Quality Assurance Project Plan

Lake Chelan Water Quality Monitoring Study

Total Phosphorus, Orthophosphate, Ammonia, Nitrate, Nitrite, Total Persulfate Nitrogen, Alkalinity, Total Organic Carbon, Chlorophyll *a*, pH, Temperature, Specific Conductivity, and Dissolved Oxygen.

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for water quality infrastructure and nonpoint source pollution projects to improve and protect water quality.

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Lake Chelan Water Quality Monitoring Study

June 2016

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2.0 Abstract

The Lake Chelan Watershed Planning Unit (LCWPU) intends to initiate a Long Term Monitoring Plan (LTMP) to assess the water quality conditions of Lake Chelan and to use the LTMP data to identify and support evaluation of any trends in water quality. Historical data are sporadic, localized, and discontinuous and therefore potentially problematic for evaluating water quality trends. The initial year of LTMP data will be collected at eight lake monitoring stations and at two tributary streams during three monitoring events in 2016. Data collection will consist of field-monitored water quality parameters and laboratory-analyzed water samples. The first year of LTMP monitoring will be conducted to assess TMDL effectiveness, following similar procedures as previous TMDL effectiveness monitoring in 1995, 1996, and 2007.

A hydrodynamic flow and water quality model, CE-QUAL-W2, will be initiated to support evaluation of the lake conditions and environmental and man-made factors that could affect water quality trends. The model will use meteorologic, hydrologic, and bathymetric data to develop the model. The water quality data will be incorporated into the model to also support model development.

The LTMP water quality monitoring results and model scenario outputs will be used by the LCWPU to evaluate the potential effectiveness of land use and water use management decisions or activities to promote and improve the water quality of Lake Chelan.

3.0 Background

The Lake Chelan Watershed Planning Unit (LCWPU) was created in 2007 to conduct comprehensive watershed planning under Washington State's Watershed Planning Act (Chapter 90.82 RCW). Phase I of the watershed planning process by the LCWPU was completed in January of 2008 (RH2 and Geomatrix 2008). Phase II activities have included identifying all Water Resource Inventory Area (WRIA) 47 waterbodies with potentially impaired water quality and identification of the parameters currently on the Clean Water Act 303(d) list (Table 1). In addition, information collected in all water quality studies conducted in WRIA 47 since 1972 were reviewed to identify monitored parameters and to assess whether existing data were sufficient to be able to detect trends in water quality.

In May 2008, the WRIA 47 Water Quality Subcommittee (Subcommittee) of the LCWPU met to discuss future objectives for assessing water quality in WRIA 47. Recognizing the importance and unique nature of Lake Chelan, the Subcommittee decided that watershed planning efforts within WRIA 47 should focus primarily on better identifying water quality trends within the lake. The Subcommittee noted that water quality issues within Lake Chelan, for the most part, have been a reactive approach to the identification of chemical concentrations exceeding a water quality limit or fish tissue threshold of concern. The Subcommittee recommended that a more proactive approach be developed that would identify water quality trends so that problems could be addressed before they reached levels of concern. In particular, the Subcommittee felt that the issues of potential nutrient enrichment (eutrophication) and changes in water clarity, should receive greater attention and monitoring.

The Subcommittee approved a recommendation to develop and implement a long-term monitoring plan (LTMP) for Lake Chelan (Amec 2009a). The Subcommittee recommended that monitoring activities should be conducted along with the calibration of appropriate water quality and food web models. Use and application of models as part of a monitoring program provides several benefits, including:

- A mechanism for understanding the sources of constituents of concern and the transfer among different environmental media.
- A way to predict how constituents of concern will change based on different loading scenarios, application of best management practices, or natural attenuation.
- A way to evaluate the relative importance of different monitored parameters to allow adjustments to be made to the monitoring design.

The LCWPU developed the Phase III Lake Chelan Watershed Plan in 2012 to formally establish water quantity, water quality, and habitat improvement objectives for the watershed. In 2013 and 2014, the LCWPU developed the Phase IV Detailed Implementation Plan to prioritize and develop a strategy to implement the objectives from the Watershed Plan. The highest priority water quality objective was to initiate the LTMP by conducting the first year of data collection to begin calibrating the water quality model, which will support the design of a food web model.

This Quality Assurance Project Plan (QAPP) supports the water clarity and eutrophication assessment portion of the LTMP.

Table 1. Summary of current 303(d) listings for Lake Chelan waterbodies.

Listing ID	Waterbody Names	Medium	Parameter	2012 Category[1]
10715	Chelan Lake	Water	pH[2]	2
11283	Chelan Lake	Water	Temperature[2]	2
14327	Chelan Lake	Tissue	Alpha-BHC	5
43078	Chelan Lake	Tissue	Chlordane	5
43057	Chelan Lake	Tissue	Dieldrin	5
43061	Chelan Lake	Tissue	Dioxin	5
14325	Chelan Lake	Tissue	4,4'-DDD	4A
8963, 14326	Chelan Lake	Tissue	4,4'-DDE	4A
14324, 36426	Chelan Lake	Tissue	4,4'-DDT	4A
8964, 14328	Chelan Lake	Tissue	PCB	4A
8965	Chelan Lake	Water	Total Phosphorus[2]	4A
2796	Chelan Lake	Habitat	Invasive Exotic Species	4C
45351	Copper Creek	Water	Lead	5
2797	Domke Lake	Habitat	Invasive Exotic Species	4C
52953	Dry Lake	Water	Total Phosphorus	4A
8430	First Creek	Water	Dissolved Oxygen	2
45353	Holden Creek	Water	Lead	5
51206	Joe Creek	Water	pH	2
47937	Joe Creek	Water	Dissolved Oxygen	5
8431	Mitchell Creek	Water	pH	2
45354	Railroad Creek	Water	Lead	2
45364, 45365, 45367, 45368	Railroad Creek	Water	Copper	5
45355, 45356, 45357, 45358	Railroad Creek	Water	Lead	5
45381, 45382, 45383, 45384	Railroad Creek	Water	Mercury	5
45388	Railroad Creek	Water	Silver	5
8966	Roses (Alkali) Lake	Tissue	4,4'-DDE	4A
22949	Roses (Alkali) Lake	Water	Total Phosphorus	4A
2798	Roses (Alkali) Lake	Habitat	Invasive Exotic Species	4C
47939, 47940, 47941	Stink Creek	Water	Dissolved Oxygen[2]	5
36424	Wapato Lake	Tissue	Dieldrin	2
2799	Wapato Lake	Habitat	Invasive Exotic Species	4C
47938	Wapato Lake Outflow	Water	Dissolved Oxygen[2]	5

[1]**Category 2 -** Waters of concern: waters where there is some evidence of a water quality problem, but not enough to require production of a water quality improvement (WQI) project (including total maximum daily load [TMDL]) at this time

[1]**Category 4a** - has a TMDL: water bodies that have an approved TMDL in place and are actively being implemented.

[1]**Category 4c** - impaired by a non-pollutant by causes that cannot be addressed through a TMDL, such as low water flow, stream channelization, and dams requiring complex solutions to for restoration.

[1]**Category 5 -** Polluted waters that require a TMDL or other WQI project: the traditional list of impaired water bodies traditionally known as the 303(d) list.

[2] Constituent monitored in this study.

