CAPITOL LAKE – DESCHUTES ESTUARY

Long-Term Management Project Environmental Impact Statement

Water Resources Methodology for Capitol Lake – Deschutes Estuary

Prepared for:

Washington State Department of Enterprise Services

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This document presents the proposed methodology to assess discipline-specific impacts of the alternatives being considered for the Capitol Lake – Deschutes Estuary Long-Term Management Project. This memorandum has been reviewed by an independent third-party expert or experts and the methodology has been presented to, and discussed with, the resource agencies and local governments on the Technical Work Group. The methodology described has been prepared early in the Environmental Impact Statement (EIS) process, as alternatives are being optimized, and may reasonably evolve as conceptual design, modeling, and analysis of the alternatives progresses. The results of this discipline-specific analysis will be presented in a Discipline Report, which will be attached to and summarized in the Draft EIS. Public comment will be solicited on the Draft EIS, consistent with rules of the State Environmental Policy Act.

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List of Acronyms and Abbreviations

Acronyms/ Abbreviations	Definition
BOD_5	Total 5-day biochemical oxygen demand
DO	Dissolved oxygen
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
EIS	Environmental Impact Statement
Enterprise Services	Washington State Department of Enterprise Services
Herrera	Herrera Environmental Consultants, Inc.
QAPP	Quality Assurance Project Plan
TMDL	Total Maximum Daily Load
TN	Total nitrogen
TP	Total phosphorus
WAC	Washington Administrative Code

1.0 Introduction

The Capitol Lake – Deschutes Estuary includes the 260-acre Capitol Lake Basin, located on the Washington State Capitol Campus, in Olympia, Washington. The waterbody has long been a valued community amenity. Capitol Lake was formed in 1951 following construction of a dam and provided an important recreational resource. Historically, the Deschutes Estuary was used by local tribes for subsistence and ceremonial purposes. Today, the expansive waterbody is closed to active public use. It is plagued by environmental issues including the presence of invasive species, violations of water quality standards, and inadequate sediment management.

The Washington State Department of Enterprise Services (Enterprise Services) is responsible for the stewardship, preservation, operation, and maintenance of the Capitol Lake Basin. The 260-acre Capitol Lake Basin is maintained by Enterprise Services under long-term lease agreement from the Washington Department of Natural Resources.

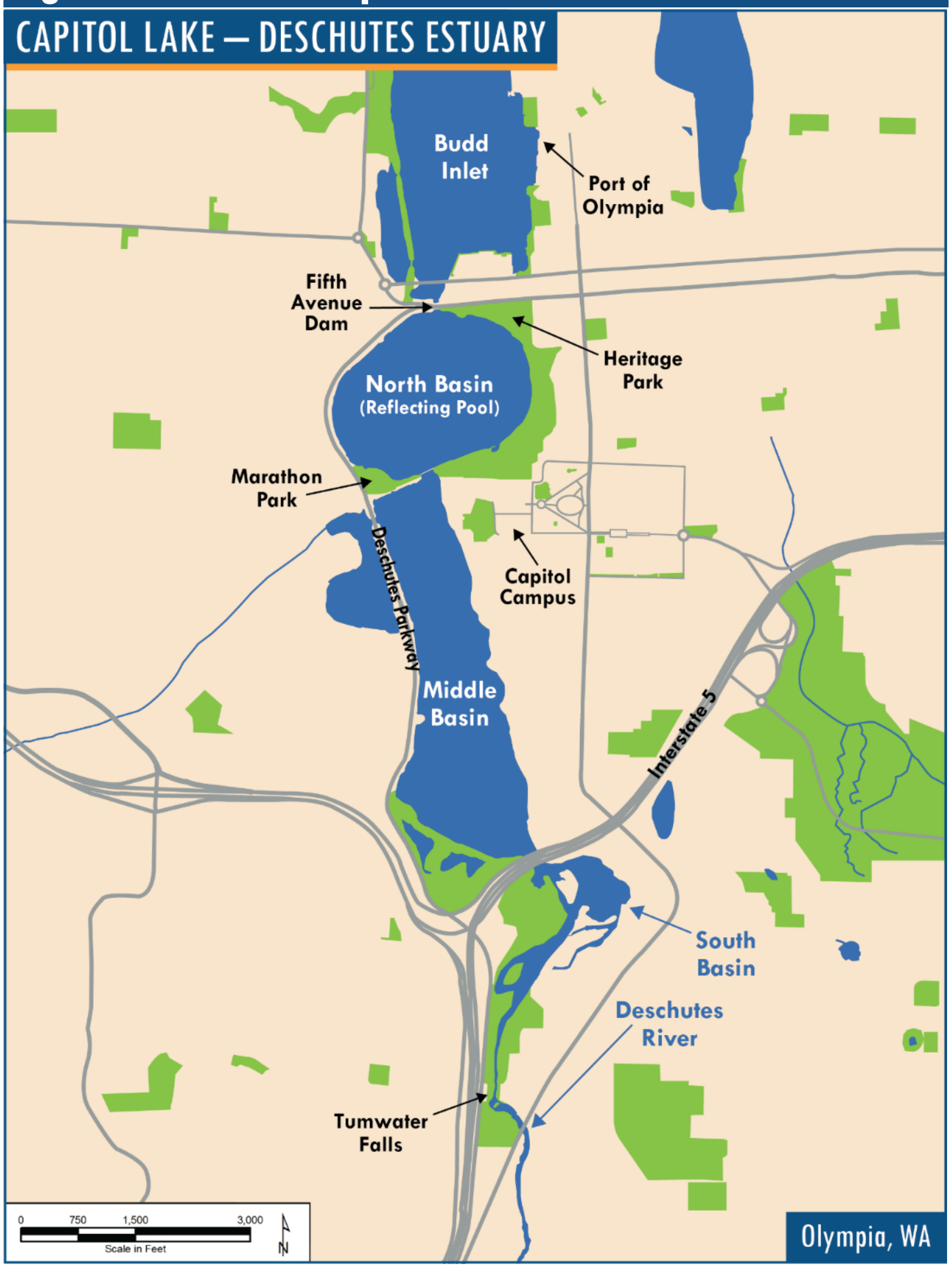
In 2016, as part of Phase 1 of long-term planning, a diverse group of stakeholders, in collaboration with the state, identified shared goals for long-term management and agreed an Environmental Impact Study (EIS) was needed to evaluate a range of alternatives and identify a preferred alternative. In 2018, the state began the EIS process. The EIS will evaluate four alternatives, including:

- **Managed Lake Alternative**: Similar to existing conditions with additional strategies to manage sediment accumulation and water quality. The Managed Lake Alternative would retain the 5th Avenue Dam and tide gate in its current configuration to maintain the reflecting pool and Capitol Lake Basin.
- **Estuary Alternative**: Full tidal hydrology would be restored throughout the basin. Sediment would be managed through initial dredging in Capitol Lake Basin and recurring maintenance dredging in Budd Inlet.
- **Hybrid Alternative**: Allows management of the Basin by establishing a tidal estuary in the western portion of the North Basin, and throughout the Middle and South Basins. A retaining wall would also be constructed resulting in a reflecting pool adjacent to Heritage Park in the North Basin.

- **No Action Alternative**: The No Action Alternative in intended to represent the most likely future for the project area if the project is not implemented.

These long-term management alternatives will be evaluated against the shared project goals of: improving water quality; managing sediment accumulation and future deposition; improving ecological functions; and enhancing community use of the resource. Refer to Figure 1.1 for the project area for long-term management. The Final EIS will identify a preferred environmentally and economically sustainable long-term management alternative for the Capitol Lake – Deschutes Estuary.

Figure 1.1 Area Map



The EIS process leverages momentum from the previous phase by continuing engagement with the existing Work Groups, which include the local governments, resource agencies, and tribe. It also provides for expanded engagement opportunities for the public, such as a community sounding board. **Additional information, including additional background context, description of project alternatives, and project goals, can be found at the project website: www.capitollakedeschutesestuaryeis.org.**

1.1 DISCIPLINE-SPECIFIC METHODOLOGY

This document has been prepared to describe the proposed approach to the water quality analysis to be conducted as part of the Capitol Lake – Deschutes Estuary Long-Term Management Project EIS. It has been prepared by Herrera Environmental Consultants, Inc. (Herrera), the water resources lead for the project, with input from Environmental Science Associates (ESA). The methodology proposed within this document has been developed following an initial review of existing background documents, available data, comments received during the scoping period, and coordination with the EIS Project Team. The purpose of this document is to solicit feedback on the water quality analysis to provide background for and increase understanding of the technical analyses before they begin and to improve the methodology through various levels of early review.

The sections below provide a summary of the process that will be used to investigate, evaluate, and describe the potential water quality effects that could occur during construction and operation of the long-term management alternatives. The long-term management alternatives that will be reviewed in the Draft EIS include Managed Lake, Estuary, Hybrid, and No Action Alternatives. The water quality analysis of these alternatives will (1) characterize existing conditions within the study area, (2) identify potential impacts and benefits of the alternatives, and (3) recommend mitigation measures that could be implemented to avoid or minimize potential adverse impacts.

2.0 What is the Study Area?

The study area is based on the area where water quality could be affected by the project, determined to include the Capitol Lake Basin (including Percival Cove) and Lower Budd Inlet. The southern boundary of the water resources analysis is generally defined as the base of Tumwater Falls, and the northern limits extend to the southern end of Priest Point Park (47 04'N) in Budd Inlet (Figure 1.1). Upstream water resources are not part of the study area for this EIS evaluation because they do not have the potential to be affected by construction or operation of a long-term management alternative. However, water quality and hydrologic data for the Capitol Lake – Deschutes Estuary will be compiled for estimating any long-term trends in watershed inputs as well as for identifying lake management techniques that might be used to support Managed Lake Alternative goals.

3.0 What Potential Water Quality Effects Will be Important to Address in the EIS?

The EIS will address potential water quality effects from construction and operation of each project alternative. Project alternatives may directly influence compliance with numerical water quality criteria for temperature, dissolved oxygen (DO), pH, turbidity, fecal coliform bacteria, *Escherichia coli* (*E. coli)* bacteria, and action thresholds for total phosphorus (TP). In addition to numerical criteria, project alternatives may directly influence compliance with narrative water quality standards for aesthetics, protection of beneficial uses, and anti-degradation. For example, algal productivity is an important issue that needs to be evaluated for its influence on several beneficial uses including recreation, aesthetics, and aquatic life. Therefore, the project alternatives will be evaluated against numerical and narrative water standards, consistent with project goals and use designations for the project area defined in the Washington Administrative Code (WAC).

Water quality affects aquatic habitat, including endangered species. Results from this evaluation will be used to characterize impacts to fish and wildlife, including threatened and endangered species. The methods used to characterize those impacts are discussed in a separate document: Fish and Wildlife Methodology.

4.0 What Existing Water Resources Data are Available?

There is an abundance of data for potential use in the water resources assessment. The key documents and databases that will be used are listed separately below for the watershed, Capitol Lake, and Budd Inlet. Appendix A presents a summary of water quality data available for each water body from the Environmental Information Management (EIM) system managed by the Washington State Department of Ecology (Ecology). Additional data not yet in EIM have been provided by Ecology to supplement the EIM data, and the data are also presented in Appendix A. Relevant data will be compiled in spreadsheets for analysis of existing water resources conditions.

4.1 WATERSHED DATA

The project watershed includes the Deschutes River watershed, Percival Creek watershed, and other areas draining to Capitol Lake from the nearshore basin. Documents and databases containing relevant water resource data for the project watershed will be reviewed for relevance to the current evaluation, and incorporated as appropriate. These data sources include the following:

- **USGS Stream Flow Monitoring:** One continuous flow monitoring station on the Deschutes River at the E Street Bridge (1946 to present). One continuous monitoring station (1987 to 1990) on Percival Creek near the mouth.
- **USGS Water Quality Monitoring:** Select water quality parameters (including temperature, turbidity, pH, and phosphate) from 1977 to 1980 for the Deschutes River at E Street Bridge.
- **Ecology Total Maximum Daily Load (TMDL) Monitoring:** Water quality monitoring of the Deschutes River for TMDL water quality model development and calibration/verification. Parameters include temperature, fecal coliform, DO, nutrients, and pH from July 2003 to March 2005.
- **Thurston County Stream Flow Monitoring:** Continuous streamflow gauging of Percival Creek near the mouth (1993 to 2015) and Black Lake Ditch (a tributary to Percival Creek) (2005 to present).

- **Thurston County Water Quality Monitoring:** Deschutes River (Tumwater Falls station since 1993); Percival Creek (one station since 1993); and Black Lake Ditch (one station since 2005). Water quality monitoring for temperature, pH, DO, conductivity, turbidity, TP, nitrate+nitrite nitrogen, and flow at all stations.
- **Thurston County Stormwater Monitoring:** Stormwater outfall sampling for outfalls discharging to the Deschutes River between Tumwater Falls and the southern end of Tumwater Falls Park. Parameters sampled include fecal coliform, turbidity, TP, nitrate+nitrite, and ammonia by Thurston County Environmental Health staff from December 1999 to February 2000.
- **Thurston County Groundwater Monitoring:** Groundwater elevation and water quality monitoring at various wells near Capitol Lake, monitoring results presented from 2008 to 2017.
- **NOAA Weather Station:** Olympia airport precipitation data.

4.2 CAPITOL LAKE DATA

Relevant water resources data for Capitol Lake include:

- **Thurston County Capitol Lake Monitoring:** Monthly summer (May to October) water quality monitoring from 1999 to 2014 at up to four stations for field profiles (pH, temperature, DO), Secchi, TP, total nitrogen (TN), nitrate, ammonia, chlorophyll *a*, fecal coliforms, and algae ID.
- **Thurston County Stormwater Monitoring:** Along with the stormwater sampling report listed above, Thurston County monitored two stations within Capitol Lake (one Middle and North Basin) for depth, pH, DO and conductivity in 1999.
- **USGS/NWIS 1974:** Capitol Lake monitoring in February, April, June, and August 1974 for 34 analytes, including pH, OC, chlorophyll *a*, calcium, temp, total suspended solids, total; dissolved solids, etc.
- **Entranco 1997 Capitol Lake Drawdown Monitoring:** Report completed to analyze the effects of drawdown of Capitol Lake by managing the dam. Consists of salinity, conductivity, temperature, and depth of Capitol Lake in the Middle and North Basins. Samples were collected before drawdown and 2 weeks after backfilling.
- **Entranco 1984:** Assessment of Capitol Lake to address issues with fish kill prevention (tide gate), sediment deposition, water quality issues, and swim beach restoration, including a water and phosphorus budget.
- **Entranco 1990:** Evaluation of the feasibility of creating wetlands in South and Middle Basin of Capitol Lake.

