Water Quality Assessments of Selected Lakes Within Washington State

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Water Quality Assessments of Selected Lakes Within Washington State

1998

by
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Acknowledgments

The Lake Water Quality Assessment Program was given the opportunity to venture into a new approach to lake assessments in 1998, making it an interesting year. This would not have been possible without the support of management and the Ecology 319 Grant process. Funding for the program was supplied by an Environmental Protection Agency (EPA) 319 grant of $128,619.

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Abstract

In 1998 the Washington State Department of Ecology (Ecology) embarked on a different approach to assessing lake water quality. Recent methods in lake monitoring focused on general assessments and long-term trends in water clarity. Although trend data are crucial in the documentation of declining or improving water quality through time, they provide little information as to whether or not beneficial uses of a lake are impaired. The original intent of the Federal Clean Water Act was to protect the beneficial uses (e.g., swimable, drinkable, fishable) of our waters. The new approach in 1998 is an attempt to evaluate the condition of the beneficial uses on certain lakes throughout the state and to recommend lake-specific nutrient criteria for those lakes in order to protect or restore the uses.

New methodology was developed to evaluate various parameters on some of our monitored lakes. Monitoring concentrated on assessing habitat, fish, wildlife, zooplankton, aquatic plants, watershed, water chemistry, and user perception. Beneficial uses were determined by evaluating the user perception surveys and talking with conservation district representatives and the Washington State Department of Fish & Wildlife biologists. A lake-specific criterion was then recommended to protect or improve conditions on the lake. Lake specific criteria were determined using procedures outlined in Washington's Water Quality Standards (WAC 173-201A). If proposed criteria are codified into the WAC, then, should they ever be exceeded in a particular lake, measures could be taken either to reduce nutrient concentrations or to conduct a more detailed study in order to refine the criteria.

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Introduction

The purpose of this report is to describe the portion of the Lake Water Quality Assessment Program that deals with lake-specific studies conducted on 20 selected lakes throughout the state.

Program Objectives

The objectives of the lake-specific studies portion of the program are as follows:

◊ Establish protocols for lake-specific studies.

◊ Recommend nutrient criteria, if possible, for each studied lake as per WAC 173-201A-030(6) "Establishing lake nutrient criteria".

◊ Establish an integrated approach to lake assessment with Washington State Department of Fish & Wildlife officials, local government officials, and citizen volunteers.

Specific goals for 1998 include:

◊ Selecting and sampling 20 lakes according to requests from within Ecology, the Washington State Department of Fish & Wildlife, and local government.

◊ Refining methodology for effective assessment of beneficial uses (including methods for habitat assessment), zooplankton indices, watershed assessment, and user perception surveys.

◊ Developing a new Y2k compliant database that integrates all the tables created for the different parameters described in the preceding goal, and that is also able to interface with the Ecology Aquatic Plant database.

Methods

Methods for lake selection, data collection, sample analysis, and data analysis are described below. Methods for quality assurance and quality control (QA/QC) of data collected for the program are discussed in the "QA/QC Evaluation and Results" section.

Lake Selection

Lakes were selected according to the needs described in the Ecology Water Quality Program appraisal for 1998 and by requests from state fish and wildlife biologists. Additional input was sought from local governments when dealing with particular lakes in Thurston, Pierce, and Jefferson counties. The U.S. Park Service was consulted before Crescent Lake was sampled and a sampling permit was obtained for sampling within the national park. Every reasonable attempt was made to recruit volunteers on all selected lakes, however, many lakes were selected for sampling too late in the year to recruit volunteers.

Field Methods

Many of the field methods implemented in 1998 were adopted from methods utilized or developed outside of Washington State, which were then customized for the program's needs.

Sample Collection

Ecology staff visited selected lakes for special study monthly from June through September. The purpose of these visits was to (1) collect Hydrolab® profile data and sample for chemical parameters from the deep site of lakes once each month; (2) conduct habitat assessments once during the season; (3) conduct watershed assessments in September; (4) collect zooplankton samples in June and August; (5) distribute user perception surveys; (6) do Secchi depth quality assurance evaluations with volunteer monitors on selected lakes.

During each field visit, the volunteer (on lakes with volunteers) escorted Ecology personnel to their monitoring site, and anchored if possible. The volunteer and Ecology staff each measured Secchi depth. Temperature, pH, dissolved oxygen, and conductivity were profiled using a Hydrolab® Surveyor III and Reporter. Temperature profile data were used to determine whether the lakes were stratified, and if they were, to determine depths within the epilimnion and hypolimnion for collecting water samples. Weather conditions, water color, and general observations about the lake were recorded. If an obvious algal bloom was occurring at the surface or at depth (as indicated by a large change in dissolved oxygen with no concurrent decrease in temperature), a sample was collected for later identification. Plant samples were either identified onsite, or collected for later identification. Algae and macrophyte samples were collected for qualitative purposes only, and results are not necessarily inclusive of all species present.

During each onsite visit, water samples for total phosphorous (TP), total persulfate nitrogen (TN), turbidity, and chlorophyll *a* were collected using a Kemmerer water sampler, and were composited from two to three equidistant depths within the strata (epilimnion or hypolimnion) sampled (Table 1).

Table 1. Analytical methods used for samples collected for the LWQA Program.

Parameter	Strata Sampled[1]	Sample Preservation[2]	Analytical Method[3]	Method Detection Limit	Holding Time	Analytical Lab[4]
Total Phosphorus	epilimnion, hypolimnion	H_2SO_4 to pH < 2	SM[5] 4500-P D	3 µg/L	28 days	MEL
Total Nitrogen	epilimnion, hypolimnion	H_2SO_4 to pH < 2	EPA 353.2	10 µg/L	28 days	MEL
Chloro-phyll a[6]	epilimnion	$MgCO_3$[7]	SM 10200H (2,B)	0.5 µg/L	28 days	MEL
Turbidity	epilimnion		SM 2540D,E	1 NTU	7 days	MEL
Fecal Coliform Bacteria	nearshore grab samples (2 sites)		SM 9222D	1 colony/ 100 mL	30 hours	MEL

1 All samples except fecal coliform bacteria were composited.
2 All samples kept on ice or stored at 4°C until delivery to the lab, or until filtered.
3 Huntamer and Hyre, 1991
4 Manchester Environmental Laboratory (MEL)
5 Standard Method (SM)
6 Corrected for pheophytin.
7 Approximately 2 mL saturated $MgCO_3$ added with last of filtrate onto filter. Filters were iced, or frozen, until delivered to lab.

Fecal coliform samples were collected approximately 20-35 feet from shore in areas which appeared (to the sampling staff) to have some potential source of bacteria. Fecal coliform bacteria sample bottles were filled by "scooping" water from about eight inches below the water surface to avoid surface films.

All samples, except those for chlorophyll *a*, were transported on ice to the lab and stored at 4°C. Chlorophyll *a* samples were filtered through Whatman 4.7 cm GF/C filters as soon as possible after collection. For most samples, 500 mL aliquots were filtered. About 2 mL of saturated $MgCO_3$ was added to the last of the filtrate to preserve the sample on the filter. Filters were placed in 10 ml of 90% acetone, then stored in the dark and on ice or refrigerated until transported to the lab for analysis.

Sampling Protocols for Zooplankton

The new approach to measure uses on a given lake includes a need to evaluate the health of a fishery. A widely utilized tool on the east coast of the United States is the measuring of zooplankton as a cost effective surrogate to collecting and measuring fish. An index has been developed in order to determine the predator/prey balance in the fish communities within a given lake (Mills and Schavone, 1982). In a study of 18 natural lakes in upstate New York, Mills and Schavone (1982) demonstrated a strong correlation between mean length of cladocerans and planktivore weight ($r^2 = .70$; $P<0.05$). In other words, the presence of large zooplankton indicate predator fish are keeping prey species in balance. Dominance of smaller zooplankton suggests an ineffective amount of predators to suppress planktivore density.

A standard approach to sampling zooplankton was followed in the field. Methods for collecting, storage, and enumeration are patterned after the "Zooplankton Workshop Reference Guide" prepared by BSA Environmental Services, Inc. (Beaver, 1997).

Sampling Period

Five vertical tows were pulled in June and five were pulled in August from the deep site of each selected lake. Tows were composited into one 125ml sample bottle. Five tows were not necessary if there were an abundance of zooplankton in the first few tows. Duplicate samples (again, five tows if necessary) were taken at duplicate TP sample sites.

Field Procedure

The Wisconsin net was pulled from a depth of one meter off the bottom or 20 meters, whichever was less. The depth was rounded to the most conservative meter to ensure bottom sediments weren't disturbed. Nets were retrieved at a rate of one meter per three seconds.

Upon retrieval of the sample, a squirt bottle filled with tap or distilled water was used to dislodge any zooplankton that may have been clinging to the mesh. Samples were discharged into a 125 mL amber, Lugol-treated sample container and preserved with approximately 15 mls of Lugol's solution.

Sample Analysis

Samples were analyzed for relative abundance of cladocerans and copepods and their mean length. Relative abundance was determined using a Sedgewick-Rafter counting chamber and a compound microscope. Subsamples were analyzed to estimate mean length of the zooplankton using a compound microscope and an ocular equipped with a reticle. Measurements were recorded to the nearest 0.2mm. Results were tabulated as the ratio of total cladocerans:total copepeods.

Data Interpretation

Due to time constraints in 1998, it was not possible to fully analyze the collected samples of zooplankton but the following provides possibilities for future data interpretation. A subset of lakes sampled by Ecology in 1998 were also surveyed by the Washington State Department of Fish and Wildlife. Zooplankton mean length data should be compared to fish length-frequency distributions to evaluate whether there is a particular mean zooplankton length that could be used as a pivot indicator of a balanced predator/prey fish population in a given lake (e.g. 1.0 mm is used in some states). An index with a range of mean lengths within given categories may be the most effective use of the zooplankton data. For example, mean zooplankton lengths between 0.9 mm and 1.0 mm may be rated as "fair" for predator/prey populations and mean lengths between 1.0 mm and 1.1 mm may rate "good" and above 1.1 mm rated as "fair," etc. A fair rating or worse could then be used to demonstrate impairment of a beneficial use.

Relative zooplankton abundance data may be correlated with nutrient and Secchi data. It is uncertain at this time whether or not zooplankton abundance is a good indicator of predator/prey balance. However, correlations with traditional water chemistry data and additional fish population data may demonstrate whether or not trophic cascade effects are present in Washington lakes (Brett and Goldman, 1996). Zooplankton data may also explain differences between total phosphorus concentrations and expected correlated values for chlorophyll *a*/Secchi measurements.

Habitat Characterization

Details of the habitat survey and methodology are covered at length in the EPA publication EPA/620/R-97/001 entitled *Surface Waters, Field Operations Manual for Lakes*, Section 5 (Kaufmann and Whittier, 1997). In order to do a whole lake assessment, an evaluation of the riparian and littoral zones is important. The new methodology published in the EPA manual provides an excellent approach to evaluating these zones. It allows for the evaluation of physical structure, aquatic vegetation and human impacts, all of which may contribute to the protection or degradation of lake water quality.

Watershed Survey

A cursory "windshield" survey of the watershed was implemented as part of the new approach to assessing lakes because knowledge of the watershed may contribute to understanding attributes of the water quality in the lake. For instance, if agriculture is predominant in the watershed, livestock or fertilizers may be impacting the lake's tributaries. Also, many poor management practices can be seen from the windshield of a vehicle. Due to the lack of time and funds, a more thorough watershed assessment was not practical. A copy of the survey form used in the field is located in Appendix A.

User Perception Questionnaire

The idea of implementing user perception surveys originated after reviewing research conducted by University of Maine's Water Research Institute. Maine's research demonstrated relationships between water clarity and property values and other socio-economic factors within the lake community (Boyle et al., 1997). WAC 173-201A-030(6) calls for public input before setting a nutrient criterion in a lake. The surveys conducted in Maine were modified and edited for Washington State then distributed, on a limited basis, to most of the lake communities studied in 1998.

The questionnaires were designed primarily to help investigators of lake water quality determine the following:

1) Primary recreational uses and their relative importance.
2) Lake user's perception of the quality of those uses.
3) Socio-economic value of the resource.

In 1998, however, efforts were focused primarily on objective #1 while objectives #2 and #3 were experimented with.

Questionnaire data was not collected rigorously and it has been cautiously interpreted. Although an effort was made to widely distribute the questionnaires, only a small fraction were returned. Returns were greatest where volunteers were available to hand-distribute the questionnaire.

Two types of questionnaires were developed, one for visitors and one for residents, though most questions were common to both. The resident questionnaire, located in Appendix A, is followed by a brief synopsis of why each question was asked.

Sample Analysis Methods

Methods used for sample analyses are listed in Table 1. Sample preservation and analytical methods used by Manchester Environmental Laboratory (MEL) are described in Huntamer and Hyre (1991).

Keys used for algal identifications were Smith (1950), Edmondson (1959), Prescott (1962; 1978), and VanLandingham (1982). Keys used for macrophyte identifications were Tarver *et al*. (1978), Prescott (1980), and others (see Parsons, 1999).

Methods Used for Estimating Trophic Status

Carlson's (1977) trophic state indices (TSI) for Secchi depth (TSI_{SD}), total phosphorus (TSI_{TP}), and chlorophyll *a* (TSI_{CHL}), tempered with professional judgment, were used to estimate the trophic status of the monitored lakes. In general, TSIs of 40 or less indicate oligotrophy, TSIs greater than 40 indicate mesotrophy, and TSIs greater than 50 indicate eutrophy (Carlson, 1979).

To describe lakes that appeared to be between trophic states, the terms “oligo-mesotrophic” and “meso-eutrophic” were used.

TSI_{SD} values were calculated from a time-weighted mean Secchi depth calculated from all Secchi data collected between mid-May and mid-October 1998. A minimum of five Secchi depth measurements separated by at least two weeks were used to calculate the TSI_{SD} for each lake. Those TSI_{SD} values failing the five measurement minimum are qualified with the letter ‘N.’ Data invalidated by the QA/QC evaluation (below) were excluded from the TSI_{SD} calculations. TSI_{TP} and TSI_{CHL} values were similarly calculated from time-weighted mean total phosphorous and chlorophyll values, respectively.

It is not valid to average TSI values from different trophic state parameters, and to use that average to summarize a lake’s trophic status. According to Carlson (1977), “the best indicator of trophic status may vary from lake to lake and also seasonally, so the best index to use should be chosen on pragmatic grounds.” A subjective assessment of all data collected during the monitoring season was used to determine which index to use for assigning trophic states. Then monitoring data, other available survey information (short term lake surveys conducted by Ecology or universities, and consultant reports from Ecology-funded lake restoration activities), and information from the volunteers (e.g. on aquatic herbicide use) were used to temper the trophic state assessment for most lakes. As a result, the trophic state estimations were not based on TSI alone, and were not necessarily based on the same parameters for all lakes. The basis for each trophic state assessment is discussed in the “Summary” section of the individual lake assessments in Appendix B.

Overall Lake Assessments and Setting Criteria

Water Quality Standards (WAC 173-201A (6)) suggest total phosphorus criteria for lakes (also referred to as “action values”) based on ecoregion and trophic state. If measured concentrations are below the action value, a criterion may be proposed at or below the action value, or a lake-specific study may be conducted. Measured concentrations above the action value or where no action value is provided require a lake-specific study. The characteristics monitored in the LWQA Program are similar to examples included in the Water Quality Standards for lake-specific studies.

An evaluation of the primary beneficial uses on each lake is one of the purposes of the lake-specific study. These were determined from the user perception surveys, observations during sampling, and discussions with volunteer monitors. Determining whether or not the water quality in the lake supports the beneficial uses required best professional judgment. The types of uses were considered and water quality was subsequently determined sufficient or insufficient to support those uses. The results of the questionnaires were reviewed to determine how the users perceive the water quality. Additionally, local governments, fish and wildlife officials, and other lake studies were consulted. Results from the habitat survey provided information on aquatic vegetation, which may impact the quality of swimming, fishing, and boating, as well as fish reproduction and wildlife habitat suitability.

If beneficial uses were supported, then the nutrient criterion recommended for the lake was generally the mean total phosphorus concentration plus an adjustment for interannual variation (described further, below) or the action value. The final recommendation also depended on best professional judgment as to whether current nutrient concentrations are higher due to anthropogenic sources.

If uses were not supported due to being adversely impacted by artificially high nutrient concentrations, then further study may be necessary to determine what nutrient concentrations are needed to support the beneficial uses. Alternatively, if uses were not supported because of habitat modifications, or other non-nutrient related attributes, then recommendations were made on how to improve conditions in order to support those uses. Recommendations can be based on the results from water quality, habitat, watershed, user perception, zooplankton, and Hydrolab® surveys. One benefit of this new approach to lake assessment is the potential to use all the information for management purposes.

The lake-specific nutrient criteria proposed in this report were selected using information compiled through the seasonal sampling. As previously discussed, the criterion was usually recommended as either the action value, or the mean total phosphorus concentration plus an adjustment to allow for natural interannual variation. This adjustment was calculated as the median interannual standard deviation of all lakes monitored by the LWQA program for more than two years with similar phosphorus concentrations to the lake being evaluated (Table 2). For example, if the seasonal mean value for phosphorus in a given lake was 18.3 ug/L, a recommendation of a nutrient criterion of 18.3 + 4.1 = 22.4 ug/L total phosphorus was made. However, if that lake were in the Puget Lowlands and was assessed as lower mesotrophic, the action value of 20 ug/L may be recommended because the action value is more protective yet is still above the mean measured concentration.

Table 2. Median inter-annual standard deviations based on historical data as a function of mean total phosphorus concentrations.

Mean Phosphorus Concentration of sampled lake	Median Inter-annual Standard Deviation (of all lakes)	Number of Lakes
Less than or equal to 10	3.0	19
>10 through 20	4.1	43
>20 through 30	5.1	17
>30 through 40	8.0	16
>40 through 60	15.0	7
>60 through 80	27.8	2
Greater than 100	70.6	8

The intent of recommended criteria is to be protective but not overly sensitive—criteria should be sensitive enough to identify lakes that may be degraded or degrading; yet they should not be so sensitive as to be meaningless as a management tool. These criteria should be considered preliminary. Once a lake has exceeded a criterion, a more detailed study should be conducted, particularly a nutrient loading analysis, the first objective of which should be an evaluation and refinement of the criterion.

Results

Individual lake assessments and proposed criteria are in Appendix B. Table 3 below, summarizes the trophic state, mean total phosphorous values, and proposed criteria for each lake.

Table 3. Summary of individual lake assessments.

Lake Name	County	Assessed Trophic State	Mean TP Concentration (ug/L)	Proposed TP Criterion (ug/L)
Crescent	Clallam	Oligotrophic	3.0 U[a]	4
Crocker	Jefferson	Eutrophic	58	73
Horseshoe	Pend Oreille	Mesoeutrophic	20.3	25.4
Island	Mason	Oligotrophic	8.1	10
Leland	Jefferson	Mesoeutrophic	18.3	20
Liberty	Spokane	Oligomestrophic	13.3	17.4
Limerick	Mason	Mesotrophic	9.0	10
Long	Kitsap	Eutrophic	29.6	34.7
Mason	Mason	Oligotrophic	4.3	7.3
Medical	Spokane	Eutrophic	29.4	None[b]
Medical, West	Spokane	Eutrophic	Nitrogen = 1.20 mg/L[c]	Nitrogen = 1.36 mg/L[c]
Moses	Grant	Eutrophic	79.2	None[d]
Offutt	Thurston	Mesotrophic	19.2	20
Phillips	Mason	Oligotrophic	7.6	10
Potholes	Grant	Eutrophic	36	44
Spanaway	Pierce	Mesoeutrophic	16.6	20
Sutherland	Clallam	Oligotrophic	4.7	7.7
William Symington	Kitsap	Mesotrophic	11.3	20
Ward	Thurston	Oligomesotrophic	8.8	10
Wildcat	Kitsap	Oligotrophic	7.7	10

[a] Phosphorus results qualified with a "U" indicate the analyte was not detected at or above the reported result.

[b] A criterion was not proposed for Medical Lake due to artificial maintenance of water quality (by aeration) and a need for further study.

[c] For lakes in which nitrogen, rather than phosphorous, is the limiting nutrient, a nitrogen criterion is recommended.

[d] A criterion for Moses Lake was not established since that was not the objective of the intensive study of this lake.

Quality Assurance and Quality Control Evaluation

All data collected for the LWQA Program were evaluated to determine whether data quality objectives for the program (Table 4) were met. Methods used for data quality evaluations are described in *Lake Water Quality Assessment Program Quality Assurance Project Plan* (Hallock, 1995-draft). QA/QC analysis for all parameters is listed in Appendix C.

Table 4. Summary of data quality objectives for the LWQA Program.

Parameter	Detection Limit	Precision	Accuracy (Bias)
Secchi Depth	--	< 10% CV[a] (daily pairs) < 5% median CV (all pairs/lake)	< 10% CV[b] (volunteer/ Ecology)
Total Phosphorus	5 µg/L	< 7.5% CV (10 lab splits)	< 2.5% relative bias (lab check standards)
Total Persulfate Nitrogen	0.050 mg/L	< 5% CV (lab splits)	< 5% relative bias (lab check standards)
Chlorophyll *a*	0.5 µg/L	< 10% CV (field dups) < 45% CV (May/August)	< 2.5% relative bias (lab check standards)
Profile parameters			
Temp.	--	--	± 1.0°C
pH	--	--	± 0.2 SU
D.O.	--	--	± 0.50 mg/L
spec. cond.	--	--	± 5 µmho/cm
Fecal Coliforms	1 colony/100 mL	< 35% CV (lab splits)	--

[a] Coefficient of Variation

[b] In the case of Secchi depth, this isn't truly "accuracy" but rather a comparison between volunteer and Ecology staff collected readings.

Profile Data

The Hydrolabs® were pre- and post-calibrated daily for pH and dissolved oxygen. The manufacturer's instructions were followed for pH calibration, using pH 7 (low ionic strength) and pH 10 (standard ionic strength) standard buffer solutions. Post-calibration readings within 0.2 pH units of the standard buffer values were considered acceptable. Two post-calibration readings out of 42 taken did not meet quality assurance requirements. The dissolved oxygen

sensor was calibrated against theoretical water-saturated air, in accordance with manufacturer's instructions. Daily field samples were collected for Winkler titrations and check standards. Post-calibration results within 0.5 mg/L were considered acceptable. Five post-calibration readings out of 38 taken failed quality assurance requirements. Three field checks of 13 taken failed quality assurance requirements. Specific conductance, a more stable parameter on the Hydrolab®, was checked periodically using the manufacturer's instructions. Potassium chloride standards used for conductivity calibration ranged from 101 to 147 µmhos/cm at 25°C (the molarity varied between individual solutions used). Post-calibration values within 5 µmhos/cm of the standard value were considered acceptable. One post-calibration reading out of four calibration checks taken did not meet quality assurance requirements. Temperature was also checked periodically against a National Bureau of Standards (NBS) mercury thermometer. Values within 1.0°C were considered acceptable. All four post-calibration results met quality assurance requirements. Post-calibration results are listed in Appendix D.

Additionally, two duplicate Hydrolab® profiles were collected on each survey. "Nonsequential" duplicates were collected from a separate station, the same station as the nutrient duplicate sample. "Sequential" duplicates were collected by retrieving the Hydrolab® and immediately repeating the measurements at the same station and depths as previously measured. The precision of duplicate readings was calculated as the median of CV%s of data pairs from the same depths. Although no specific quality assurance standards were set for duplicate Hydrolab® data, all median CV%s were under four percent, indicating good precision. As expected, nonsequential duplicates are generally slightly more variable than sequential duplicates. Median CV%s are listed below in Table 5. Additionally, profile quality assurance results are listed in Appendix D.

Table 5. Summary of Quality Assurance/Quality Control data for Hydrolab® profiles.

DISSOLVED OXYGEN				**PH**			
Nonsequential Duplicates		**Sequential Duplicates**		**Nonsequential Duplicates**		**Sequential Duplicates**	
Date	Median CV%	Date	Median CV%	Date	Median CV%	Date	Median CV%
June	2.56	June	3.04	June	2.38	June	0.5
July	3.29	July	1.72	July	0.00	July	0.85
August	1.89	August	0.94	August	0.82	August	0.00
September	3.78	September	1.28	September	0.00	September	0.00

TEMPERATURE				**CONDUCTIVITY**			
Nonsequential Duplicates		**Sequential Duplicates**		**Nonsequential Duplicates**		**Sequential Duplicates**	
Date	Median CV%	Date	Median CV%	Date	Median CV%	Date	Median CV%
June	0.71	June	0.22	June	0.17	June	0.17
July	1.15	July	0.31	July	0.17	July	0.09
August	0.31	August	0.00	August	0.00	August	0.00
September	0.34	September	2.40	September	0.16	September	0.00

Laboratory Quality Assurance

Laboratory QC requirements include the use of check standards, reference materials, matrix spikes, blanks, and lab split samples (duplicates). Lab splits are discussed below. For the most part, data quality for this project met all lab quality assurance and quality control criteria as determined and evaluated by the Manchester Environmental Laboratory. Exceptions, which caused results to be qualified as estimates include the following: sixteen turbidity samples and seven chlorophyll a samples exceeded holding times due to a shipping problem and subsequent late arrival at the lab; ten turbidity samples were qualified due to high algae concentrations; one total phosphorous sample was qualified due to spike recovery exceeding the acceptance limit; and ten total phosphorous samples were qualified due to the calibration check standard being outside of control limits. Additionally, several results were qualified as containing the analyte below the method's limit of detection. These qualifiers were noted and taken into consideration when assessing lake water quality and recommending nutrient criteria.

Field Quality Assurance

Total Phosphorous Data

Lab precision was calculated by pooling the coefficients for all pairs of lab splits. Results (Appendix C) were all under the acceptable median CV% of 7.5 percent (Table 6).

Total phosphorous samples were collected at a second site from ten lakes during the course of the survey. These duplicate samples were collected to evaluate the representativeness of collecting epilimnetic data from a single lake station. The Quality Assurance Project Plan (QAPP) for the LWQA Program (Hallock, 1995) states that the total precision of these nonsequential duplicates should be evaluated by pooling the CV%s for each pair and, if the median CV% exceeds 21 percent, then collecting from a single lake station is generally not representative of lakewide epilimnetic phosphorous. Results (Appendix C) show that the median CV% did not exceed 21 percent; therefore, sampling at one site is generally representative (Table 6).

In addition to nonsequential duplicates, sequential duplicates were collected by immediately repeating the sample collection at the nonsequential site. Although no specific quality assurance standards were set for sequential duplicate total phosphorous data, all median CV%s indicate little variance (Table 6).

Other Water Chemistry Data

QA/QC evaluations for total nitrogen, chlorophyll *a*, solids, and fecal coliform bacteria followed the methods described in Hallock (1995). All available lab QC data results are listed in Appendix C and summarized below in Table 6.

Total Nitrogen

All median CV%s for total nitrogen lab splits fell below the QAPP standard of 7.5 percent. Similarly, all nonsequential duplicate median CV%s were well under the QAPP standard of 30 percent.

Chlorophyll a

All median CV%s for chlorophyll a lab splits fell below the QAPP standard of 10 percent. However, sequential duplicate results exceeded QAPP standards for both June and July indicating difficulty in collecting consistent composite samples. However, the mean variance was high largely due to two samples with concentrations less than one, where even a small absolute difference between results can yield a large CV% (Appendix C). August and September sequential duplicate median CV%s were under the QAPP standard of 10 percent.

Fecal Coliform Bacteria

It is not possible to conduct quality assurance calculations on fecal coliform data due to the wide variability in fecal concentrations expected in the field. We do not consider a single fecal bacteria sample to be representative lakewide. These samples were generally used to assess high risk or potential source areas such as swimming beaches, heavily developed embayments, etc.

Turbidity

All turbidity readings were within 0.5 NTUs, the acceptable range set forth by the QAPP.

Table 6. Summary of Quality Assurance/Quality Control Data for 1998.

TOTAL PHOSPHOROUS

Lab Splits (QAPP standard ≤7.5%)		**Nonsequential Duplicates (standard ≤21%)**		**Sequential Duplicates (no standard)**	
Date	Median CV%	Date	Median CV%	Date	Median CV%
June	3.4	June	8.8	June	Not avail.
July	3.8	July	19.0	July	2.4
August	2.3	August	5.0	August	5.4
September	0.8	September	8.8	September	25.9

TOTAL NITROGEN

Lab Splits (QAPP standard ≤5%)		**Nonsequential Duplicates (standard ≤30%)**		**Sequential Duplicates (no standard)**	
Date	Median CV%	Date	Median CV%	Date	Median CV%
June	0.3	June	1.9	June	Not avail.
July	2.7	July	7.7	July	4.1
August	1.2	August	5.4	August	1.6
September	2.2	September	2.5	September	0.0

CHLOROPHYLL A

Lab Splits (QAPP standard ≤10%)		**Nonsequential Duplicates (no standard)**		**Sequential Duplicates (standard ≤10%)**	
Date	Median CV%	Date	Median CV%	Date	Median CV%
June	5.0	June	9.9	June	**24.7**
July	3.7	July	10.5	July	**10.9**
August	2.7	August	19.8	August	6.1
September	2.7	September	11.6	September	10.0

TURBIDITY

Lab Splits (QAPP standard within 0.5NTU)		**Nonsequential Duplicates (no standard)**		**No turbidity sequential duplicates were collected**
Date	Max. Difference	Date	Median CV%	
June	0.2	June	6.7	
July	0.1	July	Not Available	
August	0.2	August	0.0	
September	0.4	September	0.0	

Recommendations

◊ The questionnaires provided useful supporting information for the lake assessments. A more rigorous methodology for collecting and evaluating the user surveys should be developed for future use. The habitat surveys may be much harder to summarize because different habitat attributes may be more important on one lake than another; looking at results for individual metrics may be more useful than a summary. The watershed survey would be difficult to summarize and is very useful in its present form as a general overview of the watershed.

◊ The zooplankton index should be further tested as an indicator of fish predator/prey balance, as intended, and developed further to help elucidate the trophic cascade relationships in Washington lakes.

◊ An acceptable protocol is needed to recommend nutrient criteria in lakes where the water quality does not support the beneficial uses. Setting values with very little knowledge of nutrient loading conditions could be problematic.

References

Beaver, J.R., 1997. *Zooplankton Workshop Reference Guide*. North American Lake Management Society 17th Annual International Symposium; December 3-6, 1997, Houston, TX.

Boyle, K., J. Schuetz, and J. Kahl, 1997. "Great Ponds Play an Integral Role in Maine's Economy." Water Research Institute, University of Maine. Department of Resource Economics and Policy Staff Paper, REP 473, April, 1997, 50 pp.

Brett, M., and C. Goldman, 1996. "A Meta-analysis of the Freshwater Trophic Cascade." Proceeding of the National Academy of Science, 93: 7723-7726.

Carlson, R.E., 1977. "A Trophic State Index for Lakes." *Limnol. Oceanogr*. 22: 361-369.

-----, 1979. "A Review of the Philosophy and Construction of Trophic State Indices" *In* Maloney, T.E. *Lake and Reservoir Classification Systems*. U.S. Environmental Protection Agency Report No. EPA-600/3-79-074, pp. 1-52.

Edmondson, W.T. (ed.), 1959. *Fresh-Water Biology*, 2nd ed. John Wiley and Sons, Inc., NY, 1248 pp.

Hallock, D., 1995 (in draft). *Lake Water Quality Assessment Project Quality Assurance Project Plan*. Environmental Investigations and Laboratory Services Program, Washington Department of Ecology, Olympia, WA.

Huntamer, D., and J. Hyre, 1991. *Manchester Environmental Laboratory, Laboratory User's Manual*, Third Edition. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA, 342 pp.

Kaufmann, P., and T. Whittier, 1997. *Surface Waters, Field Operations Manual for Lakes*, Section 5, Habitat Characterization. U.S. Environmental Protection Agency Report No. EPA/620/R-97/001.

Mills, E. and A. Schavone, 1982. "Evaluation of Fish Communities Through Assessment of Zooplankton Populations and Measures of Lake Productivity." North American Journal of Fisheries Management 2: 14-27.

Parsons, J., 1999. Aquatic Plants Technical Assistance Program, 1998 Activity Report. Washington State Department of Ecology, Olympia, WA, Publication No. 99-328.

Prescott, G.W., 1962. *Algae of the Western Great Lakes Area*. Wm. C. Brown, Co., Dubuque, IA, 977 pp.

-----, 1978. *How to Know the Freshwater Algae*. 3rd ed., Wm C. Brown Co., Dubuque, IA, 293 pp.

-----, 1980. How to know the aquatic plants. Wm. C. Brown Co. Publishers. Dubuque, IA.

Smith, G.S., 1950. *The Freshwater Algae of the United States*. 2nd ed. McGraw-Hill Book Company, Inc., 719 pp.

Tarver, D.P., J.A. Rodgers, M.J. Mahler, and R.L. Lazor, 1978. *Aquatic and Wetland Plants of Florida*. Florida Department of Natural Resources, 128 pp.

VanLandingham, S.L., 1982. *Guide to the Identification, Environmental Requirements and Pollution Tolerance of Freshwater Blue-Green Algae (Cyanophyta).* Environmental Protection Agency EPA-600/3-82-073. 341 pp.

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Appendix A

Survey Forms

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Watershed Survey

Date: Name of Lake:

1. In reference to the watershed in general, note types of land use
   -Agriculture (commercial, not hobby)
   -Residential
   -Commercial, Industrial
   -Major transportation
   -Park, forest or natural

On a relative scale, rank the above land uses from most prominent to least in respect to how it may have the most adverse impact on the lake. (Example: A lake watershed may be 90% forest land but none of that may be under harvest at the time of survey but I-5 may transit just 200 meters from the lake with runoff from the highway going directly to the lake. Forest land may be most prominent in area but major transportation would have the most adverse impact on the lake.)

2. Impervious surfaces (Roads and parking areas)
   -Mostly curbed with storm drains (>75%)
   -About half of the surfaces are curbed (35-75%)
   -Partially curbed
   -No curbs

3. BMPs evident (Y or N)
   -Give examples of BMPs and/or lack of

4. Odors from septics or agriculture detectable?
   -If yes, please note where

5. Cattle, ducks or geese in the water? If so, where?

6. Fertilizers and weed killers appear to be used in residential or agriculture areas (Y or N). If so, where?

7. Buffer zones around steams and wetlands noticed? If lacking, where?

8. Are there any irrigation withdrawals noted from lake or tributaries of the lake? Is so, where?

9. Approximately what portion of the watershed did you survey?

Lake Survey for Residents

Date: Name of Lake:

Introduction:

The Department of Ecology is conducting a study on this lake. We are attempting to obtain information from people who are visiting the lake. Information provided will be used in conjunction with scientific measurements in an effort to adequately assess the lake and its uses. If you have already filled out this survey this summer then you may do so again if the conditions on the lake have changed to the point where your answers have changed. Attempt to answer the questions based on your experience at the time you were last recreating on the lake or lake shore and ensure that the date written above matches the date of the visit. If you have any questions, please call Kirk Smith at 360-407-6680.

General:

Are you a seasonal or permanent resident of the Lake?

☐ Seasonal Resident

☐ *Permanent Resident (if permanent, go to question 2)*

1. Where is your permanent residence?

   _____

   City/Town State

2. Including this year, how many years have you lived or come to stay at the lake?
   _____years

3. Do you own or rent this property?
   ☐ *Own*

   ☐ *Rent*

4. What is the **primary** activity you took part in when recreating on the lake today? (**check one only**)

   ☐ canoeing/kayaking
   ☐ fishing
   ☐ personal watercraft
   ☐ motor boating
   ☐ sailing
   ☐ swimming/wading
   ☐ watching birds/wildlife
   ☐ water skiing
   ☐ wind surfing
   ☐ relaxing on the shore
   ☐ other_____

The following question asks about your decision to recreate on this lake.

5. Of the following attributes, which added to or detracted from your enjoyment? **Please mark in the "Qualifiers" column when applicable** or use the blank in that column to briefly comment on that attribute.

	Added to	No Effect	Detracted from	Qualifiers (X=yes)
types of water craft allowed	☐	☐	☐	☐ Restricted use (5mph, etc.)
public access	☐	☐	☐	☐ Available?
water clarity	☐	☐	☐	
fishing quality	☐	☐	☐	
scenic views	☐	☐	☐	
having a swimming beach	☐	☐	☐	☐ Available?
water quality for swimming	☐	☐	☐	
having plants in the water	☐	☐	☐	
distance traveled to lake	☐	☐	☐	Miles (one way)?_____
Canada geese	☐	☐	☐	☐ N/A

6. On the scale of 1 to 5, how would you rate the quality of the water clarity today? 1 being poor and 5 being excellent. _____

7. When deciding to (purchase/rent) this residence, did you consider the clarity of the water?

☐ No
☐ Yes

8. Have you noticed a change in water clarity at the lake over the years?

☐ *diminished (approximately what year did the change begin?)* _____
☐ no change
☐ *enhanced (approximately what year did the change begin?)*
☐ Don't know

9. If it wasn't possible to have both, would you rather have (a) better fishing and more natural habitat or (b) clearer water? _____

10. If it wasn't possible to have both, would you rather have (a) better fishing and more natural habitat or (b) few aquatic plants? _____

11. If it wasn't possible to have both, would you rather have (a) clearer water or (b) few aquatic plants? _____

12. Please rate how important each of the following lake characteristic is to you.

(CIRCLE ONE NUMBER FOR EACH CHARACTERISTIC)

	Very Undesirable	Undesirable	Neither	Desirable	Very Desirable
Restricted watercraft use	1	2	3	4	5
Plant growth in the water	1	2	3	4	5
More natural shoreline	1	2	3	4	5
No water odor	1	2	3	4	5
Good trout/salmon fishing	1	2	3	4	5
Good bass/perch fishing	1	2	3	4	5
Good swimming	1	2	3	4	5
Less algae	1	2	3	4	5
Public access	1	2	3	4	5
Clear water	1	2	3	4	5
Views of natural scenery	1	2	3	4	5
Public beach	1	2	3	4	5
Canada geese	1	2	3	4	5
Other, please explain	1	2	3	4	5

This concludes the survey. Thank you very much for your time and cooperation. Your help is very much appreciated.

--Did you put the date and the name of the lake at the top of the survey?

Summary of Resident's Survey: The survey for day visitors is very similar to the to the survey for residents. The main exception is that more questions pertaining to socio-economics are not included. (Changes in lake quality have been shown to impact property values in addition to the enjoyment of the resource (Boyle et al., 1997)). With one exception, all of the questions below will be used to meet objective #3.

1. Helps establish where seasonal residents reside permanently. For instance, it may be important to know that most of the seasonal residents on Lake X come from the Seattle area vs. other metro areas or that more of the seasonal residents on Lake Y are from Seattle compared to Lake X even though Lake X is closer to Seattle. Investigators may then want to look at why Lake Y appears to be more popular.

2. Aids in determining whether or not the respondent has a historical perspective. A person who has been coming to the lake every summer for the last 12 years may provide more valuable information than someone who has just starting to vacation on the lake.

3. Establishes whether or not the resident is an owner of the property in which case he or she may have more of an interest in the quality of the lake.

4. Helps discern what the primary human uses are for that particular lake (part one of objective #1). The question will help narrow the scope of the data analysis by guiding the evaluation of uses.

5. Helps discern conflicts between uses and whether or not uses are impaired. For instance, high-speed water craft may impair overall scenic beauty for someone who has primarily come to the lake to relax on the shore. Also, the closeness to home question adds a component that helps evaluate the overall socio-economic importance of that water body. Lakes where users are willing to travel great distances to recreate may be said to have a greater user value. An index could be developed to show the lake value based on miles willing to travel to get to the lake. (objectives #1 part 2, #2, #3).

6. Attempts to match user perception of water clarity with Secchi readings taken for that day. Hypothetically, a percentage (40%?) indicating water clarity is poor could be set as a threshold before acceptable nutrient concentrations are exceeded for that lake. A nutrient criterion could then be established for that threshold using interpolated LWQA historical data compiled for similar lakes or some other model. This would only apply if it was determined that impaired primary recreational uses were linked to water clarity. For example: Water skiing is determined to be the primary recreational use of a lake but the use is impaired by quality of water for swimming and water clarity (questions #4 and #5). Management for water clarity may then be warranted for that particular lake (objective #2). If 56% of respondents in August indicate poor water quality for Lake X, then the beneficial uses of the lake are said to be impaired and a nutrient criterion should be set at concentrations below present levels. On the other hand, if the lake is primarily used for fishing, wildlife habitat, and scenery and there is little primary contact, then beneficial uses of the lake may not be impaired even if there are more than 40% of the respondents replying with a “yes” response. This may be also be true for lakes which habitat and watershed surveys suggest is at or near a natural condition.

7. Attempts to establish a direct relationship between water clarity and willingness to rent/buy. This question could also be used to determine if owners are more concerned about water clarity than renters.

8. Generates historical knowledge on possible trends in water quality. The answers could be difficult to interpret, especially if there was no overwhelming response for any of the choices. However, where a majority (over 50 %) of responses indicate a consistent change in clarity, results from this question may support an evaluation of historical data. Also, this question would be of particular importance when assessing lakes that have undergone some type of restoration. If restored lakes don't indicate an overwhelming perception of improved water clarity then there may be reason to believe that beneficial uses are still impaired despite restoration efforts. (objective #2)

9 – 11. Helps those being surveyed resolve in their minds what is more important, human or non-human uses. Answers to these questions may be particularly important if there are conflicting uses on the lake. For instance, if bird watching, relaxing on shore and swimming were the top beneficial uses on a lake, it may be important to determine if the survey respondents believe saving wildlife habitat is more important for that particular lake even at the expense of having clear and/or weedless water for swimming. These questions could be pivotal for some lakes (Lake Limerick in Mason County may be a good test for these questions). (objective #1)

12. Determines whether or not there is a need for protecting a use on the lake. Allows respondents to place values on the uses of the lake relative to other uses for the lake. Weighted answers could help accentuate the need or importance of some uses to be managed more than others. An example would be an extraordinarily high number of "Very Desirable" rating for "Few problem waterfowl." Such a response may direct the need for habitat management and suggest lake specific criteria be set for habitat as well as other criteria (e. g., fecal coliform bacteria). This question also demonstrates the socio-economic importance of each lake attribute. The general public may feel that water clarity has detracted from their enjoyment on the lake in question #3 but may not value that quality as much as few problem waterfowl, views of natural scenery, public access, and no water odor. Weighted answers are important to help set priorities for lake specific criteria by adding values to the uses. (objectives #1 and #3)

Appendix B

Individual Lake Assessments

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CRESCENT

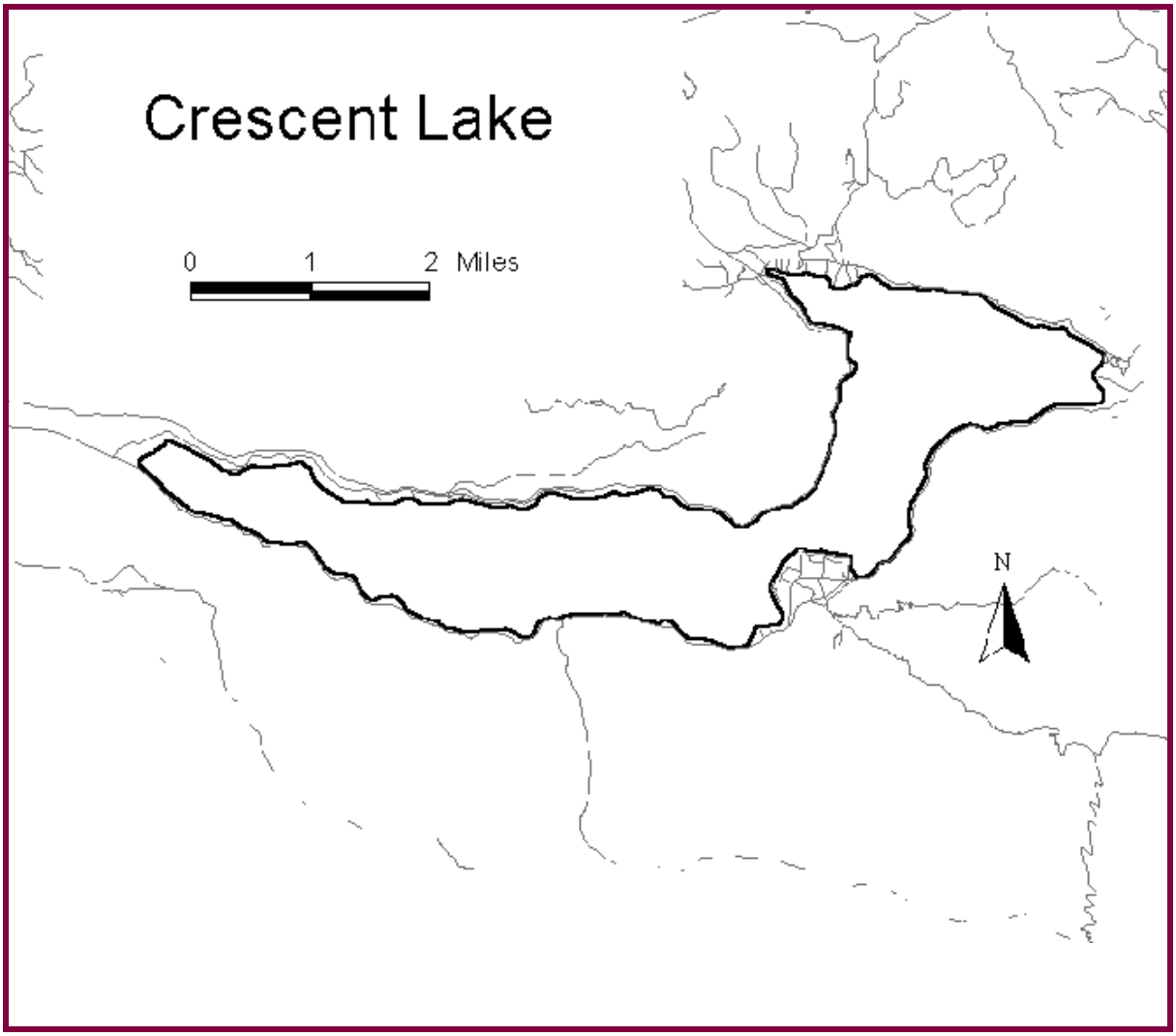
CLALLAM County

Lake ID: CRECL1

Ecoregion: 1

Crescent Lake is 14 miles west of Port Angeles. It is 8.5 miles long. Several inlets flow into the lake, including Barnes, Smith, Aurora, Lapoel, Cross, and Eagle Creeks. Crescent Lake drains via the Lyre River to the Strait of Juan de Fuca. There is a precipitous shoreline, except at both ends. It is the third largest natural lake in Western Washington. Beardslee trout are found only in Crescent Lake.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
5127	624			
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
		580	48 05 41.	123 48 14.



Station Information

CRECL1

Primary Station	Station # 1	latitude: 48 04 58.4	longitude: 123 46 62.4
	Description:	In east end of lake approximately midway between eastern shore and outlet (Lyre River)	
Secondary Station	Station # 2	latitude: 48 03 33.3	longitude: 123 49 51.5
	Description:	Approximately in middle of lake midway between Lake Crescent Lodge to the east and a picnic area to the west	

Trophic State Assessment for 1998

CRESCENT

Analyst: KIRK SMITH

TSI_Secchi:		
TSI_Phos:	20	J
TSI_Chl:	24	J
Narrative TSI:[a]	O	

Crescent Lake is an ultra-oligotrophic lake nestled in the Olympic Mountain range within the boundary of the Olympic National Park. Our Secchi line was not long enough to measure the true Secchi depth, nor were we able to accurately measure total phosphorus or chlorophyll a because our detection limits were not adequate for such low concentrations. Because Crescent is clearly pristine, we recommend a total phosphorus criterion be set at the Cascades ecoregion/ultra-oligotrophic action value of 4 ug/L pending additional studies with lower detection levels. However, Crescent Lake may be nitrogen limited, and all anthropogenic nutrient sources should be limited and controlled in this national resource.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

CRESCENT

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/8/1998		E	3 U	.01 U	3	.5 U		53.3	16800	.7
7/30/1998		E	3 U	.01 U	3	.5 U				
9/15/1998		E	3 U	.022	7	.5 U				.5 U
Station 2										
6/8/1998		E	8.2	.01 U	1	.5 U				
7/30/1998		E	3 U	.018	6					
8/13/1998		E	3 U	.041	14	.5 U				.5 U
9/15/1998		E	3 U	.01 U	3	.52 J				

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

CRESCENT

Survey Date: 9/15/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

	Agriculture(commercial, not hobby)		**Residential**
	Commercial, Industrial	2	**Park, forest or natural**
1	**Major transportation**		

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Lake shore is kept at or near natural conditions. The vast majority of the watershed is a nattional park.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☑

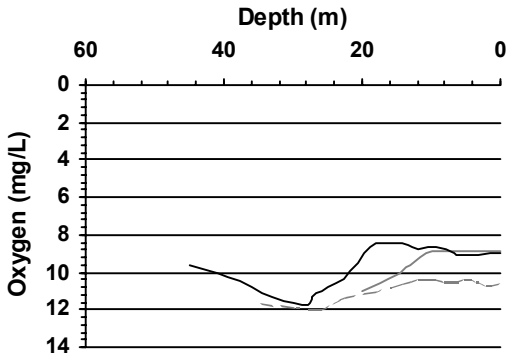
Buffer zones in place around most of the lake--very little development.

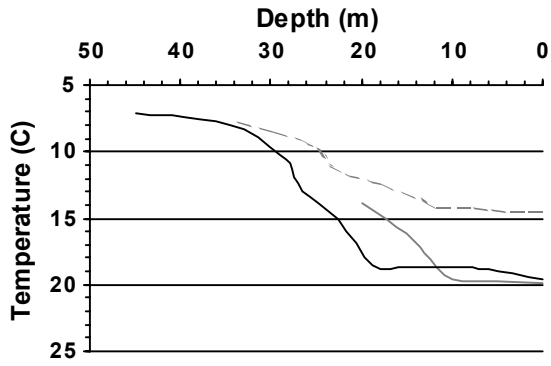
Irrigation ☐

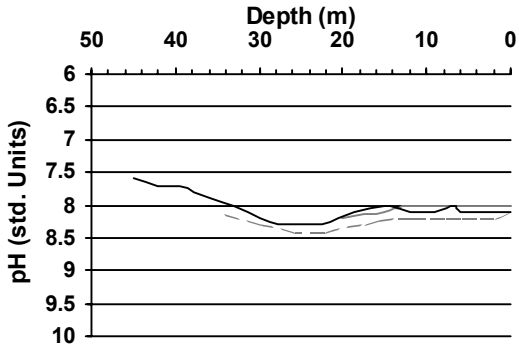
Survey Id: 90

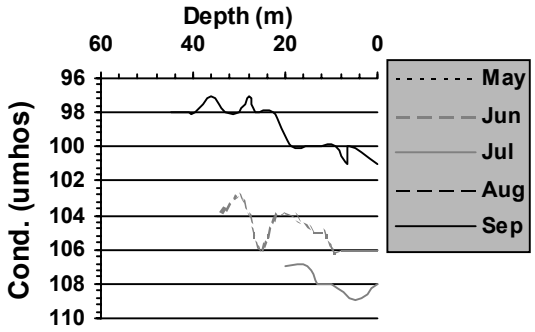
Secchi Depth and Profile Graphics

Station: 1 CRECL1









Secchi Data and Field Observations

CRESCENT

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/8/1998				1	50	4		5	5	0	0	0	0
	Sampler: SMITH			Remarks: WATER WAS A TORQUOISE BLUE. WATER WAS TOO CLEAR AND DEEP FOR A SECCHI READING									
7/31/1998				1	80	1		5	5	7	1	1	1
	Sampler: SMITH			Remarks: WATER WAS EXTREMELY CLEAR, TOO CLEAR FOR A SECCHI READING. DO TAKEN AT 5 METERS									
8/13/1998				1	0			5	5	0	0	1	3
	Sampler: SMITH			Remarks: WATER WAS TOO CLEAR AND TOO DEEP FOR A SECCHI READING.									
9/15/1998				1	50			5	5	4	5	2	0
	Sampler: SMITH			Remarks: WATER WAS TOO CLEAR AND TOO DEEP FOR A SECCHI READING. The Conductivity and oxygen results are qualified as an estimate due to postcalibration failing QA/QC requirements.									