3.1 Study Area and Surroundings

The proposed study area is confined to the lower end of the Lucerne Basin, the Wapato Basin, and the Narrows which joins the two basins within Lake Chelan (Figure 1). This is the region of Lake Chelan that has experienced the greatest development and where most of the water quality problems have been identified. This area is also more readily monitored, and previous studies (Patmont et al. 1987) concluded that water quality conditions within 5 miles upstream of the Narrows are essentially the most upgradient limit of water mixing between the Lucerne and Wapato Basins. The proposed study area consists of one lake monitoring station upstream of the Narrows, one monitoring station at the Narrows, and six lake monitoring stations in Wapato Basin (Figure 2).

Sampling stations will also be established at the mouths of the two largest perennial tributary streams to lower Lake Chelan. The tributaries are Stink Creek in lowermost Lucerne Basin and First Creek in upper Wapato Basin. Other tributaries to lower Lake Chelan consist of ephemeral streams, such as Purtteman Creek and Knapp Coulee, irrigation return drains, and constructed stormwater outfalls. The shoreline area of Chelan County and the City of Chelan are not large enough to qualify as Phase II communities and do not have an NPDES stormwater discharge permit, but both have adopted the Stormwater Management Manual for Eastern Washington. Monitoring of flow or water quality testing at these other tributaries may be considered in the future, depending on the quantity and quality of flow in these water bodies or features.

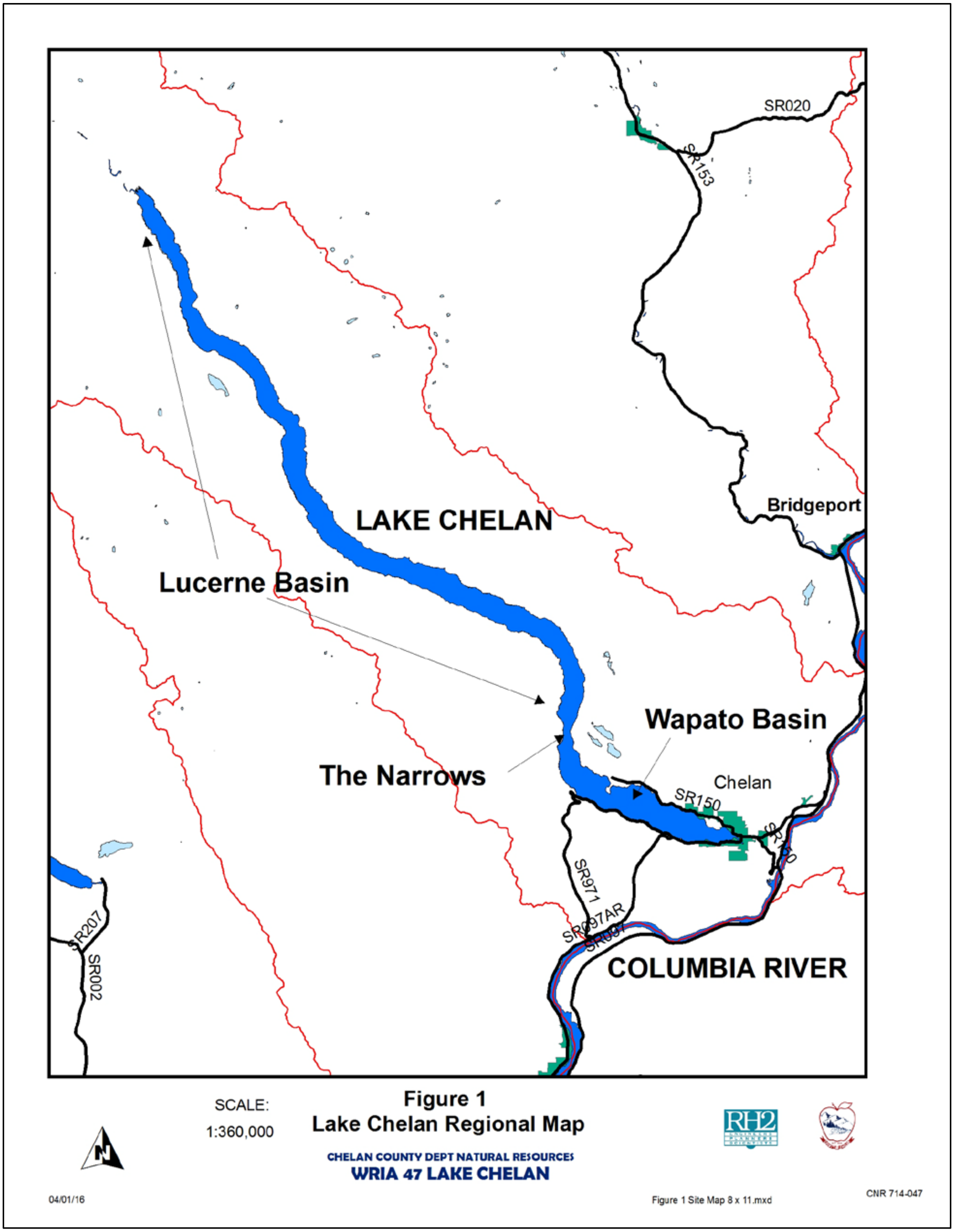

Figure 1. Lake Chelan regional map.