4.3 BUDD INLET DATA

Relevant water resources data for Budd Inlet include:

- **Ecology Ambient Monitoring Program 1973-Ongoing:** Inner and Outer Budd Inlet ambient water quality monitoring stations for profiles of temp, DO, pH, turbidity, pressure, conductivity, light transmittance, and near surface and near bottom samples for alkalinity, nitrate, nitrite, ammonium, orthophosphate, silicate, dissolved inorganic carbon, and chlorophyll *a*. Monitoring is conducted monthly every year at Outer Budd Inlet and every 5 years at Inner Budd Inlet.
- **LOTT 2000:** Scientific study of Budd Inlet to evaluate whether wastewater discharged into Budd Inlet was adversely impacting water quality. Historical data analysis, collection of temperature, DO, salinity, TN and phosphorus, chlorophyll *a*, fecal coliform, and the identification of phytoplankton and zooplankton. Modelling was also completed during this study to predict changes in seasonal inputs to Budd Inlet.
- **TMDL Technical Report 2012:** Modeling results will be reviewed as part of the evaluation of future conditions for the various alternatives.
- **Thurston County 1995:** Data collected from Budd Inlet and analyzed for various water quality parameters (turbidity, TP, nitrate, ammonia, coliform) from July 1992 to September 1994.

5.0 What Additional Water Resources Data Will be Collected for the Project?

5.1 LAKE WATER QUALITY MONITORING

While the assessment of the lake will rely heavily on existing data, some additional monitoring will occur. The primary purpose of this monitoring is to obtain current information on existing lake conditions. Water quality monitoring of Capitol Lake will be conducted from May through October 2019 to understand current water quality conditions. This time period was selected to be consistent with past monitoring of the lake and is consistent with monitoring approaches used on many lakes in Washington State. The purpose of collecting additional data is to compare current water quality conditions against historical conditions (2004 to 2014) to determine if current conditions are within the range of previous observations. Monitoring methods will follow those used by Thurston County Environmental Health for Capitol Lake, as specified in the Thurston County Surface Water Ambient Monitoring Program standard operating procedures (Appendix B) and as specified in an addendum to that Quality Assurance Project Plan (QAPP) that is included as Appendix C to this document.

As has been done by Thurston County in the past, the program will include monthly sampling from May through October at each of two mid-lake stations, historically sampled by Thurston County and located in the North and Middle Basins. Sampling will be conducted with the assistance of Washington State Department of Enterprise Services (Enterprise Services) staff, using a boat provided by Enterprise Services and dedicated to Capitol Lake. Proper equipment decontamination procedures will be used to prevent the spread of the New Zealand mudsnail in accordance with Washington Department of Fish and Wildlife protocols.

Physical and chemical variables measured will include temperature, pH, DO, specific conductivity, Secchi depth (water clarity), TP, soluble reactive phosphorus, TN, nitrate+nitrite nitrogen, ammonia nitrogen, total organic carbon, total suspended solids, total volatile suspended solids, DO, total 5-day biochemical oxygen demand (BOD_5) (filtered and unfiltered), chlorophyll *a*, fecal coliform bacteria, *E. coli* bacteria, and phytoplankton species presence and biovolume. A calibrated YSI multimeter will be used in the field to measure temperature, pH, DO, and specific conductivity at 1-meter depth intervals, and Secchi depth will be measured in the field with a standard 8-inch Secchi disk. Water samples will be collected to measure all other variables.

Water samples will be collected at two lake sites and three locations including; the surface (1-meter depth) of the North and Middle Basin stations, and the bottom (0.5 meters from the lake bottom) of the North Basin. Past Thurston County monitoring included collection of surface samples only. However, as part of this monitoring effort, a bottom water sample will be collected from the deepest part of the lake in the North Basin to evaluate vertical differences in all parameters except bacteria and phytoplankton enumeration. A total of six events will be monitored at the three locations for a total of 18 water samples, all of which will be collected with a Van Dorn sampler. Fecal coliform and *E. coli* bacteria samples will be collected at the two main lake sites as the other analytes (i.e., the North and Middle Basin sites) and additionally from a third site located near the eastern shore to represent nearshore conditions. Bacteria samples will be collected directly into sterile sample bottles by filling the bottle aseptically from just below the water surface. The samples will be analyzed by Ecology-accredited laboratories using U.S. Environmental Protection Agency-approved methods.

Total organic carbon, total suspended solids, total volatile suspended solids, and BOD_5 have not been routinely monitored in the past but will be included as part of this monitoring effort for analysis of suspended solids characteristics and DO depletion in Budd Inlet (see below).

5.2 LAKE SEDIMENT SAMPLING

Lake sediment proposed for dredging will be sampled to characterize physical and chemical parameters. The purpose of characterizing the lake sediment is to:(1) evaluate compliance with Washington State Sediment Management Standards and Model Toxics Control Act, (2) evaluate potential impacts on humans and aquatic biota from sediment removal and disposal activities, (3) develop mitigation measures for sediment removal and disposal activities, and (4) evaluate the resulting change in freshwater and marine sediment quality from the project alternatives. Sediment sampling will be conducted in accordance with a separate Sampling and Analysis Plan.

Some of the sediment core samples will be collected specifically to support development of a phosphorus budget and to evaluate potential impacts of sediment removal on lake phosphorus concentrations, under the Managed Lake Alternative. Subsamples of the core that represent the current sediment surface characteristics and sediment characteristics at various sediment depths representing the proposed dredging depth, as well as lower depths, to get closer to background conditions, will be analyzed for sediment phosphorus fractions using established methods (Pilgrim et al. 2007). Sediment core fractionation results will be used to estimate phosphorus contribution from lake sediments under existing conditions and to evaluate whether a change in sediment phosphorus loading might be expected under different dredging scenarios.

6.0 How Will Existing Conditions be Assessed?

Water quality data collected by Thurston County from 2004 through 2014 for Capitol Lake (eliminating the years between 2000 and 2004 when the brewery discharge was in operation) and collected by Ecology from 2004 through 2018 for lower Budd Inlet, will be compiled and evaluated to establish existing conditions of these project water resource elements. These compiled data sets will represent approximately 10 years of data for Capitol Lake and 15 years of data for Budd Inlet. These periods of time incorporate interannual variation and can be used to assess recent long-term trends. If no new trends are detected, it will be assumed that past conditions are reflective of existing conditions. If new, significant trends are detected, then this will be incorporated into the evaluation. While key data trends will be evaluated for the Deschutes River, Percival Creek, and other inputs to Capitol Lake, existing conditions will not be summarized for these water bodies because these upstream water resources will not be affected by the project. They would be considered consistent inputs to the project area. These water quality and hydrologic inputs from the Capitol Lake watershed will be compiled to develop a water and TP budget for Capitol Lake and for calculating loading estimates for other analytes. The water budget in combination with new lake bathymetry data (collected by others and not addressed in this document) will be used to evaluate existing lake retention time and flushing.

In general, existing water quality conditions will be assessed for Capitol Lake and Budd Inlet by comparison of historical water quality data to water quality criteria established by the Washington State Surface Water Quality Standards (WAC 173-201A). Additional thresholds may be developed for parameters of interest for which there are no numeric standards, such as nutrients and algae biomass (as chlorophyll *a*) that affect beneficial uses. Water quality statistics will be calculated for each parameter to include, but not be limited to, minimum, maximum, median, 25th/75th percentiles, percent detected, and percent exceeding water quality criteria for each year and for each month among all years. Data summaries may also be presented as seasonal summaries where warranted; for example, summertime loading estimates for phosphorus will likely be helpful. Summary statistics will be tabulated and presented in box and whisker plots for key parameters of interest.

Statistical methods for evaluating long-term trends and for determining if measured parameter values can be used to fill data gaps for parameters with a limited number of values will be selected based on data distribution.

Key water quality parameters of interest and associated criteria include:

- Temperature (WAC 173-201A criteria)
- Dissolved oxygen (WAC 173-201A criteria)
- pH (WAC 173-201A criteria)
- Turbidity (WAC 173-201A criteria)
- Secchi depth (Capitol Lake, trophic state criteria, and Budd Inlet [no criteria])
- Total suspended solids (criteria to be determined)
- Fecal coliform bacteria (WAC 173-201A criteria)
- *E. coli* bacteria (WAC 173-201A criteria)
- Chlorophyll *a* (Capitol Lake only, trophic state criteria)
- Total phosphorus (Capitol Lake only, trophic state criteria)
- Soluble reactive phosphorus (orthophosphate, no criteria)
- TN (sum of total Kjeldahl nitrogen and nitrate+nitrite nitrogen, no criteria)
- Nitrate+nitrite nitrogen (no criteria)
- Ammonia nitrogen (WAC 173-201A criteria)

Gaps in the data record for these parameters and assessment limitations will be identified. Concentrations of toxic substances (metals and organics) in the water column is a known data gap because they have not been routinely monitored in Capitol Lake or Budd Inlet. They are not routinely monitored because they are rarely detected in lakes or estuaries under normal conditions. Toxic substances will be addressed as part of the assessment of construction impacts related to sediment management activities that suspend toxic substances present in the sediments.

7.0 What Additional Data Analyses Will be Conducted for Developing the Adaptative Management Approach of the Managed Lake Alternative?

It is recognized that the Managed Lake Alternative (and at a smaller scale, the Hybrid Alternative) will need to be actively managed in order to achieve water quality standards and designated beneficial uses. The evaluation will consider common lake management objectives, upon which to develop an adaptive management plan, such as control of algae (e.g. blue-green algae and/or toxic algae blooms), bacteria, and aquatic plants. These objectives will be defined in coordination with Enterprise Services and with stakeholder input as part of the long-term planning and EIS processes.

Analysis of historical data will be used to identify whether there are trends in water quality associated with ongoing watershed management actions that should be considered in estimating watershed contributions to the lake to determine the extent to which water quality criteria can be met and beneficial uses supported under existing conditions. An analysis of phosphorus loadings was conducted during a previous restoration analysis of the lake (Entranco 1984). At that time, it was estimated that 70 percent of Capitol Lake phosphorus was contributed by the Deschutes River, while the remaining amount was contributed by Percival Creek (8 percent), Olympia Brewery discharges (14 percent), and miscellaneous sources including groundwater and internal loading (8 percent). Since that time many changes to the watershed have taken place; most significantly, the brewery has closed. An updated phosphorus budget will be developed to quantify phosphorus sources to the lake for evaluating potential effects of watershed management and sediment removal on phosphorus loadings, and to identify additional lake management actions that might be needed to meet lake management goals specified in WAC and further defined through this EIS process.

A water budget will be prepared for Capitol Lake using flow data for the Deschutes River and Percival Creek. Inflow data for the Deschutes River and Percival Creek will be separated into base flow and storm flow using a standard spreadsheet model for hydrograph separation. The water budget will be formulated on a monthly basis using up to 10 years of data from 2004 through 2014, which represents the period after the brewery discharge ended in 2003 and the most recent period that lake monitoring data are available. Inflow to the lake from storm drains in the nearshore basin will be estimated using the Simple Model (Schueler 1987) based on basin area, rainfall, and runoff coefficients for land cover types. (The Simple Model was selected because it is intended for use with small, urban catchments, consistent with the urban portion of the Capitol Lake drainage basin.) The basin consists of approximately 59 percent pervious surface, 34 percent untreated impervious surface, and 7 percent treated impervious surface (Olympia 2018). Rainfall data will be used to calculate direct precipitation input and pan evaporation data will be used to estimate lake evaporation loss. Groundwater inputs and outputs will be estimated from the residual in the volume balance of measured surface inputs and outputs. Base and storm flow inputs will be averaged for each water source by month over the 10-year study period. Lake bathymetry conducted by others will be used with lake elevation data to calculate lake storage volume.

Using the water budget described above as the water mass balance framework, a monthly phosphorus budget will be prepared for Capitol Lake by multiplying the average monthly water volumes by average monthly phosphorus concentrations. The phosphorus budget will only be prepared for the summer growing season from May through October because lake phosphorus data are not available for the remaining months and summer is the most critical period for evaluating water quality impacts. TP data sources will include:

- Inputs of direct precipitation to the lake surface using TP concentrations in rainfall samples collected by others in the region.
- Inputs of Deschutes River and Percival Creek using TP concentrations for storm and base flow events determined from the sample time and hydrograph separation or rainfall data.
- Inputs of stormwater from the nearshore basin using average TP concentrations in stormwater samples collected from the basin if available, or from the literature for representative land uses if local data are not available.
- Inputs of shallow groundwater using TP concentrations in nearby groundwater wells and baseflow stream/river TP concentrations.
- Inputs from TP release from lake sediments using sediment phosphorus fraction results of sediment core samples collected for the project.
- Inputs from aquatic plant decomposition will be estimated from published literature on phosphorus concentrations in the plants and gross estimates of plant volume. This input will be applied late in the season to reflect seasonal die-off.
- Outputs of TP by sedimentation within the lake using sedimentation rates calculated during development of the sediment budget and sediment phosphorus data collected as part of this work. (The sediment budget methodology and sediment transport modeling will be described in a separate study.)
- Outputs of the lake outlet using TP concentrations in lake surface water within the North Basin.
- Outputs of groundwater outflow using TP concentrations in lake water samples.
- Change in lake phosphorus storage using TP concentrations in the lake and changes in lake volume.

TP, total organic carbon, TN, dissolved inorganic nitrogen, and total suspended solids loading rates will be estimated for the Deschutes River and Percival Creek for summer (May through October) and winter (November through April) periods using average flow volumes and parameter concentrations measured during base and storm flow conditions for the 10-year study period. Average base and storm flow parameter concentrations will be calculated by flow weighting values if they correlate with flow. Lake outputs of these parameters, BOD_5, and chlorophyll will be estimated for the critical summer period using average lake concentrations and outflow volumes for the 10-year study period. Because total organic carbon, total suspended solids, and BOD_5 measurements have not been taken in the lake historically, they will be estimated (if possible) from historical concentrations of phosphorus, nitrogen, and chlorophyll observed in the lake based on parameter relationships measured in the summer of 2019. Differences in key lake inputs (i.e., Deschutes River and Percival Creek) and key outputs (loss over the dam) of carbon and nitrogen, along with outputs of BOD_5 and chlorophyll, will be used for evaluating the relative effects of alternatives on DO in Budd Inlet. Complete nutrient budgets for carbon and nitrogen will not be prepared because of inadequate data.

Total organic carbon inputs and outputs also will be estimated using monitoring data collected by Ecology and USGS and the loading estimates will be used to evaluate changes within the lake, and for comparing predicted oxygen depletion in Budd Inlet from lake outflow.

Total sediment inputs also will be estimated by a separate study using existing and collected data for development of the sediment rating curve and budget by various methods to include:

- Conversion of total suspended solids concentrations in samples collected from the surface of the Deschutes River to total sediment concentrations based on estimates of increasing sediment concentrations with river depth, and the relationship of total sediment loading rate with river flow rate
- Hydrotrend model of basin-wide sediment production based on river watershed characteristics and climate data
- Sediment deposition rate in the lake based on sediment core dating with lead-210 and analysis of sediment organic and inorganic fractions
- Sediment mass accumulation rate in the lake from increased sediment volume measured by two historical and one new bathymetric survey.

