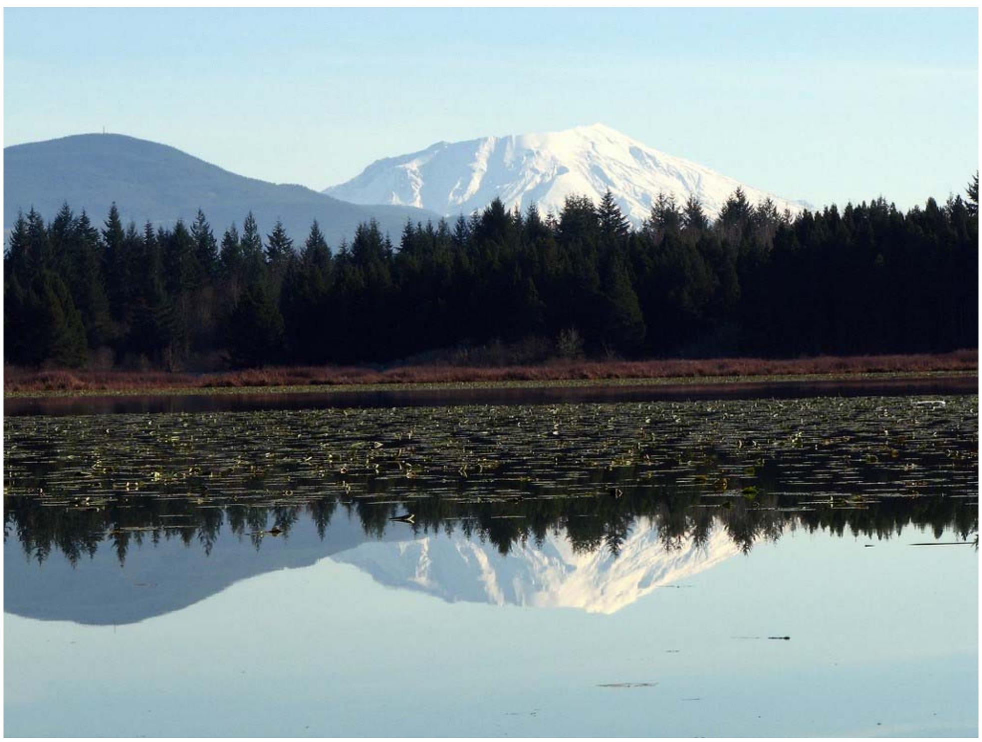
Quality Assurance Project Plan

Silver Lake

Grant ID: WQC-2015-CwCoHH-00129

Grant Name: Water Quality Testing & Improvement at Two Cowlitz County Lakes



Date: August 2015
For: Washington State Department of Ecology
By: Hilarie Larson, REHS/RS

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What is - Quality Assurance Project Plan?

"The Quality Assurance Plan (QAPP) outlines the procedures a monitoring project will use to ensure that the sample participants collect and analyze the data they store and manage, and the reports they write are of high enough quality to meet project needs." (*The Volunteer Monitor's Guide to Quality Assurance Project Plans*, US EPA 1996). This lake-specific QAPP addresses monitoring activities pertaining to Silver Lake, one of two lakes included in the project titled, "Water Quality Testing and Improvement at Two Cowlitz County Lakes." A QAPP for the second lake, Horseshoe Lake, is covered under a separate document.

Project Funding

This project has been funded, in part, by the United States Environmental Agency under an assistance agreement to the Washington State Department of Ecology (Ecology). The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use. This project is also financially supported by Cowlitz County, and is dependent on volunteer contributions from Silver Lake Watershed Advisory Council (SLWAC) and Horseshoe Lake Management Committee (HSMC).

1.0 Title Page, Table of Contents, and Distribution List

Quality Assurance Project Plan

Silver Lake - Water Quality Testing & Improvement at Two Cowlitz County Lakes

August 2015

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2.0 Abstract

Water Quality at Silver Lake in Washington State is one of two projects included in Water Quality Testing and Improvement at Two Cowlitz County Lakes, a program funded by an Ecology grant awarded to Cowlitz County Health Department (CCHD). The long term goal is to improve the water quality of two major lakes in Cowlitz County for the public's health and recreational benefit by minimizing the health risks posed by toxic algae growth events and controlling non-native noxious weeks that limit the recreational potential of each lake.

The first objective is to establish a reliable data bank with a sufficient number of data points to enable future evaluation and long term planning actions to improve the water quality of Silver Lake. This ambient water quality monitoring program includes a two-year period of record with a completion goal of December, 2017. The study-target includes 5 sampling sites for total phosphorus and chlorophyll *a*, and 6 sampling sites for *Escherichia coli (E. coli*). Three of the deepest locations will be accompanied by Secchi depth readings and in situ testing for temperature, pH, conductivity, dissolved oxygen, and turbidity. Carlson's Trophic State Index (1977) will be calculated and a trophic state estimation of the lake will be made using total phosphorus, chlorophyll *a*, and Secchi depth. In addition, a sample for two blue green algae toxins will take place weekly at one location for twelve weeks from mid-June to mid-September. Also, supporting weekly data regarding lake conditions will be collected.

Another objective is to encourage local discussion and improve understanding of how individuals can have a positive effect on their lake water quality. This will be accomplished through the creation of a public web site, and conducting public educational meetings.

The outcome of the project will be a reliable data bank for each lake presented in a usable format and publically displayed so that water quality professionals and stakeholders can later analyze it to help plan long-term mitigation, education, and restoration efforts.

3.0 Background

3.1 Study area and surroundings

Silver Lake is an important regional water resource located in southwestern Washington near Castle Rock and Toutle in Cowlitz County, with reports of eutrophication since the 1970s. The 1,650-acre lake is one of the few warm water reservoirs in Washington State, with a maximum depth of 8 feet and a mean depth of 5 feet (KCM, 1998). It offers spectacular views of both Mount St. Helens and Mt. Rainer, and water activities such as swimming, water-skiing, motor boating, bird watching, fishing, as well as camping near its shores. The Mount St. Helens Visitor Center and Seaquest State Park are located adjacent to Silver Lake and are extremely popular attractions. Many tourists continue up route 504, past Silver Lake to visit the Forest Learning Center and Johnston Ridge Observatory.

The lake lies in the center of a depression in the western Cascade foothills. Silver Lake watershed includes approximately 26,000 acres (Figure 1. Silver Lake Watershed). Low rolling hills border the lake to the north, south, and west side, while the east side is a flat plain. Elevation ranges from 486 feet at the lake to 2,000 feet at the ridgetop. The major tributaries to the lake are Sucker Creek, which enters at the southwest corner of the lake, and Hemlock Creek, which enters on the southeast corner. Several unnamed tributaries enter on the south and west sides of the lake. The lake discharges to Outlet Creek, which flows out of the east side of the lake (Bhagat, 1975).

The climate of the Silver Lake watershed is controlled mainly by the prevailing westerly winds from the Pacific Ocean. The area is characterized by cool summers and mild, wet winters. The average January temperature is 38 degrees F, and the average July temperature is 63.5 degrees F. Average annual precipitation for the watershed is 62 inches, with most precipitation occurring as rainfall between October and March (Bhagat, 1975).

Silver Lake contains spiny ray fish (perch, crappie, catfish, bass, bluegill, pumpkinseed), rainbow trout, and brown bullhead. Small animals in the watershed include beaver, ducks, and geese. Large animals include black bear and deer. Principal tree species are Douglas fir, red alder, western red cedar, big leaf maple, western hemlock, black cottonwood, Oregon white oak, cascara, and Oregon ash. Plants include salal, salmonberry, swordfern, blackenfern, vine maple, elderberry, hazel, evergreen blackberry and willow (Call, 1974).

3.1.1 Logistical problems

No logistical problems are anticipated. The lake is easily accessible via state route 504. Inclement weather could interfere with sampling events, but should be of short enough duration to reschedule within the same month.

3.1.2 History of study area

As described in Silver Lake Watershed Management Plan, Silver Lake was formed about 2,500 years ago when very large mudflows, caused by the catastrophic draining of a lake or lakes that had been dammed by debris, avalanched from nearby volcanic Mount St. Helens. The mudflows deposited into Outlet Creek, damned up its valley, and formed Silver Lake. The resulting dam did not allow efficient drainage of the lake, and lake levels were known to fluctuate greatly. In response to concerns regarding loss of shorefront property, property damage, and flooding septic systems, citizens initiated a study to explore the feasibility of installing a water level control structure on Outlet Creek. In October, 1971, sufficient funding was obtained and such a structure was installed. Since then, several extensive studies have been conducted (see Appendix A, A-1 Timeline for Silver Lake Documents and Activities).

Within two years, excessive weed growth was observed in the lake. Concerns arose over the loss of recreational opportunities due to accelerated weed growth. In 1975, Washington State University completed a study (Bhagat, 1975) of lake eutrophication to help determine problems and explore possible solutions. Key points included:

1) At least 50% of the inflow of nutrients were retained in the lake.
2) Hemlock Creek contributed more than 33% of the total annual nitrogen inflow and 45% of the phosphorus.
3) Private septic systems contributed significant phosphorus but should be reduced by the recent installation of a public sewer system.

The study recommended selective harvesting of aquatic plants, short-circuiting or by-passing Hemlock Creek flows, lake-level management, nutrient reduction from adjacent land use activities, and controlling the input of nutrients from septic systems as the practical and economical means to control the excessive growth of aquatic plants (Bhagat, 1975, p. 161). The Silver Lake Rehabilitation Program Grant Application was submitted in 1976. Little activity occurred until the Centennial Clean Water Fund (CCWF) legislation passed in 1986. In 1987, Cowlitz County and Ecology initiated the Silver Lake Restoration Project Phase I, and Washington State University was funded to prepare a diagnostic and feasibility study for the restoration of Silver Lake (Moore, 1990). This study identified phosphorus as the nutrient of concern in the lake and identified several restoration schemes to be considered for a Phase II Silver Lake Restoration Project. Schemes included dividing the lake into three management zones, biological macrophyte control, dredging, bottom screening, waterfowl management, watershed nutrient diversion, and public information and education. Moore concluded, "Without intervention, the lake will probably become essentially a large marsh, without any open water areas, within the next decade. As such, the lake can be expected to become totally unsuitable for supporting any fish populations of recreational or economic value."

In 1991, Cowlitz County was granted funding through Ecology's CCWF to begin Phase II of the Silver Lake Restoration Project. The three tasks accomplished included:

1) The introduction of 83,000 grass carp to the lake in 1992.
2) Several years of long-term water quality monitoring provided by KCM consultants.
3) Assistance with a Watershed Management Plan (WMP) completed in 1994 by Cowlitz Conservation District.

An unexpected consequence of the grass carp developed, as described by KCM consultant Scherer: "The grass carp have eaten essentially all the submersed plants in Silver Lake…The project goal of reducing the cover of submersed plants by 40 to 60 percent has been greatly exceeded." Furthermore, the carp did not affect the frequency of the algal blooms (KCM, 1998). Public health cautionary postings for algal blooms occurred six times between 2009 and 2013. Some of these blooms have resulted in thick, carpet-like growth of cyanobacteria, which in turn has elevated public concern. Cyanobacteria toxins can be harmful and potentially lethal to humans and pets.

SLWAC has been conducting water quality sampling regularly since August of 2012 (see Appendix A, charts A-2 through A-4), but the results have suffered from inconsistent Washington Department of Fish and Wildlife (WDFW) participation and subsequent withdrawal of their support since October of 2013. Citizens are eager to take further action to slow and reverse eutrophication. The carp project was a lesson that actions may have unanticipated and ineffectual results. Thus, remedial action should be well planned. This study will supply the necessary scientific evaluation of the lake in order to support the planning of further mitigation.

3.1.3 Contaminants of concern

The potential effects of toxic algal growth in Silver Lake is a major public concern. The three parameters most commonly used to measure the algal condition of a lake include Secchi depth (a measure of water clarity and, indirectly, of algal density), chlorophyll *a* (a more reliable indicator of algal density); and total phosphorous (a measure of water fertility). (EPA 440-4-91-002). This study will generate data points for all three of these constituents.

These three parameters will also be used to determine trophic state, which is not the same thing as water quality, but it is one aspect of water quality. The trophic state is the total weight of living biological material (biomass) in a water body at a specific location and time. The trophic state index (TSI) of Carlson (1977) uses algal biomass as the basis for trophic state classification. The range of the index is from approximately 0 to 100, although the index theoretically has no lower or upper bounds. Three variables independently estimate algal mass including chlorophyll pigments, Secchi depth, and total phosphorus, and also result in Carlson's (1977) trophic state indices (TSI) for Secchi depth (TSI_{SD}), total phosphorus (TSI_{TP}), and chlorophyll *a* (TSI_{CHL}) (Carlson, 1996).

Two bluegreen algae toxins which are potentially lethal to people and animals will be directly tested for on a weekly basis during the summer months near a popular recreation site. To further ensure public safety of the lake, sampling will occur for *E. coli* during the summer months at four locations of primary recreation. During the entire year, monthly testing of *E. coli* will take place at Hemlock creek due to public concern regarding cow pastures, and at Sucker Inlet due to public concern regarding a nearby landfill. We will also sample for fecal coliform at 10% of the *E. coli* sampling events for future WQ assessment.

This study will also measure water temperature, pH, conductivity, dissolved oxygen and turbidity.

3.1.4 Results of previous studies

Studies on Silver Lake span over more than 40 years. Two of the more recent studies include The Cowlitz County Silver Lake Phase II Restoration Monitoring report, dated June 1998, and the SLWAC monitoring results from August 2012 to May of 2015.

The Cowlitz County Silver Lake Phase II Restoration Monitoring report, dated June 1998, notes the following about water quality:

1) The total phosphorus concentration in the lake exceeded the 24 μg/L threshold for eutrophic conditions most of the time. The 1997 weighted mean for total phosphorus was 34 μg/L, with a high of 197 μg/L at the East Station. The high for the first WSU study (Bhagat, 1975) was 50 μg/L, with a mean of about 30 μg/L.

