interval 5 feet
5
10
15
20
25
30
35
40
45
50
55
60


DEPTH (meters)
0.0
3.4
6.8
10.2
13.6
17.0
2.0
6.6
11.2
15.8
20.4
25.0
June
Sept
TEMPERATURE C


DEPTH (meters)
0.0
3.4
6.8
10.2
13.6
17.0
0.0
10.0
20.0
June
Sept
DISSOLVED OXYGEN mg/L


DEPTH (meters)
0.0
3.4
6.8
10.2
13.6
17.0
5.5
6.5
7.5
8.5
9.5
10.5
June
Sept
pH


DEPTH (meters)
0.0
3.4
6.8
10.2
13.6
17.0
0.0
20.0
40.0
60.0
80.0
100.0
June
Sept
% LIGHT TRANSMISSION

BIG LAKE - SKAGIT COUNTY

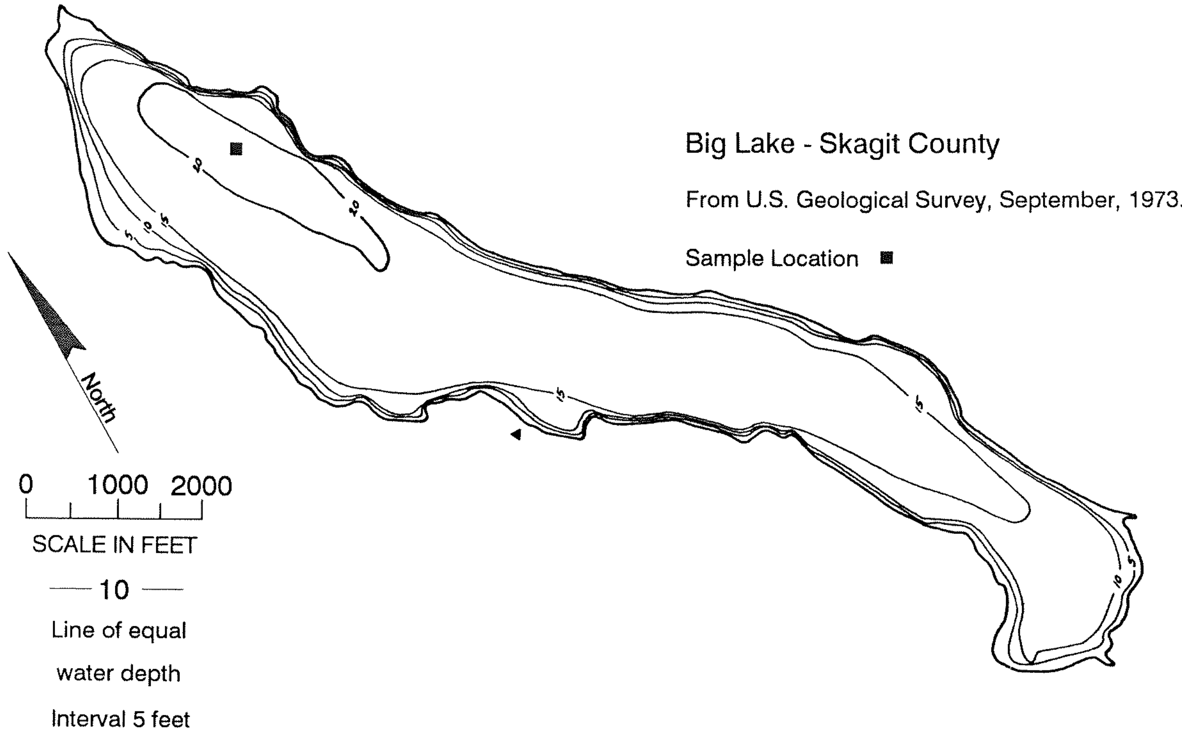
Big Lake is 2.75 miles long and is located five miles southeast of Mt. Vernon, Washington, within the Skagit River Basin. It was the largest of the lakes studied, covering 520 acres and draining 22.4 square miles. Big Lake has a mean depth of 14 feet and a maximum depth of 23 feet. There is a perennial inflow from Lake Creek. Outflow is to the Skagit River via Nookachamps Creek. Roughly 98 percent of the northern portion of the lake is residentially developed. There is a large wetland at the south end of the lake. Land use in the drainage remains largely forested.

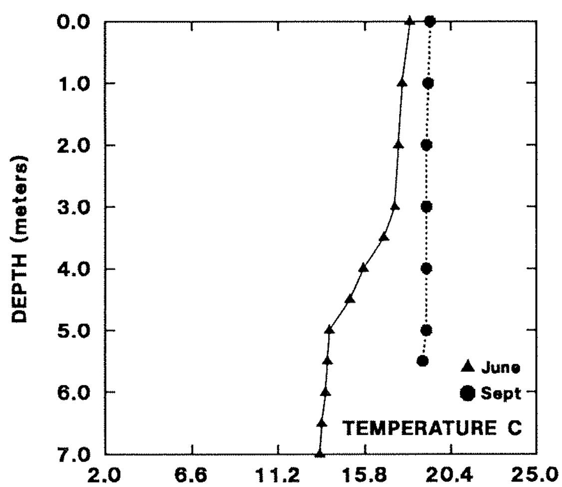
Except for low TP concentrations found in June, trophic state indices estimate that Big Lake is eutrophic. It was stratified in June and had turned over by September. Relative to other survey lakes, nutrients in Big Lake were high in June and mid-range in September. The TN:TP ratio indicates Big Lake may have been nitrogen limited in September. A June surface algal bloom of *Asterionella* and *Tabellaria* (diatoms) resulted in the highest turbidity and lowest transparency ranking. In September, aggregate clumps of *Microcystis aeruginosa* (blue-green) were observed on the surface and a green algae bloom was noticed on the shoreline (a septic odor was detected on the lake and at the boat launch). Water color was brown in June and moderate to light green in September. Drainage basin and highway 9 run-off are probable sources of nutrients to Big Lake in addition to lakeside septic systems.

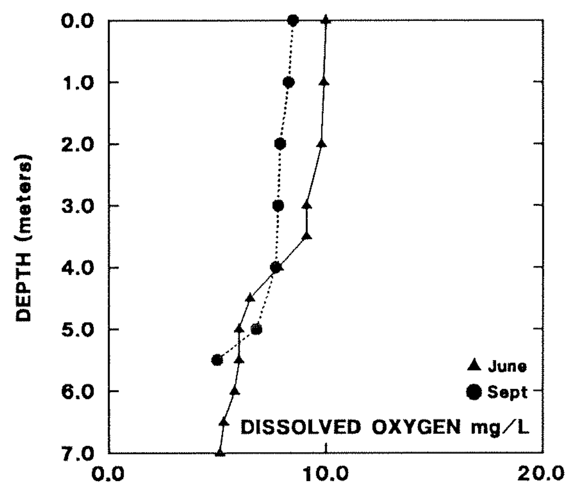
BIG LAKE - SKAGIT COUNTY
1990 WATER QUALITY DATA

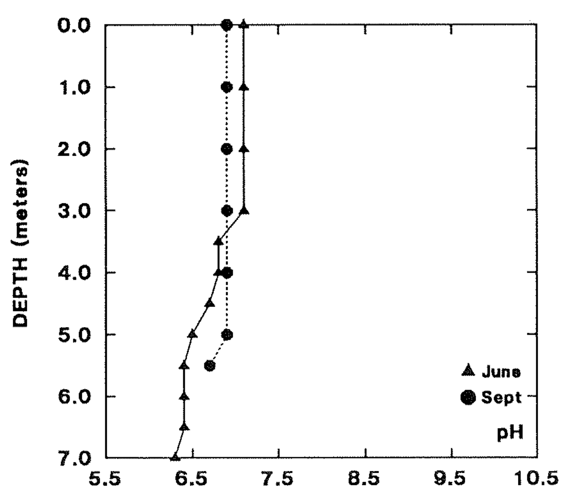
Parameter (mg/L unless noted)	June 18 E	June 18 H	Sept. 17 E	Sept. 17 H
Depth (m)(composite sample)	0,1.5,3	5,6,7	1,3,5	-
Nitrate + Nitrite (NO_3 + NO_2-N)	0.220	0.290	0.013	-
Ammonia (NH_3-N)	0.014	0.052	0.012	-
Total Nitrogen (TN)	0.475	0.570	0.333	-
Orthophosphate (PO_4-P)	-	-	0.007	-
Total Phosphorus (TP)	0.007J	0.015J	0.037	-
Nitrogen/Phosphorus ratio (TN/TP)	67.9	38.0	9.0	-
Specific Conductance (umhos/cm)	72	73	87	-
Turbidity (NTU)	7.9*	-	3.4	-
Chlorophyll-*a* (μg/L)	6.9	-	11.9	-
Secchi disc (m)	1.2		2.1	
Fecal Coliform (#/00 mL)	7H		0	
Predominant Algae	*Asterionella, Tabellaria*		*Microcystis aeruginosa*	
Macrophytes present	*Elodea canadensis, E. densa, Nuphar polysepalum, Ceratophyllum demersum, Iris pseudacorus, Brasenia schreberi, Vallesneria americana, Potamogeton foliosus, P. epihydrus, P. richardsonii, Scirpus, Nymphaea odorata*, Sedge			
Trophic State Index				
TSI_{SD}	57		49	
TSI_{TP}	32		56	
TSI_{Chl}	50		55	

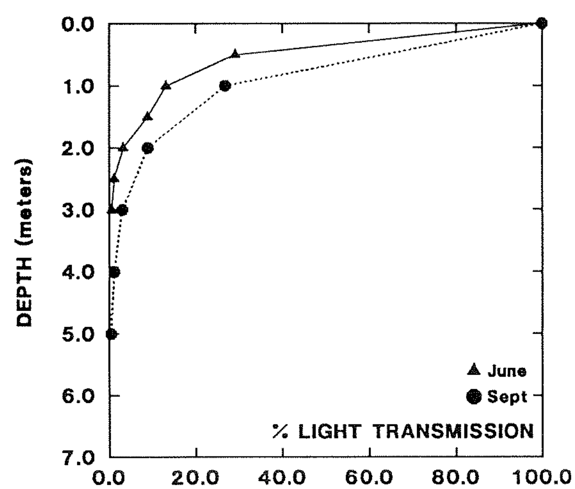
J Value an estimate; sample was not field acidified for preservation.
H Samples age exceeded holding time.


Big Lake - Skagit County
From U.S. Geological Survey, September, 1973.
Sample Location
North
0 1000 2000
SCALE IN FEET
10
Line of equal
water depth
Interval 5 feet


DEPTH (meters)
June
Sept
TEMPERATURE C


DEPTH (meters)
June
Sept
DISSOLVED OXYGEN mg/L


DEPTH (meters)
June
Sept
pH


DEPTH (meters)
June
Sept
% LIGHT TRANSMISSION

DAVIS LAKE - PEND OREILLE COUNTY

Davis Lake is located 5.7 miles south of Usk, Washington, within the Pend Oreille River Basin. It has a surface area of 146 acres and drains 17.8 square miles. Davis has an altitude of 2,178 feet, and was the deepest lake surveyed, with a mean depth of 83 feet and a maximum depth of 150 feet. Davis Lake has a perennial inflow from Deer Creek and drains via Davis Creek to the Pend Oreille River. Lakeside residential development is roughly 20 percent and its drainage basin is dominated by forest or unproductive land use. The water level is stabilized by a small dam at the outlet.

Chlorophyll-*a* and Secchi disc TSI's indicate Davis Lake is oligotrophic. Although the TP index is within the mesotrophic range, the generally more reliable chlorophyll-*a* TSI was used to estimate the trophic status. The lake was stratified in both June and September. Relative to other survey lakes, Davis had low nutrient levels. In June, Davis Lake ranked the highest for fecal coliform at the surface. A slight dissolved oxygen pulse was also noted in the spring from 3 to 10 meters, probably from algal productivity. The oxygen decline at 7 meters in September may have been due to respiration of zooplankton, decomposition of organic matter, or both. The temperature profile indicates there may have been a density gradient able to suspend sedimenting materials. Macrophytes were confined mostly to the southern, more shallow end of the lake. Water was a green-brown "tea" color, probably from humic substances from the watershed.

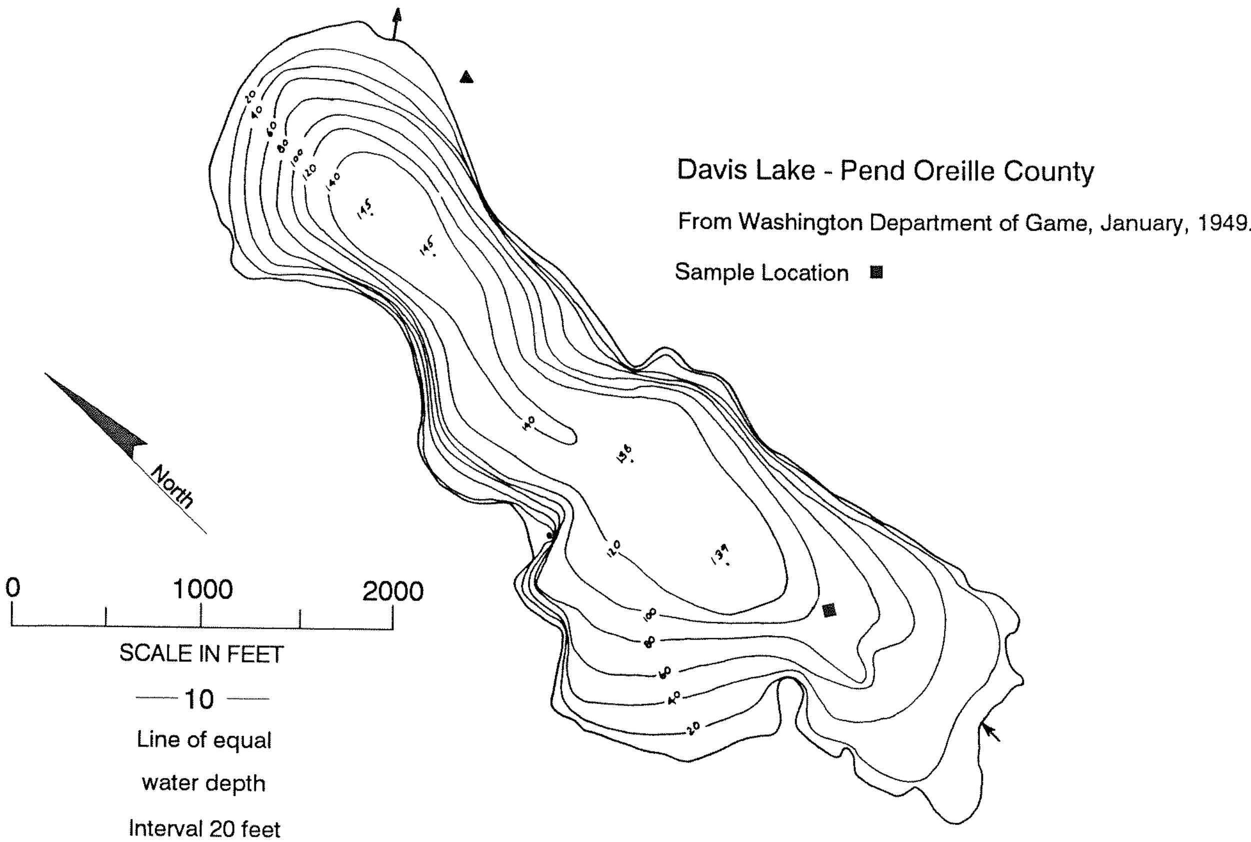
DAVIS LAKE - PEND OREILLE COUNTY
1990 WATER QUALITY DATA

Parameter (mg/L unless noted)	June 26 E	June 26 H	Sept. 25 E	Sept. 25 H
Depth (m)(composite sample)	0,1.5,3	16,18,21	1,3,6	12,24,36
Nitrate + Nitrite (NO_3 + NO_2-N)	0.021	0.056	0.006U	0.037
Ammonia (NH_3-N)	0.003	0.008	0.004	0.016
Total Nitrogen (TN)	0.253	0.181	0.215	0.187
Orthophosphate (PO_4-P)	0.008	0.008	0.008	0.014
Total Phosphorus (TP)	0.016	0.008	0.014	0.008
Nitrogen/Phosphorus ratio (TN/TP)	15.8	22.6	15.4	23.4
Specific Conductance (umhos/cm)	87	95	96	88
Turbidity (NTU)	1.2	-	0.7	-
Chlorophyll-*a* (μg/L)	2.9	-	0.9	-
Secchi disc (m)	3.5		5.5	
Fecal Coliform (#/100 mL)	14		0	
Predominant Algae	-		-	

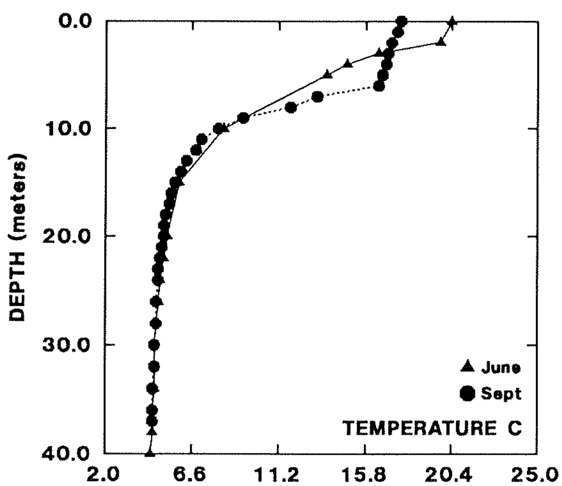
Macrophytes present: *Potamogeton zosteriformis, P. amphlifolious, P. berchtoldii, P. richardsonii, P. epihydrus, Typha, Brasenia schreberi, Elodea canadensis, Scirpus, Nitella, Ranunculus aquatilus, Nuphar polysepalum, Ceratophyllum demersum, Myriophyllum,* Gramineae

Trophic State Index	June 26	Sept. 25
TSI_{SD}	42	35
TSI_{TP}	44	42
TSI_{Chl}	41	30

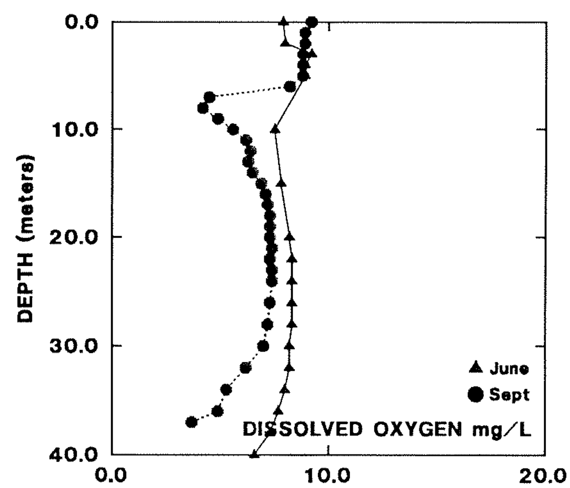
U Analyte was not found at the method detection limit shown.



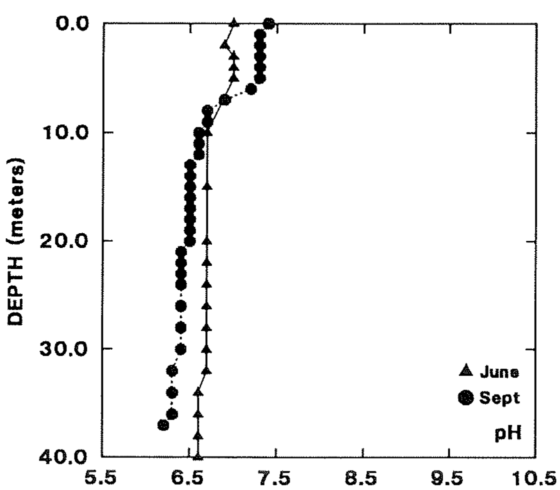
Davis Lake - Pend Oreille County
From Washington Department of Game, January, 1949.
Sample Location
North
0
1000
2000
SCALE IN FEET
10
Line of equal water depth
Interval 20 feet



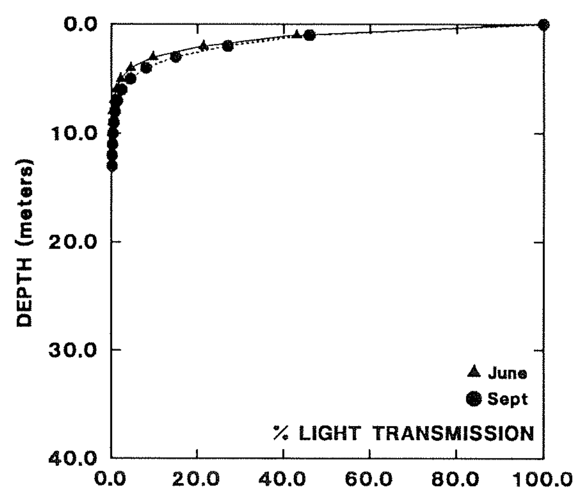
DEPTH (meters)
June
Sept
TEMPERATURE C



DEPTH (meters)
June
Sept
DISSOLVED OXYGEN mg/L



DEPTH (meters)
June
Sept
pH



DEPTH (meters)
June
Sept
% LIGHT TRANSMISSION

FLOWING LAKE - SNOHOMISH COUNTY

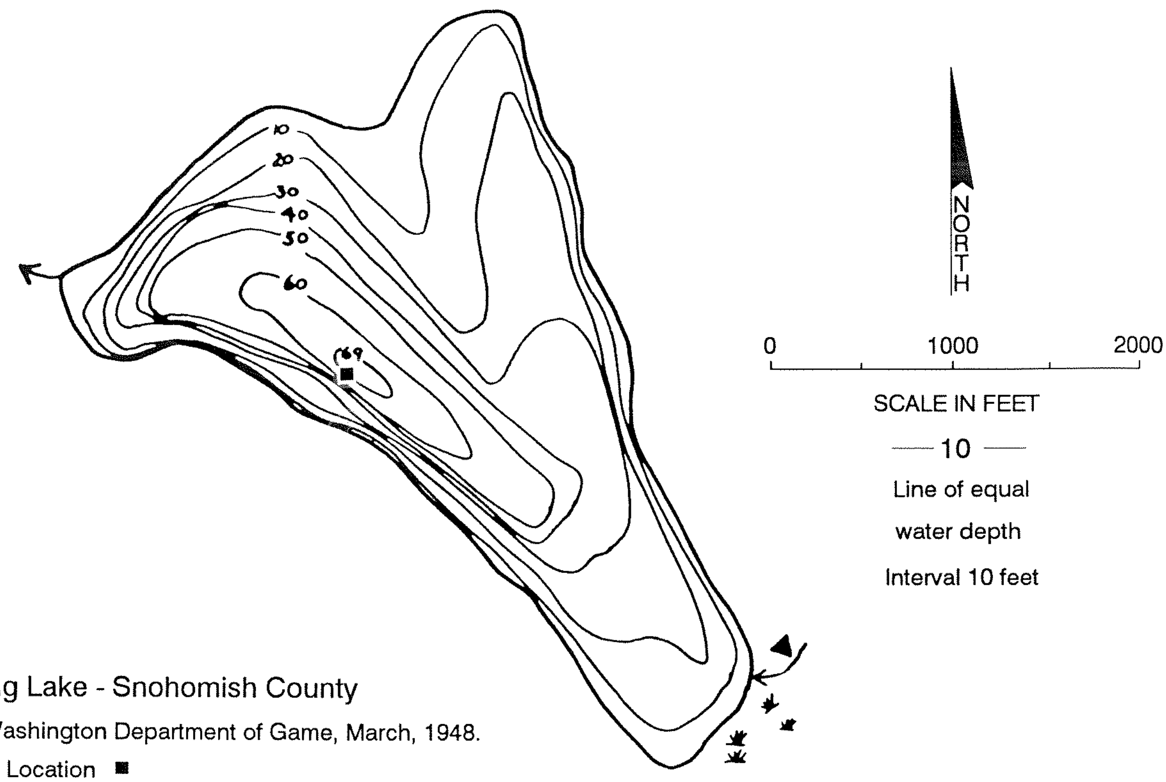
Flowing Lake is located six miles north of Monroe, Washington, within the Snohomish River Basin. It has a surface area of 130 acres and a 0.79 square mile drainage basin; the smallest drainage of all lakes surveyed. Flowing Lake has a mean depth of 28 feet and maximum depth of 69 feet. The inflow from Storm Lake is intermittent and drainage is to the Pilchuck River via Panther Lake. Shoreline development is roughly 90 percent and land use in the watershed approaches 50 percent forest or unproductive. Recreational use during the summer is heavy.