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CROCKER

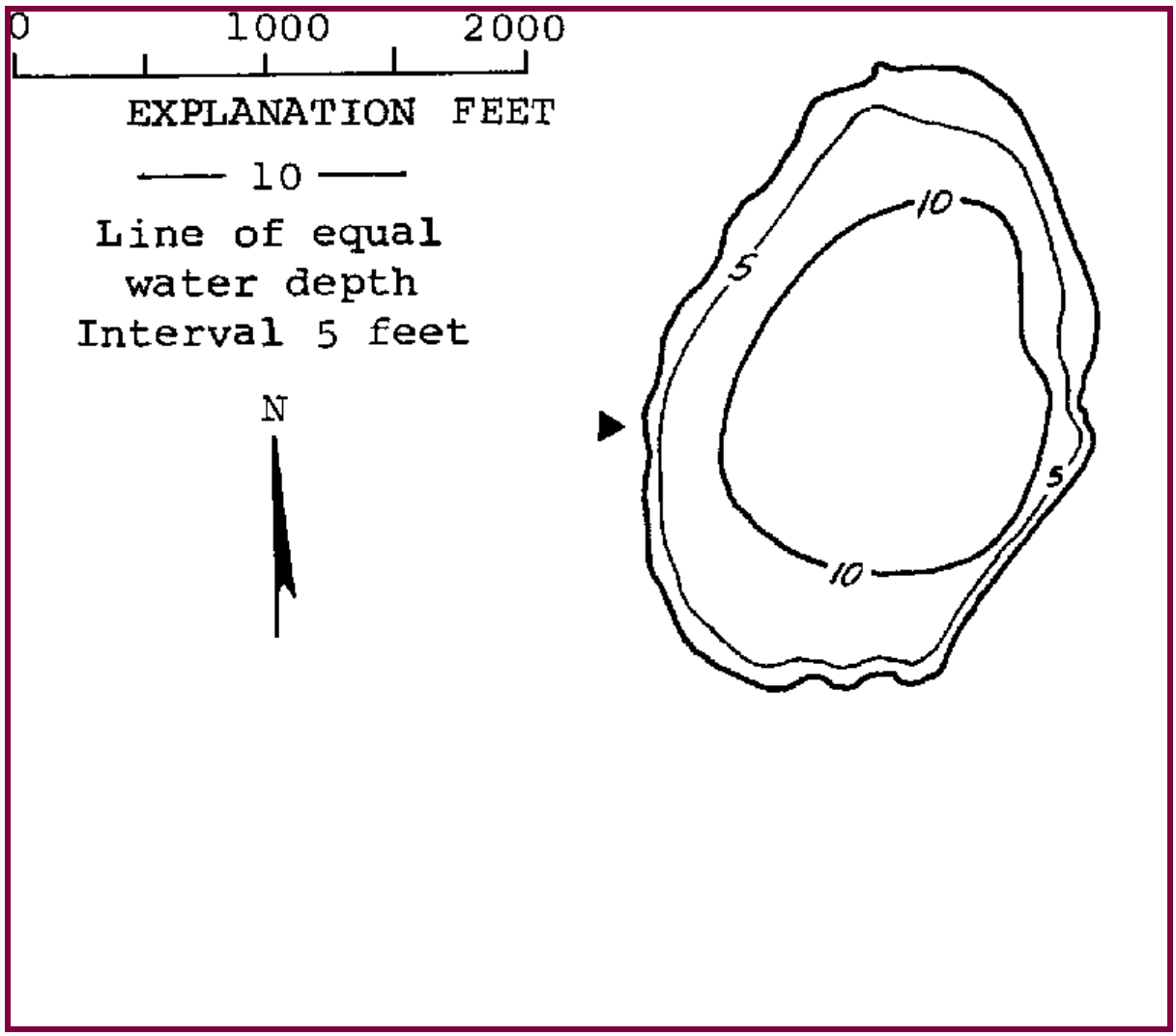
JEFFERSON County

Lake ID: CROJE1

Ecoregion: 2

Crocker Lake is one of the most visible lakes on the Olympic Penninsula for those driving from the Seattle suburbs to Port Angeles along Highway 104. The lake is easily seen from the highway as you're heading west just before the intersection with Highway 101. This small eutrophic lake is abundant with natural aquatic vegetation yet, as of 1998, Crocker Lake lacks the invasive Egeria densa (Brazilian elodea) of its neighbor lake, Lake Leland.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
76	13	9	3	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
663	1.29	190	47 56 22.	122 52 45.



Station Information

CROJE1

Primary Station Station # 1 latitude: 47 56 03.9 longitude: 122 53 01.7

Description: Deep part of lake, mid lake directly east of boat launch

Trophic State Assessment for 1998

CROCKER

Analyst: KIRK SMITH

TSI_Secchi:	54	N
TSI_Phos:	66	
TSI_Chl:	58	J
Narrative TSI:[a]	E	

Crocker is a shallow lake with abundant nutrients and macrophyte growth. It is a typical naturally eutrophic lake. The watershed is largely undisturbed with some agriculture and tree cutting in the area. The water quality appears to support both the human and non-human uses in the lake. Zooplankton were quite large, which can be indicative of a large fish predator base. In fact, Crocker was treated on 8 July 1998 with rotenone by the Washington Department of Fish and Wildlife to remove illegally stocked northern pike. High late summer TP could be from nutrient release from anoxic sediments (although the lake was not thermally stratified at the time of sampling, there was an oxycline most months) or possibly from decomposing fish, left in the lake after the rotenone treatment. The lake may have been phosphorous limited during the first half of the summer, becoming nitrogen limited later as phosphorus concentrations rose. However, the very dark colored water may also diminish light penetration into the water column thereby limiting primary production. One fecal sample, collected near the boat launch in August, was unusually high for lakes (140 colonies/100mL).

In our judgement, uses are being supported and the eutrophic state of the lake is natural. We recommend that a total phosphorus criterion be established at 73 ug/L, the seasonal mean of our 1998 samples with an adjustment to account for inter-annual variability (mean of 58 ug/L total phosphorus plus std. dev. of 15 ug/L). However, because of the rotenone treatment our mean could be biased high, and this should be considered an interim criterion pending further TP sampling.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

CROCKER

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
8/12/1998		L					140			
Station 1										
6/5/1998		E	18.4	.397	22	10.3		25	5820	3 J

7/30/1998	E	50.3	1.1	22	42.8		
8/12/1998	E	60.6	.854	14	21.8		3.9
9/14/1998	E	103	.755	7	3.9 J		3.1 J

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

CROCKER

Survey Date: 9/14/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

2	**Agriculture(commercial, not hobby)**		**Residential**
	Commercial, Industrial	1	**Park, forest or natural**
3	**Major transportation**		

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☑

Select cutting at a near-by forest.

Odors ☑

Yes, a farm one-mile from lake with a strong manure odor.

Cattle ☐ **Ducks** ☐ **Geese** ☑

3 domestic geese by the boat ramp

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☑

Irrigation ☐

Survey Id: 70

Habitat Survey Summary Report

CROCKER

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 9/3/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	3.0	**Number of stations with canopy:**	4
Understory Avg:	2.9	**Number of stations with understory:**	7

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	0.5

	trees< 0.3 m DBH	1.0
Understory:	**woody shrubs saplings**	1.9
	tall herbs, forbs grasses	2.7
Ground Cover:	**woody shrubs seedlings**	1.0
	herbs, forbs, grasses	1.3
	standing water or inundated veg	1.0
	barren or buildings	0.3
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.0
	cobble/gravel	0.2
	loose sand	0.5
	other fine soil/sediment	0.3
	vegetated	3.6
	other	0.5
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.0
	vertical dist (M from wtrln to high wt):	0.3
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence

(0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	0.3
commercial	0.0
park facilities	0.1
docks/boats	0.1
walls, dikes, or revetments	0.0
litter, trash dump, or landfill	0.2
roads or railroad	0.4
row crops	0.0
pasture or hayfield	0.2
orchard	0.0
lawn	0.2
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	0.9

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.0
cobble	0.1
gravel	0.4
sand	1.2
silt	2.7
woody debris	0.6

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)	
submergent	3.2
emergent	1.5
floating	1.7
total weed cover	3.6
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.8

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)	
aquatic weeds	1.8
snags	0.6
brush or woody debris	0.4
inundated live trees	0.0
overhanging vegetation	0.2
rock ledges or sharp dropoffs	0.0
boulders	0.0
human structures	0.2

Zooplankton Report

CROJE1

Date 6/5/1998 Station: 1
Sample ID 12

Only large predators present, Northern Pike, so no known planktivores or very few planktivores present; 1 mL analyzed.

Number of organisms measured: 64

Group	Percent
Cladoceran	50.0%
Copepod	50.0%
Other	

Group	Percent
Small < 1mm	25.0%
Large >= 1mm	75.0%
Ratio of large to Small:	3.00
Average size (mm):	1.06

Aquatic Plant Data

CROCKER

Sampler: Parsons, Bell-McKinnon Survey Date: 9/3/1998

Max depth of growth (M): 2

Comments Sunny, wind. Did vegetation survey form for Kirk Smith. Bare sediment in shallows with patchy E. canadensis. Nuphar dying back. The lake was treated with rotenone to remove Pike several weeks ago. Water very muddy brown. Emergent stems of the Sagittaria rigida grazed off through much of the lake. Many ducks, newt.

SPECIES LIST

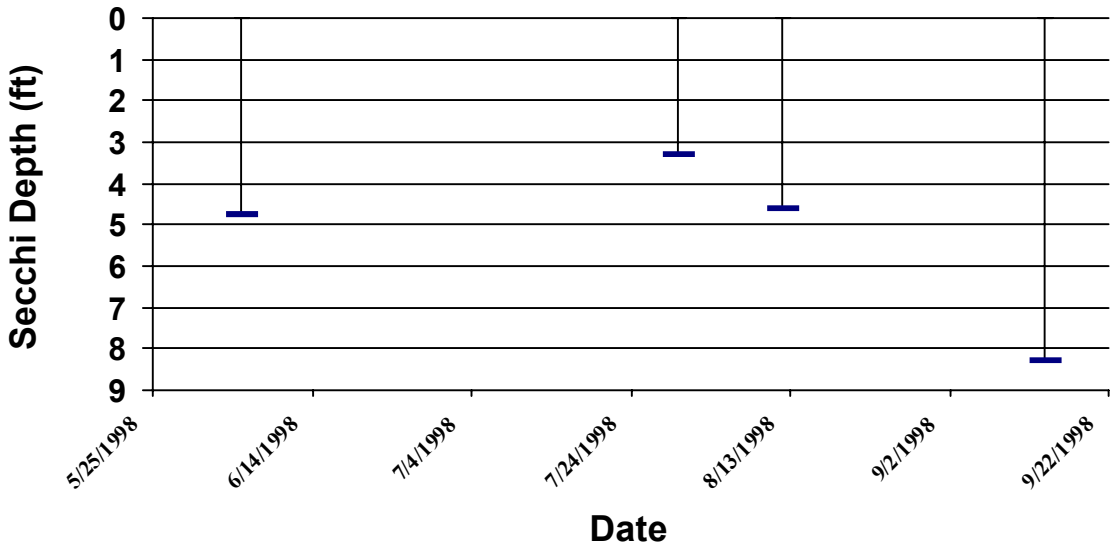
Scientific Name	Common Name	Dist [a]	Comments
Ceratophyllum demersum	Coontail; hornwort	2	
Chara sp.	muskwort	2	
Elodea canadensis	common elodea	4	very dense in shallows
Najas flexilis	common naiad	2	
Nuphar polysepala	spatter-dock, yellow water-lily	3	

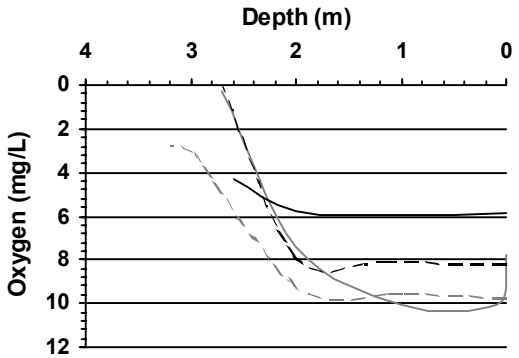
Potamogeton obtusifolius	bluntleaf pondweed	1	on east side
Potamogeton praelongus	whitestem pondweed	2	
Potamogeton pusillus	slender pondweed	1	at north end
Sagittaria rigida	bur arrowhead	2	mostly at south end
Scirpus sp.	bulrush	2	
Typha latifolia	common cat-tail	2	
Utricularia sp.	bladderwort	1	

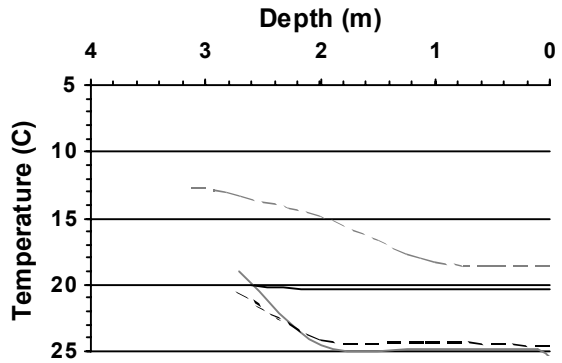
[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

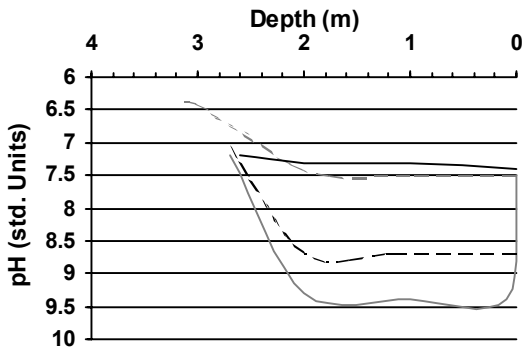
Secchi Depth and Profile Graphics

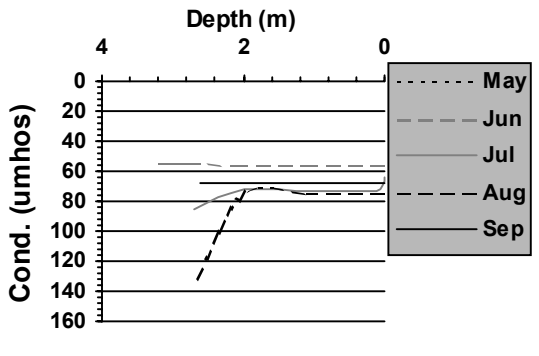
Station: 1 CROJE1











Secchi Data and Field Observations

CROCKER

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/5/1998			4.75	8	100			5	2	23	5	1	0
	Sampler: SMITH			Remarks: 3 METERS FOR ZOOPLANKTON TOW.									
7/30/1998			3.3	7	100	2		3	2	9	18	0	0
	Sampler: SMITH			Remarks: WATER WAS POISONED WITH ROTENONE ON 7/8/98. MUCH LOGGING AND CLEAR-CUTTING IN THE AREA. FEW RESIDENTIAL HOMES.									
8/12/1998			4.62	8	0	2		2	2	3	33	0	0
	Sampler: SMITH			Remarks: FIELD VISIT									
9/14/1998			8.25	9	0			4	3	38	23	0	0
	Sampler: SMITH			Remarks: NEW BOAT LAUNCH INSTALLED. The Conductivity and Oxygen results are qualified as an estimate due to postcalibration failing QA/QC requirements.									

HORSESHOE

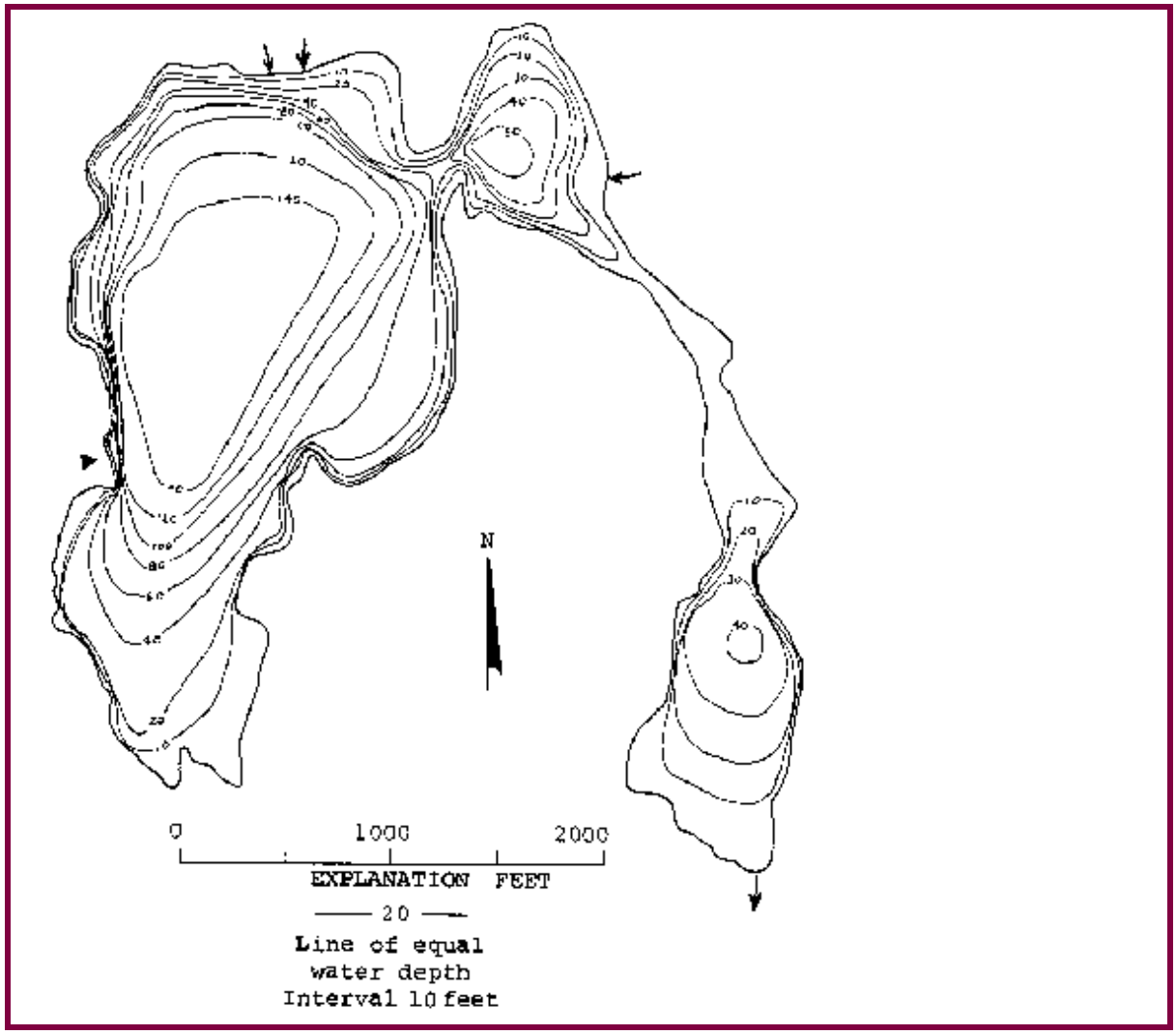
PEND OREILLE County

Lake ID: HORPE1

Ecoregion: 8

Horseshoe Lake is approximately 25 miles northwest of Spokane located near the corner where three counties (Spokane, Pend Oreille and Stevens) meet. It is fed by Heel and Buck Creeks and drains to the Little Spokane River through Eloika Lake.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
141	150	64	80	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
9002	3.84	1975	48 06 19.	117 24 28.



Station Information

HORPE1

Primary Station Station # 1 latitude: 48 06 41.0 longitude: 117 25 10.0

Description: Deep part of lake, directly north of boat launch

Trophic State Assessment for 1998

HORSESHOE

Analyst: KIRK SMITH

TSI_Secchi:	47	N
TSI_Phos:	45	
TSI_Chl:	62	
Narrative TSI:[a]	ME	

The trophic state of Horseshoe Lake is probably near natural conditions. Results from the watershed and habitat surveys suggest there is relatively little anthropogenic disturbance and the meso-eutrophic state of the lake should be acceptable in supporting the uses of the lake. Questionnaires indicated a strong desire among respondents to restrict motorboat use as well as an appreciation for the scenery. Whether to restrict motorboat use is largely an aesthetic decision; the shoreline is not particularly susceptible to erosion from motorboats. The lake should support an excellent coldwater fishery. It is productive yet retains a very cold and mostly oxygenated hypolimnion. There was only slight evidence of internal phosphorus loading (in August). Average chlorophyll concentrations were higher than would be expected given phosphorus and transparency averages. Our early June chlorophyll reading was highest; this could have been the tail end of a spring response to under-ice nutrient release from senescing macrophytes.

Because uses are being supported and the trophic state of the lake is natural, a total phosphorus criterion may be set at the seasonal mean that was established during 1998 sampling, adjusted for interannual variability. Therefore, a nutrient criterion for the lake of 25.4 ug/L total phosphorus (mean 20.3 ug/L plus std. dev. of 5.1 ug/L) is recommended..

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

HORSESHOE

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
7/13/1998		L					1 J			
		L					1 U			
8/10/1998		L					3			
		L					1 U			
9/14/1998		L					2			

Station 1

6/15/1998	E	29.7	.178	6	33.5	19	3.3 J
	H	20.1					
7/13/1998	E	20.5	.414	20	13.8		2.5
	H	23.9	.192	8			
8/10/1998	E	18.4	.517	28	24.2		2.1
	H	62.8	.399	6			
9/14/1998	E	11.7	.229	20	4.2		.7
	H	14.4	.247	17			

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

HORSESHOE

Survey Date: 9/14/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [ ] **Agriculture(commercial, not hobby)**
- [ ] **Commercial, Industrial**
- [ ] **Major transportation**
- [2] **Residential**
- [1] **Park, forest or natural**

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Probably not too degraded from natural conditions and not too suceptible provided good forest practices. Shoreline is cobble/broken shale and probably not susceptible to erosion. 17 homes on lake--probably not many more in watershed.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☐

Irrigation ☐

Survey Id:

Habitat Survey Summary Report

HORSESHOE

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/13/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.2	**Number of stations with canopy:**	10
Understory Avg:	2.4	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.8
	trees< 0.3 m DBH	0.7
Understory:	**woody shrubs saplings**	2.0
	tall herbs, forbs grasses	1.8
Ground Cover:	**woody shrubs seedlings**	1.6
	herbs, forbs, grasses	1.2
	standing water or inundated veg	0.5
	barren or buildings	1.6
Substrate Type (within shoreline plot):	**bedrock**	0.3
	boulders	0.4
	cobble/gravel	1.8
	loose sand	0.8
	other fine soil/sediment	0.4
	vegetated	2.5
	other	0.2
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.8
	vertical dist (M from wtrln to high wt):	0.1
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	0.6
commercial	0.0
park facilities	0.1
docks/boats	0.7
walls, dikes, or revetments	0.0
litter, trash dump, or landfill	0.0
roads or railroad	0.3
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	0.0
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	4.5

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.4

boulders	0.2
cobble	1.1
gravel	2.4
sand	0.9
silt	0.8
woody debris	0.6

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	1.5
emergent	1.0
floating	0.0
total weed cover	1.7
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.3

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.2
snags	0.1
brush or woody debris	0.9
inundated live trees	0.0
overhanging vegetation	0.4
rock ledges or sharp dropoffs	0.0
boulders	0.2
human structures	0.3

Questionnaire

HORSESHOE

Results compiled from 6 **Surveys.** **Average time (years) respondents spent on lake:** 7.33

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	-0.2	View:	1.0	Distance to Lake:	0.5
Public Access:	-0.3	Swim Beach:	0.5	Canada Geese:	0.7
Water Clarity:	0.2	Water Qual. for Swim:	0.0		
Fishing Quality:	0.5	Aquatic Plants:	-0.2		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **3.5**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.2
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.3
1) Clearer water, or 2) fewer aquatic plants?	1.3

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	4.7	Good Warmwtr Fishing:	4.0	Natural Scenery:	5.0
Plant Growth:	3.2	Good Swimming:	4.3	Public Beach:	2.2
Natural Shoreline:	4.2	Less Algae:	3.8	Canada Geese:	4.3
No Odors:	4.2	Public Access:	2.2		
Good Coldwtr Fishing:	4.0	Clear Water:	4.0		

Good Coldwtr Fishing: [illegible] Clear Water: [illegible]

Tabulated Results

Survey ID	Date	Residency		Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
47	12/31/1998	Visitor			SEVERAL OF THE A	☐	Unknown	
60	8/10/1998	Resident	Permanent	Rent	several of the above	☑	Worse	5 to 10 year
	It is very desirable that the public launch be managed better because swimmers are using the launch at the same time people are attempting to launch boats. It would help to have gas motors banned.							
71	8/17/1998	Resident	Permanent	Rent	7	☐	Worse	1996
82	8/15/1998	Resident	Permanent	Rent	run a business	☐	No	
84	12/31/1998	Visitor			4	☐	No	
85	8/8/1998	Resident	Permanent	Rent	run a business	☐	No	

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

HORPE1

Date 6/15/1998 Station: 1 Sample ID 5

Anabaena prevalent, 4 mLs observed

Number of organisms measured: 35

Group	Percent
Cladoceran	20.0%
Copepod	80.0%
Other	

Group	Percent
Small < 1mm	57.1%
Large >= 1mm	42.9%
Ratio of large to Small:	0.75
Average size (mm):	0.84

Aquatic Plant Data

HORSESHOE

Sampler: Parsons, O'Neal

Survey Date: 7/13/1998

Max depth of growth (M): variable ~3.5

Comments gusty wind, breeze, partly cloudy. Goose family, ducks, bullfrog, osprey nest on SE shore. Productive lake! Water greenish, heavy algae growth on most submersed plants. Dense plant growth in protected areas. Most places max depth of plant growth about 3 m.

SPECIES LIST

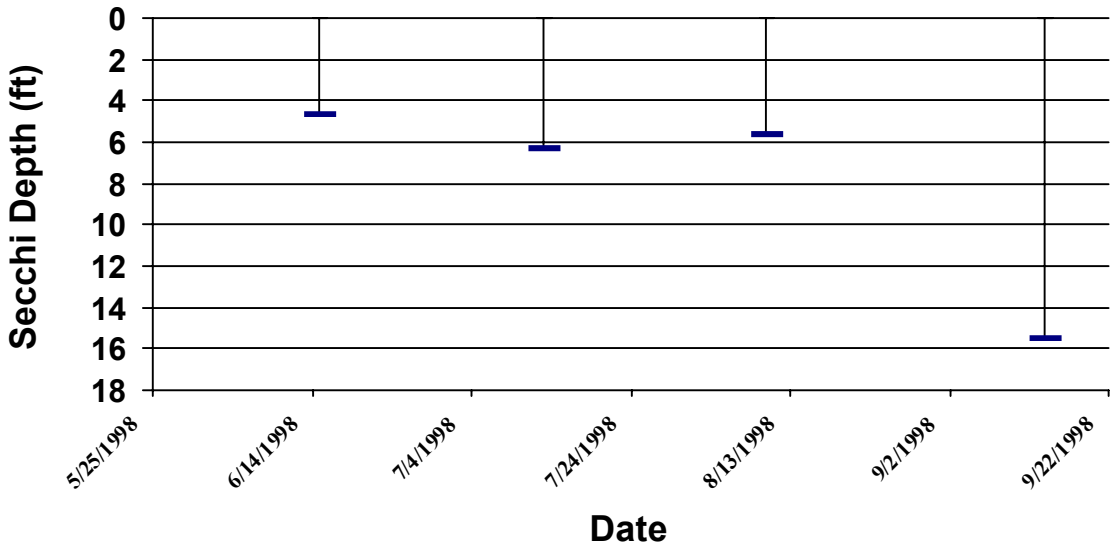
Scientific Name	Common Name	Dist [a]	Comments
Brasenia schreberi	watershield	2	patches, never dense
Carex sp.	sedge	2	shoreline
Ceratophyllum demersum	Coontail; hornwort	2	
Eleocharis sp.	spike-rush	2	shoreline
Elodea canadensis	common elodea	3	sometimes very dense, blooming
Juncus sp.	rush	2	
Nuphar polysepala	spatter-dock, yellow water-lily	2	at south end
Phalaris arundinacia	reed canarygrass	2	
Potamogeton amplifolius	large-leaf pondweed	2	
Potamogeton epihydrus	ribbonleaf pondweed	2	

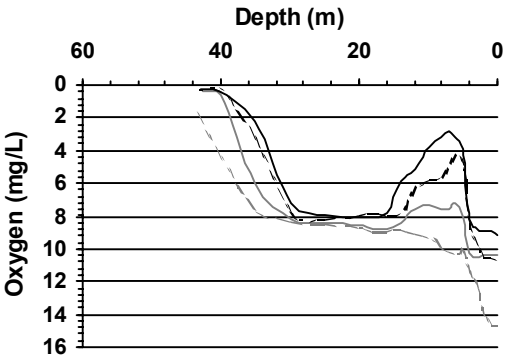
Potamogeton robbinsii	fern leaf pondweed	3	few dense areas in deeper water
Scirpus sp.	bulrush	2	
Typha sp.	cat-tail	2	

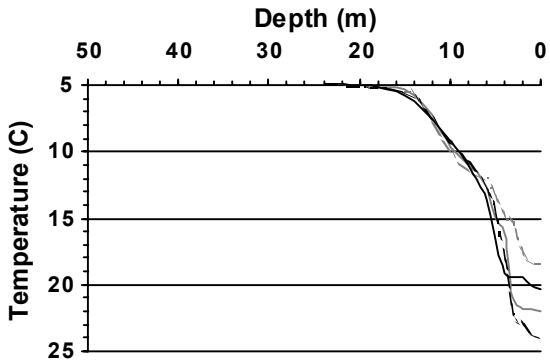
[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

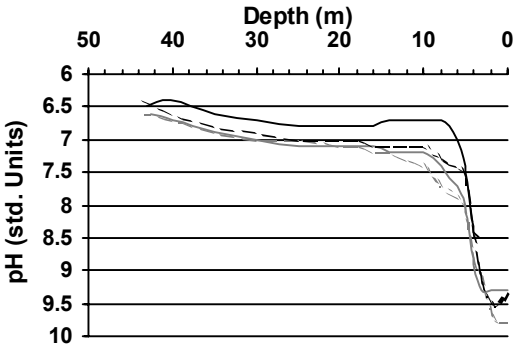
Secchi Depth and Profile Graphics

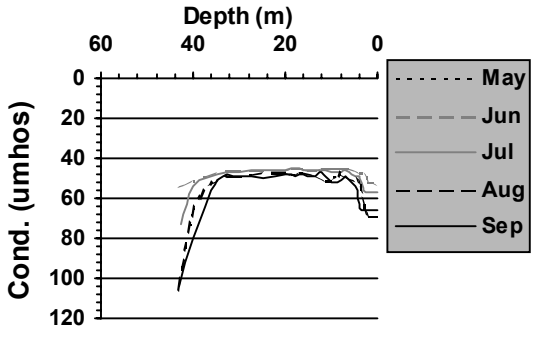
Station: 1 HORPE1











Secchi Data and Field Observations

HORSESHOE

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/15/1998			4.62	3	50	2	2	4	3	8	1	0	0
	Sampler: HALLOCK			Remarks:	APPROX. 20 HOMES SCATTERED AROUND SHORE. TIMBERED SLOPES, LOTS OF BEDROCK OUTCROPS AND CLIFFS. 1 RESORT. LOTS OF BLUE-GREEN IN THE WATER.								
7/13/1998			6.27	3	50	3		3	2	8	1	0	0
	Sampler: HALLOCK			Remarks:	AESTHETICS ARE FAIR BUT GOOD HABITAT FOR WILDLIFE. SMALL ALGAL COLONIES ABUNDANT. PEOPLE SWIMMING AT RESORT AND JUMPING OFF CLIFFS.								
8/10/1998			5.61	6	0	1		3	3	0	0	3	0
	Sampler: HALLOCK			Remarks:	H2S @ 40 M BUT NOT AT 10 OR 25 M. SOME BIRDS WADING AT ACCESS, ONE PERSON FISHING.								
9/14/1998			15.51	6	0	1		4	4	0	0	0	0
	Sampler: HALLOCK			Remarks:									

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ISLAND

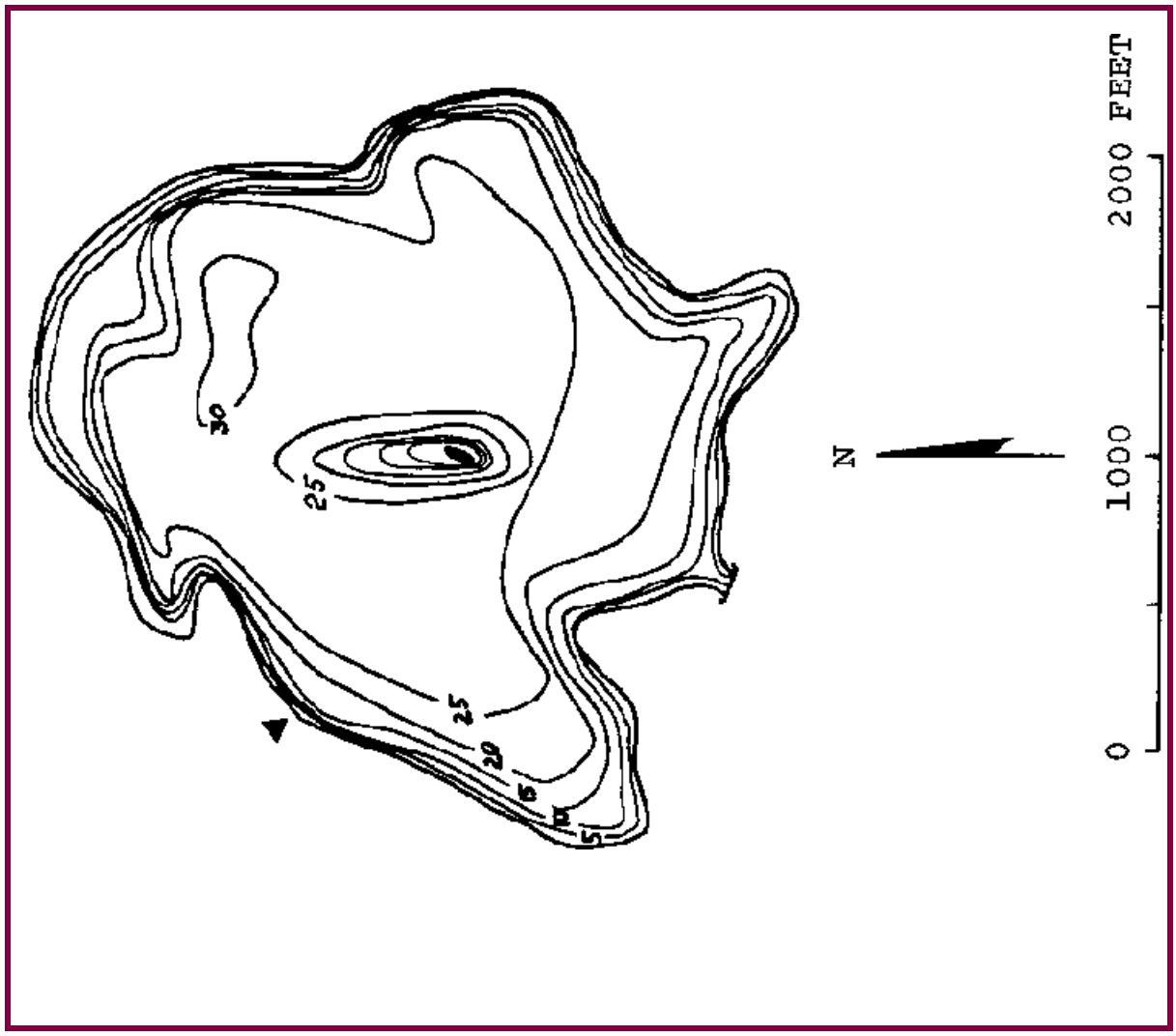
MASON County

Lake ID: ISLMA1

Ecoregion: 2

Island Lake is located 2.5 miles north of Shelton. It drains via a swamp to Goldsborough Creek and Oakland Bay.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
108	31	21		
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
2246	1.74	230	47 14 44.	123 06 40.



Station Information

ISLMA1

Primary Station	Station # 1	latitude: 47 14 51.7	longitude: 123 06 45.2
	Description:	Deep part of lake, directly east of first cove north of boat luanch, approximately 500 feet west of eastern shore	
Secondary Station	Station # 2	latitude: 47 14 55.3	longitude: 123 06 59.8
	Description:	Approximately midway between boat launch and first major point south of boat launch (point between large cove to the west and culvert leading to swamp to the east)	

Trophic State Assessment for 1998

ISLAND

Analyst: KIRK SMITH

TSI_Secchi:	36
TSI_Phos:	35
TSI_Chl:	43
Narrative TSI:[a]	O

Island Lake is an oligotrophic lake in a suburban setting. The shoreline is about 60% natural vegetation, though about 70% of the shoreline is developed residential. There was a Sonar application for Eurasian water milfoil on 14 August 98. The excellent water quality and water clarity in the lake is surprising considering how developed the shoreline is. Eurasian milfoil was the dominant aquatic plant in 1998, growing in nearly monospecific patches. Milfoil remains the biggest threat to the beneficial uses on the lake.

We recommend that a nutrient criterion be set at 10 ug/L total phosphorus, the action value for Puget Lowland oligotrophic lakes.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

ISLAND

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/2/1998		E	8.7	.216	25	3.7		18.5	4460	.8
7/25/1998		E	5.2	.199	38	3.4				.7 J
8/17/1998		E	9.6	.199	21	4.2				.9
9/17/1998		E	8.7	.193	22	2.5				.8
Station 2										
6/2/1998		E	9.6	.191	20	2.6				
7/25/1998		E	10.1	.178	18	3				
8/17/1998		E	9.2	.18	20	4.4				
Station 3										

6/2/1998	L	1
	L	1
9/17/1998	L	3
	L	1

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

ISLAND

Survey Date: 9/17/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

	Agriculture(commercial, not hobby)	1	**Residential**
	Commercial, Industrial	2	**Park, forest or natural**
3	**Major transportation**		

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Lack of shoreline errosion control where a new home was being built.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

Lots of green lawns/landscaping on lakeshore properties.

Buffer zones around streams and wetlands ☐

Buffer zones absent on lakeshore property. Forrested areas appeared OK. Natural vegetation was rare.

Irrigation ☑

2 separate locations

Survey Id:

Habitat Survey Summary Report

ISLAND

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/9/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:		**Number of stations with canopy:**	0
Understory Avg:		**Number of stations with understory:**	0

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.7
	trees< 0.3 m DBH	0.6
Understory:	**woody shrubs saplings**	1.9
	tall herbs, forbs grasses	0.7
Ground Cover:	**woody shrubs seedlings**	0.9
	herbs, forbs, grasses	2.1
	standing water or inundated veg	0.6
	barren or buildings	1.5
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.0
	cobble/gravel	1.5
	loose sand	0.4
	other fine soil/sediment	0.5
	vegetated	2.8
	other	0.8
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	
	vertical dist (M from wtrln to high wt):	0.1
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence

(0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.2
commercial	0.0
park facilities	0.0
docks/boats	1.4
walls, dikes, or revetments	1.2
litter, trash dump, or landfill	0.0
roads or railroad	0.0
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	1.4
other	0.2

Physical Habitat Characteristics

station depth (at 10 m from shore)	3.2

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.0
cobble	1.5
gravel	1.9
sand	0.3
silt	2.5

woody debris	0.8

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	2.5
emergent	0.6
floating	1.5
total weed cover	3.1
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.4

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.8
snags	0.1
brush or woody debris	1.0
inundated live trees	0.0
overhanging vegetation	1.2
rock ledges or sharp dropoffs	0.0
boulders	0.0
human structures	1.1

Zooplankton Report

ISLMA1

Date 6/2/1998 Station: 1 Sample ID 19

2 mLs measured

Number of organisms measured: 98

Group	Percent
Cladoceran	25.5%
Copepod	74.5%
Other	

Group	Percent
Small < 1mm	98.0%
Large >= 1mm	2.0%
Ratio of large to Small:	0.02
Average size (mm):	0.46

Date 6/2/1998 Station: 2 Sample ID 7

Cyclopoid Copepods with very long term. Setae, ~75% of body length; 1 mL observed

Number of organisms measured: 76

Group	Percent
Cladoceran	53.9%
Copepod	46.1%
Other	

Group	Percent
Small < 1mm	71.1%
Large >= 1mm	28.9%
Ratio of large to Small:	0.41
Average size (mm):	0.77

Aquatic Plant Data

ISLAND

Sampler: Parsons, O'Neal

Survey Date: 7/9/1998

Max depth of growth (M): 4

Comments Calm, partly cloudy. Lake treated with sonar June 24, 1998 - plants starting to show some

bleaching, especially the Najas. Milfoil mostly still not showing signs, a little bright green. Milfoil very dense in many areas, mostly near the boat launch and to the north. East side still just individual plants with occasional dense patches. Bullfrogs heard. Conducted habitat survey for Kirk Smith.

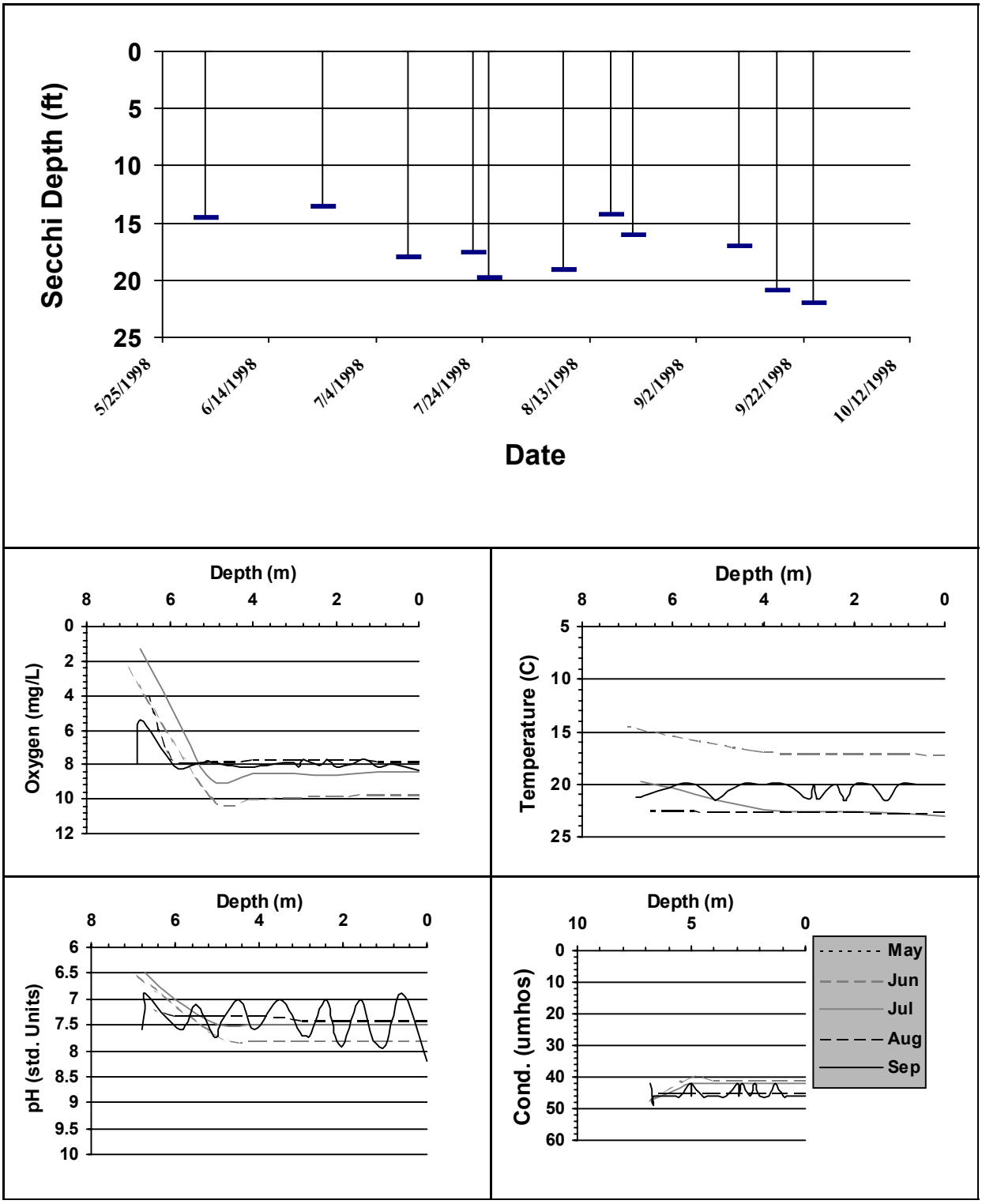
SPECIES LIST

Scientific Name	Common Name	Dist [a]	Comments
Brasenia schreberi	watershield	3	some dense patches, esp along south shore
Eleocharis sp.	spike-rush	1	
Elodea canadensis	common elodea	2	
Iris pseudacorus	yellow flag	2	
Myriophyllum spicatum	Eurasian water-milfoil	4	to 4 m deep
Najas flexilis	common naiad	2	
Nitella sp.	stonewort	2	
Nymphaea odorata	fragrant waterlily	1	one or 2 patches, east shore
Potamogeton amplifolius	large-leaf pondweed	2	
Potamogeton sp (thin leaved)	thin leaved pondweed	1	
Scirpus sp.	bulrush	2	

[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

Secchi Depth and Profile Graphics

Station: 1 ISLMA1



Secchi Data and Field Observations

ISLAND

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/2/1998			14.5	2	100		2	4	1	3	0	0	0
	Sampler: SMITH			Remarks: AQUATIC HERBICIDE ADDED									
6/24/1998		18	13.5	2	75	3	3	5	5	30	0	1	0
	Sampler: YOUNG			Remarks: LAKE WAS RECEIVING A HERBICIDE (SONAR) TREATMENT.									
7/10/1998		20.5	18	2	0	3	1	4	4	25	0	0	0
	Sampler: YOUNG			Remarks:									
7/22/1998		23	17.5	2	0	1	1	5	5	8	0	2	1
	Sampler: YOUNG			Remarks: WARM DAY - MANY SHORE SWIMMERS (EST. 25).									
7/25/1998			19.8	2	0			5	5	0	2	0	1
	Sampler: SMITH			Remarks: 70% OF THE SHORELINE DEVELOPED. CONSTRUCTION ALONG SHORELINE NEAR SITE #2 WITH NO SILT SCREENS. SLIGHT BLUE-GREEN BLOOM. 5 SWIMMERS.									
8/8/1998		23	19	2	0	2	1	5	5	0	0	2	0
	Sampler: YOUNG			Remarks:									
8/17/1998			14.2	3	90	1		4	2	1	0	0	2
	Sampler: SMITH			Remarks: 8-14-98 SONAR TREATMENT FOR MILFOIL. SLIGHT BLUE-GREEN BLOOM.									
8/21/1998		22	16	2	50	2	1	5	5	3	0	1	0
	Sampler: YOUNG			Remarks:									
9/10/1998		22	17	2	0	1	1	5	5	0		0	0
	Sampler: YOUNG			Remarks: MILFOIL DEPRESSED.									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
9/17/1998			20.79	2	60			5	5	2	2	0	0
	Sampler: SMITH			Remarks:	FEC #1 TAKEN AT ISLAND SIDE FACING BOAT RAMP. The Conductivity result is qualified as an estimate due to postcalibration failing QA/QC requirements.								
9/24/1998		19.5	22	2	75	3	2	5	5	0	0	1	0
	Sampler: YOUNG			Remarks:									
9/24/1998			22		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									

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LELAND

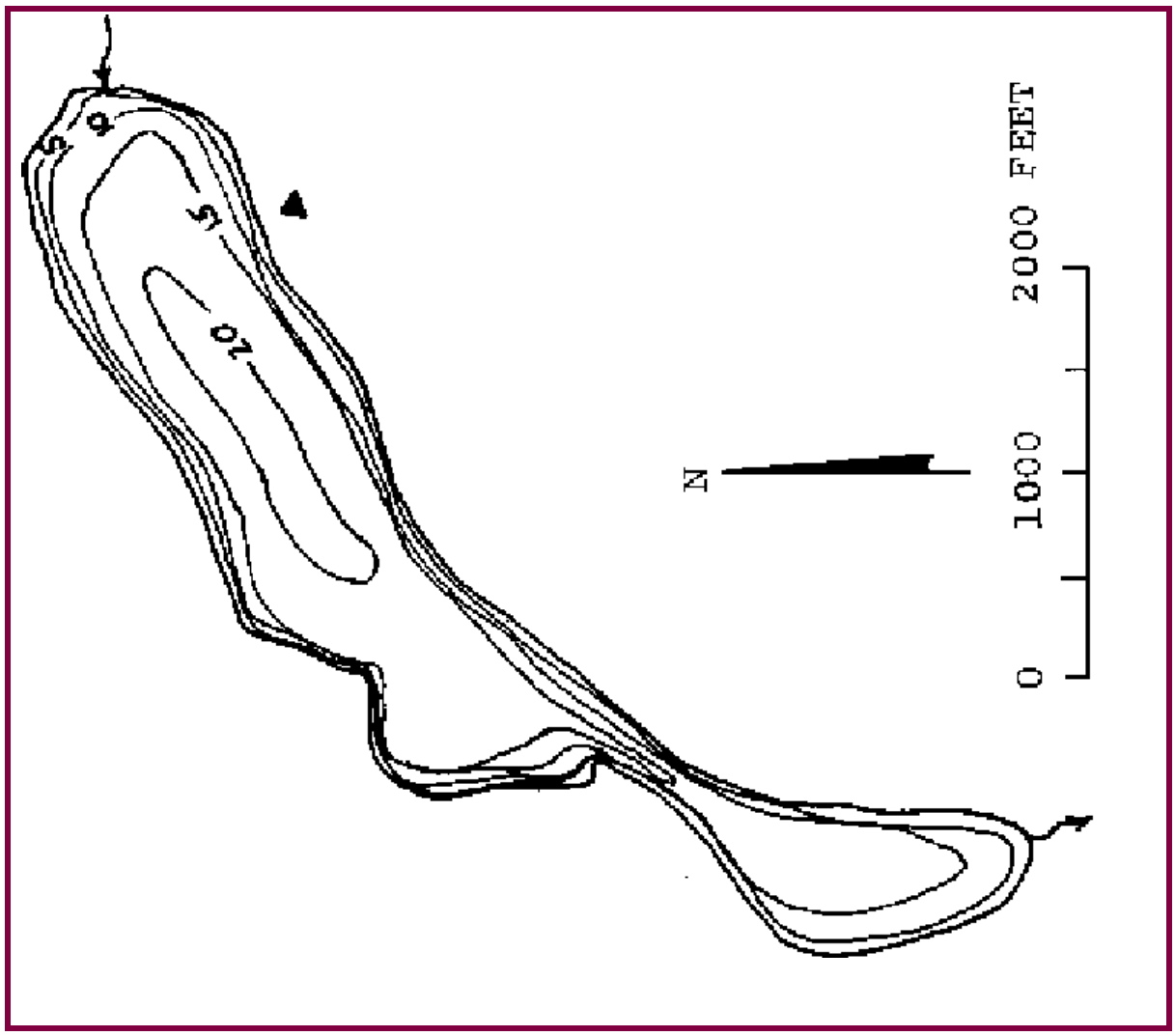
JEFFERSON County

Lake ID: LELJE1

Ecoregion: 2

Leland Lake is a prime fishing lake nestled on the eastern slopes of the Olympics. The lake is located approximately 5 miles north of Quilcene, just west of Highway 101. Leland Lake's outlet is Leland Creek which flows into the Little Quilcene River

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
107	20	13	6	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
1415	2.75	190	47 53 12.	122 53 05.



Station Information

LELJE1

Primary Station	Station # 1	latitude: 47 56 47.3	longitude: 122 52 50.5
	Description: Deep part of lake, directly west from boat launch		
Secondary Station	Station # 2	latitude: 47 53 16.8	longitude: 122 53 18.4
	Description: Approximate center of southernmost arm of lake		

Trophic State Assessment for 1998

LELAND

Analyst: KIRK SMITH

TSI_Secchi:	47	
TSI_Phos:	48	
TSI_Chl:	51	J
Narrative TSI:[a]	ME	

Lake Leland is a productive shallow lake which has been infested with the non-native aquatic plant, Brazilian elodea (Egeria densa). Questionnaire results from residents indicate the primary use on the lake is most likely swimming/wading and the secondary use appears to be enjoyment of the view/watching wildlife. Survey respondents indicated a desire for more restrictive motorboat regulations. The survey suggests that water clarity may be impairing the water quality for swimming. Historic data suggests that there may be even fewer nutrients now than before and swimming conditions may be as good as could reasonably be expected. The lake supports a good bass fishery and water quality parameters suggests the lake could be very productive for a warmwater fishery but somewhat limiting for a coldwater fishery due to the substantial decrease in hypolimnetic oxygen in the summer.

Our mean measured total phosphorus concentration was 18.3 ug/L. We recommend the nutrient criterion for Lake Leland be set at 20ug/L total phosphorus, the action value for Puget Lowlands lower mesotrophic lakes.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

LELAND

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
8/12/1998		L					54			
Station 1										
6/5/1998		E	17.2	.416	24	4.3		25	5590	1 J
		H	32.6	.784	24					
7/30/1998		E	15.7	.371	24	4.6				
		H	330	1.07	3					

8/12/1998	E	18.2	.384	21	4.8	1.3
	H	254	.813	3		
9/14/1998	E	22.1	.56	25	17.5 J	2.1 J
	H	273	.725	3		
Station 2						
6/5/1998	E	14.8	.415	28		1.1 J
7/30/1998	E	22	.437	20	4.4	
8/12/1998	E	20.1	.386	19	6.8	1.3
9/14/1998	E	28.8	.57	20	19.4 J	2.1 J

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

LELAND

Survey Date: 9/14/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

	Agriculture(commercial, not hobby)	2	**Residential**
	Commercial, Industrial	1	**Park, forest or natural**
	Major transportation		

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Lots of natural shoreline on the lake.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☑

Irrigation ☐

Survey Id: 50

Habitat Survey Summary Report

LELAND

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 9/3/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.6	**Number of stations with canopy:**	10
Understory Avg:	2.5	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.7
	trees< 0.3 m DBH	1.2
Understory:	**woody shrubs saplings**	1.6
	tall herbs, forbs grasses	1.8
Ground Cover:	**woody shrubs seedlings**	0.7
	herbs, forbs, grasses	1.4
	standing water or inundated veg	1.5
	barren or buildings	0.5
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.1
	cobble/gravel	0.3
	loose sand	0.1
	other fine soil/sediment	0.3
	vegetated	3.6
	other	0.6
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.3
	vertical dist (M from wtrln to high wt):	0.2
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	0.8
commercial	0.0
park facilities	0.2
docks/boats	1.0
walls, dikes, or revetments	0.0
litter, trash dump, or landfill	0.0
roads or railroad	0.1
row crops	0.0
pasture or hayfield	0.2
orchard	0.0
lawn	0.8
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	2.9

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0

boulders	0.0
cobble	0.2
gravel	0.9
sand	1.1
silt	3.0
woody debris	0.4

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	3.1
emergent	1.5
floating	1.0
total weed cover	3.4
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.4

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	2.0
snags	0.5
brush or woody debris	0.2
inundated live trees	0.3
overhanging vegetation	0.9
rock ledges or sharp dropoffs	0.0
boulders	0.0
human structures	0.3

Questionnaire

LELAND

Results compiled from 15 **Surveys.** **Average time (years) respondents spent on lake:** 15.09

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	-0.3	View:	0.9	Distance to Lake:	0.2
Public Access:	-0.2	Swim Beach:	0.2	Canada Geese:	0.1
Water Clarity:	-0.1	Water Qual. for Swim:	-0.1		
Fishing Quality:	0.1	Aquatic Plants:	-0.3		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **2.4**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.4
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.3
1) Clearer water, or 2) fewer aquatic plants?	1.3

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	4.4	Good Warmwtr Fishing:	3.5	Natural Scenery:	4.8
Plant Growth:	2.8	Good Swimming:	4.3	Public Beach:	3.1
Natural Shoreline:	3.9	Less Algae:	4.3	Canada Geese:	3.4
No Odors:	4.3	Public Access:	3.0		
Good Coldwtr Fishing:	4.1	Clear Water:	4.4		

Good Coldwtr Fishing: ... Clear Water: ...