2) In 1994, the nitrate-nitrogen concentration was above minimum levels, ranging from less than 10 µg/L to over 330 µg/L, probably due to external loading and to the feeding of the grass carp and the rapid cycling of nitrate-nitrogen in the lake. However, the 1997 weighted mean was 28 µg/L, and the nitrate-nitrogen concentration often remained below the detection limit of 10 µg/L with the disappearance of the submersed plants.

SLWAC's water quality monitoring from August 2012 to current has shown that nitrogen levels in Silver Lake are quite low. *E. coli* has occasionally spiked up into the 200 colonies/ 100 mL level, but never sustains levels that exceed state standards for primary or secondary recreation, or EPA 212 Recreational Water Quality Criteria. However, phosphorus measures over the threshold for eutrophic lakes of 25 µg/L nearly 90% of the time. (Bell-McKinnon, 1994). See Appendix A, charts A-2 through A-4, Averages of SLWAC Lab Tests.

3.1.5 Regulatory criteria or standards

This study will not be used to determine compliance with regulatory standards or criteria. However, there are some guiding regulations that apply:

Washington Administration Code (WAC) 173-201A-200 sets aquatic life criteria for indigenous warm water species and recreational *E. coli* standards, as described below.

For Aquatic Life:
Temperature: Highest 7-DADMax 20°C (68°F)
DO: Lowest 1 Day Minimum of 6.5 mg/L
Turbidity: Shall not exceed 10 NTU over background when the background is 50 NTU or less; or a 20 percent increase in turbidity when the background turbidity is more than 50 NTU.
pH: shall be within the range of 6.5 to 8.5 with a human-caused variation within the above range of less than 0.5 units.

For primary Contact Recreation (applies seasonally to Silver Lake during the summer months when swimming, water skiing, wake boarding, and tubing occur):

> "Fecal Coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100 mL." (Washington Administrative Code 173-201A-200).

For secondary Contact Recreation (applies when outdoor ambient temperatures do not support submerging water sports but recreation such as boating and hunting occurs):

> "Fecal coliform organisms levels must not exceed a geometric mean value of 200 colonies/100mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 400 colonies/100mL.' (Washington Administrative Code 173-201A-200).

The EPA has two applicable standards:

The first is for fresh waters in general:

Acceptable levels of *E. coli* are measured in CFU (coliform forming units) and commonly included both a 30 day mean (126 cfu/100mL) and a single sample number (235 cfu/100mL – 575 cfu/100mL). SLWAC uses the goal of samples remaining under 235 cfu/100mL. (EPA brochure "*E. coli* and enterococci").

EPA has also issued the 2012 Recreational Water Quality Criteria based on the latest epidemiological research, in which they introduce a new term: Statistical Threshold Value (STV).

The STV approximates the 90th percentile of the water quality distribution and is intended to be a value that should not be exceeded by more than 10 percent of the samples taken. Two recommendations are offered, either of which would protect the designated use of primary contact recreation. Recommendation 1: GM of 126 cfu/100mL, STV 410 cfu/100mL. Recommendation 2: GM of 100 cfu/100 mL, STV 320 cfu/100mL. (EPA, 2012).

Lastly, Washington Administrative Code 173-201A-230 indicates that lake specific studies may be initiated to set specific ambient total phosphorus range for values over 20 µg/L in Puget Lowlands Ecoregion.

4.0 Project Description

This project will provide the data necessary to evaluate the health of Silver Lake, and to plan long-term actions by the Silver Lake community.

4.1 Project goals

The long-term project goal is to improve the water quality of Silver Lake for the public's health and recreational benefit, minimizing the health risks posed by toxic algae growth events and controlling non-native noxious weeds that limit the recreational potential of the lake.

The immediate goal of this project is to provide the data and site-specific results necessary to plan, execute, and evaluate continuous improvement actions. Site specific supporting data (e.g. rainfall, lake level, and outflow) is included in data collection activities. Public access to the process and training developed for the lake, and all data collected, via a public website, is another key goal of this project.

4.2 Project objectives

The first objective is to establish a reliable data bank with a sufficient number of data points to enable future evaluation and long term planning actions to improve the water quality of Silver Lake. This study will generate a data bank that includes 160 data points for total phosphorus, 160 data points for chlorophyll *a*, and 96 data points for Secchi depth, which will support conclusions and trend analysis regarding the constituent itself as well as a calculation of the trophic state index. In addition, 128 total data points of *E. coli* and 24 data points of two bluegreen algae toxins will be established. A water quality sonde, the YSI ProDSS, will provide 6 water quality parameters, generating 96 data points for each. Supporting weekly data of five field measurements (water temperature at two levels, air temperature, and rainfall), plus two notations of air temperature and rainfall on record will generate a total 416 data points. To ensure this objective, the project's goal is to accomplish 95% or more of the sampling events following the approved QAPP. Upon completion, numerical and trending analysis of the data will be completed.

The second objective is to encourage local discussion and improve understanding of how individuals can have a positive effect on their lake water quality. To ensure this objective, the project's data will be cataloged, made available to the public via the internet, and submitted to Ecology through the Environmental Information Management (EIM) database. Public understanding and discussion will be facilitated via annual public meetings.

4.3 Information needed and sources

None needed.

4.4 Target population

The target population of this study are the water quality constituents of Silver Lake. Ambient air temperature will also be measured. Specific targeted constituents include:

- Lab-determined values of total phosphorus, chlorophyll *a*, *E. coli*, and the two bluegreen algae toxins: microcystin and anatoxin-a.
- In-situ lake characterizations including Secchi disk depth and Ysi ProDSS measurements of air and water temperature, pH, conductivity, dissolved oxygen, and turbidity.
- Supporting data including noting general conditions, measuring lake level, calculating outflow, measuring water and air temperatures, and measuring rainfall.

The segment of the general public that is concerned about or has influence over Silver Lake and its watershed is another target population, as public education and publishing of results is a component of the project.

4.5 Study

This project includes the waters of Silver Lake which is located in the north sections of T9N, R1W, and the southeast sections of T10N, R1W at 148m elevation (KCM QAPP January 1993).

4.6 Tasks required

- Develop and write a lake-specific QAPP for Ecology approval.
- Collaborate with SLWAC technical advisors in project planning and implementation.
- Compare current sampling methods with Ecology-approved Standard Operating Procedures (SOPs), and provide training and documents to eliminate any discrepancies.
- Provide oversight and audits of volunteers during field testing.
- Conduct total phosphorus and chlorophyll *a* sampling for lab analysis at 5 locations monthly from October-May and bi-monthly from June-September. 160 data points will be established for each analyte over the two year study.
- Conduct *E. coli* sampling for lab analysis at 4 locations of primary recreational activity twice each month during the summer months of June-September. 64 data points will be established for *E. coli* in recreation areas over the two year study.
- Conduct *E. coli* sampling for lab analysis at 2 locations of public concern twice each month during the summer and once each month from October - May. 64 data points will be established for *E. coli* in areas of public concern over the two year study.
- Conduct total coliform sampling, equal to 10% E. coli sample events, for future Ecology WQ assessment.
- Conduct sampling for the bluegreen toxins microcystins and anatoxin-a at one location for 12 weeks during the summer from mid-June to mid-September. 24 data points will be established for each toxin over the two year study.
- Determine Secchi disk depth at three locations twice each month during the summer months of June – September and once a month from October - May. 96 data points will be established for Secchi depth.
- Determine probe measurements for ambient air temperature, and water temperature at 1' and at 3'. In addition, at 3' depth, determine pH, conductivity, dissolved oxygen and turbidity at three locations twice each month during the summer months of June – September and once a month from October - May. 96 data points will be established for each of these measurements.
- Collect weekly supporting site data including measurement of the lake level using damped gauge, and calculation of outflow. Plus, at four locations, measure water temperatures at 1', 3', and 5', and an ambient air temperature reading. At one location, the weekly rainfall will be determined. High and low air temperature and weekly rainfall of the area on record will be recorded.
- Conduct annual public meeting to help educate the public on specific activities that they can do to have a positive effect on the lake, as well as activities that they can refrain from that have a potentially negative effect on the lake.
- Input water quality monitoring data into Ecology's EIM system annually.
- Compile and publish all data on public website.

- Submit quarterly progress reports and billings.
- Annually, in January, submit grant load reductions report.
- Conduct numerical and trending analysis of the study's data.
- Submit a report to Ecology Project Manager summarizing data results and data analysis.
- Submit recipient closeout report.

4.7 Practical constraints

No practical constraints are expected. Winter sampling may need to be occasionally rescheduled due to inclement conditions.

4.8 Systematic planning process

This document serves as the systematic planning process for this project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Personnel	Title	Responsibility	Phone
Chris Bischoff	Environmental Health Manager	Supervision	360-414-5599
Season Long	Environmental Health Specialist Lead	Project oversight	360-414-5599
Hilarie Larson	Environmental Health Specialist	Project Lead	360-414-5599
Del Gilkerson	SLWAC Technical Advisor	Project Planning	360- 751-3321
Neil Skogland	SLWAC Technical Advisor	Project Planning	206-734-6345
Chris Leaf	Project Manager at ALS Global	Manage Lab Tasks	360-501-3275
Colin Elliot	Environmental Lab Scientist III	Manage Lab Tasks	206-477-7113

5.2 Special training and certifications

The Cowlitz County Health Department - Environmental Health Unit (CCHD-EHU) and the SLWAC will provide personnel for this project.

<u>With CCHD-EHU:</u>

Chris Bischoff is the Environmental Health Manager and will serve as the overall supervisor for this project. He earned his Bachelor of Science in Biology and is a Registered Sanitarian.

Hilarie Larson, Environmental Health Specialist, is also a Registered Sanitarian. She has a Bachelor of Science from Pacific University and six years of experience in local and state environmental health programs. She conducted water quality sampling previously in Tillamook

County and administered the shellfish safety program, among other environmental health experiences.

Season Long, Environmental Health Specialist Lead, has a Bachelor of Science in Biology and a Master of Marine Resource Management. She worked on multiple research teams and focused much of her work on collecting and analyzing water quality samples, including ground water monitoring at Columbia Ridge Landfill for Oregon Department of Environmental Quality, and wetland/watershed water quality assessment for Earth Design Consultants.

Megan Erickson, Environmental Health Specialist, earned a Bachelor of Science in Food Science and Human Nutrition. Before working for the County she spent two years at Columbia Analytical Services/ALS where she performed microbiological testing including: total coliform, fecal coliform, *E. coli*, BOD, CBOD, DO, pH, and turbidity.

Jeremiah Maschmann has a Bachelor of Science in Biology and a total of nine years working in water quality programs. Prior to working for the County, he spent seven years with the Federal Bureau of Reclamation Water Quality Lab and two years with Columbia Analytical Services/ALS, conducting various forms of analytical testing in both places.

<u>With SLWAC:</u>

The SLWAC was created by the Cowlitz County Board of Commissioners and includes seven local residents, a representative from the county, the Southwest Clean Air Agency, the Cowlitz County Tourism Bureau, the US Army Corps of Engineers, the state departments of Ecology, Natural Resources, Washington Department of Fish & Wildlife, Weyerhaeuser Co, the Cowlitz Conservation District, and the Silver Lake Flood Control District. Many SLWAC members have sampling experience and an array of technical backgrounds sufficient to assure competent and accurate sampling practices;

SLWAC volunteer Gary Fredericks is the Director of Cowlitz County WSE Extension Office. He has a BS in Bacteriology/Animal Nutrition and a MS in Dairy Nutrition from WSU. He has been the WSU Extension Agent for Cowlitz, Pacific, and Lewis counties since 1984.

SLWAC volunteer Marilyn Coleman is the SLWAC chair and has been a resident/property owner on Silver Lake for over 35 years. She has partnered with WDFW and Cowlitz County to hold informational meeting to educate residents and encourage them to participate in council activities. She holds a psychology degree and made her career in the medical/dental industry.

SLWAC volunteer Del Gilkerson is the SLWAC's technical coordinator, and has managed the collection and recording of lake water samples since August of 2012. He graduated from WSU with a Bachelor of Science in Physics, and has worked for over 20 years in research and testing laboratories conducting work similar to that of this project's. He also served for over a decade as manager of the Cowlitz County Mosquito Control District, which also does similar sampling and testing work throughout the area.

SLWAC volunteer Dave York has been a shoreline resident for over 30 years and is an avid fisherman who is familiar with all of the lake. He has participated in water sampling since 2012.

SLWAC volunteer Paul Moore and his family have owned property in the Silver Lake watershed for over 100 years. Paul is also an avid fisherman and has assisted with the majority of Silver Lake water sampling, providing his boat and local knowledge. Paul also has technical experience in developing water sampling techniques for Weyerhaeuser facilities throughout the region.

SLWAC volunteer Pansy Nofsiger worked over a decade on the Oregon Scenic Waterways Advisory Committee, and she wrote legislation for the Deschutes River Management Plan that passed into law.

SLWAC volunteer Neil Skogland, a resident on Walden Island in the middle of the lake that requires boat transportation to access, also participates in water sampling. He is a mechanical engineer with over 30 years of experience with design and manufacture of custom-engineered machinery. His career included technical writing, and he and his wife were the authors of the grant application for this project.

5.3 Organizations

Three organizations are involved with this project: Ecology, CCHD, and SLWAC. Ecology has awarded a task-specific grant to CCHD. CCHD is responsible for administering and managing the project, and must meet Ecology administrative and technical requirements and documentation. Per Ecology's Scope of Work document, Cowlitz County is to retain ownership of equipment purchased with the grant. The grant was awarded because of demonstrated volunteerism of SLWAC members, and is dependent on their involvement in sampling tasks.