8.0 How Will Water Quality for the Project Alternatives be Assessed?

Impacts related to both long-term operation and construction will be evaluated, with a focus on comparatively evaluating the alternatives. In general, construction-related impacts will be based on impacts associated with dredging because that represents the major construction impact, however, impacts from other in-water construction will also be described. Future, long-term impacts and benefits of each of the four project alternatives will be evaluated based on the combination of historical trends and current conditions analysis. Qualitative categories such as "no substantial change," "minor improvement," or "major improvement" will be used to compare expected differences in key water quality variables and beneficial use impairments. These categories will be defined based on the success of meeting water quality criteria or lake-specific thresholds defined for other parameters. Using DO in Budd Inlet as an example, changes in DO would be considered an improvement if DO levels generally were expected to increase in the lower inlet. The change would be considered a major improvement if it is predicted that DO would change from frequently not meeting criteria to nearly always meeting criteria in the majority of the inlet. An example of a water quality impact summary matrix and type of color coding that would be used to depict the differences is presented in Figure 8.1. The details of this qualitative analysis would be further refined as part of the EIS process.

Figure 8.1 Water Quality Impact Summary Matrix—Representative Example

Capitol Lake – Deschutes Estuary Operation Water Quality Impact Summary

	Temp	DO	pH	Turbidity	Nutrients	Algae	Fecals	Metals	Organics
Capitol Lake									
Existing									
No Action									
Lake									
Estuary									
Hybrid									
Budd Inlet									
Existing									
No Action									
Lake									
Estuary									
Hybrid									

Example Impact Summary Legend

No Change
Major Improvement
Minor Improvement
Major Deterioration
Minor Deterioration

8.1 NO ACTION ALTERNATIVE

Historical data (2004 through 2012) will be evaluated in addition to the 2019 monitoring data described in this document to evaluate Capitol Lake water quality conditions for the No Action Alternative and to assess whether there have been any long-term trends in water quality that would result in changes beyond the existing condition. For example, if there are existing trends in phosphorus concentrations in the Deschutes River that can be assumed to reflect past watershed management activities, these trends will be used to predict future lake phosphorus concentrations and algae growth from future watershed management activities. Sediment budget results will be used to predict future water depths in the lake.

Capital Improvement Project lists from the City of Olympia, City of Tumwater, and Thurston County will be reviewed to evaluate whether planned watershed management efforts are likely to have a significant impact on the key water quality variables that are of interest to this project (i.e., summer period phosphorus, turbidity, DO, or flow conditions). It is assumed that these projects will occur under all alternatives and, therefore, any change in water quality from these efforts would apply across all alternatives.

Budd Inlet water quality conditions for the No Action Alternative will be assessed using results of the historical trend analysis and Ecology's TMDL Technical Report results (Ecology 2012).

8.2 MANAGED LAKE ALTERNATIVE

8.2.1 Identification of Operational Impacts

The Managed Lake Alternative will be designed to address water quality thresholds that will be defined for this project based on meeting beneficial use goals and assuming implementation of a long-term adaptive management plan. The water and phosphorus budgets for Capitol Lake will be used to identify feasible lake restoration methods for meeting beneficial use goals. For example, if there is a contact recreation goal, lake management techniques aimed at reducing algae or occurrence of toxic algae blooms and watershed control techniques for reducing bacteria will be considered. Changes in summer average concentrations of algae biomass (as chlorophyll *a)*, will be estimated from predicted changes in phosphorus concentrations as a result of estimated changes in phosphorus loadings based on historical relationships between these parameters for Capitol Lake.

Up to three lake management scenarios for the Managed Lake Alternative will be evaluated at a conceptual level to address feasibility and costs of various lake management techniques for improving water quality and meeting lake management goals. It is assumed that the scenarios will range from low to high degrees of management for sediment removal, water quality treatment, aquatic macrophyte control and invasive species control. The lake water quality evaluation will be primarily based on estimates of reduced phosphorus loadings and algae biomass and will consider the anticipated effectiveness and cost of management techniques, which may consider previously recommended active management approaches, as applicable.

Water quality impacts (both positive and negative) to Budd Inlet for the Managed Lake Alternative will be assessed for DO using Ecology's model output as reported in the TMDL Technical Report (Ecology 2012) and the estimated reduction in algae biomass and associated total organic carbon loadings discharged from Capitol Lake. Impacts on DO in Budd Inlet will also be assessed by examining relationships in summer DO concentrations with suspended solids, nutrient, BOD_5, and algae loadings from Capitol Lake over the 10-year study period with consideration of tidal mixing conditions and other factors. Impacts to other parameters (e.g., temperature, turbidity, pH, bacteria, and metals) will be qualitatively assessed based on the predicted changes to algae and DO.

8.2.2 Identification of Construction Impacts

Construction impacts of the Managed Lake Alternative would occur during dredging of lake sediments. The dredging approach and frequency, and handling and disposal of material will be defined as part of the EIS but have not yet been defined. Common water quality concerns during dredging include an increase in suspended solids, release of nutrients, and resuspension of potentially contaminated sediments. Water quality impacts of sediment dredging (and in-lake disposal if selected) will be assessed using current sediment quality data collected for this project combined with historical sediment quality and elutriate testing data for dredging investigations. Concentrations of toxic substances found in sediment elutriates will be related to those in the tested sediments for predicting potential exceedance of water quality criteria in Capitol Lake during future dredging and disposal actions based on the current sediment quality and quantity in the planned dredging areas. Potential impacts to Budd Inlet from suspended sediments will be assessed based on the distance from dredging/disposal locations to the dam and the anticipated sedimentation rates based on sediment grain size data collected for this project.

Dredged sediments within Capitol Lake also contain New Zealand mudsnails, which may require in situ chemical treatment prior to offsite disposal. Water quality impacts of in situ treatment (including impacts from tool and equipment cleaning) will be identified using literature for the selected chemical(s). These impacts would apply to all the Managed Lake, Estuary and Hybrid Alternatives.

8.3 ESTUARY ALTERNATIVE

8.3.1 Identification of Operational Impacts

The Estuary Alternative would create a river-estuary transitional zone where Capitol Lake currently exists between the mouth of the Deschutes River at the South Basin of the lake and Budd Inlet at the lake dam. Water quality effects of this alternative in Budd Inlet are described in the TMDL Technical Report (Ecology 2012), and those results will be used to describe impacts (both positive and negative) of the Estuary Alternative on temperature, DO, total organic carbon, nitrogen, and algae biomass (as chlorophyll *a*). Some modeling assumptions may vary between the proposed action and the model, a qualitative assessment of the impacts (both positive and negative) on predicted water quality will be made. In addition, impacts on DO in Budd Inlet will also be assessed from anticipated changes in loadings of oxygen-demanding substances (sediments, nutrients, and algae) to the inlet by removal of the dam. Water quality conditions in the transition zone and Percival Cove will be estimated to range from river/stream conditions during low tide to estuary conditions during high tide. Because the lower portion of Budd Inlet has variable water quality, the high tide estuary conditions will be based on modeling results as presented in the TMDL Technical Report (Ecology 2012)s from the southernmost portion of the inlet (near the Port of Olympia) rather than results from mid inlet since this will be a better representation of the water that will move into the transition zone/existing lake. Longer term impacts to lower Budd Inlet will be evaluated based on sediment transport modeling and potential turbidity increases and dredging needs. The methods for evaluating impacts from sediment transport will be described in a separate document.

8.3.2 Identification of Construction Impacts

Construction impacts of the Estuary Alternative will occur during sediment dredging/disposal and dam removal and during the years after dredging if modeling indicates that sediments will continue to move to the inlet over a multiple-year time scale. Water quality impacts from construction would primarily be related to increased suspended sediment concentrations and resuspension of potentially chemically impacted sediments during these activities. Sediment dredging/disposal would occur before dam removal; thus, immediate water quality impacts to Budd Inlet should be similar to those identified for the Managed Lake Alternative. Mitigation measures to prevent water quality impacts during dam removal will be identified to not exceed turbidity criteria at the compliance zone boundary in Budd Inlet. The compliance zone boundary will be predicted from those commonly applied by construction permits.

8.4 HYBRID ALTERNATIVE

8.4.1 Identification of Operational Impacts

The Hybrid Alternative will be similar to the Estuary Alternative except that a managed lake will be physically isolated from the estuary in the eastern portion of the North Basin of the existing lake by constructing a barrier across the basin, isolating a lake behind the wall. As this alternative includes both the lake and estuary areas, similar conditions will both apply to this alternative.

Impacts of the lake portion will depend on lake size, water source (groundwater, river water, and/or estuary water), flushing rate, phosphorus loading, and water resource management decisions. It is assumed that lake management goals for the lake portion will be the same as those developed for the Managed Lake Alternative to support beneficial uses. Phosphorus loading to the lake portion will be estimated using the methods and data described for the lake phosphorus budget with adjustments for the lake portion design elements, and assumptions about the water source used and flushing. Impacts of different lake water sources could be evaluated by predicting algae biomass in the lake portion based on observed relationships between chlorophyll *a* and phosphorus loading rates in lakes(Cooke et al. 2005). Cost-effective in-lake management techniques will be identified for meeting lake management goals and successfully creating a reflecting pool.

Impacts and benefits to Budd Inlet will be evaluated following the method used for the Estuary Alternative since the same estuarine processes will occur in a smaller transition zone between the Deschutes River and Budd Inlet. Impacts on DO in Budd Inlet from the lake portion will be estimated using results of Ecology's model as reported in the TMDL Technical Report (Ecology 2012) and accounting for changes in total organic carbon loading from the smaller lake portion.

8.4.2 Identification of Construction Impacts

Construction impacts will be evaluated for the Hybrid Alternative to include sediment dredging/disposal and dam removal, similar to the Estuary Alternative. Additional construction impacts will occur from construction of the barrier wall to separate the estuary and lake portions. Potential impacts to water quality will depend on construction methods and mitigation measures and will be evaluated based on the potential for increases in suspended solids and turbidity and resuspension of potentially chemically impacted sediments within Capitol Lake. Mitigation measures, such as constructing the wall before removing the dam and others, would be identified and evaluated for preventing downstream impacts to Budd Inlet during construction.

9.0 References

City of Olympia (Olympia). 2018. *Storm and Surface Water Plan*. City of Olympia Water Resources. Olympia, Washington.

Cooke, G.D., E.B. Welch, S.A. Peterson, and S.A. Nichols. 2005. *Restoration and Management of Lakes and Reservoirs*. Third Edition. CRC Press. May 9.

Entranco. 1984. *Capitol Lake Restoration Analysis*. Bellevue, Washington.

Pilgrim, K.M., B.J. Huser, and P.L Bresonik. 2007. "A Method for Comparative Evaluation of Whole-Lake and Inflow Alum Treatment." *Water Research.* 41:1215–1224.

Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Metropolitan Washington Council of Government, Washington DC.

Washington State Department of Ecology (Ecology). 2012. *Deschutes River, Capitol Lake, and Budd Inlet Temperature, Fecal Coliform Bacteria, Dissolved Oxygen, pH, and fine Sediment Total Maximum Daily Load Technical Report: Water Quality Study Findings*. June. Publication No. 12-03-008

Appendix A:
Available EIM Data and Additional Data Requested

Table A-1. Water Quality Data From EIM For Capitol Lake Deschutes Estuary EIS.

	Budd Inlet	Capitol Lake	Deschutes R at E St	Deschutes R Upstream	Percival Ck Downstm	Percival Ck Upstream	Black Lake Ditch	Nearshore Basin	
								Stormwater	Groundwater
Number of Stations	0	21	6	21	8	6	5	2	244
Number of Studies	0	3	10	5	1	1	5	1	21
Record Begin Year		1974	1941	1941	2003	2003	2003	2013	2003
Record End Year		2013	2017	2016	2013	2013	2009	2013	2018
Number of Values									
Conventionals									
Alkalinity, Total as CaCO3		22	68	178				3	1
Biochemical Oxygen Demand					2				
Chemical Oxygen Demand			3						
Chloride				3					
Conductivity		526	358	646	1			4	3
Dissolved Organic Carbon		99	84	64	20			3	5
Dissolved Oxygen		1516	879	1105	92		34	4	6
Dissolved Oxygen % Saturation		95	465	174					
Flow			486	402	18	12	3	3	1
Hardness, Total as CaCO3			161	144					
pH		573	878	1407	101	2	36	4	13
Silicon			16						
Specific Conductivity (at 25 deg C)		2	512	493	20	11			6
Stream/River Discharge					14	11	3		
Temperature, water		1474	889	1207	62	13	14	4	11
Total Suspended Solids		32	499	267	14			3	5
Total Organic Carbon								1	
Turbidity			475	331					
Water Transparency		7							
Well Water Level									114
Nutrients									
Chlorophyll		22							
Ammonia		98	514	458	45		14		4
Nitrate			165	147					
Nitrate-Nitrite as N			554						
Nitrite		5	237	191					
Nitrite-Nitrate		98	311	233	46		14		4
Nitrogen				1					
Ortho-Phosphate		100	514	405	46		14		4
Phosphorus		98	391	372			13		4
Total Kjeldahl Nitrogen				43					
Total Organic Carbon		90	80	64	20				
Total Persulfate Nitrogen		120	364	149	65		21		4
Total Phosphorus			139	33					
Bacteria									
E. coli			7	2	2				
Enterococci			12						
Fecal Coliform		68	532	398	126	6	41		
Metals									
Antimony									1
Arsenic			60					3	106
Barium									25
Cadmium			60					6	102
Chromium			60						
Copper			61	6				6	8
Lead			60					6	233
Manganese									1
Mercury			30						92
Nickel			60					6	8
Selenium									25
Silver			60						25
Tin									1
Zinc			61	6				6	8
PCBs									
PCB-aroclors									34
Petroleum Hydrocarbons									
Gasoline Range Organics									368
Gasoline									133
Diesel Range Organics									402
Diesel Fuel									27
#2 Diesel									7
Heavy Fuel Oil									94
Lube Oil									201
Motor Oil									86
Oil and Grease									33
Extractable Petroleum Hydrocarbons									4
Volatile Petroleum Hydrocarbons									4

Table A-1. Water Quality Data From EIM For Capitol Lake Deschutes Estuary EIS.