The chlorophyll-*a* and TP TSI's indicate Flowing Lake is oligotrophic. Low Secchi disc readings, the presence of blue-green algae and low dissolved oxygen in September suggest a higher trophic level, but the other parameters were given priority. Higher Secchi disc TSI may be in part from natural color from drainage basin run-off. Flowing Lake was thermally stratified in both June and September. During September there was a distinct thermocline from 4 to 6 meters with a corresponding drop to anoxic conditions. The temperature profile suggests a density gradient may have been responsible for oxygen depletion at the thermocline by suspending respiring zooplankton and decomposing organic matter. Relative to other lakes, epilimnetic nitrate-plus-nitrite ranked highest in June and lowest in September. This is likely due to biological use of nutrients by epilimnetic algae throughout the summer. Ammonia (epilimnion) and fecal coliform (surface) ranked second highest for all lakes surveyed in June and September, respectively. In June there was a slight algal bloom of *Dinobryon* (golden brown) and *Spirogyra* (green). Fall found aggregate clumps of *Gloeotrichia* (blue-green), emergent macrophytes and water color a greenish-brown. The high TN:TP ratio suggests additional phosphorus inputs could pose a threat to this lake's trophic status.

FLOWING LAKE - SNOHOMISH COUNTY
1990 WATER QUALITY DATA

Parameter (mg/L unless noted)	June 18 E	June 18 H	Sept. 17 E	Sept. 17 H
Depth (m)(composite sample)	0,1.5,3	17,18,19	1,2,4	9,11,13
Nitrate + Nitrite (NO_3 + NO_2-N)	0.230	0.270	0.006U	0.222
Ammonia (NH_3-N)	0.017	0.026	0.005	0.029
Total Nitrogen (TN)	0.470	0.450	0.389	0.437●
Orthophosphate (PO_4-P)	-	-	0.004	0.006
Total Phosphorus (TP)	0.004J	0.022J	0.009	0.011
Nitrogen/Phosphorus ratio (TN/TP)	118.0	20.5	43.2	39.7
Specific Conductance (umhos/cm)	41	49	43	44
Turbidity (NTU)	1.4H	-	0.9	-
Chlorophyll-*a* (μg/L)	1.3	-	2.3	-
Secchi disc (m)	3.0		3.7	
Fecal Coliform (#/100 mL)	0H		4	
Predominant Algae	*Dinobryon, Spirogyra*		*Gloeotrichia*	
Macrophytes present	*Iris pseudacorus, Nuphar polysepalum, Typha latifolia, Nymphaea odonata*			
Trophic State Index				
TSI_{SD}	44		41	
TSI_{TP}	24		36	
TSI_{Chl}	33		39	

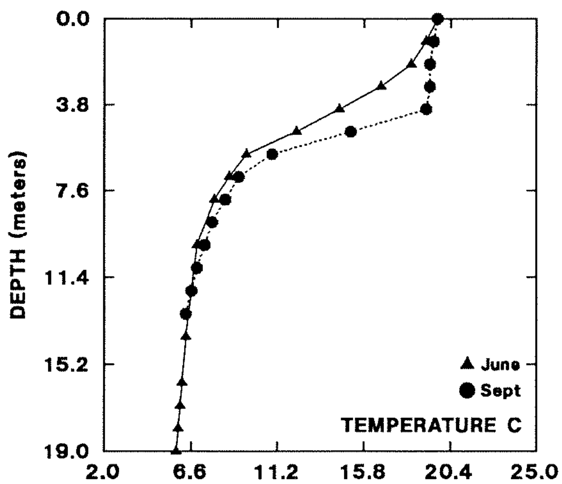
U Analyte was not found at the method detection limit shown.
● Sample was filtered in the lab; result may or may not be biased low.
J Value an estimate; sample was not field acidified for preservation.
H Samples age exceeded holding time.

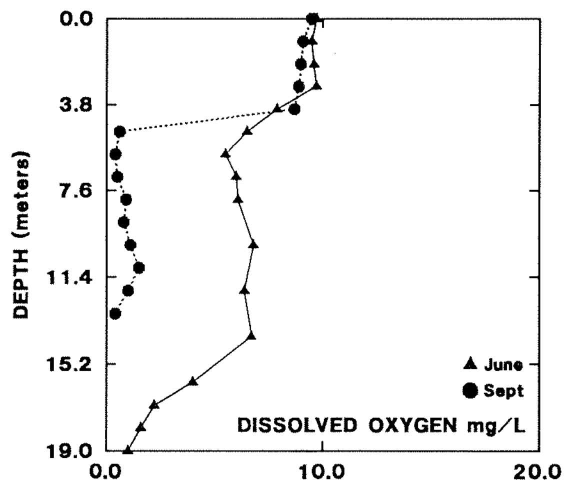


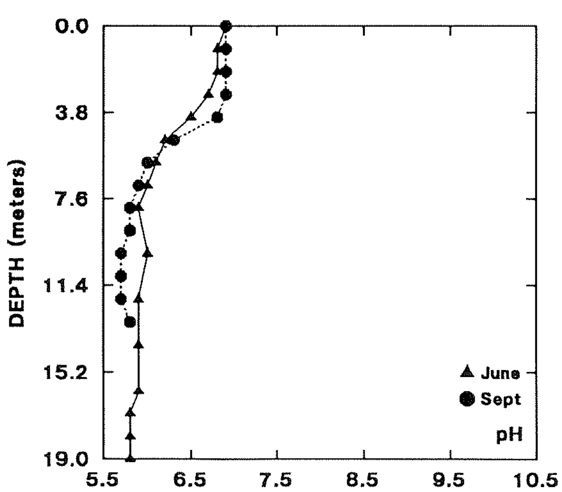
Flowing Lake - Snohomish County

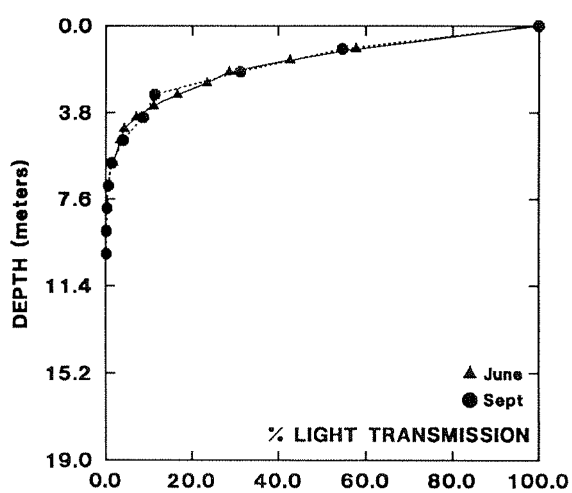
From Washington Department of Game, March, 1948.

Sample Location ■









LAKE KAHLOTUS - FRANKLIN COUNTY

Lake Kahlotus is located 40 miles northeast of Pasco, Washington, within the Columbia River Basin. It has a drainage area of 167 square miles, the largest of the lakes surveyed. A drastic change has occurred in the lake's physical attributes since a 1974 survey by Dion *et al.*, (1976b). The lake's maximum depth was found to be 8 feet instead of the reported 24 feet and the surface area reduced accordingly. The lake drains westerly into Washtucna Coulee. There is no shoreline residential development. Land use in the drainage is dominated by agriculture.

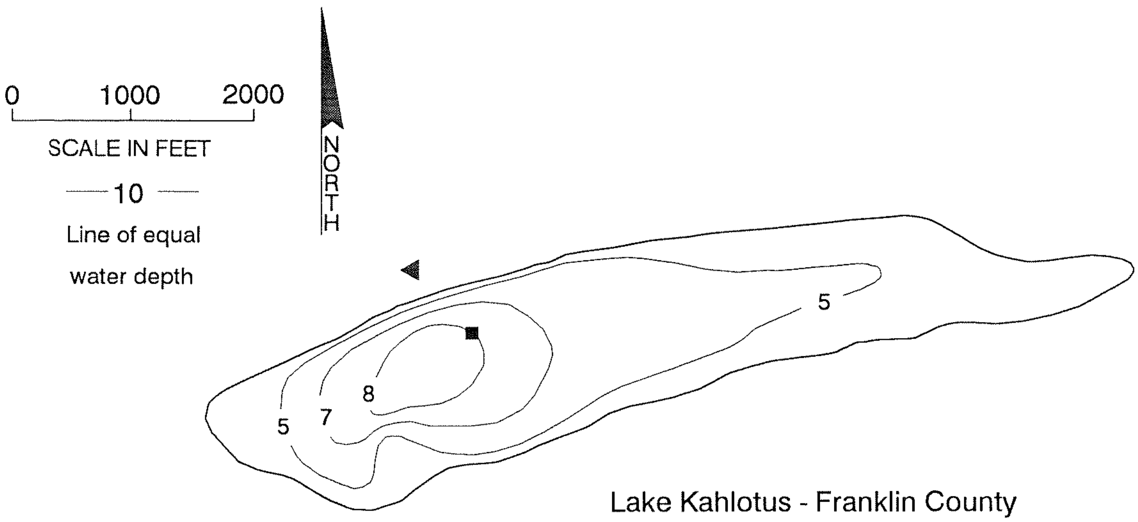
Although the chlorophyll-*a* TSI indicates mesotrophy, for the following reasons Lake Kahlotus is estimated as eutrophic: lower spring algal densities were likely a result of competition by macrophytes; presence of blue-green algae in spring; TP well within the eutrophic range; high nutrient content; shallow depth; abundant macrophytes; and low dissolved oxygen in September. Kahlotus ranked highest for total nitrogen and total phosphorus on both dates, highest and second highest for orthophosphate in June and September, respectively, and second highest for specific conductance both dates. In spring, there was a surface algal bloom of *Anabaena* (blue-green) and *Spirogyra* (green) and many waterfowl were seen at the lake. Spring also found a number of dead bluegill on the surface, possibly related to stress from the wide diurnal swings in dissolved oxygen and pH commonly associated with shallow, highly productive waterbodies. In September, floating mats of *Potamogeton* were observed. Water color was a moderate green. Run-off from agricultural land is probably a major contributor of nutrients to the lake.

LAKE KAHLOTUS - FRANKLIN COUNTY
1990 WATER QUALITY DATA

Parameter (mg/L unless noted)	June 22 E	June 22 H	Sept. 24 E	Sept. 24 H
Depth (m)(composite sample)	0,1	2.4	0.5,1	-
Nitrate + Nitrite (NO_3 + NO_2-N)	0.015	0.013	0.006U	-
Ammonia (NH_3-N)	0.008	0.005	0.012	-
Total Nitrogen (TN)	2.110	1.920	2.740	-
Orthophosphate (PO_4-P)	0.035	0.047	0.039	-
Total Phosphorus (TP)	0.061	0.075	0.140	-
Nitrogen/Phosphorus ratio (TN/TP)	34.6	25.6	19.6	-
Specific Conductance (umhos/cm)	1211	1221	1398	-
Turbidity (NTU)	1.3	-	2.6	-
Chlorophyll-*a* (μg/L)	4.1	-	8.8	-
Secchi disc (m)	-♦		-♦	
Fecal Coliform (#/100 mL)	0		0	
Predominant Algae	*Anabaena, Spirogyra*		Not sampled	
Macrophytes present	*Potamogeton pectinatus, Myriophyllum*			
Trophic State Index				
TSI_{SD}	♦		♦	
TSI_{TP}	63		75	
TSI_{Chl}	44		52	

U Analyte was not found at the method detection limit shown.

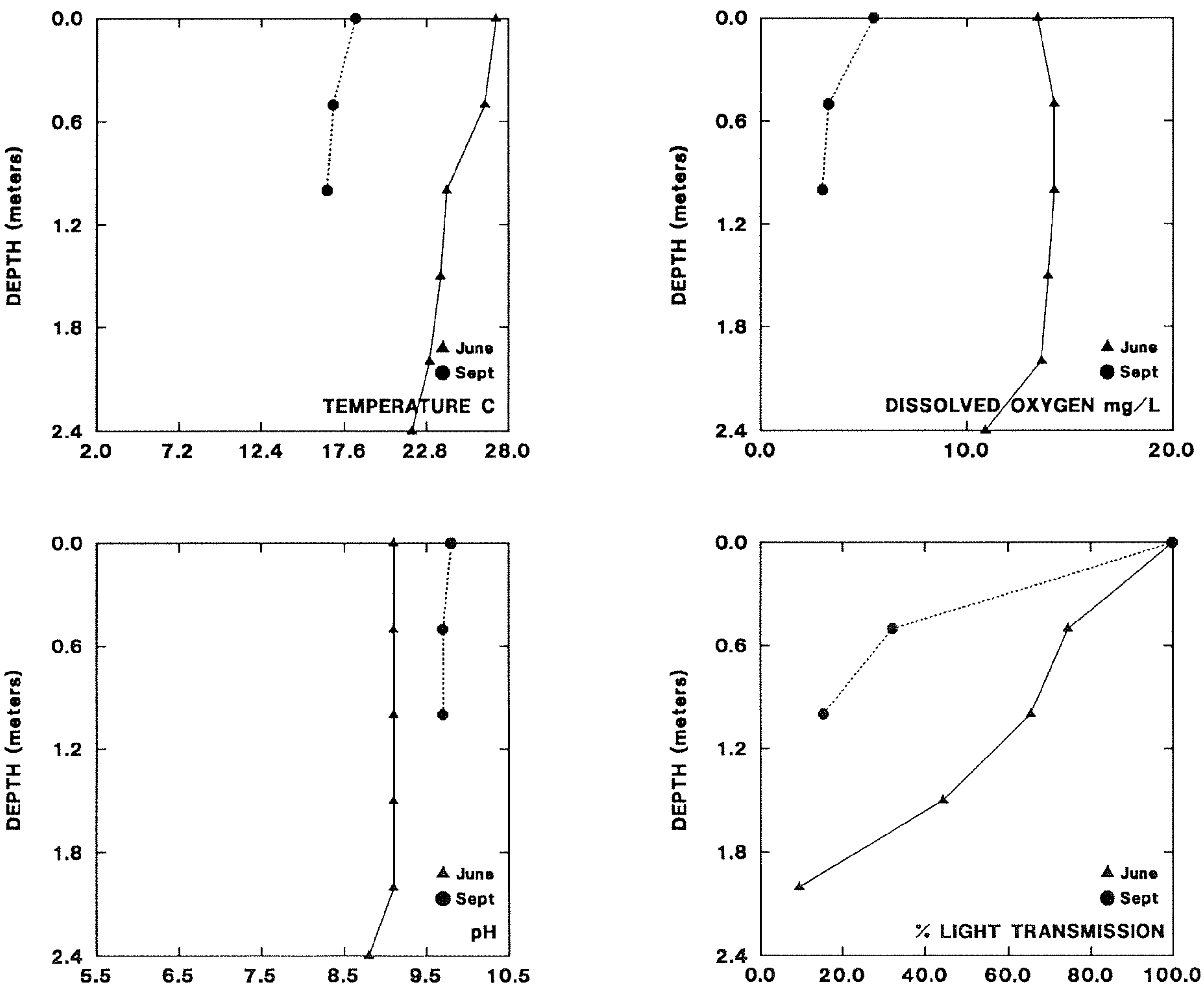
♦ Secchi disc reading >2.4 meter in June and >1.0 meter in September.



Lake Kahlotus - Franklin County

Digitized From Washington Department of Game, July, 1954.

Sample Location ■



KITSAP LAKE - KITSAP COUNTY

Kitsap Lake is an urban lake located 3 miles west of Bremerton, Washington, within the Puget Sound Basin. Its surface area is 250 acres and its drainage area is 2.7 square miles. Kitsap Lake has a mean depth of 18 feet and a maximum depth of 29 feet. Inflow is from an intermittent unnamed tributary. The lake is stabilized by a 5 foot dam. Kitsap's outflow is to Dyes Inlet via Kitsap Creek. Lakeside residential development is reported at 75 percent and drainage basin land use is 71 percent forest or unproductive (Sumioka and Dion, 1985).

Based on results of this survey, Kitsap Lake is approaching the upper limits of mesotrophy. Fall TSI's indicate Kitsap Lake is eutrophic, however, the spring TSI's ranging from oligotrophic (TSI_{SD}), to mesotrophic (TSI_{Chl}) were given priority. Additionally, elevated dissolved oxygen levels throughout the water column would indicate a mesotrophic classification. In both June and September the lake was fully mixed. Near-bottom samples were taken in June. Kitsap ranked low to mid-range for nutrients relative to other lakes surveyed. Ratios of TN to TP fell within an area of uncertainty as to which nutrient is limiting, nitrogen and/or phosphorus. A moderate blue-green algal bloom of *Anabaena* and *Gloeotrichia* was observed at the surface in June. A high percentage of shoreline and lake bottom was occupied by emergent and submergent macrophytes. Recent clearcutting had occurred within the drainage basin. The water color was clear in June and green/brown in September.

KITSAP LAKE - KITSAP COUNTY
1990 WATER QUALITY DATA

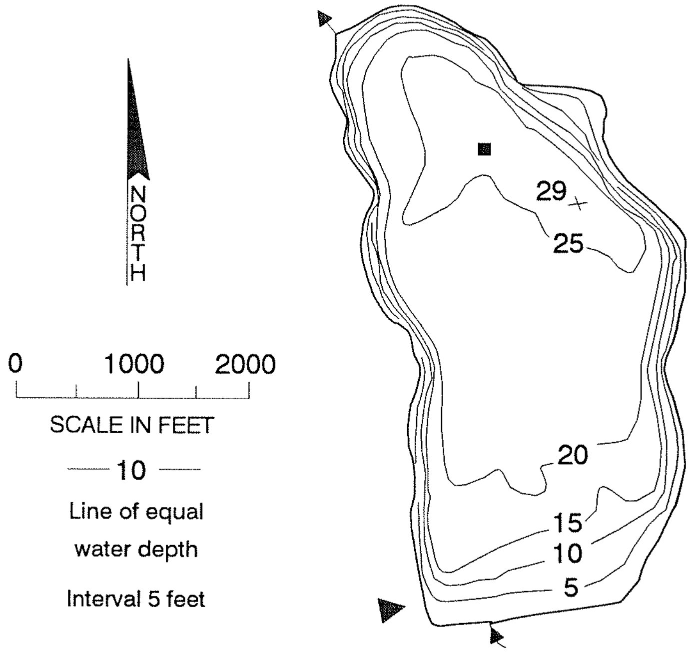
Parameter (mg/L unless noted)	June 13 E	June 13 H	Sept. 12 E	Sept. 12 H
Depth (m)(composite sample)	0,1,2	6,7,8	1,3,5	-
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006U	0.006U	0.006U	-
Ammonia (NH_3-N)	0.011	0.017	0.011	-
Total Nitrogen (TN)	0.189	0.195	0.346	-
Orthophosphate (PO_4-P)	-	0.010	0.011	-
Total Phosphorus (TP)	0.012J	0.012J	0.032	-
Nitrogen/Phosphorus ratio (TN/TP)	15.8	16.3	10.8	-
Specific Conductance (umhos/cm)	89	94	104	-
Turbidity (NTU)	1.2	-	1.4	-
Chlorophyll-*a* (μg/L)	3.5	-	7.9	-
Secchi disc (m)	5.0		1.9	
Fecal Coliform (#/100 mL)	0		2	
Predominant Algae	*Anabaena, Gloeotrichia*		-	
Macrophytes present	*Potamogeton zosteriformis, P. amplifolius, Iris pseudacorus, Nuphar polysepalum, Scirpus, Elodea canadensis, Ceratophyllum demersum, Cruciferae, Typha,* Gramineae			
Trophic State Index				
TSI_{SD}	37		51	
TSI_{TP}	40		54	
TSI_{Chl}	43		51	

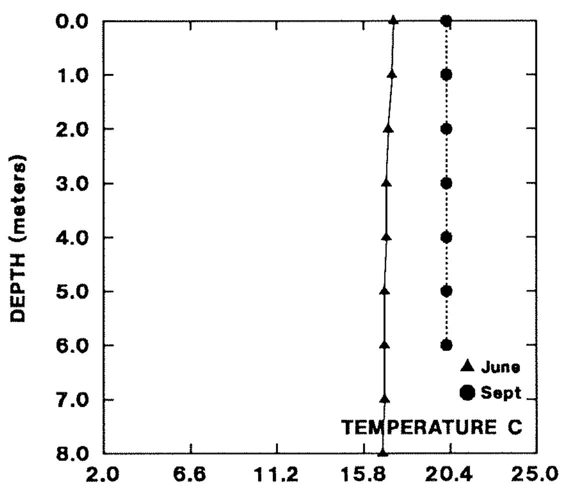
U Analyte was not found at the method detection limit shown.
J Value an estimate; sample was not field acidified for preservation.