5.4 Project schedule

Date	Task or accomplishment
Jul early 2015	Complete QAPP
Jul 2015	Complete procurement of Probe Calendar Quarter Report Due
Aug late 2015	Receive QAPP approval
Sept early 2015	Volunteer Training
Sept late 2015	Volunteer Training & Sample Set 1
Oct early 2015	Sample Set 2
Oct late 2015	Ecology Quarter Report due
Nov early 2015	Sample Set 3 + Quarterly Probe Blanks + Quarterly Lab Replicate (1 site)
Nov late 2015	Perform Tech Systems Audit per 12.1
Dec early 2015	Sample Set 4 & Field Audit
Jan early 2016	Sample Set 5
Jan late 2016	Ecology Quarterly Report due
Feb early 2016	Sample Set 6
Mar early 2016	Sample Set 7 + Quarterly Probe Blanks + Quarterly Lab Replicate (1 site) & Website Launch
Apr early 2016	Sample Set 8 & Field Audit + Ecology Quarter Report due
May early 2016	Sample Set 9 & Duplicate Sample
Jun early 2016	Sample Set 10 + Quarterly Probe Blanks +Quarterly Lab Replicate (1 site)
Jun late 2016	Sample Set 11 & Field Audit
Jul early 2016	Sample Set 12
Jul late 2016	Sample Set 13 + Quarterly Probe Blanks + Quarterly Lab Replicate (1 site) + Ecology Quarter Report due
Aug early 2016	Sample Set 14 & Field Audit
Aug late 2016	Sample Set 15
Sep early 2016	Sample Set 16
Sep mid 2016	Compile data & submit to EIM
Sep late 2016	Conduct annual public meeting
Sep late 2016	Sample Set 17 & website update
Oct early 2016	Sample Set 18 & Field Audit
Nov early 2016	Sample Set 19 & Quarterly Probe Blanks + Quarterly Lab Replicate (1 site)
Oct late 2016	Ecology Quarterly Report due
Dec early 2016	Sample Set 20
Jan early 2016	Sample Set 21
Feb early 2017	Sample Set 22 & Field Audit
Jan late 2017	Ecology Quarterly Report Due
Mar early 2017	Sample Set 23 + Quarterly Probe Blanks + Quarterly Lab Replicate & Website Update
Apr early 2017	Sample Set 24
Apr late 2017	Ecology Quarterly Report due
May early 2017	Sample Set 25
Jun early 2017	Sample Set 26 + Quarterly Probe Blank + Quarterly Lab Replicate (1 site) & Field Audit
Jun late 2017	Sample Set 27
Jul early 2017	Sample Set 28
Jul late 2017	Sample Set 29 + Quarterly Probe Blank + Quarterly Lab Replicate (1 site) + Ecology Quarterly Report due
Aug early 2017	Sample Set 30 & Field Audit
Aug late 2017	Sample Set 31
Sep early 2017	Sample Set 32
Sep 2017	Compile data & submit to EIM
Sept 2017	Analyze data & website update
Oct 2017	Conduct annual public meeting + Ecology Quarter Report due
Nov 2017	Draft final report
Dec 2017	Submit final report

5.5 Limitations on schedule

The above schedule in section 5.4 provides enough flexibility to recover from a cancelled sampling event due to weather conditions. SLWAC also provides sufficient volunteers that the schedule should not be compromised if a volunteer experiences boating equipment problems. If the water sample probe experiences a malfunction or mechanical problem, then a gap in some water quality parameters could occur.

5.6 Budget and funding

Budget is described below for the grant in its entirety, which also includes the Horseshoe Lake project. The total eligible cost for this dual project is $143,028. Of that, Ecology will fund $107,271.00 and Cowlitz County will fund $35,757.00. See below charts for delineation of budget funds.

Total Project Budget for Both Lakes				
Task ID	**Task Description**	**Budget**	**Ecology Share 75%**	**Project Match 25%m**
1	Project Administration	28,392	21,294	7,098
2	Water Lab Sampling & Testing	114,636	85,977	28,659
	Total	143,028	107,271	35,757

Project Budget for Task 1 Specific Activities for Both Lakes							
Task ID	**Task Description**	**Hours**	**Cost/hr**	**Total**	**Budget**	**Ecology Share**	**Project Match**
1A		80	52.88	4230.4		3172.80	1057.6
1B		157	52.88	8302.16		6226.62	2075.54
1B		79.92	52.88	4226.17		3169.63	1056.54
1B		220	52.88	11633.60		8725.20	2908.40
					rounded:	rounded:	rounded:
		536.92		28,392.33	28,392	21,294	7,098

Project Budget for Task 2 Specific Activities for Both Lakes							
Task ID	**Task Description**	**#**	**Unit**	**Price /unit**	**Event**	**Ecology Share 75%**	**Project Match 25%**
2G	County Mobilization	1.33	hr	52.88	64	4501.15	
2G	Volunteer Mobilization	1	hr	22.69	64		1452.16
2C	Data entry	1	hr	22.69	64		1452.16
2A	QAPPs	306	hr	52.88	1	16181.3	
2B	training	10	hr	52.88	9	4759.2	
2H	Public meetings	16	hr	52.88	2	1692.16	
2G	Boat value - Silver	4	hr	16.95	32		2169.6
2G	Boat value - Horseshoe	1.5	hr	16.95	32		813.6
2G	Sampling volunteers - Silver	9	hr	22.69	32		6534.72
2G	Sampling volunteers - Horseshoe	3	hr	22.69	32		2178.24
2G	Mileage costs - Silver	78	miles	0.57	32	1422.72	
2G	Mileage costs – Horseshoe	48	miles	0.57	32	875.52	
2G	Transport samples - Horseshoe	1.25	hr	22.69	32		907.6
2G	Transport samples - Silver	1.5	hr	22.69	32		1089.12
2G	Lab charges Silver Lake	1	event	788	32	25216	
2G	Lab charges Horseshoe Lake	0.625	event	788	32	15760	
2E	Website update - Silver	1	hr	22.69	32		726.08
2E	Website update - Horseshoe	0.5	hr	22.69	32		363.04
2G	temp, level and outflow	1		22.69	208		4719.52
2G	weather and data entry	0.5		22.69	208		2359.76
2G	boat costs	1		16.95	208		3525.6
2F	YSI ProDss Sonde Purchase	1		9500	1	9,500	
2F	other equipment purchase	1		3400	1	3400	
2C	website creation	60	hr	22.69	1		1361.4
2E	Stat analysis	50	hr	52.88	1	2644	
	Project Total					85,952	29,652.6
	Target: 114,636 x 75% and 25%					85,977	28,659
	Difference Project Total & Target					-25	933.6
	% of Total Budget (114, 636)					0.75	0.26
	% of Project Total (115,604.60)					0.74	0.26

6.0 Quality Objectives

6.1 Decision Quality Objectives (DQOs)

N/A

6.2 Measurement Quality Objectives (MQOs)

MQOs – Precision & Bias in Field Constituents				
Analyte	**Accuracy (deviation of % deviation from true value**	**Resolution**	**Bias (% deviation from true value)**	**Estimated Range**
Secchi Depth	NA	+/- 20%	NA	0.5 to 4 ft
Temperature	+/- 0.2 ° C	0.1° C	NA	33-74 °F
pH	+/- 0.2 pH units	0.01 pH units	NA	6-10 pH units
Specific Conductance	0-100 mS/cm: +/- 0.5% of reading or 0.001mS/cm, whichever is greater. 20-50 mg/L: +/- 1.0% of reading	0.001, 0.01, or 0.1µS/cm (range dependent)	NA	unknown
Dissolved Oxygen	0 to 20 mg/L: +/- 0.1 mg/L or 1% of reading, whichever is greater. 20 to 50 mg/L: +/- 8% of reading	0.01 mg/L and 0.1%, or 0.1 mg/L and 1% (user selectable)	NA	2-10mg/L

MQOs – ALS Global Lab Constituents **Analysis Method, Detection and Quantitation Limits, Lab Quality Control Limits**							
Analyte	**Method**	**MDL**	**MRL**	**Units**	**Accuracy LCS %Rec**	**Matrix Spike %Rec**	**Precision % RPD**
Phosphorus, Total	EPA 365.3	0.004	0.01	mg/L	85-115	70-130	20
Chlorophyll-a	SM10200 H	0.3	0.8	mg/m3	88-113	NA	20
E. coli	SM 9224B	NA	1	MPN/100 mL	NA	NA	NA

MQOs – King County Environmental Lab Constituents **Analysis Method, Detection and Quantitation Limits, Lab Quality Control Limits**							
Analyte	Method	MDL	RDL	Units	Accuracy LCS %Rec	Matrix Spike %Red	Precision %RPD
Microcystins	ELISA – Envirologix # EP022HS	0.16	0.16	µg/L	50-150%	80-160%	45%
Anatoxin-a	LC/MS-MS – King County SOP #466	0.01	0.05	µg/L	50-150%	50-150%	45%

ELISA = Enzyme-linked Immunoassay

LC/MS-MS = Liquid Chromatography with Mass Spectrometric detection

MDL = Method Detection Limit

RDL = Reporting Detection Limit (practical quantitation limit)

LCS = Lab Control Sample

RPD = Relative Percent Difference

6.2.1 Targets for Precision, Bias, and Sensitivity

6.2.1.1 Precision

At concentrations near the lowest concentration of interest, it will not be possible to meet the percentage MQOs indicated above because errors expressed as a percentage increase at lower concentrations. However, at lower concentrations, the acceptable error is generally greater. The precision MQO is in line with MEL's historic performance for most constituents. Chlorophyll, which is inherently more variable, has a less stringent MQO.

The above MQO table is intended to indicate the quality of the result from a particular sample (or pooled set of samples) and therefore to apply to lab or field *splits*. Field duplicate samples (i.e., sequentially collected), which include some environmental variability, may be used to determine if MQOs have been met; however, some judgment may be required regarding the amount of environmental variability in the sample.

6.2.1.2 Bias

Sampling bias will be minimized by strictly adhering to the protocols discussed and referenced herein. This QAPP provides procedures for collecting representative and valid samples. However, as is true for all sampling, some sampling bias is likely present in the results even if not measurable or confirmed. Assessment and management of bias will occur mostly at the laboratory. We expect that bias in the chemical analyses will be corrected so that long-term bias will not occur within a single method. Measurement Quality Objectives for bias are listed in the MQO table above.

6.2.1.3 Sensitivity

MQOs – Sensitivity				
Water Quality Parameter	**Measurement Range**	**Accuracy**	**Resolution**	**Instrument or method**
Water clarity	0-30 feet	NA	NA	Secchi disc
Turbidity	0-4000 FNU	0-999 FNU: 0.3 FNU or 3% (whichever is greater), 1000 to 4000 FNU: +/- 5% of reading	0.1 FNU	ProDSS
Temperature	-5 to 70 °C	+/- 0.2°C	+/- 0.1°C or 0.1°F	ProDSS
pH	0 to 14 pH units	+/- 0.2 pH units	0.01 pH units	ProDSS
Dissolved Oxygen	0 to 50 mg/L	0 to 20 mg/L +/- 0.1mg/L or 1%, whichever is greater. 20 to 50 mg/L +/-8%	0.01 mg/L and 0.1% or 0.1 mg/L and 1% (user selectable)	ProDSS
Total phosphorus	0.01 to 100 mg/L	0.01 mg/L +/- 10%	0.004 mg/L	EPA 365.3
Chlorophyll-a	0.2 to 1000 mg/L	0.2 µg/L +/- 10%	0.08 mg/L	SM 10200H
E. coli	MPN/100mL	NA	NA	SM9223B
Water Quality Parameter	Measurement Range	Accuracy	Resolution	Instrument or method
Microcystins	0.16 to 2.5 ug/L (higher with dilution)	+/- 11% (per kit insert)	0.16 ug/L	ELISA
Anatoxin-a	0.01 to 5 ug/L (higher with dilution)	+/- 15%	0.01 ug/L	LC/MS-MS

6.2.2 Targets for Comparability, Representativeness, and Completeness

6.2.2.1 Comparability

All measurement and analytical procedures are documented so that the data will be comparable with samples collected and analyzed in a like manner according to attached SOPs.

6.2.2.2 Representativeness

The study will span over two years, and conditions of sampling are expected to vary. Because the lake is shallow, with a mean depth of 5 feet, grab samples taken at 3 feet are considered to be representative.
Grab samples will be shaken before poured into lab containers per Silver Lake SOPs to aid in representativeness.

Added weather and lake water data collected weekly will provide the opportunity to correlate sampling results with other lake conditions. Added data will include:

- Lake level compared to Dam Crest
- Estimated outflow, using level and gate position data
- Local precipitation total and general lake weather (still, windy, choppy, etc.)
- Air temperatures, high/low
- Water temperatures at standard depths including surface (1 foot) and 3 feet.

The six *E. coli* sampling sites were chosen to represent the areas of the lake where primary recreational contact occurs most frequently. The bluegreen algae toxin site was chosen to represent the area where the most primary recreation occurs.

Three of the five total phosphorus and chlorophyll *a* sampling sites were chosen to represent general geographical locations of the lake; the outlet, the deepest part of the west side of the lake, and the deepest part of the east side of the lake. The other two locations are were retained from SLWC's sampling program that ran from August 2012 to May 2015, in accordance with public concern regarding farm use and the presence of a landfill; Hemlock and Sucker Inlet respectively. These sample locations represent potential problem areas, as opposed to overall lake conditions.

6.2.2.3 Completeness

There are no legal or compliance uses anticipated for the Silver Lake data. In addition, there is no fraction of the planned data that must be collected in order to fulfill statistical criteria. It is expected that at least 95% of the sampling events will occur unless unanticipated and prolonged inclement weather conditions prevent sampling.

7.0 Sampling Process Design

7.1 Study Design

Nine sites will be sampled at a frequency ranging from weekly to monthly. See Figure 1: Study Sample Location Map in section 7.2 below. The study includes four different lab tests, Secchi depth determination, and several in-situ tests. Two of the labs (chlorophyll *a* and phosphorus) and Secchi depth will be used to determine Carlson's trophic state index.