	Budd Inlet	Capitol Lake	Deschutes R at E St	Deschutes R Upstream	Percival Ck Downstm	Percival Ck Upstream	Black Lake Ditch	Nearshore Basin	
								Stormwater	Groundwater
Other Organic Chemicals									
1,1,1,2-Tetrachloroethane									63
1,1,1-Trichloroethane									77
1,1,2,2-Tetrachloroethane									63
1,1,2-Trichloroethane									76
1,1-Dichloroethane									77
1,1-Dichloroethene									138
1,1-Dichloropropene									76
1,2,3-Trichlorobenzene									61
1,2,3-Trichloropropane									63
1,2,4-Trichlorobenzene									64
1,2,4-Trimethylbenzene									67
1,2-acenaphthylenedione								3	1
1,2-Dibromo-3-Chloropropane									63
1,2-Dichlorobenzene									77
1,2-Dichloroethane									99
1,2-Dichloroethene									26
1,2-Dichloropropane									76
1,2-Diphenylhydrazine									1
1,3,5-Trichlorobenzene									2
1,3,5-Trimethylbenzene									63
1,3-Dichlorobenzene									77
1,3-Dichloropropane									60
1,3-Dichloropropene									3
1,4-Dichlorobenzene									77
1-Methylnaphthalene								3	50
2,2-Dichloropropane									76
2,4,5-Trichlorophenol									1
2,4,6-Trichlorophenol									1
2,4-Dichlorophenol									1
2,4-Dimethylphenol									1
2,4-Dinitrophenol									1
2,4-Dinitrotoluene									1
2,6-Dinitrotoluene									1
2-Chlorophenol									1
2-Chlorotoluene									76
2-Hexanone									37
2-Methylnaphthalene								3	50
2-Nitroaniline									1
2-Nitrophenol									1
3,3'-Dichlorobenzidine									1
4,6-Dinitro-2-Methylphenol									1
4-Chloro-3-Methylphenol									1
4-Chlorophenyl-Phenylether									1
4-Chlorotoluene									76
4-Nitroaniline									1
4-Nitrophenol									1
4-Nonylphenol									1
5,12-Naphthacenequinone								3	1
7,12-Benz[a]anthracenquinone								3	1
9,10-Anthracenedione								3	1
9-Fluorenone								3	1
Aceanthrenequinone								3	1
Acenaphthene									36
Acenaphthylene									36
Acetone									37
Anthracene								3	36
Benz[a]anthracene								3	57
Benzanthrone								3	1
Benzene									505
Benzene, methyl(1-methylethyl)-									19
Benzo(a)pyrene								3	57
Benzo(b)fluoranthene								3	52
Benzo(ghi)perylene								3	36
Benzo(k)fluoranthene								3	52
Benzo[a]fluorenone								3	1
Benzo[cd]pyrenone								3	1
Benzofluoranthenes, Total (b+k+j)									5
Benzoic Acid									1
Benzyl Alcohol									1
Bis(2-chloro-1-methylethyl) ether									1
Bis(2-Chloroethoxy)Methane									1
Bis(2-Chloroethyl)Ether									1

Table A-1. Water Quality Data From EIM For Capitol Lake Deschutes Estuary EIS.

	Budd Inlet	Capitol Lake	Deschutes R at E St	Deschutes R Upstream	Percival Ck Downstm	Percival Ck Upstream	Black Lake Ditch	Nearshore Basin	
								Stormwater	Groundwater
Bisphenol A									1
Bromobenzene									63
Bromochloromethane									29
Bromoform									63
Bromomethane									63
Butyl benzyl phthalate									1
Caffeine									1
Carbazole								3	2
Carbon Tetrachloride									76
Captan								3	
CFC-11									63
CFC-12									60
Chlorobenzene									63
Chlorodibromomethane									63
Chloroethane									77
Chloroform									76
Chloromethane									76
Cholesterol									1
Chromium									101
Chromium, Hexavalent									2
Chrysene								3	57
Cis-1,2-Dichloroethene									139
Cis-1,3-Dichloropropene									76
Coprosterol									1
Cumene									63
Cyanide									8
Cyclohexane									2
cyclopenta(def)phenanthrenone								3	1
Di(2-ethylhexyl) phthalate									1
Dibenzo(a,h)anthracene								3	57
Dibenzofuran								3	2
Dibromomethane									63
Dibutyl phthalate									1
Dichlorobromomethane									63
Dichlorodifluoroethylene									3
Diethyl phthalate									1
Dimethyl phthalate									1
Di-n-octyl phthalate									1
Ethylbenzene									497
Ethylene dibromide									113
Fluoranthene								3	36
Fluorene								3	36
Fluoride									7
Hexachlorobenzene									1
Hexachlorobutadiene									64
Hexachlorocyclopentadiene									1
Hexachloroethane									1
Hexane									5
Indeno(1,2,3-cd)pyrene								3	57
Isophorone									1
m, p-Xylene									52
Methyl ethyl ketone									37
Methyl isobutyl ketone									37
Methyl t-butyl ether									100
Methylene Chloride									64
m-Nitroaniline									1
Naphthalene								3	130
n-Butylbenzene									50
Nitrobenzene									1
N-Nitrosodi-n-propylamine									1
N-Nitrosodiphenylamine									1
n-Propylbenzene									63
o-Cresol									1
o-Xylene									52
Paraffin oils									68
PBDE-003									1
PCN-002								3	2
p-Cresol									1
Pentachlorophenol									1
Phenanthrene								3	36
Phenol									1
p-Isopropyltoluene									44
Pyrene								3	36

Table A-1. Water Quality Data From EIM For Capitol Lake Deschutes Estuary EIS.

	Budd Inlet	Capitol Lake	Deschutes R at E St	Deschutes R Upstream	Percival Ck Downstm	Percival Ck Upstream	Black Lake Ditch	Nearshore Basin	
								Stormwater	Groundwater
Retene								3	2
Sec-Butylbenzene									63
Styrene									63
Tert-Butylbenzene									67
Tetrachloroethene								3	139
Toluene									497
Total Xylenes									423
Trans-1,2-Dichloroethene									139
Trans-1,3-Dichloropropene									76
Trichloroethene									139
Triclosan									1
Triethyl citrate									1
Vertical Hydraulic Gradient									9
Vinyl Chloride									139
Xylene									22

Capitol Lake Deschutes Estuary EIS Water Resource Data Requests by Herrera

CITY OF OLYMPIA

1. Reports and data in spreadsheets for water elevation and water quality parameter values in the West Bay Lagoon.
2. Stormwater flow and water quality monitoring data in spreadsheets for drainages in the Capitol Lake watershed.
3. Groundwater elevation and water quality parameter values in spreadsheets for wells located in the vicinity of Capitol Lake.
4. Spreadsheet or GIS shape file of all water monitoring locations.

THURSTON COUNTY ENVIRONMENTAL HEALTH

1. Water quality monitoring plans for the Thurston County Surface Water Ambient Monitoring Program prepared since or supplement to the Standard Operating Procedures revised in February 2009.
2. Capitol Lake water quality monitoring data in spreadsheets for all lake monitoring stations, all years, and all parameters including field parameter profiles, nutrients, chlorophyll, fecal coliform bacteria, phytoplankton, cyanotoxins, and trace metals/organics.
3. Percival Creek flow (continuous and discrete) and water quality data in spreadsheets for all stations, all years, and all parameters.
4. Deschutes River flow (continuous and discrete) and water quality data in spreadsheets for all stations, all years, and all parameters.
5. Stormwater flow and water quality monitoring data in spreadsheets for drainages in the Capitol Lake watershed.
6. Groundwater reports and elevation and water quality parameter values in spreadsheets for wells located in the vicinity of Capitol Lake.
7. Precipitation data in spreadsheets for the rain gauge nearest Capitol Lake
8. Spreadsheet or GIS shape file of all water gauging and monitoring locations.
9. Spreadsheet or GIS shape file of all known storm drain outfalls in Capitol Lake.
10. GIS shapefile of all drainage basins in the Capitol Lake watershed.

WASHINGTON STATE DEPARTMENT OF ECOLOGY

1. Water quality data collected by Ecology and not available from EIM for Capitol Lake, Deschutes River, Percival Creek, stormwater in the vicinity of Capitol Lake, and groundwater in the vicinity of Capitol Lake.
2. Tables and figures of water quality modeling output data for the Deschutes River, Percival Creek, Capitol Lake, and Budd Inlet.

DEPARTMENT OF ENTERPRISE SERVICES

1. Water surface elevation and outflow/inflow data in spreadsheets for Capitol Lake at the dam.

Appendix B:
Thurston County Surface Water Ambient Monitoring Program; Standard Operating Procedures and Analysis Methods for Water Quality Monitoring

These standard operating procedures and analysis methods have been adopted by the Capitol Lake -- Deschutes Estuary EIS Project Team for water quality sampling in Capitol Lake. This document guided the sampling conducted by Thurston County in Capitol Lake historically and is intended to ensure that quality data is collected.

Thurston County
Surface Water Ambient Monitoring Program

Standard Operating Procedures and Analysis Methods
For Water Quality Monitoring

Revised February 2009

Thurston County Public Health and Social Services Department
Environmental Health Division

Project Manager: Sue Davis
(360) 754-4111 ext 7316

****Contact Update: Jane Mountjoy-Venning**
360-867-2643

Updated 10/11/17

QAPP Submitted for:

Protecting Puget Sound Watersheds, Water Quality and Aquatic Resources from the Impacts of Growth EPA Grant Project # WS-96073601-0 (Project Name)	
Thurston County Dept. of Water and Waste Management (Agency responsible for Grant)	
July 1, 2008 (Date)	
Thurston Co. Grant Project Manager	Barb Wood
Signature / Date	Barb Wood 2/20/09
Thurston Co. Water Quality Project Manager	Sue Davis
Signature / Date	Sue Davis 2/19/09
EPA Project Officer, EPA Region 10	Tony Fournier 3/11/09
Signature / Date	for GGG 3/5/09 *see attached email 3/5/09 w/comments.
EPA QA Manager, EPA Region 10	Gina Grepo-Grove
Signature / Date	
EPA Project Monitor, EPA Region 10	Krista Mendelman
Signature / Date	3/10/09

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APPENDICES

Project Organization

The Thurston County surface water ambient monitoring program is coordinated through the Thurston County Department of Water and Waste Management, Storm and Surface Water Utility. The water quality monitoring element of the ambient monitoring program is conducted by staff in the Public Health and Social Services Department, Environmental Health Division. The individuals involved in the water quality monitoring are as follows:

Sue Davis, Project Manager and Field Collection
Cathy Hansen, Data Management and Reporting
Linda Hofstad, Data Management and Reporting
Heather Saunders, Field Collection
Mike Clark, Thurston County Environmental Health Laboratory Manager
Steven Lazoff, Aquatic Research, Inc., Laboratory Manager

Project Background

The Thurston County ambient surface water quality monitoring program is part of the overall, on-going Thurston County monitoring program, which includes surface water quality monitoring, stream discharge gauging, lake level monitoring, and precipitation gauging. Most rivers, streams, and public-access lakes in the county are being monitored. The monitoring network is supported by Thurston County and the Cities of Lacey, Olympia, and Tumwater. The program compliments the marine and fresh water quality monitoring conducted by Washington Departments of Health and Ecology and the US Geological Survey stream discharge measurement program.

The data generated by this project are used by the local jurisdictions' storm and surface water utilities and by the public, professional consultants, tribes, and other environmental agencies such as Washington Department of Ecology and US Environmental Protection Agency.

Project Description and Design

Project Objectives

The objectives of this long-term water quality monitoring program are the following:

- Provide a long-term, consistent water quality baseline of data for streams and lakes;
- Provide data that is used to track water quality and quantity trends over time and identify problems areas where corrective actions should be taken.
- Enable broad analysis of the data with the capacity for comparison between areas;
- Ensure that monitoring equipment is available for routine monitoring and emergency response;
- Provide easy access to information/data by jurisdictions, agencies, and citizens;

- Compliment state Departments of Health and Ecology marine and freshwater monitoring programs.

Project Tasks and Timetable

Table 1. Tasks and Timetable

Activity	Frequency	Completion Date
Field data collection and sampling	Monthly	On-going
QA/QC	Monthly	On-going
Data management	Monthly	On-going
Data posting to County website	Annually	January 31
Report preparation	Every 2 years	June 30

For EPA project # WS-96073601-0, the project began July 1, 2008.

Sampling Locations and Selection Rationale

All monitored rivers and streams have sampling stations near their mouths to evaluate the impacts of activities in the watershed on the receiving water. A few of the rivers and streams have additional up-stream stations to segment sections based upon major land-uses or to isolate known problem areas.

Most lakes in the monitoring program have one sampling station located over the deepest part of the lake. Those lakes that have multiple basins have a monitoring station in two basins. The lakes that are included in the 2009 monitoring program include Long (2 sites), Pattison (2 sites), St Clair (2 sites), Capitol (2 sites), Hicks, Deep, Ward, Black, and Summit.

The number and locations of monitoring stations are periodically adjusted as the program is adapted to new information or changing priorities. Table 2 on the following page lists the streams and rivers in the 2008/2009 water year monitoring program is included below. A map showing the sampling locations for all of the water bodies is included in Appendix B.

Table 2. Stream Sampling Sites

2008/09 Ambient WQ Monitoring Sites

Monitoring Sites	Location	Site ID	Stream Ambient	TCEH Macros	NH_3
NISQUALLY					
McAllister	Southbound I-5 on-ramp	NISMC0000	X		
Eaton	at Yelm Hwy	NISEA0000	X		
Yelm @ 103rd	at 103rd and Creek St.	NISYL0030	X		
Yelm mouth	off Mud Run Rd	NISYL0000	X new		
Thompson	At Centralia Power Park	NISTH0000	X new		
HENDERSON					
Woodard	4116 Libby	HENWO0000	X	X	
Tanglewilde	Tanglewilde Outfall	HENWL0800	X		X
Woodland	at Pleasant Glade Rd	HENWL0000	X		
BUDD/DESCHUTES					
Black Lk Ditch	at RW Johnson	BUDBD0000	X		
Chambers	off end of 58th	DESCH0300	X	X	
Deschutes @ Tumwater	at Tumwater Falls Park under bridge	DESDE0000	x		
Deschutes @ Waldrick	off bridge at Waldrick Rd.	DESDE0025	X		
Deschutes @ Vail Lp	under bridge at Vail Lp. Rd.	DESDE0045	X		
Percival	at Footbridge	BUDPE0000	X	X	
Spurgeon	at Boe residence off Rich Road	DESSP0500	X		
Reichel	at Vail Loop Rd	DESRE1100	X		
Indian	at Quince Ave	BUDIN0010	X		
Mission	at East Bay Dr	BUDMI0000	X		
Ellis	at East Bay Dr	BUDEL0000	X		
Moxlie	at Marine Dr	BUDMO0000	X		X
Schneider B	at West Bay Dr	BUDSC0000	X		
ELD					
Green Cove	mouth off Cooper Pt Rd	ELDGC0000	X	X	
McLane	mouth at Delphi Rd bridge	ELDMC0000	X	X	
Perry	off Perry Creek Rd	ELDPE0000	X	X	
TOTTEN					
Kennedy	at Mouth	TOTKE0000	X	X	
Schneider T	Pneumonia Gulch off 101	TOTSC0000	X	X	
Schneider Head	upstream of Steamboat Interchange	TOTSC0040	X		
CHEHALIS					
Beaver	at Littlerock Rd	BLABE0700	X		
Black @ Moon	at Moon Rd	BLABL0010	X		
Black @ 128th	at 128th in Littlerock	BLABL0050	X		
Chehalis	At Independence Rd	CHECH0010	X		
Prairie	Off Old Highway 9	CHEPR0510	X		
Salmon	at Littlerock Rd by Quarry	BLASA1020	X		
Scatter @ James	at James	CHESC0100	X		
Scatter @ Gibson	at Gibson Rd	BLASA1020	X		
Blooms Ditch	off 110th	BLABM0910	X		
Skook	at Highway 507	SKOSK0000	X		

Sampling Frequency and Rationale

The streams and rivers are **sampled monthly** throughout the year. The monthly ambient monitoring program has been in place since December 2003. The major water quality impacts of concern in this region occur during the wet season and are associated with contaminants washing off the land into the streams during storm events. The typical water quality concerns associated with dry season/low flow conditions are high water temperature, low dissolved oxygen, and elevated concentrations of specific contaminants associated with continuous (not storm related) pollution sources. To acquire a sufficient amount of data which reflects both wet and dry season influences, samples are collected monthly.