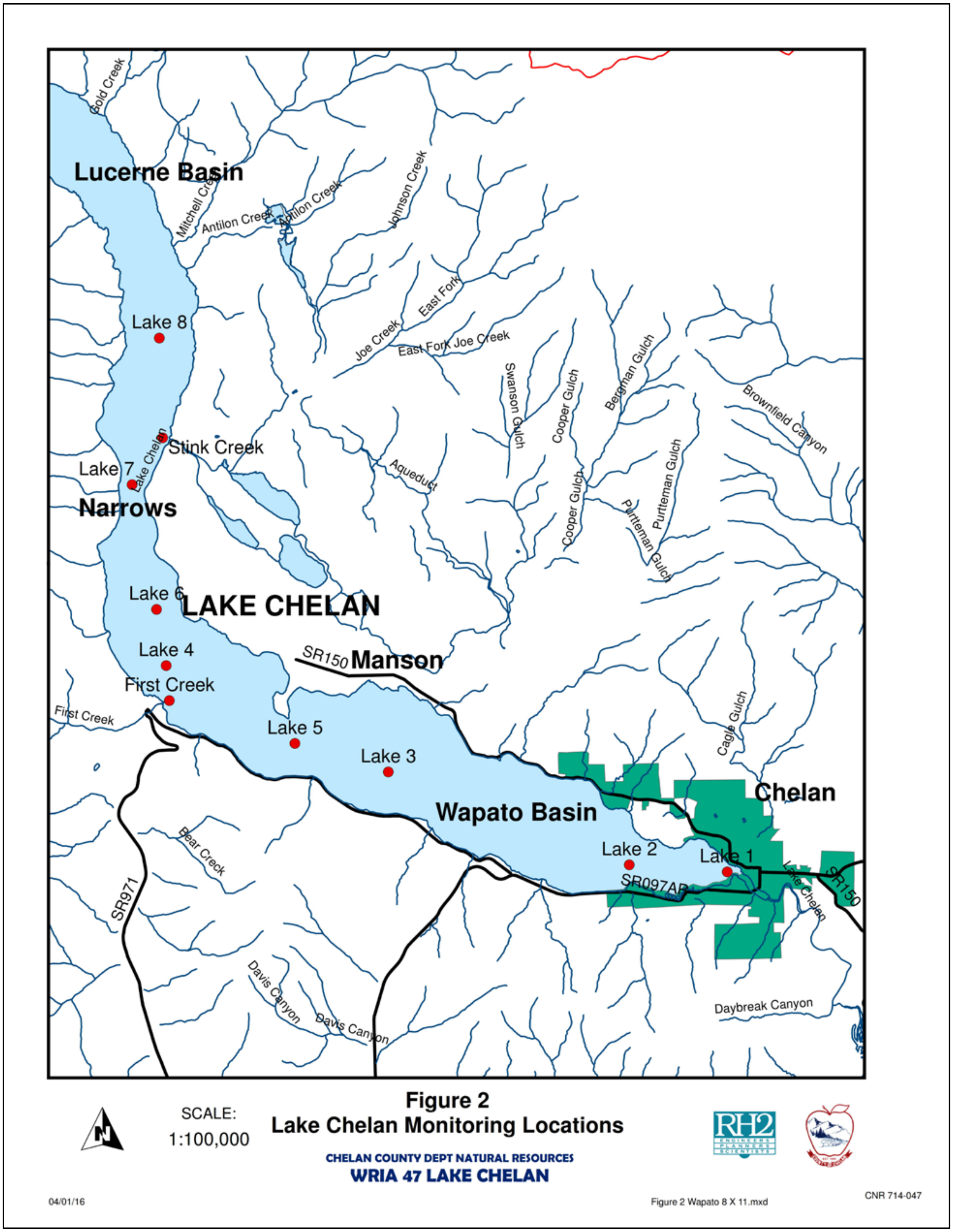

Figure 2. Lake Chelan monitoring locations.

3.1.1 Logistical Problems

Sampling of lake reaches will require use of a small powered boat with sufficient room for the field crew and sampling equipment. Sampling will be conducted directly from the boat at each lake monitoring station. Logistical problems could include adverse weather conditions making it difficult to launch the boat at the public dock/rental facility and to retrieve samples. Afternoon winds could make it difficult to maintain a stable position on the lake during sampling.

Sampling of tributary streams will require limited wading and shoreline access. Logistical problems could include adverse weather conditions or extreme surface water flows that could hamper field activities. A prolonged drought could diminish stream flow, which may prevent collection of a representative sample.

Logistical problems will be managed by maintaining a flexible schedule to access the monitoring locations during stable conditions.

3.1.2 History of the Study Area

Large scale permanent residential occupation and irrigation in the Lake Chelan watershed started before 1900. Hydropower generation began in 1926 with the construction of Chelan Dam. Hillsides above the lakeshore and lower elevation uplands are irrigated for orchard, vineyard, and pasture. Lake Chelan is managed for multiple uses including hydropower, recreation, irrigation, potable water supply, historic and cultural preservation, fisheries, wildlife, and habitat. Chelan PUD typically maintains the lake level within a range of 1,084 to 1,100 feet above sea level during most years. In extremely wet years, the lake level could be lowered to 1,083 feet above sea level, or lower (the regulated minimum is 1,079 feet above sea level), as more room is needed to capture increased runoff. During June to September, the lake level is maintained at 1,100 feet, and then is drawn down from October to April to accommodate spring runoff.

Shoreline access to the lake is available through public beaches and docks. Detailed summary of water and land use conditions are summarized in the Lake Chelan Watershed Plan (RH2 2012).

Most of Lake Chelan watershed is under federal management, primarily by the US Forest Service and National Park Service; approximately 87 percent of the Lake Chelan watershed is in federal, state, and local-government ownership. The remaining 13 percent of the watershed is in private ownership.

The lower basin of Lake Chelan (Wapato Basin) experiences the most land and water use, and supports the majority of residential, recreational, irrigation, and commercial activities in Lake Chelan. Consequently, most of the man-made impacts to water quality occur in the Wapato Basin.

3.1.3 Parameters of Interest

Phase 2 Water Quality Assessment activities from the Lake Chelan Watershed Plan summarized water quality data from previous assessments, including identifying all WRIA 47 water bodies with potentially impaired water quality, and identifying the parameters currently on the Clean Water Act 303(d) list (Table 1). The information collected in all of the available water quality studies conducted in WRIA 47 since 1972 were reviewed to identify monitored parameters and to assess whether existing data sufficiently indicated detectable trends in water quality. The findings of the assessment and the compilation of information from the available water quality studies were summarized in two separate technical memos prepared in 2009: Assessment of Water Quality Issues within WRIA 47 (AMEC 2009a); and Review and Summary of Existing Water Quality Studies within WRIA 47 (AMEC 2009b).

Water quality assessment of phosphorous in Lake Chelan was conducted between 1986 and 1989 with oversight from the Washington Department of Ecology (Ecology), and a Total Maximum Daily Load (TMDL) for phosphorous in Lake Chelan was approved by Ecology and EPA in 1993 (Ecology 1993).

The Lake Chelan DDT/PCB TMDL to address DDT and PCB contamination contained in the tissues of fish in the Lake Chelan Watershed was initiated in 2003 and completed in 2006 (Ecology 2006). The TMDL identified potential actions designed to prevent DDT and PCB inputs to Lake Chelan and Roses Lake.

Existing water quality concerns within WRIA 47 include elevated fish tissue concentrations of organochlorine pesticides (alpha-BHC, chlordane, DDT, DDE, DDD, and dieldrin), polychlorinated biphenyls (PCBs) and polychlorinated dibenzodioxins/furans. In addition, some waterbodies have water quality concerns as a result of elevated total phosphorus concentrations, pH, and metals, decreased levels of dissolved oxygen, and the presence of invasive exotic plants.

The parameters that will be the focus of this study consist of constituents that indicate eutrophication potential and include total phosphorous, orthophosphate, nitrate-nitrite, ammonia, total nitrogen, total organic carbon, alkalinity, chlorophyll α, dissolved oxygen, specific conductance, pH, temperature, and water clarity.

3.1.4 Results of Previous Studies

AMEC reviewed publicly available reports, memoranda, and databases presenting water quality data or discussing water quality conditions within WRIA 47 over the last 40 years (AMEC 2009b). A summary table and figure showing the results of the historical data review are presented in Appendix A.

The review of the existing information shows that while a large list of conventional water quality parameters and toxics have been measured in WRIA 47 waterbodies over the last 35 years, there are relatively few parameters that have been consistently measured by the studies. The lack of consistent methods and monitoring stations, and varying frequency of sampling events, makes it difficult to assess temporal or spatial trends in water quality within WRIA 47.
Most of the studies within WRIA 47 (see Appendix A) were conducted to meet study-specific objectives that did not include evaluation of long-term trends in water quality,

except for TMDL effectiveness monitoring studies that compared total phosphorous results and trends.

The water quality assessment of Lake Chelan in 1987 (Patmont et al. 1989) measured nutrients, metals, bacteria, and water quality parameters in the Wapato and Lucerne Basins. The study identified and evaluated the complex hydrodynamics of the lake through water level, temperature, specific conductivity and flow monitoring, and determined that the lake is stratified in the spring and summer months, but with no distinct thermocline, but generally at a depth of 100 to 130 feet.

The elongated shape of the lake and persistent, strong winds develop a seiche, or oscillation of the lake surface which affects the shape and depth of the thermocline in the Lucerne Basin and creates significant currents, mostly at the Narrows between the Lucerne and Wapato Basins. The currents result in extensive mixing of water to a distance of 3 miles on either side of the Narrows. The mixing diminishes in the summer months, so that the basins are more isolated, and that currents generally flow in the Wapato Basin towards the lake outlet with little exchange upstream of the Narrows.