Tabulated Results

Survey ID	Date	Residency		Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
4	12/31/1998	Visitor			2	☐	Unknown	
	Bass fishing catch and release only. Campers harvest too many bass.							
7	7/7/1998	Resident	Permanent	Rent	6	☐	Unknown	
8	9/13/1998	Resident	Seasonal	Rent	2	☐	Unknown	
9	8/24/1998	Resident	Permanent	Rent	1	☐	Worse	
10	7/11/1998	Resident	Permanent	Rent	7	☐	Worse	early 90s
	too much shoreline vegetation							
11	9/13/1998	Resident	Permanent	Rent	10	☐	No	
65	8/23/1998	Resident	Permanent	Rent	10	☐	No	
66	8/25/1998	Resident	Permanent	Rent	6	☑	Worse	1997
	In order to encourage the conservation of this little lake, we need to knock out the elodia noxious weed through non-chemical means and remove gas motors from the lake.							
67	9/29/1998	Resident	Seasonal	Rent	6	☑	Unknown	
	good water quality--fecals, nitrates, etc.							
68	8/26/1998	Resident	Permanent	Rent	6	☑	Worse	10 to 15 yea
70	8/23/1998	Resident	Permanent	Rent	7	☐	Unknown	
74	8/23/1998	Resident	Permanent	Rent		☐	No	
77	8/23/1998	Resident	Permanent	Rent	6	☐	No	
78	8/22/1998	Resident	Permanent	Rent	6	☑	No	
79	8/27/1998	Resident	Permanent	Rent	2	☐	No	

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

LELJE1

Date 6/5/1998 Station: 1 Sample ID 22

Sample full of Aphonizomenon; 9 mLs measured

Number of organisms measured: 55

Group	Percent
Cladoceran	21.8%
Copepod	78.2%
Other	

Group	Percent
Small < 1mm	81.8%
Large >= 1mm	18.2%
Ratio of large to Small:	0.22
Average size (mm):	0.57

Date 6/5/1998 Station: 2 Sample ID 18

Lots of Aphanizominon; 6 mLs observed

Number of organisms measured: 62

Group	Percent
Cladoceran	19.4%
Copepod	80.6%
Other	

Group	Percent
Small < 1mm	64.5%
Large >= 1mm	35.5%
Ratio of large to Small:	0.55
Average size (mm):	0.73

Date 8/12/1998 Station: 1 Sample ID 29

Date may be wrong--difficult label to read; LOTS of algae in sample (mostly nostoc, and something else, single-celled).

Number of organisms measured: 145

Group	Percent
Cladoceran	17.2%
Copepod	82.8%
Other	

Group	Percent
Small < 1mm	77.2%
Large >= 1mm	22.8%
Ratio of large to Small:	0.29
Average size (mm):	0.48

Aquatic Plant Data

LELAND

Sampler: Parsons, Bell-McKinnon

Survey Date: 9/3/1998

Max depth of growth (M): 3

Comments Sunny, calm. Visited to do vegetation survey for Kirk Smith. Egeria still patchy in main part of lake, though well distributed. Also plentiful P. praelongus and P. robbinsii. Egeria not at surface in most of lake, though dense below surface at the west end.

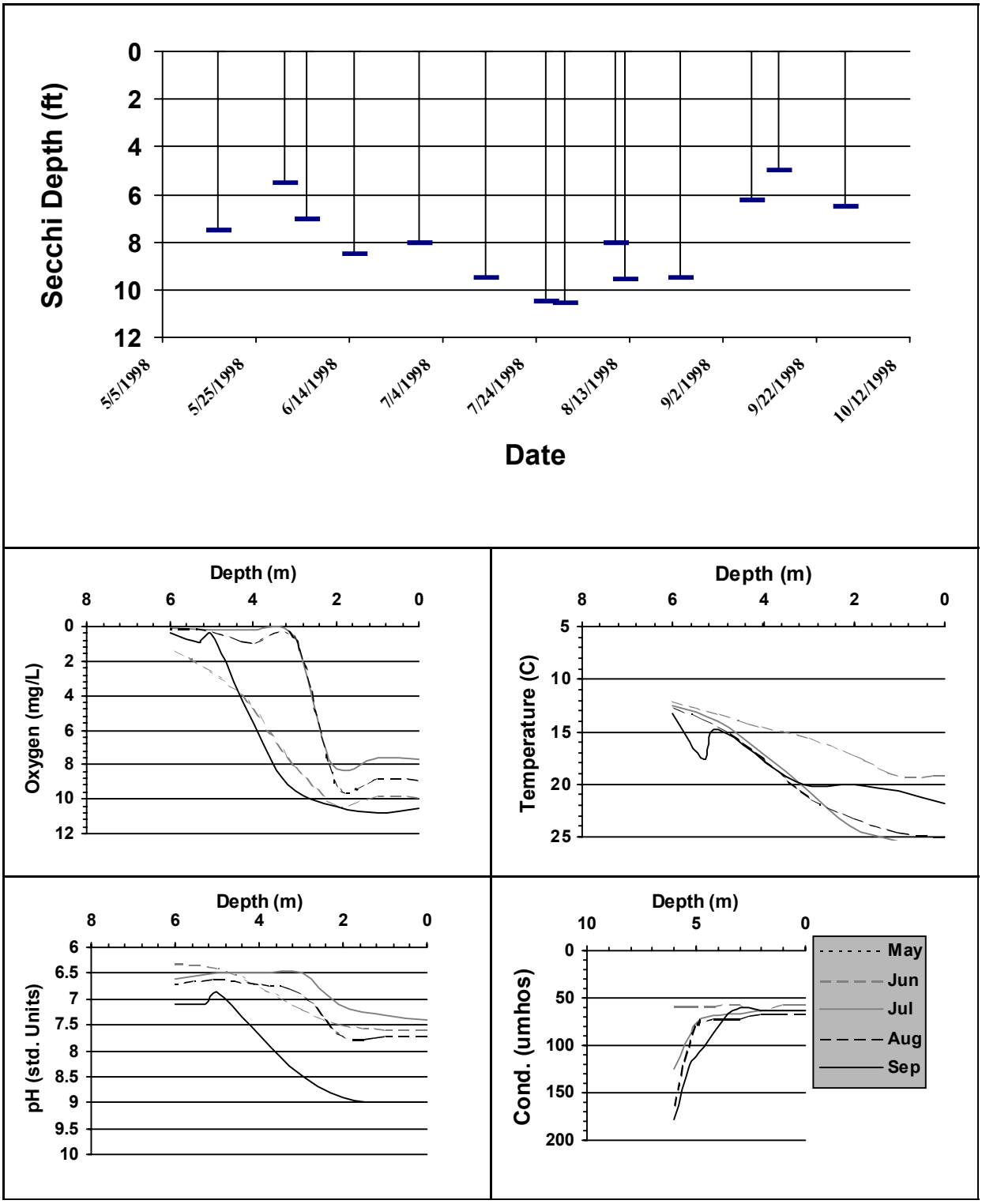
SPECIES LIST

Scientific Name	Common Name	Dist [a]	Comments
Ceratophyllum demersum	Coontail; hornwort	2	
Egeria densa	Brazilian elodea	4	flowering toward SW end, heavy epiphytic growth
Elodea canadensis	common elodea	2	
Iris pseudacorus	yellow flag	3	
Nuphar polysepala	spatter-dock, yellow water-lily	2	
Nymphaea odorata	fragrant waterlily	1	one patch seen on S shore
Phalaris arundinacia	reed canarygrass	2	
Potentilla palustris	purple (marsh) cinquefoil	2	
Potamogeton praelongus	whitestem pondweed	3	
Potamogeton robbinsii	fern leaf pondweed	3	
Potamogeton sp (thin leaved)	thin leaved pondweed	1	
Sagittaria sp.	arrowhead	1	vicinity of Don Case's house
Utricularia sp.	bladderwort	1	in wetland at NE end
Zizania aquatica	wild rice	2	

[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

Secchi Depth and Profile Graphics

Station: 1 LELJE1



Secchi Data and Field Observations

LELAND

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
5/17/1998		15.6	7.5	7	100	1	2	5	5	4		3	0
	Sampler: CASE			Remarks: NEW STAFF GAUGE - NEW = 2.25, OLD =14.00.									
5/31/1998		20	5.5	9	50	1	2	5	5	0	0	6	0
	Sampler: CASE			Remarks:									
6/5/1998			7	9	100			4	2	0	0	2	0
	Sampler: SMITH			Remarks: RESIDENT SUSPECTS LOGGING IN AREA HAS CONTRIBUTED TO HIGH WATER LEVELS OVER THE LAS FEW YEARS.									
6/15/1998		19.4	8.5	8	50	2	2	5	5	0	0	1	0
	Sampler: CASE			Remarks:									
6/29/1998		22.8	8	8	0	2	1	5	5	0	0	2	0
	Sampler: CASE			Remarks:									
7/13/1998		21.1	9.5	8	50	2	3	5	5	0	0	0	0
	Sampler: CASE			Remarks:									
7/26/1998		24.4	10.5	7	0	1	1	5	5	0	0	4	0
	Sampler: CASE			Remarks:									
7/30/1998			10.56	9	100	1				0	0	0	0
	Sampler: SMITH			Remarks: MUCH LESS BLUE-GREEN ALGAE THAN USE TO SEEING IN THE LAKE. VERY DARK WATER! 2 OSPREY									
8/10/1998		22.2	8	8	25	1	1	5	5	0	0	0	0
	Sampler: CASE			Remarks:									
8/12/1998			9.57		0	1		4	3	0	3	1	0
	Sampler: SMITH			Remarks: STRONG H2S IN HYPOLIMNION									
8/24/1998		22.2	9.5	7	0	2	1	5	5	0	0	1	0
	Sampler: CASE			Remarks:									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
9/8/1998		21.7	6.25	7	75	1	3	5	5	0	0	0	0
	Sampler: CASE			Remarks:									
9/14/1998			4.95	2	0			3	3	0	0	0	0
	Sampler: SMITH			Remarks:	The conductivity and dissolved oxygen results are qualified as estimates due to postcalibration failing QA/QC requirements.								
9/28/1998		17.8	6.5	7	0	2	1	5	5	0	0	1	0
	Sampler: CASE			Remarks:									

LIBERTY

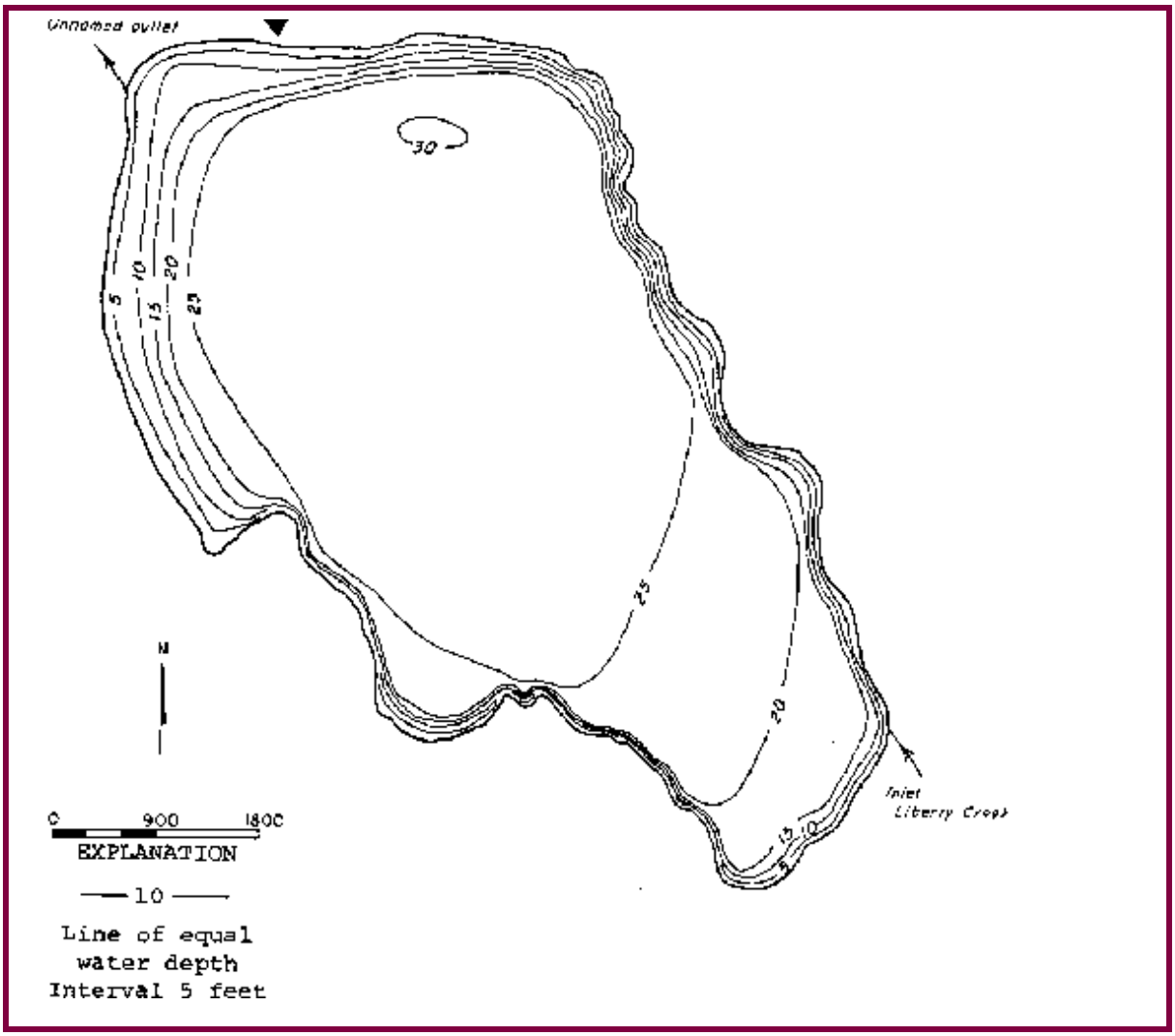
SPOKANE County

Lake ID: LIBSP1

Ecoregion: 7

Liberty Lake is a popular lake just outside the Spokane city limits to the west. Its shores are only a mile from the Idaho border. The inlet for Liberty Lake is Liberty Creek and the outlet is an unnamed creek.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
710	30	23	13	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
16000	4.77	2053	47 39 09.	117 05 20.



Station Information

LIBSP1

Primary Station Station # 1 latitude: 47 39 01.0 longitude: 117 04 33.0

Description: Lake's deep site, several hundred meters from shore, SW of public access.

Trophic State Assessment for 1998

LIBERTY

Analyst: KIRK SMITH

TSI_Secchi:	38
TSI_Phos:	42
TSI_Chl:	39
Narrative TSI:[a]	OM

Liberty Lake has a well developed shoreline but the watershed appears to be mostly undeveloped with abundant timber and some timber harvest. The residential area around the lake is partially curbed; however, many roads run perpendicular to the lake so runoff could enter directly into the lake. The lake has undergone recent restoration efforts and is currently being monitored by both residents and by the Liberty Lake Sewer District. Dr. Funk (Washington State University) has been actively monitoring the lake for many years in conjunction with the sewer district.

Some lakeside landscaping appeared to include the use of lawn chemicals. Zooplankton samples collected in the spring suggest a healthy zooplankton population with large daphnia to support a sport fishery. Water quality measurements suggest the lake is oligo-mesotrophic; our seasonal mean TP was 13.3 ug/L. The vast majority of the user surveys were answered by lakeside residents who were primarily interested in maintaining water clarity. Several respondents reported seagulls to be a nuisance.

Dr. Funk considers nutrient deposition from wild fowl to be a threat to the water quality of the lake. He also recommends the repair of the dike separating the marsh from the lake (Funk, W. H. 2000. Water quality annual report for Liberty Lake, Washington. Submitted to Liberty Lake Sewer District).

The total phosphorus action value for Liberty Lake is 20 ug/L; however, we recommend a criterion be set at current TP levels (plus an adjustment to account for inter-annual variation) in order to protect present uses. Therefore, the recommended nutrient criterion for Liberty Lake is (13.3 + 4.1=) 17.4 ug/L total phosphorus.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

LIBERTY

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
7/13/1998		L					1 U			

	L					3 J		
8/10/1998	L					1		
	L					2		
9/14/1998	L					8		
	L					9		
Station 1								
6/15/1998	E	11	.225	20	1.5		14.7	.6 J
	H	21.5	.225	10				
7/13/1998	E	12.9	.236	18	2.5			.8
	H	14	.236	17				
8/10/1998	E	12.9	.251	19	2.3			.6
	H	25.9	.289	11				
9/14/1998	E	16.3	.25	15	4.8			1

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

LIBERTY

Survey Date: 9/14/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [ ] **Agriculture(commercial, not hobby)**
- [ ] **Commercial, Industrial**
- [ ] **Major transportation**
- [1] **Residential**
- [2] **Park, forest or natural**

Impervious surfaces (Roads and parking area): Partially Curbed

Observations (check mark denotes presence)

BMP's ☑

Sediment screen at base of Clark Ave. (which is perpendicular to the lake, separated by steep straight path to lake). Selective thinning approx. 200 yds from the water. Rds perpendicular to the lake, directly upslope have berms in poor shape.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☑

A couple of geese at private park west of outlet.

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

Many lawns are green and groomed, some extending to bulkhead.

Buffer zones around streams and wetlands ☐

No development around inlet stream or wetland @ S. end. Overall assessment of lake--little improvement needed.

Irrigation ☐

Survey Id: 100

Habitat Survey Summary Report

LIBERTY

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/13/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.6	**Number of stations with canopy:**	10
Understory Avg:	2.2	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.5
	trees< 0.3 m DBH	0.8
Understory:	**woody shrubs saplings**	1.6
	tall herbs, forbs grasses	0.7
Ground Cover:	**woody shrubs seedlings**	1.6
	herbs, forbs, grasses	2.7
	standing water or inundated veg	0.2
	barren or buildings	1.8
Substrate Type (within shoreline plot):	**bedrock**	0.7
	boulders	0.8
	cobble/gravel	0.7
	loose sand	2.3
	other fine soil/sediment	0.4
	vegetated	1.5
	other	0.6
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.4
	vertical dist (M from wtrln to high wt):	0.2
	horiz. dist. (M from wtrln to high wt):	0.2

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.4
commercial	0.0
park facilities	0.1
docks/boats	1.6
walls, dikes, or revetments	1.6
litter, trash dump, or landfill	0.2
roads or railroad	0.1
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	1.4
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	1.7

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.3
boulders	0.4
cobble	0.8
gravel	1.5
sand	2.3
silt	1.3
woody debris	0.1

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	1.5
emergent	0.2
floating	0.1
total weed cover	1.6
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-1.0

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.3
snags	0.0
brush or woody debris	0.0
inundated live trees	0.0
overhanging vegetation	0.5
rock ledges or sharp dropoffs	0.2
boulders	0.4
human structures	1.4

Questionnaire

LIBERTY

Results compiled from 21 **Surveys.** **Average time (years) respondents spent on lake:** 26.05

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	-0.6	View:	0.8	Distance to Lake:	0.5
Public Access:	-0.2	Swim Beach:	0.5	Canada Geese:	-0.2
Water Clarity:	0.4	Water Qual. for Swim:	0.4		
Fishing Quality:	0.3	Aquatic Plants:	-0.6		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **3.5**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.8
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.4
1) Clearer water, or 2) fewer aquatic plants?	1.2

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	4.1	Good Warmwtr Fishing:	3.4	Natural Scenery:	4.6
Plant Growth:	2.6	Good Swimming:	4.8	Public Beach:	2.9
Natural Shoreline:	3.6	Less Algae:	4.5	Canada Geese:	3.0
No Odors:	4.0	Public Access:	2.6		
Good Coldwtr Fishing:	3.1	Clear Water:	4.8		

Tabulated Results

Survey ID	Date	Residency		Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
5	9/28/1998	Visitor			2	☐	Unknown	
	Would like more shoreline access. Should have questions about fishing access.							
6	9/28/1998	Resident	Permanent	Rent	6	☑	Better	
	We have too many ducks--they do not add to the clarity of the water.							
12	9/28/1998	Resident	Permanent	Rent	10	☑	No	
13	9/28/1998	Resident	Permanent	Rent	10	☑	Unknown	
	Personal watercraft are irritating and at times dangerous on this small, crowded lake (ski-dos, wave-runners, etc.)							
14	9/28/1998	Resident	Permanent	Rent	6	☑	Better	early 90s
15	9/28/1998	Resident	Permanent	Rent	living	☐	Worse	after first po
16	9/28/1998	Resident	Permanent	Rent	10	☑	Worse	1994-1995
	Remove swimmer's itch--goes with getting rid of plants and snails. Plants were not introduced naturally and should be removed.							
17	9/28/1998	Resident	Permanent	Rent	7	☑	Better	1990
18	9/28/1998	Resident	Permanent	Rent	1	☐	Better	1998
19	9/28/1998	Resident	Permanent	Rent	10	☑	Better	
	Would like to see the ducks, seagulls and geese eliminated. They are causing more pollution problems than anything else.							
20	9/28/1998	Resident	Permanent	Rent	4	☑	Better	
21	9/28/1998	Resident	Permanent	Rent	7	☑	No	
22	9/28/1998	Resident	Permanent	Rent	7	☑	Better	When sewer
23	9/28/1998	Resident		Rent	4	☑	Better	since the 70
	Seagulls are a nuisance							
24	9/28/1998	Resident	Permanent	Rent	10	☐	Worse	
25	9/28/1998	Resident	Permanent	Rent	4	☑	No	
26	9/28/1998	Resident	Permanent	Rent	10	☐	Better	80s after the
	Manage a control public access. Remove it from high residential area and restrict it to current county park including boater access.							
27	9/28/1998	Resident	Permanent	Rent	none	☐	No	
	I was born here 82 years ago. I remember good fishing (no trout), algae and a great pleasure lake. Now it is almost a closed lake for the very few. How sad.							
28	9/28/1998	Resident	Permanent	Rent	many of the above	☑	Unknown	clarity very
29	12/31/1998	Resident		Rent		☐	Unknown	
87	9/28/1998	Resident	Permanent	Rent	10	☑	Better	

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

LIBSP1

Date 6/15/1998 Station: 1

Sample ID 15

Number of organisms measured: 116

Group	Percent	Group	Percent
Cladoceran	25.9%	Small < 1mm	77.6%
Copepod	74.1%	Large >= 1mm	22.4%
Other		Ratio of large to Small:	0.29
		Average size (mm):	0.56

Date 8/10/1998 Station: 1 Sample ID 9

Lots of large rotifers

Number of organisms measured: 119

Group	Percent	Group	Percent
Cladoceran	7.6%	Small < 1mm	77.3%
Copepod	92.4%	Large >= 1mm	22.7%
Other		Ratio of large to Small:	0.29
		Average size (mm):	0.53

Aquatic Plant Data

LIBERTY

Sampler: Parsons, O'Neal

Survey Date: 7/13/1998

Max depth of growth (M): 6.5

Comments Breezy, partly cloudy. Nice plant community. Few plants in water less than 1.5 m deep, deeper water with plants approaching surface to 3 m deep. Deep water with Elodea, P. pusillus and Chara. Mergansers, greebes, osprey. Did habitat survey for Kirk Smith.

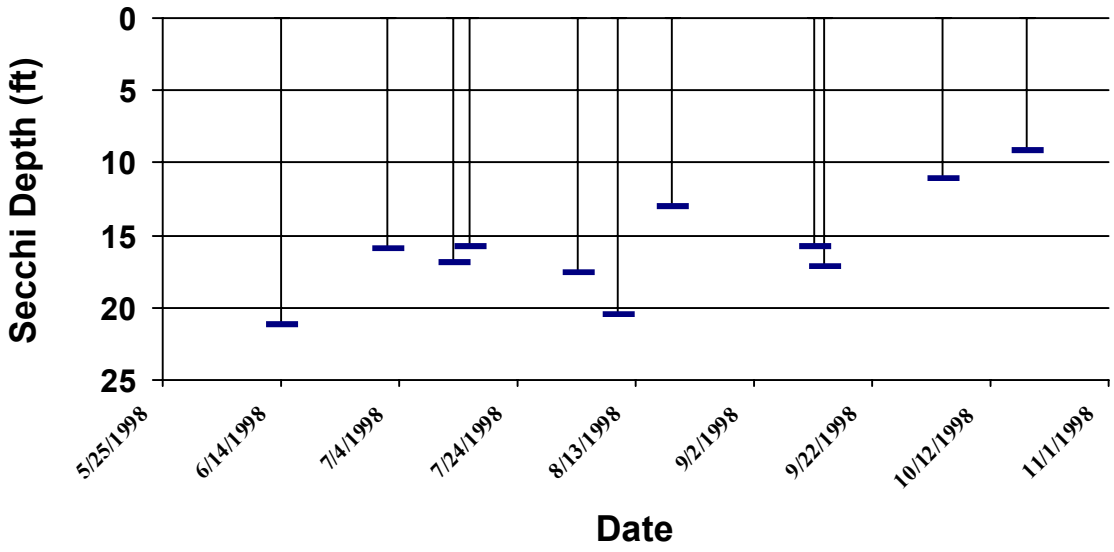
SPECIES LIST

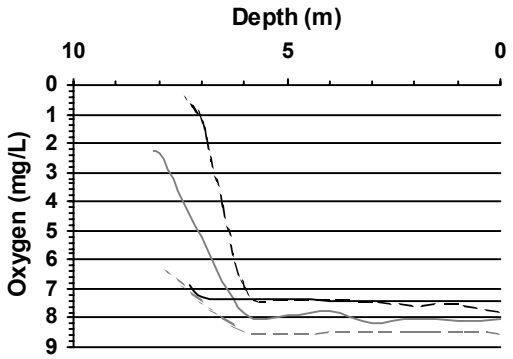
Scientific Name	Common Name	Dist [a]	Comments
Chara sp.	muskwort	2	in shallow to deep water
Elodea canadensis	common elodea	3	blooming
Myriophyllum spicatum	Eurasian water-milfoil	1	seen at wetland, south end, several plants (also known from north end)
Nuphar polysepala	spatter-dock, yellow water-lily	2	
Phalaris arundinacia	reed canarygrass	2	most in wetland, south end
Phragmites communis	common reed	1	
Potamogeton amplifolius	large-leaf pondweed	3	
Potamogeton pusillus	slender pondweed	2	
Potamogeton robbinsii	fern leaf pondweed	3	
Potamogeton sp (thin leaved)	thin leaved pondweed	2	may also be P. pusillus, in deep water
Scirpus sp.	bulrush	2	bulrush, south end

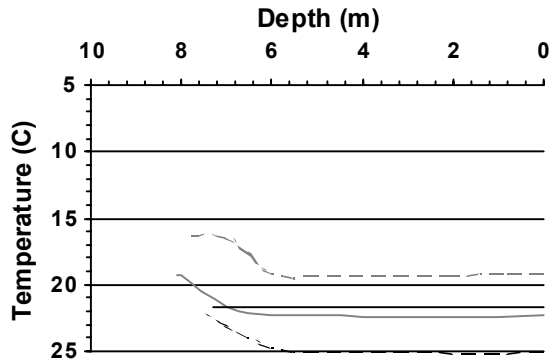
[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

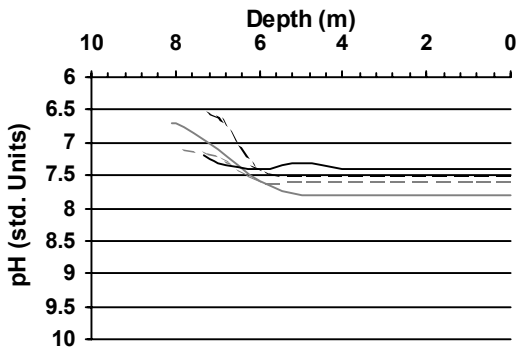
Secchi Depth and Profile Graphics

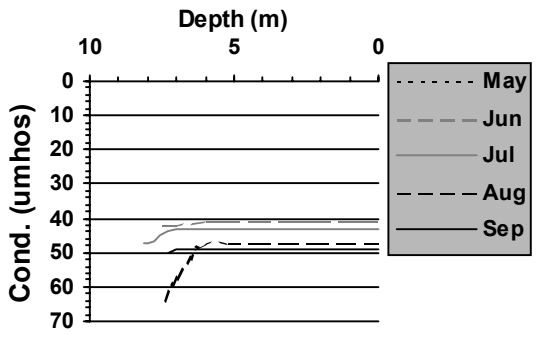
Station: 1 LIBSP1











Secchi Data and Field Observations

LIBERTY

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/14/1998		19.5	21.2	6	50	3	3	5	5	0	0	2	3
	Sampler: KLAPP			Remarks:									
6/14/1998		19.5	21.2	6	100	1		5	5	0	0	0	0
	Sampler: HALLOCK			Remarks: 2 PARTIES BANK FISHING AT ACCESS. MOSTLY TIMBER IN WSHED. SHORELINE DEVELOPED HEAVILY IN SOME AREAS. ALL SEWERED.									
7/2/1998		22.2	15.83	6	0	3	2	5	5	0	0	0	1
	Sampler: KLAPP			Remarks: FORGOT THE VIEW TUBE THIS TIME BUT EXPECT TO USE IT REGULARLY.									
7/13/1998			16.8	6	20	3		5	5	0	25	3	1
	Sampler: HALLOCK			Remarks: ONE TRAILER AT ACCESS. TWO OTHERS FISHING AT ACCESS									
7/16/1998		25	15.7	6	0	1	1	5	5	0	1	2	2
	Sampler: KLAPP			Remarks:									
8/3/1998		27	17.6	6	0	2	2	5	5	0	3	1	2
	Sampler: KLAPP			Remarks:									
8/10/1998			20.46	6	0					0	9	2	2
	Sampler: HALLOCK			Remarks: VOL HASN'T SEEN GEESE ON THE LAKE SINCE GOLF COURSE OPENED. GLEOTRICHIA IN WATER COLUMN.									
8/19/1998		23.8	13	6	0	2	1	5	5	0	5	0	2
	Sampler: KLAPP			Remarks:									
9/12/1998		23	15.7	6	0	1	2	5	5	0	4	0	2
	Sampler: KLAPP			Remarks:									
9/14/1998			17.16	6	0			4	4	2	0	1	0
	Sampler: HALLOCK			Remarks: GLEOTRICHIA PRESENT IN WATER COLUMN. COUNTY PARK IS ACCESSIBLE BY ROAD.									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
10/4/1998		16.2	11.1	6	50	2	1	5	5	0	5	0	0
	Sampler: KLAPP				Remarks: "PECTINATELLA" NOTED 9/12/98.								
10/18/1998		12.3	9.1	6	0	1	3	5	3	0	2	0	0
	Sampler: KLAPP				Remarks:								

LIMERICK

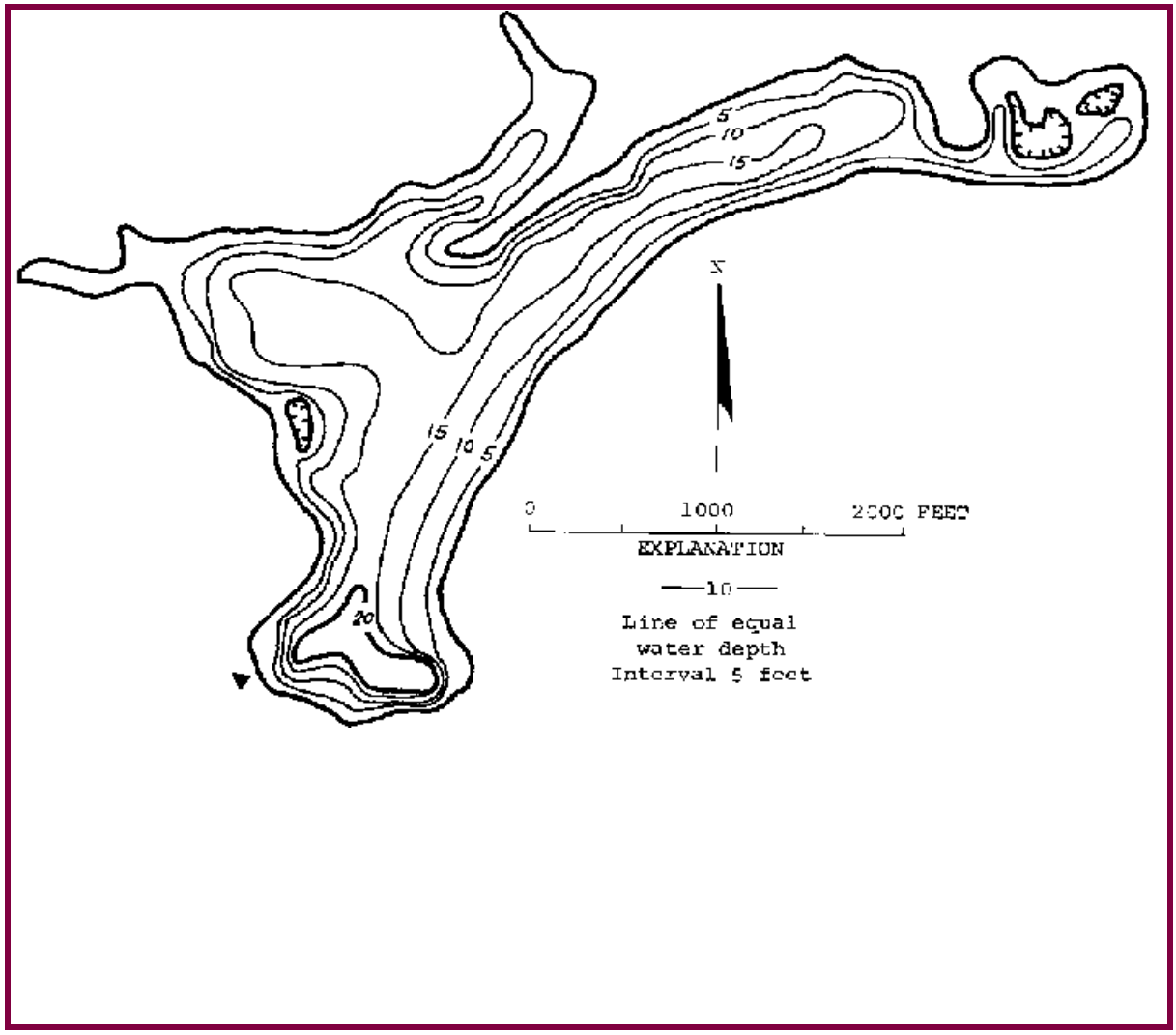
MASON County

Lake ID: LIMMA1

Ecoregion: 2

Lake Limerick is located about five miles northeast of Shelton. It was formed in 1966 by the impoundment of Cranberry Creek. Lake Limerick is fed mainly by Cranberry Creek, as well as three other minor inlets. The lake level is stabilized by a control weir at its outlet to Cranberry Creek.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
129	24	9	13	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
1210	4.39	220	47 16 59.	123 02 51.



Station Information

LIMMA1

Primary Station Station # 1 latitude: 47 16 48.8 longitude: 123 02 45.7

Description: Deep part of lake in approximate center of southernmost cove

Trophic State Assessment for 1998

LIMERICK

Analyst: KIRK SMITH

TSI_Secchi:	43
TSI_Phos:	36
TSI_Chl:	42
Narrative TSI:[a]	M

Lake Limerick is relatively low in nutrients (mean total phosphorus was 9.0 ug/L) but rich in aquatic macrophytes. It is surprising more nutrients are not showing up in the water column considering Cranberry Lake (a bog-like wetland with considerably higher nutrient concentrations) drains into Lake Limerick. It is possible that much of the total phosphorus is bound to sediment particles or accumulated in macrophyte biomass. The abundant aquatic plants appear to impair the beneficial uses of the lake more than the nutrient concentrations. Limiting the nutrients, however, will not necessarily reduce the aquatic macrophyte biomass because those nutrients typically come from sediment and not from the water column.

We recommend the ecoregional action value for oligotrophic Puget Lowland lakes (10 ug/L) be set as a total phosphorus criterion for Lake Limmerick.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

LIMERICK

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
7/27/1998		L					6			
		L					7			
8/18/1998		L					5			
		L					30			
Station 1										
6/4/1998		E	8.8	.186	21	2.8		21.4	4890	.9
7/27/1998		E	7.4	.247	33	2.4				1.3
		H	16.3	.269	17					
8/18/1998		E	9.6	.335	35	3.8				2
9/18/1998		E	10.4	.283	27	4.3				.8 J

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

Watershed Survey

LIMERICK

Survey Date: 9/18/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

	Agriculture(commercial, not hobby)	1	**Residential**
	Commercial, Industrial	2	**Park, forest or natural**
	Major transportation		

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Lawns were mowed right down to the lake

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☑

Many geese use the lake. Volunteer has mentioned that geese have just recently produced offspring on the lake.

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

On the neighborhood golf course and lakeside lawns

Buffer zones around streams and wetlands ☐

lacking on the inlet stream where homes are built and the stream is treated more like a canal than a stream

Irrigation ☑

at boat launch near the dam

Survey Id: 30

Habitat Survey Summary Report

LIMERICK

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/8/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.2	**Number of stations with canopy:**	10
Understory Avg:	2.4	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	2.4
	trees< 0.3 m DBH	0.7
Understory:	**woody shrubs saplings**	1.9

	tall herbs, forbs grasses	0.5
Ground Cover:	**woody shrubs seedlings**	1.5
	herbs, forbs, grasses	2.2
	standing water or inundated veg	0.2
	barren or buildings	1.9
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.2
	cobble/gravel	1.4
	loose sand	0.0
	other fine soil/sediment	0.4
	vegetated	3.1
	other	0.5
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	
	vertical dist (M from wtrln to high wt):	0.2
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.1
commercial	0.0
park facilities	0.0
docks/boats	1.3
walls, dikes, or revetments	0.9
litter, trash dump, or landfill	0.2
roads or railroad	0.4
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	1.3
other	0.1

Physical Habitat Characteristics

station depth (at 10 m from shore)	1.6

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.0
cobble	0.4
gravel	1.3
sand	0.6
silt	3.0
woody debris	0.1

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	1.7

emergent	0.6
floating	0.0
total weed cover	1.7
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-1.0

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.4
snags	0.0
brush or woody debris	0.2
inundated live trees	0.0
overhanging vegetation	0.7
rock ledges or sharp dropoffs	0.1
boulders	0.0
human structures	1.1

Zooplankton Report

LIMMA1

Date 6/4/1998 Station: 1 Sample ID 32

Lots of rotifers in sample.

Number of organisms measured: 180

Group	Percent
Cladoceran	31.7%
Copepod	68.3%
Other	

Group	Percent
Small < 1mm	91.7%
Large >= 1mm	8.3%
Ratio of large to Small:	0.09
Average size (mm):	0.48

Date 8/18/1998 Station: 1 Sample ID 28

Lots of rotifers, nostic and worms (!) in sample.

Number of organisms measured: 104

Group	Percent
Cladoceran	23.1%
Copepod	76.9%
Other	

Group	Percent
Small < 1mm	92.3%
Large >= 1mm	7.7%
Ratio of large to Small:	0.08
Average size (mm):	0.39

Aquatic Plant Data

LIMERICK

Sampler: Parsons, O'Neal Survey Date: 7/8/1998

Max depth of growth (M): 2.5

Comments Partly cloudy, calm. Vegetation survey done for Kirk Smith. Bullfrog. Did not survey whole shoreline carefully. Patches of dense P. amplifolius, thin leaved pondweed, many aeas with much algae and few plants. Egeria densa found during snorkling at launch in water ~ 2 m deep, widely scattered small plants, at islands patchy, some dense growth

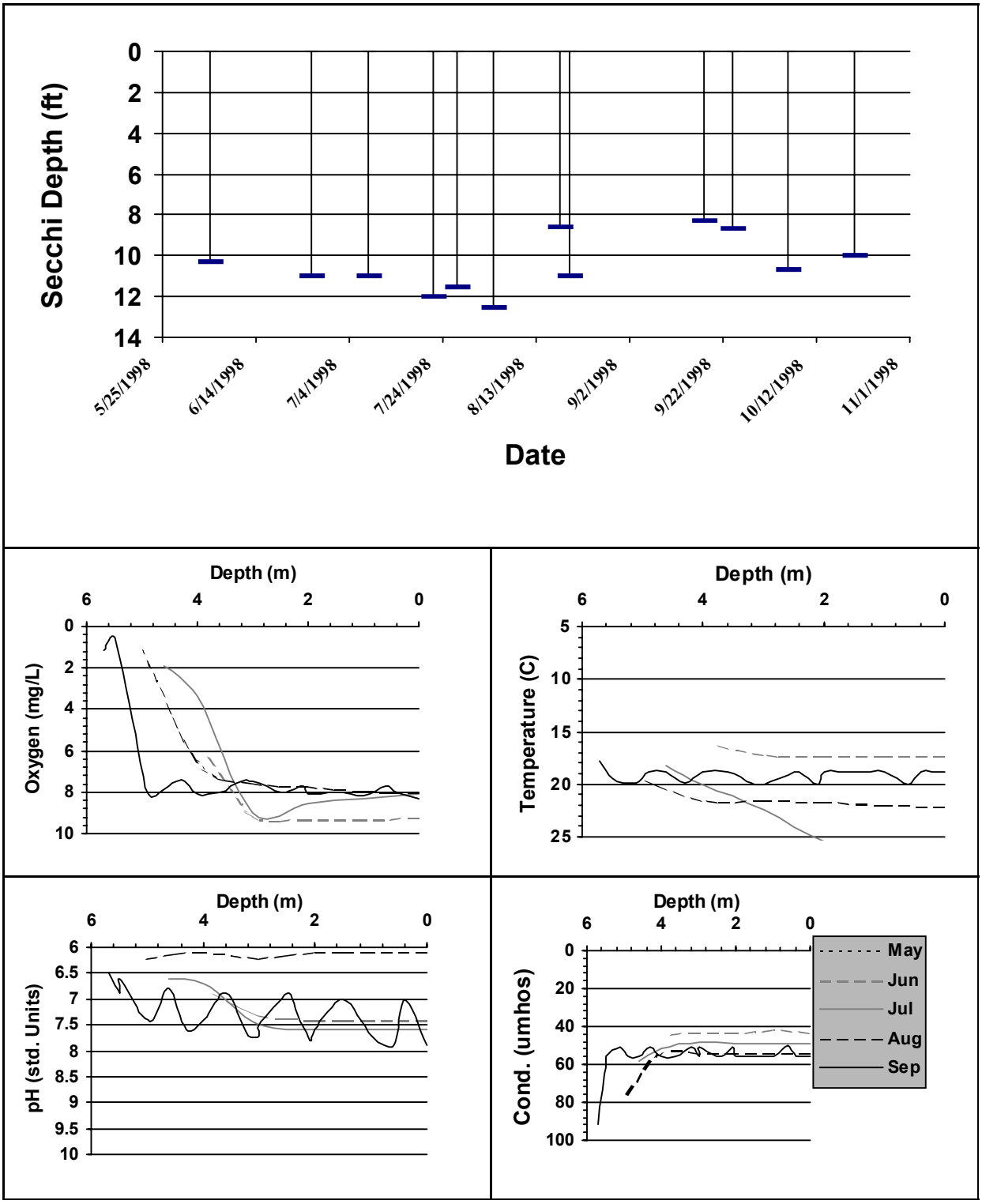
SPECIES LIST

Scientific Name	Common Name	Dist [a]	Comments
Brasenia schreberi	watershield	1	
Callitriche stagnalis	pond water-starwort	1	at one site
Carex sp.	sedge	2	on shore
Chara sp.	muskwort	3	shallow to deep water
Dulichium arundinaceum	Dulichium	1	near islands
Egeria densa	Brazilian elodea	1	patch around islands, and deeper water near launch
Elodea canadensis	common elodea	2	
Equisetum sp.	horse tail	1	
Juncus sp. or Eleocharis sp.	small grass-like plants	1	shallow gravelly areas
Juncus sp.	rush	2	on shore
Ludwigia palustris	water-purslane	2	on shore near inflow
Myriophyllum sp.	water-milfoil	2	near islands, probably M. hippuroides
Nitella sp.	stonewort	2	shallow to deep water
Potamogeton amplifolius	large-leaf pondweed	3	
Potamogeton gramineus	grass-leaved pondweed	1	1 patch seen
Potamogeton natans	floating leaf pondweed	2	
Potentilla palustris	purple (marsh) cinquefoil	2	
Potamogeton sp (thin leaved)	thin leaved pondweed	3	is P. pusillus
Sparganium sp.	bur-reed	2	
Utricularia inflata	big floating bladderwort	3	few blooming, much on the bottom
Vallisneria americana	water celery	1	in inflow area

[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

Secchi Depth and Profile Graphics

Station: 1 LIMMA1



Secchi Data and Field Observations

LIMERICK

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/4/1998		16.6667	10.25	7	100	1	1	5	5	30	16	0	0
	Sampler: SMITH			Remarks:	FIRST TIME VOL HAS SEEN GOSLINGS ON LAKE. BLADDERWORT NOTICED, GREEN ALGAL MATS. MOSTLY TIMBER LAND IN WSHED. The Oxygen result is qualified as an estimate due to postcalibration failing QA/QC requirements.								
6/26/1998		17.8	11	7	75	2	4	5	5	0	0	2	0
	Sampler: WESTON			Remarks:									
7/8/1998		20.6	11	6	100	2	1	5	5	0	6	1	0
	Sampler: WESTON			Remarks:									
7/22/1998		24.4	12	6	0	1	1	5	5	0	0	1	0
	Sampler: WESTON			Remarks:									
7/27/1998			11.55		0			3	2	15	5	0	2
	Sampler: SMITH			Remarks:	WATER UNUSUALLY CLEAR FOR LIMERICK. DEAD PLANTS IN WATER FROM HERB TREATMENT--MAKES FOR BORDERLINE SWIMMING CONDITIONS								
8/4/1998		23.3	12.5	6	0	1	1	5	5	15	6	0	0
	Sampler: WESTON			Remarks:									
8/18/1998			8.58	6	100			4	3	5	0	0	0
	Sampler: SMITH			Remarks:	FEC#1 AT OUTFALL NEAR BOAT LAUNCH. FEC#2 AT COMMUNITY CENTER DOCK. The pH results are qualified as estimates due to postcalibration failing QA/QC requirements.								
8/20/1998		22.2	11	6	25	1	1	5	5	0		1	0
	Sampler: WESTON			Remarks:									
9/18/1998			8.25	6	90	1		4	3	2	1	0	0
	Sampler: SMITH			Remarks:	The conductivity result is qualified as an estimate due to postcalibration failing QA/QC requirements.								
9/24/1998		18.9	8.66	8	100	3	1	5	5			0	0
	Sampler: WESTON			Remarks:									
9/24/1998			8.66		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
10/6/1998		15.6	10.66	6	25	1	1	5	5		8	0	0
	Sampler: WESTON			Remarks:									
10/20/1998		13.9	10	7	0	1	1	5	3	0	102	0	0
	Sampler: WESTON			Remarks:	LAKE HEIGHT AT THIS TIME YEAR DUE TO REMOVAL OF BOARDS IN THE DAM TO HELP THE SALMON RUN. I COUNTED AT LEAST THREE SALMON IN BEAVER CREEK.								

LONG

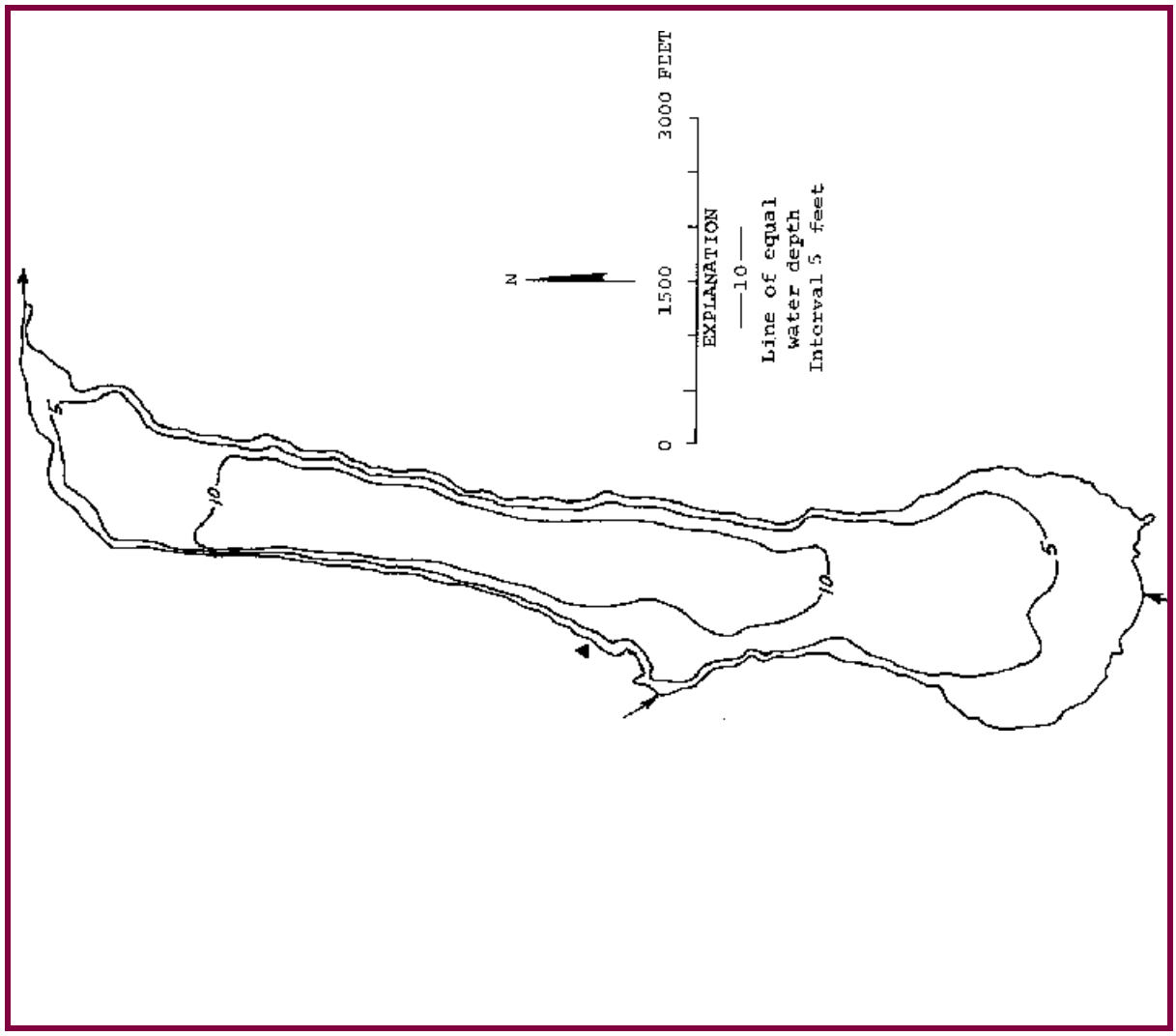
KITSAP County

Lake ID: LONKI1

Ecoregion: 2

Long Lake is located 3.5 miles southeast of Port Orchard. It is two miles long. The lake is fed principally by Salmonberry Creek, and drains via Curley Creek to Yukon Harbor.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
339	12	6	9	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
2180	5.07	118	47 28 58.	122 35 12.



Station Information

LONKI1

Primary Station	Station # 1	latitude: 47 29 26.6	longitude: 122 35 17.4
	Description:	In approximate middle of lake, about 1000 feet northeast of launch	
Secondary Station	Station # 2	latitude: 47 28 39.5	longitude: 122 35 36.4
	Description:	In horizontal middle of lake approximately 2000 feet south of northern shore	

Trophic State Assessment for 1998

LONG

Analyst: KIRK SMITH

TSI_Secchi:	53	N
TSI_Phos:	54	
TSI_Chl:	53	
Narrative TSI:[a]	E	

Long Lake in Kitsap County is a shallow, naturally eutrophic lake. Historically, Long Lake has been subjected to intensive studies and restoration efforts but we suspect that Long Lake is naturally eutrophic and will always be rich in nutrients without unreasonably extensive and expensive management. All the chlorophyll samples for the lake were well within the eutrophic range with the exception of the June sample. There were no user surveys distributed around Long Lake but the county closed the public swimming beach for a short time due to fecal contamination which they attributed to human sources (presumably swimmers). Fecal bacteria concentration from this study were unusually high for lakes. Also, the lake is notorious for its abundant macrophyte growth and algal blooms both of which have adversely affected primary contact uses in the past. Our habitat survey also confirmed the abundant macrophyte growth in the lake. The lake does have two noxious weeds, Brazilian elodea (Egeria densa) and Eurasian water milfoil (Myriophyllum spicatum). Zooplankton had a relatively large average size with cladocerans dominant. The abundant macrophyte growth may impair foraging by the large fish predators while at the same time enhancing the protective cover for salmon smolts. Historical data from 1973 suggests TP concentrations to be similar or perhaps even higher than concentrations detected in this study.