The emphasis for lake sampling is during the warm weather growing season because it is the period when symptoms of nutrient enrichment are manifested and beneficial uses may be impaired. Lake sampling is conducted **six times per year, monthly from May through October**.

Sampling Parameters

Parameters measured at **stream and river** stations include:

- temperature
- pH
- dissolved oxygen
- specific conductance
- stream discharge
- staff gage level (if present)
- total phosphorus
- nitrate-nitrite
- ammonia
- turbidity
- fecal coliform bacteria
- field observations - including any changes from previous sampling events, water appearance, etc.

Parameters measured at **lake** stations include:

- temperature
- pH
- dissolved oxygen
- specific conductance
- secchi disk visibility
- total phosphorus - at surface and bottom depths
- total nitrogen - at surface and bottom depths
- chlorophyll *a* (phaeophyton *a* adjusted) - epilimnion composite
- algae identification - epilimnion composite
- field observations - including water color and appearance, changes from previous sampling, macrophyte growth, etc.

Measurement Quality Objectives and Quality Control Requirements

Laboratory Quality Control

Quality assurance objectives for measurement data are usually expressed in terms of accuracy, precision, completeness, representativeness, and comparability. The laboratory submits quality control and quality assurance results and calculations to the project manager with the analytical reports. A sample QA/QC reports from Aquatic Research, Inc. is included in Appendix C.

Definitions of these characteristics are as follows:

Accuracy: A sample spike is prepared by adding a known amount of a pure compound to the environmental sample (before extraction for extractable), and the compound is the same or similar (as in isotopically labeled compound) as that being tested for in the environmental sample. These spikes simulate the background and interference found in the actual sample. The percent recovery of the spike is taken as a measure of accuracy and is calculated as follows:

$$\%R = \frac{100\,(O-X)}{T}$$

where: %R = Percent recovery; O = Measured value of analyte concentration after addition of spike; X = Measured value of analyte concentration in the sample before the spike is added; and T = Value of spike.

Tolerance limits for acceptable percent recovery established by the lab in accordance with contract laboratory procedures (CLP) guidelines will be followed for this program. Sample spike recoveries that fall outside the tolerance limits shall be assessed and the problem identified and corrected by the lab.

Surrogate spikes are also a measure of accuracy. When surrogate recoveries are outside the control limits, the corrective action procedures specified in the methods must be followed by the laboratory.

Laboratory blanks are analyzed by the lab to ensure samples are not contaminated during the analytical process of the lab. If there is contamination in the blank, the lab should be contacted immediately and requested to check their QA data. Samples should be re-analyzed if holding times have not been exceeded. If an environmental sample result is greater than ten times the concentration in the blank, then the data is acceptable but always qualified. If the sample result is less than ten times the concentration in the blank, the data must be discarded. If holding times have expired and the data is essential, then re-sample.

Precision: Precision is the degree to which a set of results are repeatable using the same methods and performed under the same conditions. To examine precision the lab performs duplicate analyses. Two aliquots of the same sample are made in the laboratory and each aliquot is treated exactly the same throughout the analytical method. The percent difference between the values of the duplicates, as calculated below, is taken as a measure of the precision of the analytical method.

$$\%D = 2\ \underline{(D1 - D2)} \times 100$$

$$(D1 + D2)$$

where: %D = Percent difference; D1 = First sample value; and D2 = Second sample value (duplicate)

The tolerance limit for percent difference between laboratory duplicates will be +/- 25%. If the precision values are outside the limits, the laboratory will recheck the calculations and/or identify the problem. Reanalysis may be required. Sample results associated with the out-of-control precision results may be qualified at the time of validation.

Completeness: Completeness is a measure of analytical effort and will be measured as:

$$\%C = V/T \times 100$$

where: C = Completeness of analytical effort, in percent; V = Number of sample analyses that have been validated (validation is the process of review and approval of sample data); and T = Total number of samples that have been submitted for validation.

The target for completeness by the analytical laboratory is 95 percent.

Table 3 shows the acceptance levels for data generated from this program.

Table 3. Quality Assurance/Quality Control Criteria for Laboratory Analysis

PARAMETER	PRECISION (RPD)	ACCURACY (%)	COMPLETENESS (%)
nutrients	25	>80% <120%	95%
chlorophyll a	25	--	95%

RPD = Relative Percent Difference from duplicate analysis; Control limit is 25 RPD if result is > 5 times the detection limit, and is ± the detection limit if the result is ≤ 5 times detection limit.

The target for completeness of the overall project data is 83%, or 10 of 12 sampling events for streams and 5 of 6 sampling events for lakes.

Representativeness: Representativeness is the degree to which data accurately and precisely represent the true value of a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is maximized by following standard procedures for sampling and analysis.

Replicate samples are taken every ten samples (10%) for all sampled parameters. The replicates are taken side-by-side to reduce field variability. In the lab, blanks, spikes, and splits are used to evaluate the accuracy and precision of the analysis. Field replicates are used to evaluate overall variability. There are no control limits established for field replicates. Data from field replicates are averaged and entered as one number in the database system.

Comparability: Comparability is maximized through the use of standard analytical methods with demonstrable equivalency in terms of method performance criteria and equivalent reported units. Use of standard methods applies to both the laboratory analysis and field procedures.

Field Instrument Quality Control

Table 4 provides instrument specifications for the field instruments used in the ambient monitoring program.

Table 4 - Instrument Specifications

Parameter	Instrument	Range	Accuracy	Resolution
pH	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	0-14 units	+/-0.2 units	0.01 units
Temperature	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	-5 to 45 °C	+/- 0.15 °C	0.01 °C
Conductivity	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	0 to 100 mS/cm	+/- 5% of reading +0.001mS/cm	0.001 mS/cm - 0.1 mS/cm (range dependent)
Dissolved Oxygen	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	0 to 50 mg/L	Within 0 to 20 mg/L, +/- 2% of the reading or 0.2 mg/l, whichever is greater	0.01 mg/L
Turbidity	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	0 to 1000 NTU	+/- 5% of the reading or 2 NTU, (whichever is greater) relative to calibration stds	0.1 NTU
Discharge	Swoffer Model 2100 current meter	0.1 to 25 ft/ sec	± 1%	

All field instruments are pre- and post-calibrated. The results of the calibrations and any deviation from the expected values are recorded. Significant deviations result in a variety of actions, including: using new standards for calibration, changing membranes, cleaning probes, replacing probes. The action(s) taken are recorded, along with the results of the actions. Table 5 shows the tolerances for drift in the field instruments between the pre-and post-calibrations. Drift beyond those levels will result in the data being flagged or discarded. For temperature, the instruments will be checked, annually, using a certified thermometer under ice bath and room temperature conditions. If the instrument is greater than ± 0.5 degrees C, the instrument will be sent to the manufacturer for re-calibration.

Table 5. Field Instrument Drift Tolerance Limits

Parameter	Post-Calibration Drift Tolerance Limit
pH	±0.2 units
dissolved oxygen	±0.5 mg/l
specific conductance	±10%
turbidity	±10%

Data Quality Control

When, during post-calibration procedures, a field parameter falls outside of the acceptable range, the field data for that sampling date is either flagged or discarded.

Lab data is reviewed against criteria in Table 3 upon receipt. It is also reviewed to identify any data that appears to be an outlier. If any problems are found, project staff contact the lab to discuss the data. Based on the findings, a decision is made to either accept, flag (qualify), or discard the data.

Instrument Calibration and Frequency

Calibration Procedures for YSI Model 6920 sonde with 650 MDS display

The instrument is calibrated prior to sampling each day. The instrument is post-calibrated following a day of sampling to ensure that the instrument performed within the acceptable range of accuracy and precision. The manufacturer's calibration procedures are followed for each parameter in accordance with the instrument manual provided. Calibration for dissolved oxygen is an air calibration. Conductivity is calibrated using a single calibration standard solution. pH and turbidity probes are calibrated using a two point calibration method with certified calibration standards. The two pH calibration standards used for stream sampling are 4 and 7, and for lakes they are 7 and 10. The turbidity calibration standards used are 0 and 100 NTU. Between the calibration of each probe, the instrument is rinsed three times with deionized water and once with the next parameter's standard solution.

As with the other instruments, all calibration information is recorded in a calibration logbook. If, during post-calibration procedures, a parameter falls outside of the acceptable range, staff troubleshoot the problem and take action in accordance with the equipment manual. Actions taken may include cleaning probes, soaking probes in specific solutions, changing a membrane, replacing a probe, or sending to the instrument for service to the manufacturer.

The equipment is routinely cleaned and maintained in accordance with the manufacturer's recommendations contained in the equipment manual.

Calibration Procedures for Swoffer Model 2100 Current Meter

1. Switch to CALIBRATE and read the calibration number. If the displayed number is lower, check the battery. A weak battery will allow the calibration number to "drift" downward and cause erroneous readings. Always keep a fully charged 9 volt battery in the spare compartment.

   Changes in the calibration number are proportional to the measurement error on a percentage basis. If the calibration number is 186 and the meter reads 184 then the velocity error due to calibration error will be about 1%. Record the calibration number in the logbook.

   Swoffer Meter #1 Calibration number is 175.
   Swoffer Meter #2 Calibration number is 186.
   Swoffer Meter #3 Calibration number is 184.

2. Check the propeller for damage, such as cracks or rough edges, which would change the calibration. Rough edges can be repaired with fine sandpaper. Cracks and other major damage require the replacement of the propeller.

3. Spin-test the instrument by laying the wading rod on a table or floor with the propeller perpendicular to the floor. Set the knob to "count". Blow on the propeller, and hit the reset button at the moment you stop blowing on the propeller. The propeller should free-spin to a count of at least 400 or greater. If it does not, the instrument should be cleaned or parts replaced as necessary to obtain that level of free-spin before use.

Sampling Methods

A. Field Instruments

Field parameters (temperature, pH, dissolved oxygen, and turbidity) are measured using a Yellow Springs Instrument (YSI) multi-parameter field instrument, Model 6920 and display unit 650 MDS. For streams, the instrument is placed in the flow with the probes facing upstream. For lakes, field parameters are measured by lower the instrument into the lake by one or two meter increments from the surface to the bottom of the lake, as determined by the depth sensor on the instrument.

The nutrient samples for lakes at the bottom are collected using a Kemmerer sampler. Chlorophyll *a* samples are taken as composite samples from the epilimnion (warm surface layer) or the photic zone (the surface area where sunlight can penetrate) using the Kemmerer sampler. Secchi disk visibility (or water clarity) is measured using a standard black and white quadrant disk. A Swoffer Model 2100 current meter is used to measure stream discharge using the wading technique.

B. Field Procedures

A field log is used to record field measurements and observations, including samples collected, date, time, station, weather, field personnel, field instruments used, and any notes regarding deviation from standard procedures. The following is a step-by-step procedure for taking measurements and samples in the field.

1. Streams

Field Measurements and Observations

- record date, time, weather conditions, field crew, field instruments used, field measurements, visual observations, samples taken, and any changes in procedures at each sampling station. Data will be recorded in a water-proof field book.
- allow instrument to stabilize
- record measurements in field book
- measure stream discharge using the primarily the six-tenth wading method described by US Geological Survey (USGS Water Supply Paper 2175, 1982), or the two-point method where depth is greater than 2.5 feet.

Sample Collection

- Stream samples, where possible, will be collected mid-channel and mid-depth. Usually collection is accomplished by wading. At non-wadable sites, samples will be taken mid-stream off a bridge with a custom sampling device.

- Mark sample bottles with the **station identification, date, time, parameters to be analyzed for, field personnel, source of water, and budget charged**. For fecal coliform bacteria samples, fill out the laboratory form with the above information and wrap the form around the sample bottle.

- Store samples on ice in a cooler until returned to the office. Store all bottles in a refrigerator until shipped (in a cooler on ice) or analyzed. Deliver bacteria samples to the Thurston County Health Lab upon returning from the field.

  <u>*Fecal Coliform Bacteria Samples*</u>

  Use pre-cleaned and sterilized bottles prepared by the Thurston County Environmental Health Lab. When sampling for bacteria, avoid touch the inside or mouth of the bottle. If there is any question about the sterility of a bottle, use another bottle. This parameter is time sensitive and should be analyzed no more than 24 hours after collection.

  To sample:
  - open the bottle with care (do not touch the mouth or inside of the bottle);
  - do **not** rinse the bottle as the bottle contains a preservative;
  - sample from mid-stream and mid-depth if possible, avoiding the surface micro-layer;
  - face up-stream when collecting the sample to ensure collecting water unimpacted by the presence of the field personnel;
  - fill the bottle to the neck, leaving some air space;
  - cap the bottle and attach the completed lab slip;
  - transport in cooler on ice and deliver to the EH lab same day.

Nutrients

Collect samples in pre-cleaned polyethylene bottles supplied by the laboratory. Nutrient samples may include ammonia, nitrate + nitrite, total nitrogen, soluble reactive phosphorus, and total phosphorus.

To sample:

- rinse the bottle(s) two times with the sample water;
- sample from mid-stream and mid-depth when possible;
- face up-stream when collecting the sample to ensure collecting water unimpacted by the presence of the field personnel;
- fill the bottle to the neck, leaving some air space;
- transport on ice, store refrigerated until shipped, ship on ice in a cooler to the analyzing lab.

2. Lakes

Lake stations will be sampled monthly from May through October. The stations are generally located over the deepest basin in the lake. Field parameters are measured at one-meter depth increments (or 2-meter depth increments for lakes over ten meters deep) to identify stratification. The temperature and dissolved oxygen profiles are used to determine appropriate sampling depths for chlorophyll *a* and algae samples and to determine the depth for bottom sample collection.