7.1.1 Sampling location and frequency

Table 7.1.1 (A)

Silver Lake Sampling Plan							
Location	**Letter**	**Bluegreen Toxins**	**Phosphorus & Chlorophyll a**	***E. coli***	**In-Situ and Secchi Depth**	**Latitude**	**Longitude**
Outlet Cr	a		Yes		Yes	tbd	tbd
Deep West	b		Yes		Yes	tbd	tbd
Deep East	c		Yes		Yes	tbd	tbd
Hemlock	d		Yes	Yes		46.17.903	122.44.627
Sucker Inlet	e		Yes	Yes		46.16.315	122.48.569
Streeters N.	f	Yes*		Yes*		46.18.356	122.46.171
Silver Resort	g			Yes*		46.17.745	122.48.360
Walden East	h			Yes*		46.17.811	122.47.378
SE Tree House	i			Yes*		tbd	tbd

*seasonal, see table 7.1.1 (B) Sample and Test Schedule

Table 7.1.1 (B)

Sample and Test Schedule (Per Calendar Year)						
Month / Week	BG Algae toxins	Total Phosphorus	Chlorophyll *a*	*E. coli* (+ fecal coliform 10% of samples)	In-Situ	Secchi Depth
Jan wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(2) d, e	(3) a, b, c	(3) a, b, c
Feb wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(2) d, e	(3) a, b, c	(3) a, b, c
Mar wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(3) d, e ^	(3) a, b, c	(3) a, b, c
Apr wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(2) d, e	(3) a, b, c	(3) a, b, c
May wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(2) d, e	(3) a, b, c	(3) a, b, c
Jun wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(7) d, e, f, g, h, i ^	(3) a, b, c	(3) a, b, c
Jun wk 2						
Jun wk 3	(1) f	(5) a, b, c, d, e	(5) a, b, c, d, e	(4) f, g, h, i	(3) a, b, c	(3) a, b, c
Jun wk 4	(1) f					
Jul wk 1	(1) f	(5) a, b, c, d, e	(5) a, b, c, d, e	(7) d, e, f, g, h, i ^	(3) a, b, c	(3) a, b, c
Jul wk 2	(1) f					
Jul wk 3	(1) f	(5) a, b, c, d, e	(5) a, b, c, d, e	(4) f, g, h, i	(3) a, b, c	(3) a, b, c
Jul wk 4	(1) f					
Aug wk 1	(1) f	(5) a, b, c, d, e	(5) a, b, c, d, e	(7) d, e, f, g, h, i ^	(3) a, b, c	(3) a, b, c
Aug wk 2	(1) f					
Aug wk 3	(1) f	(5) a, b, c, d, e	(5) a, b, c, d, e	(4) f, g, h, i	(3) a, b, c	(3) a, b, c
Aug wk 4	(1) f					
Sep wk 1	(1) f	(5) a, b, c, d, e	(5) a, b, c, d, e	(6) d, e, f, g, h, i	(3) a, b, c	(3) a, b, c
Sep wk 2	(1) f					
Sep wk 3		(5) a, b, c, d, e	(5) a, b, c, d, e	(4) f, g, h, i ^	(3) a, b, c	(3) a, b, c
Oct wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(2) d, e	(3) a, b, c	(3) a, b, c
Nov wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(2) d, e	(3) a, b, c	(3) a, b, c
Dec wk 1		(5) a, b, c, d, e	(5) a, b, c, d, e	(2) d, e ^	(3) a, b, c	(3) a, b, c

^ = also take fecal coliform sample at one location, equal to 10% E. coli sampling, for future Ecology WA assessment.

7.1.2 Parameters to be determined

Sampling for bluegreen algae toxins will occur for 12 weeks during the summer at the Streeter location, which is the most heavily used primary recreation site.

Total phosphorus and chlorophyll *a* grab samples will be obtained two times a month during the summer months of June-September, and once a month during the remaining months October-May at five locations. Outlet location is retained from SLWAC sampling. Two locations are new; Deep West and Deep East, chosen for better overall representativeness. Latitude and longitude of these locations will be determined with the Ysi ProDSS GPS on the probe, and recorded for use and direction in all further sampling events. Two additional locations including Hemlock and Sucker Inlet are retained from SLWAC sampling that occurred from August 2012 to May 2015, not because of previous test results, but due to public concern regarding the nearby agricultural use and landfill proximity.

E. coli sampling will occur seasonally, during the summer months of June-September, in four areas of primary contact recreation. Three of these locations are historic SLWAC sampling sites, and one was added due to gaining popularity as a swimming site. *E. coli* testing will occur year round (twice during the summer and once from October – May) at the two sites of public concern including Hemlock and Sucker Inlet.

The results of chlorophyll *a,* will be used to independently calculate Carlson's Trophic State Index (TSI). Total phosphorus and Secchi depth will be also be used to calculate trophic state, but used as supporting calculations and not considered independently, since "neither transparency or phosphorus are independent estimators of trophic state. Using transparency or phosphorus as an estimator of chlorophyll is very different from assuming equal and independent status of the variables." (Carlson, 1983).

Calculating the TSI

Per Carlson (1996) as described on http://www.secchidipin.org/index.php/monitoring-methods/trophic-state-equations/ (July 2, 2015), the index is relatively simple to calculate and to use. Three equations are used: Secchi disk, TSI(SD); chlorophyll pigments, TSI(CHL); and total phosphorus, TSI(TP).

The simplified equations are:

$$TSI(SD) = 60 – 14.41 \ln(SD)$$

$$TSI(CHL) = 9.81 \ln(CHL) + 30.6$$

$$TSI(TP) = 14.42 \ln(TP) + 4.15$$

The three variables will not be averaged. The index is predicated on the idea that it is predicting algal biomass. Chlorophyll is a better predictor than either of the other two indices. There is no logic in combining a good predictor with two that are not (Carlson 1983).

7.1.3 Field measurements

In-situ probe tests and Secchi depth will occur at three sites twice during the summer months of June – September and once a month from October – May. In-situ tests include ambient air temperature, water temperature at surface and 3 feet, pH at 3 feet, conductivity at 3 feet. (necessary to determine dissolved oxygen), dissolved oxygen at 3 feet, and turbidity at 3 feet.

Field measurements include Secchi depth, read in feet to the nearest 1/4th. Additional measurements include ambient air temperature read from sitting position in boat, and surface water temperature. Also using Ysi ProDSS per manufacturer's instructions, reading will be taken at 3 foot depth in lake for water temperature, pH, conductivity, dissolved oxygen and turbidity.

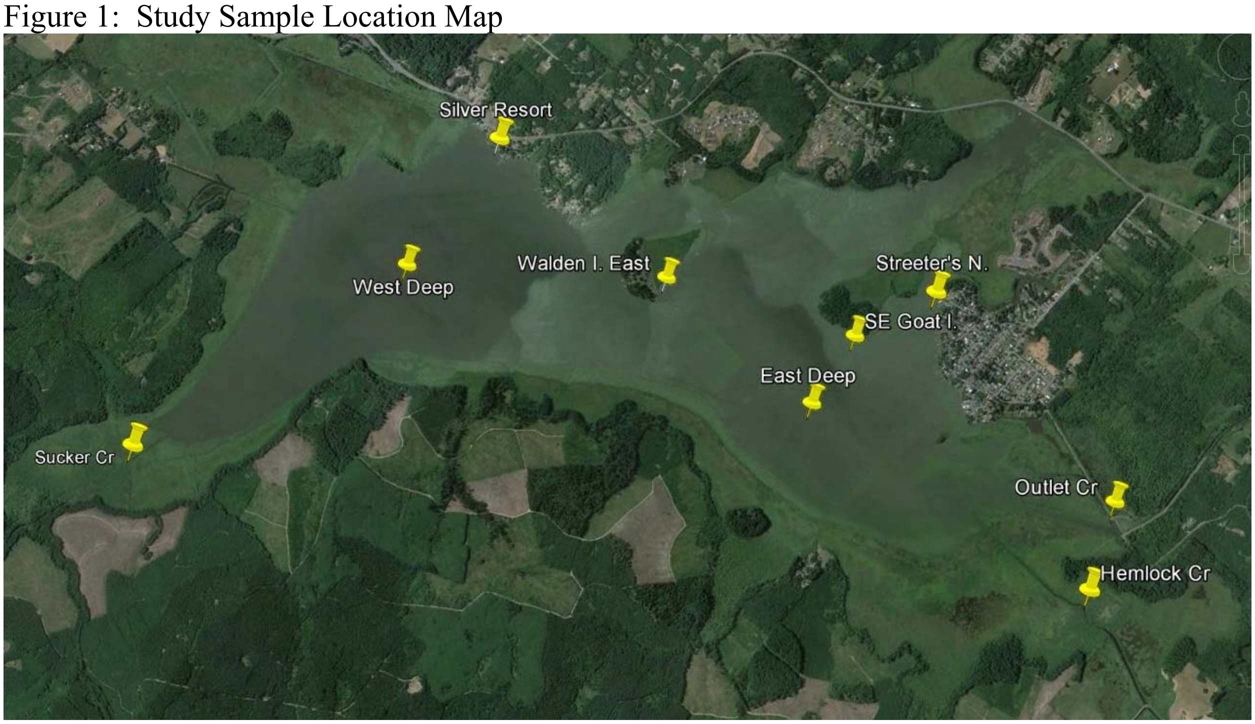
Log Sheet for ProDSS sonde testing							
Location	**Secchi Depth**	**Air Temp**	**Water Temp 1'**	**Water Temp 3'**	**pH 3'**	**DO 3'**	**Turbidity 3'**
Outlet 1st							
Outlet 2nd							
Outlet Average							
Deep West 1st							
Deep West 2nd							
Deep West Average							
Deep East 1st							
Deep East 2nd							
Deep East Average							

Separate from sampling activity, at locations along his commute from the island to the mainland as named below, Neil Skogland will collect weekly supporting data. This will include notation of general conditions (still, windy, choppy, etc), precise measurement of lake level using a damped gauge, calculations of outflow from the lake level data and Cubic Feet per Second (CFS) estimates at the dam, using current Tainter Gate position data. In addition, the high and low air temperature on record and the weekly rainfall on record will be noted.

Silver Lake Weekly Data		**General Conditions:**		**Lake Level:**		**Calculated outflow:**	
Location	**Water temp at 1 foot**	**Water temp at 3 feet**	**Water temp at 5 feet**	**Air temp in field**	**Air temp on record High/Low**	**Weekly Rainfall in field**	**Weekly Rainfall on record**
Bulk Water Sheltered							
Bulk Water Unsheltered							
Near Shore Water Open to Sun							
Near Shore Water Shielded from Sun							

7.2 Map

Figure 1: Study Sample Location Map



7.3 Assumptions underlying design

SLWAC testing results from sampling that occurred August 2012 to May 2015 were considered in the design of this sampling plan. Ecology, CCHD, and SLWAC agreed that nitrogen levels consistently showed results that are below levels of concern, and this constituent was consequently taken out of this project's sampling plan. Oppositely, SLAC's test results for phosphorus were consistently above levels of concern, and therefore phosphorus were retained as a constituent for this study.

7.4 Relation to objectives and site characteristics

The long term goal of this project is to improve the water quality of Silver Lake for the public's health and recreational benefit by minimizing the health risks posed by toxic algae growth events and controlling non-native noxious weeks that limit the recreational potential of each lake.

The first objective is to establish a reliable data bank with a sufficient number of data points to enable future evaluation and long term planning actions to improve the water quality of Silver Lake. The result will be current and reliable data appropriate and available for use in professional and citizen planning. The sampling plan supports this objective.

Another objective is to encourage local discussion and improve understanding of how individuals can have a positive effect on their lake water quality. Results will be improved individual understanding and sense of empowerment regarding Silver Lake water quality issues. The sampling plan supports this objective as well.

The study design supports the final outcome of the project by creating a reliable data bank presented in a usable format. This will be publically displayed so that water quality professionals and stakeholders can later analyze it to help plan long-term mitigation, education, and restoration efforts.

7.5 Characteristics of existing data

Volunteer generated SLWAC data from August 2012 to May 2015 has been consistent. The same volunteers performed the same sampling functions, which reduced the potential for variability. This study will better address current constituents of concern, and the sampling will benefit from QAPP planning and procedures.

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

Procedures and task from measuring phosphorus, chlorophyll a, and Secchi depth are adopted from EPA Office of Water Volunteer Lake Monitoring document EPA440-4-91-002, as well as SOP EAP303, SOP EAP012, and Silver Lake Sampling Procedures (May 2013).

See Appendix A, A-5 Silver Lake SOPs.

All field measurements taken via Ysi ProDSS including ambient air temperature, water temperatures, pH, conductivity, dissolved oxygen, and turbidity will strictly follow the ProDSS User Manual Document #626973-01 REF (https://www.ysi.com/ProDSS).

8.2 Containers, preservation methods, holding times

Sample Volume, Container, Preservation, Storage, and Hold Time Requirements

Analyte(s)	Container	Preservation Technique	Analysis Holding Time
Microcystins and Anatoxin-a	250-mL WM Amber HPDE	Cool to $\leq 6°$ C	48 to 72 hours
		Freeze at < 18° C	7 days

HDPE = High density polyethylene

Analyte(s)	Container	Preservation Technique	Analysis Holding Time
Total Phosphorus	500 mL Plastic H_2SO_4	9N H_2SO_4: Cool to 4± 2ºC	28 days
(Analysis of) Chlorophyll *a* (Preparation)	Unfiltered: 1 L unpreserved opaque plastic container	Unpres.; Cool to 4± 2ºC, no light exposure	Filter within 48 Hrs.
	Field Filtered: Glass Fiber Filter	Frozen	28 days
E. coli	100 mL Sterile Cup	$Na_2S_2O_3$, Cool to < 10ºC (4± 2ºC after 2hrs)	8 hrs from collection

8.3 Invasive species evaluation

Silver Lake is listed in Washington's 303(d) list of impaired waters for invasive species. Per EAP070 section 6.1, field activities will be conducted to minimize the contact between equipment and potential sources of invasive species, particularly aquatic plants, sediment and fish. Methods of minimization may include (sections 6.1.4.1 – 6.1.4.5); sampling from areas of less weed growth to more dense weed growth, avoid running boat onto sediment, avoid getting plants, sediment and fish inside boats or other sampling gear, avoid driving or walking through areas of mud and high weed growth, to the extent possible as the sampling team navigates to each specific sampling site.