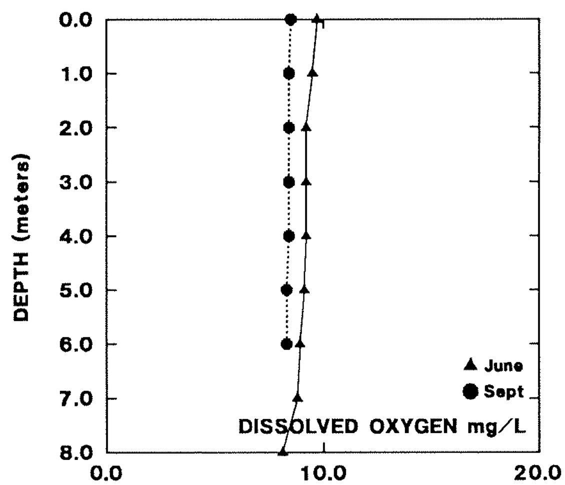
Kitsap Lake - Kitsap County

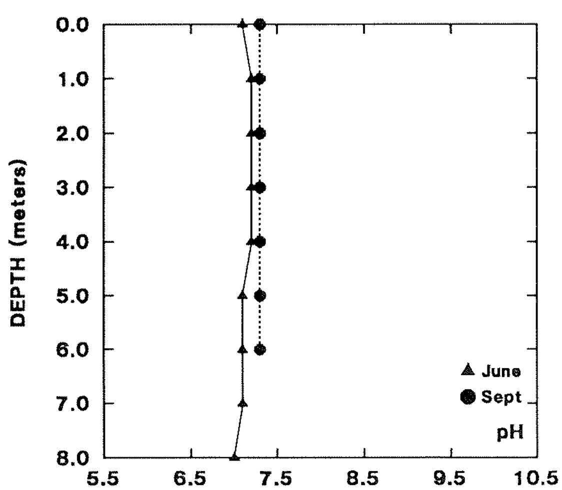
From Washington Department of Game, September, 1974.

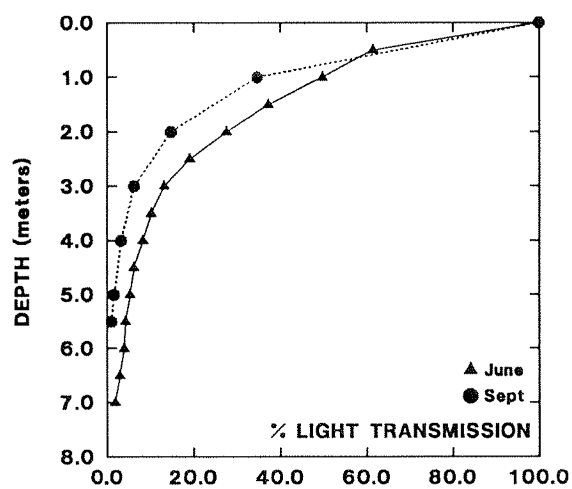
Sample Location ■











LEECH LAKE - YAKIMA COUNTY

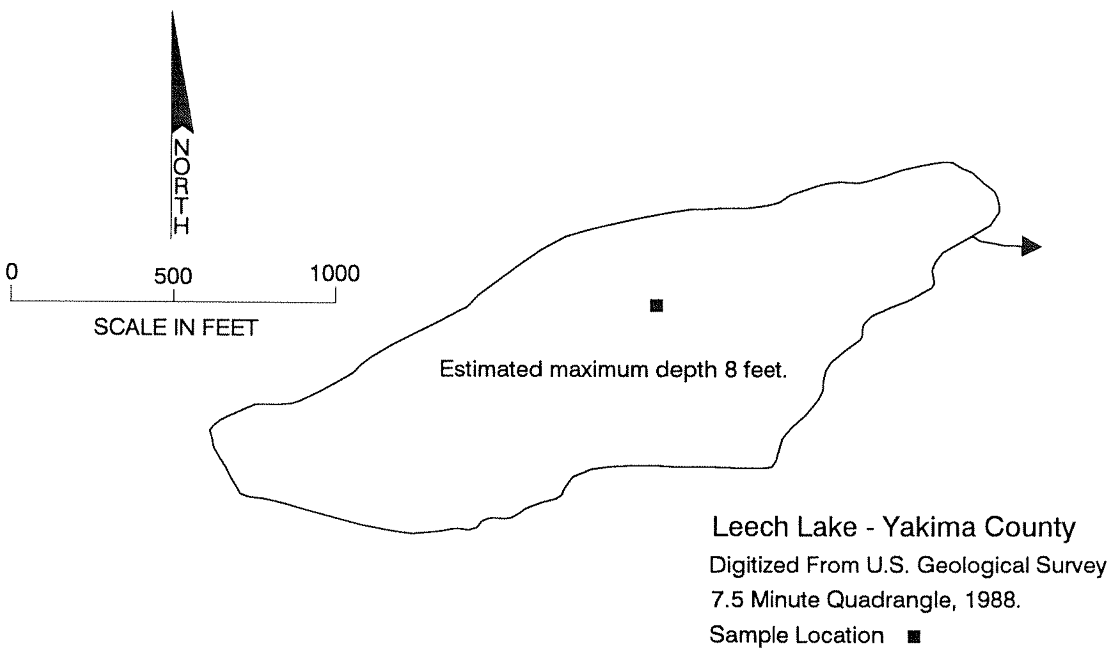
Leech Lake is located along Highway 12 at the crest of the Cascade Mountain Range, adjacent to the White Pass Ski Resort. Its 4,412 foot altitude makes it the highest lake surveyed. Leech was also the smallest, with a surface area of 40.6 acres and shallowest, with a maximum depth of 7.5 feet. Drainage is easterly via South Fork Clear Creek into Clear Lake. There is no residential development of the shoreline and the surrounding drainage is dominated by forest.

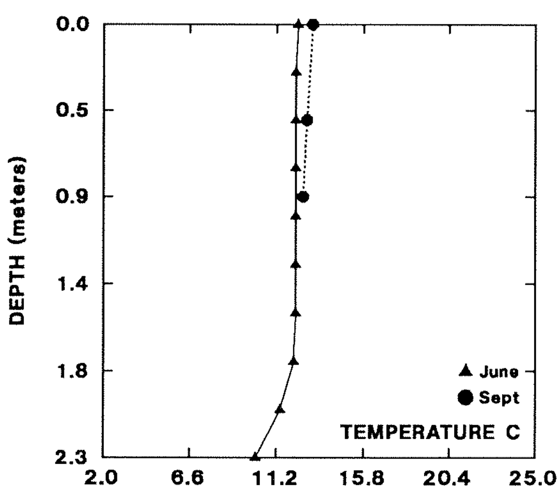
Although the chlorophyll-*a* index estimates oligotrophy, Leech Lake is estimated as mesotrophic for the following reasons: abundant macrophytes; algal densities may have been inhibited due to competition from dense macrophyte growth; and fall productivity as indicated by the dissolved oxygen and pH increase with depth. Near bottom samples were taken in June. Relative to other lakes, Leech ranked low for nutrients. Ratios of TN to TP indicate nitrogen was limiting in spring and by fall there was uncertainty as to which nutrient was limiting, nitrogen and/or phosphorus. Dissolved oxygen was near saturation throughout the water column. The lake bottom was covered with submergents, as indicated by dissolved oxygen and pH increasing with depth in September and the near bottom pulse in June. Emergents cover approximately ten percent of the lake surface and about 98 percent of the shoreline. Water color was green. The volume of macrophytes in and around the shoreline suggests this lake is moving toward a more eutrophic state. Monitoring for nutrient increases would be warranted.

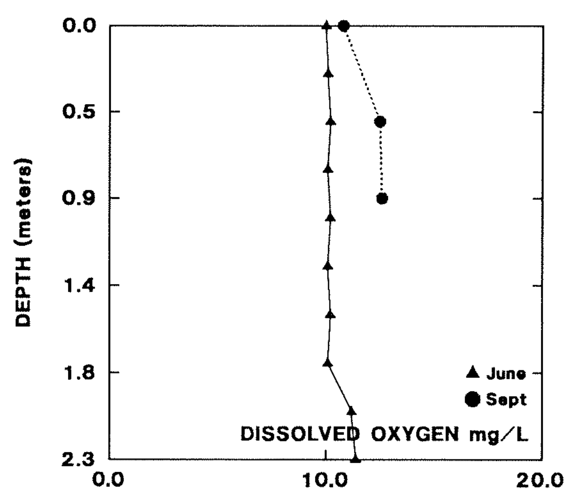
LEECH LAKE - YAKIMA COUNTY
1990 WATER QUALITY DATA

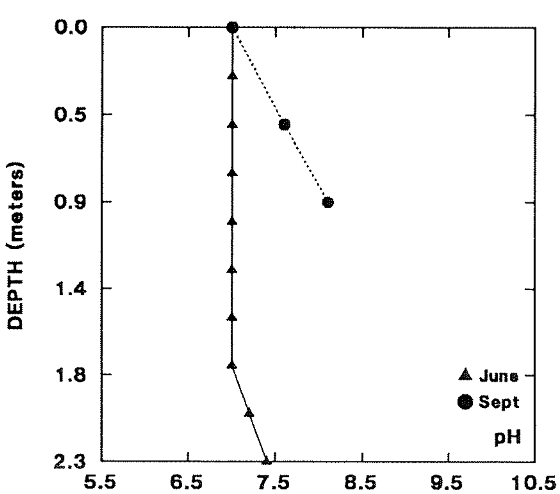
	June 19		Sept. 18	
Parameter (mg/L unless noted)	E	H	E	H
Depth (m)(composite sample)	0,1	1.5,2	0.5,0.5■	-
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006U	0.011	0.009	-
Ammonia (NH_3-N)	0.013	0.007	0.012	-
Total Nitrogen (TN)	0.057	0.063	0.282	-
Orthophosphate (PO_4-P)	0.004	0.005	0.009	-
Total Phosphorus (TP)	0.009J	0.008J	0.022	-
Nitrogen/Phosphorus ratio (TN/TP)	6.3	7.9	12.8	-
Specific Conductance (umhos/cm)	34	34	52	-
Turbidity (NTU)	0.9	-	0.7	-
Chlorophyll-*a* (μg/L)	0.6	-	1.1	-
Secchi disc (m)	-♦		-♦	
Fecal Coliform (#/100 mL)	0		0H	
Predominant Algae	-		-	
Macrophytes present	*Myriophyllum, Elodea canadensis, E. nuttalli, Potamogeton illinoensis, P. richardsonii, P. berchtoldii, P. amplifolius, Nuphar polysepalum, Equisetum fluviatile*			
Trophic State Index				
TSI_{SD}	♦		♦	
TSI_{TP}	36		49	
TSI_{Chl}	26		31	

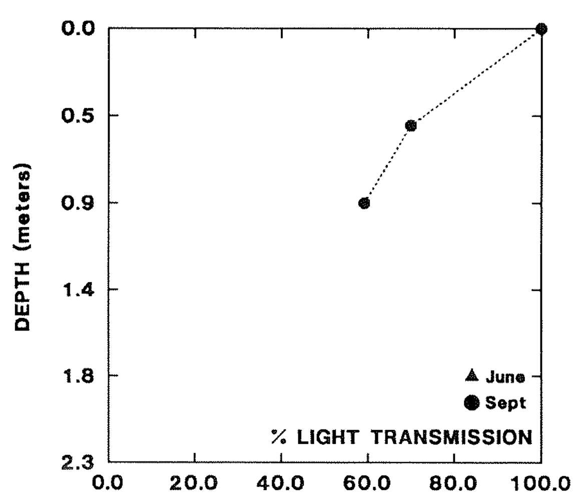
■ Epilimnion composite made up of two 0.5 meter grab samples.
U Analyte was not found at the method detection limit shown.
J Value an estimate; sample was not field acidified for preservation.
♦ Secchi disc reading >2.25 meter in June and >0.9 meter in September.
H Samples age exceeded holding time.


NORTH
0
500
1000
SCALE IN FEET
Estimated maximum depth 8 feet.
Leech Lake - Yakima County
Digitized From U.S. Geological Survey
7.5 Minute Quadrangle, 1988.
Sample Location


DEPTH (meters)
0.0
0.5
0.9
1.4
1.8
2.3
2.0
6.6
11.2
15.8
20.4
25.0
June
Sept
TEMPERATURE C


DEPTH (meters)
0.0
0.5
0.9
1.4
1.8
2.3
0.0
10.0
20.0
June
Sept
DISSOLVED OXYGEN mg/L


DEPTH (meters)
0.0
0.5
0.9
1.4
1.8
2.3
5.5
6.5
7.5
8.5
9.5
10.5
June
Sept
pH


DEPTH (meters)
0.0
0.5
0.9
1.4
1.8
2.3
0.0
20.0
40.0
60.0
80.0
100.0
June
Sept
% LIGHT TRANSMISSION

LOOMIS LAKE - PACIFIC COUNTY

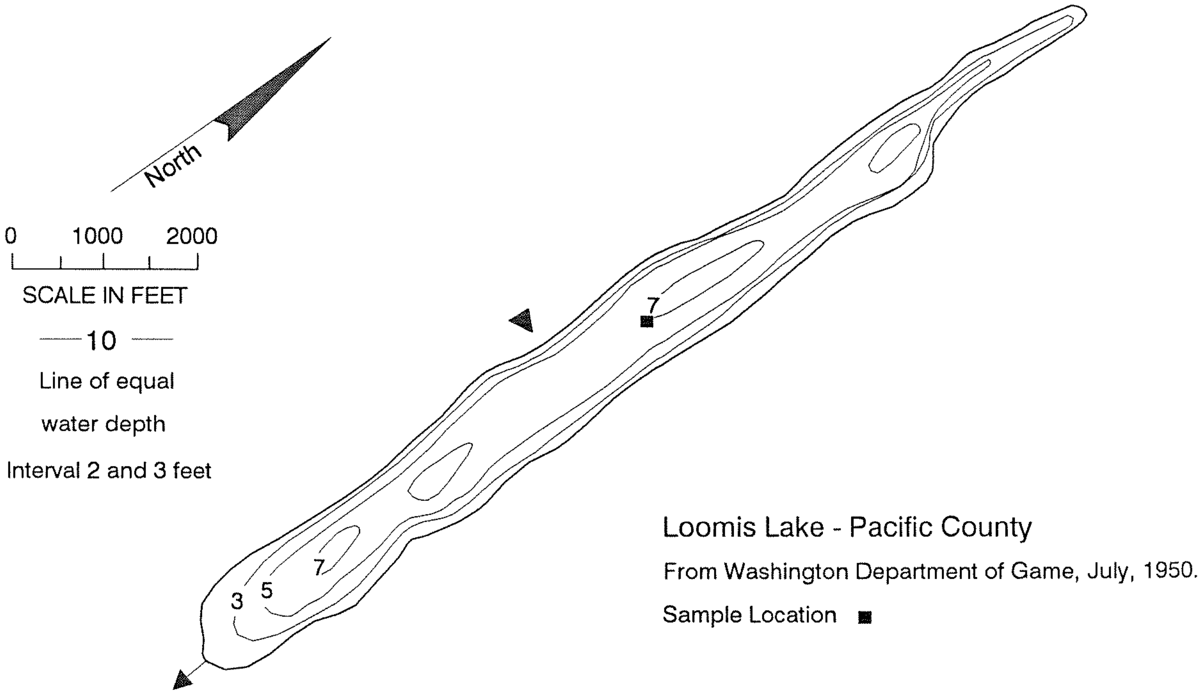
Loomis Lake is located 2.5 miles south of Ocean Park, Washington, on the Long Beach Peninsula. Its surface area is 170 acres and drainage basin is 1.4 square miles, the second smallest drainage of the surveyed lakes. This narrow lake has a mean depth of five feet and a maximum depth of nine feet. There is a large wetland at the south end of the lake. Loomis Lake drains via Loomis Creek to the Pacific Ocean. Roughly two percent of the lakeshore is residentially developed. Forest or unproductive land use dominate the drainage basin.

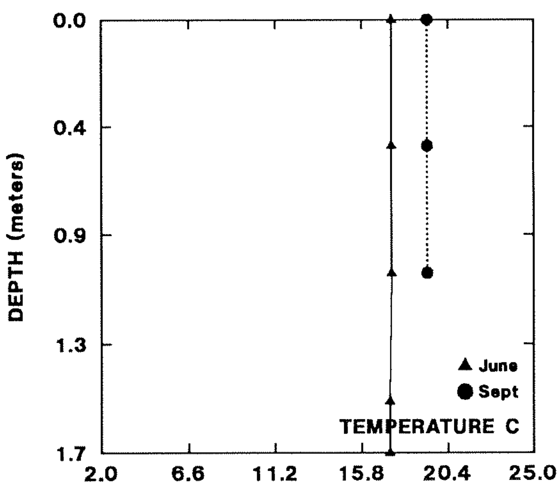
All three trophic state indices estimate that Loomis Lake is eutrophic. Because of exposure to frequent ocean winds and shallow depth, there was no thermal stratification. Nutrient data from June and September show Loomis Lake ranks high relative to other lakes, and appears to be nitrogen limited. Loomis had the largest June to September increase in turbidity and chlorophyll-*a*, ranking highest for both in September. It also had the second lowest transparency in June and lowest in September. In August a blue-green algal bloom in the north portion of the lake was reported to Ecology and verified (Randall, personal communication). By the September sampling the bloom was not apparent, although detrital particles were in the water column and water color was a "muddy" green-brown. Emergent macrophytes were observed along roughly 95 percent of the shoreline. Septic systems and nitrogen fertilizers applied to lawns, gardens and crops (i.e. cranberry bogs) are suspected sources of nitrates to the shallow (0-15 feet) water table of the Long Beach Peninsula (Carey and Yake, 1990). The peninsula's well drained soils with potential nutrient sources make Loomis Lake vulnerable to cultural eutrophication. The nutrient increases from June to September indicate there are significant contributions reaching Loomis Lake, although further study would be needed to determine the sources.

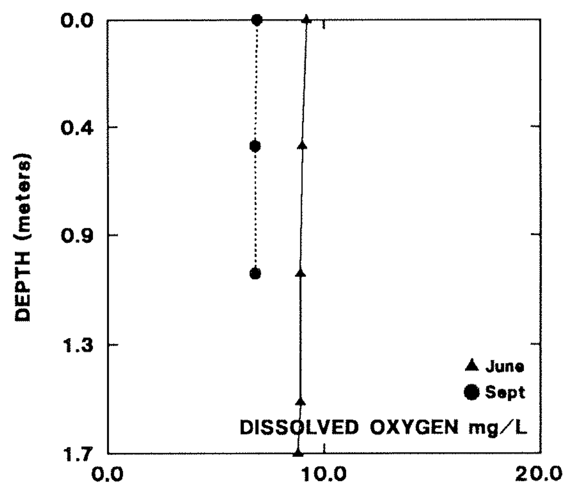
LOOMIS LAKE - PACIFIC COUNTY
1990 WATER QUALITY DATA

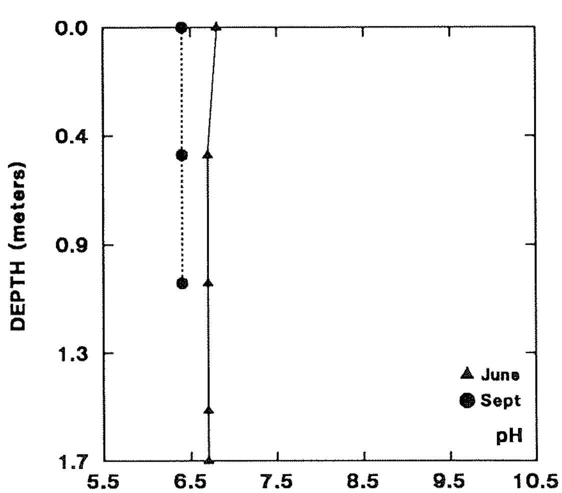
Parameter (mg/L unless noted)	June 12 E	June 12 H	Sept. 11 E	Sept. 11 H
Depth (m)(composite sample)	0,0.5	1.5,1.7	0.25,0.50	-
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006U	0.006U	0.240	-
Ammonia (NH_3-N)	0.014	0.009	0.017	-
Total Nitrogen (TN)	0.411	0.526	0.914	-
Orthophosphate (PO_4-P)	0.022	0.018	0.054	-
Total Phosphorus (TP)	0.057J	0.071J	0.131	-
Nitrogen/Phosphorus ratio (TN/TP)	7.2	7.4	7.0	-
Specific Conductance (umhos/cm)	119	119	132	-
Turbidity (NTU)	2.5	-	13.0	-
Chlorophyll-*a* (μg/L)	4.8	-	22.1	-
Secchi disc (m)	1.3		0.8	
Fecal Coliform (#/100 mL)	1		3H	
Predominant Algae	-		-	
Macrophytes present	*Nuphar polysepalum, Sparganium eurycarpum, Utricularia vulgaris, Carex, Rumex, Potentilla,* Cyperaceae			
Trophic State Index				
TSI_{SD}	56		63	
TSI_{TP}	62		74	
TSI_{Chl}	46		61	

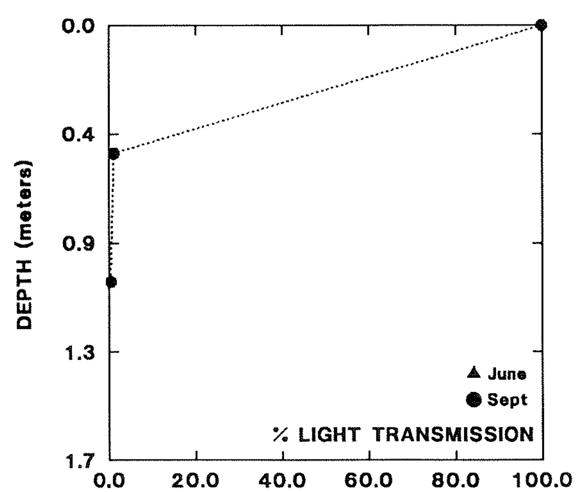
U Analyte was not found at the method detection limit shown.
J Value an estimate; sample was not field acidified for preservation.
H Samples age exceeded holding time.