Field Measurements and Observations

At the established lake station, first check the depth reading before placing the instrument in the water and zero if necessary. Place the YSI instrument in the water so all the probes are completely covered. Wait for all of the parameters to stabilize before recording. Record depth, temperature, pH, conductivity, and dissolved oxygen in the field book. Also record: date, time, field personnel, equipment used, lake color, weather (including wind conditions). Then lower the instrument one meter at a time using the depth reading on the instrument, and record the field parameters at each depth increment (take measurements every two meters in lakes where depth exceeds ten meters).

Secchi Disk Measurement

- lower disk into the water to the point where it cannot be seen;
- pull it back up to where it is just visible;
- record the depth (in meters to the nearest hundredth) in the field book.

Sample Collection

Chlorophyll a (and Phaeophyton a) and Algae Identification Samples

Samples will be collected using a Kemmerer water sampler and composited from two or three discreet samples to obtain a one-liter composite sample for chlorophyll and a 250-ml sample for algae.

To sample:

- determine sampling depths necessary for the composite sample (Use the temperature profile data to determine extent of the epilimnion in the summer. The epilimnion is the warm upper layer of water having a fairly uniform temperature. If sampling in the winter when most local lakes are not stratified, use 1.5 times the secchi disk depth as the surface layer to sample);
- record the composite sampling depths in the field book;
- lower the Kemmerer column sampler to the determined depth;
- rinse the bottle with water in the epilimnion (surface is OK);
- fill the sample bottle from the Kemmerer sampler with the appropriate volume of water to have an equal volumes from each depth, i.e. fill bottle one-third volume from each depth if three depths will be sampled to comprise the composite.
- repeat steps above the appropriate number of times to fill the composite samples;
- add the 1 mg/L $MgCO_3$ preservative to the chlorophyll samples and shake;
- transport in cooler on ice, store refrigerated until shipped or analyzed
- preserve the algae identification samples with 4 drops of the preservative Lugols solution

Nutrients

Samples are taken at approximately 0.5 meters below the surface and 0.5 meters above the lake bottom with a Kemmerer sampler. Procedure is as follows:

- label the sample bottles. The sample identification is "station identification" followed by an "A" for surface sample or a "B" for bottom sample;
- determine the lake depth with the YSI instrument;
- for the near-surface sample, rinse the bottle with lake surface water two times;
- collect the near-surface sample by submerging the bottle mouth down in the water, when at 1.5 feet depth tilt the bottle side-wise and move forward in a scooping motion until filled. Empty enough liquid to bring the water level to the shoulder of the bottle.
- For the near-bottom sample, lower the Kemmerer to the appropriate depth, using caution to avoid hitting the bottom and disturbing the bottom sediment;
- rinse the sample bottle twice with the sample water from the Kemmerer;
- discard the bottom sample if suspended sediment is present; sample again as necessary;
- record the sampling depths in the field book;
- transport in cooler on ice, store refrigerated, Shipped in a cooler on ice to the analyzing lab via Greyhound bus

Sample Handling and Custody Procedures

Samples to be analyzed at the Thurston County Environmental Health lab are delivered directly to the lab by field staff on the same day as collection. Attached to every sample is a sample slip completed by the field staff. Samples are analyzed within 30 hours of collection.

Samples to be analyzed by Aquatic Research, Inc. are stored in the Environmental Health sample refrigerator immediately upon returning from the field. The morning after completion of the sampling event, a chain of custody form is completed and enclosed in a cooler with the samples and blue ice. The cooler is shipped via Greyhound bus to the Aquatic Research lab in Seattle. The samples arrive in Seattle and are picked up by lab staff on the same day as shipped.

Analytical Methods

Pre-cleaned water sampling bottles are supplied by the analyzing laboratory with the exception of algae identification bottles which are prepared by Environmental Health ambient program staff.

Analyzing entities used for this project have the appropriate certification from Washington Department of Ecology or Washington Department of Health for the parameters tested. The Quality Assurance Plan for the Thurston County Environmental Health Laboratory is in Appendix A. The analytical methods are listed in the table below.

Table 6. Analysis of Surface Water Samples

Chemical Analysis	Reporting Units	Recommended Holding Times	Analytical Method	Detection Limit
Ammonia-Nitrogen (NH_3)	mg/L as N (ppm)	7 days	EPA350.1	0.010 mg/l
Chlorophyll *a* (with Phaeophyton *a*)	ug/l	30 days	SM18 10200H.1 & 2	0.1 ug/l
Fecal Coliform (FC) most probable number membrane filter	cfu/100 mL	30 hours	APHA-9221C APHA-9222D	1 cfu/100ml
Nitrate + Nitrite (NO_3+NO_2)	mg/L as N	48 hours OR 28 days if preserved	EPA353.2	0.010 mg/l
Total Nitrogen (TN)	mg/L as N	28 days	SM 20 4500N-C	0.100 mg/l
Total Phosphorous (TP)	mg/L as P	28 days	SM18 4500PF	0.002 mg/l

Nutrient samples analyzed by Aquatic Research for this project are analyzed within 5 days of collection and are not acid preserved. The rationale for this is as follows: 1) This ambient monitoring program requires low level detection limits due to the nature of the waters being sampled. Acid preserving would require samples to be neutralized before analysis and then diluted, which would raise the detection limits above the desired limits. 2) For the nutrient parameters being analyzed, there is expected to be very little measurable loss or conversion between time of collection and time of analysis when analyzed within 5 days of collection .

Data Analysis and Reporting

At the end of each water year (September 30), the data is compiled and compared against the data objectives. Laboratory reports, QA worksheets, chain-of-custody records, and field notes are retained in the ambient monitoring program records. Upon completion of the data analysis, the project will be evaluated against the stated project goals and objectives.

Specific QA information that is evaluated is as follows:

- changes in the monitoring / QA project plan
- results of performance and/or systems audits
- significant QA problems and recommended solutions
- data quality assessment in terms of precision, accuracy, representativeness, completeness, comparability, and detection limits
- data qualifiers and rejections
- examination of whether the QA objectives were met, and the resulting impact on decision-making limitations on use of the measurement data

Data generated from this project are annually posted to the County website for accessibility by the public. Every two-year water resources monitoring report is prepared, and the document is posted to the website. In addition to being a compilation of two-years of data, the data is compared to the state water quality standards established in Chapter 173-201A WAC and shown in Table 7 below. Streams with several years of data are graphed to examine trends.

Water Quality Standards

The Washington State water quality standards for all surface water bodies are established in Chapter 173-201A of the Washington Administrative Code (WAC) which was amended July 1, 2003. Water quality standards for surface waters were established consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife. The standards for the parameters that are monitored by Thurston County are shown in Table 6. Refer to WAC 173-201A for a complete description of the water quality standards.

Table 7. Water Quality Standards for Surface Waters

Water Contact Recreation Criteria				
Parameter	Extraordinary Primary Contact Recreation (includes lakes)	Primary Contact Recreation	Secondary Contact Recreation	
Fecal Coliform (colonies/100 mL) Freshwater – geometric mean and not more than 10% of the samples >XXX	50; 100	100; 200	200; 400	
Freshwater Aquatic Life Uses Criteria				
	Char	Salmon & Trout Spawning, **Core** Rearing, and Migration	Salmon & Trout Spawning, **Non-core** Rearing, and Migration	Salmon & Trout Rearing and Migration **Only**
Dissolved Oxygen (mg/l) Lowest 1-Day Minimum	9.5	9.5	8.0	6.5
Temperature (degrees C) Highest 7-DAD* Maximum	12°C (53.6°F)	16°C (60.8°F)	17.5°C (63.5°F)	17.5°C (63.5°F)

pH Within range shown with human-caused variation within the range of less than XX units.	6.5 – 8.5; 0.2	6.5 – 8.5; 0.2	6.5 – 8.5; 0.5	6.5 – 8.5; 0.5
Turbidity (NTUs) Not exceed X over background when background is 50 NTU or less; or a XX% increase in turbidity when background is > 50 NTU.	5; 10%	5; 10%	5; 10%	10; 20%

*7 day average of the daily maximum temperatures

The "General Water Quality" condition stated in the descriptive summary for each stream and lake in the water resources report is made on the basis of the guidelines below.

Stream Water Quality Categories

"Excellent" - No water quality standard violations, and very low fecal coliform and nutrient concentrations.

"Good" - Usually meets water quality standards; OR violates only one part of the two part fecal coliform standard; OR the violation is most likely the result of natural conditions rather than pollution.

"Fair" - Frequently fails one or more water quality standards and other parameters such as nutrients indicate water quality is being impacted by pollution.

"Poor" - Routinely fails water quality standards by a large margin; other parameters such as nutrients are at elevated concentrations.

Lake Water Quality Categories

"Excellent" - Very low nutrient and chlorophyll *a* concentrations, and very high water clarity; Classified as Oligotrophic; Uses not impaired.

"Good" - Low to moderate nutrient and chlorophyll *a* concentrations, and moderate to high water clarity; Classified as Mesotrophic; Uses not impaired.

"Fair" - Moderate to high nutrient and chlorophyll *a* concentrations, and low to moderate water clarity; Classified as Eutrophic; Uses sometimes impaired.

"Poor" - High nutrient and chlorophyll *a* concentrations, and low water clarity; Classified as Eutrophic; Uses impaired during most of the summer season by excess algae and/or aquatic macrophyte (plant) growth.

Data Management Procedures

The lab data for fecal coliform bacteria results is received as hard copies of individual sample sheets. The lab data from Aquatic Research Inc is received as hard copies of lab reports for each sampling event. The field data is kept in field notebooks. These records are stored in ambient monitoring program files by water year.

The field and lab data is entered into the Thurston County's surface water Access database, from which it is easily accessible and can be transferred electronically upon request. The data entry is check by the data entry staff and ten percent of the data entry is reviewed for errors by a second project staff. At the end of each water-year after the data management activities are complete, the data is posted on the County ambient monitoring website for easy public access.

Audits and Reports

The Thurston County Environmental Health laboratory is certified by Ecology to perform the fecal coliform bacteria analyses and participate in audits by Ecology. These performance and system audits have verified the adequacy of the laboratory standard operating procedures, which include preventive maintenance and data reduction procedures.

The Thurston County Environmental Health Department laboratory schedule for auditing methodology and quality control is every two years by Department of Ecology. All quality control reports as required for certification are maintained on-site in the lab. The responsible person is Thurston County microbiologist, Mike Clark, at (360) 786-5465. The Ecology staff who conducts the audits is Aimee Bennett from the Laboratory Accreditation Program.

Aquatic Research, Inc is certified by Ecology to perform the nutrient and chlorophyll analysis. The responsible person is Steve Lazoff, at (206) 632-2715. The Ecology staff who conducts the audits is Aimee Bennett from the Laboratory Accreditation Program. A copy of the Scope of Accreditation can be found in Appendix D.

Data Validation and Verification

Field and laboratory data will be verified and validated throughout the project and at the completion of the data collection period. The staff will verify in the field the measurement collected and upon completion of the instrument post-calibration process. The lab staff will verify all lab-generated data following standard protocol.

The project manager will validate the data according the data objective in this QA Project Plan.

APPENDIX A

THURSTON COUNTY

ENVIRONMENTAL HEALTH

QUALITY ASSURANCE PLAN

FOR

SURFACE WATER ANALYSIS

INTRODUCTION

To assure that routinely generated analytical data in the Thurston County Environmental Health Laboratory is scientifically valid and defensible, a regime of quality assurance procedures are in place. The following is a description of these procedures. Where appropriate reference is made to Standard Method for the Examination of Water and Wastewater, 16th Edition.

I. Sampling Procedures:

Upon receipt of a sample in our laboratory the date and time of receipt as well as the initials of the person receiving the sample is written on the accompanying sample information form. The sample is then either immediately placed in the laboratory refrigerator to await analysis or analysis is begun at once. Every attempt is made to begin analysis the same day that a sample is taken and in all cases within 24 hours.

To begin analysis, each sample is unwrapped and placed on it's accompanying form. The form is then examined for information completeness and accuracy and a decision is made whether to subject the sample to membrane filtration (MF) or multiple tube fermentation (MTF). Generally, sewage effluent and very turbid surface water samples are subjected to the MTF technique; all other samples are run MF. Each sample bottle and it's accompanying form are given a number and the 'date of analysis" is stamped on the form. The bottle and form are then separated and analysis is begun. The information on each form is computerized and printed out on a laboratory log sheet (See Dilution Log Book). Each test's data is then entered in the appropriate space on the log sheets next to the respective sample information.

After analysis, each sample bottle is autoclaved, emptied, washed, and sterilized according to Standard Methods Section 9040.

II. Measurements and Calibrations:

All instruments, reagents, and media are monitored regularly to assure their accuracy and performance. The following table summarizes the type of measurements or calibrations and their frequency:

INSTRUMENT OR MEDIA	TYPE OF MEASUREMENTS OR CALIBRATIONS	FREQUENCY
Autoclave	Sterilizing of spore strips. Maximum reg. thermometer timer accuracy	Monthly Quarterly Quarterly
Automatic Pipettor	Accuracy at 10ml.	Quarterly
pH Meter	To pH 4 and 7	Weekly
Conductivity Meter	To 10 Micromhos	Monthly
Thermometers	To incubator temperature with NBS thermometer	Annual
Balance	1mg. to 100gm	Quarterly
MF Funnels	To 100ml, 50ml, 20ml, 10ml	Annual
Air Incubator	To 35 $\pm$ .5 C	Twice Daily
Water Bath Incubator	To 44.5 $\pm$ .2 C	Twice Daily
Refrigerator	TO $\leq$ 5 C	Daily

Pure Water System	Conductivity Plate Count pH Chlorine Residual	Monthly
	Biological Suitability	Annual
	Trace Metals Analysis	Annual
Oven	Thermometer - 175 C Timer: 2 Hours	Annual Annual
UV Sterilizer	Effectiveness on Control Cultures as measured by plate count.	Biannual
Media	pH Control Cultures	Each Batch
Sample Bottles	Sterility	Each Batch
Buffer	pH Sterility	Each Batch

III. Data Reduction, Validation, and Reporting:

Data Reduction: MF fecal coliform analyses are performed on a variety of sample volumes in an attempt to produce a culture plate with twenty (20) to sixty (60) CFU's. Once the appropriate plate is counted, the colony number is converted to colony forming unites per 100ml. using the following formula.

$$\# \text{ colonies per 100ml} = \frac{\text{colonies counted X 100}}{\text{ML sample filtered}}$$

MTF serial dilutions are reported directly as fecal coliforms per 100ml. No data conversion is necessary.

Data Validation: Water bacteriological report forms are filled out and the data is rechecked against the log book data.

Reporting: All analytical data is reported directly to the individual who submitted the sample. A copy is kept on file by Thurston County Environmental Health. All data is also kept on computer disk.

IV. External Quality Control Checks:

Annual EPA proficiency samples are analyzed for total and fecal coliform bacteria by Membrane Filtration and Multiple Tube Fermentation.