In summary, Long Lake appears to be naturally eutrophic. Beneficial uses do not appear to be impacted from the abundant nutrients considering the eutrophic state of the lake. Uses may suffer impacts from excessive aquatic plant growth although that growth may provide a protective nursery for coho salmon smolts. Also, reducing nutrients in the lake most likely would not reduce the plant biomass and may actually increase biomass should the decrease in algal concentrations allow for greater light penetration. Therefore, we recommend that the nutrient criterion be set at 34.7 ug/L, the mean total phosphorus concentration from this study plus an adjustment for inter-annual variability (mean = 29.6 ug/L + std. dev. = 5.1 ug/L).

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

LONG

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
8/19/1998		L					71			
		L					27			
9/23/1998		L					160			
		L					88			
Station 1										
6/10/1998		E	21.4	.367	17	5.7		40.3	8100	1.7
7/24/1998		E	28.3	.487	17	8.2				2.4 J
8/19/1998		E	39.3	.559	14	26.6				3.9
9/23/1998		E	28.1	.44	16	9.5				2.1
Station 2										
8/19/1998		E	35							
9/23/1998		E	26.3	.45	17	11.2				

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

LONG

Survey Date: 9/23/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [ ] **Agriculture(commercial, not hobby)**
- [ ] **Commercial, Industrial**
- [2] **Major transportation**
- [1] **Residential**
- [ ] **Park, forest or natural**

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

None needed at this time.

Odors ☐

None detected

Cattle ☐ **Ducks** ☐ **Geese** ☐

None

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

Some fertilizers appear to be used on lawns around the lake.

Buffer zones around streams and wetlands ☑

Irrigation ☐

Survey Id: 90

Habitat Survey Summary Report

LONG

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 8/19/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.8	**Number of stations with canopy:**	10
Understory Avg:	2.4	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.7
	trees< 0.3 m DBH	1.1
Understory:	**woody shrubs saplings**	1.9
	tall herbs, forbs grasses	0.5
Ground Cover:	**woody shrubs seedlings**	1.5
	herbs, forbs, grasses	1.3
	standing water or inundated veg	0.8
	barren or buildings	0.9
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.6
	cobble/gravel	1.0
	loose sand	2.0
	other fine soil/sediment	0.8
	vegetated	2.6
	other	0.0
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.3
	vertical dist (M from wtrln to high wt):	0.2
	horiz. dist. (M from wtrln to high wt):	0.9

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	0.8
commercial	0.0
park facilities	0.2
docks/boats	0.9
walls, dikes, or revetments	0.7
litter, trash dump, or landfill	0.0
roads or railroad	0.4
row crops	0.0
pasture or hayfield	0.2

orchard	0.0
lawn	1.1
other	0.2

Physical Habitat Characteristics

station depth (at 10 m from shore)	1.4

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.0
cobble	0.0
gravel	1.0
sand	1.6
silt	2.8
woody debris	0.2

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	2.6
emergent	0.7
floating	1.0
total weed cover	2.9
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-1.0

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.9
snags	0.0
brush or woody debris	0.8
inundated live trees	0.3
overhanging vegetation	1.0
rock ledges or sharp dropoffs	0.0
boulders	0.0
human structures	1.1

Zooplankton Report

LONKI1

Date 6/10/1998 Station: 1
Sample ID 25

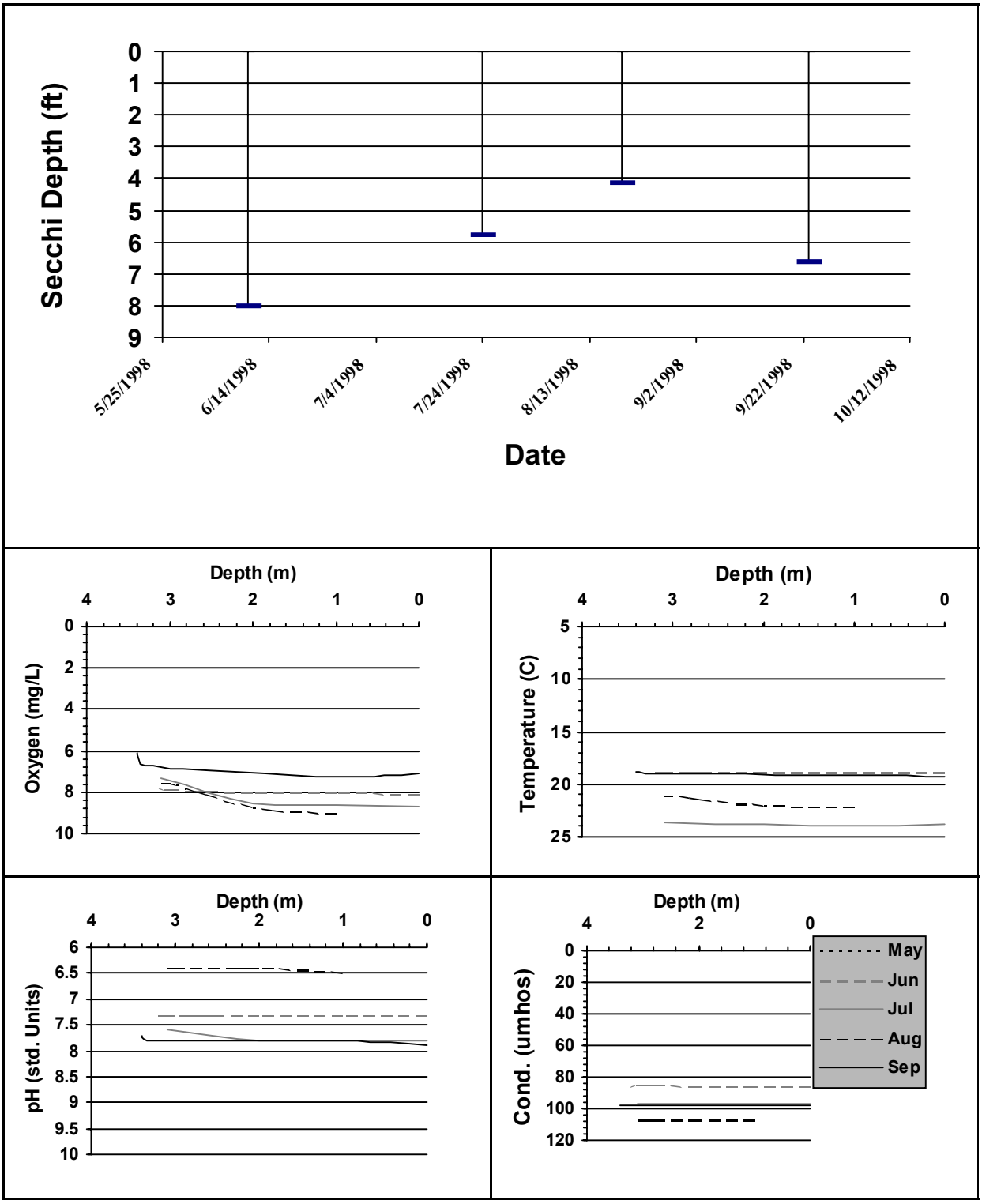
Number of organisms measured: 59

Group	Percent
Cladoceran	83.1%
Copepod	16.9%
Other	

Group	Percent
Small < 1mm	72.9%
Large >= 1mm	27.1%
Ratio of large to Small:	0.37
Average size (mm):	0.75

Secchi Depth and Profile Graphics

Station: 1 LONKI1



Secchi Data and Field Observations

LONG

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/10/1998			8	8	100			3	3	0	0	0	1
	Sampler: SMITH			Remarks: SECCHI DIPS CONDUCTED WITH KITSAP COUNTY HEALTH FOR QC PURPOSES. 229 HOMES ON LAKE. WSHED 15% LOGGING, 85% RESIDENTIAL; SHORELINE 35% NATURAL VEGETATION									
7/24/1998			5.78	6	100			2	1	17	5	1	0
	Sampler: SMITH			Remarks: 1 EAGLE OBSERVED. 2 PEOPLE FISHING AT BOAT LAUNCH. MANY NEW HOMES ALONG SHORELINE. The Oxygen result is qualified as an estimate due to postcalibration failing QA/QC requirements.									
8/19/1998			4.13	3	0	2		3	2	0	0	0	0
	Sampler: SMITH			Remarks: ABUNDANT ALGAL BLOOM. APPEARS TO BE APHANIZOMENON. BRAZILIAN ELODEA THROUGHOUT BOTTOM FROM SHORE TO SHORE									
9/23/1998			6.6	2	0	1		3	2	58	165	0	2
	Sampler: SMITH			Remarks: FEC#1 AT PUB SWIM BEACH, #2 AT BOAT LAUNCH. ONE BALD EAGLE OBSERVED. The Conductivity and Oxygen results are qualified as an estimate due to postcalibration failing QA/QC requirements.									

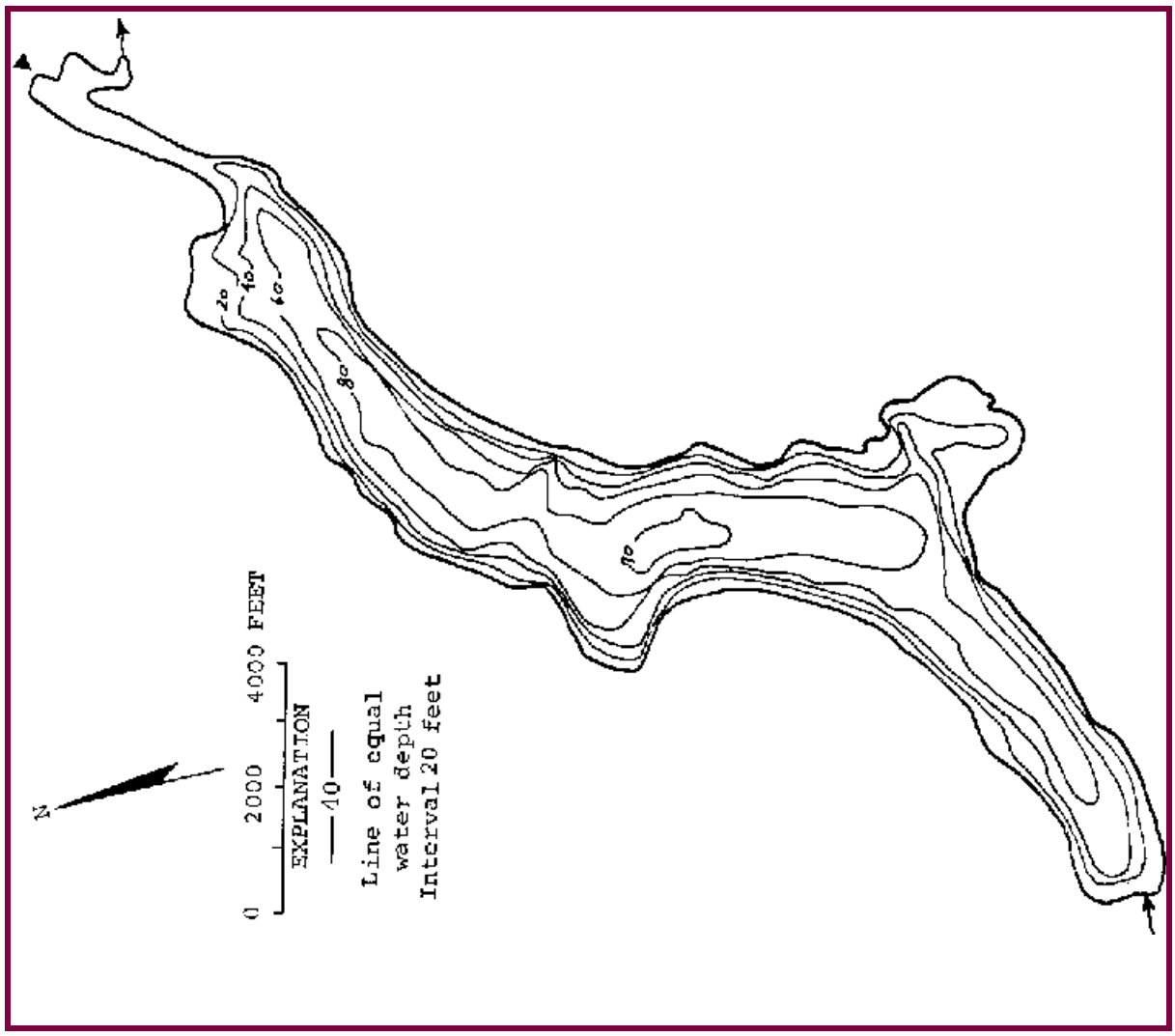
MASON

MASON County *Lake ID:* MASMA1

Ecoregion: 2

Mason Lake is located eight miles southwest of Belfair. It is four miles long and is fed by Shumocher Creek. Mason Lake drains via Sherwood Creek to North Bay and Case Inlet. It is the largest and deepest lake in Mason County.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
1000	90	48	20	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
49000	10.9	194	47 21 14.	122 55 17.



Station Information

MASMA1

Secondary Station	Station # 1	latitude:	longitude:
	Description:	Located approximately 3500 feet up from the inlet at the southern end of the lake. The station is midway between the east and west shorelines at a spot where the water is about 60 feet in depth.	
Secondary Station	Station # 2	latitude:	longitude:
	Description:	Located at the far southern end of the 80 foot contour line (see bathymetric map) midway between both shorelines. Station is directly across from a concrete boathouse on the western shore and a brown house on the eastern shore.	
Secondary Station	Station # 3	latitude: 47 19 38.7	longitude: 122 56 17.0
	Description:	Located at the northern end of the 60 foot contour line, midway between both shorelines (see bathymetric map). The station is directly across from a red boathouse on the western shore and a yellow boathouse on the eastern shore.	
Primary Station	Station # 4	latitude: 47 20 16.0	longitude: 122 57 18.1
	Description:	Located in the deepest part of the lake in the middle of the 90 foot contour line (see the bathymetric map). The station is in the approximate center of a line extending from the southern edge of a large cove on the western shore to a smaller cove on the east shore.	
Secondary Station	Station # 5	latitude:	longitude:
	Description:	Located approximately 2 miles south of the boat launch. The station is midway between the east and west shorelines and where the water depth is about 80 feet.	

Trophic State Assessment for 1998

MASON

Analyst: KIRK SMITH

TSI_Secchi:	32
TSI_Phos:	24
TSI_Chl:	31
Narrative TSI:[a]	O

Mason Lake is an oligotrophic lake in the Puget Lowlands ecoregion. Mason Lake remains relatively clear despite the densely developed shoreline. The watershed is mostly timber and some of it has been clear-cut within the last decade. This disturbance in the watershed has not shown any apparent impact on lake nutrient concentrations; Ecology records do not indicate an increase in total phosphorus concentrations throughout the decade. Although water clarity is very good, blooms of blue-green algae (Gleotrichia sp.) are apparent in mid and late summer. The first invasion of Eurasian milfoil (Myriophyllum spicatum) on Mason Lake was observed in 1998 along the east shore, midlake. Although the watershed appeared fairly stable (even in the clear-cut areas), it was rare to see any natural habitat along the shoreline. The habitat survey revealed considerable human disturbance in the riparian and littoral zones. These disturbances could adversely impact fish

populations. The results of the user survey suggests the water clarity is sufficient to support primary contact uses--although only 3 surveys were returned. Our 1998 sampling found a mean total phosphorus concentration of 4.3 ug/L. Although there may be reason to suspect impairment to habitat from human disturbance and there is a potential for increased phosphorus loading from the recent milfoil introduction, there is not enough information to conclude that there is currently any impairment to the uses of the lake. Milfoil most likely offers the biggest threat to beneficial uses in the near future.

The phosphorus criterion for Mason Lake could be set at 10 ug/L, the action value in the water quality regulations for Puget Lowlands Oligotrophic lakes; however, to protect this valuable resource from degradation, we recommend a criterion be set at 7.3 ug/L, the current total phosphorus concentration plus an adjustment for inter-annual variability.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

MASON

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
7/26/1998		L					4			
		L					1 U			
8/18/1998		L					22			
		L					1			
Station 3										
6/4/1998		E	5.8	.104	18					
7/26/1998		E	3.8	.081	21	.73				
9/18/1998		E	4.3							
Station 4										
6/4/1998		E	5.3	.121	23	1.2		19.8	4560	.5 U
		H	6.1 J	.081	13					
7/26/1998		E	3.1	.09	29	.5 U				.5 U
		H	5	.068	14					
8/18/1998		E	3.7	.087	24	1.1				.5 U
		H	8.5	.066	8					
9/18/1998		E	5.2	.066	13	1.2				.5 U
		H	14	.04	3					

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

MASON

Survey Date: 9/18/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

	Agriculture(commercial, not hobby)	1	**Residential**
	Commercial, Industrial	2	**Park, forest or natural**
	Major transportation		

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Extensive clear cutting on the hill at the west side of the lake. The cutting looked recent, perhaps within the last 5 - 8 years.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

Fertilizers and weed killer appear to be in use on lakeshore property.

Buffer zones around streams and wetlands ☑

There is one small patch of buffer zone along lakeshore. This appears to be Simpson property at the very northwest end of the lake.

Irrigation ☐

Survey Id: 50

Habitat Survey Summary Report

MASON

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 9/14/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.4	**Number of stations with canopy:**	10
Understory Avg:	2.1	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	2.3
	trees< 0.3 m DBH	1.0
Understory:	**woody shrubs saplings**	2.4

	tall herbs, forbs grasses	1.1
Ground Cover:	**woody shrubs seedlings**	1.7
	herbs, forbs, grasses	3.2
	standing water or inundated veg	0.3
	barren or buildings	1.6
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.0
	cobble/gravel	3.1
	loose sand	0.6
	other fine soil/sediment	1.2
	vegetated	1.0
	other	0.4
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.2
	vertical dist (M from wtrln to high wt):	0.3
	horiz. dist. (M from wtrln to high wt):	0.2

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.5
commercial	0.0
park facilities	0.0
docks/boats	1.5
walls, dikes, or revetments	1.3
litter, trash dump, or landfill	0.4
roads or railroad	0.0
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	1.6
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	2.5

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.1
boulders	0.1
cobble	1.1
gravel	2.3
sand	2.2
silt	1.5
woody debris	0.8

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	1.3

emergent	0.3
floating	0.1
total weed cover	1.3
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-1.0

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.3
snags	0.0
brush or woody debris	0.4
inundated live trees	0.0
overhanging vegetation	0.2
rock ledges or sharp dropoffs	0.0
boulders	0.1
human structures	1.3

Questionnaire

MASON

Results compiled from 3 **Surveys.** **Average time (years) respondents spent on lake:** 24.33

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	-0.3	View:	0.3	Distance to Lake:	0.0
Public Access:	-0.3	Swim Beach:	0.7	Canada Geese:	-1.0
Water Clarity:	0.3	Water Qual. for Swim:	0.3		
Fishing Quality:	0.0	Aquatic Plants:	-0.7		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **4.3**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.7
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.3
1) Clearer water, or 2) fewer aquatic plants?	1.3

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	4.0	Good Warmwtr Fishing:	4.0	Natural Scenery:	4.0
Plant Growth:	1.7	Good Swimming:	4.3	Public Beach:	1.3
Natural Shoreline:	3.3	Less Algae:	4.7	Canada Geese:	2.3
No Odors:	4.0	Public Access:	1.3		
Good Coldwtr Fishing:	4.0	Clear Water:	4.3		

Tabulated Results

Survey ID	Date	Residency	Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
42	9/7/1998	Resident	Permanent	Rent	several of the above	☑	Worse	1985
	No more public access. Get rid of Canada geese and ducks.							
51	8/29/1998	Resident	Seasonal	Rent	10	☑	No	
	Better or more enforcement of state boating regulations							

59	8/29/1998	Resident	Seasonal	Rent	10	☐	No

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

MASMA1

Date 8/18/1998 Station: 1
Sample ID 27

Number of organisms measured: 174

Group	Percent
Cladoceran	12.1%
Copepod	87.9%
Other	

Group	Percent
Small < 1mm	98.3%
Large >= 1mm	1.7%
Ratio of large to Small:	0.02
Average size (mm):	0.46

Aquatic Plant Data

MASON

Sampler: Parsons, O'Neal

Survey Date: 9/14/1998

Max depth of growth (M): >6

Comments Sunny, calm. Surveyed entire shoreline, did habitat survey for Kirk Smith. Plants patchy, occasional dense areas of P. amplifolius, but many areas with open sediment. Much tiny ball-like algae suspended in water. M. spicatum only seen in Paradise Estates launch area. Observed a loon at south end, herons, few mallards, fish, osprey, heard frogs (didn't sound like adult bullfrogs).

SPECIES LIST

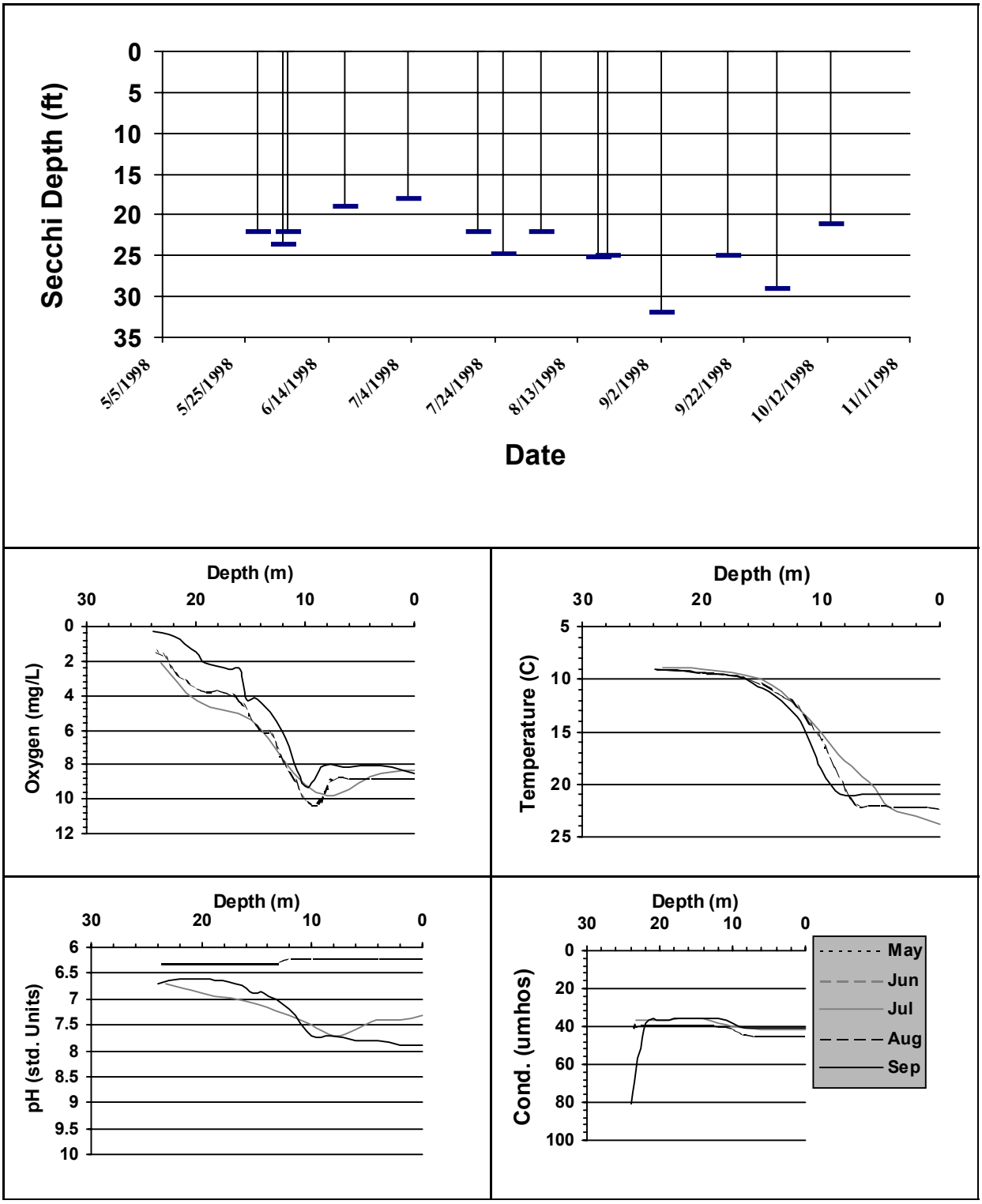
Scientific Name	Common Name	Dist [a]	Comments
Brasenia schreberi	watershield	1	
Carex sp.	sedge	1	
Elodea canadensis	common elodea	2	
Hippuris vulgaris	common marestail	1	
Iris pseudacorus	yellow flag	2	
Isoetes sp.	quillwort	3	
Juncus sp.	rush	2	
Lilaeopsis occidentalis	lilaeopsis	1	shallows and shoreline at SW end
Lobelia dortmanna	water gladiole; water lobelia	2	
Myriophyllum sp.	water-milfoil	1	looks like M. hippuroides
Myriophyllum spicatum	Eurasian water-milfoil	1	only found in the area of Paradise Estates boat launch
Nitella sp.	stonewort	2	
Nuphar polysepala	spatter-dock, yellow water-lily	1	only a couple of patches
Potamogeton amplifolius	large-leaf pondweed	3	
Potamogeton epihydrus	ribbonleaf pondweed	1	
Potamogeton gramineus	grass-leaved pondweed	2	also may be a hybrid
Potamogeton robbinsii	fern leaf pondweed	2	
Potamogeton sp (thin leaved)	thin leaved pondweed	1	low growing, no achenes
Ranunculus aquatilis	water-buttercup	2	
Sagittaria graminea	slender arrowhead	1	dense around private launch, NE end of lake

Utricularia sp.	bladderwort	1	may be U. inflata, very small winter buds
Vallisneria americana	water celery	2	

[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

Secchi Depth and Profile Graphics

Station: 4 MASMA1



Secchi Data and Field Observations

MASON

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 2													
5/30/1998		14.4	22	2	75	2	1	5	5	0	0	0	0
	Sampler: HOLM			Remarks:									
6/13/1998		17.8	19	2	100	2	3	5	5	2	0	1	1
	Sampler: HOLM			Remarks:									
6/30/1998		20	17	2	75	2	1	5	4	0	0	0	0
	Sampler: HOLM			Remarks:									
7/16/1998		21.1	22	2	0		4	5	5	0	0	0	1
	Sampler: HOLM			Remarks:									
7/31/1998		24.4	21	2	100	1	3	5	4	0	0	0	1
	Sampler: HOLM			Remarks:									
8/13/1998		25	26	2	0	1	1	5	5	0	0	1	3
	Sampler: HOLM			Remarks:	BEAUTIFUL DAY.								
8/27/1998		23	25	2	0			5	5	0	0	0	1
	Sampler: HOLM			Remarks:									
9/11/1998		23	27	2	0	1	1	5	5	0	0	0	0
	Sampler: HOLM			Remarks:									
9/27/1998		20	29	2	0	1	3	5	5	0	0	0	1
	Sampler: HOLM			Remarks:									
10/13/1998		17	23	2	100	3	5	1	1	0	0	0	0
	Sampler: HOLM			Remarks:									
Station 3													
5/28/1998		15	22	2	0	3	2	5	5	0	0	0	0
	Sampler: SCOTT			Remarks:	LATE WITH TESTING DUE TO WEATHER.								

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
6/10/1998		20	19	2	75	1	4	4	4	0	0	0	0
	Sampler: SCOTT			Remarks:									
6/22/1998		19	17	2	25	3	1	4	4	0	0	0	0
	Sampler: SCOTT			Remarks:									
7/9/1998		22	17	2	75	1	1	4	4	0	0	0	2
	Sampler: SCOTT			Remarks:									
7/24/1998		28	20	2	100	1	1	5	5	0	0	0	1
	Sampler: SCOTT			Remarks:									
8/8/1998		24	25	2	0	1	1	5	5	0	0	0	2
	Sampler: SCOTT			Remarks:	SATURDAY.								
8/24/1998		22	21	2	100	1	1	4	4	2	0	0	2
	Sampler: SCOTT			Remarks:									
9/8/1998		23	25		100	1	1	4	4	0	0	0	0
	Sampler: SCOTT			Remarks:									
9/20/1998		23	27	2	0	1	2	3	3	0	0	0	0
	Sampler: SCOTT			Remarks:	SUNDAY.								
Station 4													
5/28/1998		15	22	2	0	3	2	5	5	0	0	0	0
	Sampler: NELSON			Remarks:	LATE GETTING STARTED DUE TO BAD WEATHER.								
6/3/1998		17	23.5	2	100	2	1	5	5	0	0	0	0
	Sampler: NELSON			Remarks:									
6/4/1998			22	2	100	4	1	5	4	0	1	0	0
	Sampler: SMITH			Remarks:	VERY WINDY DAY. EXTREMELY DIFFICULT FOR SAMPLING. DRIFTING TOO MUCH FOR ZOO TOW. WSHED 100% TIMBER, SHORELINE ALL RESIDENTIAL (~400 HOMES). NO RESTRICTED USES. The Oxygen result is qualified as an estimate due to postcalibration failing QA/QC requirements.								

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
6/18/1998		16.7	19	2	100	3	1	5	5	0	0	0	0
	Sampler: NELSON			Remarks:									
7/3/1998		18	18	2	75	3	3	5	5	0	0	0	0
	Sampler: NELSON			Remarks:									
7/20/1998		23	22	2	0	2	1	5	5	0	0	1	0
	Sampler: NELSON			Remarks:									
7/26/1998			24.7	6	0			3	5	6	9	0	0
	Sampler: SMITH			Remarks:									
8/4/1998		23	22	6	100	2	1	5	5	0	0	0	0
	Sampler: NELSON			Remarks:									
8/18/1998			25.08	2	90			5	5	0	13	1	4
	Sampler: SMITH			Remarks:	WATER REALLY SHALLOW AT BOAT RAMP. VERY SLIGHT BLUE-GREEN BLOOM. The pH results are qualified as estimates due to postcalibration failing QA/QC requirements.								
8/20/1998		25	25	2	0	2	1				0	0	0
	Sampler: NELSON			Remarks:									
9/2/1998		23.9	32	2	0	1	1	5	5	0	0	0	0
	Sampler: NELSON			Remarks:									
9/18/1998		21.1	25	2	100	1	2	5	5	0	0	0	0
	Sampler: NELSON			Remarks:									
9/18/1998			24.75	2	80	1		5	5	0	7	0	0
	Sampler: SMITH			Remarks:									
9/30/1998		20	29	2	0	2	1	5	5	0	0	0	0
	Sampler: NELSON			Remarks:									
10/13/1998		17	21	2	100	3	5	1	1	0	0	0	0
	Sampler: NELSON			Remarks:									
10/13/1998			21		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									

MEDICAL

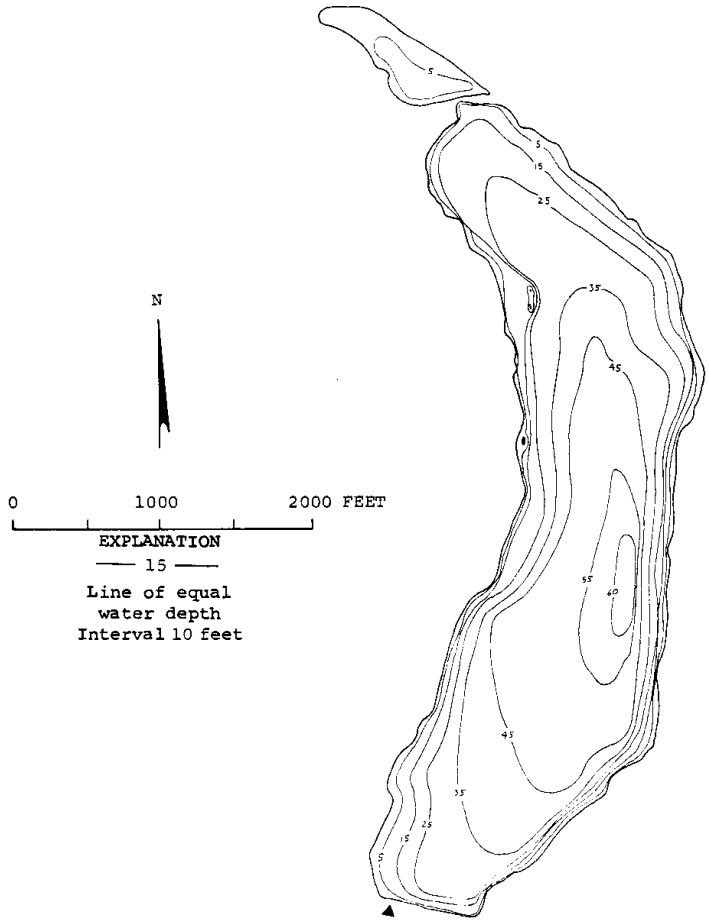
SPOKANE County

Lake ID: MEDSP1

Ecoregion: 7

Medical Lake is located approximately 10 miles southwest of Spokane. The City of Medical Lake lies along its eastern shore. The west shore is mostly undeveloped, with Consolidated Support Services set back from the lake to the west. Residential homes line much of the eastern shore. There is a city park on the north shore and a walking/biking trail around lake. Medical Lake's water quality is improved with the help of an aerator. The lake is a popular recreational lake and supports a variety of uses despite the rich eutrophic conditions. Motors are prohibited on the lake.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
160	60	32	1.35	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
5000	3.14	2394	47 33 48.	117 41 21.



Medical Lake, Spokane County. From Washington Department of Game, February 12, 1955.

Station Information

MEDSP1

Primary Station	Station # 1	latitude: 47 34 18.8	longitude: 117 41 16.0
	Description: Site is 50' south of S. aerator		

Trophic State Assessment for 1998

MEDICAL

Analyst: KIRK SMITH

TSI_Secchi:	53	N
TSI_Phos:	53	
TSI_Chl:	44	
Narrative TSI:[a]	E	

Medical lake is probably naturally eutrophic. Kemmerer reported eutrophic conditions there in 1924. The lake was treated with alum in 1977 and an aerator has been operated in the lake since 1987 (see Soltero, et al., 1994, Partial and full lift hypolimnetic aeration of Medical Lake, WA to improve water quality, Wat. Res. 28(11):2297-2308). Despite the aeration, however, in 1998 the hypolimnion remained nearly anoxic through most of the summer and internal nutrient loading was pronounced.

The lake supports multiple uses including fishing, swimming, and wildlife. The zooplankton community appears to be healthy enough to support a good sport fishery; however, the low hypolimnetic dissolved oxygen and warm surface temperatures are not ideal for a trout fishery. If the lake is to be managed as a coldwater fishery, increased aeration may be desirable. Only five user surveys were returned; two of the respondents believed the water quality had improved in the lake. Two others believed the water quality had deteriorated while one person did not know.

Fecal bacteria concentrations were extremely high at the city park at the north end of the lake. Geese were almost certainly the source and control options should be considered to keep geese out of the park. Soils on the east shore were eroding and might benefit from management such as planting of native shrubs.

It is difficult to set nutrient criteria in a lake that has been altered in a restoration effort and where the trophic state and other parameters are artificially maintained. The beneficial uses appear to be supported, at present, through the use of the aerator. We cannot recommend a criterion for Medical Lake without further study. We recommend continued use of the aerator and continued efforts to tune aeration volume to reduce internal nutrient loading.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

MEDICAL

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/16/1998		L					3			
		L					25			
7/14/1998		L					1 U			
		L					4			
8/11/1998		L					1000 G			
		L					2			
9/15/1998		L					84			
		L					100			
Station 1										
6/16/1998		E	42.2	.822	19	5.7		142		5.4
		H	121 J	1.09	9					
7/14/1998		E	37	1.02	28	1.7				4.8
		H	152	1.77	12					
8/11/1998		E	25.7	1.19	46	2.5				3.9
		H	122	1.53	13					
9/15/1998		E	25.5	.982	39	2.9				3.5
		H	145	1.65	11					

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

Watershed Survey

MEDICAL

Survey Date: 9/15/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [2] **Agriculture(commercial, not hobby)**
- [1] **Residential**
- [3] **Commercial, Industrial**
- [4] **Park, forest or natural**
- [ ] **Major transportation**

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☑

Geese at N. end of the city park (Peper Park--high fecs there too).

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

CSS lawns, Med. Lake residents lawns, wheat fields to west of CSS.

Buffer zones around streams and wetlands ☑

Shoreline is mostly natural and rocky--not particularly susceptible to erosion in most place (however, see aquatic plant surve). Overall watershed assessment--no clear major impacts.

Irrigation ☐

Survey Id: 75

Habitat Survey Summary Report

MEDICAL

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/14/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.2	**Number of stations with canopy:**	10
Understory Avg:	2.6	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.1
	trees< 0.3 m DBH	0.9
Understory:	**woody shrubs saplings**	1.4
	tall herbs, forbs grasses	1.6
Ground Cover:	**woody shrubs seedlings**	1.2
	herbs, forbs, grasses	1.5
	standing water or inundated veg	0.2
	barren or buildings	1.1
Substrate Type (within shoreline plot):	**bedrock**	0.7
	boulders	1.4
	cobble/gravel	1.0
	loose sand	0.0
	other fine soil/sediment	0.5
	vegetated	2.4
	other	0.2
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.7
	vertical dist (M from wtrln to high wt):	0.2
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

	buildings	0.6

commercial	0.0
park facilities	0.2
docks/boats	0.3
walls, dikes, or revetments	0.6
litter, trash dump, or landfill	0.0
roads or railroad	0.2
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	0.3
other	0.3

Physical Habitat Characteristics

station depth (at 10 m from shore)	3.4

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.6
boulders	1.1
cobble	1.5
gravel	0.3
sand	0.0
silt	2.5
woody debris	0.1

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	2.7
emergent	0.5
floating	0.0
total weed cover	2.7
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.7

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.7
snags	0.5
brush or woody debris	0.6
inundated live trees	0.0
overhanging vegetation	0.5
rock ledges or sharp dropoffs	0.1
boulders	0.7
human structures	0.1

Questionnaire

MEDICAL

Results compiled from 5 **Surveys.** **Average time (years) respondents spent on lake:** 9.60

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	0.8	View:	1.0	Distance to Lake:	0.3
Public Access:	0.8	Swim Beach:	0.2	Canada Geese:	-0.2
Water Clarity:	-0.4	Water Qual. for Swim:	-0.4		
Fishing Quality:	-0.2	Aquatic Plants:	-0.2		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **2.2**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.8
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.4
1) Clearer water, or 2) fewer aquatic plants?	1.0

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	5.0	Good Warmwtr Fishing:	3.8	Natural Scenery:	4.6
Plant Growth:	2.2	Good Swimming:	5.0	Public Beach:	3.8
Natural Shoreline:	4.2	Less Algae:	4.6	Canada Geese:	3.6
No Odors:	5.0	Public Access:	3.0		
Good Coldwtr Fishing:	3.6	Clear Water:	4.8		

Tabulated Results

Survey ID	Date	Residency		Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
30	8/11/1998	Resident	Seasonal	Own	10	☐	Better	compared to
31	8/11/1998	Resident	Permanent	Own	6	☐	Worse	1996
	Good beach access. Smells, especially @ spring turnover. Quality is horrible.							
35	8/14/1998	Resident	Permanent	Rent	7	☐	Better	
80	8/26/1998	Resident	Permanent	Rent	6	☐	Unknown	
81	8/14/1998	Resident	Permanent	Rent	10	☑	Worse	
	Since no power boats are allowed, the lake environment is, for the most part, quiet and peaceful. Lots of ducks and geese which I like. Walking path around the lake is excellent.							

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

MEDSP1

Date 6/16/1998 Station: 1
Sample ID 30

Date difficult to read on label, may be incorrect.

Number of organisms measured: 302

Group	Percent
Cladoceran	26.2%
Copepod	73.8%
Other	

Group	Percent
Small < 1mm	93.0%
Large >= 1mm	7.0%
Ratio of large to Small:	0.07
Average size (mm):	0.46

Date 8/11/1998 Station: 1
Sample ID 31

Number of organisms measured: 356

Group	Percent
Cladoceran	84.8%
Copepod	15.2%
Other	

Group	Percent
Small < 1mm	98.9%
Large >= 1mm	1.1%
Ratio of large to Small:	0.01
Average size (mm):	0.48

Aquatic Plant Data

MEDICAL

Sampler: Parsons, O'Neal

Survey Date: 7/14/1998

Max depth of growth (M): ~ 4

Comments Water color blue-green and opaque. Paved bike path circles lake on west shore, homes along most of east shore. Soils on east shore erroding, some shrub plantings might help. Popular recreational lake. Much algae in water - forming mats along west, south and north and parts of east shore, much periphyton on plants. Did habitat survey for Kirk Smith

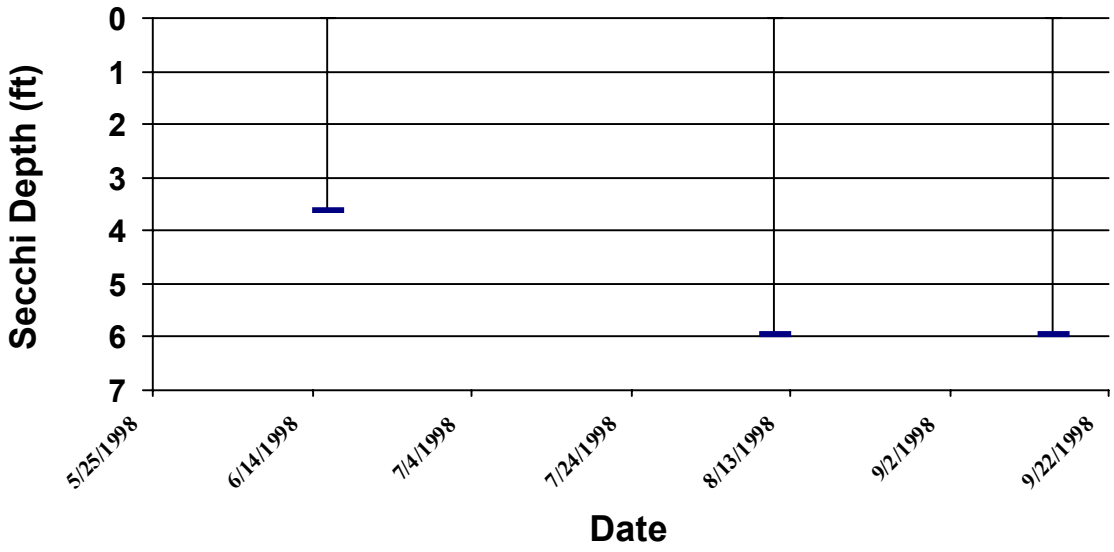
SPECIES LIST

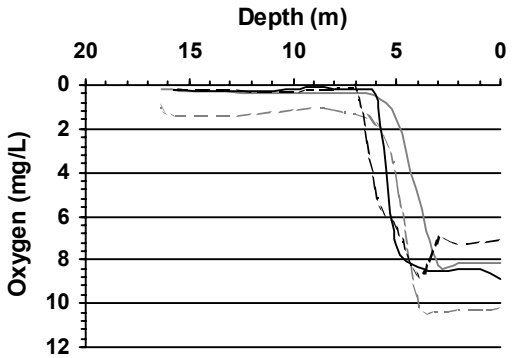
Scientific Name	Common Name	Dist [a]	Comments
Myriophyllum sibiricum	northern watermilfoil	2	blooming
Phalaris arundinacia	reed canarygrass	3	
Potamogeton pectinatus	sago pondweed	3	with fruit
Ranunculus aquatilis	water-buttercup	2	blooming
Ruppia maritima	ditch-grass	4	blooming
Scirpus sp.	bulrush	2	
Typha latifolia	common cat-tail	2	blooming

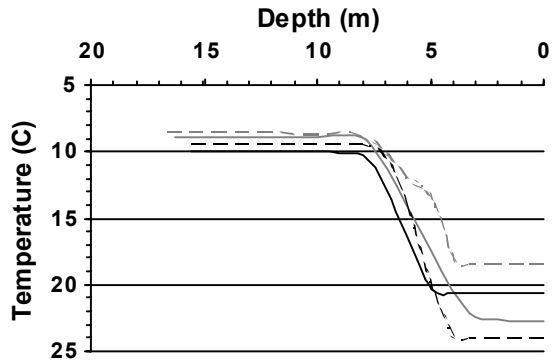
[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

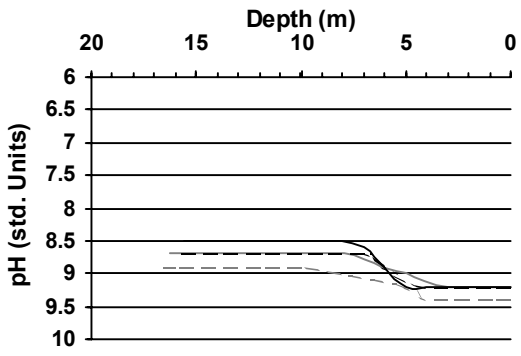
Secchi Depth and Profile Graphics

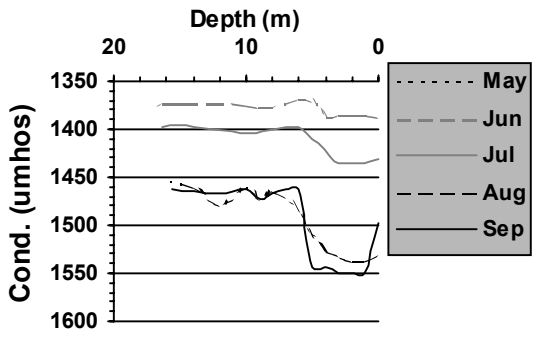
Station: 1 MEDSP1











Secchi Data and Field Observations

MEDICAL

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/16/1998			3.63	2	100	1	1	3	3	30	3	0	0
	Sampler: HALLOCK			Remarks:									
7/14/1998					80	1		2	2	30	11	0	0
	Sampler: HALLOCK			Remarks:	CLOUDY GREEN. OCCASIONAL CLUMPS OF FIBROUS, TAN ALGAE; SAMPLE TAKEN								
8/11/1998			5.94	2	0	1		2	3	100	25	0	0
	Sampler: HALLOCK			Remarks:	LOTS OF ZOOPLANKTON, INCLUDING A FEW LARGE DAPHNIA. MILD ANOXIC SMELL @ 10 AND 15M BUT NOT H2S. APPROX 40 HOMES ON EAST SHORE.								
9/15/1998			5.94	6	0	1		3	3	20	0	0	0
	Sampler: HALLOCK			Remarks:	NO COLONIAL ALGAE VISIBLE. HYPOLIMNION ALMOST ENTIRELY ANOXIC. THE USUAL BUBBLES (NEAR SHORELINE) FROM AERATOR ARE VISIBLE. HYPO SAMPLES ARE SLIGHTLY BLACK. 15M SAMPLE, SLIGHT H2S SMELL.								

MEDICAL, WEST

SPOKANE County

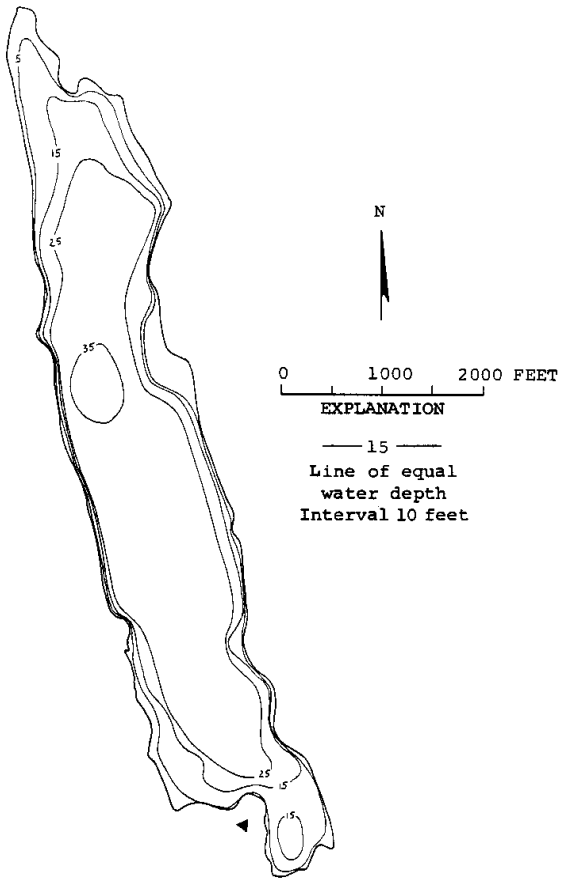
Lake ID: *MEDSP2*

Ecoregion: 7

West Medical lake is a very eutrophic lake located approximately 30 miles southwest of Spokane. It is one of the few lakes in the state with a permitted waste water discharge.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*
220	35	22	2

Volume (ac-ft)	*Shoreline (miles)*	*Altitude (ft abv msl)*	*Latitude*	*Longitude*
4900	3.98	2423	47 33 42.	117 42 06.



Medical, West Lake, Spokane County. From
Washington Department of Game, February 3, 1955.

Station Information

MEDSP2

Primary Station	Station # 1	latitude: 47 34 28.6	longitude: 117 42 33.4
	Description:	Deep part of lake approximately 500 feet east of a white slumped bank on west shore	
Secondary Station	Station # 3	latitude: 47 34 11.9	longitude: 117 42 28.1
	Description:	Approximately 750 feet west of east shore hospital access	
Secondary Station	Station # 2	latitude: 47 34 44.9	longitude: 117 42 40.3
	Description:	Northern end of lake in approximate center of a line extending from the east shore to the west shore about 2500 feet south of northern tip of lake	

Trophic State Assessment for 1998

MEDICAL, WEST

Analyst: KIRK SMITH

TSI Secchi: [a]	38	N
TSI Phos:	120	
TSI Chl:	53	
Narrative TSI: [b]	E	

West Medical Lake is one of the few lakes in Washington State which receives a waste treatment plant discharge. Because of this, the lake is unusually high in nutrients. The lake shoreline is mostly natural and the watershed is mostly agriculture with large wheat fields close by. The west shore is undeveloped with wheat fields some 200 meters back from the lake. The east shore is undeveloped except for a picnic access. There is a boat rental place/fishing dock and a large public access on the south end; there is a pumphouse on the north end. The lake has a 50 mph speed limit but we seldom saw boats exceed trolling speed during our sampling visits. The lake is a popular fishing lake and the zooplankton population appears to be healthy and supportive of a good sport fishery. Aquatic plants were thick in places; coontail (Ceratophyllum demersum) was dominant. The water clarity was surprisingly good considering the sizeable nutrient load within the lake. Wildlife were diverse and abundant. Unlike Medical Lake, a mile to the east, West Medical Lake is not typically used for primary contact recreation, though we do not know what uses would be if water quality were better. The abundant vegetation and nutrients do not appear to greatly interfere with current uses, though too much vegetation may interfere with forage by predator fish or be so thick that it is impenetrable even by the smaller prey fish. It can also potentially interfere with fishing. Hydrogen sulfide odor was observed very deep in the water column (8 meters) and there were many blue-green colonies (probably Mycrocystis) but again, these typical indicators of poor water quality do not appear to impact the current uses of the lake. An aerator has been operated in the lake in the past.

In 1992, Willms, R. and G. Pelletier reported high fecal bacteria near the treatment plant outfall, mean TPs of 2.35 mg/L (max 2.8), and mean TN of 1.68 (Impacts of Eastern State Hospital and Lakeland Village Wastewater discharges on the quality of

West Medical Lake, Washington State Department of Ecology, 36 pp.). In 1998, we found no high fecal bacteria concentrations, much higher TP concentrations (epilimnion mean 3.03, whole lake max 4.91) and a similar TN concentration (1.36). Willms and Pelletier reported evidence of significant internal nutrient loading; internal loading was even more pronounced during our study, perhaps because thermal stratification was greater.

There are plans to redirect the treatment plant outfall out of the lake in the near future.

West Medical Lake is almost certainly nitrogen limited with TN/TP ratios below 2. (Nitrogen limitation would also explain why the mean Secchi and chlorophyll concentrations were so much lower than mean TP concentrations would indicate.) Pending a more thorough study, we recommend that a nitrogen criterion for West Medical Lake be set at current levels plus a correction for inter-annual variability: 1.36 mg/L (= mean 1.20 mg/L + std. dev. 0.16).

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

MEDICAL, WEST

Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/16/1998		L					1 U			
		L					1 U			
7/14/1998		L					19			
		L					1 U			
8/11/1998		L					1			
		L					1 U			
9/15/1998		L					1 U			
		L					1 U			
Station 1										
6/16/1998		E	3310 J	.912	0	7.3		164		1
		H	3590 J	.99	0					
7/14/1998		E	3000	1.36	0	12.3				.8 J
		H	4000	1.78	0					
8/11/1998		E	2750	1.42	1	16.4				1.4 J
		H	4330	1.83	0					
9/15/1998		E	3050	1.13	0	12.4				.8

	H	4910	2.86	1	
Station 2					
7/14/1998	E	2900	1.33	0	10.6
9/15/1998	E	2680	1.12	0	11.3
Station 3					
8/11/1998	E	2840	1.28	0	13.2
	H	2630	1.31	0	13.8

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

Watershed Survey

MEDICAL, WEST

Survey Date: 9/15/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

2 **Agriculture(commercial, not hobby)**
1 **Commercial, Industrial**
☐ **Major transportation**
☐ **Residential**
☐ **Park, forest or natural**

Impervious surfaces (Roads and parking area) No Curbs

Observations (check mark denotes presence)

BMP's ☐

Cattle and horses have access to low-lying areas but not sure if the areas are upstream or down.