Per EAP070 section 6.2, after field work all equipment will be inspected, cleaned and drained. The sampling team will inspect and clean all equipment that contacted (terrestrial or aquatic) soil, vegetation, or water. They will remove any visible vertebrates, invertebrates, plants, algae or sediment. If necessary, they will use a scrub brush and rinse with clean water either from the site or brought for that purpose, until the equipment is clean. In addition, the sampling team will drain water in bilges, samplers or other equipment that could hold water from the site. Since no hose is available at the launch, the sampling team will ensure that no debris will leave the equipment and potentially spread invasive species during transit or cleaning.

The sampling team will be asked to not wear felt soles. Since sampling procedures do not include wading, no issue is anticipated.

8.4 Equipment decontamination

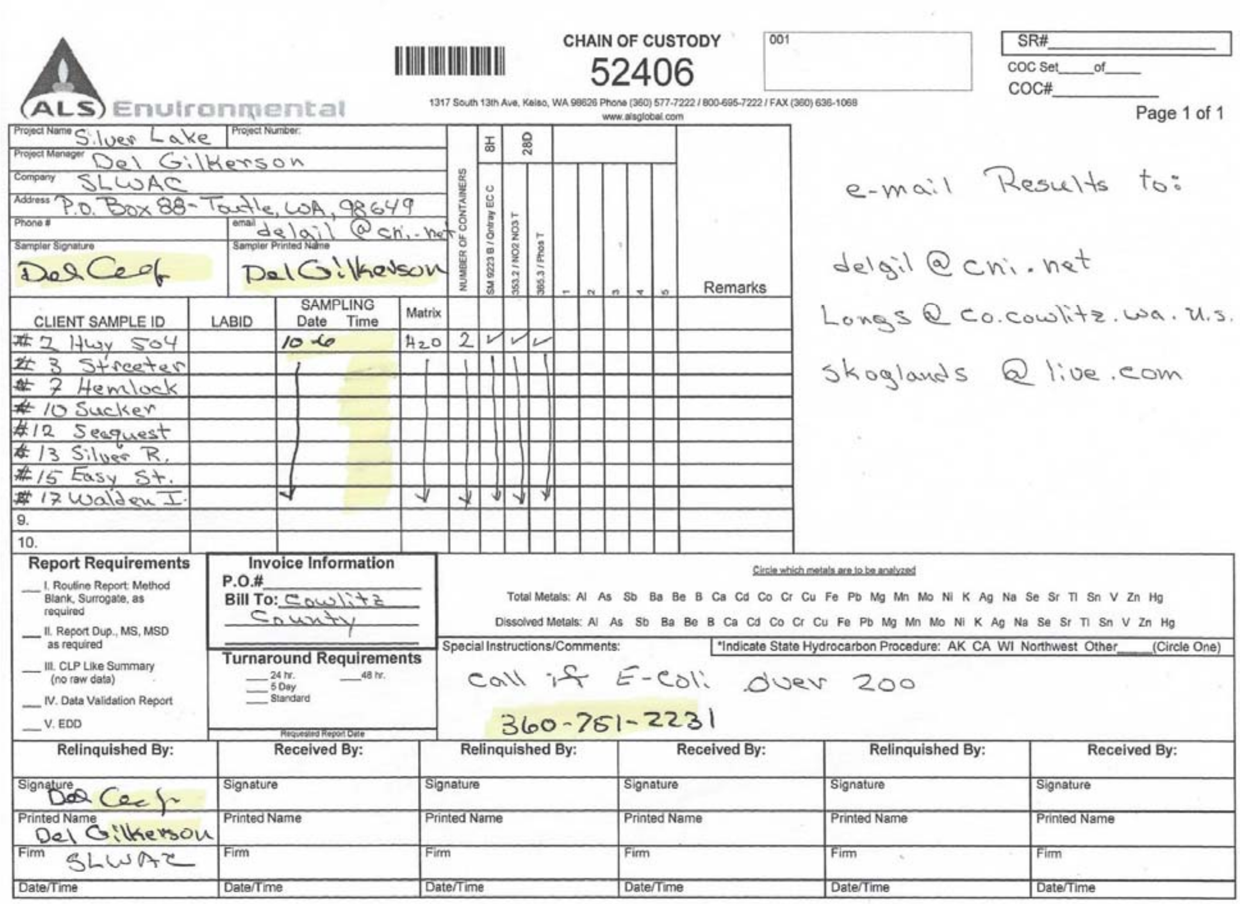
N/A

8.5 Sample ID

Standard sample ID protocol for each laboratory will be followed, according to chain of custody report.

8.6 Chain-of-custody, if required

Standard ALS Chain of Custody forms will be used, such as shown below:



ALS Environmental

CHAIN OF CUSTODY 52406

1317 South 13th Ave, Kelso, WA 98626 Phone (360) 577-7222 / 800-695-7222 / FAX (360) 636-1068 www.alsglobal.com

001

SR#______

COC Set____of____

COC#______

Page 1 of 1

Project Name: Silver Lake
Project Number:
Project Manager: Del Gilkerson
Company: SLWAC
Address: P.O. Box 88 - Toutle, WA, 98649
Phone #:
email: delgil @cni.net
Sampler Signature: Del Ceof
Sampler Printed Name: Del Gilkerson

Analyses: NUMBER OF CONTAINERS; 8H SM 9223 B / Quitray EC C; 28D 353.2 / NO2 NO3 T; 365.3 / Phos T; 1; 2; 3; 4; 5; Remarks

CLIENT SAMPLE ID	LABID	SAMPLING Date	SAMPLING Time	Matrix	NUMBER OF CONTAINERS	SM 9223 B / Quitray EC C	353.2 / NO2 NO3 T	365.3 / Phos T
# 2 Hwy 504		10-6		H2O	2	✓	✓	✓
# 3 Streeter		↓		↓	↓	↓	↓	↓
# 7 Hemlock								
# 10 Sucker								
#12 Seaquest								
# 13 Silver R.								
# 15 Easy St.								
# 17 Walden I.								
9.								
10.								

e-mail Results to:
delgil @ cni.net
Longs @ co.cowlitz.wa.u.s.
skoglands @ live.com

Report Requirements
__ I. Routine Report: Method Blank, Surrogate, as required
__ II. Report Dup., MS, MSD as required
__ III. CLP Like Summary (no raw data)
__ IV. Data Validation Report
__ V. EDD

Invoice Information
P.O.#
Bill To: Cowlitz County

Turnaround Requirements
__ 24 hr. __ 48 hr.
__ 5 Day
__ Standard
Requested Report Date

Circle which metals are to be analyzed
Total Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg
Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

Special Instructions/Comments: call if E-Coli over 200 360-751-2231

*Indicate State Hydrocarbon Procedure: AK CA WI Northwest Other____ (Circle One)

Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature: Del Ceof	Signature	Signature	Signature	Signature	Signature
Printed Name: Del Gilkerson	Printed Name	Printed Name	Printed Name	Printed Name	Printed Name
Firm: SLWAC	Firm	Firm	Firm	Firm	Firm
Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time

8.7 Field log requirements

Field logs will be printed on waterproof paper, numbered, and bound in a notebook. Permanent, waterproof ink will be used for all entries. Corrections will be made with single line strikethroughs, initials and date of correction. White-out or correction fluid will NOT be used.

In addition to ALS Chain of Custody form, the following forms will also be used:
Log Sheet for Silver Lake Lab Samples
Log Sheet for Silver Lake Tests

Log sheet for Silver Lake Lab Samples

Fill out this log sheet each time samples are collected

Date: ______________________ **People:**

Time:______________________ ____________________________

		Target			Actual Location		Sample ID for			
#	Location	Latitude	Longitude	Time	Latitude	Longitude	Phos.	Cloro. a	E Coli	BG Algae
a	Streeters N.	46.18.356	122.46.171							
b	Outlet Cr									
c	Hemlock Cr	46.17.903	122.44.627							
d	East Deep									
e	West Deep									
f	Sucker Cr	46.16.315	122.48.569							
g	Silver Resort	46.17.745	122.48.360							
h	Walden Island East									
i	Goat Island SW									

Comments:

Eg Weather, QA samples, QAPP deviations,

Log Sheet for ProDSS sonde testing							
Location	**Secchi Depth**	**Air Temp**	**Water Temp 1’**	**Water Temp 3’**	**pH 3’**	**DO 3’**	**Turbidity 3’**
Outlet 1st							
Outlet 2nd							
Outlet Average							
Deep West 1st							
Deep West 2nd							
Deep West Average							
Deep East 1st							
Deep East 2nd							
Deep East Average							

8.8 Other activities

SLWAC field volunteers have been involved with sampling for several years now. The project lead will hold an initial briefing to go over new QAPP approved sampling methods, emphasizing any identifiable differences between past sampling techniques and QAPP approved techniques. The project lead will provide on-going supervision of sampling activities, as it is anticipated that the project lead will be present in order to administer the probe testing. Minimally, field staff will receive an informal audit on a quarterly basis by the project lead as they conduct their sampling activities.

Maintenance for field instrumentation will be conducted according to manufacturer’s recommendations and specifications. The YSI representative will be consulted prior to initial calibrations, and the ProDSS user’s manual will be closely adhered to throughout the study.

9.0 Measurement Methods

Measurement Methods Table		
Field Analysis Table		
Analyte	**Matrix**	**Sample Number**
Secchi Depth	Water	96
Temperature	Air	96
Temperature 1'	water	96
Temperature 3'	Water	96
pH	Water	96
Dissolved Oxygen	Water	96
Turbidity	Water	96
Lab Procedures Table		
Analyte	**Matrix**	**Sample Number**
Total Phosphorus	Water	160
Chlorophyll *a*	Water	160
E. coli	Water	128
Microcystins	Water	24
Anatoxin a	Water	24

9.1 Field procedures table/field analysis table

Field and Lab procedures tables have been combined per template suggestion.
Please see chart above in 9.0 Measurement Methods.

9.2 Lab Procedures Table. This includes:

Field and Lab procedures tables have been combined per template suggestion.
Please see chart above in 9.0 Measurement Methods.

9.2.1 Analyte

Please see chart above in 9.0 Measurement Methods.

9.2.2 Matrix

Please see chart above in 9.0 Measurement Methods.

9.2.3 Number of samples

Please see chart above in 9.0 Measurement Methods.

9.2.4 Expected range of results

Based on the most recent testing carried out by SLWAC;
Phosphorus is expected to 0 and 1 mg/L.
E. coli is expected to range between 0 and 1400 MPN/100mL#.

9.2.5 Analytical method

See Chart Below at 9.2.6.

9.2.6 Sensitivity/Method Detection Limit (MDL)

ALS Lab Measurement Methods							
Analyte	Method	MDL	MRL	Units	Accuracy LCS %Rec	Matrix Spike %Rec	Precision % RPD
Phosphorus, Total	365.3	0.004	0.01	mg/L	85-115	70-130	20
Chlorophyll-*a*	SM10200 H	0.3	0.8	mg/m3	88-113	NA	20
E. coli	SM 9223 B	NA	<1	MPN/100 mL	NA	NA	NA

King County Environmental Lab Constituents Analysis Method, Detection and Quantitation Limits, Lab Quality Control Limits							
Analyte	Method	MDL	RDL	Units	Accuracy LCS %Rec	Matrix Spike %Rec	Precision %RPD
Microcystins	ELISA – Envirologix # EP022HS	0.16	0.16	µg/L	50-150%	80-160%	45%
Anatoxin-a	LC/MS-MS – King County SOP #466	0.01	0.05	µg/L	50-150%	50-150%	45%

ELISA = Enzyme-linked Immunoassay

LC/MS-MS = Liquid Chromatography with Mass Spectrometric detection

MDL = Method Detection Limit

RDL = Reporting Detection Limit (practical quantitation limit)

LCS = Lab Control Sample

RPD = Relative Percent Difference

Water Quality Parameter	Measurement Range	Accuracy	Resolution	Instrument or method
Microcystins	0.16 to 2.5 ug/L (higher with dilution)	+/- 11% (per kit insert)	0.16 ug/L	ELISA
Anatoxin-a	0.01 to 5 ug/L (higher with dilution)	+/- 15%	0.01 ug/L	LC/MS-MS

9.3 Sample preparation method(s)

Microcystins are prepared by freezing a 5 mL subsample at -23 o C overnight in order to lyse any cyanobacteria cells in the sample. After thawing, the sample is sonicated to further disrupt the cell membranes and release any intra-cellular toxins into the water. After filtration, the filtrate is ready for analysis by ELISA.

Samples for Anatoxin-a are prepared by lysing the cells using an acid digestion procedure in a 60 ◦C oven overnight. After cooling, the sample pH is adjusted to approximately 7.1 and filtered, as needed, to remove visible particulates. Samples are then concentrated and interferences removed by Solid Phase Extraction.

9.4 Special method requirements

NA

9.5 Lab(s) accredited for method(s)

CCHD has inspected and has on file the paper work of both laboratories, and has confirmed that the labs are Ecology accredited for the specific methods.

10.0 Quality Control (QC) Procedures

10.1 Table of field and lab QC required

QC Samples, Types and Frequency

Parameter	Field		Laboratory			
	Blanks	Field Replicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
Temp	Quarterly	Each event	NA	NA	NA	NA
pH	Quarterly	Each event	NA	NA	NA	NA
Conductivity	Quarterly	Each event	NA	NA	NA	NA
Dissolved O2	Quarterly	Each event	NA	NA	NA	NA
Turbidity	Quarterly	Each event	NA	NA	NA	NA
Total Phosphorus	Annually	Quarterly	1 per Batch or 1 per 20 samples	1 per Batch or 1 per 20 samples	1 per Batch or 1 per 20 samples	1 per Batch or 1 per 20 samples
Chlorophyll *a*	Annually	quarterly	1 per Batch or 1 per 20 samples	1 per Batch or 1 per 20 samples	Per client request	NA
E. coli	Annually	Quarterly	+/- Control Checks	NA	Per client request	NA
Microcystins	Annually	Annually	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples
Anatoxin-a	Annually	Annually	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples

For tests conducted with ALS Laboratories including total phosphorus, chlorophyll a, and *E. coli*, two co-located samples will be collected once every three months (at the same time as field audits) to estimate overall variability due to sampling and analysis. The site chosen for the co-located (duplicate) sample will be chosen at random and documented by the project lead. The duplicate sample will be taken sequentially (taken at the same location and depth as the original sample) and will include all parameters scheduled for collection at that point.