V. Preventive Maintenance Procedures and Schedules:

Autoclave: Under contract with MDT Corporation - inspected and serviced four times per year:

MDT Corporation
177 E. Henrietta Road
Rochester, NY 14623

Mettier Balance: Serviced and calibrated annually by:

Quality Control Services
516 SE Morrison, Suite 213
Portland, Oregon 97214

Pure Water System: Maintained and serviced biannually by:

Continental Water Systems NW
PO Box 1084
Kent, Washington 98035

Other laboratory equipment is cleaned and serviced as necessary by laboratory personnel.

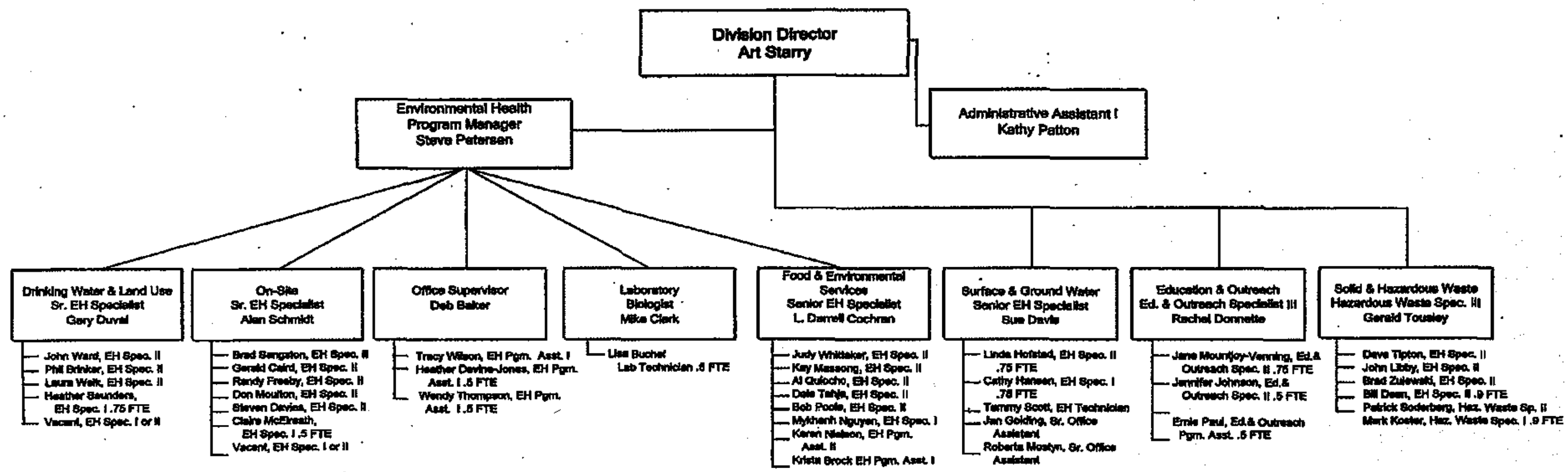
VI. Data Quality Control:

Ten percent (10%) of all growth positive countable MF plates are subcultured to verify up to ten colonies per plate and up to ten colony forming units per plate subcultured to EC broth. If there is a disparity between initial counts and verified counts, the final count is amended accordingly.

"Begin Run" and "End Run" controls are performed on each Membrane Filtration Series. If controls show any growth, the data from that MF series is deemed invalid and requests for new samples are made.

With MTF cultures (A-1 Broth), growth and gas positive tubes do not require further verification.

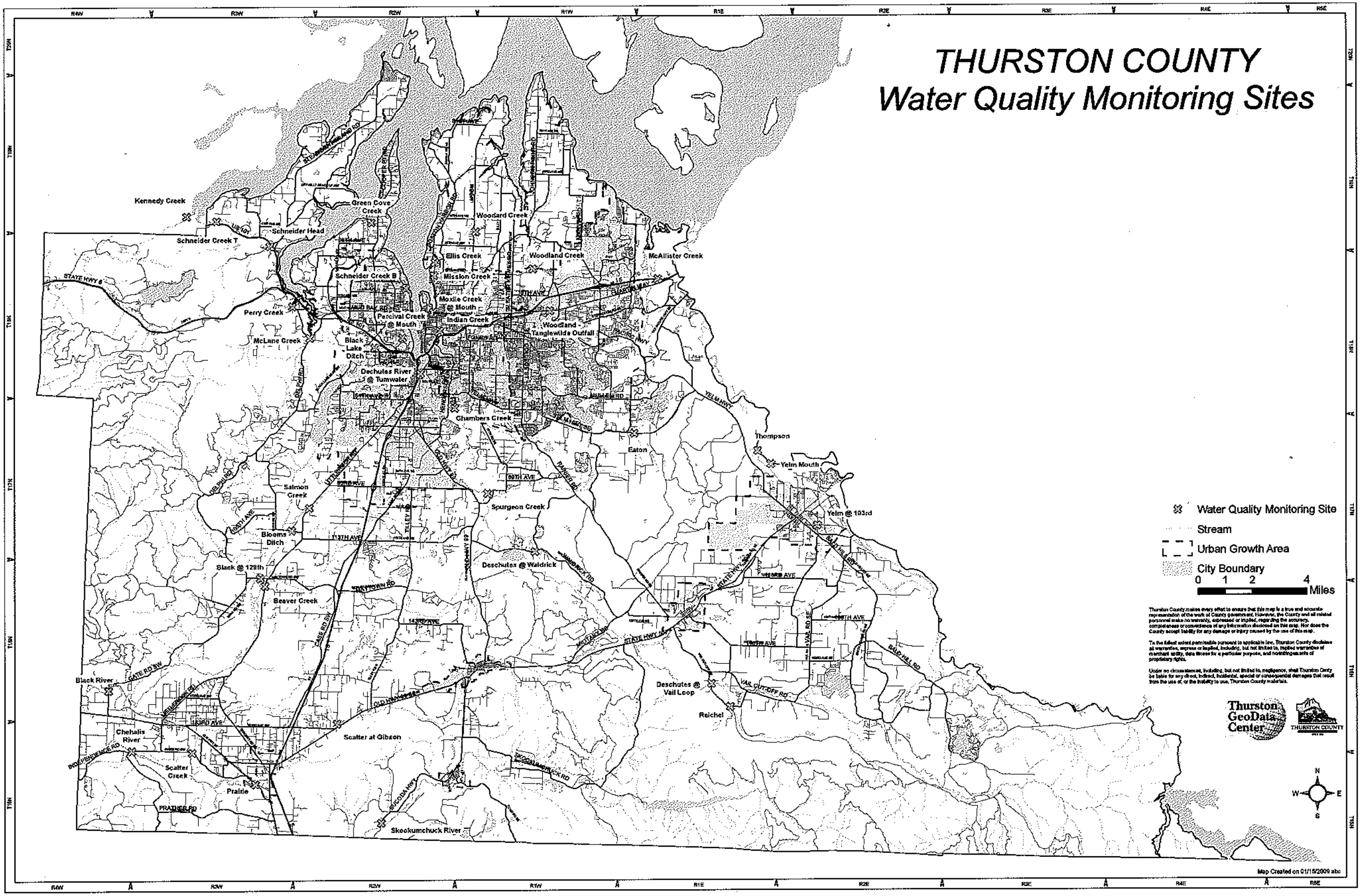
Environmental Health Division
Organization Chart



9/14/2005

APPENDIX B

THURSTON COUNTY
Water Quality Monitoring Sites



APPENDIX C

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: TCH031-74 **PAGE 3**

REPORT DATE: 05/30/08

DATE SAMPLED: 05/19-21/08 **DATE RECEIVED:** 05/22/08

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM THURSTON COUNTY HEALTH / LAKES PROGRAM

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOTAL-N (mg/l)	AMMONIA (mg/l)	NO3+NO2 (mg/l)
METHOD	SM18 4500PF	SM20 4500N-C	EPA 350.1	EPA 353.2
DATE ANALYZED	05/28/08	05/27/08	05/23/08	05/23/08
DETECTION LIMIT	0.002	0.100	0.010	0.010
DUPLICATE				
SAMPLE ID	CA2	CA2	BATCH	BATCH
ORIGINAL	0.022	0.558	0.020	0.330
DUPLICATE	0.022	0.558	0.021	0.331
RPD	0.55%	0.05%	6.32%	0.36%
SPIKE SAMPLE				
SAMPLE ID	CA2	CA2	BATCH	BATCH
ORIGINAL	0.022	0.558	0.020	0.330
SPIKED SAMPLE	0.078	1.63	0.208	0.531
SPIKE ADDED	0.050	1.00	0.200	0.200
% RECOVERY	112.67%	107.05%	94.15%	100.36%
QC CHECK				
FOUND	0.091	0.435	0.304	0.416
TRUE	0.090	0.435	0.324	0.408
% RECOVERY	100.88%	100.02%	93.75%	101.91%
BLANK	<0.002	<0.100	<0.010	<0.010

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

APPENDIX D

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

Post Office Box 488 • Manchester, Washington 98353-0488 • (360) 895-6144

August 5, 2008

Mr. Steven Lazoff
Aquatic Research, Inc.
3927 Aurora Ave N
Seattle, WA 98103

Dear Mr Lazoff:

Thank you for submitting the information we requested in support of your accreditation for metals by ICP-MS. Here is a revised Scope of Accreditation showing full accreditation for all of the metals for which we have received satisfactory proficiency testing (PT) sample results. Accreditation will granted for silver and vanadium upon receipt of the necessary PT sample results.

If you have any questions concerning the accreditation of your lab, please contact me at (360) 895-6148, fax (360) 895-6180, or by e-mail at slom461@ecy.wa.gov.

Sincerely,

Stewart M. Lombard
Lab Accreditation Unit Supervisor

SML:sml
Enclosures

Scope of Accreditation

Aquatic Research, Inc.

Seattle, WA

is accredited by the State of Washington Department of Ecology to perform analyses for the parameters listed below using the analytical methods indicated. This Scope of Accreditation may apply to any of the following matrix types: non-potable water, drinking water, solid and chemical materials, and air and emissions. Accreditation for all parameters is final unless indicated otherwise in a note. Accreditation is for the latest version of a method unless otherwise specified in a note. EPA refers to the U.S. Environmental Protection Agency. SM refers to American Public Health Association's publication, Standard Methods for the Examination of Water and Wastewater, 18th, 19th or 20th Edition, unless otherwise noted. ASTM stands for the American Society for Testing and Materials. PSEP stands for Puget Sound Estuary Program. Other references are detailed in the notes section.

Matrix Type/Parameter Name	Reference	Method Number	Notes
Drinking Water			
Alkalinity, Total	SM	2320 B(4a)	
Color	SM	2120 B	
Cyanide, Total	SM	4500-CN E	
Fluoride	SM	4500-F C	
Hardness, Total (as CaCO3)	SM	2340 C	
Nitrate	SM	4500-NO3 F	
Nitrate + Nitrite	EPA	353.2	
Nitrite	SM	4500-NO3 F	
Orthophosphate	EPA	365.1	
Orthophosphate	SM	4500-P F	
Solids, Total Dissolved	SM	2540 C	
Specific Conductance	SM	2510 B	
Sulfate	SM	4500-SO4 E	
Sulfate	ASTM	D516-02	
Total Organic Carbon	SM	5310 B	
Turbidity	EPA	180.1	1
Aluminum	EPA	200.8	
Aluminum	SM 18/19	3113 B	
Aluminum	EPA	200.7	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Antimony	EPA	200.8	
Antimony	SM 18/19	3113 B	
Arsenic	SM 18/19	3113 B	1
Arsenic	EPA	200.8	
Barium	EPA	200.7	
Barium	EPA	200.8	
Beryllium	EPA	200.8	
Beryllium	SM 18/19	3113 B	
Cadmium	EPA	200.8	
Cadmium	EPA	200.7	
Calcium	EPA	200.7	1
Chromium	EPA	200.7	
Chromium	EPA	200.8	
Copper	EPA	200.8	
Copper	EPA	200.7	
Copper	SM 18/19	3113 B	
Iron	EPA	200.7	
Iron	EPA	200.8	
Lead	EPA	200.8	
Lead	SM 18/19	3113 B	
Magnesium	EPA	200.7	
Manganese	EPA	200.8	
Manganese	EPA	200.7	
Mercury	EPA	245.1	
Mercury	EPA	200.8	
Nickel	EPA	200.7	
Nickel	EPA	200.8	
Selenium	EPA	200.8	
Selenium	SM 18/19	3113 B	
Silver	EPA	200.7	

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Matrix Type/Parameter Name	Reference	Method Number	Notes
Sodium	EPA	200.7	
Thallium	EPA	200.8	
Zinc	EPA	200.8	
Zinc	EPA	200.7	
Chlorinated Pesticides	EPA	508.1	1
PCBs	EPA	508.1	1
Organic Compounds	EPA	525.2	1
Purgeable Organic Compounds	EPA	524.2	
Trihalomethanes	EPA	524.2	
Vinyl Chloride	EPA	524.2	1
Non-potable Water			
Acidity	SM	2310 B(4b)	
Alkalinity, Total	SM	2320 B(4b)	
Ammonia	EPA	350.1	
Ammonia	SM 18	4500-NH3 H	
Anionic Surfactants	SM	5540 C	
Biochemical Oxygen Demand, BOD/CBOD	SM	5210 B	
Chemical Oxygen Demand (COD)	SM	5220 D	
Chloride	SM	4500-Cl- C	
Color	SM	2120 B	
Cyanide, Total	SM	4500-CN E	
Fluoride	SM	4500-F C	
Hardness, Total (as CaCO3)	SM	2340 C	
Hexane Extractable Material	EPA	1664	
Nitrate	EPA	353.2	
Nitrate	SM	4500-NO3 F	
Nitrate + Nitrite	EPA	353.2	
Nitrogen, Total	SM 20	4500-N C	
Nitrogen, Total Kjeldahl	SM	4500-Norg C	
Nitrogen, Total Kjeldahl	EPA	351.1	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Orthophosphate	SM	4500-P F	
Orthophosphate	EPA	365.1	
Phosphorus, Total	EPA	365.1	
Phosphorus, Total Persulfate	SM	4500-P F	
Solids, Total Dissolved	SM	2540 C	
Solids, Total Suspended	SM	2540 D	
Solids, Total Volatile	SM	2540 E	
Specific Conductance	SM	2510 B	
Sulfate	SM	4500-SO4 E	
Sulfate	ASTM	D516-02	
Sulfide	SM	4500-S2 D	
Sulfide	SM	4500-S2 F	
Total Organic Carbon	SM	5310 B	
Turbidity	SM	2130 B	
Aluminum	SM 18/19	3113 B	
Aluminum	EPA	200.7	
Aluminum	EPA	200.8	
Antimony	SM 18/19	3113 B	
Antimony	EPA	200.8	
Arsenic	EPA	200.8	
Arsenic	SM 18/19	3113 B	1
Barium	EPA	200.8	
Barium	EPA	200.7	
Beryllium	EPA	200.8	
Beryllium	SM 18/19	3113 B	
Boron	EPA	200.8	
Cadmium	EPA	200.7	
Cadmium	EPA	200.8	
Cadmium	SM 18/19	3113 B	
Calcium	EPA	200.7	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Chromium	EPA	200.8	
Chromium	EPA	200.7	
Chromium	SM 18/19	3113 B	1
Copper	EPA	200.8	
Copper	SM 18/19	3113 B	
Copper	EPA	200.7	
Hardness, Total (as CaCO3)	EPA	200.7	1
Iron	EPA	200.7	
Iron	EPA	200.8	
Lead	EPA	200.7	1
Lead	SM 18/19	3113 B	
Lead	EPA	200.8	
Magnesium	EPA	200.7	
Manganese	EPA	200.7	
Manganese	EPA	200.8	
Mercury	EPA	1631	
Mercury	EPA	200.8	
Molybdenum	SM	3113 B	1
Molybdenum	EPA	200.8	
Nickel	EPA	200.7	
Nickel	EPA	200.8	
Potassium	EPA	200.7	1
Selenium	SM 18/19	3113 B	
Selenium	EPA	200.8	
Silica	EPA	200.7	
Silver	SM 18/18	3113 B	1
Silver	EPA	200.7	
Sodium	EPA	200.7	
Thallium	EPA	200.8	
Vanadium	EPA	200.7	1