North
0
1000
2000
SCALE IN FEET
10
Line of equal
water depth
Interval 2 and 3 feet
7
7
5
3
Loomis Lake - Pacific County
From Washington Department of Game, July, 1950.
Sample Location


DEPTH (meters)
0.0
0.4
0.9
1.3
1.7
2.0
6.6
11.2
15.8
20.4
25.0
June
Sept
TEMPERATURE C


DEPTH (meters)
0.0
0.4
0.9
1.3
1.7
0.0
10.0
20.0
June
Sept
DISSOLVED OXYGEN mg/L


DEPTH (meters)
0.0
0.4
0.9
1.3
1.7
5.5
6.5
7.5
8.5
9.5
10.5
June
Sept
pH


DEPTH (meters)
0.0
0.4
0.9
1.3
1.7
0.0
20.0
40.0
60.0
80.0
100.0
June
Sept
% LIGHT TRANSMISSION

MERRILL LAKE - COWLITZ COUNTY

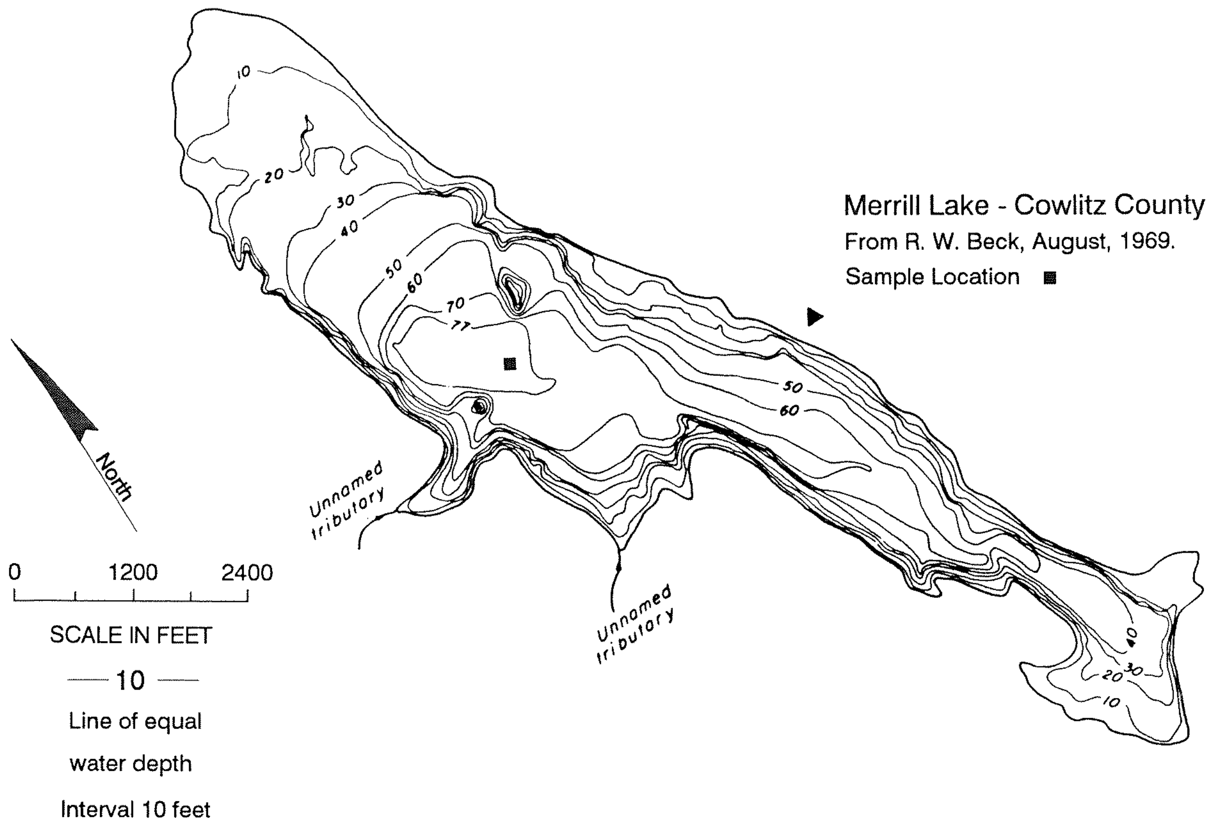
Merrill Lake is located two miles north of Cougar, Washington, within the Kalama River Basin. Its surface area is variable due to wide seasonal fluctuations in water level, but reports range from 344 acres (Wolcott, 1973a) to 490 acres (Bortleson, *et al.*, 1976d). Merrill's drainage area is 9.1 square miles and measured maximum depth was 53 feet. There were indications the lake level was down considerably in September compared to June. Inflow is from three perennial unnamed tributaries, in addition to smaller intermittent streams. There were no visible outflows and drainage is thought to be by seepage northerly to the Kalama River. There was no residential development on the lake and the drainage basin remains dominated by forest.

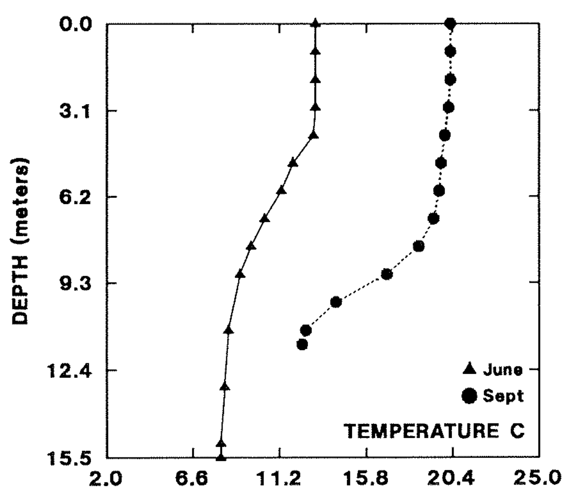
All three trophic state indices estimate that Merrill Lake is oligotrophic. It was thermally stratified in both June and September. Relative to other survey lakes, Merrill ranked low in nutrients. Ratios of TN to TP indicate in June the lake was nitrogen limited and by fall there was uncertainty as to which nutrient was limiting, nitrogen and/or phosphorus. Merrill Lake had the highest transparency of all lakes both sample dates. No surface algal blooms or macrophytes were observed during sampling. Water color was green. An estimated 20 percent of the watershed had recently been clearcut. If clearcutting is continued within the drainage, Merrill Lake should be monitored for nutrient increases. Logging practices within the basin may pose a threat to the future trophic status of this lake.

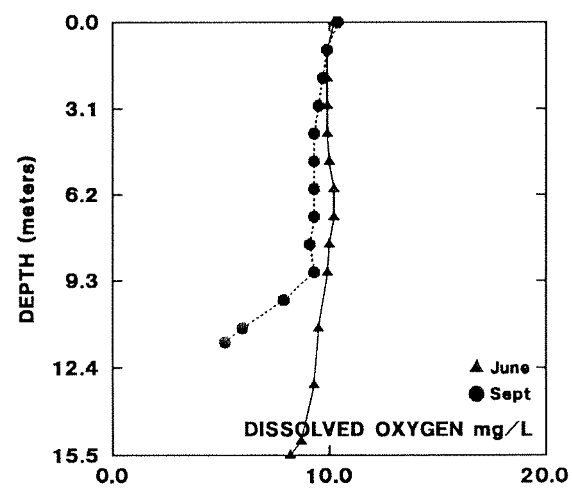
MERRILL LAKE - COWLITZ COUNTY
1990 WATER QUALITY DATA

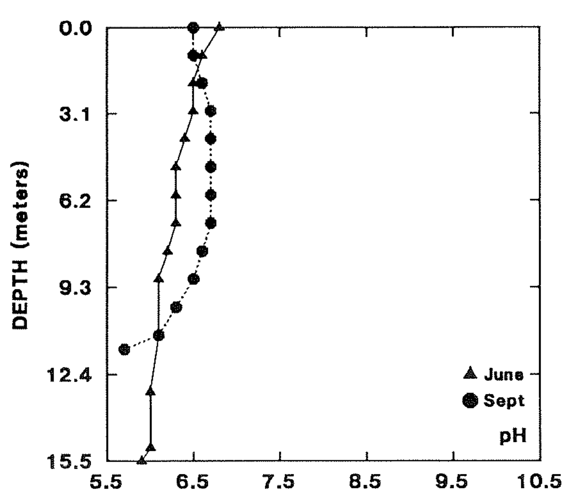
Parameter (mg/L unless noted)	June 12 E	June 12 H	Sept. 11 E	Sept. 11 H
Depth (m)(composite sample)	0,1.5,3	12,13,14	1,3,6	9,10,11
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006U	0.008	0.006U	0.013
Ammonia (NH_3-N)	0.011	0.012	0.003U	0.010
Total Nitrogen (TN)	0.048	0.059	0.120	0.080
Orthophosphate (PO_4-P)	0.004	0.002	-	0.006
Total Phosphorus (TP)	0.010J	0.007J	0.010	0.013
Nitrogen/Phosphorus ratio (TN/TP)	4.8	8.4	12.0	6.2
Specific Conductance (umhos/cm)	26	32	28	27
Turbidity (NTU)	1.1	-	0.6	-
Chlorophyll-*a* (μg/L)	1.0	-	0.8	-
Secchi disc (m)	5.5		7.5	
Fecal Coliform (#/100 mL)	0		0H	
Predominant Algae	-		-	
Macrophytes present	-		-	
Trophic State Index				
TSI_{SD}	35		31	
TSI_{TP}	37		37	
TSI_{Chl}	31		28	

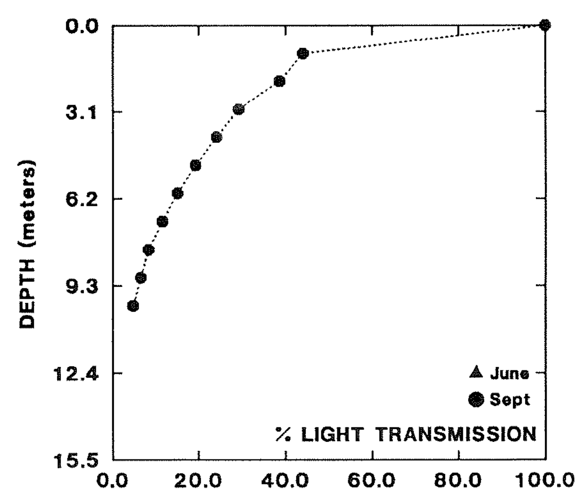
U Analyte was not found at the method detection limit shown.
J Value an estimate; sample was not field acidified for preservation.
H Samples age exceeded holding time.


Merrill Lake - Cowlitz County
From R. W. Beck, August, 1969.
Sample Location
North
0
1200
2400
SCALE IN FEET
10
Line of equal
water depth
Interval 10 feet
Unnamed tributary
Unnamed tributary
10
20
30
40
50
60
70
77
50
60
40
30
20
10


DEPTH (meters)
0.0
3.1
6.2
9.3
12.4
15.5
2.0
6.6
11.2
15.8
20.4
25.0
June
Sept
TEMPERATURE C


DEPTH (meters)
0.0
3.1
6.2
9.3
12.4
15.5
0.0
10.0
20.0
June
Sept
DISSOLVED OXYGEN mg/L


DEPTH (meters)
0.0
3.1
6.2
9.3
12.4
15.5
5.5
6.5
7.5
8.5
9.5
10.5
June
Sept
pH


DEPTH (meters)
0.0
3.1
6.2
9.3
12.4
15.5
0.0
20.0
40.0
60.0
80.0
100.0
June
Sept
% LIGHT TRANSMISSION

LAKE NAHWATZEL - MASON COUNTY

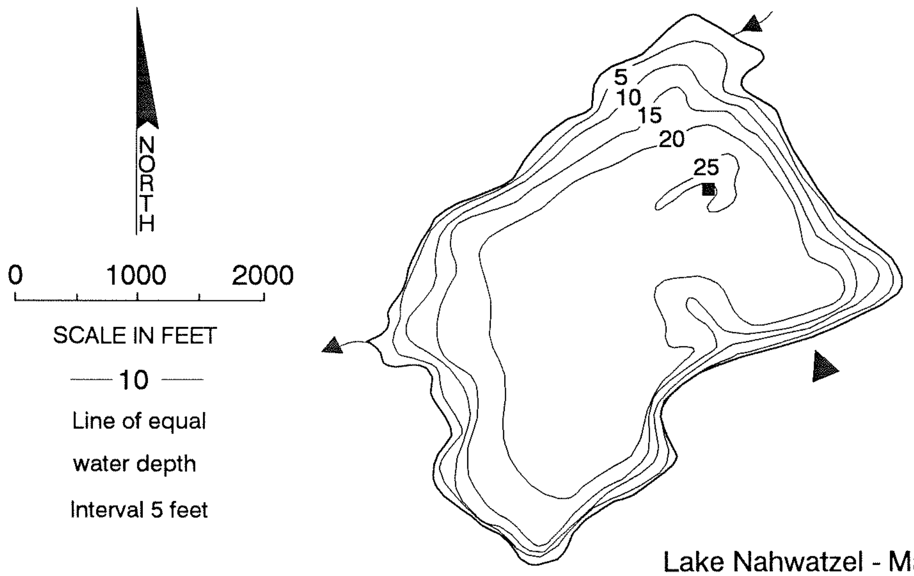
Lake Nahwatzel is located 11 miles west of Shelton, Washington, within the Chehalis River Basin. Its surface area is 270 acres and drainage basin is 6.2 square miles. Nahwatzel has a mean depth of 17 feet and a maximum depth of 25 feet. Inflow is from a perennial unnamed stream, and it drains via Outlet Creek to the East Fork of the Satsop River. A reported 70 percent of the shoreline is residentially developed and drainage basin land use is 91 percent forest or unproductive (Sumioka and Dion, 1985).

The TP index estimates Lake Nahwatzel is oligotrophic. However, the generally more reliable chlorophyll-*a* and Secchi disc indices were lower oligo-mesotrophic and were given priority. Chlorophyll-*a* and Secchi disc indices were the same in June and September while the TP had slightly increased by fall. There was no thermal stratification in either June or September, although near bottom samples were taken in June. Dissolved oxygen was high throughout the water column. Relative to other lakes, Nahwatzel was low in nutrients. It had the lowest nitrate-plus-nitrite and specific conductance during both survey months. There were no obvious surface algal blooms and submerged macrophytes were sparse. *Scirpus* was found along an estimated 40 percent of the shoreline. Water color was a moderate green.

LAKE NAHWATZEL - MASON COUNTY
1990 WATER QUALITY DATA

Parameter (mg/L unless noted)	June 13		Sept. 12	
	E	H	E	H
Depth (m)(composite sample)	0,1,2	5,6,7	1,3,5	-
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006U	0.006U	0.006U	-
Ammonia (NH_3-N)	0.016	0.011	0.006	-
Total Nitrogen (TN)	0.147	0.170	0.209	-
Orthophosphate (PO_4-P)	0.005	0.005	0.004	-
Total Phosphorus (TP)	0.007J	0.008J	0.010	-
Nitrogen/Phosphorus ratio (TN/TP)	21.0	21.3	20.9	-
Specific Conductance (umhos/cm)	23	26	24	-
Turbidity (NTU)	1.2	-	0.7	-
Chlorophyll-*a* (μg/L)	2.2	-	2.2	-
Secchi disc (m)	4.2		4.3	
Fecal Coliform (#/100 mL)	2		2	
Predominant Algae	-		-	
Macrophytes present	*Scirpus*, *Iris pseudacorus*, Campanulaceae, Cyperaceae			
Trophic State Index				
TSI_{SD}	39		39	
TSI_{TP}	32		37	
TSI_{Chl}	38		38	

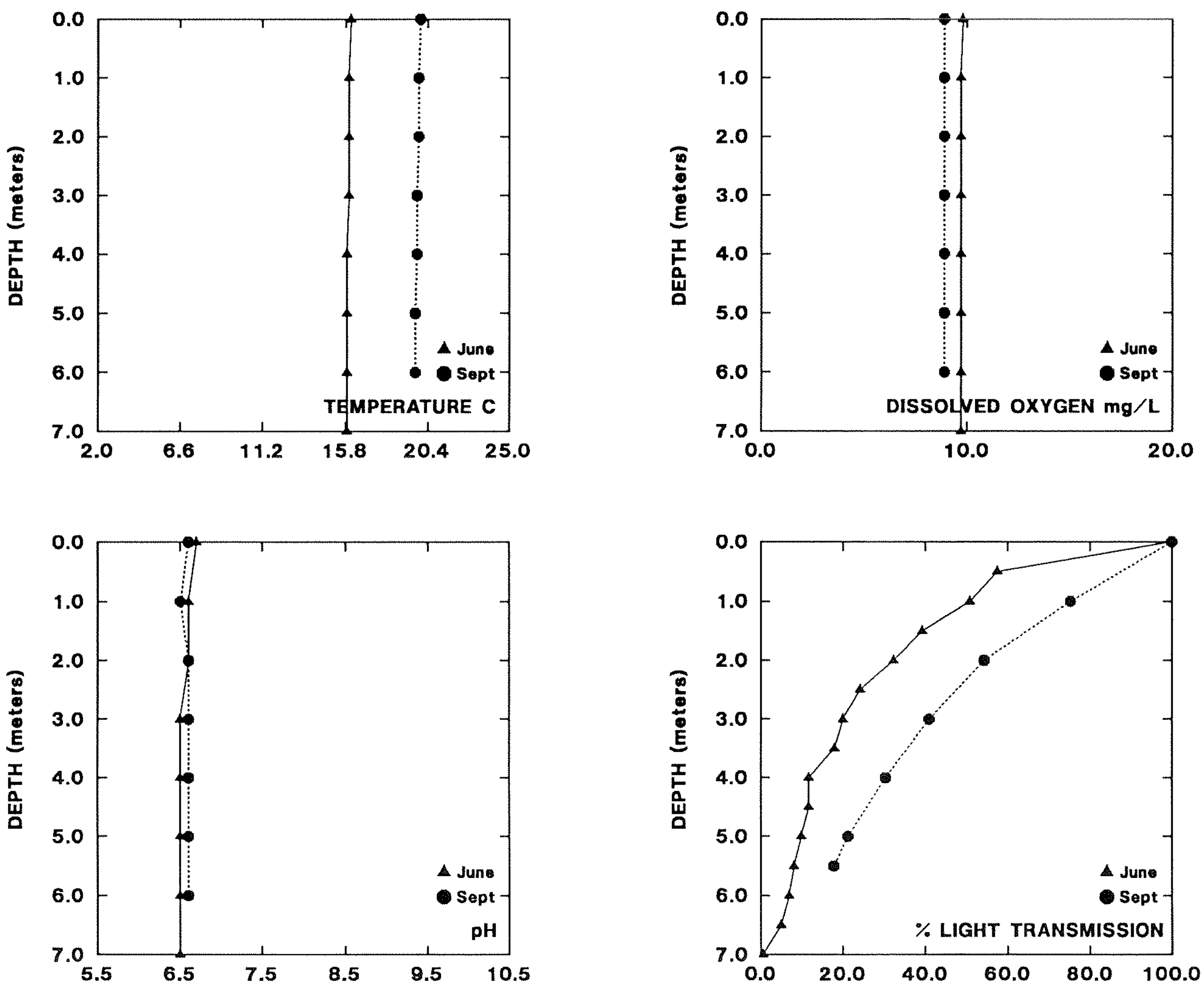
J Value an estimate; sample was not field acidified for preservation.
U Analyte was not found at the method detection limit shown.



Lake Nahwatzel - Mason County

From Washington Department of Game, June, 1949.