Water samples were collected at specific depths to evaluate the vertical characteristics of water quality conditions and identified phosphorous as the limiting nutrient for aquatic plant growth in Lake Chelan. Considering the results of the study, Ecology completed an assessment to establish a TMDL for total phosphorus (TP) in 1991 that established a management goal of maintaining the ultra-oligotrophic condition of the Lake Chelan (Pelletier 1991). This goal was to be met by ensuring that TP loads for various land uses to the lake do not result in a mean epilimnetic (i.e., the upper portion of the water column) TP concentration exceeding 4.5 µg/L (Ecology 1993).

In 1995 and 1996, the mean epilimnetic TP concentration was measured in the Wapato Basin of Lake Chelan (Congdon, 1996; Sargeant, 1997). The mean epilimnion TP concentration was based on collected of samples at specific depths of 0.3, 10, and 20 meters (approximately 2, 32, and 65 feet). In 1995, the mean epilimnetic TP concentration was 2.2 µg/L; in 1996, the mean TP concentration was 2.6 µg/L. Both of these values are statistically less than the TP concentration measured in 1987 (3.5 µg/L). The 1996 TP concentration is also statistically greater than the 1995 TP concentration. All three studies (1987, 1995, and 1996) used different analytical laboratories, different analytical methods, and different sampling personnel. Since we are unable to assess how these study differences may affect the comparability of the data sets, attributing the changes to a “trend” has a large amount of uncertainty. However, the three studies do provide confirmation that TP concentrations in the Wapato Basin are below the TP management goal of 4.5 µg/L.

In 2007, Ecology collected samples to calculate the mean epilimnetic TP concentration in the Wapato Basin (Sargeant 2007, Newell and Coffin 2011). Sampling stations and collection methods were identical to Ecology’s 1996 study. The TMDL criterion for the Wapato Basin was met (not exceeded) in 2007, based on TP concentrations measured in these samples. For 2007 this mean was less than 2.6 µg/L, with 95% confidence, which is lower than the TMDL criterion of 4.5 µg/L. Weak decreasing trends in total phosphorus concentrations from 1987 to 2007 were found to be more than 95% significant at each station and depth monitored. Confirmation of good water quality in Lake Chelan was provided by low chlorophyll-a concentrations and high water transparency. Phosphorus remains the limiting nutrient in the lake based on nitrogen-to-phosphorus ratios and the trophic state index (TSI).

Chelan PUD has conducted stream temperature monitoring in the Chelan River below the Chelan Dam and conducted a water quality assessment in 1999 (Anchor Environmental 2000) as part of its FERC relicensing requirements. The assessment was conducted similarly to TMDL effectiveness monitoring in 1995, 1996, and 2007, and concluded that water quality conditions were generally unchanged or stable since 1987. Total phosphorous concentrations were below 4.5 µg/L.

The proposed approach for the LTMP is based on the findings of the previous studies and will evaluate the concentrations of selected nutrients and water quality parameters that will indicate the general water quality and potential temporal trends and/or stability of water quality conditions in Lake Chelan. The first year of the LTMP will include TMDL effectiveness monitoring to evaluate whether the total phosphorous criterion in Lake Chelan continues to been met.

3.1.5 Regulatory Criteria or Standards

The Washington State Water Quality Standards (Chapter 173-201A of the Washington Administrative Code [WAC]) include designated beneficial uses, water body classifications, and numeric and narrative water quality criteria for surface waters of the state.

Beneficial use designations in WAC 173-201A-600 for both Lake Chelan and its tributaries include water supply (domestic, industrial, agricultural, and stock), recreation (primary contact), aquatic life uses, wildlife habitat, fish and shellfish harvesting, commerce and navigation, boating, and aesthetics.

Numeric criteria for specific water quality parameters are intended to protect designated uses. Lake Chelan and its tributaries, except the Stehekin River, do not have specific listings in Chapter 173-201A-602, therefore the default criteria for all waters of the state listed in WAC 173-201A-200 Fresh Water Designated Uses and Criteria apply to Lake Chelan. All lake and stream sampling stations in this study will be monitored for temperature, dissolved oxygen, and pH, which have specific water quality criteria.

Elevated concentrations of phosphorus in surface waters can result in increased algal productivity, leading to changes in the abundance and diversity of aquatic biota, pH changes, and reduced water clarity. Numeric criteria for phosphorus concentrations in surface water in Washington are established in WAC 173-201A-230. Ecology (1993) established a management goal for total phosphorus in Lake Chelan to maintain the ultra-oligotrophic (very low productivity) nature of the lake. This goal is to ensure that the mean epilimnetic (upper water column) concentration of total phosphorus does not exceed 4.5 µg/L (LCWQC 1991). The loading capacity was established as 51 kg of phosphorous per day to Lake Chelan, under the assumption of a background loading of 57 kg phosphorous per day.

The default numeric criteria for pH in waters of the state is: *pH shall be within the range of 6.5 to 8.5 with a human-caused variation within the above range of less than 0.5 units*. The numeric criteria for dissolved oxygen and temperature are based on continuous monitoring to establish 7-day average of daily maximum temperatures and lowest 1-day minimum values of dissolved oxygen.

All waters with the State of Washington are protected by the anti-degradation policy described in WAC 173-201A-300. Anti-degradation protection is divided into three tiers. Tier I applies to all waters and includes the provisions shown below (WAC 173-201A-310):

Tier I – Protection and maintenance of existing and designated uses.

1) *Existing and designated uses must be maintained and protected. No degradation may be allowed that would interfere with, or become injurious to, existing or designated uses, except as provided by in this chapter.*
2) *For waters that do not meet assigned criteria, or protect existing or designated uses, the department will take appropriate and definitive steps to bring the water quality back into compliance with the water quality standards.*
3) *Whenever the natural conditions of a water body are of a lower quality than the assigned criteria, the natural conditions constitute the water quality criteria. Where water quality criteria are not met because of natural conditions, human action are not allowed to further lower the water quality, except where explicitly allowed in this chapter.*

4.0 Project Description

4.1 Project Goals

Lake Chelan has a long history of multiple land and water uses, and protecting the exceptional lake clarity and high water quality are the primary goals for watershed stakeholders. Historic and current land use practices may have degraded lake water quality. Future land use practices have the potential to further degrade lake water quality. The LCWPU seeks to develop and implement a long term monitoring plan to understand water quality conditions and that will provide consistent monitoring data to assess water quality trends. The monitoring data and trend analysis would be used to evaluate performance of water and land use practices and to support decisions for land and water management.

4.2 Project Objectives

Project objectives for the study consist of conducting TMDL effectiveness monitoring for total phosphorous, and obtaining high quality baseline monitoring data to evaluate the effectiveness and suitability of monitoring methods, locations, and frequency to promote the development and improvement of a long term monitoring program. Water quality parameters will consist of total phosphorous, orthophosphate, nitrate-nitrite, ammonia, total persulfate nitrogen, total organic carbon, alkalinity, chlorophyll α, dissolved oxygen, pH, specific conductance, temperature, and water clarity.

The initial year of monitoring data will support the development of the CE-QUAL-W2 hydrodynamic and water quality model for use in evaluating the hydrodynamic conditions of Lake Chelan that could affect the distribution and fate of nutrients in the lake and potential effects of lake management decisions. Current and historic meteorologic, hydrologic, and bathymetric data will be collected to develop the boundaries and conditions of the model.