Odors ☐

Cattle ☐ **Ducks** ☑ **Geese** ☐

Ducks are all over.

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

Wheat fields and at prison

Buffer zones around streams and wetlands ☐

Irrigation ☑

north end of lake

Survey Id: 75

Habitat Survey Summary Report

MEDICAL, WEST

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/14/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg: 1.2 **Number of stations with canopy:** 6

Understory Avg:	2.3	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.3
	trees< 0.3 m DBH	0.6
Understory:	**woody shrubs saplings**	1.3
	tall herbs, forbs grasses	2.3
Ground Cover:	**woody shrubs seedlings**	1.5
	herbs, forbs, grasses	2.8
	standing water or inundated veg	0.7
	barren or buildings	0.5
Substrate Type (within shoreline plot):	**bedrock**	0.7
	boulders	0.4
	cobble/gravel	0.4
	loose sand	0.0
	other fine soil/sediment	0.9
	vegetated	3.4
	other	0.0
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.7
	vertical dist (M from wtrln to high wt):	0.2
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	0.2
commercial	0.0
park facilities	0.0
docks/boats	0.1
walls, dikes, or revetments	0.0
litter, trash dump, or landfill	0.7
roads or railroad	0.4
row crops	0.1
pasture or hayfield	0.7
orchard	0.0
lawn	0.0
other	0.1

Physical Habitat Characteristics

station depth (at 10 m from shore)	2.4

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.3
boulders	0.3
cobble	0.0

gravel	0.0
sand	0.0
silt	3.3
woody debris	0.6

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	3.2
emergent	1.4
floating	0.2
total weed cover	3.3
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.8

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.9
snags	0.3
brush or woody debris	0.6
inundated live trees	0.1
overhanging vegetation	0.2
rock ledges or sharp dropoffs	0.2
boulders	0.3
human structures	0.0

Questionnaire

MEDICAL, WEST

Results compiled from 1 **Surveys.** **Average time (years) respondents spent on lake:** 12.00

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	0.0	View:	0.0	Distance to Lake:	0.0
Public Access:	0.0	Swim Beach:	0.0	Canada Geese:	
Water Clarity:	-1.0	Water Qual. for Swim:	0.0		
Fishing Quality:	0.0	Aquatic Plants:	-1.0		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **2.0**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	2.0
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	2.0
1) Clearer water, or 2) fewer aquatic plants?	1.0

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	3.0	Good Warmwtr Fishing:	3.0	Natural Scenery:	3.0
Plant Growth:	1.0	Good Swimming:	3.0	Public Beach:	3.0
Natural Shoreline:	3.0	Less Algae:	5.0	Canada Geese:	3.0
No Odors:	3.0	Public Access:	3.0		
Good Coldwtr Fishing:	3.0	Clear Water:	5.0		

Tabulated Results

Survey ID	Date	Residency	Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
62	8/11/1998	Visitor		2	☐	Worse	1987

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

MEDSP2

Date 8/11/1998 Station: 1
Sample ID 11

Cladoceran appear daphnia-like but lack the long spine, distinct eye-spot and head. Looks like giant Ostracod but has obvious Cladoceran features. More round than oval. Most likely D. schodleri

Number of organisms measured: 72

Group	Percent
Cladoceran	100.0%
Copepod	
Other	

Group	Percent
Small < 1mm	81.9%
Large >= 1mm	18.1%
Ratio of large to Small	0.22
Average size (mm):	0.76

Aquatic Plant Data

MEDICAL, WEST

Sampler: Parsons, O'Neal

Survey Date: 7/14/1998

Max depth of growth (M): 4.5

Comments Sunny, breeze. Much long thin blue-green algae in water. Ceratophyllum is dominant submersed plant. Animals observed include: many duck families (dabblers and greebes). Raccoons on shore. Ruddy ducks, osprey, heron, geese, many blackbirds, some dead fish floating, gold fish, turtle. Conducted habitat survey for Kirk Smith. Heavy algae growth on some plants (deeper ones), forming surface scum unprotected areas. Water level seems up, all Ponderosa pines along shore are dead.

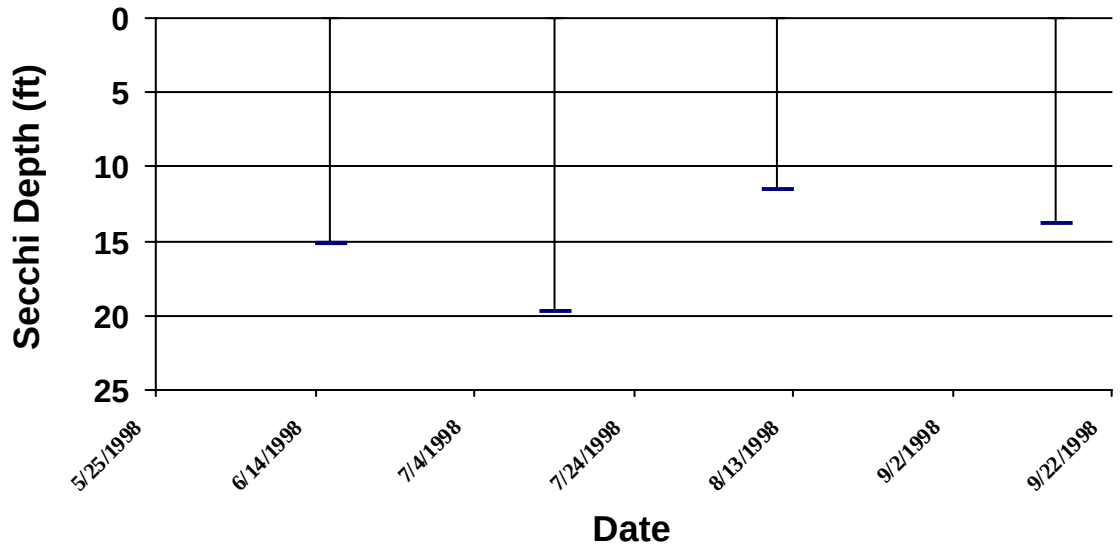
SPECIES LIST

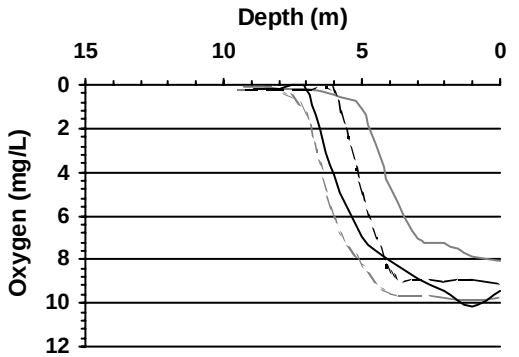
Scientific Name	Common Name	Dist [a]	Comments
Ceratophyllum demersum	Coontail; hornwort	4	dominant in much of lake, forming surface mats
Lemna sp.	duckweed	2	more common at south end
Myriophyllum sibiricum	northern watermilfoil	2	blooming
Phalaris arundinacia	reed canarygrass	3	along shore
Potamogeton crispus	curly leaf pondweed	2	patches along west and east shores
Potamogeton pectinatus	sago pondweed	3	some dense stands
Potamogeton pusillus	slender pondweed	1	not much, fruiting
Scirpus sp.	bulrush	2	
Typha sp.	cat-tail	2	

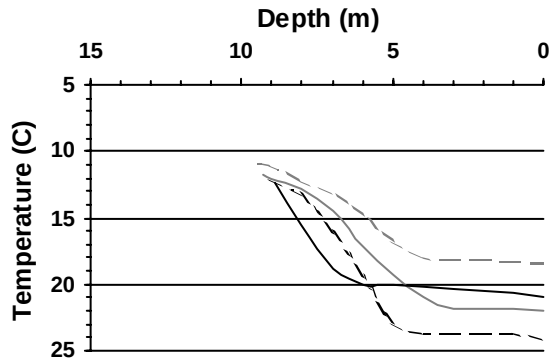
[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

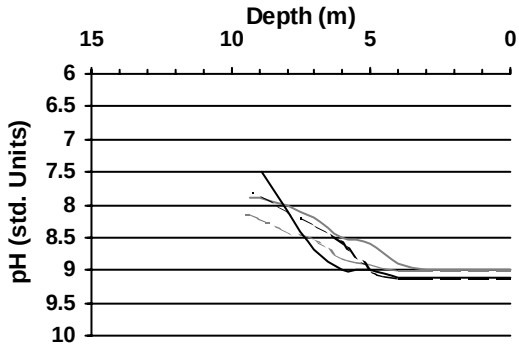
Secchi Depth and Profile Graphics

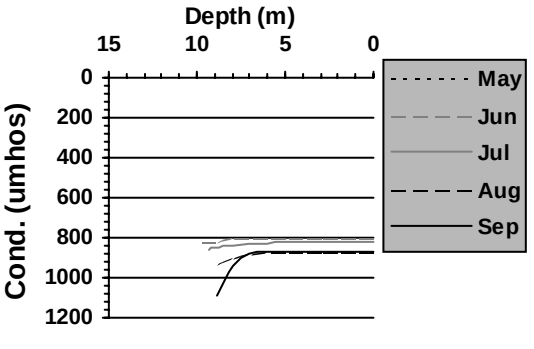
Station: 1 MEDSP2











Secchi Data and Field Observations

MEDICAL, WEST

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/16/1998			15.18	3	0	1				6	7	9	0
	Sampler: HALLOCK			Remarks: APHANIZOMENON BLOOM IN PROGRESS. NO BLUE-GREEN AT 6M BUT LARGE DAPHNIA. NO BIOTA AT 8M									
7/14/1998			19.8	6	5	1		3	3	30	31	4	0
	Sampler: HALLOCK			Remarks: COWS ALONG SHORE. LOTS OF ALGAL CLUMPS W/OCCASIONAL APHANIZOMENON FLAKES. GOLDFISH OBSERVED									
8/11/1998			11.55	3	0	1		3	1	0	17	2	0
	Sampler: HALLOCK			Remarks: MODERATE APHANIZOMENON BLOOM									
9/15/1998			13.86	6	0	1		3	1	0	23	2	0
	Sampler: HALLOCK			Remarks: COLONIAL ALGAL BLOOM EVIDENT--SAMPLE TAKEN. H2S SMELL EVIDENT AT 8M AND ON ANCHOR.									
Station 2													
7/14/1998			19.8	6	0	1				0	0	0	0
	Sampler: HALLOCK			Remarks:									
Station 3													
8/11/1998			12.21	3	0					0	0	0	0
	Sampler: HALLOCK			Remarks:									
9/15/1998			13.2	6	0					0	0	0	0
	Sampler: HALLOCK			Remarks:									

MOSES

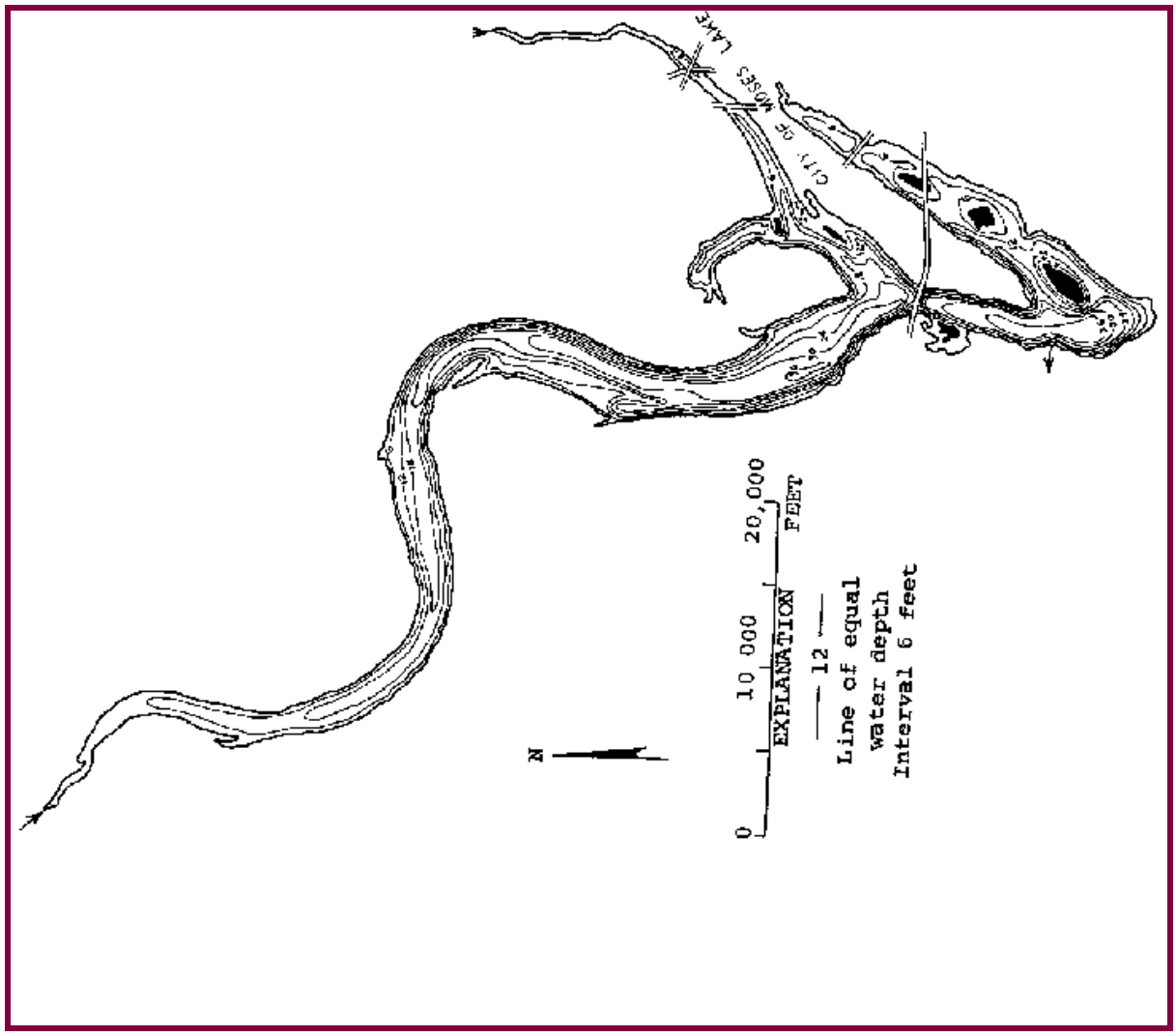
GRANT County

Lake ID: MOSGR1

Ecoregion: 7

Moses Lake provides a large aquatic recreational opportunity for the arid central part of Washington State. This large lake is located along I-90 just to the west of the City of Moses Lake.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
6800	38	19	3080	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
131000	62.31	1046	47 03 47.	119 19 08.



Station Information

MOSGR1

Primary Station	Station # 1	latitude: 47 06 40.5	longitude: 119 18 47.9
	Description:	Near the south end of Parker Horn; northeast of the state park and across from a boat launch on the east shore.	
Secondary Station	Station # 2	latitude: 47 05 15.8	longitude: 119 18 25.1
	Description:	Approximately mid-lake out from the WDFW launch on Pelican Horn.	
Secondary Station	Station # 3	latitude: 47 10 10.0	longitude: 119 19 58.9
	Description:	In main lake approximately 7500 feet southeast of Connelly Park (around the bend where the lake turns south, opposite inlet on west bank).	
Secondary Station	Station # 4	latitude: 47 07 22.1	longitude: 119 20 33.2
	Description:	Deep spot about 1.5 miles NW of state park launch. Out from white house with wood railed stairway on west shore.	
Secondary Station	Station # 5	latitude: 47 05 03.5	longitude: 119 19 36.3
	Description:	Just north of northern-most outlet. Slightly west of center channel.	

Trophic State Assessment for 1998

MOSES

Analyst: KIRK SMITH

TSI_Secchi:	58	N
TSI_Phos:	63	
TSI_Chl:	64	
Narrative TSI:[a]	E	

Moses Lake has a long history of water quality problems and has been the subject of restoration efforts in the past. It remains in a eutrophic condition, though the water quality of the lake is improved as a result of earlier restoration efforts. There were no user perception surveys distributed for this lake so we cannot ascertain the public's desired uses or perception of the water quality in Moses Lake. This information is particularly important for this lake because Moses Lake is a large water body near a relatively densely populated city in central Washington. It is a valuable recreational and wildlife asset for the community; still, further management to improve water quality will likely be very expensive. The zooplankton community appears to be healthy and could support a good fishery. There were many blue-green algae colonies in the water column during all sampling events. Aphanizomenon and Microcystis were particularly abundant. Late summer anoxia in the hypolimnion is to be expected for this lake considering the high nutrient and chlorophyll concentrations. The lake may be nitrogen limited through most of the growing season. Although nutrient rich, the habitat survey did not reveal an overabundance of aquatic vegetation. This may be because of the reduced water clarity in the lake. Human influences (see habitat survey) may have an impact on waterfowl abundance. In particular, geese were observed congregating at parks and other grassy areas.

Our objectives for monitoring Moses Lake were to fulfill post-management monitoring requirements and to support work being conducted by others in 1998. Establishing a nutrient criterion for Moses Lake was not one of our objectives for this lake.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

MOSES

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/17/1998		L					2			
		L					88			
		L					13			
7/15/1998		L					6			
		L					1 U			
		L					1 U			
8/12/1998		L					33 J			
		L					1000 G			
		L					1 U			
9/16/1998		L					1 U			
		L					1 U			
		L					1 U			
Station 1										
6/17/1998		E	98.4 J	.655	7	50		150		13 J
7/15/1998		E	111	1.15	10	45.9				7 J
		H	78.8	.759	10					
8/12/1998		E	38.5	.521	14	19.2				7.9
9/16/1998		E	69	.507	7	42.5				3.9
Station 2										
6/17/1998		E	45.1 J	.573	13	19.8				8.3 J
7/15/1998		E	48.1	.868	18	47.7				10 J
8/12/1998		E	48.5	.665	14	15				8
		H	42.7	.614	14					
9/16/1998		E	53	.491	9	27.8				3.8
Station 3										
6/17/1998		E	57.5 J	.644	11	31.6				10 J
7/15/1998		E	67.2	.858	13	42.5				10 J
		H	102	1.11	11					

8/12/1998	E	44.3	.65	15	13.3	10
	H	175	1.58	9		
9/16/1998	E	46	.598	13	13	3

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

MOSES

Survey Date: 9/16/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

1	**Agriculture(commercial, not hobby)**	2	**Residential**
4	**Commercial, Industrial**		**Park, forest or natural**
3	**Major transportation**		

Impervious surfaces (Roads and parking area): Mostly Curbed

Observations (check mark denotes presence)

BMP's ☐

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

Agriculture areas.

Buffer zones around streams and wetlands ☐

Irrigation ☐

Survey Id: 10

Habitat Survey Summary Report

MOSES

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/19/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.8	**Number of stations with canopy:**	10
Understory Avg:	2.9	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.4

	trees< 0.3 m DBH	0.7
Understory:	**woody shrubs saplings**	2.1
	tall herbs, forbs grasses	2.1
Ground Cover:	**woody shrubs seedlings**	1.6
	herbs, forbs, grasses	3.0
	standing water or inundated veg	1.6
	barren or buildings	1.0
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.0
	cobble/gravel	1.0
	loose sand	0.2
	other fine soil/sediment	0.2
	vegetated	3.6
	other	0.3
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	1.2
	vertical dist (M from wtrln to high wt):	0.2
	horiz. dist. (M from wtrln to high wt):	0.0

Human Influence

(0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	0.5
commercial	0.0
park facilities	0.1
docks/boats	0.5
walls, dikes, or revetments	0.2
litter, trash dump, or landfill	0.0
roads or railroad	0.1
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	0.5
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	1.6

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.4
cobble	1.3
gravel	1.3
sand	1.9
silt	0.9
woody debris	0.2

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)	
submergent	1.8
emergent	1.3
floating	0.0
total weed cover	2.2
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.5

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)	
aquatic weeds	1.8
snags	0.0
brush or woody debris	0.4
inundated live trees	0.0
overhanging vegetation	1.0
rock ledges or sharp dropoffs	0.2
boulders	0.1
human structures	0.1

Zooplankton Report

MOSGR1

Date 8/12/1998 Station: 2 Lots of algal growth
Sample ID 13

Number of organisms measured: 54

Group	Percent
Cladoceran	63.0%
Copepod	37.0%
Other	

Group	Percent
Small < 1mm	53.7%
Large >= 1mm	46.3%
Ratio of large to Small:	0.86
Average size (mm):	0.90

Aquatic Plant Data

MOSES

Sampler: Parsons, O'Neal Survey Date: 7/15/1998

Max depth of growth (M): 2.5

Comments sunny, calm. Blue-green algae bloom forming surface scum near shore in many areas. Lots of big carp, cormorants, greebes, geese, fish jumping. Bottom mostly rocky/sandy, not many submersed plants. Large sections of shoreline undeveloped. Conducted habitat survey for Kirk Smith.

SPECIES LIST

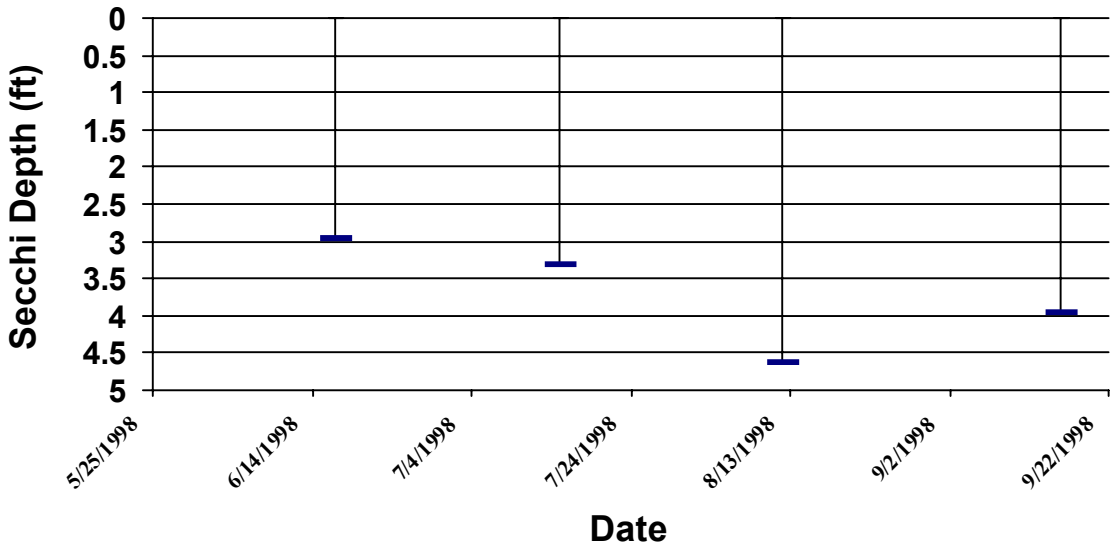
Scientific Name	Common Name	Dist [a]	Comments
Carex sp.	sedge	1	in undeveloped areas of shore
Ceratophyllum demersum	Coontail; hornwort	1	only saw 1 sprig in deeper water
Iris pseudacorus	yellow flag	2	in south end
Juncus sp.	rush	1	in undeveloped areas of shore

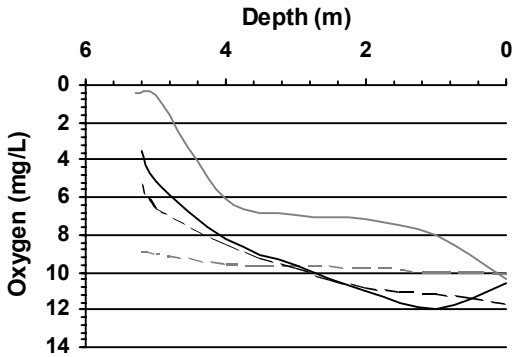
Lythrum salicaria	purple loosestrife	2	northern end
Myriophyllum sp.	water-milfoil	1	one fragment found at MontLake Park dock
Phalaris arundinacia	reed canarygrass	3	
Phragmites communis	common reed	2	more at north-most site
Potamogeton crispus	curly leaf pondweed	2	
Potamogeton illinoensis	Illinois pondweed	2	
Potamogeton pectinatus	sago pondweed	3	
Potamogeton sp (thin leaved)	thin leaved pondweed	2	in deeper water
Scirpus sp.	bulrush	3	bulrush, some dense patches in undeveloped areas
Typha latifolia	common cat-tail	2	seen at north end

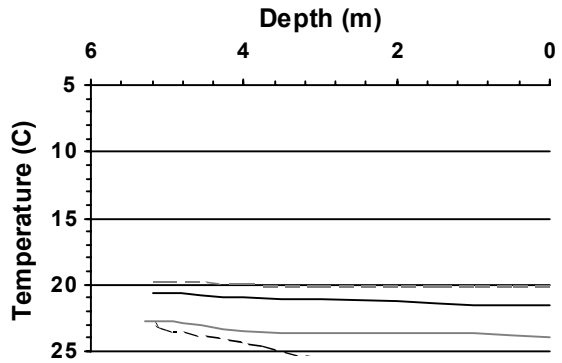
[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

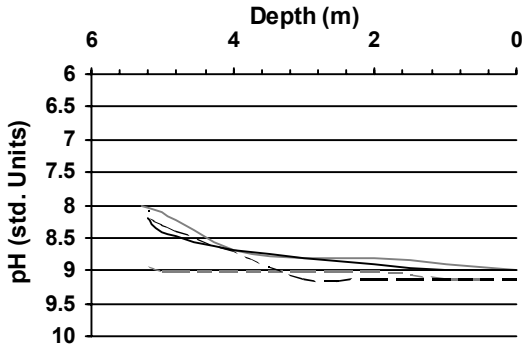
Secchi Depth and Profile Graphics

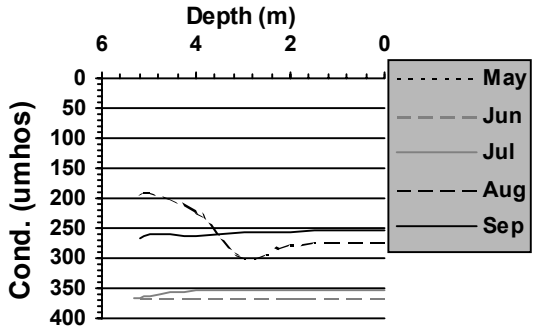
Station: 1 MOSGR1











Secchi Data and Field Observations

MOSES

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/17/1998			2.97	2	0	1		2	1	0	2	1	0
	Sampler: HALLOCK			Remarks: APHANIZOMENON BLOOM IN PROGRESS. TOOK SAMPLES. A FEW LARGE DAPHNIA IN ALL CASTS BUT NOT MANY. ST PARK IS ONLY UNDEVELOPED SHORELINE IN VIEW. RESORT HOTEL, CONDOS, LARGE HOMES. THERE ARE A DOZEN PARKS/WATER REC. AREAS AROUND LAKE.								
7/15/1998			3.3	3	70			1	1	37	7	4	0
	Sampler: HALLOCK			Remarks: LOTS OF NON-GAME FISH JUMPING. THICK APHANIZOMENON BLOOM, W/CLUMPS OF OTHER ALGAE. LARGE DAPHNIA IN ALL CASTS BUT NOT ABUNDANT. LESS APHANIZOMENON. AT 4.5M BUT STILL PRESENT. FINE GREASY CONSOLIDATED SEDIMENT ON ANCHOR.								
8/12/1998			4.62	6	0			1	1	0	15	1	1
	Sampler: HALLOCK			Remarks: NO APHANIZOMENON NOW. BLOOM IS MOSTLY SMALL SPECS W/SOME CLUMPS AND SHORT THIN TRICHOMES. TOOK SAMPLE									
9/16/1998			3.96	6	10			1	1	0	25	4	0
	Sampler: HALLOCK			Remarks: ALGAE BLOOM THICK THROUGHOUT BUT ESPECIALLY CLUMPING AND SCUMMY DOWNWIND. TOOK SAMPLE. ALSO TOOK ZOOPLANTON SAMPLE AT STATE PARK ACCESS									
Station 2													
6/17/1998			3.96	2	0	2		2	1	0	1	2	0
	Sampler: HALLOCK			Remarks: APHANIZONMENON BLOOM NOT AS SEVERE AS SITE 1. NO CLUMPS. SOME LARGE DAPHNIA IN ALL CASTS. HEAVY MUD ON ANCHOR WHICH WAS SO FILLED WITH SMALL SNAIL SHELLS AS TO FEEL LIKE SAND.								
7/15/1998			3.63	2	30			1	1	0	2	2	0
	Sampler: HALLOCK			Remarks: LITTLE APHANIZOMENON BUT LOTS OF SMALL BLUE-GREEN CLUMPS. NOT AS MANY LARGE DAPHNIA AS SITE ONE BUT SOME SMALLER COPEPODS.									
8/12/1998			3.3	6	0			1	1	0	6	1	0
	Sampler: HALLOCK			Remarks: SIMILAR ALGAE ASSEMBLEDGE AS SITE #1 PERHAPS FEWER LARGER CLUMPS									
9/16/1998			4.95	6	20			1	1	30	0	4	0
	Sampler: HALLOCK			Remarks: ALGAE BLOOM EVIDENT HERE TOO BUT NOT AS BAD AS AT STATION 1									
Station 3													

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
6/17/1998			2.64	2	10	2		2	1	0	0	2	0
	Sampler: HALLOCK			Remarks:	APHANIZOMENON BLOOM SIMILAR TO SITE#2. FISHERMEN REPORT WALLEYE AND PERCH. LOTS OF DEAD CARP. THIS BASIN SPARSELY DEVELOPED.								
7/15/1998			4.29	2	50			1	1	0	3	1	0
	Sampler: HALLOCK			Remarks:	SURFACE ALGAE SMALLER COLONIES; APHANIZOMENON SPARSE BUT LOTS OF APHAN AT 2 AND 3M (MOVE DOWN DURING DAY?) 6M NO NOTICEABLE ALGAE. LOTS OF DAPHNIA AND COPEPODS. CONNOLLY PARK LAUNCH BAY IS FULL W/THICK BLUE-GREEN FORMING MATS.								
8/12/1998			3.63	2	0	1		2	2	0	0	2	0
	Sampler: HALLOCK			Remarks:	5 & 6 M SAMPLES HAVE STRONG H2S SMELL. MUCH LESS CLUMPING THAT STATION #1.								
9/16/1998			7.26	6	35	1		1	1	0	33	0	0
	Sampler: HALLOCK			Remarks:	ALGAE BLOOM HERE TOO BUT LESS SEVERE THAN AT SITE #1. SAMPLED FOR VELIGERS OFF CONNELLY PARK								

OFFUTT

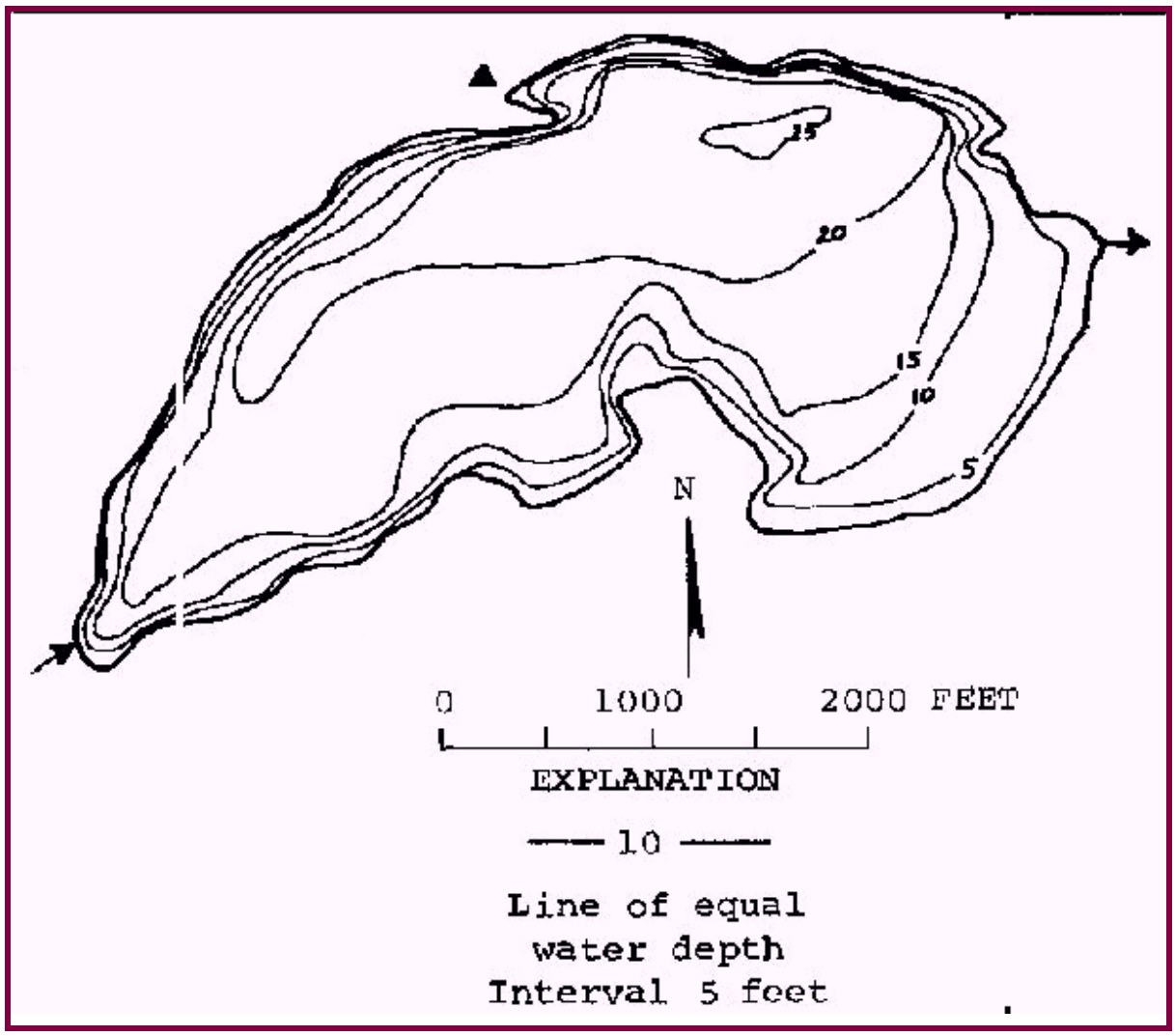
THURSTON County

Lake ID: OFFTH1

Ecoregion: 2

Offutt Lake is in rural Thurston County, about 10 miles south of Olympia. It is fed by an unnamed surface inlet and drains to the Deschutes River. There is a small resort on the lake; however the lake receives little recreational use. Livestock has access to the western shores of the lake.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
200	25	15	3	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
2900	2.86	230	46 55 06.	122 49 04.



Station Information

OFFTH1

Primary Station	Station # 1	latitude: 46 55 05.9	longitude: 122 49 37.4
	Description:	Deep part of lake approximately 250 feet north of the middle of a line extending from boat launch to outlet	

Trophic State Assessment for 1998

OFFUTT

Analyst: KIRK SMITH

TSI_Secchi:	44
TSI_Phos:	47
TSI_Chl:	49
Narrative TSI:[a]	M

Offut Lake is a relatively shallow lake that shows signs of natural eutrophication. The lake has retained most of its natural aesthetic appeal despite the established residential community surrounding the lake. There are large areas where natural vegetation has been allowed to flourish. Aquatic plants were generally sparse. Nutrients in the epilimnion were quite low except in September when concentrations may have been raised after mixing (mean total phosphorus 19.2). Water clarity somewhat indicates a mesotrophic lake despite the tannin colored water which may bias Secchi readings low. Hypolimnetic phosphorus concentrations were very high indicating internal loading. Our 1998 data indicate that Offut Lake may be phosphorus limited in mid-summer and nitrogen limited in early and late summer. With only four samples in one season, however, this is a very tenuous conclusion; a more thorough examination into biologically active forms of both phosphorus and nitrogen may reveal the true dynamic of nutrient limitation. The habitat survey revealed a shoreline influenced by human structures and modifications. These modifications may not affect water quality much, but they may attract an undesirable population of Canada geese. There were no user surveys returned for Offut Lake. There is a resort on the lake with a fishing dock so fishing is most likely a valued recreational use. Water quality measurements suggest a "put and take" fishery could be supported; zooplankton tended to be on the small side and dominated by copepods. There is an area where livestock water on the lake. Although there were colonies of blue-green algae observed in the water samples, dense algal blooms were not observed; lake water should be safe for drinking by livestock. There is the potential for livestock to contaminate water supplies with fecal material and nutrients; however, the water samples analyzed in 1998 for fecal coliform bacteria did not indicate a fecal contamination problem.

We recommend that the remaining natural shoreline be protected so that available habitat for Canada geese will not be artificially increased. We recommend the total phosphorus nutrient criterion for Offut Lake be set at 20 ug/L, the action value in the water quality regulations for Puget Lowlands lower mesotrophic lakes. Due to the limitations of the sampling conducted during this study, it is difficult to determine whether nitrogen is also limiting to the system. Future studies may propose a nitrogen criterion. Some septic infiltration into the lake from some of the older homes

along the lake may be occurring. In particular, these septic fields may be a source of nitrogen. Therefore, future investigation of Offut Lake should include evaluating the effects of nitrogen in the system and consultation with Thurston County officials to determine whether or not there is a septic seepage problem.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

OFFUTT

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/1/1998		L					10			
		L					4			
7/23/1998		L					25			
		L					9 J			
8/10/1998		L					4			
		L					6			
9/24/1998		L					1 U			
		L					1			
Station 1										
6/1/1998		E	19.1	.229	12	3		17.9		.8
		H	60.6	.337	6					
7/23/1998		E	7.3	.25	34	2.1				.7
		H	114	.377	3					
8/10/1998		E	12.5	.517	41	7.7				.9
		H	246	.254	1					
9/24/1998		E	38.1	.457	12	21.2				1.8
		H	60.1	.53	9					

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

OFFUTT

Survey Date: 9/24/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

1	**Agriculture(commercial, not hobby)**	2	**Residential**
	Commercial, Industrial	3	**Park, forest or natural**
	Major transportation		

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Odors ☐

Cattle ☑ **Ducks** ☐ **Geese** ☐

Cattle have been observed entering the lake along the north-west shore of the lake. There is no fencing to keep the cattle out.

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☑

Most of the shoreline has natural vegetation along the shore. The wooded area along the northwest shore is where the cattle enter the lake.

Irrigation ☐

Survey Id: 30

Habitat Survey Summary Report

OFFUTT

Data are averages of *10* **Stations Surveyed** **Date of Visit:** 7/7/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	2.2	**Number of stations with canopy:**	10
Understory Avg:	2.9	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.9
	trees< 0.3 m DBH	1.5
Understory:	**woody shrubs saplings**	2.1
	tall herbs, forbs grasses	1.2
Ground Cover:	**woody shrubs seedlings**	1.0
	herbs, forbs, grasses	1.1
	standing water or inundated veg	0.6
	barren or buildings	1.3
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.2
	cobble/gravel	1.2
	loose sand	0.3
	other fine soil/sediment	0.7
	vegetated	3.2
	other	0.2

Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.2
	vertical dist (M from wtrln to high wt):	0.1
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.0
commercial	0.2
park facilities	0.4
docks/boats	0.9
walls, dikes, or revetments	0.6
litter, trash dump, or landfill	0.2
roads or railroad	0.2
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	0.8
other	0.2

Physical Habitat Characteristics

station depth (at 10 m from shore)	2.6

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.0
cobble	1.0
gravel	1.4
sand	0.5
silt	1.3
woody debris	0.8

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	0.9
emergent	1.1
floating	0.9
total weed cover	1.8
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.3

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	0.9
snags	0.3
brush or woody debris	1.3
inundated live trees	0.0
overhanging vegetation	1.4
rock ledges or sharp dropoffs	0.0

boulders	0.0
human structures	0.8

Zooplankton Report

OFFTH1

Date 6/1/1998 Station: 1
Sample ID 17

Number of organisms measured: 193

Group	Percent
Cladoceran	9.3%
Copepod	90.7%
Other	

Group	Percent
Small < 1mm	91.2%
Large >= 1mm	8.8%
Ratio of large to Small:	0.10
Average size (mm):	0.40

Aquatic Plant Data

OFFUTT

Sampler: Parsons, O'Neal Survey Date: 7/7/1998

Max depth of growth (M): 3 +

Comments cloudy, calm. Did habitat survey for Kirk Smith - LWQA program. Macrophytes sparse except at inflow and outflow wetland areas. Many patches of Nymphaea.

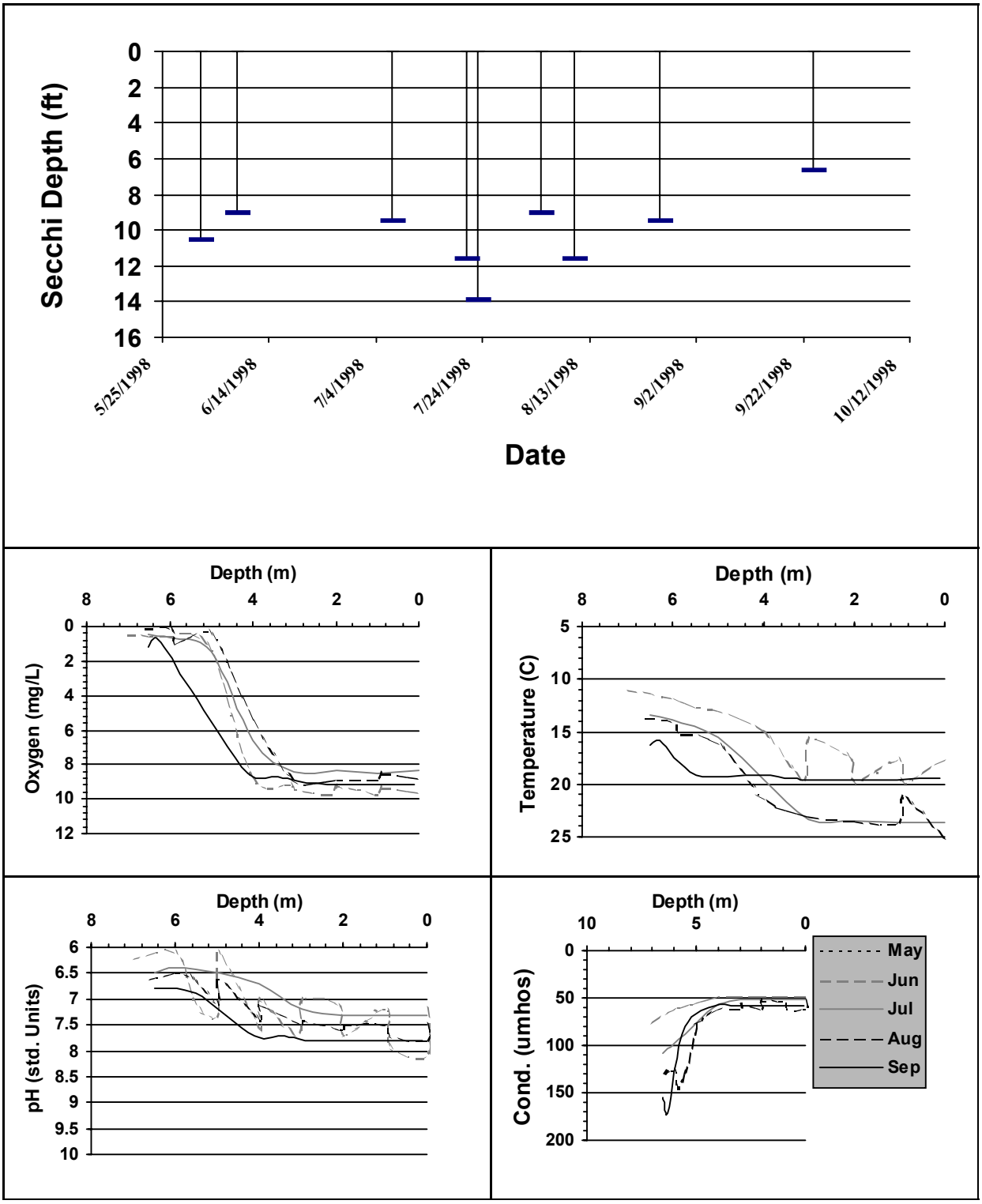
SPECIES LIST

Scientific Name	Common Name	Dist [a]	Comments
Brasenia schreberi	watershield	2	
Carex sp.	sedge	1	
Chara sp.	muskwort	2	
Eleocharis sp.	spike-rush	2	
Elodea canadensis	common elodea	2	
Iris pseudacorus	yellow flag	2	
Juncus sp.	rush	2	
Ludwigia palustris	water-purslane	1	
Nuphar polysepala	spatter-dock, yellow water-lily	2	
Nymphaea odorata	fragrant waterlily	3	
Polygonum sp.	smartweed	2	
Potamogeton amplifolius	large-leaf pondweed	3	
Potentilla palustris	purple (marsh) cinquefoil	1	
Potamogeton sp (thin leaved)	thin leaved pondweed	2	
Salix sp.	willow		on shore
Scirpus sp.	bulrush	2	bulrush
Tolypella intricata	macro algae	1	
Typha sp.	cat-tail	2	

a 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

Secchi Depth and Profile Graphics

Station: 1 OFFTH1



Secchi Data and Field Observations

OFFUTT

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/1/1998			10.5	7	100	2	1	4	4	0	7	6	0
	Sampler: SMITH			Remarks: ZOO NET PULLED THROUGH 6 METERS. FEC#1 AT RESORT, #2 AT BOAT LAUNCH									
6/8/1998		20	9	6	75	2	1	5	4	0		6	0
	Sampler: KELLY			Remarks:									
6/8/1998			9		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									
7/7/1998		20	9.5	6	25	2	2	4	4	0	6	4	0
	Sampler: KELLY			Remarks:									
7/21/1998		23	11.58	6	0	2	1	4	4	0	10	1	0
	Sampler: KELLY			Remarks:									
7/23/1998			13.86	2	20			5	5	0	6	0	0
	Sampler: SMITH			Remarks: SLIGHT BLUE-GREEN BLOOM. LOTS OF FRAGRENT LILLIES									
8/4/1998		23	9	6	100	1	1	4	4	0	0	2	0
	Sampler: KELLY			Remarks:									
8/10/1998			11.55	3	0			4	3	0	0	3	0
	Sampler: SMITH			Remarks: NOTICEABLE BLUE-GREEN BLOOM. LARGE MASSES OF BRYOZOANS NEAR BOAT LAUNCH. STRONG MANUE IN THE BREEZE. FEC SAMPLES TAKEN SAME PLACE AS JULY									
8/26/1998		23	9.5	6	100	1	1	4	4	0	0	1	0
	Sampler: KELLY			Remarks: LAKE HEIGHT STICK BROKEN.									
8/26/1998			9.5		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									
9/24/1998			6.6		100	3		4	2	0	134	0	0
	Sampler: SMITH			Remarks:									

PHILLIPS

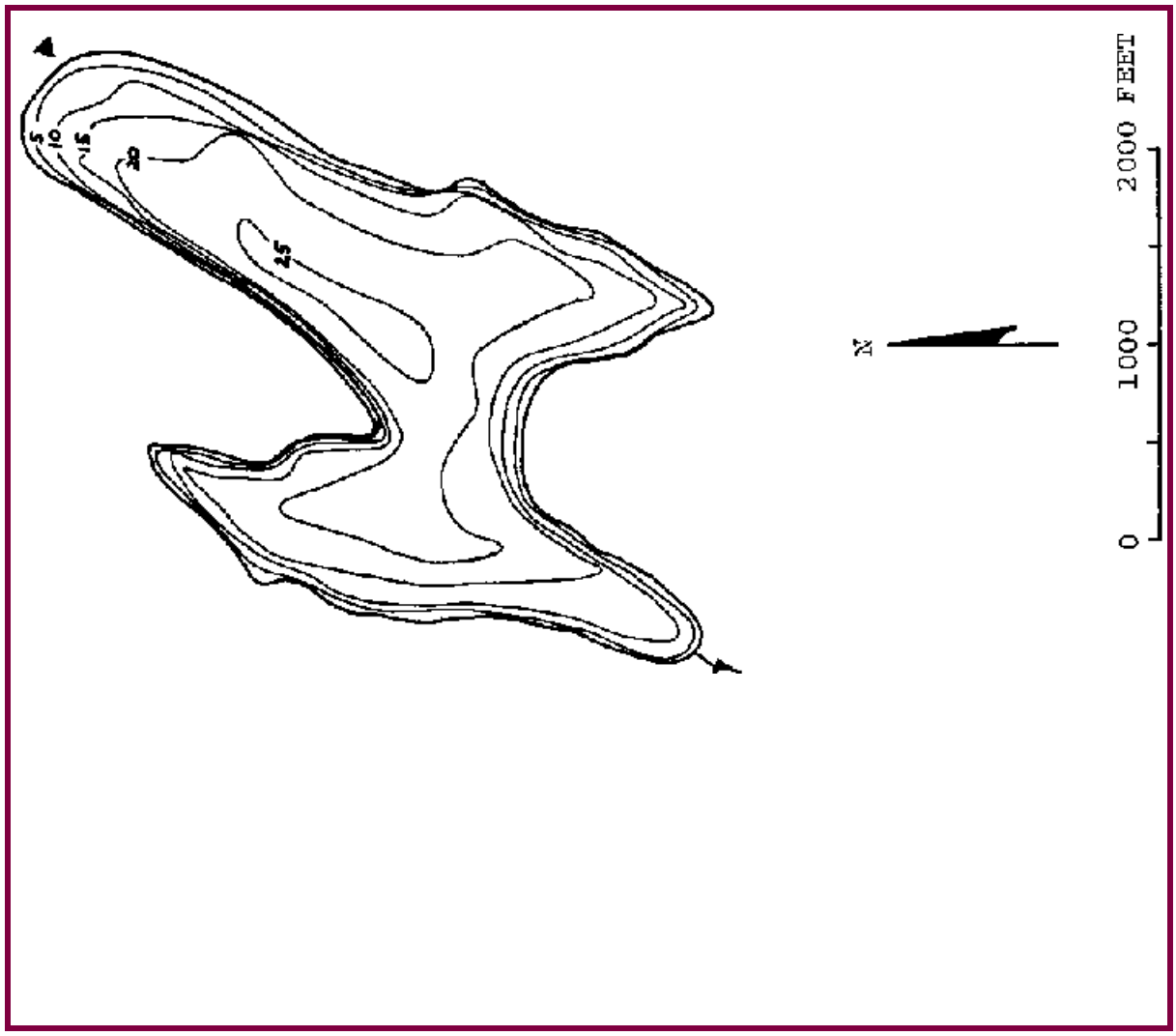
MASON County

Lake ID: *PHIMA1*

Ecoregion: 2

Phillips Lake is located seven miles north of Shelton. It has no surface inlets, and drains via Campbell Creek through a marshy area to Oakland Bay.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
110	25	16	1	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
1800	2.63	188	47 14 52.	122 57 52.



Station Information

PHIMA1

Primary Station	Station # 1	latitude: 47 15 32.6	longitude: 122 58 09.7
	Description:	Deep site, approximately 500 feet east of a major point on the northern shore which bisects the lake into two distinct sides.	
Secondary Station	Station # 2	latitude:	longitude:
	Description:	Due south (about 1500 feet) from the northwesternmost tip of the lake.	

Trophic State Assessment for 1998

PHILLIPS

Analyst: KIRK SMITH

TSI_Secchi:	39
TSI_Phos:	34
TSI_Chl:	38
Narrative TSI:[a]	O

Phillips Lake is an oligotrophic lake that is heavily used in the summer and is nearly built-out along the shoreline. Despite the heavy use, the water quality remains generally good, though there are periodic blue-green algal blooms. The mean phosphorus concentration was relatively low (7.6 ug/L). Non-toxic blooms of Anabaena flos-aquae have been identified in the past. Conductivity was extremely low. If more people become permanent residents there may be a higher likelihood of deteriorating water quality. The habitat survey shows substantial human influence along the shoreline. How human influence has impacted the lake is unclear, except that it may be attracting more Canada geese than desired. There have been reports of fish kills on Phillips Lake but there are no obvious water quality problems that may have contributed to those kills. There were no user surveys returned for the lake so we cannot determine whether there is a general perception of deteriorating water quality; however, some lake residents have formally expressed concern in the past by petitioning county commissioners to apply for a grant to study the lake and stop "the deteriorating condition." All beneficial uses appear to be supported. The lake is most likely phosphorus limited.

We recommend the phosphorus criterion for Phillips Lake be set at 10 ug/L, the action value in the water quality regulations for Puget Lowlands oligotrophic lakes.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

PHILLIPS

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/2/1998		L					1 U			
		L					3			

8/17/1998	L					1			
	L					4			
9/17/1998	L					3			
Station 1									
6/2/1998	E	6.6	.237	36	.86		9.6	2260	.9
7/25/1998	E	6.2	.235	38	1.5				1.4 J
8/17/1998	E	9.3 J	.277	30	4.1				1
9/17/1998	E	8.1	.247	30	4.2				.9
Station 2									
6/2/1998	E	11.2 J	.234	21	.91				
7/25/1998	E	7							
8/17/1998	E	7.9	.263	33					

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

PHILLIPS

Survey Date: 9/17/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [ ] **Agriculture(commercial, not hobby)**
- [ ] **Commercial, Industrial**
- [ ] **Major transportation**
- [1] **Residential**
- [2] **Park, forest or natural**

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

No silt screens at construction sites.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☐

Buffer zones were rare around the lake. Clear cuts were well away from the water.