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Matrix Type/Parameter Name	Reference	Method Number	Notes
Zinc	EPA	200.7	
Zinc	EPA	200.8	
BNA Extr (Semivolatile) Organics	EPA	8270	
Volatile Organic Compounds	EPA	8260	
Fecal Coliform - count	SM	9222 D	2
Total & Fecal Coli - count	SM	9221 B1,2,C&E1	
Solid and Chemical Materials			
Aluminum	EPA	6010	1
Barium	EPA	6010	1
Beryllium	EPA	6010	1
Cadmium	EPA	6010	1
Calcium	EPA	6010	1
Chromium	EPA	6010	1
Cobalt	EPA	6010	1
Copper	EPA	6010	1
Iron	EPA	6010	1
Lead	EPA	6010	1
Manganese	EPA	6010	1
Molybdenum	EPA	6010	1
Nickel	EPA	6010	1
Silver	EPA	6010	1
Sodium	EPA	6010	1
Strontium	EPA	6010	1
Titanium	EPA	6010	1
Vanadium	EPA	6010	1
Zinc	EPA	6010	1
Glycols	EPA	8015	
Total Pet Hydrocarbons - Diesel	WDOE	NWTPH-Dx	1
BNA Extr (Semivolatile) Organics	EPA	8270	1

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Matrix Type/Parameter Name	Reference	Method Number	Notes

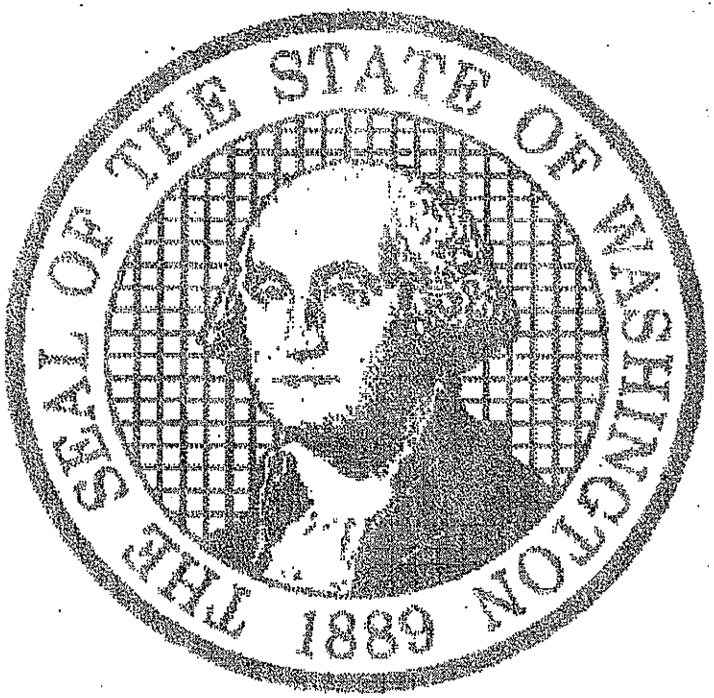
Accredited Parameter Note Detail

(1) Provisional pending acceptable proficiency testing (PT) results (WAC 173-50-110). (2) Provisional pending receipt of eveidence that requirements in the microbiology audit report have been met.

Authentication Signature

August 5, 2008
Date

Stewart M. Lombard, Lab Accreditation Unit Supervisor



Appendix C:
QAPP Addendum to Support 2019 Capitol Lake Monitoring Program

QAPP Addendum to Support 2019 Capitol Lake Monitoring Program

The following includes data quality objectives for analytes not included in the adopted Thurston County Surface Water Ambient Monitoring Program Standard Operating Procedures and Analysis Methods (Appendix B). The analytes described in this Quality Assurance Project Plan (QAPP), which will supplement the Thurston County plan adopted for this project, include total organic carbon, total suspended solids, total volatile suspended solids and filtered and unfiltered BOD5. The QAPP also addresses methods for collecting phytoplankton species and biovolume data which are described in Attachment C.1.

SAMPLE HANDLING AND CUSTODY PROCEDURES

Additional analyte samples will be collected at sampling locations, and following sampling procedures outlined in Thurston County QAPP (Thurston County, 2009). All samples will be delivered on ice directly to the lab by field staff the same day as collection, apart from phytoplankton which will be preserved and mailed to the Aquatic Analysts. Sample chain of custody forms will be completed and enclosed in phytoplankton shipment.

Samples are to be analyzed at three separate laboratories, Table C1 indicates which analytes will be measured at each laboratory. Laboratories include:

- IEH Laboratory: Seattle, WA
- LabCor: Seattle, WA
- Aquatic Analysts: Friday Harbor, WA

Laboratory analytical procedures will follow USEPA approved methods (APHA 1998; USEPA 1983, 2015b). These methods provide detection limits that are below the state and federal regulatory criteria or guidelines, and they will enable direct comparison of analytical results with these criteria.

The laboratories identified for this project are certified by the Washington State Department of Ecology (Ecology) for each of the analytical parameters. IEH participates in audits and inter-laboratory studies by Ecology and USEPA. These performance and system audits have verified the adequacy of the laboratory standard operating procedures, which include preventative maintenance and data reduction procedures.

The laboratories will report the analytical results within 30 days of receipt of the samples. If necessary, the laboratory will provide draft results within hours of receipt of the samples. Sample and quality control data will be reported in a standard format. The reports will also include a case narrative summarizing any problems encountered in the analyses.

Laboratory data quality objectives are listed below in Table C.1. Samples analyzed for phytoplankton species and biovolume data will following procedures included in Attachment C.1.

Table C.1

Analyte	Method	Holding Time	Method Reporting Limit	Control Sample Recovery (%)	Matrix Spike Recovery (%)	Duplicate Relative Percent Difference	Lab
TSS	SM 2540D	7 days	0.5 mg/L	80–120%	NA	≤20%	IEH
TVSS	SM 2540E	48 hrs	0.5 mg/L	80–120%	NA	≤20%	IEH
Total Organic Carbon	SM 5310B	7 days	0.25 mg/L	80–120%	NA	≤20%	IEH
BOD5	SM 5210B	48 hrs	4 mg/L	80–120%	NA	≤20%	IEH
Total Phosphorus	SM 4500PF	28 days	0.002 mg/L	80–120%	75–125%	≤20%	IEH
Soluble Reactive Phosphorus	SM 4500PF	48 hrs	0.001 mg/L	80–120%	75–125%	≤20%	IEH
Total Persulfate Nitrogen	SM 4500NC	28 days	0.05 mg/L	80–120%	75–125%	≤20%	IEH
Ammonia Nitrogen	SM 4500NH3H	7 days	0.01 mg/L	80–120%	75–125%	≤20%	IEH
Nitrate+Nitrite Nitrogen	SM 4500NO3F	48 hrs	0.01 mg/L	80–120%	75–125%	≤20%	IEH
Chlorophyll *a*	SM 10200H	28 days	0.1 µg/L	NA	NA	≤20%	IEH
Fecal Coliform/ *E. coli*	SM 9222 D	30 hrs	1 CFU/ 100 mL	NA	NA	≤ 35%	LabCor
Phytoplankton Cell/Biovolume	Microscope	6 mo	cells/mL	NA	NA	≤ 30%	AA

Abbreviations:

AA	Aquatic Analysts
BOD5	5-day biochemical oxygen demand
CFU	Colony-forming unit
hrs	Hours
IEH	IEH Laboratory
µg/L	Micrograms per liter
mg/L	Milligrams per liter
mL	Milliliters
mo	Months
NA	Not applicable
TSS	Total suspended solids
TVSS	Total volatile suspended solids

Attachment C.1

Aquatic Analysts

Algae Analytical and Quality Assurance Procedures

September 3, 2018

These quality assurance procedures have been adopted by the Capitol Lake – Deschutes Estuary Long-Term Management Project Environmental Impact Statement Project Team for collecting phytoplankton species and biovolume data. These procedures will supplement the Thurston County Surface Water Ambient Monitoring Program Standard Operating Procedures and Analysis Methods, which has been adopted for water quality sampling in Capitol Lake.

Sample Handling

<u>Sample Collection and Preservation</u>

Phytoplankton are collected by filling bottles with natural water samples. Samples are collected at either discrete depths, or integrated through the photic zone of lakes. A volume of 125 mL is sufficient for most samples.

These samples are preserved with 1% Lugol's solution immediately after collection. Refrigeration is not necessary, and holding times are a year or more.

<u>Sample Tracking</u>

All samples received in the laboratory are immediately logged into a Sample Receipt Log. All samples are stored in a dedicated area until they are processed. After samples are processed and analyzed and data reports have been submitted to clients, samples are placed in storage for at least one year.

<u>Sample Preparation</u>

Permanent microscope slides are prepared from each sample by filtering an appropriate aliquot of the sample through a 0.45 micrometer membrane filter (APHA Standard Methods, 1992, 10200.D.2; McNabb, 1960). A section is cut out and placed on a glass slide with immersion oil added to make the filter transparent, followed by placing a cover slip on top, with nail polish applied to the periphery for permanency. A benefit to this method is that samples can be archived indefinitely; we have nearly 35,000 slides archived.

Microscopic Analyses

Algae Identifications

Aquatic Analysts has an extensive library of algae literature, including journal reprints, standard reference books, and internet reference sites. We also maintain files, notes, and photographs of algae we've encountered during the past 35 years of identifying algae. Most algae are identified by cross-referencing several taxonomic sources.

Enumeration

Algal units (defined as discrete particles - either cells, colonies, or filaments) are counted along a measured transect of the microscope slide with a Zeiss standard microscope (1000X, phase contrast). Only those algae that were believed to be alive at the time of collection (intact chloroplast) are counted. A minimum of 100 algal units are counted. (Standard Methods, 1992, 10200.F.2.c.).

Biovolume Estimates

Average biovolume estimates of each species are obtained from calculations of microscopic measurements of each alga. The number of cells per colony is recorded during sample analysis to arrive at biovolume per unit-alga. Average biovolumes for algae are stored in a computer, and measurements are verified for each sample analyzed.

Data Analyses and Reports

Sample Reports

Results of sample and data analyses are provided to the client in electronic format. Deliverables include individual sample reports, data summaries, database file, and combined species lists.

Individual sample reports include sample identification, a trophic state index, total sample density, total sample biovolume, and a list of algae species with their absolute and relative densities and biovolumes. All data are reported in Excel format.

Data summaries include sample identification, total density, total biovolume, the trophic state index, and the top 5 most common algae species (codes) and their relative densities. The summary format allows for easy calculations and graphs of algae sample data.

Database files include information for each species from each sample within a sample set. Information includes sample ID, species names and codes, densities and biovolumes, taxonomic group, and any notes on each sample.

Combined species lists of all species within related groups of samples allow greater sensitivity in comparing different lakes, sites, dates, or depth. Algae species are compiled according to their relative densities.

Trophic State Index

A Trophic State Index based upon phytoplankton biovolume has been developed from a data set of several hundred lakes located throughout the Pacific Northwest (Sweet, 1986, Report to EPA). The index was derived in a similar fashion as Carlson (1977) derived indices for Secchi depth, chlorophyll concentration, and total phosphorus concentration. The biovolume index ranges from 1 for ultraoligotrophic lakes to 100 for hypereutrophic lakes. Values agree well with Carlson's indices.

The index is defined as:

TSI (biovolume) = (Log-base 2 (B+1)) * 5

Where B is the phytoplankton biovolume in cubic micrometers per milliliter divided by 1000.

TSI values below 20 are generally considered to be ultraoligotrophic, values from 20 to 35 are oligotrophic, 35 to 50 mesotrophic, 50 to 65 eutrophic, and above 65 is hypereutrophic.

Quality Assurance

Microscope Calibration

Aquatic Analysts use a Zeiss Standard phase-contrast microscope primarily with a 1000X magnification for identification and enumeration of algal samples. The diameter of the field of view at 1000X magnification is 0.182 mm. The effective area of a filter is 201 millimeters square.

Algae are enumerated along a measured transect, measured accurately to 0.1 mm with a stage micrometer. The algal densities are calculated from the area observed (transect length times diameter of field of view), the effective filter area, and the volume of sample filtered.

The microscope was calibrated using a standard concentration of latex spheres provided by EPA (Cincinnati, OH). The concentration of these spheres was 12,075 per milliliter. Duplicate preparations of the standard spheres were analyzed; the average result was 11,700 spheres per milliliter (96.9 percent). The computer program used to calculate algae densities compensates for this 3.1% error.

Replicates

Replicate algae samples are analyzed at the client’s request. We encourage blind replicates for approximately 10% of all samples collected. Replicates are assessed for algae abundance (relative mean difference of densities) and species composition (similarity indices, species lists).

Independent Analyses

Aquatic Analysts has participated in the analyses of split algae samples on several occasions, with general agreement between samples in terms of algae density and algae species compositions. On occasion, we also contract independent algae analysts for second opinions on some difficult to identify algae species.

Internal Data Verification

A custom computer program handles all calculations and data analyses. Final sample reports are compared with laboratory bench sheets before releasing data.

Data summaries, tables of similarity indices, abundance graphs, and combined species lists are searched for inconsistencies, outliers, and interrupted patterns that may indicate possible errors.

Archives

Aquatic Analysts maintains an herbarium of all microscope slides analyzed (over 35,000 to date). These may be reviewed if questions arise after data are reported. In addition, all computer data (sample tracking data, raw count data, final reported data, data analyses, narrative reports) are archived on CD's in permanent storage.