4.3 Information Needed and Sources

Water quality parameters will be collected at defined monitoring stations over a sufficient period of time to characterize summer conditions at multiple locations in lower Lake Chelan. The first year of monitoring data will be sufficient to evaluate the effectiveness of TMDL for TP, initiate the development of the CE-QUAL-W2 model. Water quality data will be collected within eight lake stations at multiple depths, and from tributary streams. Water quality samples will be monitored in the field for water quality parameters and analyzed for constituent concentrations.

CE-QUAL-W2 is a two-dimensional, longitudinal/vertical, hydrodynamic and water quality model. Because the model assumes lateral homogeneity, it is best suited for relatively long and narrow waterbodies exhibiting longitudinal and vertical water quality gradients. The model has been applied to rivers, lakes, reservoirs, estuaries, and combinations thereof including entire river basins with multiple reservoirs and river segments. Data needs for developing the CE-QUAL-W2 model require information for a water balance (inflows, surface water elevation, and outflows), inflow constituent concentrations, and longitudinal and vertical profiles specifying conditions for each cell (lake reach and layer depths). Ecology developed a bathymetric map of the lake bottom (Kendra and Singleton 1987). Public and privately operated meteorologic stations established in Chelan, Manson, Stehekin, and the south lake shoreline measure and store temperature, precipitation, wind velocity, and solar radiation data. Chelan PUD and USGS monitor and store river flow, temperature, and stage for Stehekin and Chelan Rivers and Railroad Creek, and Chelan PUD continuously monitors lake level. These data are used to establish boundary and initial conditions for the model, and to assess the potential range of meteorologic and hydrologic conditions measured at the lake which will support model development, sensitivity analysis, and ultimately, calibration.

4.4 Target Population

The target population is the surface water within the lowermost Lucerne Basin of Lake Chelan and all of the Wapato Basin of Lake Chelan, and two primary tributary streams of lower Lake Chelan.

4.5 Study Boundaries

The study area consists of the lower end of the Lucerne Basin and all of the Wapato Basin within Lake Chelan (Figure 1 and Figure 2).

4.6 Tasks Required

The tasks required for this project include the following:

- Insure that a health and safety plan is in place for field monitoring activities.
- Mobilization of necessary equipment and qualified field personnel to Lake Chelan.
- Field collection of water quality data and water samples.
- Sample processing and chain-of-custody procedures.
- Sample laboratory analysis and reporting.
- Analysis and reporting of field data
- CE-QUAL-W2 model development.

4.7 Practical Constraints

Collecting representative water quality data within a large deep lake that experiences great range of weather conditions may be limited by the number of samples, the sample location and/or time of collection to sufficiently represent lake conditions. Samples will be collected in the upper layer (epilimnion) of the lake during summer months where nutrient conditions have the greatest effect on water clarity. Monitoring will focus on the lowermost Lucerne Basin and the Wapato Basin where the public interest in water quality is greatest and at the locations of previous TMDL effectiveness monitoring to maximize comparability with previous data. Water samples from potentially ephemeral or “flashy” streams will be relied upon to indicate contribution of tributaries to lake water quality; the streams will be monitored only after several days have passed since the most recent storm event.

Hydrodynamic modeling will rely upon meteorologic, river, and topographic data developed by others, primarily by public agencies and private weather station operators. Meteorologic data provide broad coverage of the Lake Chelan area and generally have recorded 10 years of continuous data. River data extend back more than 40 years and provide a sufficient length of record to indicate average and extreme flows for use in model development and calibration.

4.8 Systematic Planning Process Used

The approach for the LTMP was developed through the Lake Chelan Watershed Plan (RH2 2012) and Detailed Implementation Plan (RH2 2015). The LCWPU has been the consistent management organization to lead watershed planning efforts and establish the goals, objectives, and outcomes for the LTMP. The LCWPU has relied upon water quality professionals and consultants to support the watershed planning process by summarizing the water quality concerns and conditions, summarize the opportunities and methods to develop a LTMP, and to summarize the data needs, data quality objectives, and monitoring and analysis methods to initiate the LTMP. Since 2008, the watershed planning process has involved LCWPU and watershed stakeholders with periodic opportunities to develop and refine the goals, methods, and objectives of the LTMP through meetings, planning documents, and review by state and federal agencies.

In addition, this QAPP, and the Ecology planning process it’s based on, represents the systematic planning process to document the objectives, methods, analysis, and quality of the data collection and interpretation to meet the project goals.

5.0 Organization and Schedule

The LTMP will be managed by Chelan County Natural Resources Department (CCNR), which is the lead organization of LCWPU. CCNR will conduct field monitoring activities and has contracted RH2 to support field activities and data evaluation and water quality modeling. CCNR will subcontract University of Washington Marine Chemistry Laboratory (UWMCL) of Seattle, Washington and Cascade Analytical, Inc. of Wenatchee (CAI), Washington. CCNR and RH2 will periodically communicate project status and findings to the LCWPU. Both labs are accredited by Ecology.

5.1 Key Individuals and Responsibilities

CCNR is the implementing agency for this QAPP. Key individuals with Ecology and partnering organizations are included in Table 2.

Table 2. Key individuals and their responsibilities.

Name	Organization	Responsibilities
Mike Kaputa Paul Heffernan	CCNR	Managing the project budget, tasks, and public communication. Will direct the project, coordinate preparation and submission of data and documents to Ecology, and coordinate public presentation of study findings. Conducting field monitoring activities and data management. Responsible for preparing and communicating data and reporting to Ecology. Ensuring adherence to QAPP.
Steve Nelson, LHG	RH2 Engineering, Inc.	Supporting field monitoring activities, analysis, and water quality modeling. Supporting adherence to QAPP.
Katherine Krogslund Laura Mrachek	UW Marine Chemistry Laboratory Cascade Analytical	Responsible for providing laboratory services that will meet data quality objectives.
Heather Simmons	Ecology, Water Quality, Central Region	Reviewing and managing project budget, reviewing schedule of activities, initial QAPP reviewer.
Daniel Dugger	Ecology, EAP, Central Region	Technical review of QAPP.

5.2 Special Training and Certification

Lead staff involved have the necessary training and relevant experience for water quality monitoring. Any staff helping in the field that lack experience will always be paired with someone who does have the training and experience needed. The experienced person will lead the field data collection and oversee/mentor the less experienced staff.

A licensed hydrogeologist will review any appropriate technical analyses and modeling elements of the study before the project report and results are finalized.

Modeling efforts will be led by RH2 Engineering staff trained by developers of the CE-QUAL-W2 modeling software at Portland State University, who will also provide periodic peer review of the modeling design and results.

5.3 Organizational Chart

CCNR (with RH2) will periodically present the findings to the LCWPU and will provide progress summaries to Ecology. The organizational flow chart is provided in Figure 3.