Irrigation ☐

Survey Id: 50

Habitat Survey Summary Report

PHILLIPS

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/21/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.4	**Number of stations with canopy:**	10
Understory Avg:	2.7	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	2.7
	trees< 0.3 m DBH	0.7
Understory:	**woody shrubs saplings**	2.7
	tall herbs, forbs grasses	1.3
Ground Cover:	**woody shrubs seedlings**	2.1
	herbs, forbs, grasses	2.4
	standing water or inundated veg	0.1
	barren or buildings	1.1
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.0
	cobble/gravel	0.9
	loose sand	0.0
	other fine soil/sediment	0.0
	vegetated	2.1
	other	2.6
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	1.0
	vertical dist (M from wtrln to high wt):	0.1
	horiz. dist. (M from wtrln to high wt):	0.1

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.3
commercial	0.0
park facilities	0.0
docks/boats	2.0
walls, dikes, or revetments	1.6
litter, trash dump, or landfill	0.4
roads or railroad	0.0
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	1.2
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	2.1

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.0
cobble	0.8
gravel	2.3
sand	2.3
silt	2.0
woody debris	1.6

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	1.5
emergent	0.1
floating	0.0
total weed cover	1.5
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.9

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.5
snags	0.1
brush or woody debris	1.4
inundated live trees	0.0
overhanging vegetation	0.9
rock ledges or sharp dropoffs	0.1
boulders	0.0
human structures	1.7

Zooplankton Report

PHIMA1

Date 6/2/1998 Station: 1 Sample ID 16

Unknowns in Daphnia may not be Daphnia

Number of organisms measured: 154

Group	Percent
Cladoceran	55.2%
Copepod	44.8%
Other	

Group	Percent
Small < 1mm	81.8%
Large >= 1mm	18.2%
Ratio of large to Small:	0.22
Average size (mm):	0.54

Date 8/17/1998 Station: 1 Sample ID 42

Site number one. Full of algae (? Or maybe some kind of tiny seed), made ID difficult. Also, many Cladoceran sheaths without bodes (weren't counted unless they were recognizable).

Number of organisms measured: 115

Group	Percent
Cladoceran	18.3%
Copepod	81.7%
Other	

Group	Percent
Small < 1mm	96.5%
Large >= 1mm	3.5%
Ratio of large to Small:	0.04
Average size (mm):	0.32

Aquatic Plant Data

PHILLIPS

Sampler: Parsons, O'Neal

Survey Date: 7/20/1998

Max depth of growth (M): >6

Comments Sunny, light breeze. Shoreline is developed, many bulkheads but also many trees left standing, and many down and submersed. Aquatic plant community sparse and low growing. Much epiphytic algae on substrate and plants in NE end. Observed rough-skinned newts, bullfrog, many small fish. Conducted habitat survey for Kirk Smith.

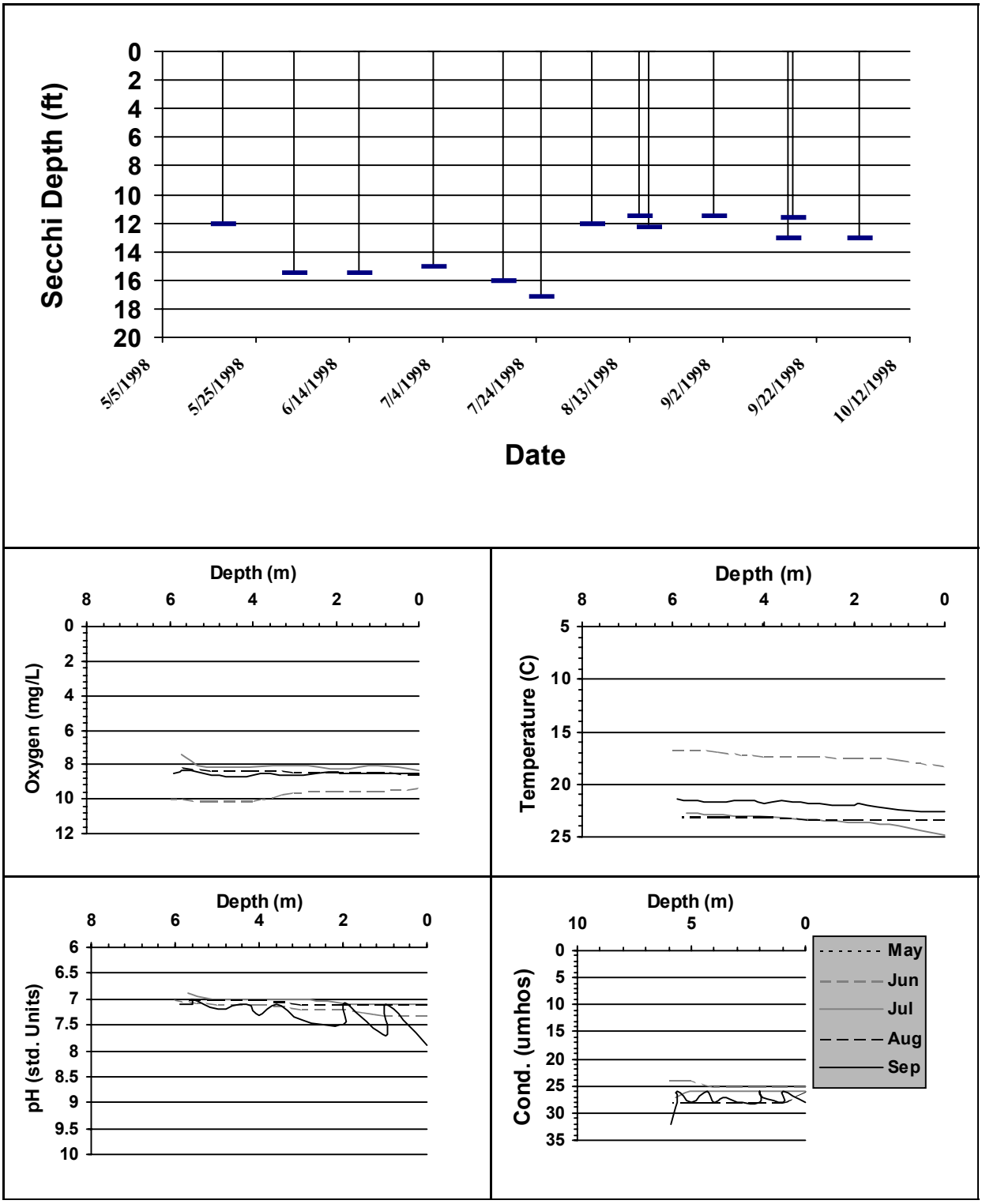
SPECIES LIST

Scientific Name	Common Name	Dist [a]	Comments
Dulichium arundinaceum	Dulichium	1	
Elodea canadensis	common elodea	2	
Iris pseudacorus	yellow flag	2	
Isoetes sp.	quillwort	3	in shallow to deeper water
Juncus sp. or Eleocharis sp.	small grass-like plants		
Juncus sp.	rush	2	emergent, few patches
Najas flexilis	common naiad	1	
Nitella sp.	stonewort	2	
Potamogeton pusillus	slender pondweed	2	
Utricularia sp.	bladderwort	2	in deep water, no flowers

[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

Secchi Depth and Profile Graphics

Station: 1 PHIMA1



Secchi Data and Field Observations

PHILLIPS

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
5/18/1998		15	12	2	50	2	2	3	3	2	6	2	0
	Sampler: KEELEY			Remarks: STARTED TO RAIN.									
6/2/1998		17.7778	14.5	2	0					0	0	0	0
	Sampler: SMITH			Remarks:									
6/2/1998		17.8	15.5	2	0	2	1	4	3			1	0
	Sampler: KEELEY			Remarks:									
6/16/1998		17.8	15.5	2	50	2	1	3	3	0	5	2	0
	Sampler: KEELEY			Remarks:									
7/2/1998		19.4	15	2	50		2	4	4	7	6	1	1
	Sampler: KEELEY			Remarks:									
7/17/1998		22.2	16	2	0	2	3	4	4	0	2	0	0
	Sampler: KEELEY			Remarks:									
7/25/1998			17.16	2	0			4	4	0	0	0	8
	Sampler: SMITH			Remarks: LOTS OF BOATS. MANY SWIMMERS AT LAUNCH.									
8/5/1998		23.9	12	2	0	3	1		3	3	2	0	0
	Sampler: KEELEY			Remarks:									
8/15/1998		23.3	11.5	6	50	2	3	2	2	4	0	2	1
	Sampler: KEELEY			Remarks: ALGAE BLOOM CONTINUES TO GET WORSE - WATER LOW.									
8/17/1998			12.21	2	90			4	4	0	0	0	0
	Sampler: SMITH			Remarks: CONSIDERABLE ALGAL BLOOM									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
8/31/1998		23.3	11.5	6	0	2	1	2	3	8	2	0	1
	Sampler: KEELEY			Remarks: ALGAE BLOOM.									
9/16/1998		22.2	13	6	0	1	1	4	3		5	0	1
	Sampler: KEELEY			Remarks: NO ALGAE BLOOM.									
9/17/1998			11.55		50	1		5	5	0	2	0	0
	Sampler: SMITH			Remarks: FEC#1 TAKEN AT INLET ON 2ND BASIN. FEC #2 AT BOAT LAUNCH. The Conductivity result is qualified as an estimate due to postcalibration failing QA/QC requirements.									
10/1/1998		17.8	13	2	75	2	1	3	4	0	5	0	0
	Sampler: KEELEY			Remarks:									

POTHOLES

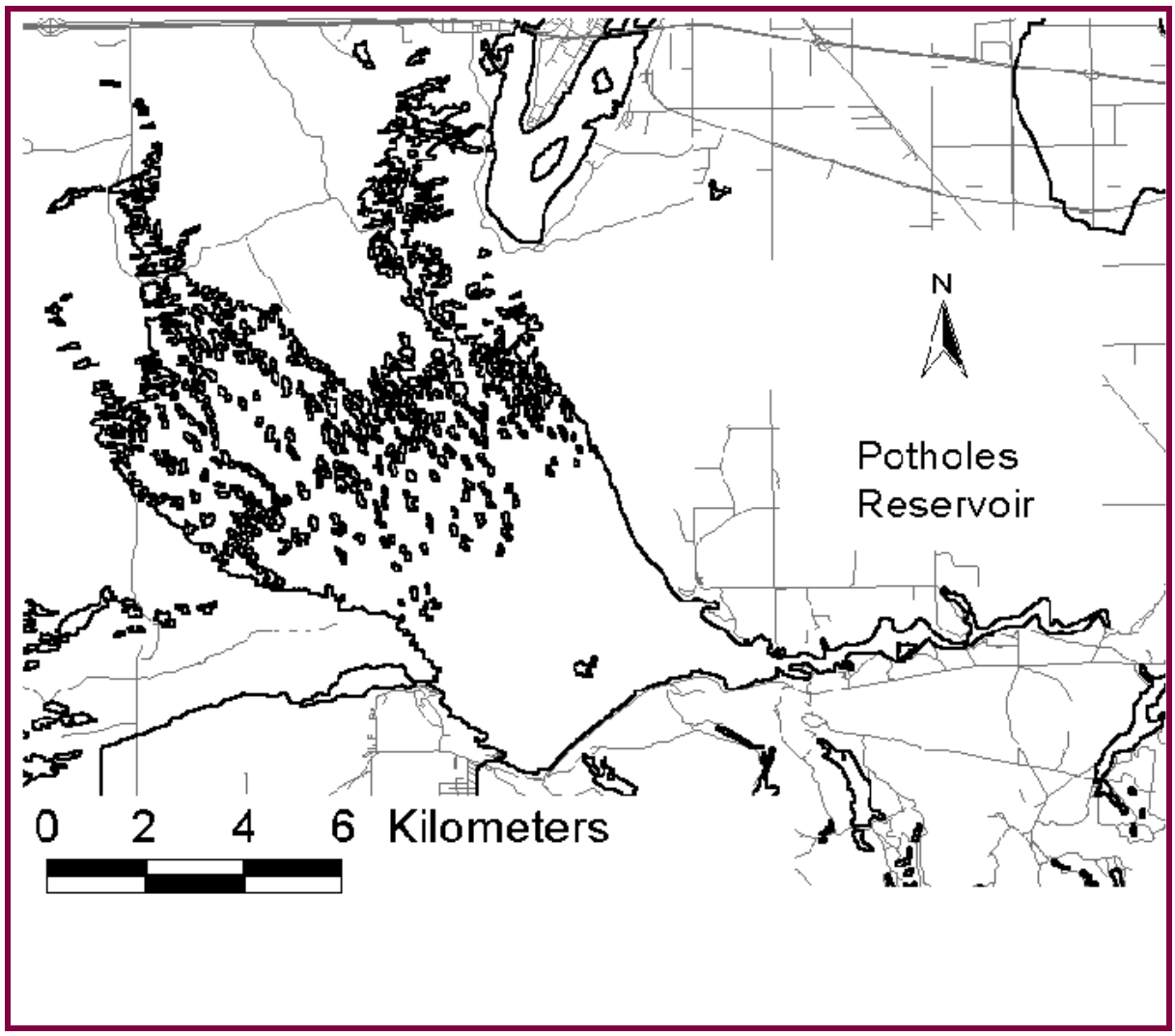
GRANT County

Lake ID: POTGR1

Ecoregion: 7

Potholes Reservoir is approximately 5 miles south of the City of Moses Lake and provides a large recreational opportunity for water enthusiasts. It receives water from Moses Lake and irrigation canals and provides water to the Columbia National Wildlife Refuge and the Seep Lakes Wildlife Area as well as many irrigation canals.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
28000	142	18		
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
500000		1046	46 58 58.	119 15 49.



Station Information

POTGR1

Primary Station	Station # 1	latitude: 46 59 40.0	longitude: 119 19 53.0
	Description:	Approx due east out from State Park launch, half-way to island.	
Secondary Station	Station # 2	latitude: 46 59 30.0	longitude: 119 20 30.0
	Description:	From primary station, go parallel to shore about half-way to north-end islands.	

Trophic State Assessment for 1998

POTHOLES

Analyst: KIRK SMITH

TSI_Secchi:	56	N
TSI_Phos:	55	
TSI_Chl:	60	
Narrative TSI:[a]	E	

Potholes Reservoir is an interesting reservoir in that it receives nutrient rich water from Moses Lake and agricultural irrigation runoff and/or surplus. Consequently, Potholes Reservoir is a collecting point for water, nutrients and contaminants before entering the Potholes Canal system. The lake is a major wintering area for waterfowl. Water samples revealed an algae community rich in blue-greens. Oscillatoria, Aphanizomenon, Anabaena and Microcystis were all abundant. Oscillatoria appeared to be the dominant blue-green. Anoxia in the summertime hypolimnion resulted in phosphorus release from the sediments. The zooplankton appear to be sufficient to support a warmwater fishery, however, the anoxic hypolimnion and warm epilimnion may stress coldwater and coolwater fish species such as trout and walleye. This was especially evident in August and less so in July and September.

Few user surveys were returned for Potholes even though scores of them were distributed. Based on communications with a park ranger, a consultant from Dames and Moore, and personal observations, we believe the lake is a significant recreational resource for boaters, jet skiers, water skiers, some swimmers, especially at the State Park beach, and fishermen. Many fishermen still visit the lake even though the fishery has declined substantially in the last few years. Anecdotal information from a state fishery biologist suggest the fishery in the lake has collapsed. The water quality information collected in 1998 does not suggest water quality as the reason for the decline in that beneficial use. Although coldwater fish species may be stressed by the low dissolved oxygen and high water temperature condition of mid-summer, this condition has most likely remained unchanged historically and probably is similar to conditions when the fishery was thriving. Zooplankton populations appeared healthy with quitelarge average length, especially in August. The habitat survey does suggest there is very little structure, cover or vegetation for fish which inhabit the littoral zone. Aquatic plants were quite patchy and sparse, presumably due in part to the large water level fluctuations in the reservoir. The lack of structure combined with human and non-human fishing

pressure could be contributing to the declining fishery--though this is conjecture.

Water level fluctuation are likely also responsible for the high turbidity as waves from wind and boaters erode freshly exposed sediments along the shoreline. Even though the water clarity is not ideal for primary contact recreation (high chlorophyll and turbidity), it is better than conditions in nearby Moses Lake and most likely as good as could reasonably be expected.

Our primary purpose for monitoring Potholes was to support WDFW fisheries work. The system is large and complicated and our simple sampling design is inadequate to precisely identify a protective nutrient criterion for the lake. However, pending a more detailed analysis, we recommend a phosphorus criterion for Potholes Reservoir be set at current levels with an adjustment to for inter-annual variability (36 + 8.0 = 44 ug/L total phosphorus).

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

POTHOLES

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/18/1998		E	41.7	1.19	29	13		156		2.3 J
		H	115 J	1.58	14					
7/16/1998		E	30.2	.841	28	20.3				5.5 J
		H	126	1.48	12					
8/13/1998		E	27.8	.879	32	17.1				6.5
		H	120	1.96	16					
9/16/1998		E	42.2	1.06	25	45.9				
		H	188	2.16	11					

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

POTHOLES

Survey Date: 9/16/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [1] **Agriculture(commercial, not hobby)**
- [2] **Residential**
- [ ] **Commercial, Industrial**
- [ ] **Park, forest or natural**
- [ ] **Major transportation**

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Odors ☐

Cattle ☐ **Ducks** ☑ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☐

Shoreline is natural but largely soft sediments which, w/large water level fluctuations and high winds, is susceptible to erosion.

Irrigation ☐

Survey Id: 50

Habitat Survey Summary Report

POTHOLES

Data are averages of *10* **Stations Surveyed** **Date of Visit:** 7/16/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	0.3	**Number of stations with canopy:**	10
Understory Avg:	1.5	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	0.1
	trees< 0.3 m DBH	0.0
Understory:	**woody shrubs saplings**	1.5
	tall herbs, forbs grasses	0.2
Ground Cover:	**woody shrubs seedlings**	0.7
	herbs, forbs, grasses	0.6
	standing water or inundated veg	0.5
	barren or buildings	2.1
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.4
	cobble/gravel	1.5
	loose sand	2.6
	other fine soil/sediment	0.9
	vegetated	0.7
	other	0.0
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.2
	vertical dist (M from wtrln to high wt):	2.1

horiz. dist. (M from wtrln to high wt):	22.1

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	0.2
commercial	0.0
park facilities	0.3
docks/boats	0.2
walls, dikes, or revetments	0.3
litter, trash dump, or landfill	0.0
roads or railroad	0.5
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	0.1
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	1.8

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.5
cobble	1.2
gravel	1.5
sand	2.8
silt	0.2
woody debris	0.3

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	0.8
emergent	0.0
floating	0.0
total weed cover	0.8
Do macrophytes extend lakeward (-1 = yes, 0 = no)	0.0

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	0.6
snags	0.0
brush or woody debris	0.5
inundated live trees	0.0
overhanging vegetation	0.1
rock ledges or sharp dropoffs	0.0
boulders	0.4
human structures	0.0

Questionnaire

POTHOLES

Results compiled from 3 **Surveys.** **Average time (years) respondents spent on lake:** 9.00

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	-0.3	View:	0.3	Distance to Lake:	0.0
Public Access:	0.0	Swim Beach:	0.3	Canada Geese:	0.7
Water Clarity:	-0.3	Water Qual. for Swim:	0.0		
Fishing Quality:	0.3	Aquatic Plants:	0.0		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **1.3**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.7
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.0
1) Clearer water, or 2) fewer aquatic plants?	1.3

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	1.5	Good Warmwtr Fishing:	4.0	Natural Scenery:	4.0
Plant Growth:	3.0	Good Swimming:	4.0	Public Beach:	3.0
Natural Shoreline:	3.0	Less Algae:	4.0	Canada Geese:	4.0
No Odors:	3.0	Public Access:	3.5		
Good Coldwtr Fishing:	4.5	Clear Water:	4.0		

Tabulated Results

Survey ID	Date	Residency	Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
32	9/15/1998	Resident Permanent	Own	4	☐	No	
	We like the lake/sand dunes and usually boat and sun but mostly on weekdays. We also do some fishing. The desert lake and surroundings are beautiful. The water is cloudy when it gets warmer.						
50	8/20/1998	Visitor		2	☐	Unknown	
64	8/12/1998	Visitor		2	☐	Unknown	

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

POTGR1

Date 6/18/1998 Station: 1 Sample ID 3

Lots of blue-greens (Microcystis, Anabaena, Aphanizomenon)

Number of organisms measured: 139

Group	Percent
Cladoceran	20.1%
Copepod	79.9%
Other	

Group	Percent
Small < 1mm	73.4%
Large >= 1mm	26.6%
Ratio of large to Small:	0.36
Average size (mm):	0.61

Date 8/13/1998 Station: 1 Sample ID 1

Number of organisms measured: 90

Group	Percent
Cladoceran	51.1%
Copepod	48.9%
Other	

Group	Percent
Small < 1mm	46.7%
Large >= 1mm	53.3%
Ratio of large to Small:	1.14
Average size (mm):	1.09

Aquatic Plant Data

POTHOLES

Sampler: Parsons, O'Neal

Survey Date: 7/16/1998

Max depth of growth (M): 1.2

Comments Sunny, light breeze. Did habitat survey for Kirk Smith. Did not spend time in islands area. Most of shoreline with willows except along dam and east shore - which have barren rock and sand. Submersed plants patchy in protected areas mostly. No milfoil seen.

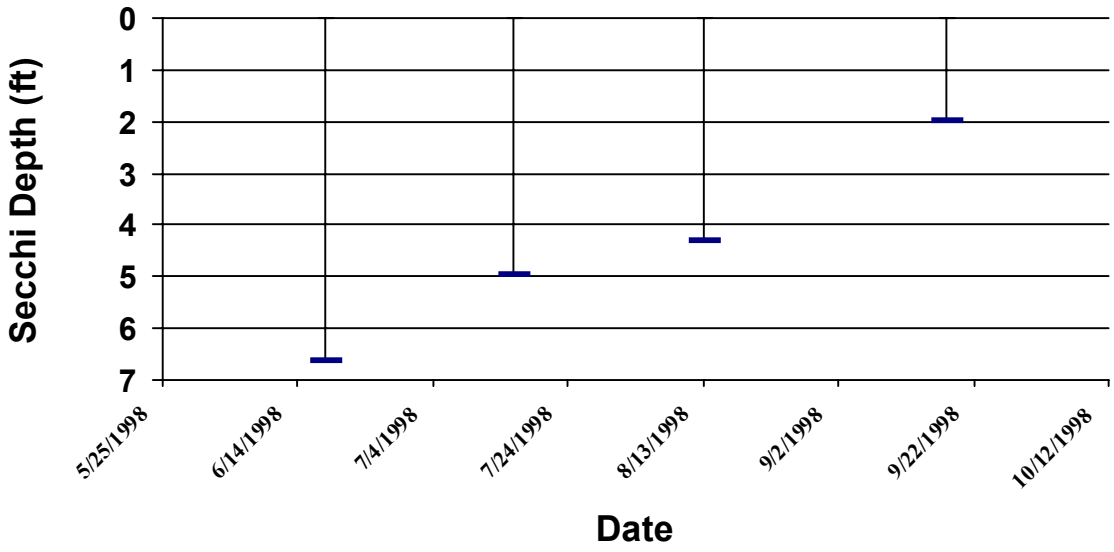
SPECIES LIST

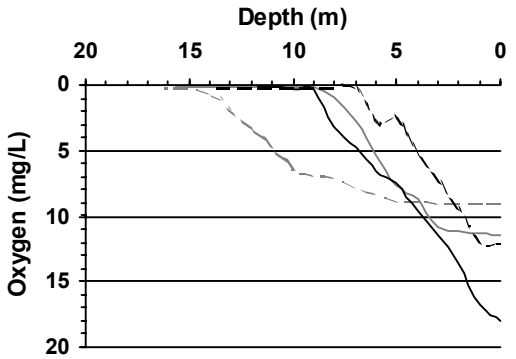
Scientific Name	Common Name	Dist [a]	Comments
Juncus sp.	rush	1	
Lemna sp.	duckweed	1	few, near shore
Polygonum sp.	smartweed	2	pink flowers, on shore
Potamogeton crispus	curly leaf pondweed	2	the most common submersed plant
Potamogeton pectinatus	sago pondweed	1	in northern islands area
Salix sp.	willow	3	along shore or in shallow water
Zannichellia palustris	horned pondweed	2	most seen as uprooted floating mats

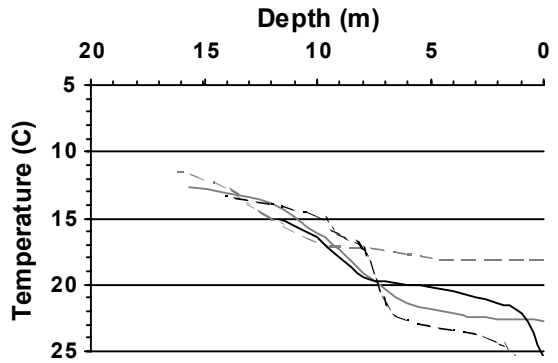
[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

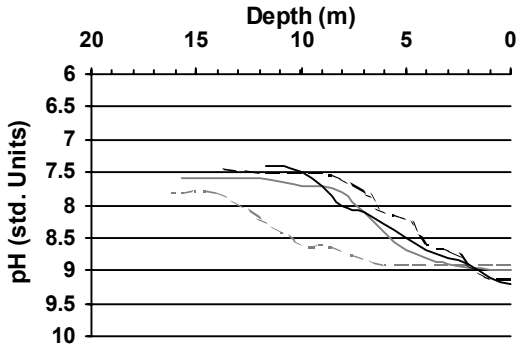
Secchi Depth and Profile Graphics

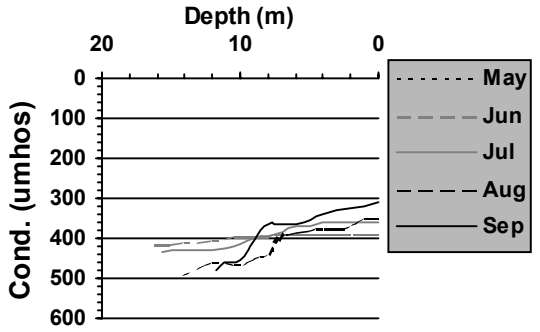
Station: 1 POTGR1











Secchi Data and Field Observations

POTHOLES

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/18/1998			6.6	2	0	2		3	2	0	0	12	0
	Sampler: HALLOCK			Remarks:	ALGAE FILAGMENTS CLEARLY VISIBLE IN WATER COLUMN. OSCILLATORIA-LIKE PERHAPS SOME APHANIZOMENON. A VERY FEW LARGE DAPHNIA IN ALL CASTS EXCEPT 14M WHICH HAS LOTS. DFW DOING WALLEYE STUDY								
7/16/1998			4.95	6	0			3	2	0	36	7	0
	Sampler: SMITH			Remarks:	LOTS OF SHORT, FINE FILAMENTOUS ALGAE IN SURFACE CASTS. FAINT H2S AT 11M, STRONG AT 14M.								
8/13/1998			4.29	6	0			1	1	0	50	12	0
	Sampler: HALLOCK			Remarks:	ALGAE BLOOM LIKE MOSES STATION #2. SOME CLUMPS BUT NOT MANY. H2S @ 8 AND ESP. 13M. WATER LEVEL DOWN APPROX. 4 FEET FROM LAST MONTH. LARGE DEAD WHITEFISH								
9/18/1998			1.98	6	15			1	1	0	300	6	2
	Sampler: HALLOCK			Remarks:	ALGAE BLOOM SIMILAR TO MOSES LAKE SITE #1 BUT LESS AGGREGATE. NOTE: ALL PREVIOUS SAMPLINGS HAVE BEEN IN AM. SURFACE DO IS OFF SCALE (>16.9 MG/L) . STRONG H2S SMELL AT 10M. TOOK ZEBRA MUSSEL SAMPLE AT PARK ACCESS.								

SPANAWAY

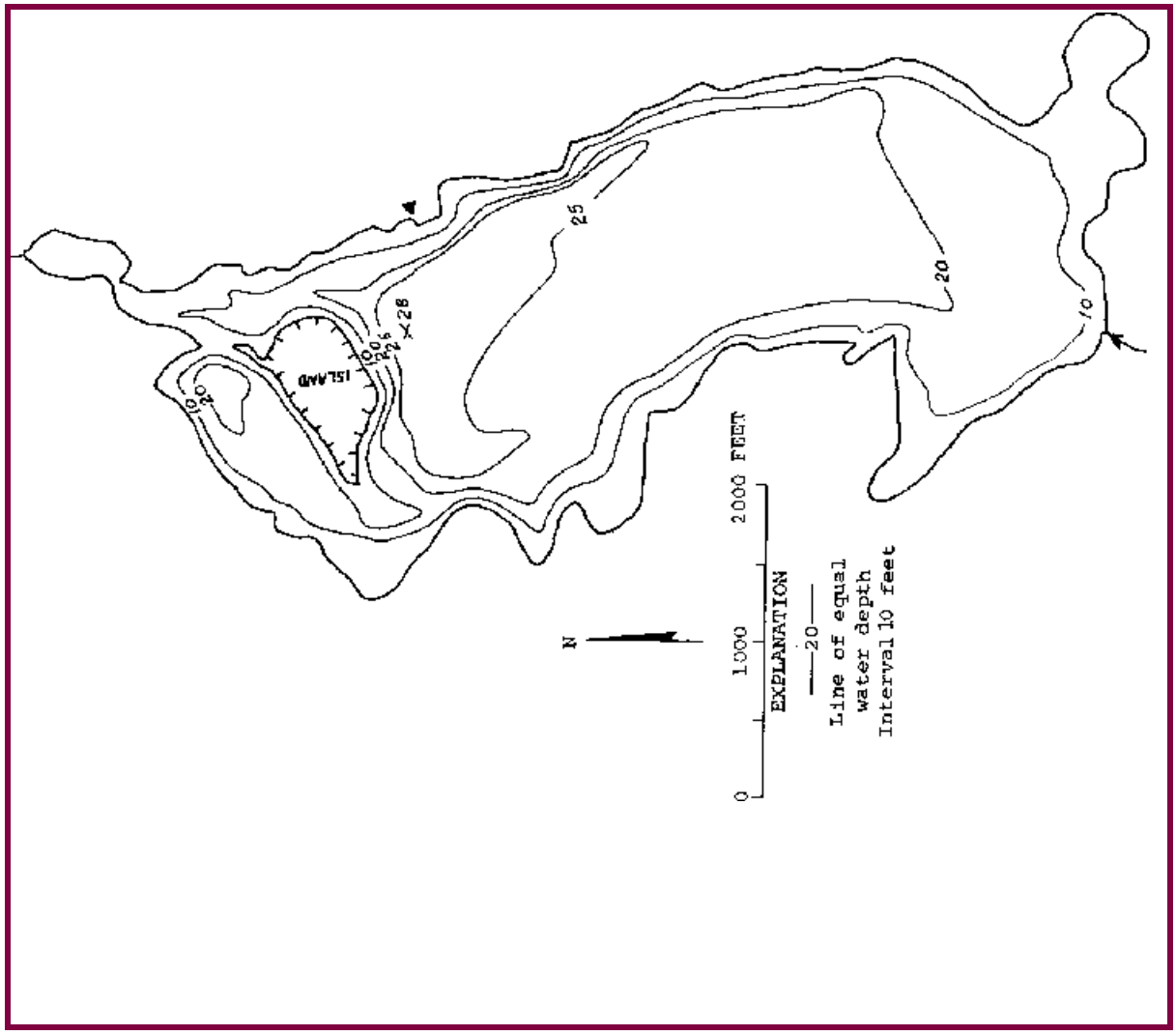
PIERCE County

Lake ID: SPAPI1

Ecoregion: 2

Lake Spanaway is located ten miles south of Tacoma, and 0.5 mile west of Spanaway. It is fed by drainage from a swampy area, and drains via Spanaway Creek to Clover Creek and Lake Steilacoom. Daron Island lies in the north portion of the lake

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
280	28	16	17	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
4600	4.36	320	47 07 11.	122 26 45.



Station Information

SPAPI1

Primary Station	Station # 1	latitude: 47 06 47.0	longitude: 122 27 01.7
	Description:	In deep part of lake, due west of public boat launch and south of eastern shore of island	
Secondary Station	Station # 2	latitude: 47 06 24.4	longitude: 122 26 58.7
	Description:	Across from boat launch, approximately 500 feet east of west shore at point directly across from boat launch	
Secondary Station	Station # 3	latitude:	longitude:
	Description:	In horizontal middle of lake near south end, directly south of boat launch and directly east of a small cove just north of southern portion of lake; no coordinates recorded	

Trophic State Assessment for 1998

SPANAWAY

Analyst: KIRK SMITH

TSI_Secchi:	44
TSI_Phos:	48
TSI_Chl:	54
Narrative TSI:[a]	ME

Spanaway Lake is an urban lake bordered by a large city park along its northeast shore. The lake has suffered numerous blue-green algal blooms in recent history and shows a tendency to go anoxic in the hypolimnion during the summer, resulting in periodic internal nutrient release and very high hypolimnetic phosphorus concentrations. Records show that the lake was once dredged, which may have provided for many years of artificially clear water. Spanaway Lake is fed by a stream originating from a wetland. The wetland, park, and golf course are potential sources of nutrients to the lake. Natural shoreline is altered in the park and fertilizer runoff from the golf course may contribute to the eutrophication--although most of the runoff likely enters near the outlet of the lake. The user survey suggests the water clarity is deteriorating through the years with only one respondent out of 11 believing the clarity has improved. Detractors to the use of the lake, according to survey respondents, include the poor water clarity and the abundant Canada geese. All respondents said they'd rather have clearer water than fewer aquatic plants. A significant Aphanizomenon bloom was observed in August.

Although the lake has been productive for largemouth bass fishing in recent history, it's questionable whether the extensive anoxia in the summertime hypolimnion is conducive to a good trout fishery. Having both a good trout and bass fishery is important to the residents who responded to the survey. Water clarity may impair primary contact recreation at times but the overall Secchi TSI suggests more mesotrophic conditions. We assigned an overall assessment of meso-eutrophic. The habitat survey revealed significant human influence (lawns, buildings and docks) on the habitat of the lake. There was also a high population of geese on the lake to take advantage of all the human influences conveniently provided.

We recommend that a nutrient criterion be set at the ecoregion action value for lower mesotrophic Puget Lowland lakes, 20 ug/L.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

SPANAWAY

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
8/19/1998		L					8			
		L					13			
9/23/1998		L					8			
		L					12			
Station 1										
6/12/1998		E	12.8	.818	64	11		41.7	10800	1.6 J
		H	29.3	1.11	38					
7/30/1998		E	15.8	.476	30	6.8				1.5 J
		H	340	2.31	7					
8/19/1998		E	16.6	.4	24	15.5				1.5
		H	15.3	1.63	107					
9/23/1998		E	21.3	.356	17	11.2				1.5
		H	318	2.39	8					
Station 3										
6/12/1998		E	12.7			8.8				
9/23/1998		E	29.2	.339	12					

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

SPANAWAY

Survey Date: 9/23/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

	Agriculture(commercial, not hobby)	1	**Residential**
4	**Commercial, Industrial**	2	**Park, forest or natural**
3	**Major transportation**		

Impervious surfaces (Roads and parking area): Partially Curbed

Observations (check mark denotes presence)

BMP's ☐

Natural vegetation lacking along shoreline.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

Yes, manicured lawns and a public golf course.

Buffer zones around streams and wetlands ☑

Irrigation ☐

Survey Id: 30

Habitat Survey Summary Report

SPANAWAY

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 8/19/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.6	**Number of stations with canopy:**	10
Understory Avg:	2.7	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.5
	trees< 0.3 m DBH	0.6
Understory:	**woody shrubs saplings**	2.2
	tall herbs, forbs grasses	1.5
Ground Cover:	**woody shrubs seedlings**	2.1
	herbs, forbs, grasses	2.7
	standing water or inundated veg	0.9
	barren or buildings	1.3
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.1
	cobble/gravel	1.8
	loose sand	0.7
	other fine soil/sediment	0.6
	vegetated	2.5
	other	0.8
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.5
	vertical dist (M from wtrln to high wt):	0.2

horiz. dist. (M from wtrln to high wt):	0.5

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.0
commercial	0.0
park facilities	0.4
docks/boats	1.2
walls, dikes, or revetments	0.9
litter, trash dump, or landfill	0.2
roads or railroad	0.0
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	1.4
other	0.2

Physical Habitat Characteristics

station depth (at 10 m from shore)	1.8

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.1
cobble	1.6
gravel	1.9
sand	1.2
silt	1.2
woody debris	0.3

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	0.5
emergent	1.2
floating	0.3
total weed cover	1.1
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.3

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	0.8
snags	0.0
brush or woody debris	0.9
inundated live trees	0.1
overhanging vegetation	2.0
rock ledges or sharp dropoffs	0.0
boulders	0.0
human structures	1.2

Questionnaire

SPANAWAY

Results compiled from 11 **Surveys.** **Average time (years) respondents spent on lake:** 10.20

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	-0.5	View:	0.7	Distance to Lake:	0.5
Public Access:	-0.3	Swim Beach:	-0.5	Canada Geese:	-0.9
Water Clarity:	-0.7	Water Qual. for Swim:	-0.6		
Fishing Quality:	0.0	Aquatic Plants:	-0.3		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **2.0**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.6
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.5
1) Clearer water, or 2) fewer aquatic plants?	1.0

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	3.6	Good Warmwtr Fishing:	4.4	Natural Scenery:	4.4
Plant Growth:	2.3	Good Swimming:	4.1	Public Beach:	2.2
Natural Shoreline:	3.5	Less Algae:	4.2	Canada Geese:	1.6
No Odors:	4.3	Public Access:	2.5		
Good Coldwtr Fishing:	4.4	Clear Water:	4.1		

Tabulated Results

Survey ID	Date	Residency		Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
53	7/22/1998	Resident	Permanent	Rent	10	☑	Worse	1991
54	7/25/1998	Resident	Permanent	Rent	8	☑	Worse	1989-1990
55	8/10/1998	Resident	Permanent	Rent	10	☐	Worse	1994
56	8/16/1998	Resident	Permanent	Rent	8	☑	Worse	1996
57	8/25/1998	Resident	Permanent	Rent	3	☑	Worse	1997
58	7/29/1998	Resident	Permanent	Rent	1	☑	Worse	
69	8/24/1998	Resident	Permanent	Rent	7	☐	No	
73	8/31/1998	Resident	Permanent	Rent	several of the above	☐	No	
75	12/31/1998	Resident		Rent		☐	Unknown	
76	8/29/1998	Visitor			2	☐	Better	1993
83	8/19/1998	Visitor			10	☐	Unknown	

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

SPAPI1

Date 6/12/1998 Station: 1 Too few to count

Sample ID 14

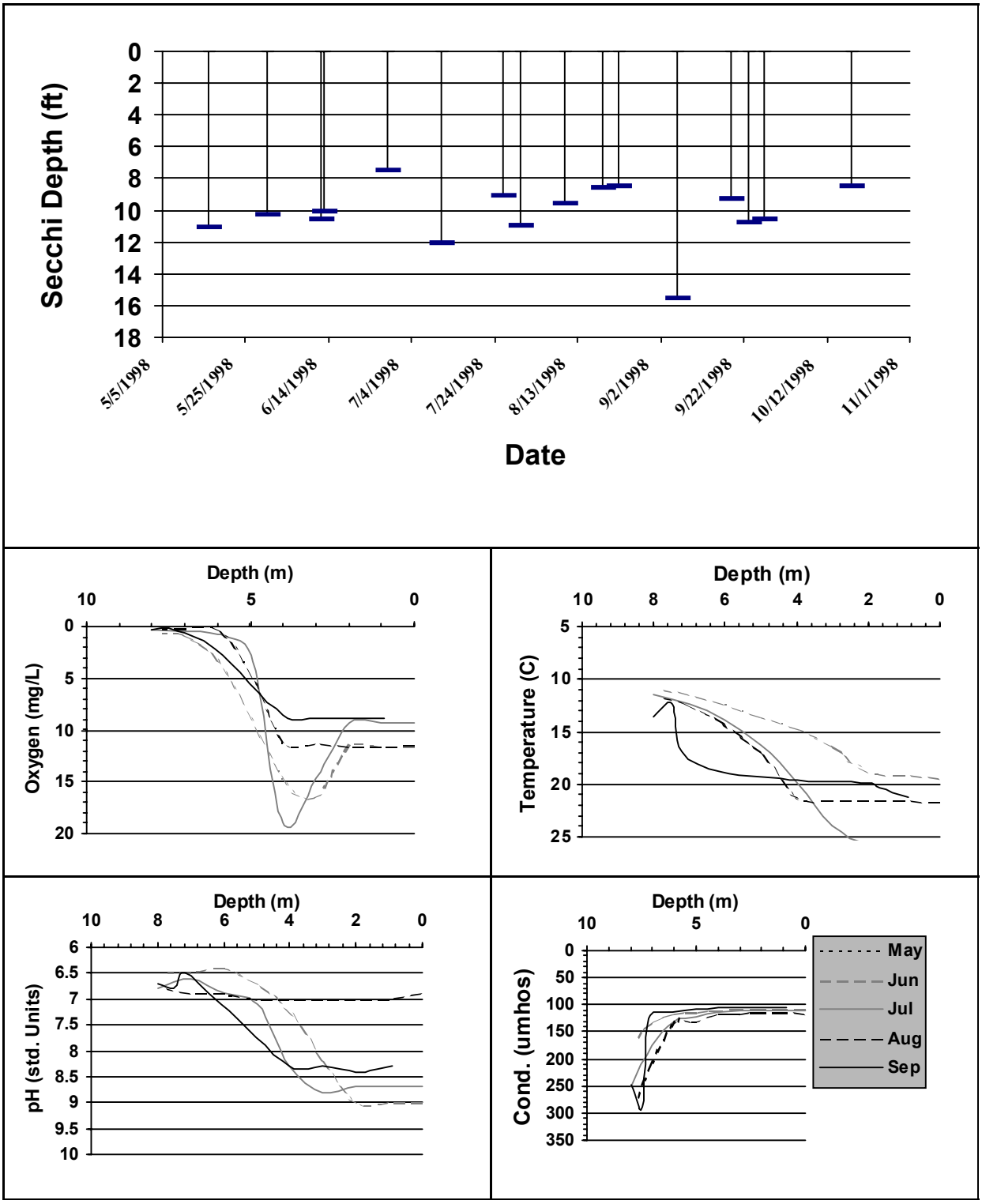
Number of organisms measured: 14

Group	Percent
Cladoceran	21.4%
Copepod	78.6%
Other	

Group	Percent
Small < 1mm	85.7%
Large >= 1mm	14.3%
Ratio of large to Small:	0.17
Average size (mm):	0.51

Secchi Depth and Profile Graphics

Station: 1 SPAPI1



Secchi Data and Field Observations

SPANAWAY

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
5/16/1998		13.3	11	6	100	4	4	4	4	5	6	1	0
	Sampler: THOMPSON			Remarks:									
5/30/1998		15.6	10.25	6	100	2	2	3	3	8	6	6	1
	Sampler: THOMPSON			Remarks:									
6/12/1998		18.8889	10.5	6	30			3	3	0	0	0	0
	Sampler: SMITH			Remarks:	H2S ODOR AT 7 METERS. TWO ZOO TOWS AT SITE #3. The Oxygen result is qualified as an estimate due to postcalibration failing QA/QC requirements.								
6/13/1998		18.9	10	6	100	2	1	3	3	20	6	5	2
	Sampler: THOMPSON			Remarks:									
6/28/1998		19.4	7.5	6	0	3	1	3	3	12	6	0	4
	Sampler: THOMPSON			Remarks:	ALOT OF ALGAE.								
7/11/1998		20.6	12	6	75	2	3	3	3	26	2	12	1
	Sampler: THOMPSON			Remarks:	JULY 17TH - WARNING POSTED AT COUNTY PARK ON LAKE - "HIGH LEVELS OF FECAL COLIFORM; SWIM AT OWN RISK".								
7/26/1998		25.6	9	6	0	2	1	1	1	28	0	2	23
	Sampler: THOMPSON			Remarks:	LAKE STILL CLOSED TO SWIMMERS DUE TO HIGH LEVELS OF FECAL COLIFORM. LAKE HAS BEEN CLOSED SINCE JULY 17, 1998.								
7/30/1998			10.89	6	100	2		1	1	74	110	0	0
	Sampler: SMITH			Remarks:	FECS IN THE WATER, CLOSED FOR SWIMMING. PARK ATTENDENT SAID THERE MAY HAVE BEEN ILLEGAL HERB APPLICATIONS ON ISLAND								
8/10/1998		24.4	9.5	6	0	2	1	1	1	25	8	5	5
	Sampler: THOMPSON			Remarks:	LAKE STILL OFFICIALLY CLOSED BY TACOMA HEALTH DEPT. DUE TO HIGH LEVELS OF FECAL COLIFORM. LAKE HAS BEEN CLOSED SINCE JULY 17, 1998.								
8/19/1998			8.58	3	0			3	3	0	0	0	0
	Sampler: SMITH			Remarks:	2 OSPREY FLYING TOGETHER. EXTREMELY STRONG H2S ODOR FROM 7.5M SAMPLE. ABUNDANT APHANIZOMENON BLOOM, SAMPLE TAKEN. NO BOATS OR WATERFOWL COUNTED.								

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
8/23/1998		21.1	8.5	6	25	2	1	1	1	44	8	5	1
	Sampler: THOMPSON			Remarks: LAKE STILL CLOSED PER HEALTH DEPT. DUE TO FECAL COLIFORM.									
9/6/1998		22.2	15.5	6	0	1	1	3	3	24	6	3	7
	Sampler: THOMPSON			Remarks: HEALTH DEPT. REOPENED SPANAWAY LAKE ON 9/14/98. GREAT CLARITY TODAY BUT MORE WEEDS THAN I'VE SEEN IN TEN YEARS.									
9/19/1998		20	9.25	6	25	1	4	3	3	16	6	3	3
	Sampler: THOMPSON			Remarks: LAKE REOPENED 9/4/98.									
9/23/1998			10.73	3	0			4	3	30	260	2	0
	Sampler: SMITH			Remarks: BALD EAGLE SPOTTED. FEC#1 AT PLATFORM ON SOUTH END; FEC#2 AT PLATFORM AT SWIM BEACH. STRONG H2S IN HYPO.									
9/27/1998		16.7	10.5	6	100	2	5	3	3	8	8	5	0
	Sampler: THOMPSON			Remarks:									
10/18/1998		14.4	8.5	8	50	1	3	1	1	6	400	7	1
	Sampler: THOMPSON			Remarks: BLUE-GREEN ALGAE MODERATE ALONG SHORE. LAKE WATER HAS TURNED BROWN! HUNDREDS(400+) OF ROOTS ON THE LAKE.									

SUTHERLAND

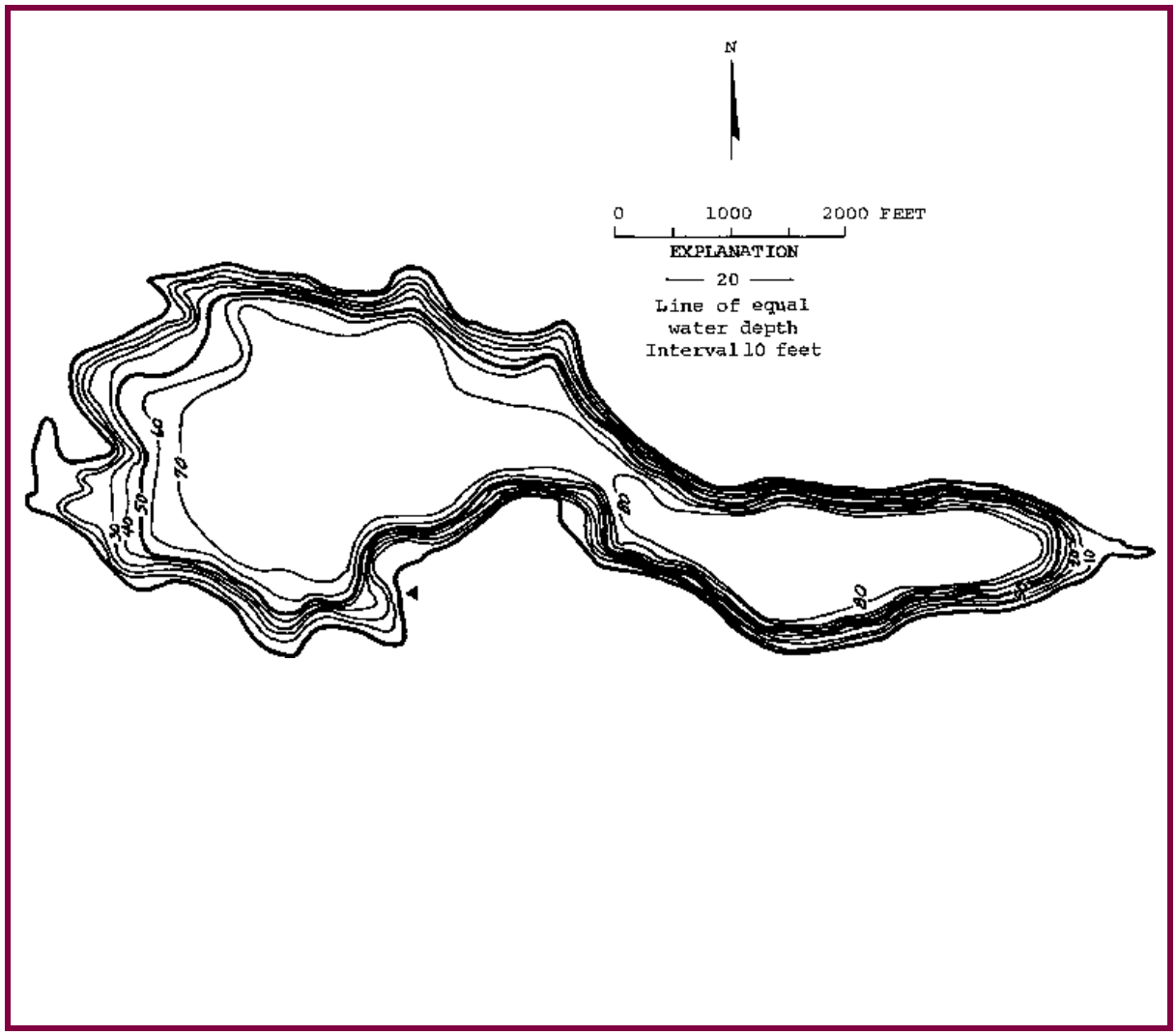
CLALLAM County

Lake ID: SUTCL1

Ecoregion: 1

Lake Sutherland is located just south of and adjacent to highway 101, approximately 3 miles east of Crescent Lake and 10 miles west of Port Angeles. Its outfall empties into Indian Creek which enters the Elwha River.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
369	86	57	8	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
20800	4.92	501	48 04 31.	123 41 09.



Station Information

SUTCL1

Primary Station	Station # 1	latitude: 48 04 32.8	longitude: 123 42 03.5
	Description:	Deep part of lake approximately midway on a line extending from boat launch to east end of lake	
Secondary Station	Station # 2	latitude: 48 04 37.7	longitude: 123 42 29.2
	Description:	In approximate middle of western portion of lake, about 1500 feet east of westernmost point of west shore	

Trophic State Assessment for 1998

SUTHERLAND

Analyst: KIRK SMITH

TSI_Secchi:	27	N
TSI_Phos:	26	
TSI_Chl:	26	
Narrative TSI:[a]	O	

Lake Sutherland is a very clear lake nestled in a valley just east of Crescent Lake. The lake is heavily used by boaters and jet skiers. Most of the homes around the lake are used seasonally only, but there are two recently constructed housing developments along the north shore. The water was particularly clear with Secchi depths so deep in June we could not measure the exact depth of the disk. Clarity, phosphorus, and chlorophyll concentrations were all near ultra-oligotrophic; however, the hypolimnion was anoxic during most of the summer and there was internal phosphorus loading to the hypolimnion. These are ominous signs; anthropogenic nutrient sources should be controlled before there is a response in surface water quality, not after. We do not know the status of the fishery, but zooplankton were fairly large, which generally indicates a good predator-prey ratio. Types of watercraft use appear to be the biggest detractor for survey respondents. There were also several complaints of the smell of gasoline on the water (which we noted also) and swimmers getting coated with a thin oily film after swimming in the lake. This most likely originated from the outboard motors and jet skis on the lake. To survey respondents, no odors in the water, good swimming, and natural scenery were the most desirable characteristics. The watershed survey showed a lack of a buffer zone at the inflow near the boat launch. There was recent clear-cutting in the watershed but no erosion observed. The habitat survey revealed a shoreline lined with cottages and homes. There were many docks on the shoreline as well. The substrate was mostly silt with considerable woody debris.

We recommend that local officials evaluate the use of the lake by various watercraft in order to determine whether or not restrictions are needed in order to protect beneficial uses. Local government should also consider applying for funding to further study the lake and watershed to identify and manage nutrient sources. For now, we recommend a nutrient criterion for total phosphorus of 7.7 ug/L (the average of our measured concentrations, 4.7 ug/L, plus an adjustment for inter-annual variability, 3.0 ug/L).

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

SUTHERLAND

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
8/13/1998		L					1 U			
		L					2			
9/16/1998		L					1 U			
		L					1			
Station 1										
6/8/1998		E	5.1	.062	12	.5 U		65.9	19600	.5 U
		H	16	.137	9					
7/30/1998		E	3 U	.063	21	.64				
		H	70.2	.165	2					
8/13/1998		E	4.4	.049	11	.5 U				.5 U
		H	66.9	.163	2					
9/16/1998		E	6.2	.052	8	1.1				.8
		H	5.3	.157	30					
Station 2										
7/30/1998		E	4							
8/13/1998		E	4.1	.064	16					
9/16/1998		E		.042		.83				

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

SUTHERLAND

Survey Date: 9/16/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [ ] **Agriculture(commercial, not hobby)**
- [ ] **Commercial, Industrial**
- [3] **Major transportation**
- [1] **Residential**
- [2] **Park, forest or natural**

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

Shoreline very much developed around the lake. Lots of recent clear-cutting in watershed but no erosion observed.