Sample Location ■



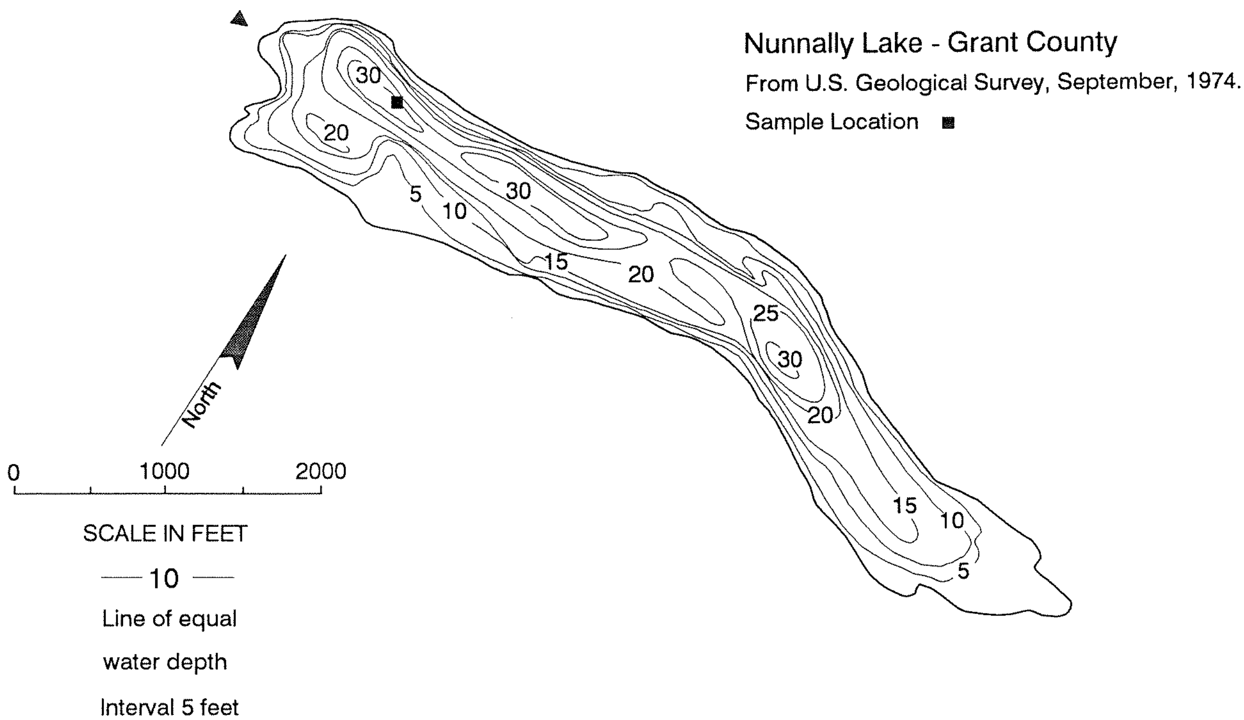
NUNNALLY LAKE - GRANT COUNTY

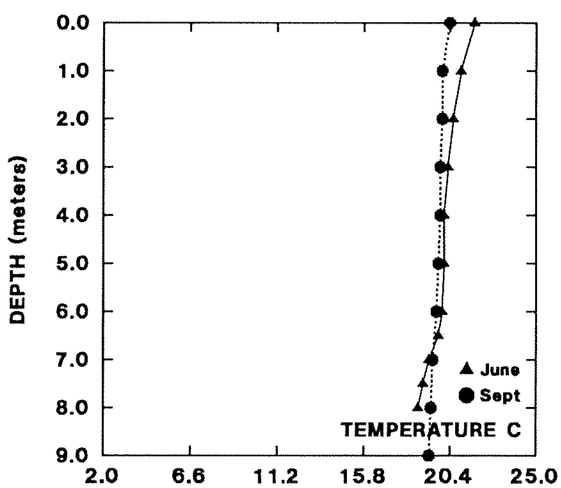
Nunnally Lake is located 34 miles west of Othello, Washington, within the Crab Creek Basin. It has a surface area of 120 acres and the second largest drainage basin of all lakes surveyed (33.8 square miles). Nunnally's mean depth is 13 feet and maximum depth is 34 feet. The inflow is intermittent. Only one residence was observed on the lake. Nunnally's drainage area is dominated by agriculture. Recreational use of the lake is reported to be heavy (Dion *et al.*, 1976b).

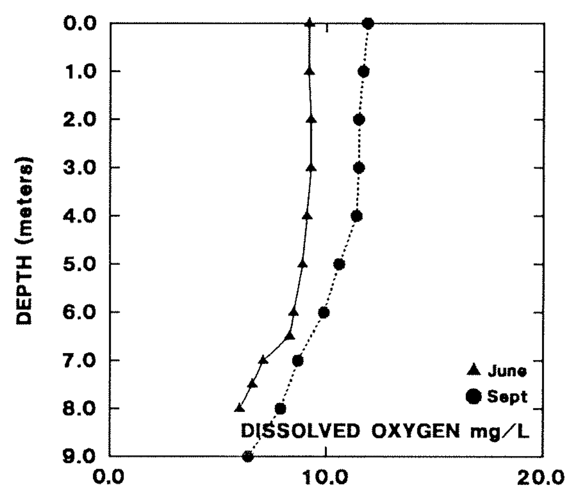
Based on the chlorophyll-*a* index Nunnally Lake is estimated as mesotrophic. The average TP and Secchi disc indices estimate an oligo-mesotrophic classification, however, the chlorophyll-*a* parameter was given priority. It was not thermally stratified in either June or September. Near-bottom samples were taken in June. Nunnally ranked mid-range for nutrients relative to other survey lakes. It had the largest increase in nitrate-plus-nitrite from June to September of all survey lakes. Nunnally ranked the highest for nitrate-plus-nitrite and second highest for ammonia in September. It had the second highest transparency in the fall, although aggregate clumps of the algae, *Oscillatoria* (blue-green), were observed on the surface. Most, if not all, of the lake bottom was covered with macrophytes. Water color was green. The large June to September increase in nitrate-plus-nitrite, high TN:TP ratio and high percentage of agriculture in the drainage suggests any increases in phosphorus could pose a threat to the future trophic status of the lake.

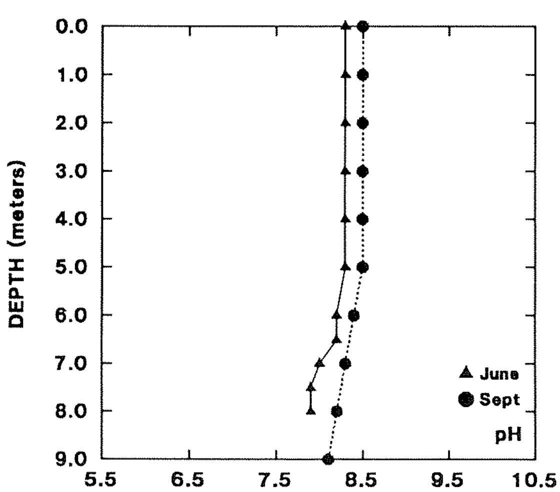
NUNNALLY LAKE - GRANT COUNTY
1990 WATER QUALITY DATA

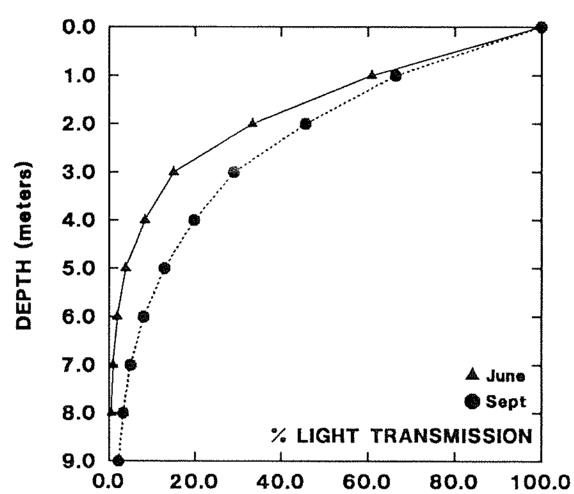
Parameter (mg/L unless noted)	June 25 E	June 25 H	Sept. 24 E	Sept. 24 H
Depth (m)(composite sample)	0,1.5,3	7,8	1,5,9	-
Nitrate + Nitrite (NO_3 + NO_2-N)	0.016	0.027	0.332	-
Ammonia (NH_3-N)	0.008	0.019	0.031	-
Total Nitrogen (TN)	0.473	0.481	0.594	-
Orthophosphate (PO_4-P)	-	-	0.014	-
Total Phosphorus (TP)	0.008	0.019	0.015	-
Nitrogen/Phosphorus ratio (TN/TP)	59.1	25.3	39.6	-
Specific Conductance (umhos/cm)	338	357	301	-
Turbidity (NTU)	1.4	-	1.3	-
Chlorophyll-*a* (μg/L)	8.9	-	3.3	-
Secchi disc (m)	2.3		5.9	
Fecal Coliform (#/100 mL)	0		0	
Predominant Algae	-		*Oscillatoria*	
Macrophytes present	*Potamogeton, Nitella, Typha latifolia, Chara, Scirpus*			
Trophic State Index				
TSI_{SD}	48		34	
TSI_{TP}	34		43	
TSI_{Chl}	52		42	


Nunnally Lake - Grant County
From U.S. Geological Survey, September, 1974.
Sample Location ■
North
0 1000 2000
SCALE IN FEET
— 10 —
Line of equal
water depth
Interval 5 feet


DEPTH (meters)
▲ June
● Sept
TEMPERATURE C


DEPTH (meters)
▲ June
● Sept
DISSOLVED OXYGEN mg/L


DEPTH (meters)
▲ June
● Sept
pH


DEPTH (meters)
▲ June
● Sept
% LIGHT TRANSMISSION

SIDLEY LAKE - OKANOGAN COUNTY

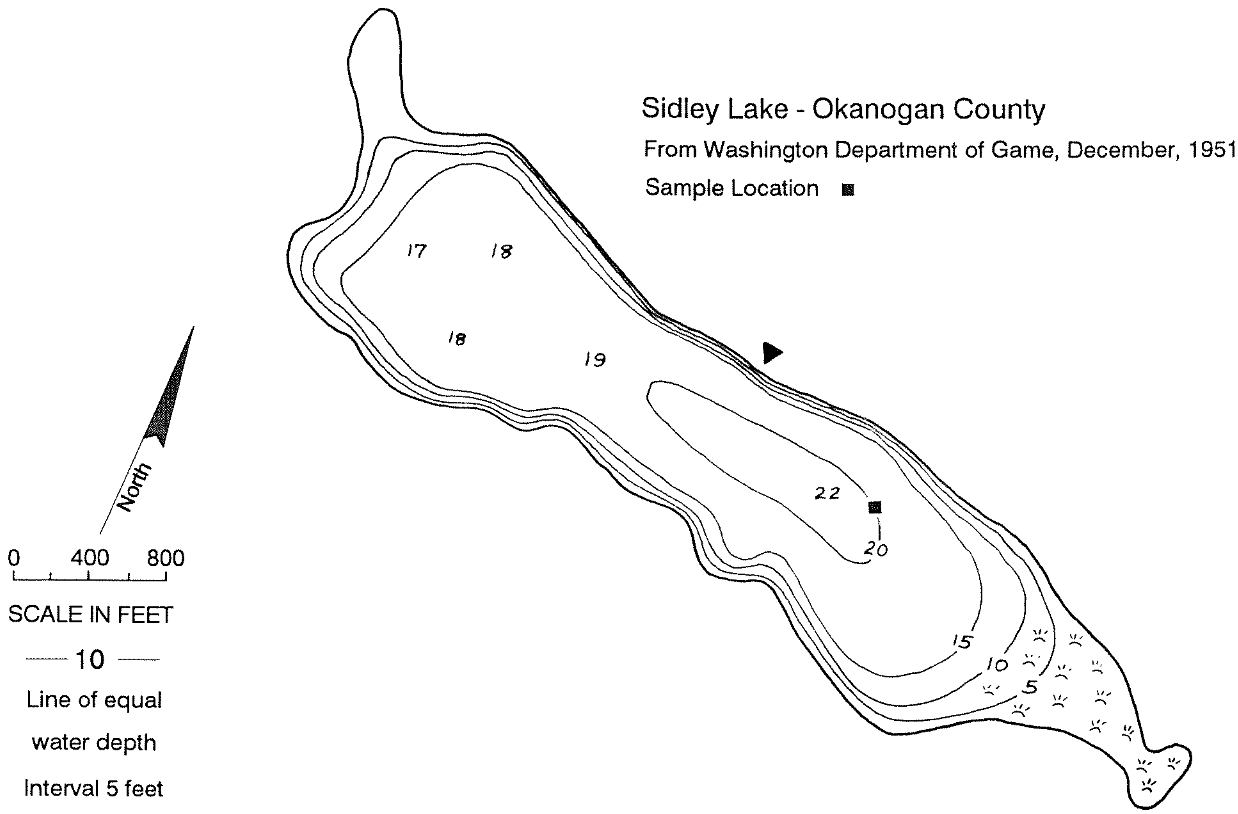
Sidley Lake is located 0.7 miles northwest of Molson, Washington, within the Kettle River Basin. It has a surface area of 120 acres and drains 2.5 square miles. Sidley Lake has a mean depth of 15 feet, with a maximum depth of 22 feet and no visible surface inflow or outflow. There is an aerator located at the west end of the lake, which is operated by the Department of Wildlife to maintain Sidley's dissolved oxygen levels to support trout plantings. There is very little residential development and slightly more agriculture than forest/unproductive land use in the drainage.

The chlorophyll-*a* and Secchi disc indices estimate Sidley Lake is upper meso-eutrophic. However, considering the high spring TP and the lake's productivity it is estimated as eutrophic. During spring, the dissolved oxygen increased below 2 meters of depth, likely a result of algal productivity. Algae in this portion of the water column would not have been included in the chlorophyll-*a* composite. Abundant zooplankton were observed in water samples in June. The lake was thermally stratified in June and had turned over by September. Sidley's conductivity was unusually high, nearly two-fold higher than any other survey lake. Relative to other lakes, nutrients in Sidley Lake ranked mid-range in June and high in September. It had the second highest total nitrogen in both months and second lowest transparency in September. Sidley displayed the second highest increase from June to September in chlorophyll-*a*. A slight surface algal bloom was noticed in both months. Macrophytes were not dense, but the bottom was covered with an aquatic moss. Cattle were numerous around the lake in June. The water color was "pea" green in September.

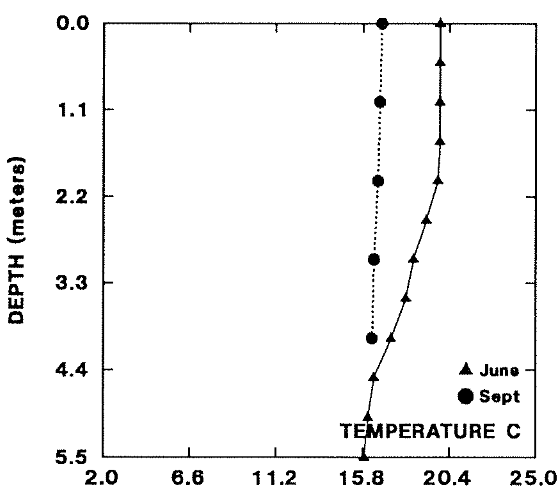
SIDLEY LAKE - OKANOGAN COUNTY
1990 WATER QUALITY DATA

	June 27		Sept. 26	
Parameter (mg/L unless noted)	E	H	E	H
Depth (m)(composite sample)	0,1,2	5.5	1,2,4	-
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006U	0.006U	0.006U	-
Ammonia (NH_3-N)	0.005	0.006	0.036	-
Total Nitrogen (TN)	1.430	1.630	1.750	-
Orthophosphate (PO_4-P)	0.004	0.004	0.019	-
Total Phosphorus (TP)	0.031	0.045	0.046	-
Nitrogen/Phosphorus ratio (TN/TP)	46.1	36.2	38.0	-
Specific Conductance (umhos/cm)	2114	2120	2308	-
Turbidity (NTU)	1.1	-	2.8	-
Chlorophyll-*a* (μg/L)	3.4	-	14.5	-
Secchi disc (m)	3.0		1.2	
Fecal Coliform (#/100 mL)	1		2	
Predominant Algae	*Microcystis*		*Gonyaulax, Microcystis, Chroococcus*	
Macrophytes present	*Scirpus, Potamogeton pectinatus, Chara, Nitella*			
Trophic State Index				
TSI_{SD}	44		57	
TSI_{TP}	54		59	
TSI_{Chl}	43		57	

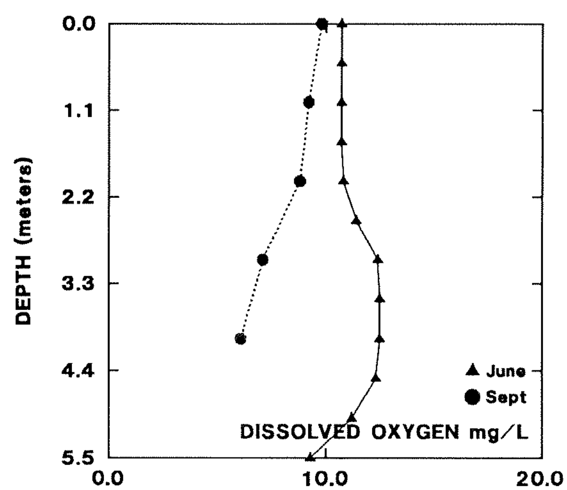
U Analyte was not found at the method detection limit shown.



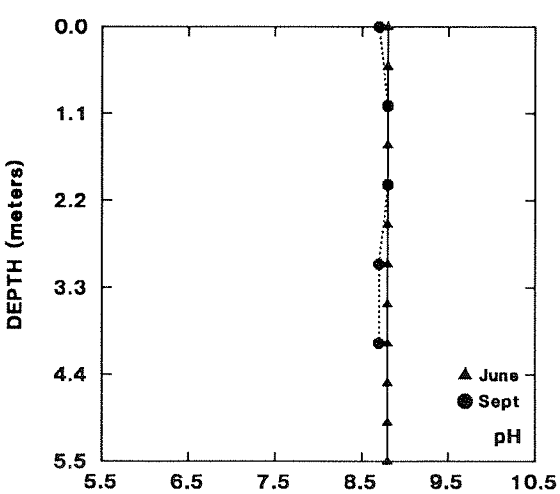
Sidley Lake - Okanogan County
From Washington Department of Game, December, 1951.
Sample Location
North
0 400 800
SCALE IN FEET
10
Line of equal
water depth
Interval 5 feet
17
18
18
19
22
20
15
10
5



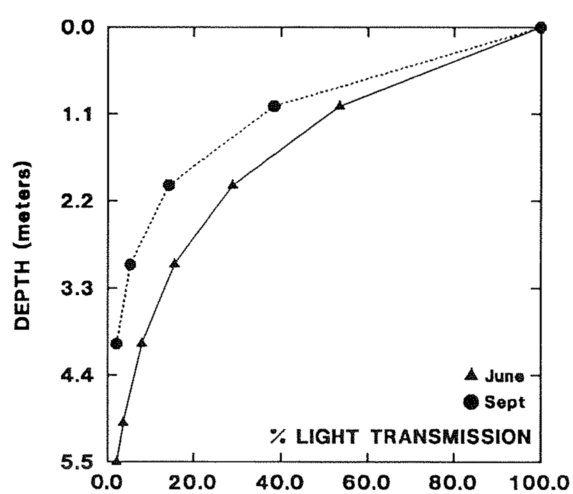
DEPTH (meters)
June
Sept
TEMPERATURE C



DEPTH (meters)
June
Sept
DISSOLVED OXYGEN mg/L



DEPTH (meters)
June
Sept
pH



DEPTH (meters)
June
Sept
% LIGHT TRANSMISSION

LAKE ST. CLAIR (South Arm) - THURSTON COUNTY

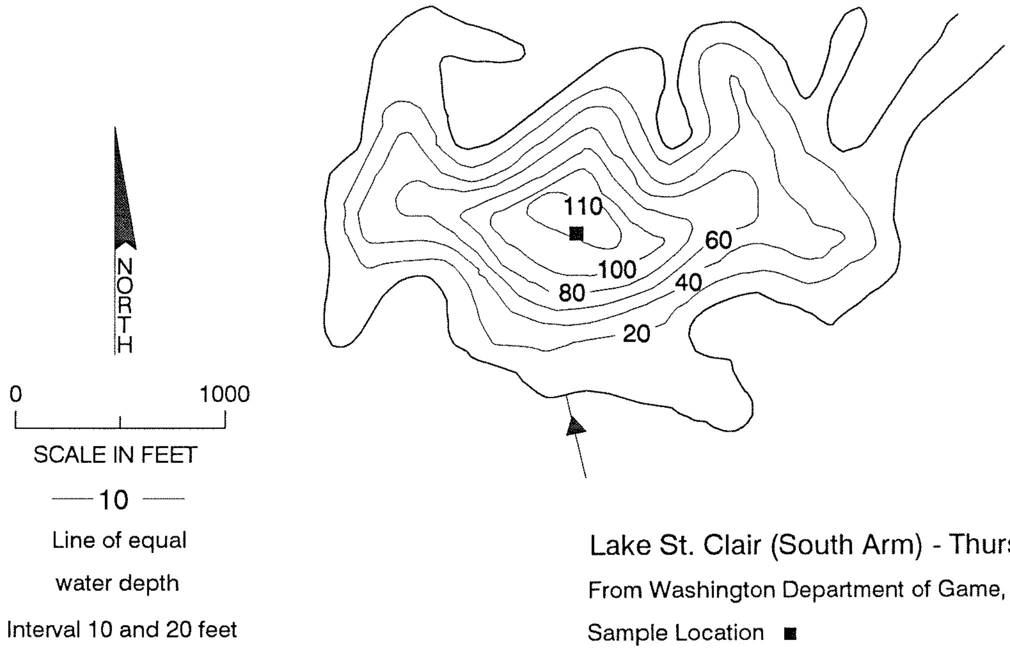
Lake St. Clair is located 6.5 miles northwest of Yelm, Washington, within the Nisqually River Basin. The south arm of Lake St. Clair is the largest basin of the lake and is connected to the north arm by a shallow narrow channel. It has a surface area of 88 acres and drains 14.5 square miles. The south arm of Lake St. Clair has a mean depth of 41 feet, and was one of the deepest lakes surveyed, with a maximum depth of 110 feet. There is a perennial inflow from Eaton Creek. Sumioka and Dion (1985) report shoreline development at 50 percent and agricultural and forest or unproductive land use in the drainage at 29 and 70 percent, respectively. This lake receives heavy recreational use.