For bluegreen algae toxin testing a King County Environmental Health, two co-located samples will be collected once a year to estimate overall variability due to sampling and analysis. The duplicate sample will be taken sequentially (taken at the same location and depth as the original sample) and will include all parameters scheduled for collection at that point.

The results from an original sample and its duplicate (sequentially collected) sample are used to calculate the expected variance that is due to short-term environmental factors, filed collection and processing, and laboratory analysis.

Contamination will be assessed by the submission of field blanks. Once a year, fresh distilled water will be submitted rather than the co-located (duplicate) sample. These will be "transport" blanks for constituents where there is no field processing of the sample (e.g. nutrients), and "rinsate blanks" for filtered constituents. Blank results are expected to be below reporting limits.

Laboratory QC will follow each lab's internal procedures.

Profile data will be collected using Ysi ProDSS datasonde, calibrated and used according to manufacturer's instructions (https://www.ysi.com/ProDSS). To verify accurate calibration, lab samples for turbidity will be taken at the three in situ locations during the first sampling event and thereafter on a quarterly basis. Field duplicates will be taken upon every sampling event, with a minimum of 5 minutes time between sampling. Field blanks will be measured, in the field, on a quarterly basis.

10.2 Corrective action processes

If analytical results fall outside of the quality control acceptance criteria, and the analytical method does not state the consequence, then the results should be flagged as such and the project lead will assess the best course of action.

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

The laboratory verifies its measurement results. In addition, the following procedures will be followed and are the responsibility of the project lead:

- Standard lab and field QC procedures will be adhered to.
- The data will be checked for data entry errors and completeness.
- Results will be checked for reasonableness
- Lab and Field QC results will be evaluated to ensure that the measurement quality objectives (MQOs) were met. Data failing to meet MQOs will be either coded or discarded.

11.2 Lab data package requirements

Standard with Excel and text formats.
King County Environmental Lab will supply a narrative, tabulated sample results and quality control data for each data submission set. These will be available within 10 working days of sample delivery.

11.3 Electronic transfer requirements

Data will be imported onto the project's comprehensive excel spreadsheet to limit reentry issues and facilitate the analysis of the data**.**

King County Environmental lab will supply lab results in a format compatible with EIM data entry templates. This will be supplied annually, within 30 days of the end of the algae toxin sampling events that year.

11.4 Acceptance criteria for existing data

NA

11.5 EIM/STORET data upload procedures

Annually, at the end of each full year of sampling, all data will be input into Ecology's EIM.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

The project lead will perform a technical systems audit (a qualitative audit of conformance to the QA Project Plan) within the first three months of the commencement of work. A brief report will be generated discussing the relevant sections of the QAPP, any necessary corrective actions, and included in the progress and final report.

Proficiency Testing is worked into the schedule with duplicate samples submitted to lab once a year.

12.2 Responsible personnel

All reports will be the responsibility of the project lead.

12.3 Frequency and distribution of report

CCHD will submit progress reports to Ecology quarterly as described in the grant's scope of work. In addition, the project lead will email Ecology with a brief description of the technical systems audit results.

12.4 Responsibility for reports

The CCHD project lead will write the final report.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

The following procedures will be followed and are the responsibility of the project lead:

- Standard field QC procedures will be adhered to.
- The data will be checked for data entry errors and completeness by the project lead.
- Results will be checked for reasonableness by the project lead.
- Field QC results will be evaluated to ensure that the measurement quality objectives (MQOs) were met. Data failing to meet MQOs will be either coded as estimates or discarded.
- In this study, data is generated by the lab, the volunteers, and in the case of probe generated data, the project lead. The project lead will perform the data verification.

13.2 Lab data verification

Lab data verification will be according to internal QC procedures.

13.3 Validation requirements, if necessary

N/A

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

QA assessments for precision will be made by comparing calculated standard deviation of split sample pairs to the larger of the percent relative standard deviation times the mean of the sample pair or the maximum standard deviation tabulated in the MQOs (Table X).

Data will be compiled, and computation of the results' mean, variance and standard deviation will occur. Results will be presented graphically and in such a way that significant trends are easily identified. Carlson's Trophic State Index (Carlson, 1977) will also be calculated using Secchi depth, phosphorus, and chlorophyll *a*, independently.

14.2 Data analysis and presentation methods

Results of this study will be compared to those of the SLWAC sampling.

All results will be graphed, and further statistical analysis will include mean, variance, and standard deviation.
QA assessments for precision will be made by comparing calcualted standard deviations of split sample pairs to the larger of the percent relative standard deviation times the mean of the sample pair or the maximum standard deviation tabulated in the MQOs (Table 3). Standard deviation for paired samples may be calculated according to Equation 1:

$$s = \sqrt{(r_1 - r_2)^2 / 2}$$

where s is the standard deviation and r_1 and r_2 are paired results.

Where results are to be combined then QC pairs may be pooled using Equation 2:

$$s_p = \sqrt{\sum (r_1 - r_2)^2 / 2m}$$

where sp is the pooled standard deviation and m is the number of pairs. The value sp may then be compared to the MQOs in Table X.

14.3 Treatment of non-detects

Non-detects will be handled as zero's.

14.4 Sampling design evaluation

One intent for this sampling plan is to identify and explore any correlation of a constituent(s) that occurs before or upon an algal bloom. This theorized correlation could be further tested by a subsequent bluegreen algae toxin grant, eventually leading to a lake specific water quality predictor of bluegreen algae toxins. If no such correlation is demonstrated, it is likely either because of the limited bluegreen algae toxin testing that occurs in this study, or because we did not study the corresponding water quality parameter(s).

14.5 Documentation of assessment

All documentation of assessment will be presented in the final report.

15.0 References

Bhagat, S. K. et. al. (1975). Study of Silver Lake Eutrophication – Current Problems And Possible Solutions. State of Washington Water Research Center, Washington State University and University of Washington, Report No. 19. Pgs v, 1-5

Bell-McKinnon, Maggie. (2014). Personal Communication with SLWAC, transcribed and filed at CCHD.

Call, Willard A. (1974). Soil Survey of Cowlitz Area, Washington. U.S. Department of Agriculture, Soil Conservation Service in cooperation with Washington Agricultural Experiment Station. APO.

Carlson, R.E. (1977). A trophic state index for lakes. Limnology and Oceanography. 22:361-369.

Carlson, R.E. and J. Simpson. (1996). *A Coordinator's Guide to Volunteer Lake Monitoring Methods*. North American Lake Management Society. 96pp. http://www.secchidipin.org/index.php/monitoring-methods/trophic-state-equations/ (July 2, 2015)

Entranco Engineers (1976). Silver Lake Rehabilitation Program P.L. 92-500, Section 104(h) Grant Application.

KCM (1998). Silver Lake Phase II Restoration Monitoring. KCM, Inc., Seattle WA

Cowlitz County Conservation District (1994). Silver Lake Watershed Management Plan. Cowlitz County Conservation District. Pgs 1-4

Moore, B. C. and Funk, W. H., (1990). Silver Lake Restoration Phase I: Diagnostic/Feasibility Study. State of Washington Water Research Center. Report No. 73.

Sumioka S. S. and Dion N. P. (1985). Trophic classification of Washington lakes using reconnaissance data. Washington State Department of Ecology. Water-Supply Bulletin 57.

16.0 Figures

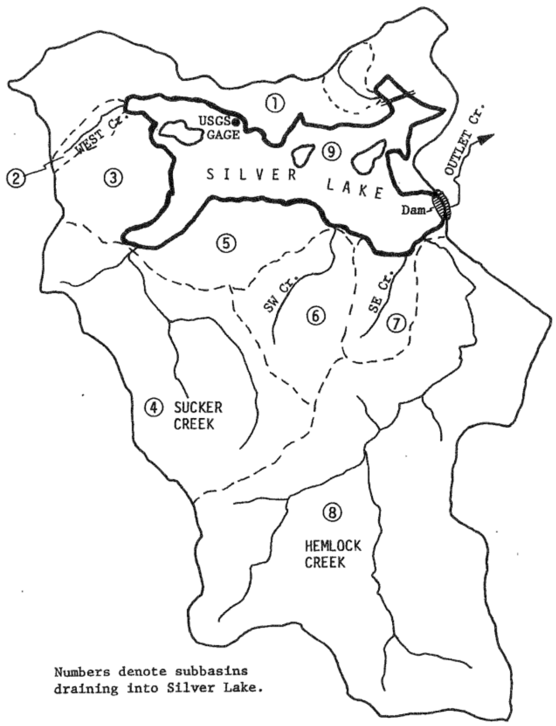


Figure 2. Silver Lake Watershed

17.0 Tables

Tables are located in the relevant sections above.

18.0 Appendices

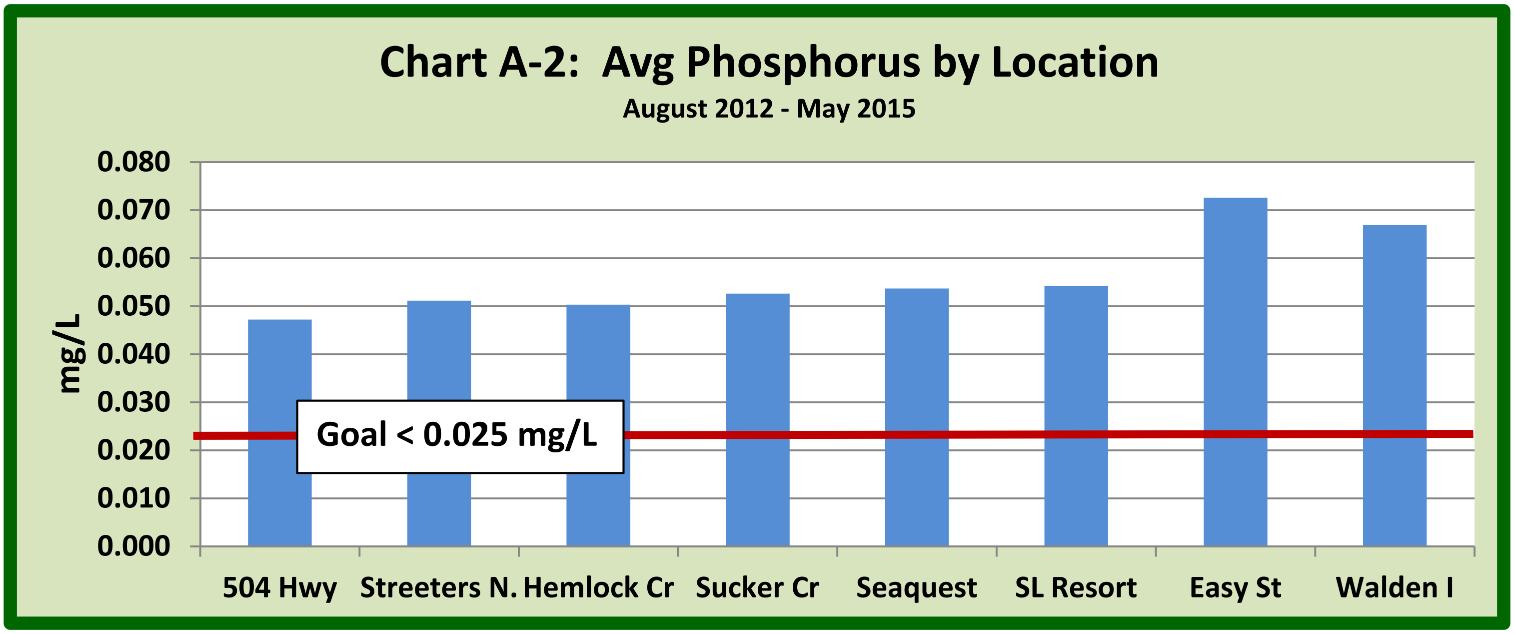
Appendix A.