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☐

Buffer zone absent around inflow near boat launch. Most of shoreline around the lake is developed but watershed is largely undevelped forest land with some clear-cutting in the recent past.

Irrigation ☐

Survey Id: 90

Habitat Survey Summary Report

SUTHERLAND

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 9/16/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.9	**Number of stations with canopy:**	10
Understory Avg:	1.9	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.1
	trees< 0.3 m DBH	2.1
Understory:	**woody shrubs saplings**	2.6
	tall herbs, forbs grasses	0.5
Ground Cover:	**woody shrubs seedlings**	2.3
	herbs, forbs, grasses	1.1
	standing water or inundated veg	0.8
	barren or buildings	0.8
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.5
	cobble/gravel	1.0
	loose sand	0.4
	other fine soil/sediment	0.1
	vegetated	2.4
	other	1.2
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	1.2
	vertical dist (M from wtrln to high wt):	0.2
	horiz. dist. (M from wtrln to high wt):	0.6

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

	buildings	1.4

commercial	0.0
park facilities	0.2
docks/boats	1.8
walls, dikes, or revetments	0.8
litter, trash dump, or landfill	0.4
roads or railroad	0.4
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	0.7
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	6.8

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.4
cobble	0.9
gravel	0.9
sand	0.2
silt	2.7
woody debris	2.1

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	1.3
emergent	0.0
floating	0.1
total weed cover	0.1
Do macrophytes extend lakeward (-1 = yes, 0 = no)	0.0

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	0.8
snags	0.2
brush or woody debris	1.2
inundated live trees	0.0
overhanging vegetation	0.7
rock ledges or sharp dropoffs	0.3
boulders	0.1
human structures	1.0

Questionnaire

SUTHERLAND

Results compiled from 13 **Surveys.** **Average time (years) respondents spent on lake:** 20.77

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	-0.4	View:	0.8	Distance to Lake:	0.0
Public Access:	0.0	Swim Beach:	0.3	Canada Geese:	0.0
Water Clarity:	0.0	Water Qual. for Swim:	-0.1		
Fishing Quality:	0.3	Aquatic Plants:	-0.2		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **3.2**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.8
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.3
1) Clearer water, or 2) fewer aquatic plants?	1.0

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	4.3	Good Warmwtr Fishing:	2.4	Natural Scenery:	4.7
Plant Growth:	2.4	Good Swimming:	4.7	Public Beach:	3.2
Natural Shoreline:	3.2	Less Algae:	4.1	Canada Geese:	3.1
No Odors:	4.7	Public Access:	2.9		
Good Coldwtr Fishing:	4.2	Clear Water:	4.8		

Tabulated Results

Survey ID	Date	Residency		Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	When?
34	9/12/1998	Resident	Permanent	Rent	10	☑	No	
36	9/9/1998	Resident	Seasonal	Rent	6	☑	Worse	1988
	Water that does not smell like gas and oil and does not leave a film on glasses.							
37	9/3/1998	Resident	Permanent	Rent	6	☑	Worse	1995
	Jet skis are very undesirable							
38	9/8/1998	Resident	Permanent	Rent	6	☑	Worse	95-96
	Jet skis are very undesirable							
39	9/8/1998	Resident	Seasonal	Rent	3	☐	Unknown	
40	9/4/1998	Resident	Permanent	Rent	2	☑	No	
	Very desirable to have quiet boats and quiet people							
41	9/5/1998	Resident	Permanent	Rent	6	☑	Worse	1993
	We must limit jet skis. They are a danger to swimmers and small boaters. I notice burning eyes after swimming. They are also operated in a very aggressive manner, bothering ducks and noise.							
44	9/8/1998	Resident	Permanent	Rent	several of the above	☐	Better	1998
	Do not want personal watercraft banned but do want usage regulated as to not create an unsafe condition in regards to all other uses.							
45	9/8/1998	Resident	Seasonal	Rent	working on property	☑	Unknown	
	too many jetskis							
46	8/26/1998	Resident	Permanent	Rent	10	☑	Worse	1988
48	9/9/1998	Resident	Seasonal	Rent	6	☑	Worse	1988
	The lake smells of gas and oil from all the jet ski type personal watercraft on the lake. The noise is also not conducive to the natural scenery.							
49	9/3/1998	Resident	Permanent	Rent	6	☐	No	
52	9/16/1998	Visitor			4	☐	Unknown	

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

SUTCL1

Date 6/8/1998 Station: 1
Sample ID 24

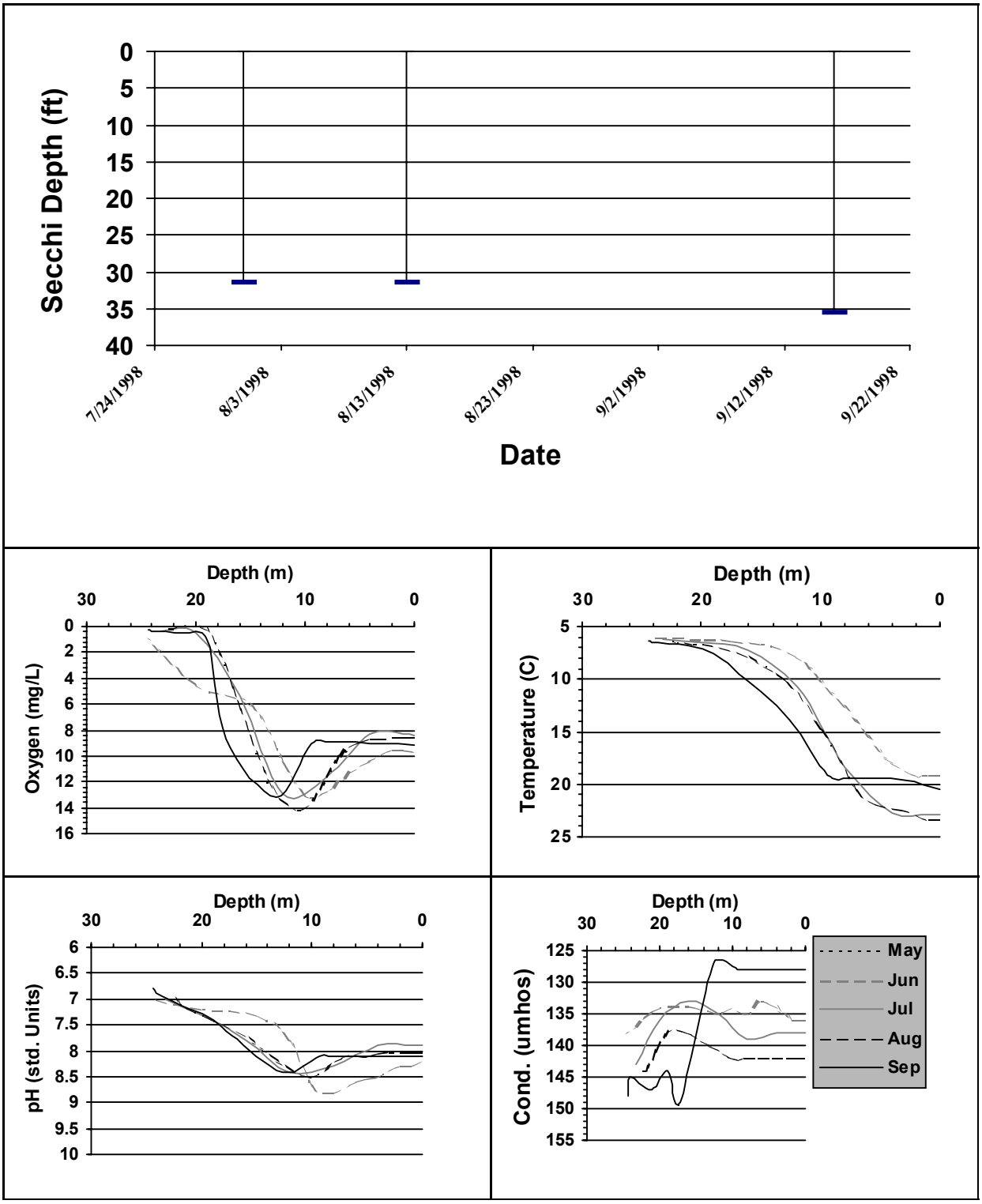
Number of organisms measured: 38

Group	Percent
Cladoceran	55.3%
Copepod	44.7%
Other	

Group	Percent
Small < 1mm	65.8%
Large >= 1mm	34.2%
Ratio of large to Small:	0.52
Average size (mm):	0.85

Secchi Depth and Profile Graphics

Station: 1 SUTCL1



Secchi Data and Field Observations

SUTHERLAND

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/8/1998				1	0	2		5	5	0	0	2	0
	Sampler: SMITH			Remarks: SEVERAL HOME OWNERS ASSOCIATIONS ON THE LAKE.									
7/31/1998			31.35		100	1		5	5	0	1	0	3
	Sampler: SMITH			Remarks: STRONG H2S ODOR FROM 22 METER SAMPLE									
8/13/1998			31.35	1	0	1		5	5	0	2	1	2
	Sampler: SMITH			Remarks: SPOKE WITH DEPUTY. STRONG H2S ODOR IN HYPO									
9/16/1998			35.5	1	0			4	5	0	183	0	0
	Sampler: SMITH			Remarks: H2S ODOR AT 22 METERS. The Conductivity and Oxygen results are qualified as estimates due to postcalibration failing QA/QC requirements.									

WILLIAM SYMINGTON

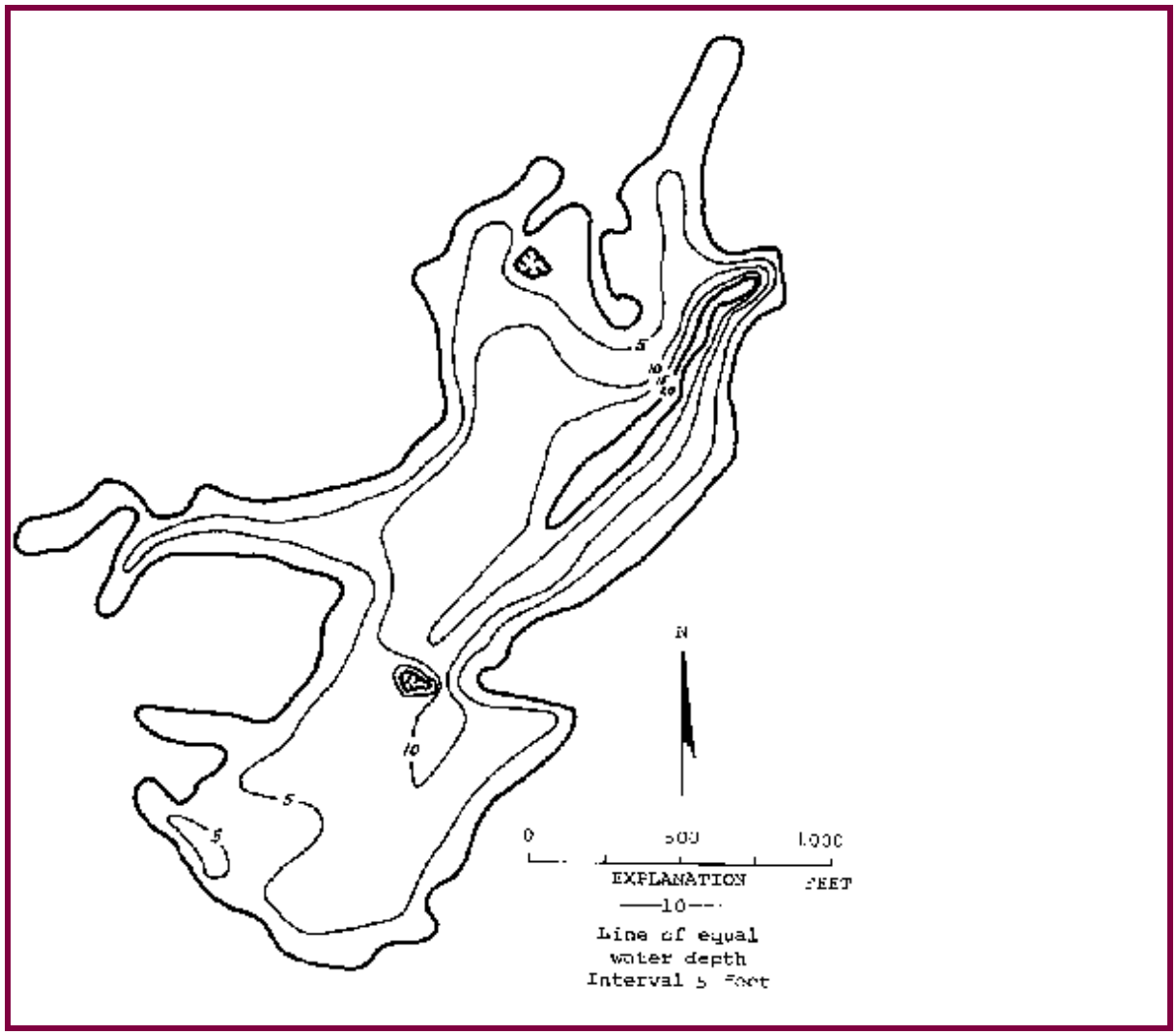
KITSAP County

Lake ID: SYMKI1

Ecoregion: 2

William Symington Reservoir is a shallow lake located along the Big Beef Creek. Two private parks line its shores. The lake has abundant aquatic life including geese and lush aquatic macrophytes.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
60	23	7	7	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
422	2.74	390	47 35 56.	122 49 27.



Station Information

SYMKI1

Secondary Station	Station # 1	latitude: 42 35 44.6	longitude: 122 49 46.0
	Description:	In deep part of lake approxiamtely midway on a line extending from southern island to northeast corner of deepest cove of lake	
Primary Station	Station # 2	latitude: 47 35 48.2	longitude: 122 49 41.2
	Description:	Directly south of eastern shore of southern island on a line extending from two coves located directly east-west from one another	

Trophic State Assessment for 1998

WILLIAM SYMINGTON

Analyst: KIRK SMITH

TSI_Secchi:	43	N
TSI_Phos:	39	
TSI_Chl:	45	
Narrative TSI:[a]	M	

William Symington Lake (Symington Lake) is a man-made reservoir in Kitsap County. The shoreline is approximately 50% developed (mostly residential) with timberland outside of the residential area. There is no public access. The lake is relatively shallow with numerous aquatic plants throughout. Waters are tannin-colored. There is a restriction on the use of outboard motors and the most prominent primary use of the lake is swimming at the two private beaches along the shoreline. It did not appear that boating of any kind was a significant form of recreation and, to survey respondents, watercraft restriction was the most desired characteristic of the lake. Having a public access and public beach were the least desired characteristics. The natural scenery is also a highly desired characteristic and the habitat survey did show very little human disturbance along the shoreline, lawns being an exception. The habitat survey confirmed the abundance of aquatic weed cover. The user survey also indicated that aquatic plants detracted from the enjoyment of the lake. Phosphorus concentrations were moderate (mean 11.3 ug/L total phosphorus).

It appears beneficial uses are supported on Symington Lake with the exception that swimming may be impaired by the abundant aquatic plant life and localized high fecal bacteria counts. Because swimming is an important characteristic, we suggest that homeowners groups (rather than local public entities because there is no public access) develop strategies to control the growth of aquatic vegetation and manage fecal bacteria sources (probably swimmers). We recommend a nutrient criterion for William Symington Lake be set at the ecoregion action value for lower mesotrophic Puget Lowland lakes, 20 ug/L.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

WILLIAM SYMINGTON

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)

Station 0									
6/9/1998	L				5				
	L				14				
7/28/1998	L				19 J				
	L				200 J				
8/17/1998	L				180				
	L				29				
9/21/1998	L				7				
	L				9				
Station 1									
6/9/1998	E	12.8	.244	19					
Station 2									
6/9/1998	E	11.7	.254	22	1.4		28.4	7100	1.2
7/28/1998	E	11.4	.244	21	2.3				1.2
	H	20.5	.291	14					
8/17/1998	E	12.2	.29	24	10.8				2
9/21/1998	E	9.9	.348	35	9				1.8

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

WILLIAM SYMINGTON

Survey Date: 9/21/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [4] **Agriculture(commercial, not hobby)**
- [ ] **Commercial, Industrial**
- [3] **Major transportation**
- [1] **Residential**
- [2] **Park, forest or natural**

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☑

Natural vegetation left around the shoreline

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Buffer zones around streams and wetlands ☐

Irrigation ☐

Habitat Survey Summary Report

WILLIAM SYMINGTON

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 9/16/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	2.5	**Number of stations with canopy:**	10
Understory Avg:	2.9	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	2.1
	trees< 0.3 m DBH	2.4
Understory:	**woody shrubs saplings**	2.6
	tall herbs, forbs grasses	1.7
Ground Cover:	**woody shrubs seedlings**	1.6
	herbs, forbs, grasses	3.2
	standing water or inundated veg	0.9
	barren or buildings	0.7
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.0
	cobble/gravel	0.6
	loose sand	0.0
	other fine soil/sediment	1.2
	vegetated	3.6
	other	0.2
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.5
	vertical dist (M from wtrln to high wt):	0.3
	horiz. dist. (M from wtrln to high wt):	0.5

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.2
commercial	0.0
park facilities	0.1
docks/boats	0.0
walls, dikes, or revetments	0.6
litter, trash dump, or landfill	0.0
roads or railroad	0.0
row crops	0.0

pasture or hayfield	0.0
orchard	0.0
lawn	1.4
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	1.2

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.0
cobble	0.0
gravel	0.3
sand	1.2
silt	3.2
woody debris	0.3

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	2.7
emergent	1.0
floating	1.4
total weed cover	3.0
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-1.0

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	2.0
snags	0.0
brush or woody debris	0.1
inundated live trees	0.0
overhanging vegetation	0.9
rock ledges or sharp dropoffs	0.1
boulders	0.0
human structures	0.1

Questionnaire

WILLIAM SYMINGTON

Results compiled from 5 **Surveys.** **Average time (years) respondents spent on lake:** 9.00

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:	0.2	View:	0.8	Distance to Lake:	0.2
Public Access:	0.3	Swim Beach:	0.6	Canada Geese:	-0.2
Water Clarity:	0.2	Water Qual. for Swim:	0.2		
Fishing Quality:	0.4	Aquatic Plants:	-0.4		

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today? **2.8**

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?	1.6
1) Better fishing and more natural habitat, or 2) fewer aquatic plants?	1.6
1) Clearer water, or 2) fewer aquatic plants?	1.4

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	4.4	Good Warmwtr Fishing:	3.0	Natural Scenery:	4.2
Plant Growth:	2.0	Good Swimming:	4.2	Public Beach:	1.4
Natural Shoreline:	3.0	Less Algae:	3.2	Canada Geese:	3.2
No Odors:	4.0	Public Access:	1.6		
Good Coldwtr Fishing:	3.6	Clear Water:	4.2		

Tabulated Results

Survey ID	Date	Residency		Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
43	8/20/1998	Resident	Permanent	Rent	10	☑	No	
61	8/16/1998	Resident	Permanent	Rent	1	☐	No	
63	8/25/1998	Resident	Permanent	Rent	6	☑	Worse	1996
72	8/15/1998	Resident	Permanent	Rent	7	☐	Unknown	
86	8/20/1998	Resident	Permanent	Rent	10	☑	Worse	

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

SYMKI1

Date 6/9/1998 Station: 2 Sample ID 20 — 11 mLs observed

Number of organisms measured: 69

Group	Percent
Cladoceran	39.1%
Copepod	60.9%
Other	

Group	Percent
Small < 1mm	87.0%
Large >= 1mm	13.0%
Ratio of large to Small:	0.15
Average size (mm):	0.52

Aquatic Plant Data

WILLIAM SYMINGTON

Sampler: Parsons, O'Neal — Survey Date: 9/16/1998

Max depth of growth (M): 3

Comments: Sunny, light breeze. Did habitat survey form for Kirk Smith. Dammed creek to create the lake. Most of the lake is shallow and filled with vegetation. Water tea colored, especially in channels. Plant growth dense in shallows, the shoreline is modified from what the map indicates.

SPECIES LIST

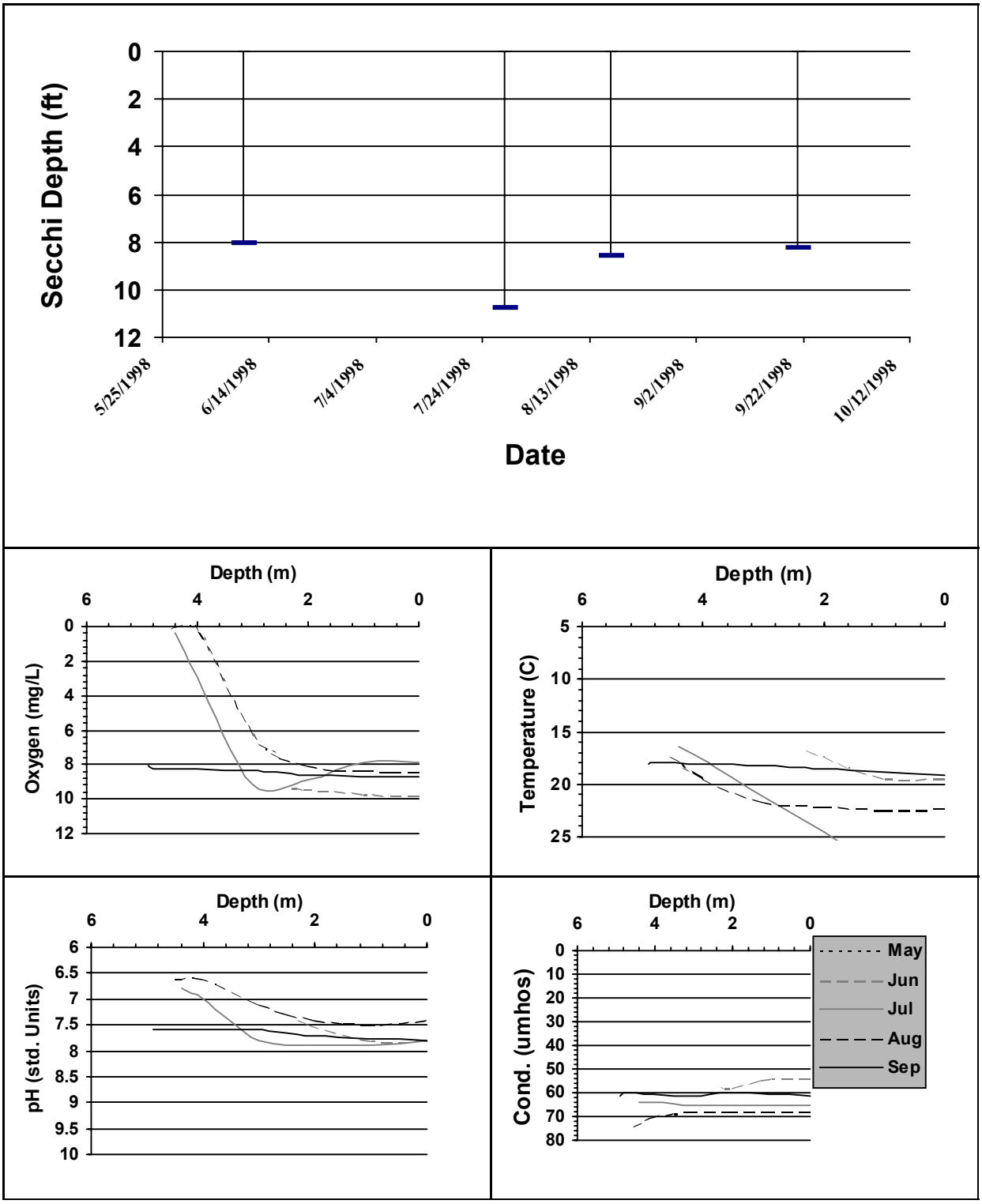
Scientific Name	Common Name	Dist [a]	Comments
Brasenia schreberi	watershield	3	
Elodea canadensis	common elodea	3	some dense patches
Najas flexilis	common naiad	2	

Nitella sp.	stonewort	3	a few species
Nuphar polysepala	spatter-dock, yellow water-lily	2	
Potamogeton amplifolius	large-leaf pondweed	3	some dense patches
Potamogeton epihydrus	ribbonleaf pondweed	2	
Potamogeton natans	floating leaf pondweed	2	
Potentilla palustris	purple (marsh) cinquefoil	2	
Potamogeton pusillus	slender pondweed	2	
Potamogeton zosteriformis	eel-grass pondweed	3	
Typha latifolia	common cat-tail	2	
unknown plant	unknown	2	at north end
Utricularia sp.	bladderwort	2	U. minor?

[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

Secchi Depth and Profile Graphics

Station: 2 SYMKI1



Secchi Data and Field Observations

WILLIAM SYMINGTON

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 2													
6/9/1998			8 B	7	100	2		4	1	40	6	0	0
	Sampler: SMITH			Remarks:									
7/28/1998			10.73	8	0			4	3	0	0	0	0
	Sampler: SMITH			Remarks: SAMPLES TAKEN AT SITE#2 (DEEP SITE). MANY SWIMMERS. Fecal bacteria were samples collected at the two parks.									
8/17/1998			8.58	7	100	1		4	3	0	26	0	0
	Sampler: SMITH			Remarks: FECS TAKEN AT PARKS FEC#1 AT DIV 5 PARK, FEC #2 AT DIV 1-4 PARK.									
9/21/1998			8.25	6	0	1		5	4	12	56	0	0
	Sampler: SMITH			Remarks: FEC#1 TAKEN NEAR BEACH AREA IN COVE NORTH OR DAM. FEC#2 AT COMMUNITY PARK FOR DIV 1-4. The Conductivity and Oxygen result is qualified as an estimate due to postcalibration failing QA/QC requirements.									

WARD

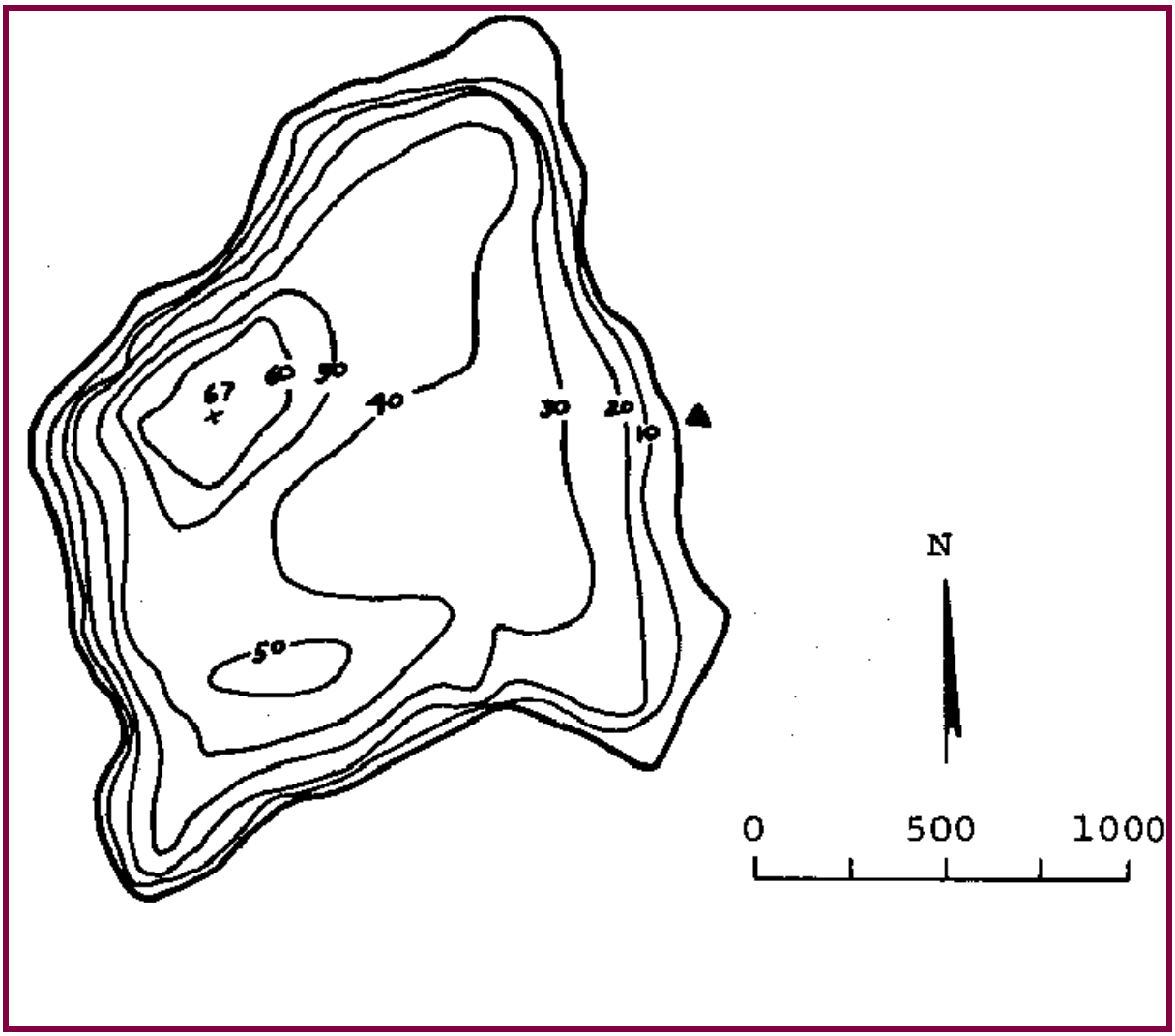
THURSTON County

Lake ID: WARTH1

Ecoregion: 2

Ward Lake is located 2.5 miles south of Olympia, in a kettle depression. It is spring-fed, and has no surface outlets. It is within the Deschutes River watershed.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
65	67	33	1	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
2100	1.36	123	47 00 21.	122 52 36.



Station Information

WARTH1

Primary Station	Station # 1	latitude: 47 00 26.3	longitude: 122 52 44.2
	Description:	Deep part of lake directly west of boat launch about 500 feet east of west shore	

Trophic State Assessment for 1998

WARD

Analyst: KIRK SMITH

TSI_Secchi:	40
TSI_Phos:	34
TSI_Chl:	37
Narrative TSI:[a]	OM

About 60% of Ward Lake's shoreline is densely residential, the rest is undeveloped. The watershed is very small. The lake shows many characteristics of an oligotrophic lake (mean total phosphorus was 8.8 ug/L) but its late summer anoxic hypolimnion, significant internal loading, and noticeable algal blooms are more indicative of a mesotrophic lake. We have assigned an oligo-mesotrophic assessment. There were only two user surveys returned for Ward Lake and we cannot draw conclusions based on so few questionnaires. However, Ward Lake has been included in the LWQA program for many years and its uses have remained fairly constant during that time. The lake is primarily used by residents for swimming. The boat launch is frequented by fishermen who fish the lake primarily for kokanee and trout. The lake supports a very popular and healthy kokanee fishery. The habitat survey suggests there is abundant aquatic vegetation growth in the shallow portions of the lake near the shore. The survey also indicates that human influences on the shoreline include lawns and buildings. The substrate is mostly silt. The lake may be subjected to watershed impacts from runoff of lawn fertilizers and a nearby plant nursery. Algal blooms in 1998 produced a very green lake at times which is unusual for Ward Lake, though chlorophyll concentrations were still low to moderate. However, with the exception of a high fecal bacteria count in June, it appears that all the beneficial uses of the lake are still supported by the present water quality conditions.

Therefore, we recommend the nutrient criterion for Ward Lake be set at the ecoregional action value for oligotrophic Puget Lowland lakes, 10 ug/L total phosphorus.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

WARD

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/1/1998		L					7			

	L				240 J				
7/23/1998	L				6				
	L				3				
8/10/1998	L				11				
9/24/1998	L				4				
Station 1									
6/1/1998	E	10.9	.156	14	2		5	1290	.6
	H	56.2	.366	7					
7/23/1998	E	9.1	.246	27	1.9				1.3
	H	116	.393	3					
8/10/1998	E	7.8	.222	28	1.5				.6
	H	294	.726	2					
9/24/1998	E	7.4	.237	32	2.6				.6
	H	377	.972	3					

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

WARD

Survey Date: 9/24/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [ ] **Agriculture(commercial, not hobby)**
- [2] **Commercial, Industrial**
- [3] **Major transportation**
- [1] **Residential**
- [ ] **Park, forest or natural**

Impervious surfaces (Roads and parking area): Partially Curbed

Observations (check mark denotes presence)

BMP's ☐

Odors ☐

Cattle ☐ **Ducks** ☐ **Geese** ☐

None

Fertilizers and weed killers appear to be used in residential or agriculture area ☐

Yes. Green lawns evident along lakeshore and watershed.

Buffer zones around streams and wetlands ☑

Lots of riparian habitat along lakeshore.

Irrigation ☑

Southwest end of lake

Habitat Survey Summary Report

WARD

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 7/6/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.9	**Number of stations with canopy:**	10
Understory Avg:	2.7	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.5
	trees< 0.3 m DBH	1.0
Understory:	**woody shrubs saplings**	1.9
	tall herbs, forbs grasses	1.1
Ground Cover:	**woody shrubs seedlings**	1.1
	herbs, forbs, grasses	1.1
	standing water or inundated veg	1.4
	barren or buildings	0.8
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.0
	cobble/gravel	0.4
	loose sand	0.4
	other fine soil/sediment	1.4
	vegetated	3.1
	other	0.9
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.6
	vertical dist (M from wtrln to high wt):	0.1
	horiz. dist. (M from wtrln to high wt):	0.3

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.2
commercial	0.0
park facilities	0.1
docks/boats	1.4
walls, dikes, or revetments	0.7
litter, trash dump, or landfill	0.0
roads or railroad	0.0
row crops	0.0
pasture or hayfield	0.0
orchard	0.0
lawn	1.2

other	0.3

Physical Habitat Characteristics

station depth (at 10 m from shore)	4.8

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.0
cobble	0.0
gravel	0.0
sand	0.2
silt	1.7
woody debris	0.5

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	1.3
emergent	0.7
floating	1.9
total weed cover	2.3
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.2

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.7
snags	0.1
brush or woody debris	1.0
inundated live trees	0.4
overhanging vegetation	0.9
rock ledges or sharp dropoffs	0.0
boulders	0.0
human structures	0.8

Questionnaire

WARD

Results compiled from 1 **Surveys.** **Average time (years) respondents spent on lake:**

Did the following add (+1), detract (-1), or have no effect (0) on your enjoyment of the lake today?

Types of WaterCraft:		View:	Distance to Lake:
Public Access:	1.0	Swim Beach:	Canada Geese:
Water Clarity:		Water Qual. for Swim:	
Fishing Quality:	1.0	Aquatic Plants:	

On a scale of 1 (poor) to 5 (excellent), how would you rate water quality today?

Which would you rather have, 1 or 2?

1) Better fishing and more natural habitat, or 2) clearer water?

1) Better fishing and more natural habitat, or 2) fewer aquatic plants? 1.0

1) Clearer water, or 2) fewer aquatic plants?

1) Clearer water, or 2) fewer aquatic plants?

How important is each of the following characteristics to you (1 = very undesirable, 5= very desirable):

Restricted Watercraft:	3.0	Good Warmwtr Fishing:	1.0	Natural Scenery:	4.0
Plant Growth:	3.0	Good Swimming:	1.0	Public Beach:	3.0
Natural Shoreline:	3.0	Less Algae:	5.0	Canada Geese:	1.0
No Odors:	5.0	Public Access:	3.0		
Good Coldwtr Fishing:	5.0	Clear Water:	5.0		

Tabulated Results

Survey ID	Date	Residency	Rent or Own	Primary Activity*	Water Clarity: Purchase Factor?	Water Clarity: Has it Changed?	Water Clarity: When?
3	6/6/1998	Visitor		2	☐	Unknown	

* 1=canoe/kayak, 2=fish, 3=pers. wtrcrft, 4=mtrboat, 5=sail, 6=swim/wade, 7=watch wldlf, 8=ski, 9=windsurf, 10=relaxing

Zooplankton Report

WARTH1

Date 6/1/1998 Station: 1 Sample ID 10 — 4 mLs observed

Number of organisms measured: 93

Group	Percent
Cladoceran	14.0%
Copepod	86.0%
Other	

Group	Percent
Small < 1mm	55.9%
Large >= 1mm	44.1%
Ratio of large to Small:	0.79
Average size (mm):	0.82

Aquatic Plant Data

WARD

Sampler: Parsons, O'Neal — Survey Date: 7/6/1998

Max depth of growth (M): 6

Comments: partly cloudy, light breeze, bullfrogs, sparse plant cover - mostly Nymphaea. Shoreline drops steeply in most areas, plant community pretty homogeneous. Conducted habitat survey for Kirk Smith.

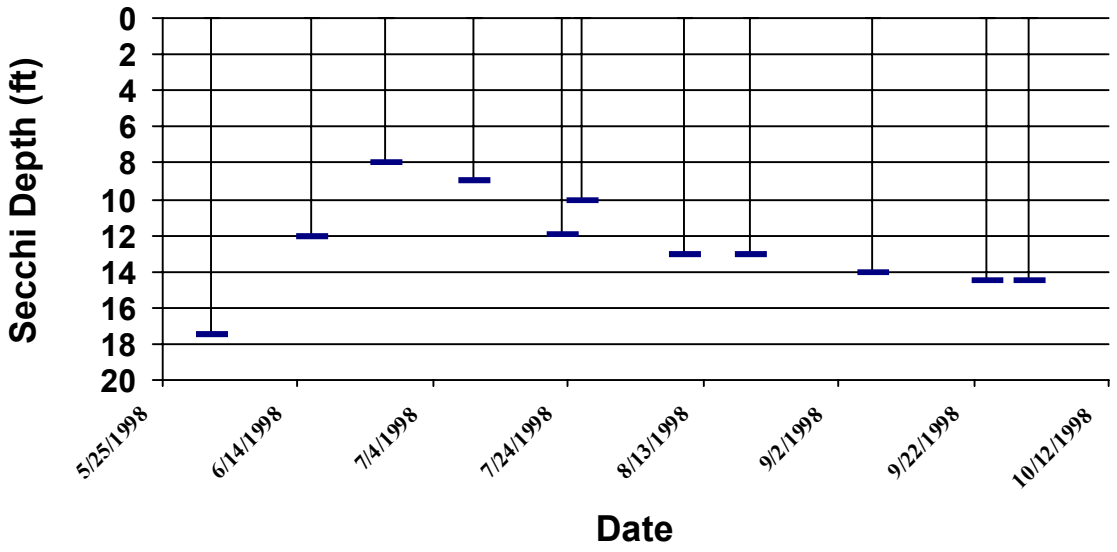
SPECIES LIST

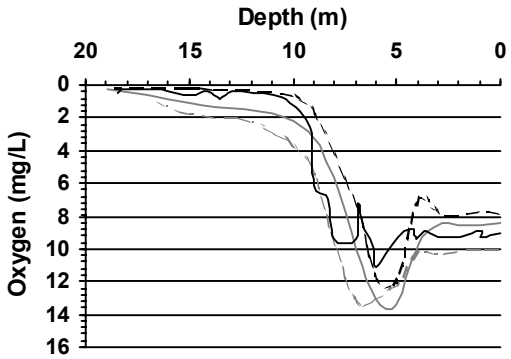
Scientific Name	Common Name	Dist [a]	Comments
Callitriche stagnalis	pond water-starwort	1	
Iris pseudacorus	yellow flag	2	
Juncus sp. or Eleocharis sp.	small grass-like plants	1	
Nitella sp.	stonewort	3	common in deep water, though not dense
Nuphar polysepala	spatter-dock, yellow water-lily	1	only saw 1 in flower
Nymphaea odorata	fragrant waterlily	3	present along most of shore to approx. 3 m deep
Scirpus sp.	bulrush	2	
Typha sp.	cat-tail	2	
Utricularia sp.	bladderwort	1	

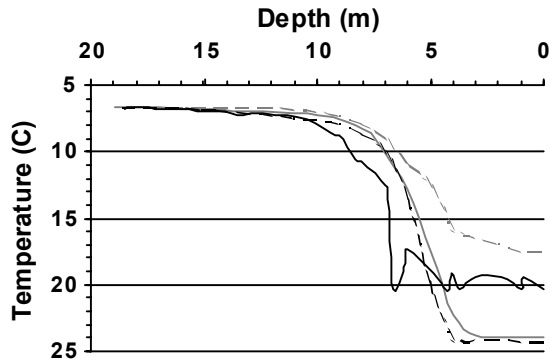
[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

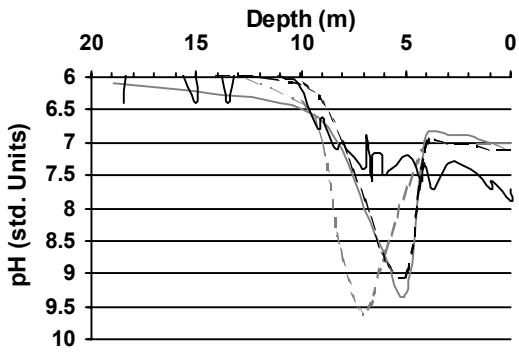
Secchi Depth and Profile Graphics

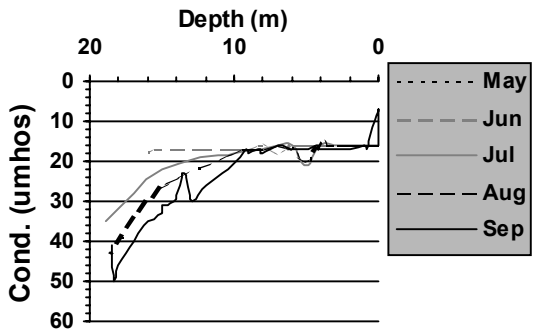
Station: 1 WARTH1











Secchi Data and Field Observations

WARD

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/1/1998			17	6	100	2		5	5	0	2	2	0
	Sampler: SMITH			Remarks: ZOO TOW DOWN TO 10 METERS AT DEEP SITE. HIGHLY RESIDENTIAL APPROX 40% SHORELINE NATURAL. SMALL WATERSHED									
6/1/1998		17.5	17.5	3	75	2	1	5	5	10	6	4	0
	Sampler: CLOUD			Remarks:									
6/1/1998			17.5		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									
6/16/1998		21	12	3	0	2	2	5	4	0	0	1	0
	Sampler: CLOUD			Remarks: BLOOM STARTING - MUCH CLEARER 4 DAYS AGO.									
6/27/1998		19	8	4	75	1	2	5	4	30	1	1	0
	Sampler: CLOUD			Remarks:									
7/10/1998		22	9	3	50	1	1						
	Sampler: CLOUD			Remarks:									
7/23/1998			11.88	2	100			4	4	0	7	2	0
	Sampler: SMITH			Remarks: H2S IN THE HYPOLIMNION									
7/26/1998		25	10	7	0	1	1	5	4	0	0	2	0
	Sampler: CLOUD			Remarks:									
8/10/1998			16.83	2	80			5	5	9	9	0	0
	Sampler: SMITH			Remarks: OXYGEN WAS INCREDIBLY LOW IN HYPOLIMNION									
8/10/1998		26	13	8	0	1	1	5	5	0	4	0	0
	Sampler: CLOUD			Remarks:									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
8/20/1998		26	13	8	0	2	1	5	5	3	4	2	0
	Sampler: CLOUD			Remarks:									
9/7/1998		26	14	9	0	1	1	5	5	0	2	2	0
	Sampler: CLOUD			Remarks:									
9/24/1998			14.52	2	100	3		4	5	0	26	1	0
	Sampler: SMITH			Remarks:	SOME COOTS MIGRATING THROUGH. SOME GREBES TOO. The Conductivity result is qualified as an estimate due to postcalibration failing QA/QC requirements.								
9/30/1998		19	14.5	3	0	2	1		5	10	0	0	0
	Sampler: CLOUD			Remarks:									
9/30/1998			14.5		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									

WILDCAT

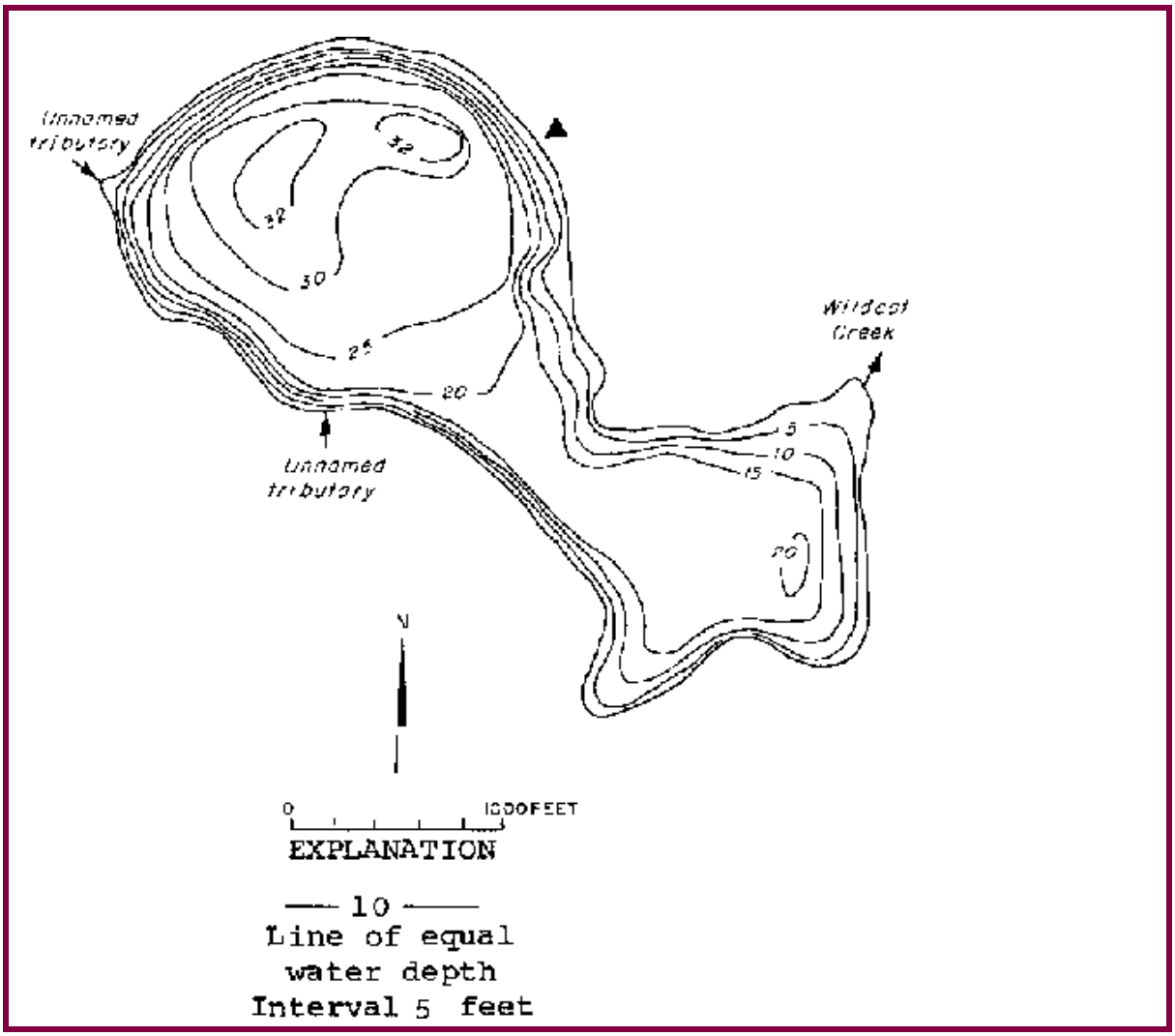
KITSAP County

Lake ID: WILKI1

Ecoregion: 2

Wildcat Lake is located six miles northwest of Bremerton. It is fed by two inlets, and drains via Wildcat Creek to Dyes Inlet.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
120	33	18	3	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
2200	2.24	377	47 35 59.	122 45 35.



Station Information

WILKI1

Secondary Station	Station # 1	latitude: 47 35 56.9	longitude: 122 46 23.8
	Description:	Approximately 200 feet from boat launch on a line extending from launch to southern tributary; pre-1996 data	
Primary Station	Station # 2	latitude: 47 35 48.1	longitude: 122 45 40.2
	Description:	Deep part of lake, in the approximate center of a line extending from northwest tributary to boat launch; post-1996 data	
Secondary Station	Station # 3	latitude:	longitude:
	Description:	In southeast portion of lake in the approximate middle of a line extending from the narrowest point in the lake to the southeasternmost end of shore	

Trophic State Assessment for 1998

WILDCAT

Analyst: KIRK SMITH

TSI_Secchi:	36
TSI_Phos:	33
TSI_Chl:	35
Narrative TSI:[a]	O

Wildcat Lake is an oligotrophic lake on the Kitsap peninsula. The watershed is about 75% forested, 15% residential, and 10% agriculture. The water is very clear and supports a put-and-take trout fishery and a bass fishery. There were no user surveys distributed on Wildcat Lake so we cannot determine the full extent of the uses and the public perception of their quality. However, besides the fishery, there is a public swimming beach on the lake. There is a speed limit for boats; no wakes are allowed. The habitat survey revealed buildings and lawns to be the most prominent human disturbances along the shoreline as is the case on most urban lakes. Aquatic vegetation was sparse which is not supportive of the bass fishery. The watershed survey revealed an area where a tributary was impacted by grazing livestock. Most of the lawns near the lake appeared to be well manicured and could be a source of nutrients from fertilizers. The lake is quite clear and low in phosphorus (mean total phosphorus was 7.7 ug/L). With little vegetation and low productivity, a bass fishery is most likely not supported in this lake. Zooplankton tended to be small with copepods dominant. The water quality is much better suited for the trout fishery and as a nursery for Coho smolts.

We recommend the nutrient criterion for Wildcat Lake be set at the ecoregional action value for oligotrophic Puget Lowland lakes, 10 ug/L total phosphorus.

[a] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

WILDCAT

Date	Time	Strata	Tot P (ug/L)	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										

Station 0									
6/16/1998	L				1				
	L				10				
8/18/1998	L				7				
	L				7				
9/21/1998	L				2				
	L				1				
Station 2									
6/16/1998	E	6.2	.231	37			20.7	5100	.5
	H	19.9	.374	19					
7/24/1998	E	9.2	.181	20	.71				.7 J
	H	11.9	.274	23					
8/18/1998	E	6.8	.161	24	.5 U				.6
	H	24.7	.28	11					
9/21/1998	E	8.5	.189	22	3				.6
Station 3									
6/16/1998	E	8 J							
7/24/1998	E	5.3	.176	33	1.4				
8/18/1998	E	6.6	.16	24	2.3				

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than

Watershed Survey

WILDCAT

Survey Date: 9/21/1998

Land Uses (1 = Primary, 2 = Secondary, etc.)

- [2] **Agriculture(commercial, not hobby)**
- [ ] **Commercial, Industrial**
- [ ] **Major transportation**
- [1] **Residential**
- [3] **Park, forest or natural**

Impervious surfaces (Roads and parking area): No Curbs

Observations (check mark denotes presence)

BMP's ☐

No BMPs observed--possibly need to keep horses from accessing water.

Odors ☐

Cattle ☑ **Ducks** ☐ **Geese** ☐

Horses, not cattle, could possibly be entering inlet streams and freely accessing lake.

Fertilizers and weed killers appear to be used in residential or agriculture area ☑

Yes, it appears the majority of lakefront homes use lawn fertilizers.

Buffer zones around streams and wetlands ☐

Irrigation ☐

Survey Id: 50

Habitat Survey Summary Report

WILDCAT

Data are averages of ***10*** **Stations Surveyed** **Date of Visit:** 8/20/1998

Vegetation Type (Avg. only of sites w/ vegetation present; 1=coniferous, 3=deciduous)

Canopy Layer Avg:	1.7	**Number of stations with canopy:**	10
Understory Avg:	2.7	**Number of stations with understory:**	10

Percent Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

Canopy Layer:	**trees > 0.3 m DBH**	1.6
	trees< 0.3 m DBH	1.3
Understory:	**woody shrubs saplings**	1.5
	tall herbs, forbs grasses	1.2
Ground Cover:	**woody shrubs seedlings**	0.9
	herbs, forbs, grasses	2.1
	standing water or inundated veg	0.6
	barren or buildings	0.8
Substrate Type (within shoreline plot):	**bedrock**	0.0
	boulders	0.4
	cobble/gravel	0.9
	loose sand	0.8
	other fine soil/sediment	0.6
	vegetated	3.0
	other	0.8
Bank Features:	**angle (O:<30; 1: 30-75; 2:nr vertical)**	0.6
	vertical dist (M from wtrln to high wt):	0.5
	horiz. dist. (M from wtrln to high wt):	0.3

Human Influence (0 = absent, 1 = adjacent to or behind plot, 2 = present within plot)

buildings	1.0
commercial	0.0
park facilities	0.2
docks/boats	1.3
walls, dikes, or revetments	0.8
litter, trash dump, or landfill	0.0

roads or railroad	0.0
row crops	0.0
pasture or hayfield	0.2
orchard	0.0
lawn	1.3
other	0.0

Physical Habitat Characteristics

station depth (at 10 m from shore)	2.1

Bottom Substrate (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

bedrock	0.0
boulders	0.1
cobble	0.4
gravel	0.9
sand	0.0
silt	3.8
woody debris	1.1

Macrophyte Areal Coverage (0 = absent, 1 = <10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%)

submergent	1.6
emergent	1.2
floating	1.7
total weed cover	2.7
Do macrophytes extend lakeward (-1 = yes, 0 = no)	-0.5

Fish Cover (0 = absent, 1 = Present but sparse, 2 = moderate to heavy)

aquatic weeds	1.5
snags	0.2
brush or woody debris	0.7
inundated live trees	0.0
overhanging vegetation	1.1
rock ledges or sharp dropoffs	0.0
boulders	0.2
human structures	1.1

Zooplankton Report

WILKI1

Date 6/16/1998 Station: 1
Sample ID 21

Number of organisms measured: 19

Group	Percent	Group	Percent
Cladoceran	15.8%	Small < 1mm	42.1%
Copepod	84.2%	Large >= 1mm	57.9%
Other		Ratio of large to Small:	1.38
		Average size (mm):	0.86

Date 6/16/1998 Station: 3 Sample ID 8

2 mLs observed, not enough bio to sample

Number of organisms measured: 62

Group	Percent	Group	Percent
Cladoceran		Small < 1mm	93.5%
Copepod	100.0%	Large >= 1mm	6.5%
Other		Ratio of large to Small:	0.07
		Average size (mm):	0.31

Date 6/16/1998 Station: 3 Sample ID 23

12 mLs measured

Number of organisms measured: 26

Group	Percent	Group	Percent
Cladoceran	7.7%	Small < 1mm	92.3%
Copepod	92.3%	Large >= 1mm	7.7%
Other		Ratio of large to Small:	0.08
		Average size (mm):	0.44

Aquatic Plant Data

WILDCAT

Sampler: Parsons, O'Neal

Survey Date: 8/20/1998

Max depth of growth (M):

Comments Sunny, calm. Popular fishing area, many people swimming at parks, and camps. Clear water. Sediments bare gravel/muck in some areas, but most areas with macrophyte growth. Did habitat survey for Kirk Smith. Observed many bass in the shallows, kingfisher, bullfrog.