All three trophic state indices estimate that the south arm of Lake St. Clair is eutrophic. It was thermally stratified in both June and September. Nutrients from St. Clair's south arm were high relative to other lakes. Fecal coliform (surface) was second highest in both months. Dissolved oxygen dropped to anoxic conditions at 3 meters, pulsed, then resumed anoxia in both June and September. The temperature profile suggests there may have been a density gradient at 3 meters able to suspend sedimenting organic matter to decompose and deplete dissolved oxygen. St. Clair's morphological features could also be responsible for the lack of dissolved oxygen at 3 meters. A layer of anoxic water from large shallow areas where organic sediments have lowered dissolved oxygen levels may have spread horizontally across the lake (Cole, 1979). Also possible is a layer of anoxic water from groundwater inflow. A slight surface algal bloom was noticed in September. St. Clair's south arm supports dense macrophyte growth. Water is a "tea" color, likely from humic materials from the drainage basin and resulted in poor light transmission.

LAKE ST. CLAIR (South Arm) - THURSTON COUNTY
1990 WATER QUALITY DATA

Parameter (mg/L unless noted)	June 11 E	June 11 H	Sept. 19 E	Sept. 19 H
Depth (m)(composite sample)	0,1,2	25,26.5,28	1,2,3	8,18,25
Nitrate + Nitrite (NO_3 + NO_2-N)	0.086	0.172	0.017	0.351
Ammonia (NH_3-N)	0.034	-	0.018	0.592
Total Nitrogen (TN)	0.625	4.000	0.656	1.570●
Orthophosphate (PO_4-P)	-	1.187	0.015	0.196
Total Phosphorus (TP)	0.035J	1.330J	0.025	0.209
Nitrogen/Phosphorus ratio (TN/TP)	17.9	3.0	26.2	7.5
Specific Conductance (umhos/cm)	97	183	109	111
Turbidity (NTU)	3.0	-	2.2	-
Chlorophyll-*a* (μg/L)	11.6	-	10.1	-
Secchi disc (m)	1.5		1.7	
Fecal Coliform (#/100 mL)	11		4	
Predominant Algae	-		*Aphanizomenon*	
Macrophytes present	*Typha latifolia, Nymphaea odorota, Iris pseudacorus, Elodea canadensis, Valisneria americana, Nitella, Potamogeton amplifolius, P. zosteriformis, Scirpus, Ceratophyllum demersum,* Sedge			
Trophic State Index				
TSI_{SD}	54		52	
TSI_{TP}	55		51	
TSI_{Chl}	55		53	

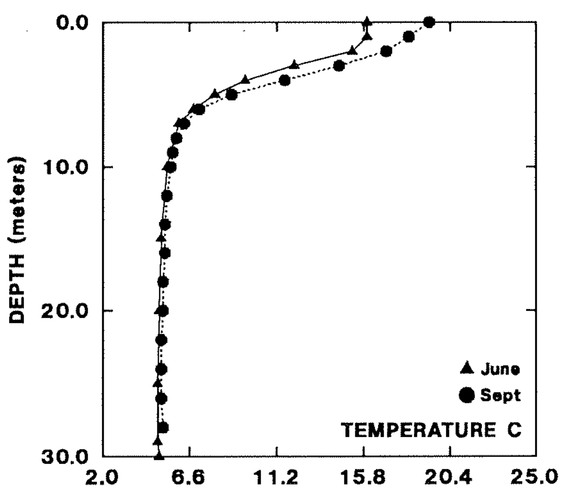
● Sample was filtered in the lab; result may or may not be biased low.
J Value an estimate; sample was not field acidified for preservation.

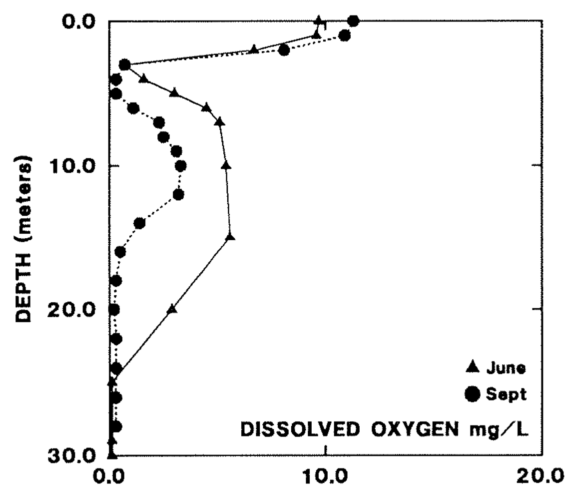


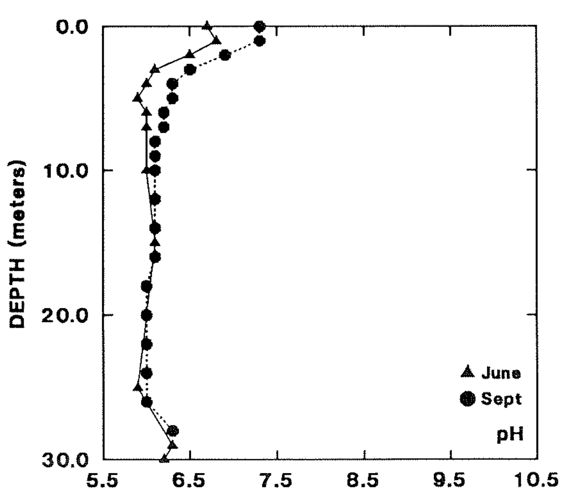
Lake St. Clair (South Arm) - Thurston County

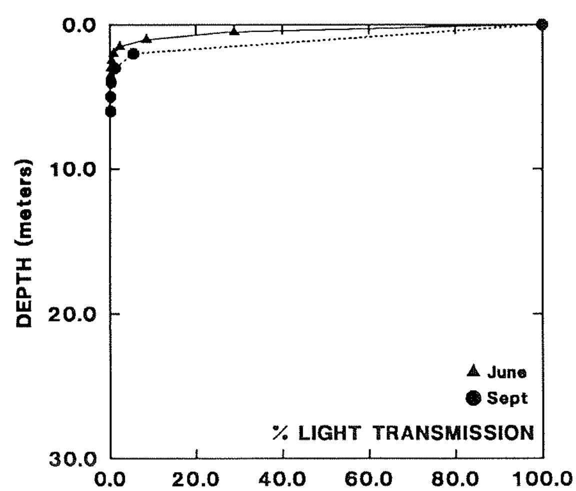
From Washington Department of Game, February, 1951.

Sample Location ■









TANWAX LAKE - PIERCE COUNTY

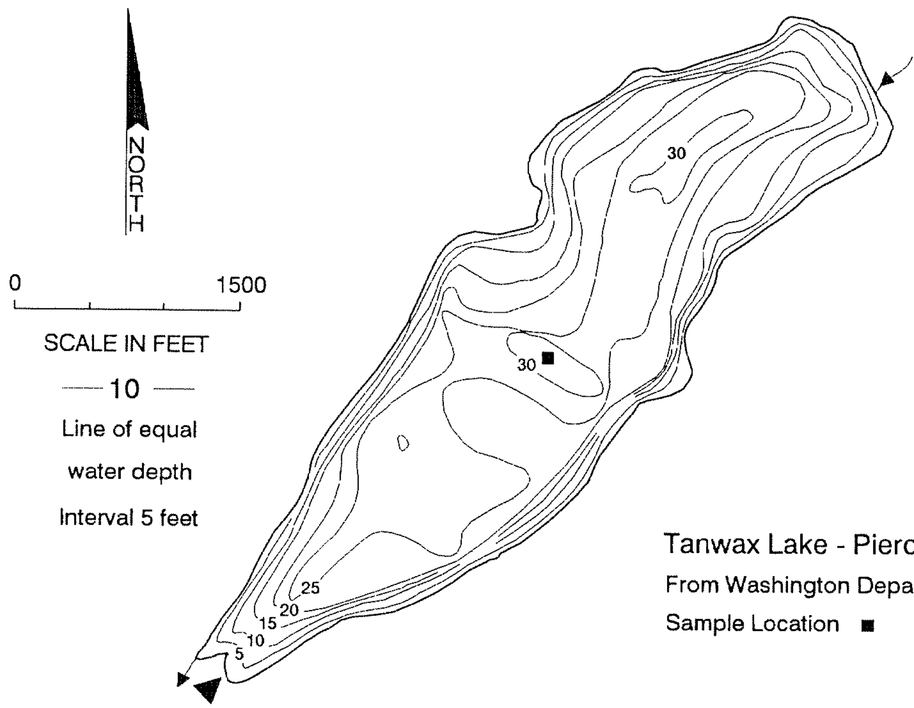
Tanwax Lake is located 5.5 miles north of Eatonville, Washington, within the Nisqually River Basin. It has a surface area of 170 acres and drains 4.1 square miles. Tanwax has a mean depth of 20 feet and a maximum depth of 30 feet. The lake is fed by the Benbow Lakes group (Wolcott, 1973a). Outflow is to Tanwax Creek. Shoreline development is a reported 70 percent and the drainage basin is 62 percent forest or unproductive (Sumioka and Dion, 1985).

All three trophic state indices estimate that Tanwax Lake is eutrophic. Other eutrophic characteristics of the lake include the anoxic hypolimnion, high spring nutrient concentrations and the presence of blue-green algae species. Relative to other lakes, Tanwax ranked high in June and mid-range in September for nutrients. It had the highest chlorophyll-*a* in June, and second highest chlorophyll-*a* and highest fecal coliform in September. Dissolved oxygen decreased to anoxic conditions below 3 meters in September. A surface algal bloom was visible both June and September. No submerged macrophytes were found, although Tanwax Lake supports a large floating-leaved population dominated by *Nuphar*. Water was "tea" colored in June and "pea" green in September.

TANWAX LAKE - PIERCE COUNTY
1990 WATER QUALITY DATA

Parameter (mg/L unless noted)	June 11		Sept. 10	
	E	H	E	H
Depth (m)(composite sample)	0,1.5,3	6.5,7	1,2	4,4.5
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006U	0.006U	0.006U	0.006U
Ammonia (NH_3-N)	0.016	0.293	0.019	0.025
Total Nitrogen (TN)	0.556	0.740	0.869	0.573●
Orthophosphate (PO_4-P)	0.013	0.115	0.013	0.037
Total Phosphorus (TP)	0.029J	0.140J	0.032	0.053●
Nitrogen/Phosphorus ratio (TN/TP)	19.2	5.3	27.2	10.8
Specific Conductance (umhos/cm)	70	96	76	102
Turbidity (NTU)	2.3	-	3.2	-
Chlorophyll-*a* (μg/L)	15.4	-	18.1	-
Secchi disc (m)	1.3		1.4	
Fecal Coliform (#/100 mL)	6		5H	
Predominant Algae	*Aphanizomenon flos-aquae*		*Anabaena*	
Macrophytes present	*Nuphar polysepalum, Nymphaea ordorata, Typha latifolia, Scirpus, Utricularia vulgaris, Iris pseudacorus, Equisetum fluviatile, Vallisneria americana*			
Trophic State Index				
TSI_{SD}	56		55	
TSI_{TP}	53		54	
TSI_{Chl}	57		59	

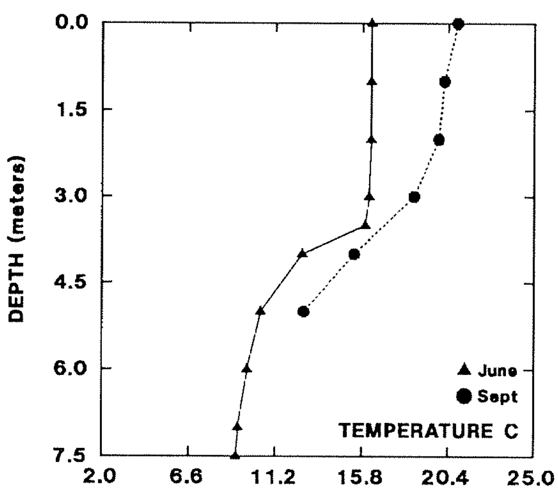
U Analyte was not found at the method detection limit shown.
● Sample was filtered in the lab; result may or may not be biased low.
J Value an estimate; sample was not field acidified for preservation.
H Samples age exceeded holding time.

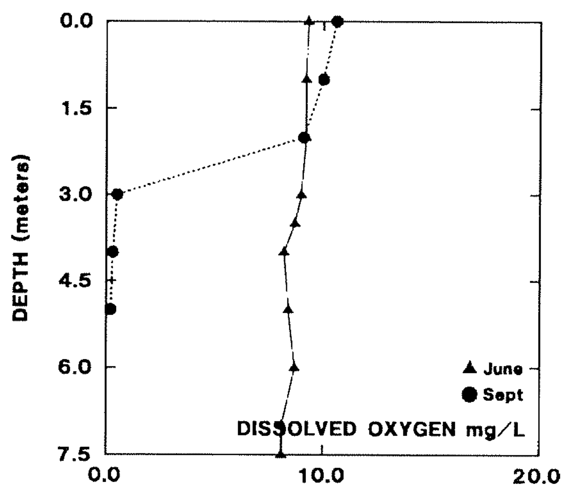


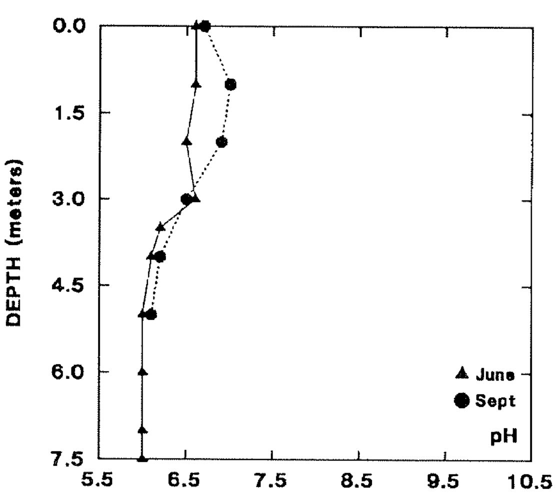
Tanwax Lake - Pierce County

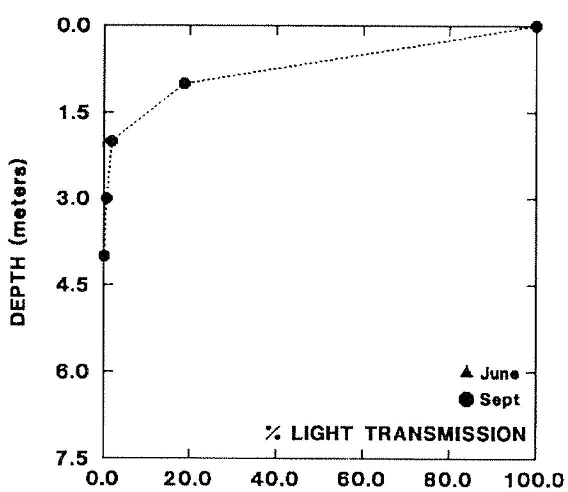
From Washington Department of Game, June, 1952.

Sample Location ■









WAITTS LAKE -STEVENS COUNTY

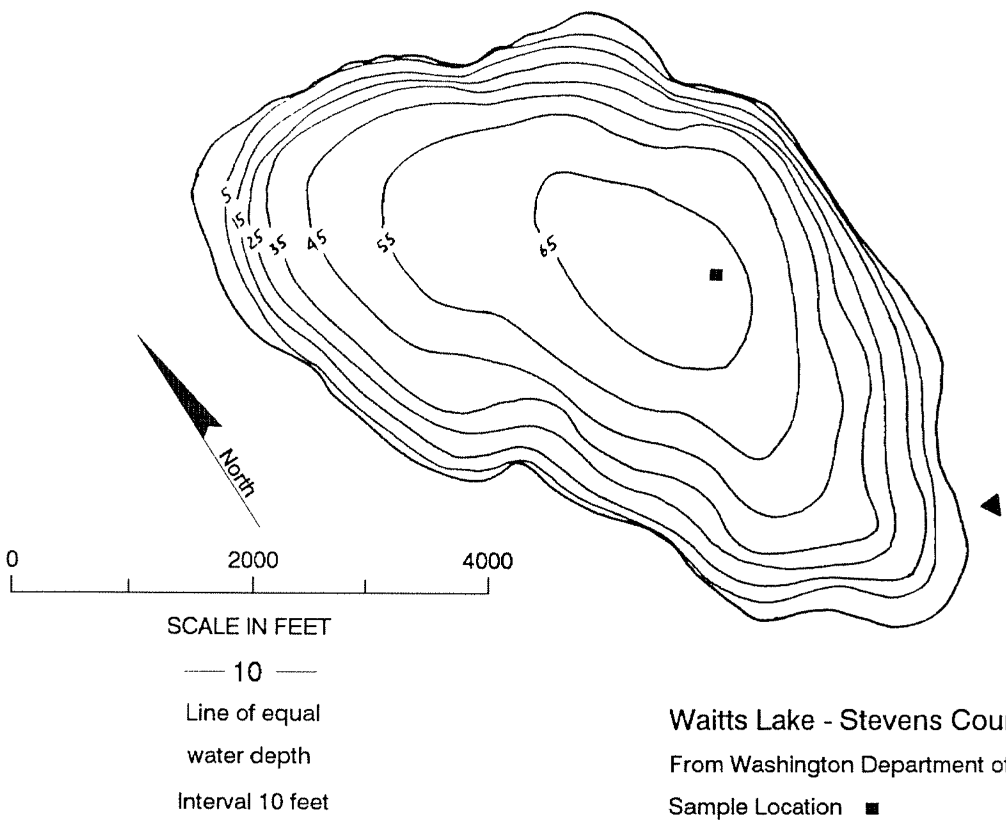
Waitts Lake is located seven miles south of Chewelah, Washington, within the Pend Oreille River Basin. It has a surface area of 470 acres and drains 11.7 square miles. Waitts Lake has a mean depth of 40 feet and a maximum depth of 68 feet. Inflow is from Waitts Creek, a perennial stream from the southwest and two intermittent unnamed streams. Discharge is also to Waitts Creek to the northeast. Residential development of the lakeshore is reported at 55 percent and land use in the drainage basin is 79 percent forest or unproductive (Sumioka and Dion, 1985). This lake is stabilized by a low dam.

Although all three trophic state indices suggest Waitts Lake is oligotrophic, an oligo-mesotrophic status seems more appropriate for the following reasons: bottom waters were anoxic; hydrogen sulfide was detected in bottom samples; and the presence of blue-green algae. Waitts Lake had a well defined thermocline in both June and September. Relative to other survey lakes, Waitts ranked mid-range in June and low mid-range in September for nutrients. Waitts tied for the highest transparency in September. A dissolved oxygen pulse occurred within the metalimnion both months. This was likely due to productivity by algae and would not have been represented in the chlorophyll-*a* composite. This suggests TSI_{Chl} was not representative of the lake's productivity. After the June and September pulse, a sharp decline to anoxic conditions was measured. In September, clumps of *Gloeotrichia* were seen on the surface, heavy marl deposits were observed on submergent macrophytes and the odor of hydrogen sulfide was noticed in bottom samples. Water color was clear in June and light green in September.

WAITTS LAKE - STEVENS COUNTY
1990 WATER QUALITY DATA

Parameter (mg/L unless noted)	June 26		Sept. 25	
	E	H	E	H
Depth (m)(composite sample)	0,1.5,3	13,17,21	1,3,6	12,14,16
Nitrate + Nitrite (NO_3 + NO_2-N)	0.006	0.008	0.006U	0.006U
Ammonia (NH_3-N)	0.003U	0.557	0.010	0.315
Total Nitrogen (TN)	0.412	1.210	0.403	1.115
Orthophosphate (PO_4-P)	0.005	0.086	0.006	0.037
Total Phosphorus (TP)	0.010	0.126	0.008	0.069
Nitrogen/Phosphorus ratio (TN/TP)	41.2	9.6	50.4	16.2
Specific Conductance (umhos/cm)	257	293	255	289
Turbidity (NTU)	1.1	-	0.6	-
Chlorophyll-*a* (μg/L)	1.7	-	1.5	-
Secchi disc (m)	4.2		7.5	
Fecal Coliform (#/100 mL)	0		0	
Predominant Algae	-		*Gloeotrichia*	
Macrophytes present	*Nuphar polysepalum, Potamogeton pectinatus, P. illinoensis, Chara, Myriophyllum, Scirpus, Ceratophyllum demersum, Elodea canadensis, Typha*			
Trophic State Index				
TSI_{SD}	39		31	
TSI_{TP}	37		34	
TSI_{Chl}	36		35	

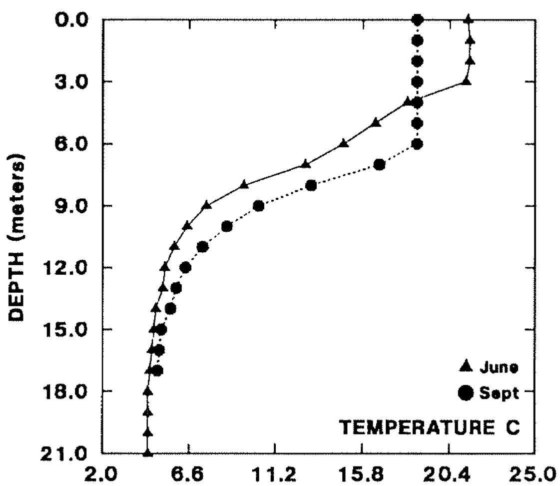
U Analyte was not found at the method detection limit shown.