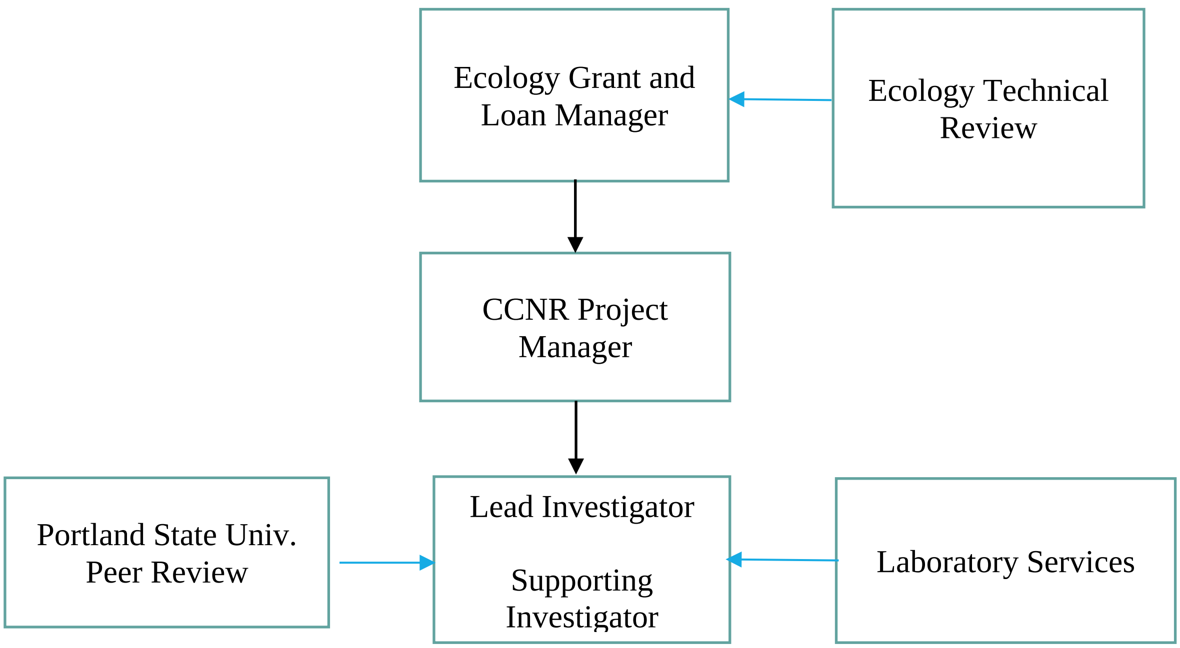

Figure 3. Organizational flow chart.

5.4 Project Schedule

A tentative schedule for the project outlining activity timeframes is shown in Table 3.

Table 3. Project schedule documenting anticipated activity timelines.

Monitoring Task	Date
Preparation and approval of the QAPP	June 2016
Periodic water quality monitoring data collection	1 sample event each in month of June, August, and October 2016
Delivery of samples to the laboratory	within 1 day of sample collection
Reporting measurement results	within 3 weeks of sample delivery
Verification and validation of data	within 2 weeks of laboratory reporting
Data entry to Ecology's EIM	within 2 weeks of data verification and validation
Progress, draft, and final reports	
Field activities summary memo from RH2 to CCNR	within 1 week of field activities
Laboratory verification summary memo from RH2 to CCNR	within 1 week of laboratory reporting
Summary draft report of field monitoring activities and laboratory results	December 31, 2016
Final report of first year of LTMP	April 30, 2017
Modeling Task	**Date**
Compilation of meteorologic, topographic, and hydrologic data	August 31, 2016
Initial development of CE-QUAL-W2 model: boundary conditions and initial conditions	October 31, 2016
Steady state hydrodynamic model development	December 31, 2017
Incorporation of water quality parameters	February 28, 2017
Technical memo summarizing modeling efforts	April 30, 2017

5.5 Limitations on Schedule

Significant storm events could affect scheduling of the field activities on a weekly time scale, but should not affect the overall schedule, as there will be several weeks between each field event. Laboratory services will be given sufficient lead time to prepare for receiving samples and conducting analysis. All lake and streams monitoring locations will be accessed through public lands and no permissions will be required.

5.6 Budget and Funding

The budget and funding for the first year of monitoring is summarized in Table 4.

Table 4. Budget and funding summary.

Project Task									**Task Total**
Project Administration/Management									$27,000
Field Activities									$22,000
Equipment and Rental									$19,000
Laboratory Costs - discrete samples, field replicates, field blanks									
Analyte	Total P	OrthoP	NH4	NO3-NO2	TPN	Chlor a	Alk	TOC	
# Samples	30	30	30	30	30	30	30	30	
Cost per sample	$19	$17	$17	$19	$20	$14	$26	$43	
Total Cost	$561	$504	$504	$561	$600	$414	$780	$1,298	$20,000
Data QA and Management									$7,000
Initiation of LTMP and First Year of Monitoring									$68,000
Water Quality Monitoring & Modeling Report									$66,000
								Total	**$161,000**

6.0 Quality Objectives

The quality objective for this project is to obtain sufficiently high quality data in the first year of field monitoring to determine whether TP concentrations in meet the TMDL criteria, to establish baseline conditions for continued long-term water quality monitoring, and to provide data for the initial development of a water quality model, given the variability in meteorological and hydrological conditions that could result in a range of sampling conditions. These objectives will be achieved through careful attention to consistent sampling methods during typical seasonal conditions, labeling, sample processing, storage, measurement, and quality control procedures, which are described in this plan.

6.1 Decision Quality Objectives

Decision-making is not the primary focus or intended outcome of this data collection. The project data will be used to collect high quality data for comparison to TMDL, establish a baseline for future monitoring, and initiate development of the CE-QUAL-W2 model. The model output will be periodically re-calibrated with new monitoring data and the model will be used to evaluate potential effects of land or water management decisions, or changes in environmental conditions, such as wildfire or climate change) on lake water quality. The findings of the first year of monitoring will be evaluated by the LCWPU and other watershed stakeholders to identify best approaches to improve monitoring procedures, locations, parameters, and frequency, and how best to analyze water quality trends with the data. As the model is improved through future years of monitoring data, the LCWPU will be able to communicate findings of the long term monitoring plan to local, state, and federal agencies and to the public to provide water quality information to support watershed planning and policy and evaluate the effectiveness of TMDL implementation.

6.2 Measurement Quality Objectives

Measurement quality objectives (MQOs) include numeric objectives for quality control (QC). Laboratory QC checks and field blank and field replicate samples submitted to the laboratory will provide sufficient means for attaining MQOs for laboratory analyses. MQOs for field-measured data will be attained through consistent measurement methods, proper calibration, and repeat measurements to establish average measurement values.

6.2.1 Targets for Precision, Bias, and Sensitivity

6.2.1.1 Precision

Precision measures the reproducibility of measurements. Precision is defined as a measure of the closeness of agreement between independent test results obtained under stipulated conditions. Analytical precision is the measurement of the variability associated with laboratory and field replicate analyses. Laboratory replicate samples will be split in the laboratory from a field-collected sample, and replicate lake and tributary surface water samples will be collected to provide measurements of analytical precision. Analytical precision will be measured by the relative standard deviation (RSD), which is calculated as the standard deviation of the replicate measurements divided by their mean.

Total precision is the measurement of the variability associated with the entire sampling and analysis process. Total precision measures variability introduced by both the laboratory and field operations and is determined by analysis of replicate field samples.

Table 5 summarizes the MQOs for laboratory and field measurements and shows the quality control and reporting limits required to meet project objectives. Field parameter replicate samples will be collected at the rate of 3 per event.

Table 5. Precision and reporting limits for field and laboratory measurements.