SPECIES LIST

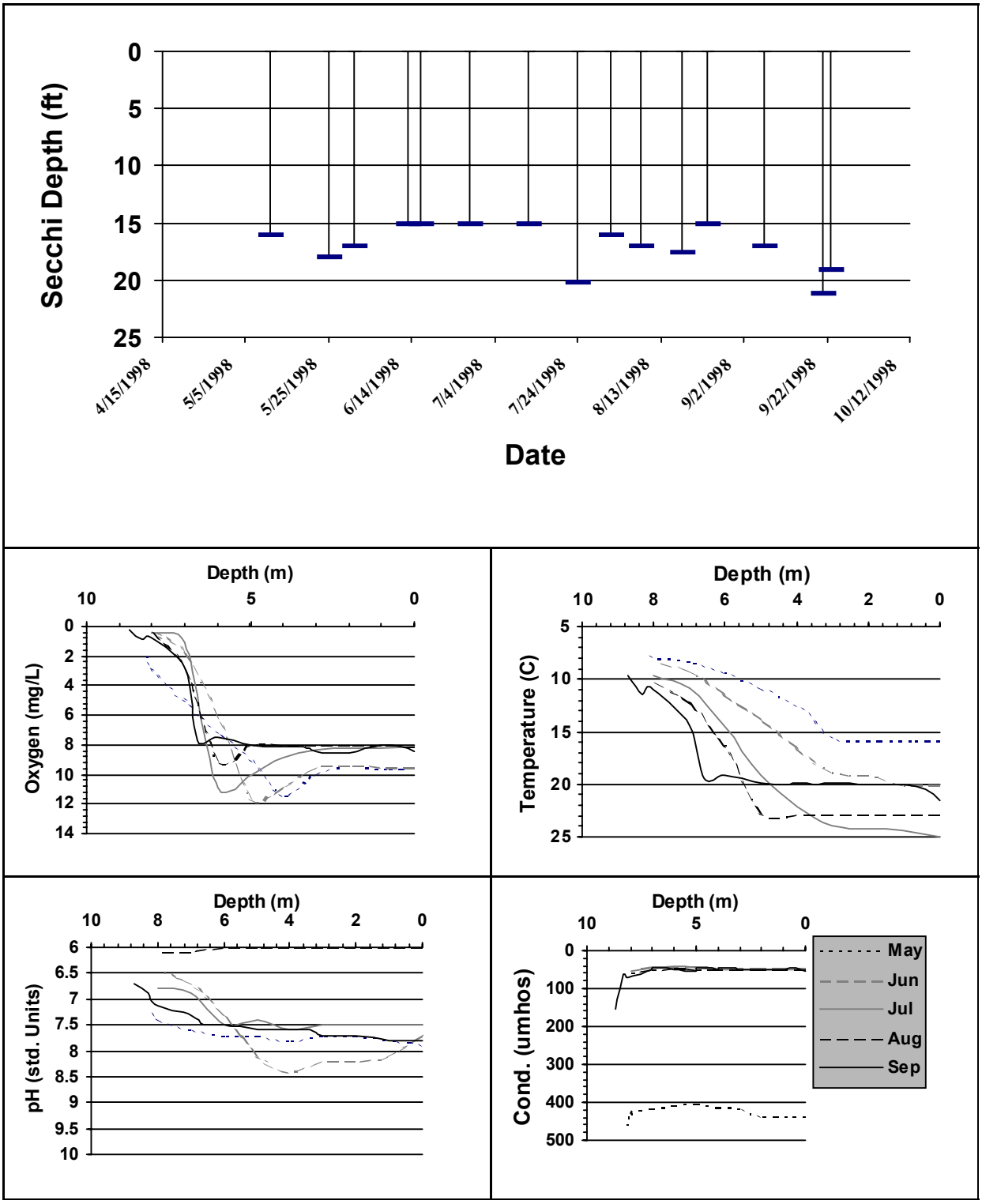
Scientific Name	Common Name	Dist [a]	Comments
Brasenia schreberi	watershield	2	
Carex sp.	sedge	2	several species on shore
Chara sp.	muskwort	1	in shallow water
Dulichium arundinaceum	Dulichium	2	
Elodea canadensis	common elodea	2	
Iris pseudacorus	yellow flag	2	
Isoetes sp.	quillwort	3	most common submersed plant
Juncus sp. or Eleocharis sp.	small grass-like plants	1	
Juncus sp.	rush	2	several species, on shore
Mentha piperita	peppermint	1	
Nuphar polysepala	spatter-dock, yellow water-lily	2	
Nymphaea odorata	fragrant waterlily	3	dense in patches

Potamogeton amplifolius	large-leaf pondweed	1	
Potamogeton gramineus	grass-leaved pondweed	2	
Potentilla palustris	purple (marsh) cinquefoil	1	
Potamogeton robbinsii	fern leaf pondweed	2	
Potamogeton sp (thin leaved)	thin leaved pondweed	2	
Potamogeton zosteriformis	eel-grass pondweed	1	few seen
Ranunculus flammula	creeping buttercup	1	
Typha latifolia	common cat-tail	2	blooming
Utricularia vulgaris	common bladderwort	1	in shallows near outlet
Vallisneria americana	water celery	2	patch on south shore

[a] 0 - value not recorded (plant may not be submersed)
1 - few plants in only 1 or a few locations
2 - few plants, but with a wide patchy distribution
3 - plants in large patches, codominant with other plants
4 - plants in nearly monospecific patches, dominant
5 - thick growth covering substrate to exclusion of other species

Secchi Depth and Profile Graphics

Station: 2 WILKI1



Secchi Data and Field Observations

WILDCAT

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 2													
5/11/1998		16.7	16	7	75	2	3	5	5	0	2	3	0
	Sampler: SNOW			Remarks: FIRST READING OF 1998.									
5/11/1998			16		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									
5/25/1998		16.7	18	7	75	2	3	5	5	2		1	0
	Sampler: SNOW			Remarks: SPEED LIMIT 7 MPH ON LAKE.									
5/31/1998		20	17	6	0	1	2	5	5	30	4	7	0
	Sampler: SNOW			Remarks: 70 DEGREES IN THE SHADE.									
6/13/1998		21.1	15	7	25	1	2	5	5	0	4	2	0
	Sampler: SNOW			Remarks: TEMPERATURE IS 70 DEGREES OUTSIDE SHADE.									
6/16/1998			15	2	50					10	11	2	0
	Sampler: SMITH			Remarks: ZOOPLANKTON DUPS AT 4 METERS AT SITE #3									
6/28/1998		21.1	15	7	0	1	2	5	5	0			
	Sampler: SNOW			Remarks: 70 DEGREES IN THE SHADE.									
7/12/1998		22.2	15	7	75	1	2	5	5	30	2	4	0
	Sampler: SNOW			Remarks:									
7/24/1998			20.13	2	10					13	0	0	0
	Sampler: SMITH			Remarks:									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
8/1/1998		25.6	16	6	0	1	2	5	5	8	4	4	0
	Sampler: SNOW			Remarks: 68 DEGREES IN THE SHADE.									
8/8/1998		25.6	17	7	0	1	1	5	5	8	3	5	0
	Sampler: SNOW			Remarks: 72 DEGREES IN THE SHADE.									
8/18/1998			17.49	2	100			5	5	0	0	0	0
	Sampler: SMITH			Remarks: FEC#1 TAKEN AT POINT BETWEEN TWO BASINS; FEC#2 TAKEN AT BOAT RAMP. FECS TAKEN APPROX. 1230. NO BLUE-GREEN OBSERVED; UNUSUALLY CLEAR FOR THIS TIME OF YEAR. The pH results are qualified as estimates due to postcalibration failing QA/QC requirements.								
8/24/1998		23.3	15	7	0	1	1	5	5	0	0	0	0
	Sampler: SNOW			Remarks: 65 DEGREES. LAKE IS LOW.									
9/7/1998		23.3	17	8	75	1	1	5	5	6	4	3	0
	Sampler: SNOW			Remarks:									
9/21/1998			21.12	2	0	1		5	5	1	23	1	0
	Sampler: SMITH			Remarks: FEC #1 AT NEW SWIMMING AREA. The Conductivity and Oxygen results are qualified as estimates due to postcalibration failing QA/QC requirements.									
9/23/1998		21.7	19	7	0	2	1	5	5	2	8	0	0
	Sampler: SNOW			Remarks: 70 DEGREES IN THE SHADE.									
9/23/1998			19		0					0	0	0	0
	Sampler: BELL-MCKINNON			Remarks:									

Appendix C

Quality Assurance/Quality Control Results for 1998

For details on procedures for evaluating QC data see Ecology's *Lake Water Quality Assessment Project Quality Assurance Project Plan* (in draft) (Hallock, 1995). This appendix is an evaluation of laboratory data in accordance with the quality assurance project plan.

Appendix C - Quality Assurance/Quality Control Results for 1998

1998 TOTAL PHOSPHOROUS DATA

TOTAL PHOSPHOROUS LAB SPLITS

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Island	06/03/98	9.6	9.9	9.8	0.21	2.18	Liberty	07/13/98	12.9	13.0	13.0	0.07	0.55
Phillips	06/03/98	11.2	12.7	12.0	1.06	8.88	Wildcat	07/24/98	5.3	5.3	5.3	0.00	0.00
Spanaway H	06/15/98	29.3	28.5	28.9	0.57	1.96	Island	07/25/98	10.1	9.2	9.7	0.64	6.59
Spanaway E	06/15/98	12.7	11.1	11.9	1.13	9.51	Phillips	07/25/98	7.0	7.9	7.5	0.64	8.54
Wildcat	06/17/98	8.0	8.4	8.2	0.28	3.45	Mason	07/26/98	3.8	3.6	3.7	0.14	3.82
				Median CV %		**3.45**	Leland	07/30/98	22.0	22.2	22.1	0.14	0.64
							Sutherland	07/30/98	4.0	1.5	2.8	1.77	64.28
											Median CV %		**3.82**
West Medical	08/11/98	2840.0	2580.0	2710.0	183.85	6.78	Leland	09/14/98	28.8	30.7	29.8	1.34	4.52
Moses	08/12/98	38.5	40.9	39.7	1.70	4.27	Crescent	09/15/98	1.5	1.5	1.5	0.00	0.00
Sutherland	08/13/98	4.1	4.4	4.3	0.21	4.99	West Medical	09/15/98	2680.0	2710.0	2695.0	21.21	0.79
Island	08/17/98	9.2	9.5	9.4	0.21	2.27	Sutherland	09/16/98	76.0	76.0	76.0	0.00	0.00
Phillips	08/17/98	7.9	7.2	7.6	0.49	6.56	Phillips	09/17/98	8.1	8.1	8.1	0.00	0.00
Wildcat	08/18/98	24.7	25.1	24.9	0.28	1.14	Mason	09/18/98	4.3	4.5	4.4	0.14	3.21
Long	08/19/98	35.0	34.0	34.5	0.71	2.05	Long	09/23/98	28.1	26.9	27.5	0.85	3.09
				Median CV %		**2.27**					**Median CV %**		**0.79**

All total phosphorous lab splits fall within the acceptable limit of median CV less than 7.5%.

TOTAL PHOSPHOROUS NONSEQUENTIAL DUPLICATES

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Island	06/02/98	8.7	9.6	9.15	0.64	7.0	West Medical	07/14/98	3000	2900	2950	70.71	2.4
Phillips	06/02/98	6.6	11.2	8.9	3.25	36.5	Wildcat	07/24/98	9.2	5.3	7.25	2.76	38.0
Mason	06/04/98	5.3	5.8	5.55	0.35	6.4	Island	07/25/98	5.2	10.1	7.65	3.46	45.3
Leland	06/05/98	17.2	14.8	16	1.70	10.6	Phillips	07/25/98	6.2	7	6.6	0.57	8.6
Crescent	06/08/98	1.5	8.2	4.85	4.74	97.7	Mason	07/26/98	3.1	3.8	3.45	0.49	14.3
Symington	06/09/98	11.7	12.8	12.25	0.78	6.3	Leland	07/30/98	15.7	22	18.85	4.45	23.6
Spanaway	06/12/98	12.8	12.7	12.75	0.07	0.6	Sutherland	07/30/98	1.5	4	2.75	1.77	64.3
Wildcat	06/16/98	6.2	8	7.1	1.27	17.9	Crescent	07/30/98	1.5	1.5	1.5	0.00	0.0
				Median CV %		**8.8**					**Median CV %**		**19.0**

Appendix C - Quality Assurance/Quality Control Results for 1998

TOTAL PHOSPHOROUS NONSEQUENTIAL DUPLICATES (continued)

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Island	08/17/98	9.6	9.2	9.4	0.28	3.0	Crescent	09/15/98	1.5	1.5	1.5	0.00	0.0
Leland	08/12/98	18.2	20.1	19.15	1.34	7.0	Leland	09/14/98	22.1	28.8	25.45	4.74	18.6
Long	08/19/98	39.3	35	37.15	3.04	8.2	Long	09/23/98	28.1	26.3	27.2	1.27	4.7
West Medical	08/11/98	2750	2840	2795	63.64	2.3	Mason	09/18/98	5.2	4.3	4.75	0.64	13.4
Phillips	08/17/98	9.3	7.9	8.6	0.99	11.5	West Medical	09/15/98	3050	2680	2865	261.63	9.1
Sutherland	08/13/98	4.4	4.1	4.25	0.21	5.0	Spanaway	09/23/98	21.3	29.2	25.25	5.59	22.1
Wildcat	08/18/98	6.8	6.6	6.7	0.14	2.1					**Median CV %**		**11.3**
				Median CV %		**5.0**							

All total phosphorous nonsequential duplicates fall within the acceptable limit of median CV less than 21%.

TOTAL PHOSPHOROUS SEQUENTIAL DUPLICATES

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
West Medical	07/14/98	3000	2900	2950	70.711	2.4
West Medical	08/11/98	2630	2840	2735	148.49	5.43
West Medical	09/15/98	2680	3880	3280	848.53	25.9
				Median CV%		**5.43**

There is no QAPP standard for total phosphorous sequential duplicates.

Appendix C - Quality Assurance/Quality Control Results for 1998

1998 TOTAL NITROGEN DATA

TOTAL NITROGEN LAB SPLITS

Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Ward	06/02/98	0.156	0.164	0.160	0.006	3.5	Liberty	07/13/98	0.236	0.245	0.241	0.006	2.6
Limerick	06/03/98	0.186	0.187	0.187	0.001	0.4	Medical	07/14/98	1.020	1.020	1.020	0.000	0.0
Crescent	06/09/98	0.005	0.005	0.005	0.000	0.0	Wildcat	07/24/98	0.176	0.166	0.171	0.007	4.1
Spanaway	06/17/98	0.818	0.817	0.818	0.001	0.1	Mason	07/26/98	0.081	0.078	0.080	0.002	2.7
Medical	06/17/98	0.822	0.826	0.824	0.003	0.3	Leland	07/30/98	0.437	0.422	0.430	0.011	2.5
				Median CV %		**0.3**	Sutherland	07/30/98	0.063	0.054	0.059	0.006	10.9
											Median CV %		**2.7**
Ward	08/10/98	0.222	0.221	0.222	0.001	0.3	Leland	09/14/98	0.570	0.550	0.560	0.014	2.5
Leland	08/10/98	0.386	0.386	0.386	0.000	0.0	Crescent	09/15/98	0.005	0.005	0.005	0.000	0.0
West Medical	08/11/98	1.280	1.330	1.305	0.035	2.7	West Medical	09/15/98	1.120	1.150	1.135	0.021	1.9
Sutherland	08/13/98	0.064	0.068	0.066	0.003	4.3	Sutherland	09/16/98	0.042	0.050	0.046	0.006	12.3
Island	08/17/98	0.180	0.177	0.179	0.002	1.2	Wildcat	09/21/98	0.189	0.176	0.183	0.009	5.0
Phillips	08/17/98	0.263	0.261	0.262	0.001	0.5	Offut	09/24/98	0.530	0.534	0.532	0.003	0.5
Wildcat	08/18/98	0.280	0.289	0.285	0.006	2.2					**Median CV %**		**2.2**
				Median CV %		**1.2**							

All total nitrogen lab splits fall within the acceptable limit of CV less than 5%.

TOTAL NITROGEN NONSEQUENTIAL DUPLICATES

Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Crescent	06/08/98	0.005	0.005	0.005	0.000	0.0	Crescent	07/30/98	0.005	0.018	0.0115	0.009	79.9
Island	06/02/98	0.216	0.191	0.2035	0.018	8.7	Island	07/25/98	0.199	0.178	0.1885	0.015	7.9
Leland	06/05/98	0.416	0.415	0.4155	0.001	0.2	Leland	07/30/98	0.371	0.437	0.404	0.047	11.6
Mason	06/04/98	0.121	0.104	0.1125	0.012	10.7	Mason	07/26/98	0.09	0.081	0.0855	0.006	7.4
Phillips	06/02/98	0.237	0.234	0.2355	0.002	0.9	West Medical	07/14/98	1.36	1.33	1.345	0.021	1.6
Symington	06/09/98	0.254	0.244	0.249	0.007	2.8	Wildcat	07/24/98	0.181	0.176	0.1785	0.004	2.0
				Median CV %		**1.9**					**Median CV %**		**7.7**

Appendix C - Quality Assurance/Quality Control Results for 1998

TOTAL NITROGEN NONSEQUENTIAL DUPLICATES (continued)

Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Island	08/17/98	0.199	0.18	0.1895	0.013	7.1	Crescent	09/15/98	0.022	0.005	0.0135	0.012	89.0
Leland	08/12/98	0.384	0.386	0.385	0.001	0.4	Leland	09/14/98	0.56	0.57	0.565	0.007	1.3
West Medical	08/11/98	1.42	1.28	1.35	0.099	7.3	Long	09/23/98	0.44	0.45	0.445	0.007	1.6
Phillips	08/17/98	0.277	0.263	0.27	0.010	3.7	West Medical	09/15/98	1.13	1.12	1.125	0.007	0.6
Sutherland	08/13/98	0.049	0.064	0.0565	0.011	18.8	Spanaway	09/23/98	0.356	0.339	0.3475	0.012	3.5
Wildcat	08/18/98	0.161	0.16	0.1605	0.001	0.4	Sutherland	09/16/98	0.052	0.042	0.047	0.007	15.0
				Median CV %		**5.4**					**Median CV %**		**2.5**

All total nitrogen nonsequential duplicates fall within the acceptable limit of CV less than 30%.

TOTAL NITROGEN SEQUENTIAL DUPLICATES

Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
West Medical	07/14/98	1.33	1.41	1.37	0.06	4.1
West Medical	08/11/98	1.28	1.31	1.295	0.02	1.6
West Medical	09/15/98	1.12	1.12	1.12	0.00	0.0
				Median CV%		**1.6**

There is no QAPP standard for total nitrogen sequential duplicates.

Appendix C - Quality Assurance/Quality Control Results for 1998

1998 CHLOROPHYLL A DATA

CHLOROPHYLL A LAB SPLITS

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Crocker	06/08/98	10.3	10.7	10.5	0.28	2.7	Moses	07/15/98	42.5	44.6	43.6	1.48	3.4
Spanaway	06/15/98	11.0	10.0	10.5	0.71	6.7	Long	07/24/98	8.2	6.8	7.5	0.99	13.2
Horseshoe	06/17/98	33.5	31.4	32.5	1.48	4.6	Spanaway	07/30/98	6.8	7.2	7.0	0.28	4.0
Moses	06/18/98	50.0	54.0	52.0	2.83	5.4	Crocker	07/30/98	42.8	41.8	42.3	0.71	1.7
				Median CV %		**5.0**					**Median CV %**		**3.7**
Horseshoe	08/10/98	24.2	23.3	23.8	0.64	2.7	West Medical	09/15/98	12.4	12.0	12.2	0.28	2.3
Moses	08/12/98	19.2	19.0	19.1	0.14	0.7	West Medical	09/15/98	11.3	11.8	11.6	0.35	3.1
Potholes	08/13/98	17.1	20.3	18.7	2.26	12.1					**Median CV %**		**2.7**
				Median CV %		**2.7**							

All chlorophyll a lab splits fall within the acceptable limit of CV less than 10%.

CHLOROPHYLL A NONSEQUENTIAL DUPLICATES

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Crescent	06/08/98	0.25	0.25	0.25	0	0.0	Island	07/25/98	3.4	3	3.2	0.283	8.8
Island	06/02/98	3.7	2.6	3.15	0.7778	24.7	Leland	07/30/98	4.6	4.4	4.5	0.141	3.1
Phillips	06/02/98	0.86	0.91	0.89	0.0354	4.0	Mason	07/26/98	0.25	0.73	0.49	0.339	69.3
Spanaway	06/12/98	11	8.8	9.9	1.5556	15.7	West Medical	07/14/98	12.3	10.6	11.45	1.202	10.5
				Median CV %		**9.9**	Wildcat	07/24/98	0.71	1.4	1.055	0.488	46.2
											Median CV %		**10.5**
Island	08/17/98	4.2	4.4	4.3	0.1414	3.3	Crescent	09/15/98	0.25	0.52	0.385	0.191	49.6
Leland	08/12/98	4.8	6.8	5.8	1.4142	24.4	Leland	09/14/98	17.5	19.4	18.45	1.344	7.3
West Medical	08/11/98	16.4	13.2	14.8	2.2627	15.3	Long	09/23/98	9.5	11.2	10.35	1.202	11.6
Wildcat	08/18/98	0.25	2.3	1.28	1.4496	113.7	West Medical	09/15/98	12.4	11.3	11.85	0.778	6.6
				Median CV %		**19.8**	Sutherland	09/16/98	1.1	0.83	0.965	0.191	19.8
											Median CV %		**11.6**

There is no QAPP standard for chlorophyll a nonsequential duplicates.

Appendix C - Quality Assurance/Quality Control Results for 1998

CHLOROPHYLL A SEQUENTIAL DUPLICATES													
Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Island	06/02/98	2.6	3.7	3.15	0.778	24.7	Island	07/25/98	3	2.9	2.95	0.071	2.4
Phillips	06/02/98	0.91	1.3	1.11	0.276	25.0	Leland	07/30/98	4.4	5.3	4.85	0.636	13.1
Spanaway	06/12/98	8.8	10.2	9.5	0.990	10.4	Mason	07/26/98	0.73	0.25	0.49	0.339	69.3
				Median CV %		**24.7**	West Medical	07/14/98	10.6	10.4	10.5	0.141	1.3
							Wildcat	07/24/98	1.4	1.2	1.3	0.141	10.9
											Median CV %		**10.9**
Island	08/17/98	4.4	4.8	4.6	0.283	6.1	Crescent	09/15/98	0.52	0.25	0.385	0.191	49.6
Leland	08/12/98	6.8	5.6	6.2	0.849	13.7	Leland	09/14/98	19.4	33.5	26.45	9.970	37.7
West Medical	08/11/98	13.2	13.8	13.5	0.424	3.1	Long	09/23/98	11.2	12	11.6	0.566	4.9
				Median CV %		**6.1**	West Medical	09/15/98	11.3	12.7	12	0.990	8.2
							Sutherland	09/16/98	0.83	0.72	0.775	0.078	10.0
											Median CV %		**10.0**

August and September data are within the acceptable limit of 10% median CV. June, and July data exceed 10%, failing QAPP requirements.

Appendix C - Quality Assurance/Quality Control Results for 1998

1998 TURBIDITY DATA

TURBIDITY LAB SPLITS									
Lake	Date	#1 (NTU)	#2 (NTU)	Difference	Lake	Date	#1 (NTU)	#2 (NTU)	Difference
Ward	06/02/98	0.6	0.5	0.1	Liberty	07/13/98	0.8	0.9	0.1
Island	06/03/98	0.8	0.8	0.0	Medical	07/14/98	4.8	4.8	0.0
Limerick	06/05/98	0.9	1.0	0.1	Moses	07/15/98	10.0	10.0	0.0
Leland	06/08/98	1.0	1.0	0.0	Potholes	07/16/98	5.5	5.4	0.1
Sutherland	06/09/98	0.25	0.25	0.0	Ward	07/24/98	1.3	1.2	0.1
Wildcat	06/10/98	1.2	1.2	0.0	Mason	07/26/98	0.25	0.25	0.0
Long	06/11/98	1.7	1.6	0.1	Limerick	07/27/98	1.3	1.3	0.0
Spanaway	06/15/98	1.6	1.6	0.0	Symington	07/28/98	1.2	1.2	0.0
Wildcat	06/17/98	0.5	0.5	0.0	Spanaway	07/30/98	1.5	1.4	0.1
Moses	06/18/98	13.0	13.0	0.0			**Maximum difference**		**0.1**
Potholes	06/19/98	2.3	2.5	0.2					
		Maximum difference =		**0.2**					
Ward	08/10/98	0.6	0.6	0.0	Horseshoe	09/14/98	0.7	0.7	0.0
Moses	08/12/98	7.9	7.7	0.2	West Medical	09/15/98	0.8	0.9	0.1
Sutherland	08/13/98	0.25	0.25	0.0	Moses	09/16/98	3.0	2.6	0.4
Symington	08/17/98	2.0	2.0	0.0	Phillips	09/17/98	0.9	0.9	0.0
Wildcat	08/18/98	0.6	0.6	0.0	Limerick	09/18/98	0.8	0.8	0.0
Spanaway	08/19/98	1.5	1.6	0.1	Symington	09/21/98	1.8	1.8	0.0
		Maximum difference =		**0.2**	Spanaway	09/23/98	1.5	1.3	0.2
					Ward	09/24/98	0.6	0.6	0.0
							Maximum difference		**0.4**

All turbidity splits are within 0.5 NTU and are considered acceptable.

Appendix C - Quality Assurance/Quality Control Results for 1998

TURBIDITY NONSEQUENTIAL DUPLICATES							
Lake	Date	#1 (NTU)	#2 (NTU)	Difference	Mean	S	CV%
Leland	06/05/98	1	1.1	0.1	1.05	0.1	01/06/00
						Median CV %	**01/06/00**
Leland	08/12/98	1.3	1.3	0	1.3	0.0	01/00/00
						Median CV %	**01/00/00**
Leland	09/14/98	2.1	2.1	0	2.1	0.0	01/00/00
						Median CV %	**01/00/00**

There are no QAPP requirements for turbidity nonsequential duplicates.

Appendix D

Hydrolab® Quality Assurance/Quality Control Results for 1998

For details on procedures for evaluating hydrolab® QC data see Ecology's *Lake Water Quality Assessment Project Quality Assurance Project Plan* (in draft) (Hallock, 1995) or see the hydrolab® post-calibration results of any prior Ecology lake water quality assessment program annual report.

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

HYDROLAB POSTCALIBRATION DATA FOR 1998

Date	Postcalibration for	DO field check	pH 7	pH 10	K	T	DO calibration
6/2/1998	Ward, Offut	P	P	P	--	--	--
6/4/1998	Wildcat, Phillips	P	P	P	--	--	--
6/5/1998	Limerick, Mason	F	P	P	--	--	P
6/8/1998	Crocker, Leland	P	P	--	--	--	P
6/10/1998	Symington	P	P	P	--	--	P
6/12/1998	Long, Wildcat	P	P	P	--	--	--
6/16/1998	Spanaway	F	P	P	P	P	P
6/16/1998	Liberty, Horseshoe	--	P	P	--	--	P
6/17/1998	Medical, West Medical	--	P	P	--	--	P
6/18/1998	Moses	--	P	P	--	--	P
6/18/1998	Potholes	--	P	P	--	--	P
7/14/1998	Liberty	P	P	P	--	--	P
7/14/1998	Medical, West Medical	--	P	P	--	--	P
7/16/1998	Moses	P	P	P	--	--	P
7/16/1998	Potholes	P	P	P	--	--	P
7/25/1998	Long, Wildcat	F	P	P	--	--	P
7/26/1998	Island, Phillips	--	P	P	--	--	P
7/27/1998	Mason	--	P	P	--	--	P
7/28/1998	Limerick	--	P	P	--	--	P
7/30/1998	Symington	--	P	P	--	--	P
7/31/1998	Spanaway, Leland, Crocker	--	P	P	--	--	P
8/4/1998	Sutherland, Crescent	--	P	P	P	P	P
8/11/1998	Liberty, Horseshoe	--	P	P	--	--	P
8/12/1998	Medical, West Medical	--	P	P	--	--	P
8/12/1998	Ward, Offut	--	P	P	P	P	P
8/13/1998	Leland, Crocker	P	P	P	--	--	P
8/13/1998	Moses	--	P	P	--	--	P
8/17/1998	Crescent, Sutherland	--	P	P	--	--	P
8/18/1998	Island, Phillips, Symington	--	P	P	--	--	--
8/19/1998	Wildcat, Mason, Limerick	--	F	F	--	--	P
9/14/1998	Steilacoom	--	P	P	--	--	P
9/15/1998	Leland, Crocker	--	P	P	--	--	F
9/15/1998	Liberty, Horseshoe	--	P	P	--	--	P
9/16/1998	Medical, West Medical	--	P	P	--	--	P
9/16/1998	Crescent	--	P	P	--	--	F
9/17/1998	Sutherland	--	P	P	--	--	F
9/17/1998	Moses, Potholes	--	P	P	--	--	P
9/18/1998	Island, Phillips	--	P	P	--	--	P
9/21/1998	Mason, Limerick	--	P	P	--	--	P
9/23/1998	Wildcat, Symington	P	P	P	--	--	F
9/24/1998	Long, Spanaway	--	P	P	--	--	F
########	Offut, Ward	--	P	P	F	P	P

P = Passes QA/QC requirements
F = Fails QA/QC requirements
-- = No postcalibration done

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

1998 DISSOLVED OXYGEN HYDROLAB DATA

DO NONSEQUENTIAL DUPLICATES													
Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Island	0	9.75	10.11	9.93	0.254558	2.56	W. Medical	0	8.07	7.72	7.895	0.247487	3.13
6/2/1998	1	9.73	9.88	9.805	0.106066	1.08	7/14/1998	1	7.9	7.96	7.93	0.042426	0.54
	2	9.79	9.96	9.875	0.120208	1.22		2	7.27	7.97	7.62	0.494975	6.50
	3	9.87	10.02	9.945	0.106066	1.07		4	4.63	7.43	6.03	1.979899	32.83
	4	10.02	10.14	10.08	0.084853	0.84		5	1.12	3.08	2.1	1.385929	66.00
	5	9.98	10.22	10.1	0.169706	1.68		6	0.48	0.58	0.53	0.070711	13.34
Spanaway	0	11.61	11.09	11.35	0.367696	3.24		7	0.16	0.24	0.2	0.056569	28.28
6/12/1998	1	11.6	10.94	11.27	0.46669	4.14		8	0.15	0.18	0.165	0.021213	12.86
	2	11.61	11.16	11.39	0.318198	2.79	Island	0	8.39	8.81	8.6	0.296985	3.45
	3	16.45	15.19	15.82	0.890955	5.63	7/25/1998	1	8.47	8.41	8.44	0.042426	0.50
	4	15.29	15.35	15.32	0.042426	0.28		2	8.63	8.37	8.5	0.183848	2.16
	5	8.94	11.15	10.05	1.562706	15.56		3	8.48	8.4	8.44	0.056569	0.67
	6	3.41	2.11	2.76	0.919239	33.31		4	8.5	8.52	8.51	0.014142	0.17
				Median	**CV%**	**2.56**		5	8.88	8.98	8.93	0.070711	0.79
							Leland	1	7.64	7.9	7.77	0.183848	2.37
							7/30/1998	3	0.57	3.24	1.905	1.887975	99.11
											Median	**CV%**	**3.29**
W. Medical	0	9.05	9.31	9.18	0.183848	2.00	W. Medical	0	9.39	10.3	9.845	0.643467	6.54
8/11/1998	1	8.9	9.29	9.095	0.275772	3.03	9/15/1998	1	10.15	9.92	10.04	0.162635	1.62
	2	8.98	9.04	9.01	0.042426	0.47		2	9.47	9.35	9.41	0.084853	0.90
	3	8.85	8.65	8.75	0.141421	1.62		3	8.89	9.22	9.055	0.233345	2.58
	4	8.6	8.53	8.565	0.049497	0.58		4	8.02	8.46	8.24	0.311127	3.78
	5	5.08	2.83	3.955	1.59099	40.23		5	6.92	8.91	7.915	1.407142	17.78
	6	0.36	0.41	0.385	0.035355	9.18		6	4.09	6.72	5.405	1.859691	34.41
	7	0.21	0.2	0.205	0.007071	3.45		7	0.19	0.21	0.2	0.014142	7.07
	8	0.19	0.17	0.18	0.014142	7.86		8	0.18	0.16	0.17	0.014142	8.32
Island	0	7.79	8.06	7.925	0.190919	2.41	Phillips	1	8.61	8.92	8.765	0.219203	2.50
8/17/1998	1	7.75	7.96	7.855	0.148492	1.89	9/17/1998	4	8.51	8.82	8.665	0.219203	2.53
	2	7.74	7.94	7.84	0.141421	1.80					**Median**	**CV%**	**3.78**
	3	7.73	7.85	7.79	0.084853	1.09							
	4	7.71	7.83	7.77	0.084853	1.09							
	5	7.78	7.75	7.765	0.021213	0.27							
				Median	**CV%**	**1.89**							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

DO SEQUENTIAL DUPLICATES

Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Island	0	10.11	9.39	9.75	0.509117	5.22	W. Medical	0	7.72	7.67	7.695	0.035355	0.46
6/2/1998	1	9.88	9.56	9.72	0.226274	2.33	7/14/1998	1	7.96	7.8	7.88	0.113137	1.44
	2	9.96	9.73	9.845	0.162635	1.65		2	7.97	7.93	7.95	0.028284	0.36
	3	10.02	9.89	9.955	0.091924	0.92		4	7.43	7.52	7.475	0.06364	0.85
	4	10.14	10.04	10.09	0.070711	0.70		5	3.08	2.96	3.02	0.084853	2.81
	5	10.22	10.09	10.16	0.091924	0.91		6	0.58	0.32	0.45	0.183848	40.86
Spanaway	0	11.09	10.27	10.68	0.579828	5.43		7	0.24	0.22	0.23	0.014142	6.15
6/12/1998	1	10.94	10.67	10.81	0.190919	1.77		8	0.18	0.17	0.175	0.007071	4.04
	2	11.16	11.65	11.41	0.346482	3.04	Island	0	8.81	8.22	8.515	0.417193	4.90
	3	15.19	14.21	14.7	0.692965	4.71	7/25/1998	1	8.41	8.29	8.35	0.084853	1.02
	4	15.35	14.18	14.77	0.827315	5.60		2	8.37	8.29	8.33	0.056569	0.68
	5	11.15	8.24	9.695	2.057681	21.22		3	8.4	8.28	8.34	0.084853	1.02
	6	2.11	1.94	2.025	0.120208	5.94		4	8.52	8.37	8.445	0.106066	1.26
				Median	**CV%**	**3.04**		5	8.98	8.67	8.825	0.219203	2.48
							Leland	1	7.9	7.68	7.79	0.155563	2.00
							7/30/1998	3	3.24	3.73	3.485	0.346482	9.94
											Median	**CV%**	**1.72**
Island	0	8.06	7.91	7.985	0.106066	1.32832	Long	0	7.78	7.64	7.71	0.098995	1.284
8/17/1998	1	7.96	7.85	7.905	0.077782	0.98396	9/23/1998				**Median**	**CV%**	**1.28**
	2	7.94	7.84	7.89	0.070711	0.89621							
	3	7.85	7.89	7.87	0.028284	0.35939							
	4	7.83	7.71	7.77	0.084853	1.09206							
	5	7.75	7.68	7.715	0.049497	0.64157							
				Median	**CV%**	**0.94**							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

1998 PH HYDROLAB DATA

PH NONSEQUENTIAL DUPLICATES													
Lake	Depth	#1	#2	Mean	S	CV%	Lake	Depth	#1	#2	Mean	S	CV%
Island	0	7.77	7.26	7.515	0.360624	4.80	W. Medical	0	9	9	9	0	0.00
6/2/1998	1	7.77	7.38	7.575	0.275772	3.64	7/14/1998	1	9	9	9	0	0.00
	2	7.75	7.45	7.6	0.212132	2.79		2	9	9	9	0	0.00
	3	7.75	7.5	7.625	0.176777	2.32		4	8.9	9	8.95	0.070711	0.79
	4	7.76	7.54	7.65	0.155563	2.03		5	8.6	8.8	8.7	0.141421	1.63
	5	7.72	7.46	7.59	0.183848	2.42		6	8.5	8.5	8.5	0	0.00
Spanaway	0	8.95	8.93	8.94	0.014142	0.16		7	8.2	8.2	8.2	0	0.00
6/12/1998	1	8.98	8.96	8.97	0.014142	0.16		8	8	8	8	0	0.00
	2	8.97	8.97	8.97	0	0.00	Island	0	7.5	7.4	7.45	0.070711	0.95
	3	8.19	8.47	8.33	0.19799	2.38	7/25/1998	1	7.5	7.5	7.5	0	0.00
	4	7.32	7.99	7.655	0.473762	6.19		2	7.5	7.5	7.5	0	0.00
	5	6.69	7.29	6.99	0.424264	6.07		3	7.5	7.5	7.5	0	0.00
	6	6.44	6.43	6.435	0.007071	0.11		4	7.5	7.5	7.5	0	0.00
				Median CV%		**2.38**		5	7.5	7.7	7.6	0.141421	1.86
							Leland	1	7.3	7.5	7.4	0.141421	1.91
							7/30/1998	3	6.5	6.7	6.6	0.141421	2.14
											Median CV%		**0.00**
W. Medical	0	9.1	9.1	9.1	0	0.00	W. Medical	0	9.1	9.1	9.1	0	0.00
8/11/1998	1	9.1	9.1	9.1	0	0.00	9/15/1998	1	9.1	9.1	9.1	0	0.00
	2	9.1	9.1	9.1	0	0.00		2	9.1	9.1	9.1	0	0.00
	3	9.1	9.1	9.1	0	0.00		3	9.1	9.1	9.1	0	0.00
	4	9.1	9.1	9.1	0	0.00		4	9.1	9.1	9.1	0	0.00
	5	9	8.9	8.95	0.070711	0.79		5	9	9.1	9.05	0.070711	0.78
	6	8.6	8.7	8.65	0.070711	0.82		6	9	9	9	0	0.00
	7	8.3	8.3	8.3	0	0.00		7	8.7	8.8	8.75	0.070711	0.81
	8	8.1	8	8.05	0.070711	0.88		8	8.1	7.9	8	0.141421	1.77
Island	0	7.4	7.1	7.25	0.212132	2.93	Phillips	1	7.1	7.5	7.3	0.282843	3.87
8/17/1998	1	7.4	7.1	7.25	0.212132	2.93	9/17/1998	4	7.1	7.4	7.25	0.212132	2.93
	2	7.4	7.1	7.25	0.212132	2.93					**Median CV%**		**0.00**
	3	7.4	7.1	7.25	0.212132	2.93							
	4	7.3	7.1	7.2	0.141421	1.96							
	5	7.3	7.1	7.2	0.141421	1.96							
				Median CV%		**0.82**							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

PH SEQUENTIAL DUPLICATES

Lake	Depth	#1	#2	Mean	S	CV%	Lake	Depth	#1	#2	Mean	S	CV%
Island	0	7.26	7.79	7.525	0.374767	4.98	W. Medical	0	9	9	9	0	0.00
6/2/1998	1	7.38	7.78	7.58	0.282843	3.73	7/14/1998	1	9	9	9	0	0.00
	2	7.45	7.78	7.615	0.233345	3.06		2	9	9.1	9.05	0.070711	0.78
	3	7.5	7.77	7.635	0.190919	2.50		4	9	9	9	0	0.00
	4	7.54	7.72	7.63	0.127279	1.67		5	8.8	8.8	8.8	0	0.00
	5	7.46	7.64	7.55	0.127279	1.69		6	8.5	8.5	8.5	0	0.00
Spanaway	0	8.93	8.92	8.925	0.007071	0.08		7	8.2	8.2	8.2	0	0.00
6/12/1998	1	8.96	8.97	8.965	0.007071	0.08		8	8	8	8	0	0.00
	2	8.97	8.91	8.94	0.042426	0.47	Island	0	7.4	7.3	7.35	0.070711	0.96
	3	8.47	8.53	8.5	0.042426	0.50	7/25/1998	1	7.5	7.4	7.45	0.070711	0.95
	4	7.99	8.02	8.005	0.021213	0.26		2	7.5	7.4	7.45	0.070711	0.95
	5	7.29	7.24	7.265	0.035355	0.49		3	7.5	7.4	7.45	0.070711	0.95
	6	6.43	6.42	6.425	0.007071	0.11		4	7.5	7.4	7.45	0.070711	0.95
				Median CV%		**0.50**		5	7.7	7.6	7.65	0.070711	0.92
							Leland	1	7.5	7.2	7.35	0.212132	2.89
							7/30/1998	3	6.7	6.8	6.75	0.070711	1.05
											Median CV%		**0.85**
Island	0	7.1	7.1	7.1	0	0.00	Long	0	7.9	7.9	7.9	0	0.00
8/17/1998	1	7.1	7.1	7.1	0	0.00	9/23/1998				**Median CV%**		**0.00**
	2	7.1	7.1	7.1	0	0.00							
	3	7.1	7.1	7.1	0	0.00							
	4	7.1	7.1	7.1	0	0.00							
	5	7.1	7.1	7.1	0	0.00							
				Median CV%		**0.00**							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

1998 TEMPERATURE HYDROLAB DATA

TEMPERATURE NONSEQUENTIAL DUPLICATES													
Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%	Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%
Island	0	17.24	17.34	17.29	0.070711	0.41	W. Medical	0	22	22.2	22.1	0.141421	0.64
6/2/1998	1	17.12	17.03	17.075	0.06364	0.37	7/14/1998	1	21.9	22.1	22	0.141421	0.64
	2	17.03	16.98	17.005	0.035355	0.21		2	21.8	21.8	21.8	0	0.00
	3	16.98	16.93	16.955	0.035355	0.21		4	20.9	21.7	21.3	0.565685	2.66
	4	16.85	16.76	16.805	0.06364	0.38		5	19.3	20	19.65	0.494975	2.52
	5	16.19	15.99	16.09	0.141421	0.88		6	17.2	16.6	16.9	0.424264	2.51
Spanaway	0	19.37	19.46	19.415	0.06364	0.33		7	14.4	14.2	14.3	0.141421	0.99
6/12/1998	1	19.06	19.34	19.2	0.19799	1.03		8	12.8	12.3	12.55	0.353553	2.82
	2	18.77	18.96	18.865	0.13435	0.71	Island	0	23	23.5	23.25	0.353553	1.52
	3	16.51	17	16.755	0.346482	2.07	7/25/1998	1	22.8	22.9	22.85	0.070711	0.31
	4	14.82	15.14	14.98	0.226274	1.51		2	22.6	22.8	22.7	0.141421	0.62
	5	13.51	13.01	13.26	0.353553	2.67		3	22.6	22.6	22.6	0	0.00
	6	12.4	12.24	12.32	0.113137	0.92		4	22.5	22.5	22.5	0	0.00
				Median CV%		**0.71**		5	21.5	21.9	21.7	0.282843	1.30
							Leland	1	25.4	26	25.7	0.424264	1.65
							7/30/1998	3	20.7	21.2	20.95	0.353553	1.69
											Median CV%		**1.15**
W. Medical	0	24.1	24.3	24.2	0.141421	0.58	W. Medical	0	21	21.1	21.05	0.070711	0.34
8/11/1998	1	23.7	24.1	23.9	0.282843	1.18	9/15/1998	1	20.6	20.7	20.65	0.070711	0.34
	2	23.7	23.9	23.8	0.141421	0.59		2	20.5	20.6	20.55	0.070711	0.34
	3	23.6	23.7	23.65	0.070711	0.30		3	20.3	20.5	20.4	0.141421	0.69
	4	23.6	23.6	23.6	0	0.00		4	20.2	20.3	20.25	0.070711	0.35
	5	22.9	22.3	22.6	0.424264	1.88		5	20.1	20.1	20.1	0	0.00
	6	19.4	20.6	20	0.848528	4.24		6	20	20	20	0	0.00
	7	16.1	16.6	16.35	0.353553	2.16		7	18.9	19.2	19.05	0.212132	1.11
	8	13.3	12.9	13.1	0.282843	2.16		8	15.6	15	15.3	0.424264	2.77
Island	0	22.6	22.6	22.6	0	0.00	Phillips	1	22	21.8	21.9	0.141421	0.65
8/17/1998	1	22.7	22.6	22.65	0.070711	0.31	9/17/1998	4	21.6	21.6	21.6	0	0.00
	2	22.6	22.6	22.6	0	0.00					**Median CV%**		**0.34**
	3	22.6	22.5	22.55	0.070711	0.31							
	4	22.6	22.5	22.55	0.070711	0.31							
	5	22.6	22.5	22.55	0.070711	0.31							
				Median CV%		**0.31**							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

TEMPERATURE SEQUENTIAL DUPLICATES

Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%	Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%
Island	0	17.34	17.29	17.315	0.035355	0.20	W. Medical	0	22.2	22.2	22.2	0	0.00
6/2/1998	1	17.03	17.08	17.055	0.035355	0.21	7/14/1998	1	22.1	22.1	22.1	0	0.00
	2	16.98	16.97	16.975	0.007071	0.04		2	21.8	21.8	21.8	0	0.00
	3	16.93	16.93	16.93	0	0.00		4	21.7	21.6	21.65	0.070711	0.33
	4	16.76	16.59	16.675	0.120208	0.72		5	20	19.8	19.9	0.141421	0.71
	5	15.99	16.04	16.015	0.035355	0.22		6	16.6	16.3	16.45	0.212132	1.29
Spanaway	0	19.46	19.56	19.51	0.070711	0.36		7	14.2	14.1	14.15	0.070711	0.50
6/12/1998	1	19.34	19.46	19.4	0.084853	0.44		8	12.3	12.4	12.35	0.070711	0.57
	2	18.96	18.87	18.915	0.06364	0.34	Island	0	23.5	23.6	23.55	0.070711	0.30
	3	17	17.13	17.065	0.091924	0.54	7/25/1998	1	22.9	23	22.95	0.070711	0.31
	4	15.14	15.17	15.155	0.021213	0.14		2	22.8	22.9	22.85	0.070711	0.31
	5	13.01	13.11	13.06	0.070711	0.54		3	22.6	22.7	22.65	0.070711	0.31
	6	12.24	12.24	12.24	0	0.00		4	22.5	22.5	22.5	0	0.00
				Median CV%		**0.22**		5	21.9	22	21.95	0.070711	0.32
							Leland	1	26	26	26	0	0.00
							7/30/1998	3	21.2	21.4	21.3	0.141421	0.66
											Median CV%		**0.31**
Island	0	22.6	22.6	22.6	0	0.00	Long	0	20.3	21	20.65	0.494975	2.40
8/17/1998	1	22.6	22.6	22.6	0	0.00	9/23/1998				**Median CV%**		**2.40**
	2	22.6	22.6	22.6	0	0.00							
	3	22.5	22.5	22.5	0	0.00							
	4	22.5	22.5	22.5	0	0.00							
	5	22.5	22.5	22.5	0	0.00							
				Median CV%		**0.00**							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

1998 CONDUCTIVITY HYDROLAB DATA

CONDUCTIVITY NONSEQUENTIAL DUPLICATES													
Lake	Depth	#1 (uS/cm	#2 (uS/cm	Mean	S	CV%	Lake	Depth	#1 (uS/cm	#2 (uS/cm	Mean	S	CV%
Island	0	40.8	40.8	40.8	0	0.00	W. Medical	0	817	820	818.5	2.12132	0.26
6/2/1998	1	40.8	40.7	40.75	0.070711	0.17	7/14/1998	1	818	820	819	1.414214	0.17
	2	40.8	40.7	40.75	0.070711	0.17		2	818	820	819	1.414214	0.17
	3	40.8	40.7	40.75	0.070711	0.17		4	818	822	820	2.828427	0.34
	4	40.6	40.6	40.6	0	0.00		5	823	818	820.5	3.535534	0.43
	5	40.2	40.5	40.35	0.212132	0.53		6	827	824	825.5	2.12132	0.26
Spanaway	0	107.1	105.9	106.5	0.848528	0.80		7	833	842	837.5	6.363961	0.76
6/12/1998	1	107.2	107.2	107.2	0	0.00		8	836	844	840	5.656854	0.67
	2	106.9	106.8	106.85	0.070711	0.07	Island	1	42	42	42	0	0.00
	3	106.6	106.2	106.4	0.282843	0.27	7/25/1998	2	42	42	42	0	0.00
	4	110.7	109.3	110	0.989949	0.90		3	42	42	42	0	0.00
	5	113	117.2	115.1	2.969848	2.58		4	42	42	42	0	0.00
	6	118.3	125.7	122	5.23259	4.29		5	42	42	42	0	0.00
				Median CV%		**0.17**	Leland	1	64	64	64	0	0.00
							7/30/1998	3	66	71	68.5	3.535534	5.16
											Median CV%		**0.17**
8/11/1998	1	865	866	865.5	0.707107	0.08	9/15/1998	1	872	870	871	1.414214	0.16
	2	866	866	866	0	0.00		2	869	871	870	1.414214	0.16
	3	867	866	866.5	0.707107	0.08		3	869	870	869.5	0.707107	0.08
	4	867	867	867	0	0.00		4	869	871	870	1.414214	0.16
	5	869	868	868.5	0.707107	0.08		5	872	871	871.5	0.707107	0.08
	6	873	864	868.5	6.363961	0.73		6	874	872	873	1.414214	0.16
	7	879	870	874.5	6.363961	0.73		7	883	879	881	2.828427	0.32
	8	896	915	905.5	13.43503	1.48		8	935	946	940.5	7.778175	0.83
Island	0	45	45	45	0	0.00	Phillips	1	26	27	26.5	0.707107	2.67
8/17/1998	1	45	45	45	0	0.00	9/17/1998	4	27	27	27	0	0.00
	2	45	45	45	0	0.00					**Median CV%**		**0.16**
	3	45	45	45	0	0.00							
	4	45	45	45	0	0.00							
	5	45	45	45	0	0.00							
				Median CV%		**0.00**							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1998

CONDUCTIVITY SEQUENTIAL DUPLICATES

Lake	Depth	#1 (uS/cm	#2 (uS/cm	Mean	S	CV%	Lake	Depth	#1 (uS/cm	#2 (uS/cm	Mean	S	CV%
Island	0	40.8	40.8	40.8	0	0.00	W. Medical	0	820	819	819.5	0.707107	0.09
6/2/1998	1	40.7	40.6	40.65	0.070711	0.17	7/14/1998	1	820	817	818.5	2.12132	0.26
	2	40.7	40.7	40.7	0	0.00		2	820	814	817	4.242641	0.52
	3	40.7	40.6	40.65	0.070711	0.17		4	822	824	823	1.414214	0.17
	4	40.6	40.6	40.6	0	0.00		5	818	826	822	5.656854	0.69
	5	40.5	40.4	40.45	0.070711	0.17		6	824	820	822	2.828427	0.34
Spanaway	0	105.9	107.2	106.55	0.919239	0.86		7	842	841	841.5	0.707107	0.08
6/12/1998	1	107.2	107.2	107.2	0	0.00		8	844	858	851	9.899495	1.16
	2	106.8	107	106.9	0.141421	0.13	Island	1	42	42	42	0	0.00
	3	106.2	106.2	106.2	0	0.00	7/25/1998	2	42	42	42	0	0.00
	4	109.3	110.2	109.75	0.636396	0.58		3	42	42	42	0	0.00
	5	117.2	116.1	116.65	0.777817	0.67		4	42	42	42	0	0.00
	6	125.7	125.2	125.45	0.353553	0.28		5	42	42	42	0	0.00
				Median CV%		**0.17**		1	64	64	64	0	0.00
							Leland	3	71	70	70.5	0.707107	1.00
							7/30/1998				**Median CV%**		**0.09**
Island	0	45	45	45	0	0.00	Long	0	98	98	98	0	0.00
8/17/1998	1	45	45	45	0	0.00	9/23/1998				**Median CV%**		**0.00**
	2	45	45	45	0	0.00							
	3	45	45	45	0	0.00							
	4	45	45	45	0	0.00							
	5	45	45	45	0	0.00							
				Median CV%		**0.00**							