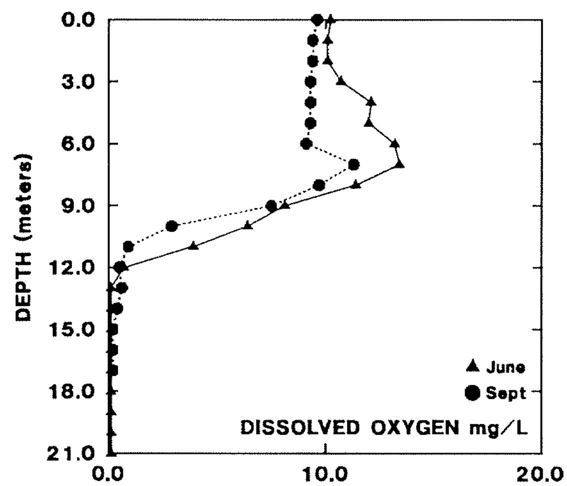


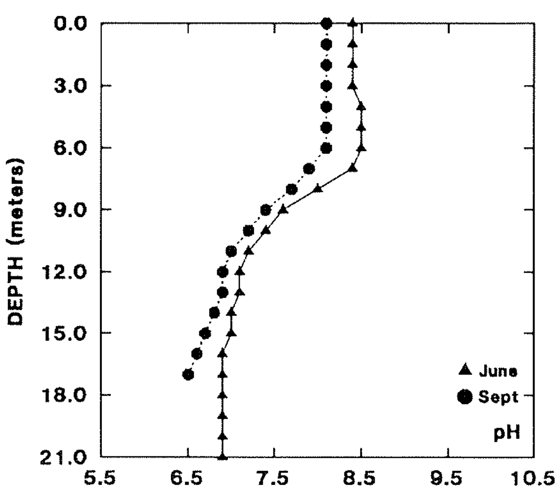
Waitts Lake - Stevens County

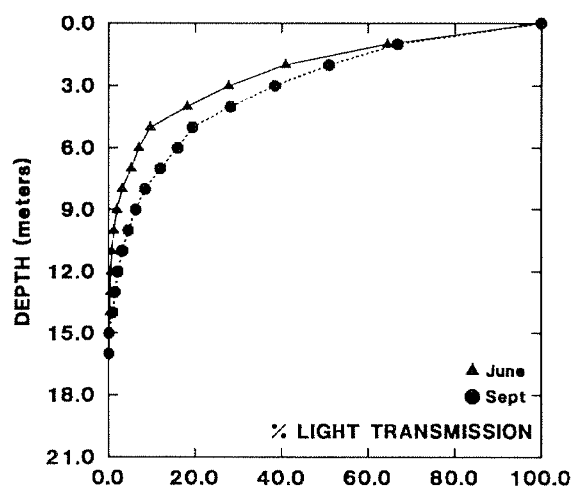
From Washington Department of Game, February, 1954.

Sample Location ■









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APPENDICES

APPENDIX A. Quality control results for EPA standard reference materials and lab check standards.

Parameter	EPA Standard Reference Material measured	EPA Standard Reference Material actual	Mean Value (95% C.I.)*	Lab Check Standards measured	Lab Check Standards actual	Mean Value
Ammonia	188	200	199	29.0	25.0	25.9
(NH_3-N)	204	200	(148-251)	31.9	25.0	
(μg/L)	206	200		24.3	25.0	
				22.4	25.0	
	45.1	50.0	46.6	21.8	25.0	
	47.0	50.0	(12.8-89.8)			
	47.6	50.0		263	250	249
				235	250	
	2090	2000	2070			
	2080	2000	(1660-2300)			
	2030	2000				
	2070	2000				
	2080	2000				
Nitrate+Nitrite	0.209	0.200	0.211	0.290	0.300	0.308
(NO_3+NO_2-N)	0.212	0.200	(0.16-0.23)	0.307	0.300	
(mg/L)	0.210	0.200		0.300	0.300	
	0.213	0.200		0.331	0.300	
				0.310	0.300	
	0.051	0.050	0.053			
	0.053	0.050	(0.020-0.070)			
	0.056	0.050				
	0.051	0.050				
	2.02	2.00	1.97			
	2.03	2.00	(1.71-2.27)			
	1.98	2.00				
	1.83	2.00				
	1.98	2.00				
Total Nitrogen	0.258	0.250	0.246	0.302	0.300	0.294
(TN) (mg/L)	0.247	0.250	(0.13-0.47)	0.281	0.300	
	0.240	0.250		0.280	0.300	
	0.248	0.250		0.318	0.300	
	0.238	0.250		0.294	0.300	
				0.288	0.300	
	0.505	0.500	0.508			
	0.512	0.500	(0.35-0.74)			
	0.507	0.500				
	0.517	0.500				
	0.498	0.500				
	4.78	5.00	4.68			
	4.69	5.00	(4.07-5.83)			
	4.45	5.00				
	4.66	5.00				
	4.84	5.00				

* The reported 95% confidence interval defined as the mean recovery ± 2 standard deviations.

APPENDIX A. Quality control results for EPA standard reference materials and lab check standards (continued).

Parameter	EPA Standard Reference Material measured	EPA Standard Reference Material actual	Mean Value (95% C.I.)	Lab Check Standards measured	Lab Check Standards actual	Mean Value
Orthophosphate	13.8	12.5	14.1	19.1	20.0	20.0
(PO_4-P) (μg/L)	14.8	12.5	(1.6-21.8)	19.9	20.0	
	13.8	12.5		21.1	20.0	
	14.8	12.5		19.2	20.0	
	13.5	12.5		20.7	20.0	
	49.6	50.0	49.6	252	250	249
	49.6	50.0	(36.5-61.9)	248	250	
	49.8	50.0		247	250	
	49.3	50.0				
	49.8	50.0				
	396	390	396			
	390	390	(310-470)			
	397	390				
	399	390				
	398	390				
Total Phosphorus	72.9	75.0	73.7	20.0	20.0	20.0
(TP) (μg/L)	73.6	75.0	(55.1-100.7)			
	73.8	75.0		105	100	101
	74.1	75.0		98.6	100	
	74.3	75.0		99.7	100	
	147	150	148	247	250	247
	147	150	(124.9-182.9)			
	149	150				
	148	150				
	150	150				
	1470	1500	1468			
	1470	1500	(1300-1760)			
	1460	1500				
	1470	1500				
	1470	1500				

APPENDIX B. Results for field replicates, lab duplicates, matrix spikes and lab blanks.

Parameter	Field Replicate		(RPD)■	Lab Duplicate		(RPD)*	Matrix Spikes☼ measured	Matrix Spikes☼ actual	Lab Blanks
Ammonia	20.0	11.8	(52)	13.7	19.9	(37)	95.0	100.0	3.0U
(NH_3-N)	295.0	291.0	(1)	3.5	3.0U	(62)	106.7	100.0	3.0U
(μg/L)	13.4	12.2	(9)	6.4	3.0U	(124)	94.3	100.0	3.0U
	7.6	6.1	(22)				100.2	100.0	3.0U
	7.1	3.9	(58)						3.0U
	15.9	4.3	(115)						10.0
	382.4	247.1	(43)						3.0U
Chlorophyll-*a*	15.8	14.9	(6)						
(μg/L)	0.7	0.5	(33)						
	2.2	2.1	(5)						
	1.3	1.7	(13)						
Fecal	0	0	(0)	0	0	(0)			0
Coliform	8	4	(67)	1	2	(67)			0
(#/100 mL)	1	2	(67)	0	0	(0)			0
	0	0	(0)	8	6	(29)			0
				4	2	(67)			0
									0
									0
Nitrate	0.006U	0.006U	(0)	0.018	0.014	(25)	0.430	0.400	0.006U
+	0.006U	0.010	(62)	0.013	0.014	(7)	0.420	0.400	0.006U
Nitrite	0.006U	0.006U	(0)				0.409	0.400	0.020
(NO_3+NO_2-N)	0.014	0.008	(55)						0.013
(mg/L)	0.006U	0.006U	(0)						0.006U
	0.006U	0.006U	(0)						0.006U
	0.006U	0.006U	(0)						0.006U
Ortho-	124.0	112.0	(10)	112.0	110.0	(2)	51.2	50.0	2.0U
phosphate	16.0	10.9	(38)	184.0	183.0	(1)	53.0	50.0	2.0U
(PO_4-P)	5.5	3.3	(50)	46.3	46.8	(1)	102.0	100.0	2.2
(μg/L)	5.5	4.0	(32)	5.5	4.8	(14)	46.3	50.0	2.0U
	3.8	3.8	(0)	29.5	29.5	(0)	49.1	50.0	2.0U
	4.6	7.1	(43)						2.6
	43.6	29.5	(39)						2.0U
									2.0U
Total	0.54	0.57	(5)	0.40	0.42	(5)	0.33	0.33	0.028U
Nitrogen	0.75	0.74	(1)	0.47	0.48	(2)	0.31	0.33	0.028U
(TN)	0.06	0.06	(0)	0.50	0.45	(11)	0.38	0.33	0.028U
(mg/L)	0.06	0.07	(15)	1.22	1.20	(2)	0.36	0.33	0.028U
	0.21	0.20	(5)	0.40	0.38	(5)			0.028U
	0.40	0.41	(3)						0.028U
	1.55	0.68	(78)						

■ Relative percent difference.
☼ Matrix spikes are field samples that have been spiked; values shown are minus the field value.
U Analyte not detected at the method detection limit shown.
* For RPD calculations samples with analyte not detected were assumed to equal one half the method detection limit.

APPENDIX B. Results for field replicates, lab duplicates, matrix spikes and lab blanks (continued).

Parameter	Field Replicate		(RPD)■	Lab Duplicate		(RPD)*	Matrix Spikes☼ measured	Matrix Spikes☼ actual	Lab Blanks
Total	28.0	29.7	(6)	37.7	32.9	(14)	50.8	50.0	3.5
Phosphorus	138.0	141.0	(2)	6.7	8.5	(24)	53.6	50.0	2.0U
(TP)	9.2	8.2	(12)	9.5	10.7	(12)	42.8	50.0	2.9
(µg/L)	7.7	7.9	(3)	42.1	49.4	(16)			2.0U
	10.0	9.5	(5)						2.0U
	7.8	8.1	(4)						
	67.9	69.3	(2)						
Turbidity	2.5	2.0	(22)	1.4	1.4	(0)			
(NTU)	1.1	0.7	(44)	7.8	7.9	(1)			
	0.7	0.7	(0)	3.5	3.3	(6)			
	0.6	0.6	(0)	0.7	0.7	(0)			
				2.8	2.8	(0)			

■ Relative percent difference.

☼ Matrix spikes are field samples that have been spiked; values shown are minus the field value.

U Analyte not detected at the method detection limit shown.

APPENDIX C. Quality assurance data comparisons of Hydrolab Surveyor II field measurements, standard buffers and independent methods.

Parameter	Date	Comparison Method	Comparison Value		Hydrolab Value	
Dissolved Oxygen*	6/11/90	Azide-modified winkler	6.2	mg/L	6.3	mg/L
Temperature*		Mercury Thermometer	15.6	°C	15.7	°C
Conductivity*		YSI Conductivity meter	64	umhos/cm	67	umhos/cm
Dissolved Oxygen		Azide-modified winkler	12.4	mg/L	12.5	mg/L
pH		pH 7 buffer solution	7.02	units	6.95	units
pH		pH 10 buffer solution	10.05	units	10.01	units
Temperature		Mercury Thermometer	17.1	°C	16.9	°C
Conductivity		Standard buffer solution	147	umhos/cm	146	umhos/cm
Dissolved Oxygen	6/13/90	Azide-modified winkler	12.5	mg/L	12.7	mg/L
pH		pH 7 buffer solution	7.02	units	7.10	units
pH		pH 10 buffer solution	10.05	units	9.97	units
Temperature		Mercury Thermometer	17.8	°C	17.7	°C
Conductivity		Standard buffer solution	147	umhos/cm	145	umhos/cm
Dissolved Oxygen*	6/14/90	Azide-modified winkler	8.9	mg/L	9.1	mg/L
pH		pH 7 buffer solution	7.02	units	6.98	units
Dissolved Oxygen	6/17/90	Azide-modified winkler	12.1	mg/L	11.9	mg/L
pH		pH 7 buffer solution	7.02	units	6.96	units
pH		pH 10 buffer solution	10.05	units	10.00	units
Temperature		Mercury Thermometer	6.4	°C	6.5	°C
Conductivity		Standard buffer solution	147	umhos/cm	146	umhos/cm
Dissolved Oxygen*	6/18/90	Azide-modified winkler	9.5	mg/L	9.3	mg/L
pH*		Beckman pH probe	6.90	units	6.70	units
Temperature*		Mercury Thermometer	20.5	°C	20.5	°C
Conductivity*		YSI Conductivity meter	35	umhos/cm	39	umhos/cm
Dissolved Oxygen	6/18/90	Azide-modified winkler	12.5	mg/L	12.5	mg/L
pH		pH 7 buffer solution	7.02	units	7.20	units
pH		pH 10 buffer solution	10.05	units	10.02	units
Dissolved Oxygen*	6/19/90	Azide-modified winkler	9.0	mg/L	8.9	mg/L
Temperature*		YSI Conductivity meter	16.3	°C	16.2	°C
Conductivity*		YSI Conductivity meter	35	umhos/cm	37	umhos/cm
Dissolved Oxygen	6/19/90	Azide-modified winkler	12.5	mg/L	12.6	mg/L
pH		pH 7 buffer solution	7.02	units	6.80	units
pH		pH 10 buffer solution	10.05	units	10.04	units
Dissolved Oxygen	6/24/90	Azide-modified winkler	12.6	mg/L	12.4	mg/L
pH		pH 7 buffer solution	7.02	units	6.93	units
pH		pH 10 buffer solution	10.05	units	9.98	units
Temperature		Mercury Thermometer	6.0	°C	5.9	°C
Conductivity		Standard buffer solution	147	umhos/cm	146	umhos/cm
Dissolved Oxygen*	6/26/90	Azide-modified winkler	8.9	mg/L	8.9	mg/L
pH*		Beckman pH probe	7.55	units	7.34	units
Temperature*		YSI Conductivity meter	21.7	°C	22.0	°C
Conductivity*		YSI Conductivity meter	79	umhos/cm	77	umhos/cm

* Identifies in the field measurements by independent methods.

APPENDIX C. Quality assurance data comparisons of Hydrolab Surveyor II field measurements, standard buffers and independent methods (continued).

Parameter	Date	Comparison Method	Comparison Value		Hydrolab Value	
Dissolved Oxygen*	6/27/90	Azide-modified winkler	11.2	mg/L	11.4	mg/L
pH*		Beckman pH probe	9.10	units	8.90	units
Temperature*		YSI Conductivity meter	24.0	°C	23.4	°C
Conductivity*		YSI Conductivity meter	277	umhos/cm	280	umhos/cm
Dissolved Oxygen		Azide-modified winkler	12.5	mg/L	12.7	mg/L
pH		pH 7 buffer solution	7.02	units	7.17	units
pH		pH 10 buffer solution	10.05	units	9.95	units
Temperature		Mercury Thermometer	5.6	°C	5.7	°C
Conductivity		Standard buffer solution	147	umhos/cm	146	umhos/cm
Dissolved Oxygen	9/10/90	Azide-modified winkler	9.1	mg/L	8.9	mg/L
pH		pH 7 buffer solution	7.01	units	7.09	units
pH		pH 10 buffer solution	10.01	units	10.05	units
Conductivity		Standard buffer solution	147	umhos/cm	147	umhos/cm
Dissolved Oxygen*	9/11/90	Azide-modified winkler	6.7	mg/L	6.8	mg/L
Dissolved Oxygen*	9/12/90	Azide-modified winkler	8.7	mg/L	8.9	mg/L
Dissolved Oxygen		Azide-modified winkler	9.3	mg/L	9.5	mg/L
pH		pH 7 buffer solution	7.02	units	7.02	units
pH		pH 10 buffer solution	10.05	units	10.03	units
Conductivity		Standard buffer solution	147	umhos/cm	147	umhos/cm
Dissolved Oxygen	9/13/90	Azide-modified winkler	9.6	mg/L	9.5	mg/L
pH		pH 7 buffer solution	7.02	units	7.00	units
pH		pH 10 buffer solution	10.03	units	10.01	units
Dissolved Oxygen	9/16/90	Azide-modified winkler	9.2	mg/L	9.3	mg/L
pH		pH 7 buffer solution	7.02	units	7.04	units
pH		pH 10 buffer solution	10.03	units	10.03	units
Conductivity		Standard buffer solution	147	umhos/cm	149	umhos/cm
Dissolved Oxygen*	9/17/90	Azide-modified winkler	9.1	mg/L	8.9	mg/L
Dissolved Oxygen	9/17/90	Azide-modified winkler	9.5	mg/L	9.3	mg/L
pH		pH 7 buffer solution	7.01	units	7.10	units
pH		pH 10 buffer solution	9.98	units	9.96	units
Dissolved Oxygen	9/18/90	Azide-modified winkler	9.3	mg/L	9.3	mg/L
pH		pH 7 buffer solution	7.01	units	7.10	units
pH		pH 10 buffer solution	9.99	units	9.99	units
Dissolved Oxygen	9/20/90	Azide-modified winkler	9.4	mg/L	9.5	mg/L
pH		pH 7 buffer solution	7.02	units	6.98	units
pH		pH 10 buffer solution	10.03	units	9.98	units
Conductivity		Standard buffer solution	147	umhos/cm	146	umhos/cm
Dissolved Oxygen	9/23/90	Azide-modified winkler	9.0	mg/L	9.1	mg/L
pH		pH 7 buffer solution	7.01	units	7.14	units
pH		pH 10 buffer solution	9.99	units	10.01	units
Dissolved Oxygen	9/25/90	Azide-modified winkler	8.2	mg/L	8.1	mg/L
pH		pH 7 buffer solution	7.01	units	7.00	units
pH		pH 10 buffer solution	10.02	units	9.99	units
Dissolved Oxygen*	9/25/90	Azide-modified winkler	5.0	mg/L	4.9	mg/L
Dissolved Oxygen	9/26/90	Azide-modified winkler	8.6	mg/L	8.7	mg/L
pH		pH 7 buffer solution	7.01	units	6.96	units
pH		pH 10 buffer solution	10.03	units	9.96	units
Dissolved Oxygen	9/27/90	Azide-modified winkler	9.7	mg/L	9.7	mg/L
pH		pH 7 buffer solution	7.02	units	7.10	units
pH		pH 10 buffer solution	10.05	units	10.08	units
Conductivity		Standard buffer solution	147	umhos/cm	147	umhos/cm

* Identifies in the field measurements by independent methods.

APPENDIX D

Vertical water column data for 15 lakes (K-specific conductivity @ 25° C, D.O.- dissolved oxygen, pH, temperature, and percent light transmission). The compensation depth is where oxygen production by algae is in equilibrium with algal respiration (Goldman and Horne, 1983). It is calculated as one percent of the total light transmission at the surface.

AENEAS LAKE (OKANOGAN)				JUNE 27, 1990 TIME: 1115
DEPTH (m)	K (µmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	286	9.7	8.7	23.5
1.0	284	9.9	8.8	22.7
2.0	285	10.1	8.7	22.6
3.0	286	11.7	8.8	21.9
4.0	300	12.0	8.8	19.2
5.0	305	11.2	8.8	17.7
6.0	329	9.5	8.5	15.8
7.0	386	8.2	8.1	13.4
8.0	412	7.6	7.9	11.9
9.0	424	5.4	7.6	9.7
10.0	426	3.3	7.3	8.3
11.0	427	2.4	7.3	7.9
12.0	428	1.4	7.2	7.8
13.0	430	0.6	7.2	7.4
14.0	433	0.1	7.1	7.0
15.0	437	0.1	7.1	6.6
16.0	439	0.1	7.1	6.4
17.0	441	0.1	7.1	6.4
17.3	441	0.1	7.1	6.3

AENEAS LAKE (OKANOGAN)				SEPT. 26, 1990 TIME: 1325
DEPTH (m)	K (µmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	304	11.2	8.7	18.8
1.0	305	11.2	8.7	18.8
2.0	304	11.3	8.8	18.7
3.0	304	11.3	8.8	18.7
4.0	306	10.8	8.7	18.4
5.0	307	10.0	8.6	18.1
6.0	356	4.9	8.0	16.7
7.0	422	1.9	7.4	13.8
8.0	430	0.4	7.2	11.3
9.0	431	0.2	7.0	9.5
10.0	436	0.2	6.9	8.3
11.0	440	0.2	6.8	7.6
12.0	441	0.2	6.8	7.3
13.0	443	0.2	6.8	7.3
14.0	446	0.2	6.7	7.2

AENEAS LAKE (OKANOGAN) — JUNE 27, 1990 — TIME: 1115

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	10.1
1.0	61.8	
2.0	45.8	
3.0	31.4	
4.0	20.6	
5.0	11.1	
6.0	6.7	
7.0	4.2	
8.0	2.9	
9.0	1.8	
10.0	1.1	
11.0	0.6	
12.0	0.4	
13.0	0.1	
14.0	<0.1	
15.0	<0.1	

AENEAS LAKE (OKANOGAN) — SEPT. 26, 1990 — TIME: 1325

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	7.8
1.0	48.9	
2.0	23.5	
3.0	14.3	
4.0	8.3	
5.0	4.4	
6.0	2.5	
7.0	1.4	
8.0	0.9	
9.0	0.5	
10.0	0.2	

BIG LAKE (SKAGIT) JUNE 18, 1990
TIME: 1000

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	72	0.0	7.1	18.2
1.0	72	9.9	7.1	17.8
2.0	72	9.8	7.1	17.6
3.0	72	9.1	7.1	17.4
3.5	75	9.1	6.8	16.8
4.0	75	7.8	6.8	15.7
4.5	74	6.5	6.7	15.0
5.0	74	6.0	6.5	13.9
5.5	73	6.0	6.4	13.8
6.0	73	5.8	6.4	13.7
6.5	73	5.3	6.4	13.5
7.0	73	5.1	6.3	13.4

BIG LAKE (SKAGIT) SEPT. 17,1990
TIME: 1045

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	87	8.5	6.9	19.3
1.0	87	8.3	6.9	19.2
2.0	87	7.9	6.9	19.1
3.0	87	7.8	6.9	19.1
4.0	87	7.7	6.9	19.1
5.0	87	6.8	6.9	19.1
5.5	87	5.0	6.7	18.9

BIG LAKE (SKAGIT)		JUNE 18, 1990 TIME: 1000
DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	2.7
0.5	29.1	
1.0	13.1	
1.5	8.8	
2.0	3.2	
2.5	1.2	
3.0	0.6	