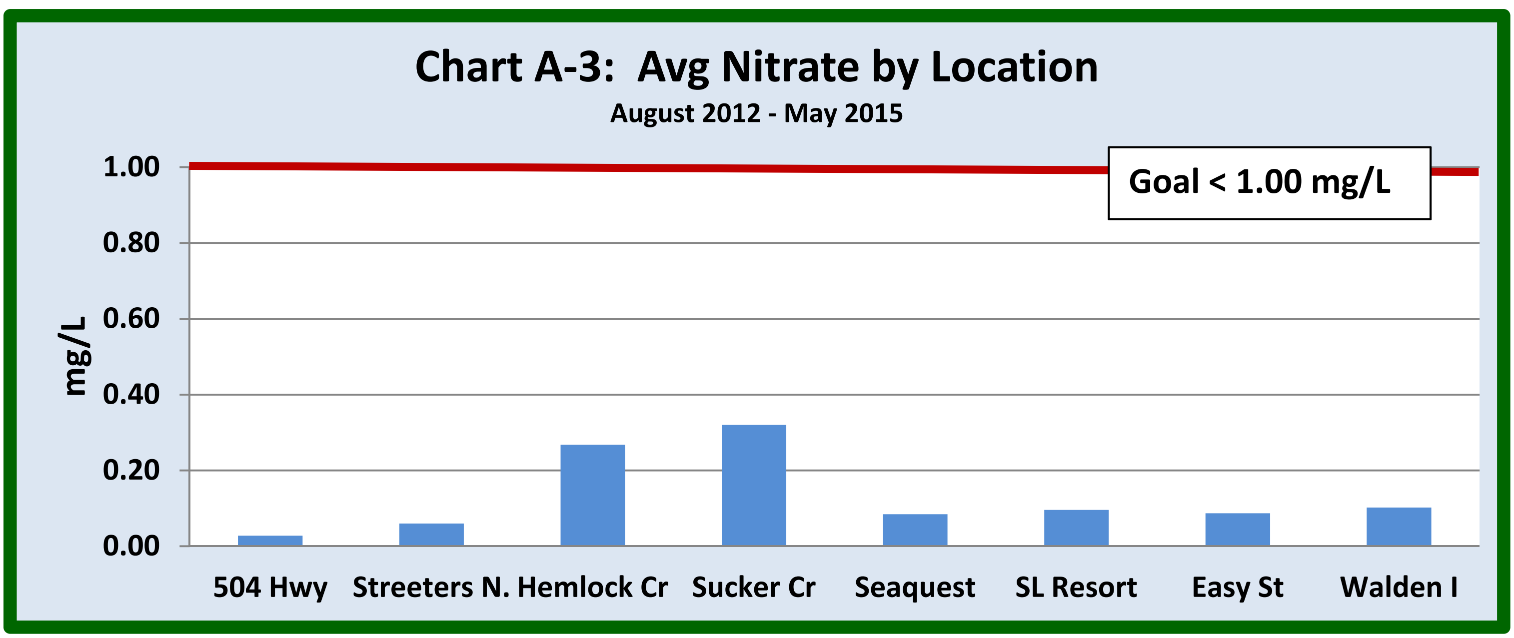
A-1. Timeline of Silver Lake Documents and *Activities*

1971 Outlet Creek Dam was constructed to control water levels
1975 Study of Silver lake Eutrophication – Current Problems and Possible Solutions
1976 Silver Lake Rehabilitation Project – Grant Application
1990 Silver Lake Restoration Phase I: Diagnostic/Feasibility Study (by Moore)
1991 Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska
1991 Baseline Surveys of Lacustrine Wetland Vegetation and Waterfowl Use – Silver Lake
1991 Preliminary Design Report – Containment Structure – Silver Lake Restoration Project
1991 Silver Lake Phase II Restoration
1991 Acknowledgements
1992 Monitoring Plan for Silver Lake Restoration (by KCM and JD White)
1992 Silver Lake Restoration Project – Fish Containment Structure
1992 Project Plan for Silver Lake Phase II Restoration Monitoring
1992 Quality Assurance Project Plan for Field Investigations to Support Silver Lake Restoration Phase II Monitoring
1992 83,000 carp were placed in the lake.
1992 1992 Annual Report – Cowlitz County Department of Community Development
1993 Silver Lake – Quarterly Report (by KCM)
1994 Silver Lake – 1993 Annual Report (by KCM)
1994 Silver Lake – Semi-Annual Report (by KCM)
1994 Silver Lake Watershed Management Plan (by Cowlitz County Conservation District)
1994 Summary – Silver Lake Watershed Management Plan.
1995 Silver Lake 1994 Annual Report (by KCM)
1996 Silver Lake 1995 Annual Report (by KCM)
1996 Research Report by State of Washington Department of Fish & Wildlife, Management of Aquatic Plants in Washington State Using Grass Carp: Effects on Aquatic Plants, Water Quality and Public Satisfaction.
1997 Silver Lake Survey: The Forage Fish Community After Removal of Aquatic Vegetation by Grass Carp (by Mueller)
1997 Silver Lake 1996 Annual Report (by KCM)
1998 Silver Lake Phase II – Restoration Monitoring (by KCM)
2009 Two public health cautionary postings for algae bloom
2010 One public health cautionary posting for algae bloom
2011 One public health cautionary posting for algae bloom
2013 Two public health cautionary postings for algae bloom

Appendix A.

A-2 through A-4: Averages of SLWAC Lab Tests





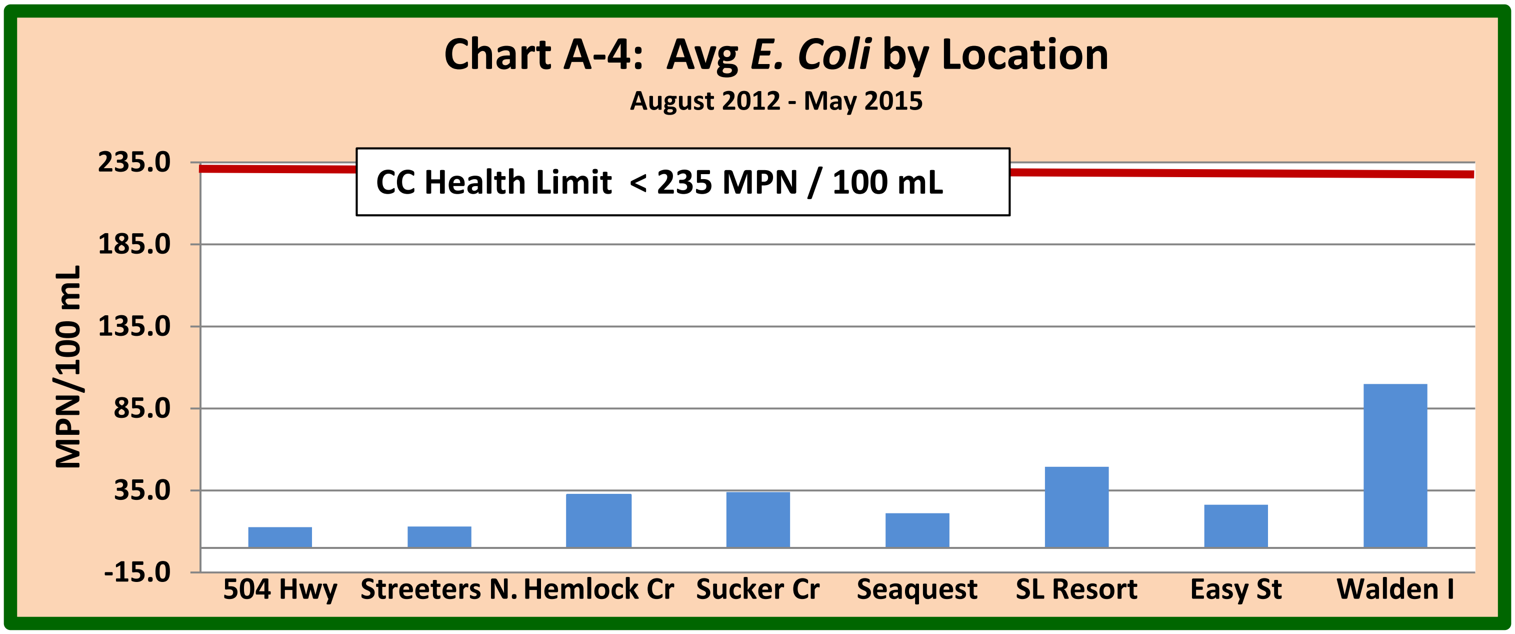
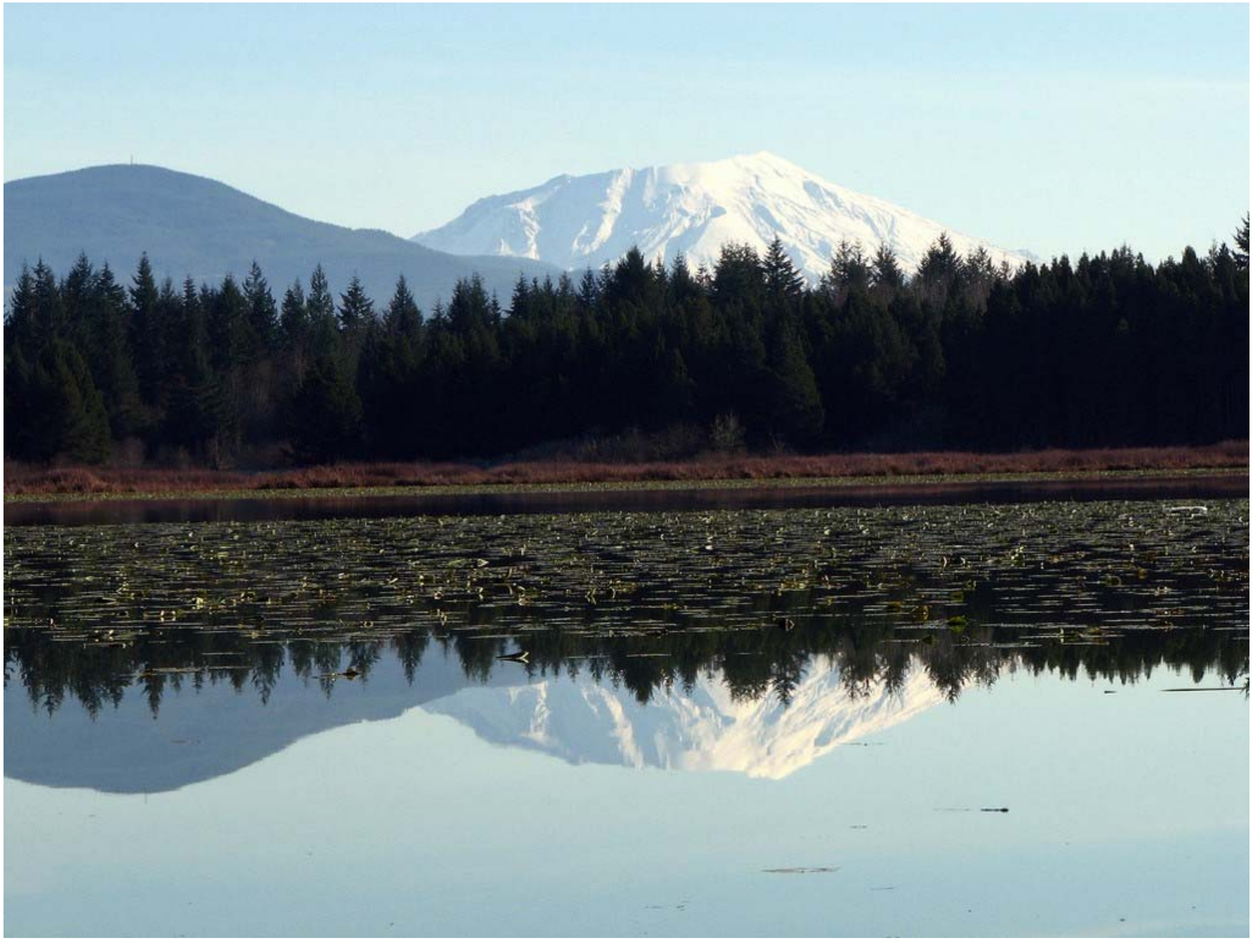


Chart A-4: Avg *E. Coli* by Location
August 2012 - May 2015
CC Health Limit < 235 MPN / 100 mL
MPN/100 mL
235.0
185.0
135.0
85.0
35.0
-15.0
504 Hwy
Streeters N.
Hemlock Cr
Sucker Cr
Seaquest
SL Resort
Easy St
Walden I

Appendix A.
A-5. Silver Lake SOPs

SOP

SILVER LAKE



BY HILARIE LARSON, REHS

COWLITIZ COUNTY ENVIRONMENTAL HEALTH UNIT

Contents

1. General Information

This Standard Operating Procedure (SOP) is applicable to the collection of representative liquid samples from Silver Lake. The intent of SOPs is to ensure safety of personnel and validity of results.

Activities for each sample event are divided into four segments: land preparation, water preparation, sampling and measuring, and shipping.

In general, sampling should occur between 10 am and 3 pm. However, there is flexibility in both the time and the day of the sampling event, especially in consideration of weather conditions. Common sense and good judgment dictate timing. Under no circumstances should volunteers be on the water during rain or electrical storms, high winds, or other unsafe conditions.

To assist in obtaining the highest quality of data possible, please keep in mind that there are two common sources of interference; cross contamination of samples and improper sample collection. Following proper decontamination procedures and minimizing disturbance of the sample site will help to eliminate these problems.

2. Land Preparation

Land Preparation includes four distinct tasks:

TASK 1 - Confirm sample schedule and plan, and weather conditions.

- Check QAPP Table 7.1.1 (B), Sample and Test Schedule (Per Calendar Year), to determine what tests to perform and what samples to take. The parentheses indicate total number of constituent to be tested, while the letters identify the locations.
- Check the current and forecasted weather and decide if the conditions allow for safe sampling. Confirm this decision after personally inspecting lake conditions prior to launching the boat and beginning the sampling trip.
- Ideal sampling days are Mondays, Tuesdays, or Wednesdays. If sampling is to occur on any other weekday, check with both receiving labs, as applicable.

TASK 2 – Prep labels and reports.

Fill out general info on bottle labels and Chain of Custody Report. Always leave “time” blank until all samples are collected, then fill it in.

TASK 3 – Check for boating safety equipment.

- Ensure that a personal flotation device is available for each person. Devices must be Coast Guard-approved, readily available, and properly sized.
- Ensure that a first aid kit is onboard.
- Check for other equipment that may be required by State and local boating laws. For example, boats may be required to carry fire extinguishers and sound-producing devices. (Also, the boat must be registered according to State and local laws.)

TASK 4 – Confirm sampling equipment and supplies

Before leaving shore, ensure that all sampling equipment and supplies are on board the boat:

- Anchor (with a measured line if a depth check is required). Two anchors are helpful on windy days, one off the bow and the other off the stern.
- Secchi disk with a measured line and a clothespin

- Water sampler instrument (for integrated or point sampling)
- Water sample collection containers
- Ice cooler (with a closable lid) with frozen ice packs
- Clipboard and pencils
- Field manual including map of lake with sampling sites and landmarks marked
- Sampling forms
- Laboratory issued shipping coolers with frozen ice packs and Chain of Custody Reports
- Phosphorus sample shipping bottle (with a small amount of acid to preserve the sample), and *E. coli* and chlorophyll *a* sample shipping bottles in ALS laboratory cooler.
- Three – four pairs of vinyl gloves (four lab tests from June – September)
- One pair of safety goggles for phosphorus pour.

3. Water Preparation

TASK 1 - Position boat at the designated sample site.
Locate the sample site on the water. Whether or not a marking buoy is used, the position should be verified using the shoreline landmark method. When the sonde (probe) is present, use its GPS function.
Once the site is located, anchor the boat if necessary. Repositioning the anchor once it is dropped should be discouraged, especially in shallow lakes, because it can stir up sediments from the lake bottom. Increasing sediment turbidity may alter data results. After anchoring, volunteers should allow the boat to stabilize.