Analysis	Method	Duplicate Samples RSD	Reporting Limits and Resolution[1]
Field Measurements			
pH[2]	Sonde	+/- 0.05 standard units	1 to 14 standard units
Water Temperature[3]	Sonde	+/- 0.1 °C	0.01 °C
Specific Conductaqnce[4]	Sonde	+/- 5% RSD	0.1 mS/cm
Dissolved Oxygen[5]	Sonde	+/- 5% RSD	0.1 mg/L
Secchi Depth[6]	Secchi Depth	+/- 1 foot	0.1 foot
Laboratory Analysis			
Alkalinity	EPA 310.1	10% RSD	10 mg/L
Total Organic Carbon	SM 5310B1	10% RSD	0.1 mg/L
Total Phosphorous	SM 4500-P	10% RSD	1.1 µg/L
Orthophosphate	EPA 365.1	10% RSD	1.1 µg/L
Ammonia	EPA 349	10% RSD	1.7 µg/L
Nitrate+Nitrite	EPA 353.4	10% RSD	2 µg/L
Total Persulfate Nitrogen	SM 4500-NO3-B	10% RSD	0.025 mg/L
Chlorophyll a	EPA 445	20% RSD	0.05 µg/L

°C = degrees Centigrade mS/cm = milliSiemens/centimeter
Mg/L = milligrans/liter µg/L = micrograms/liter
[1] Typical performance resolution for multiparameter sonde.
[2] Replicate sample test with hach colorimetric determination, Method 10076, within 24 hours of sample collection.
[3] Replicate measurement wither thermometer.
[4] Replicate sample tested at CAI, by method SW 9050A.
[5] Replicate sample tested with Winkler Method within 24 hours of sample collection.
[6] Replicate measurement by second field staff.

The number of field blanks and replicates and the number of laboratory check standards, blanks, duplicates, and matrix spices per field event are summarized in Table 6. Based on 8 lake monitoring locations with 3 sample depths at Stations 2 through 7 and 1 sample depth at Station 1, and 2 stream locations with 1 sample depth, 24 water samples will be collected per event for a total of 72 samples. Three field blanks and three field replicates for each of three events represents a total of 18 quality check samples or 12.5 percent of the total sample number for field blanks and field replicates, respectively.

Table 6. Measurement quality objectives.

Parameter	**Field**		**Laboratory**			
	Blanks	Replicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
Laboratory						
Alkalinity	3/event	3/event	1/batch	1/batch	1/batch	1/batch
Total Organic Carbon	3/event	3/event	1/batch	1/batch	1/batch	1/batch
Total phosphorus	3/event	3/event	1/batch	1/batch	1/batch	1/batch
Orthophosphate	3/event	3/event	1/batch	1/batch	1/batch	1/batch
Nitrate-Nitrite	3/event	3/event	1/batch	1/batch	1/batch	1/batch
Ammonia	3/event	3/event	1/batch	1/batch	1/batch	1/batch
Total persulfate Nitrogen	3/event	3/event	1/batch	1/batch	1/batch	1/batch
Chlorophyll *a*	3/event	3/event	1/batch	1/batch	1/batch	1/batch
Field						
pH	N/A	3/event	N/A	N/A	N/A	N/A
Water temperature	N/A	3/event	N/A	N/A	N/A	N/A
Specific conductivity	N/A	3/event	N/A	N/A	N/A	N/A
Specific conductivity	N/A	3/event	N/A	N/A	N/A	N/A
Secchi depth	N/A	3/event	N/A	N/A	N/A	N/A

N/A – not applicable

Table 7 provides a summary of field and laboratory data qualifiers.

Table 7. Summary of field and laboratory data qualifiers.

Qualifier	Description
EST	Measurement field value reported is estimated.
J	The analyte was positively identified; the quantitation is estimated.
U	The analyte was analyzed for, but not detected. The associated numerical value is at or below the reporting limit.
REJ	The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
N	The analysis indicates the presence of an analyte for which there is presumptive evidence to make a tentative identification.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

6.2.1.2 Bias

Bias is defined as a systematic error in measurement wherein the measured value displays a consistent positive or negative error as compared to a true value. Bias measurement is calculated as the percent difference from the analytical measurement and the known true value. Careful adherence to established procedures for the collection, preservation, transportation, storage, and analysis of samples should reduce or eliminate most sources of bias for this study.

Laboratory analytical bias will be evaluated using method blanks and laboratory check standards. Field method bias will be evaluated using blind-labeled field blanks. Field-blank samples (Table 6) will be submitted to the laboratory with the station location label, “LC-9” to determine any potential bias from contamination in the field and chain-of-custody procedures.

6.2.1.3 Sensitivity

The MQOs for sensitivity are expressed as the laboratory reporting limits in Table 5. The laboratory reporting limits for laboratory analytes are four to ten times lower than concentrations measured for the respective analytes in previous investigations, and will therefore provide sufficient sensitivity for accurate detection of target analytes to meet the data objectives for the project.

6.2.2 Targets for Comparability, Representativeness, and Completeness

6.2.2.1 Comparability

Comparability is the confidence with which one data set can be compared to another data set. The monitoring results will be compared to previous Total Phosphorous TMDL effectiveness monitoring results, which are summarized in Newell and Coffin (2011). Previous effectiveness monitoring used different laboratory methods. Changes in laboratory techniques and method biases will be taken into consideration when comparing data from different years and studies.

This project is designed to collect initial data for the development of the CE-QUAL-W2 model and then to use the calibrated model to evaluate potential effects of land and water management decisions and environmental changes that could affect lake eutrophication and water clarity based on data collected during subsequent monitoring events. The comparability of the current project data with subsequent data will be ensured by establishing defined sampling locations; employing consistent sample collection protocols; and using similar analytical methods, reporting limits, and Quality Assurance / Quality Control (QA/QC) procedures.

6.2.2.2 Representativeness

Previous water quality monitoring locations and methods for TMDL effectiveness monitoring were selected to represent the portion of Lake Chelan with the greatest potential for anthropogenic introduction of phosphorous into the lake, that is, in the lowermost Lucerne Basin and the Wapato Basin. The locations and timing were selected to provide a sufficient geographic and temporal range of monitoring data to reflect the most biologically active area and period in the lake. The sampling locations, field methods, equipment, and collection timing are intended to be comparable to previous TMDL effectiveness monitoring. The QAPP has been developed to ensure that data are representative of conditions in the proposed study area. Water samples will be collected in accordance with Ecology's standard operating procedure (SOP) for collecting surface water samples (Joy 2006).

6.2.2.3 Completeness

Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of intended individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not qualified with an "REJ" flag (Table 7) for an explanation of quality control flagging criteria).

6.3 Model Quality Objectives

Data used for the hydrodynamic and water quality model will be obtained by publically available meteorologic and hydrologic monitoring stations. These data will be checked for quality assurance by confirming station monitoring calibration and accuracy before incorporation into the modeling effort.

Model development will proceed under guidance of peer support by Portland State staff to confirm model assumptions and data quality, and the appropriateness of data to represent the generally complex hydrodynamics of Lake Chelan. The model will be developed incrementally from simple to complex representations, from steady state annual average representations to more complex seasonal and temporal simulations. The model output will be compared to the conditions observed during previous monitoring efforts, in particular, the results of the 1987 water quality assessment that developed the most detailed description of lake hydrodynamics. The goodness of fit will rely upon the comparison of simulated water temperature, specific conductivity, flow, and level to actual data measured in this and previous studies. Challenges with model development and characterization will consist of the complexity of lake hydrodynamics, and whether there are sufficient data to characterize this complexity in a 2-D model.