BIG LAKE (SKAGIT)		SEPT. 17, 1990 TIME 1045
DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	4.1
1.0	26.8	
2.0	8.9	
3.0	3.0	
4.0	1.1	
5.0	0.4	

JUNE 26, 1990

DAVIS LAKE (PEND OREILLE) TIME: 1200

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	87	7.9	7.0	20.4
2.0	87	8.0	6.9	19.8
3.0	87	9.2	7.0	16.5
4.0	86	8.9	7.0	14.8
5.0	86	8.9	7.0	13.7
10.0	95	7.5	6.7	8.3
15.0	96	7.8	6.7	5.9
20.0	96	8.2	6.7	5.3
22.0	95	8.3	6.7	5.1
24.0	95	8.3	6.7	4.9
26.0	96	8.3	6.7	4.8
28.0	96	8.3	6.7	4.7
30.0	95	8.2	6.7	4.6
32.0	95	8.2	6.7	4.6
34.0	95	8.0	6.6	4.6
36.0	93	7.7	6.6	4.5
38.0	94	7.3	6.6	4.5
40.0	94	6.6	6.6	4.4

DAVIS LAKE (PEND OREILLE)

SEPT. 25, 1990
TIME: 1340

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	95	9.2	7.4	17.7
1.0	95	8.9	7.3	17.5
2.0	96	8.9	7.3	17.2
3.0	95	8.8	7.3	17.0
4.0	96	8.8	7.3	16.9
5.0	96	8.8	7.3	16.7
6.0	96	8.2	7.2	16.5
7.0	88	4.5	6.9	13.2
8.0	87	4.2	6.7	11.8
9.0	88	4.9	6.7	9.3
10.0	88	5.6	6.6	8.0
11.0	89	6.2	6.6	7.1
12.0	88	6.4	6.6	6.8
13.0	88	6.3	6.5	6.3
14.0	89	6.5	6.5	6.0
15.0	88	6.9	6.5	5.7
16.0	88	7.1	6.5	5.5
17.0	87	7.2	6.5	5.4
18.0	87	7.3	6.5	5.2
19.0	87	7.3	6.5	5.1
20.0	88	7.3	6.5	5.1
21.0	88	7.4	6.4	5.0
22.0	87	7.3	6.4	4.9
23.0	86	7.4	6.4	4.8
24.0	87	7.4	6.4	4.8
26.0	89	7.3	6.4	4.7
28.0	88	7.2	6.4	4.7
30.0	88	7.0	6.4	4.6
32.0	86	6.2	6.3	4.6
34.0	86	5.3	6.3	4.5
36.0	87	4.9	6.3	4.5
37.0	88	3.7	6.2	4.5

DAVIS LAKE (PEND OREILLE)

JUNE 26, 1990
TIME: 1200

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	6.2
1.0	42.9	
2.0	21.4	
3.0	9.7	
4.0	4.6	
5.0	2.2	
6.0	1.1	
7.0	0.5	
8.0	0.3	
9.0	0.2	
10.0	0.1	
11.0	<0.1	
12.0	<0.1	

DAVIS LAKE (PEND OREILLE)

SEPT. 25, 1990
TIME: 1340

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	7.7
1.0	45.9	
2.0	27.1	
3.0	15.0	
4.0	8.1	
5.0	4.5	
6.0	2.5	
7.0	1.4	
8.0	0.8	
9.0	0.5	
10.0	0.3	
11.0	0.2	
12.0	0.1	
13.0	0.1	

FLOWING LAKE (SNOHOMISH)

JUNE 18, 1990
TIME: 1300

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	40	9.7	6.9	19.7
1.0	40	9.5	6.8	19.1
2.0	41	9.6	6.8	18.3
3.0	41	9.7	6.7	16.7
4.0	43	7.9	6.5	14.5
5.0	46	6.5	6.2	12.2
6.0	48	5.5	6.1	9.5
7.0	47	6.0	6.0	8.6
8.0	47	6.1	5.9	7.8
10.0	48	6.8	6.0	6.9
12.0	48	6.4	5.9	6.6
14.0	48	6.7	5.9	6.3
16.0	49	4.0	5.9	6.1
17.0	49	2.2	5.8	6.0
18.0	51	1.6	5.8	5.9
19.0	51	1.0	5.8	5.8

FLOWING LAKE (SNOHOMISH)

SEPT. 17, 1990
TIME: 1350

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	40	9.7	6.9	19.7
0.0	44	9.5	6.9	19.7
1.0	43	9.1	6.9	19.5
2.0	43	9.0	6.9	19.3
3.0	43	8.9	6.9	19.3
4.0	43	8.7	6.8	19.1
5.0	46	0.6	6.3	15.1
6.0	46	0.4	6.0	10.9
7.0	44	0.5	5.9	9.1
8.0	45	0.9	5.8	8.4
9.0	45	0.8	5.8	7.7
10.0	45	1.1	5.7	7.3
11.0	43	1.5	5.7	6.9
12.0	43	1.0	5.7	6.6
13.0	44	0.4	5.8	6.3

FLOWING LAKE (SNOHOMISH) — JUNE 18, 1990, TIME: 1300

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
1.0	57.7	
1.5	42.6	
2.0	28.6	
2.5	23.4	
3.0	16.6	
3.5	11.1	
4.0	7.1	
4.5	4.2	
5.0	3.4	
6.0	1.8	

FLOWING LAKE (SNOHOMISH) — SEPT. 17, 1990, TIME: 1350

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	6.5
1.0	54.6	
2.0	31.1	
3.0	11.3	
4.0	8.6	
5.0	4.0	
6.0	1.4	
7.0	0.6	
8.0	0.3	
9.0	0.1	
10.0	<0.1	

LAKE KAHLOTUS (FRANKLIN)

JUNE 25, 1990
TIME: 1500

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	1212	13.4	9.1	27.2
0.5	1220	14.2	9.1	26.5
1.0	1208	14.2	9.1	24.1
1.5	1207	13.9	9.1	23.7
2.0	1209	13.6	9.1	23.0
2.4	1221	10.9	8.8	21.9

LAKE KAHLOTUS (FRANKLIN)

SEPT. 24, 1990
TIME: 1500

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	1400	5.5	9.8	18.3
0.5	1396	3.3	9.7	16.9
1.0	1399	3.0	9.7	16.5

LAKE KAHLOTUS (FRANKLIN) — JUNE 25, 1990, TIME: 1500

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
0.5	74.4	
1.0	65.4	
1.5	44.4	
2.0	9.4	

LAKE KAHLOTUS (FRANKLIN) — SEPT. 24, 1990, TIME: 1500

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
0.5	32.1	
1.0	15.3	

KITSAP LAKE (KITSAP) — JUNE 13, 1990 — TIME: 1200

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	89	9.7	7.1	17.4
1.0	89	9.5	7.2	17.3
2.0	90	9.2	7.2	17.1
3.0	90	9.2	7.2	17.0
4.0	91	9.2	7.2	17.0
5.0	93	9.1	7.1	16.9
6.0	94	8.9	7.1	16.9
7.0	94	8.8	7.1	16.9
8.0	95	8.1	7.0	16.8

KITSAP LAKE (KITSAP) — SEPT. 12, 1990 — TIME: 1140

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	105	8.5	7.3	20.2
1.0	104	8.4	7.3	20.2
2.0	105	8.4	7.3	20.2
3.0	105	8.4	7.3	20.2
4.0	103	8.4	7.3	20.2
5.0	103	8.3	7.3	20.2
6.0	103	8.3	7.3	20.2

KITSAP LAKE (KITSAP) — JUNE 13, 1990, TIME: 1200

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
0.5	61.4	
1.0	49.7	
1.5	37.1	
2.0	27.5	
2.5	19.1	
3.0	13.2	
3.5	10.2	
4.0	8.2	
4.5	6.2	
5.0	5.3	
5.5	4.2	
6.0	3.9	
6.5	2.9	
7.0	1.9	

KITSAP LAKE (KITSAP) — SEPT. 12, 1990, TIME: 1140

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	5.5
1.0	34.6	
2.0	14.7	
3.0	6.2	
4.0	3.2	
5.0	1.6	
5.5	1.0	

LEECH LAKE (YAKIMA) — JUNE 19, 1990, TIME: 1300

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	34	10.0	7.0	12.3
0.25	34	10.1	7.0	12.2
0.50	33	10.2	7.0	12.2
0.75	33	10.1	7.0	12.2
1.00	34	10.2	7.0	12.2
1.25	33	10.1	7.0	12.2
1.50	34	10.2	7.0	12.2
1.75	34	10.1	7.0	12.1
2.00	32	11.2	7.2	11.4
2.25	33	11.4	7.4	10.1

LEECH LAKE (YAKIMA) — SEPT. 18, 1990, TIME: 1150

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	53	10.8	7.0	13.1
0.5	52	12.5	7.6	12.8
0.9	51	12.6	8.1	12.6

LEECH LAKE (YAKIMA) — SEPT. 18, 1990, TIME: 1150

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
0.5	69.9	
1.0	59.1	

LOOMIS LAKE (PACIFIC)				JUNE 12, 1990 TIME: 1530
DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	119	9.2	6.8	17.4
0.5	119	9.0	6.7	17.4
1.0	119	8.9	6.7	17.4
1.5	119	8.9	6.7	17.3
1.7	119	8.8	6.7	17.3

LOOMIS LAKE (PACIFIC)				SEPT. 11, 1990 TIME: 1715
DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	132	6.9	6.4	19.3
0.5	131	6.8	6.4	19.3
1.0	132	6.8	6.4	19.3

LOOMIS LAKE (PACIFIC)		SEPT. 11, 1990 TIME: 1715
DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	0.6
0.5	1.1	
1.0	0.4	

MERRILL LAKE (COWLITZ)

JUNE 12, 1990
TIME: 1000

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	26	10.2	6.8	13.1
1.0	26	9.9	6.6	13.1
2.0	26	9.9	6.5	13.1
3.0	26	9.9	6.5	13.1
4.0	28	9.9	6.4	13.0
5.0	29	10.0	6.3	11.9
6.0	30	10.2	6.3	11.3
7.0	30	10.2	6.3	10.4
8.0	30	10.0	6.2	9.7
9.0	31	9.9	6.1	9.1
11.0	31	9.5	6.1	8.5
13.0	31	9.3	6.0	8.3
15.0	32	8.7	6.0	8.1
15.5	32	8.2	5.9	8.1

MERRILL LAKE (COWLITZ)

SEPT.11, 1990
TIME: 1220

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	28	10.4	6.5	20.3
1.0	28	9.9	6.5	20.3
2.0	28	9.7	6.6	20.3
3.0	28	9.5	6.7	20.2
4.0	28	9.3	6.7	20.0
5.0	28	9.3	6.7	19.8
6.0	27	9.3	6.7	19.7
7.0	27	9.3	6.7	19.4
8.0	27	9.1	6.6	18.6
9.0	26	9.3	6.5	16.9
10.0	27	7.9	6.3	14.2
11.0	27	6.0	6.1	12.6
11.5	27	5.2	5.7	12.4

MERRILL LAKE (COWLITZ)

SEPT. 11, 1990
TIME: 1220

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
1.0	44.0	
2.0	38.6	
3.0	29.2	
4.0	24.1	
5.0	19.2	
6.0	15.0	
7.0	11.5	
8.0	8.3	
9.0	6.5	
10.0	4.7	

LAKE NAHWATZEL (MASON)

JUNE 13, 1990
TIME: 0850

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	24	9.8	6.7	16.1
1.0	23	9.7	6.6	16.0
2.0	23	9.7	6.6	16.0
3.0	24	9.7	6.5	16.0
4.0	25	9.7	6.5	15.9
5.0	25	9.7	6.5	15.9
6.0	26	9.7	6.5	15.9
7.0	26	9.7	6.5	15.9

LAKE NAHWATZEL (MASON)

SEPT. 12, 1990
TIME: 1425

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	25	8.9	6.6	20.0
1.0	24	8.9	6.5	19.9
2.0	24	8.9	6.6	19.9
3.0	24	8.9	6.6	19.8
4.0	23	8.9	6.6	19.8
5.0	23	8.9	6.6	19.7
6.0	23	8.9	6.6	19.7

LAKE NAHWATZEL (MASON) — JUNE 13, 1990, TIME: 0850

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	6.9
0.5	57.4	
1.0	50.8	
1.5	39.2	
2.0	32.3	
2.5	24.1	
3.0	20.0	
3.5	17.9	
4.0	11.7	
4.5	11.7	
5.0	9.9	
5.5	8.1	
6.0	6.9	
6.5	5.0	
7.0	0.5	

LAKE NAHWATZEL (MASON) — SEPT. 12, 1990, TIME: 1425

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
1.0	75.2	
2.0	54.2	
3.0	40.9	
4.0	30.3	
5.0	21.2	
5.5	17.7	

NUNNALLY LAKE (GRANT)

JUNE 25, 1990
TIME: 1100

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	336	9.2	8.3	21.7
1.0	336	9.2	8.3	21.0
2.0	339	9.3	8.3	20.6
3.0	341	9.3	8.3	20.3
4.0	343	9.1	8.3	20.1
5.0	345	8.9	8.3	20.1
6.0	348	8.5	8.2	20.0
6.5	350	8.3	8.2	19.8
7.0	358	7.1	8.0	19.3
7.5	360	6.6	7.9	19.0
8.0	361	6.0	7.9	18.7

NUNNALLY LAKE (GRANT)

SEPT. 24, 1990
TIME: 1115

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	289	11.9	8.5	20.4
1.0	290	11.7	8.5	20.0
2.0	289	11.5	8.5	20.0
3.0	289	11.5	8.5	19.9
4.0	289	11.4	8.5	19.9
5.0	290	10.6	8.5	19.8
6.0	306	9.9	8.4	19.7
7.0	317	8.7	8.3	19.5
8.0	321	7.9	8.2	19.4
9.0	328	6.4	8.1	19.3

NUNNALLY LAKE (GRANT)

JUNE 25, 1990
TIME: 1100

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	7.0
1.0	60.8	
2.0	33.2	
3.0	15.1	
4.0	8.4	
5.0	3.9	
6.0	2.0	
7.0	1.0	
8.0	0.5	

NUNNALLY LAKE (GRANT)

SEPT. 24, 1990
TIME: 1115

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
1.0	66.3	
2.0	45.6	
3.0	29.0	
4.0	19.8	
5.0	12.9	
6.0	8.1	
7.0	5.1	
8.0	3.4	
9.0	2.3	

SIDLEY LAKE (OKANOGAN)

JUNE 27, 1990
TIME: 0815

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	2130	10.7	8.8	19.9
0.5	2120	10.7	8.8	19.9
1.0	2130	10.7	8.8	19.9
1.5	2130	10.7	8.8	19.9
2.0	2130	10.8	8.8	19.8
2.5	2120	11.4	8.8	19.2
3.0	2130	12.4	8.8	18.5
3.5	2130	12.5	8.8	18.1
4.0	2130	12.5	8.8	17.3
4.5	2130	12.3	8.8	16.4
5.0	2120	11.2	8.8	16.1
5.5	2130	9.3	8.8	15.9

SIDLEY LAKE (OKANOGAN)

SEPT. 26, 1990
TIME: 1105

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	2300	9.8	8.7	16.8
1.0	2310	9.2	8.8	16.7
2.0	2310	8.8	8.8	16.6
3.0	2310	7.1	8.7	16.4
4.0	2310	6.1	8.7	16.3

SIDLEY LAKE (OKANOGAN)

JUNE 27, 1990
TIME: 0815

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
1.0	53.4	
2.0	28.8	
3.0	5.5	
4.0	7.9	
5.0	3.7	
5.5	2.1	

SIDLEY LAKE (OKANOGAN)

SEPT.26, 1990
TIME: 1105

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	--
1.0	38.4	
2.0	14.2	
3.0	5.3	
4.0	2.1	

LAKE ST. CLAIR (THURSTON)

JUNE 11, 1990
TIME: 0900

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	95	9.7	6.7	16.0
1.0	96	9.6	6.8	16.0
2.0	99	6.7	6.5	15.2
3.0	99	0.7	6.1	12.1
4.0	95	1.6	6.0	9.5
5.0	93	3.0	5.9	7.9
6.0	93	4.5	6.0	6.8
7.0	94	5.1	6.0	6.0
10.0	95	5.4	6.0	5.4
15.0	96	5.6	6.1	5.1
20.0	97	2.9	6.0	5.0
25.0	108	0.1	5.9	4.9
29.0	177	0.1	6.3	4.9
30.0	263	0.1	6.2	5.0

LAKE ST. CLAIR (THURSTON)

SEPT. 19, 1990
TIME: 1305

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	108	11.3	7.3	19.3
1.0	109	10.9	7.3	18.2
2.0	109	8.1	6.9	17.0
3.0	104	0.7	6.5	14.5
4.0	96	0.3	6.3	11.6
5.0	93	0.3	6.3	8.8
6.0	91	1.1	6.2	7.1
7.0	90	2.3	6.2	6.3
8.0	90	2.5	6.1	5.9
9.0	89	3.1	6.1	5.7
10.0	89	3.3	6.1	5.6
12.0	90	3.2	6.1	5.4
14.0	90	1.4	6.1	5.3
16.0	93	0.5	6.1	5.3
18.0	95	0.3	6.0	5.2
20.0	97	0.2	6.0	5.2
22.0	102	0.3	6.0	5.1
24.0	109	0.3	6.0	5.1
26.0	135	0.3	6.0	5.1
28.0	280	0.3	6.3	5.2

LAKE ST. CLAIR (THURSTON)

JUNE 11, 1990
TIME: 0900

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	1.8
0.5	28.9	
1.0	8.5	
1.5	2.3	
2.0	0.8	
2.5	0.4	
3.0	0.1	
3.5	0.1	
4.0	<0.1	

LAKE ST. CLAIR (THURSTON)

SEPT. 19, 1990
TIME: 1305

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	3.1
1.0	--	
2.0	5.5	
3.0	1.2	
4.0	0.2	
5.0	<0.1	
6.0	<0.1	

TANWAX LAKE (PIERCE) — JUNE 11, 1990, TIME: 1320

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	69	9.3	6.6	16.3
1.0	69	9.2	6.6	16.3
2.0	70	9.2	6.5	16.3
3.0	71	9.0	6.6	16.2
3.5	72	8.7	6.2	16.0
4.0	77	8.2	6.1	12.6
5.0	88	8.4	6.0	10.4
6.0	93	8.7	6.0	9.7
7.0	96	8.1	6.0	9.2
7.5	97	8.1	6.0	9.1

TANWAX LAKE (PIERCE) — SEPT. 10, 1990, TIME: 1400

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	77	10.6	6.7	20.9
1.0	76	10.0	7.0	20.2
2.0	76	9.1	6.9	19.9
3.0	76	0.5	6.5	18.6
4.0	89	0.3	6.2	15.4
5.0	115	0.2	6.1	12.7

TANWAX LAKE (PIERCE) — SEPT. 10, 1990, TIME: 1400

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	2.7
1.0	18.7	
2.0	1.8	
3.0	0.6	
4.0	0.1	

WAITTS LAKE (STEVENS)

JUNE 26, 1990
TIME: 0820

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	256	10.2	8.4	21.4
1.0	256	10.1	8.4	21.5
2.0	256	10.1	8.4	21.5
3.0	258	10.7	8.4	21.3
4.0	262	12.1	8.5	18.2
5.0	264	12.0	8.5	16.5
6.0	269	13.2	8.5	14.8
7.0	275	13.4	8.4	12.8
8.0	274	11.4	8.0	9.5
9.0	278	8.1	7.6	7.5
10.0	277	6.4	7.4	6.5
11.0	277	3.9	7.2	5.8
12.0	278	0.7	7.1	5.3
13.0	282	0.1	7.1	5.2
14.0	282	0.1	7.0	4.8
15.0	285	0.1	7.0	4.7
16.0	292	0.1	6.9	4.6
17.0	294	0.1	6.9	4.5
18.0	299	0.1	6.9	4.4
19.0	299	0.1	6.9	4.4
20.0	302	0.1	6.9	4.4
21.0	300	0.1	6.9	4.4

WAITTS LAKE (STEVENS)

SEPT. 25, 1990
TIME: 1100

DEPTH (m)	K (μmhos/cm)	D.O. (mg/L)	pH (S.U.)	TEMP (°C)
0.0	253	9.6	8.1	18.7
1.0	255	9.4	8.1	18.7
2.0	256	9.4	8.1	18.7
3.0	255	9.3	8.1	18.7
4.0	256	9.3	8.1	18.7
5.0	255	9.3	8.1	18.7
6.0	255	9.1	8.1	18.7
7.0	275	11.3	7.9	16.7
8.0	286	9.7	7.7	13.1
9.0	283	7.5	7.4	10.3
10.0	291	2.9	7.2	8.6
11.0	290	0.9	7.0	7.3
12.0	285	0.5	6.9	6.4
13.0	285	0.6	6.9	5.9
14.0	284	0.4	6.8	5.6
15.0	290	0.2	6.7	5.1
16.0	294	0.2	6.6	5.0
17.0	298	0.2	6.5	4.9

WAITTS LAKE (STEVENS)

JUNE 26, 1990
TIME: 0820

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	10.8
1.0	64.4	
2.0	40.8	
3.0	27.6	
4.0	18.2	
5.0	9.7	
6.0	7.0	
7.0	5.3	
8.0	3.2	
9.0	2.0	
10.0	1.3	
11.0	0.9	
12.0	0.6	
13.0	0.4	
14.0	0.2	
15.0	0.1	
16.0	<0.1	

WAITTS LAKE (STEVENS)

SEPT. 25, 1990
TIME: 1100

DEPTH (m)	PERCENT TRANSMISSION	COMPENSATION DEPTH
0.0	100.0	14.0
1.0	66.7	
2.0	50.9	
3.0	38.4	
4.0	28.1	
5.0	19.4	
6.0	16.0	
7.0	12.0	
8.0	8.5	
9.0	6.3	
10.0	4.6	
11.0	3.2	
12.0	2.2	
13.0	1.5	
14.0	1.0	
15.0	0.1	
16.0	<0.1	