TASK 2 - Complete the observations portion of the sampling form.
Record your observations about the lake and weather conditions on the sampling form. In addition, write down any unusual conditions that may affect the sampling results. Reporting visual conditions such as water color and appearance will aid in interpreting data results. For example, if the sampling trip was conducted after a storm, the water may temporarily be more be more brownish and turbid than usual. This turbidity probably will lower the Secchi disk reading and elevate the total phosphorus concentration. Without the information concerning the rainstorm, an analyst might conclude that other factors could have caused a decrease in water quality.

- If not done previously, record the name of the lake and site, the date, the time of sampling, and the names of volunteers doing the sampling.
- Record water condition observations at the site including water color, suspended sediment and algae, aquatic plants, waterfowl activity, and odor.
- Record weather conditions on the form including the amount of cloud cover (when taking the Secchi disk reading), the approximate air temperature, the wind speed and direction, and water surface conditions. Indicate any unusual weather conditions that may have occurred in the past week including storms, high winds, and temperature extremes.
- Record any other factors or conditions that make the sampling trip unusual or that may potentially influence sample results. For example, report any chemical, mechanical, or biological control of algae or aquatic weeds that may have been done recently on the lake.

4. Take Samples and Measurements

TASK 1 Water Probe Measurements.
The CCHD staff will follow all manufacturer's instructions to obtain ambient air temperature, surface water temperature at 1', and at 3': water temperature, pH, conductivity, dissolved oxygen, and turbidity. Be attentive to the fact that pH readings need a few minutes to equilibrate at each depth.

TASK 2 - Measure the Secchi disk depth.
It is preferable to have the same individual take the reading at a site throughout the entire sampling season. The line attached to the Secchi disk must be marked according to meters and designated to the nearest one-tenth meter. Meter intervals on the line can be tagged with a piece of duct tape with the interval measurement indicated on the tape.

- Check to make sure that the Secchi disk is securely attached to the measured line.
- Lean over the side of the boat and lower the Secchi disk into the water, keeping your back toward the sun to block glare.
- Continue to lower the disk until it just disappears from view. Lower the disk another one foot, and then slowly raise the disc until it just reappears. Continue to move the disk up and down until the exact vanishing/reappearing point is found.
- Make a reading if one is possible with certainty, or attach a clothespin to the line at the point where the line enters the water and slowly pull the disk out of the water and record the measurement based on the location of the clothespin on the line.

This procedure can be repeated as a quality control check; an average of the two readings should be recorded on the sampling form.

TASK 3 – Collect a point sample for appropriate lab tests.

- When you arrive at sampling location, rinse sample collection jar with surface water and shake dry.
- Attach sample collection jar to the Telescopic Jar Sampler.
- Lower the sampler gently into the water to the desired depth as marked on the pole.
- Pull the pull-ring extending from the handle to open the plunger on the telescoping pole. When bubbles stop rising from the sampler, release the pull ring to close the plunger and gently bring the sampler to the surface.
- Mark sampling time on lab containers with waterproof pen.
- Remove the sampling bottle from the pole and fill the pre-labeled lab containers.
- Shake collection jar to remove water drops.
- Place lab containers in cooler with ice.

5. Shipping

TASK 1 - Transfer sample water into shipping bottles.
Prepare to transfer sample water into laboratory bottles. If weather conditions could interfere with a safe transfer of sample water into lab bottles, then bring the boat back to shore and unload the sampling equipment and supplies, and move indoors or find an outdoor location that is dry and shielded from the wind.
Remember to leave the cap on the phosphorus lab bottle until you are ready to pour the sample into it, as it is extremely susceptible to contamination. Also remember that the phosphorus lab bottle contains an acid that preserves the sample water during transport, which can burn skin or clothing if spilled or mishandled. The bottle vapors should also be avoided. Please be familiar with the Acid Warning Info Sheet kept in the Field Manual.

A. For phosphorus sample bottle:

- Make sure the phosphorus sample bottle is (yellow) labeled with:
  - the parameter to be analyzed (total phosphorus).
  - the date and the sample lake, location, and depth.
  - any additional information such as an accession number for laboratory identification and the acid content.
- Put on a new pair of vinyl gloves.
- Confirm that there is **acid present** in the bottom of the bottle by visual inspection.
- Move the total phosphorus sample bottle into position and remove the cap, being careful not to spill the acid contents or breathe in the vapors.
- Gently shake the container with the sample water to re-suspend any settled material.
- Gently pour the sample water into the phosphorus bottle until the liquid reaches the fill line.
- Cap the sample bottle and place it into the shipment container with the frozen ice packs and close the lid so sunlight cannot reach it.

B. For *E. coli* sample bottle:

- Make sure the *E. coli* sample bottle **(sterile container)** is labeled with:
  - the parameter to be analyzed (*E. coli*).
  - the date and the sample lake, location, and depth.
  - any additional information such as an accession number for laboratory identification.
- Put on a new pair of vinyl gloves.
- Move the *E. coli* sample bottle into position and remove the cap, taking care to avoid contamination of the inside of the sample bottle.
- Gently shake the container with the sample water to re-suspend any settled material.
- Gently pour the sample water into the *E. coli* bottle until the liquid reaches the fill line.
- Cap the sample bottle and place it into the shipment container with the frozen ice packs and close the lid so sunlight cannot reach it.

C. For chlorophyll *a* sample bottle:

- Make sure the chlorophyll a sample bottle is labeled with:
  - the parameter to be analyzed (chlorophyll *a*).
  - the date and the sample lake, location, and depth.
  - any additional information such as an accession number for laboratory identification
- Move the chlorophyll *a* sample bottle into position and remove cap.
- Gently shake the container with the sample water to re-suspend any settled material.
- Gently pour the sample water into the chlorophyll *a* bottle until the liquid reaches the fill line. ***Filling to neck is best.*** A fill that is less than shoulder height will be inadequate.
- Cap the chlorophyll *a* sample bottle and place it into the shipment container with the frozen ice packs and close the lid so sunlight cannot reach it.

D. For bluegreen algae sample bottle:

- Fill out the Algae Sampling Data Supplemental Information sheet provided by Ecology.
- Wearing waterproof gloves, collect the sample at the indicated site by dipping the lab bottle **directly** into the water. If algae surface scum is present, try to collect it. Leave about an inch of space between the sample water and the top of the bottle.
- Replace the cap on the bottle and wipe the bottle dry.

- Using a permanent marker, fill out the following information; the date, time, your name, water body name, and sampling location.
- Fill out the data sheet and include it with sample.

TASK 2 – Clean Equipment and Ship Samples and Forms

Clean the sampling and laboratory equipment for the next sampling trip. The Secchi disk and water sampler should be rinsed off with fresh tap water, and the sampling containers rinsed with distilled water.

Pack and forward the shipping containers with the samples to the laboratories as soon as possible.

Wrap the bottle containing the sample with bubble wrap.

- Place the bubble-wrapped bottle, along with a frozen ice package into a Styrofoam or well-padded shipping container. The sample must remain cool or the lab will have to discard it.
- Apply the preprinted mailing label for the laboratory.
- Using duct tape or other sturdy tape, securely tape the stryrofoam container for mailing.

For bluegreen algae: Ship to King County Environmental Laboratories using an overnight delivery service. Ship samples at the beginning of the week. Never ship on Fridays. Personal delivery can be made at 322 West Ewing Street, Seattle WA from 8:30am to 5:30pm, excluding holidays. If there is any delay in shipping, refrigerate the sample (no more than a day or two).

For other sample bottles: Deliver in person to: ALS Global Laboratory, 1317 S. 13th Ave, Kelso, WA 98626 between 8am and 5pm Monday-Friday and between 8am and 12pm on Saturday.

6. Chain of Custody Sample

ALS Environmental

CHAIN OF CUSTODY 52406

001

SR#________
COC Set____of____
COC#________

Page 1 of 1

1317 South 13th Ave, Kelso, WA 98626 Phone (360) 577-7222 / 800-695-7222 / FAX (360) 636-1068
www.alsglobal.com

Project Name: Silver Lake
Project Number:
Project Manager: Del Gilkerson
Company: SLWAC
Address: P.O. Box 88- Toutle, WA, 98649
Phone #:
email: delgil @cni.net
Sampler Signature: Del Gilk
Sampler Printed Name: Del Gilkerson

e-mail Results to:

delgil @ cni.net
Longs @ co.cowlitz.wa.us
skoglands @ live.com

CLIENT SAMPLE ID	LABID	SAMPLING Date	SAMPLING Time	Matrix	NUMBER OF CONTAINERS	8H SM 9223 B / Colilert EC C	28D 353.2 / NO2 NO3 T	365.3 / Phos T	1	2	3	4	5	Remarks
# 2 Hwy 504		10	40	H2O	2	✓	✓	✓						
# 3 Streeter		↓		↓	↓	↓	↓	↓						
# 7 Hemlock														
# 10 Sucker														
#12 Seaquest														
# 13 Silver R.														
# 15 Easy St.														
# 17 Walden I.														
9.														
10.														

Report Requirements
__ I. Routine Report: Method Blank, Surrogate, as required
__ II. Report Dup., MS, MSD as required
__ III. CLP Like Summary (no raw data)
__ IV. Data Validation Report
__ V. EDD

Invoice Information
P.O.#______
Bill To: Cowlitz County

Turnaround Requirements
__ 24 hr. __ 48 hr.
__ 5 Day
__ Standard
Requested Report Date

Circle which metals are to be analyzed

Total Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

Special Instructions/Comments: call if E-Coli over 200 360-751-2231

*Indicate State Hydrocarbon Procedure: AK CA WI Northwest Other____ (Circle One)

Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature Del Gilk	Signature	Signature	Signature	Signature	Signature
Printed Name Del Gilkerson	Printed Name	Printed Name	Printed Name	Printed Name	Printed Name
Firm SLWAC	Firm	Firm	Firm	Firm	Firm
Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time

7. References

USEPA Region 9 Laboratory, Field Sampling Guidance Document #1225 Surface Water Sampling

USEPA SOP EAP030

USEPA SOP EAP012

SLWAC Sampling Procedures (May 2013), Del Gilkerson

Appendix B -- Glossary, Acronyms, and Abbreviations

Quality Assurance Glossary

Accreditation - A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy - the degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

Analyte - An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e. g. fecal coliform, Klebsiella, etc. (Kammin, 2010)

Bias - The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

Blank - A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

Calibration - The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. (Ecology, 2004)

Check standard - A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards, but should be referred to by their actual designator. (i. e. CRM, LCS, etc.) (Kammin, 2010; Ecology, 2004))

Comparability - The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

Continuing Calibration Verification Standard (CCV) - A QC sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run. (Kammin, 2010)

Control chart - A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system. (Kammin, 2010; Ecology 2004)

Control limits - Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean. (Kammin, 2010)

Data Integrity- A qualitative DQI that evaluates the extent to which a dataset contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

Data Quality Indicators (DQI) - Data Quality Indicators (DQIs) are commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity. (USEPA, 2006)

Data Quality Objectives (DQO) - Data Quality Objectives are qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. (USEPA, 2006)

Dataset - A grouping of samples organized by date, time, analyte, etc (Kammin, 2010)

Data validation - An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the dataset. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation
- Use of third-party assessors
- Dataset is complex
- Use of EPA Functional Guidelines or equivalent for review

Examples of data types commonly validated would be:

- Gas Chromatography (GC)
- Gas Chromatography-Mass Spectrometry (GC-MS)
- Inductively Coupled Plasma (ICP)

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier, data is usable for intended purposes
- J (or a J variant), data is estimated, may be usable, may be biased high or low

- REJ, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004)

Data verification - Examination of a dataset for errors or omissions, and assessment of the Data Quality Indicators related to that dataset for compliance with acceptance criteria (MQO's). Verification is a detailed quality review of a dataset. (Ecology, 2004)

Detection limit (limit of detection) - The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

Duplicate samples - two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

Field blank - A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

Initial Calibration Verification Standard (ICV) - A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples. (Kammin, 2010)

Laboratory Control Sample (LCS) - A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. (USEPA, 1997)

Matrix spike - A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

Measurement Quality Objectives (MQOs) - Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness. (USEPA, 2006)

Measurement result - A value obtained by performing the procedure described in a method. (Ecology, 2004)

Method - A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

Method blank - A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

Method Detection Limit (MDL) - This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

Percent Relative Standard Deviation (%RSD) - A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010)

Parameter - A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all "parameters" (Kammin, 2010; Ecology, 2004)

Population - The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

Precision - The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

Quality Assurance (QA) - A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

Quality Assurance Project Plan (QAPP) - A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

Quality Control (QC) - The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

Relative Percent Difference (RPD) - RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples - two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

Representativeness - The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

Sample (field) – A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

Sample (statistical) – A finite part or subset of a statistical population. (USEPA, 1997)

Sensitivity - In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)

Spiked blank - A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

Spiked sample - A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency. (USEPA, 1997)

Split Sample – The term split sample denotes when a discrete sample is further subdivided into portions, usually duplicates. (Kammin, 2010)

Standard Operating Procedure (SOP) – A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010)

Surrogate – For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis. (Kammin, 2010)

Systematic planning - A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning. (USEPA, 2006)

Quality Assurance Glossary References

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Glossary – General Terms

Ambient: Background or away from point sources of contamination.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Eutrophic: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

Fecal coliform: That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities. This includes, but is not limited to, atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination is considered a nonpoint source. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act is a nonpoint source.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or is likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Any fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char is considered a salmonid. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Total suspended solids (TSS): Portion of solids retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standard, and are not expected to improve within the next two years.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
GPS	Global Positioning System
i.e.	In other words
MQO	Measurement quality objective
NPDES	(See Glossary above)
QA	Quality assurance
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
SRM	Standard reference materials
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cms	cubic meters per second, a unit of flow.
ft	feet
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams.
km	kilometer, a unit of length equal to 1,000 meters.
m	meter

mg	milligram
mg/L	milligrams per liter (parts per million)
mL	milliliters
mm	millimeter
NTU	nephelometric turbidity units
ug/L	micrograms per liter (parts per billion)
um	micrometer
uS/cm	microsiemens per centimeter, a unit of conductivity