7.0 Sampling Process Design

7.1 Study Design

This section describes the proposed study design, including information about the study locations and the study parameters.

7.1.1 Water Model Approach and Data Source

CE-QUAL-W2 is a two dimensional (longitudinal/vertical) water quality and hydrodynamic model supported by the U.S. Army Corps of Engineers Waterway Experiments Station. The model has been under continuous development and enhancement since 1975. The latest upgrade occurred in August 2015 with the release of Version 3.72 developed by researchers at Portland State University (Scott Wells, PhD and Chris Berger, PhD; http://www.ce.pdx.edu/w2/). The model has been widely applied to simulate water quality in lakes and reservoirs. CE-QUAL-W2 allows any combination of constituents to be included or excluded from a simulation. Version 3.72 includes the following water quality variables in addition to temperature:

- Any number of generic constituents defined along with a decay rate and/or settling velocity and/or Arrhenius temperature rate multiplier to define a conservative tracer, hydraulic residence time, coliform bacteria, or contaminants.
- Any number of phytoplankton, periphyton, macrophyte, and zooplankton groups.
- Nutrients (ammonium, nitrate-nitrite, bioavailable phosphorus).
- Inorganic and organic carbon (labile and refractory and dissolved and particulate species).
- Alkalinity, dissolved oxygen, and pH.
- Organic sediment contributions to nutrients and dissolved oxygen.

CE-QUAL-W2 models basic eutrophication processes such as relationships between temperature, nutrients, algae, dissolved oxygen, organic matter, and sediment. Application of this model to Lake Chelan would provide a comprehensive framework for understanding relationships among water quality parameters and provide a tool to predict how water quality would be impacted by future changes in nutrient loads or implementation of best management practices (BMPs).

Application of the model requires that the lake be divided into segments which are arranged in a series along the longitudinal axis of the lake. Three input files (bathymetry file, control file, and meteorological file) must be created for each model application. Data needs for applying the model require information for a water balance (inflows, surface water elevation, and outflows), inflow constituent concentrations, and longitudinal and vertical profiles specifying initial conditions for each cell.

The CE-QUAL-W2 model relies upon meteorologic, topographic (bathymetric), and hydrologic data to develop the hydrodynamic conditions of the water body, and water quality parameter data to develop the water quality conditions of the water body. The model may be structured to calculate an average, steady state condition or a time-series representation of the change in water body conditions over time. The hydrodynamics of Lake Chelan are complex, as indicated in Patmont et al (1989). The model will be developed incrementally using available historic data and data recorded during the study period. Modeling will first consist of developing an average steady state model using boundary conditions and initial conditions from existing data.

Meteorologic stations positioned around Lake Chelan have recorded and currently record temperature, precipitation, wind velocity, and solar radiation data and hydrologic stations at the inlet (Stehekin River) and outlet (Chelan Dam, Chelan River) have recorded and currently record water flow, and stage. Locations of meteorologic and hydrologic stations and data range and history are summarized in Appendix C. The meteorologic and hydrologic data have collected by public agencies since at least 2007 or earlier. These data will provide a sufficient range of values for initial model development and support the evaluation of the sensitivity of model results to data input and the sufficiency and suitability of the available data for more detailed modeling efforts over time.

7.1.2 Sampling Locations and Frequencies

Eight sampling stations will be established within Lake Chelan and two tributary stream stations will be established at the mouths of two tributaries to Lake Chelan (Stink Creek and First Creek). The locations are shown on Figure 2, and the latitude and longitudinal coordinates for the monitoring stations are provided in Table 8. All monitoring station coordinates will be recorded using a hand-held global positioning system (GPS) and the information will be recorded on the field data sheet (see Appendix B).

Samples will be collected on three events in June, August, and October 2016. A total of 66 lake water samples and 6 tributary stream samples will be collected in this study. Lake samples will be collected at three depths in the epilimnion (except at lake station LC-1, where a sample will only be collected at a depth of 0.3 m) and tributary stream samples will be collected at the stream midpoint at the point of discharge into Lake Chelan. Detailed sampling methods are summarized in Section 8.

Table 8. Latitudinal and longitudinal coordinates of sample sites.

Station Code	Latitude	Longitude
47-LC-1	47.839875°	-120.025390°
47-LC-2	47. 843278°	-120.067764°
47-LC-3	47.861907°	-120.141088°
47-LC-4	47.883897°	-120.198431°
47-LC-5	47.866235°	-120.154807°
47-LC-6	47.906488°	-120.205257°
47-LC-7	47.923779°	-120.204411°
47-LC-8	47.950036°	-120.196871°
47-SC-1	47.929658°	-120.193556°
47-FC-1	47.875640°	-120.197502°

LC – Lake Chelan
SC - Stink Creek outlet
FC - First Creek outlet
NAD 83 Datum

7.1.3 Parameters to Be Determined

The parameters that will be measured at each sampling site include total organic carbon, alkalinity, total phosphorus, orthophosphate, ammonia, nitrate+nitrite, total persulfate nitrogen, chlorophyll *a*, pH, temperature, specific conductivity, dissolved oxygen, and water clarity/Secchi extinction depth.

Table 9 provides the analytical methods for each analyte measured in the laboratory and Table 10 provides the methods for each parameter measured in the field. The rationale for the selection of these parameters is provided below.

Table 9. Summary of laboratory measurements and methods.

Parameter	Minimum Container Size	Holding Time	Method[1]	Reporting Limits	Expected Range of Results
Alkalinity[2]	Polyethylene, 100 mL	14 days	EPA 310.1	10 mg/L	1.0 to 10 mg $CaCO_3$/L
Total organic carbon	Polyethylene with Teflon-lined cap, 250 mL	28 days	SM 5310B1	0.01 mg/L	<0.250 to 2.0 mg/L
Total phosphorus	Polyethylene, 50 mL	28 days	SM 4500-P J	1.1 µg/L	0.002 to 0.05 mg/L
Orthophosphate	Polyethylene, 50 mL	48 hrs	EPA 365.5	0.9 µg/L	0.001 to 0.2 mg/L
Ammonia	Polyethylene, 100 mL	28 days	EPA 349	1.7 µg/L	0.010 to 0.5 mg/L
Nitrate+Nitrite	Polyethylene, 100 mL	48 hrs	EPA 353.4	2.1 µg/L	0.010 to 0.1 mg/L
Total persulfate nitrogen	Polyethylene, 50 mL	48 hrs	SM 4500-NO_3^-B	6.2 µg/L	0.05 to 0.2 mg/L
Chlorophyll *a*	Amber glass, 1,000 mL – pre-filtered	28 days	EPA 445	0.02 µg/L	0.02 µg/L

[1] SM indicates Standard Methods rather than an EPA method.
[2] Analysis performed by CAI. All other analyses performed by UWMCL.

Table 10. Summary of field measurements and methods.

Parameter	Method	Instrument Resolution	Expected Range of Results
pH pH replicate	Sonde Hach 10076	1 to 14 Standard Units	6.5 to 8.5 Standard Units
Dissolved Oxygen DO replicate	Sonde Winkler Titration	0.1 mg/L	<0.250 to 2.0 mg/L
Temperature Temp replicate	Sonde Thermometer	0.01 C	0.002 to 0.05 mg/L
Specific Conductance SC replicate[1]	Sonde EPA 9050A	0.1µS/cm	0.001 to 0.2 mg/L
Water Clarity	Secchi	0.1 ft	20 to 60 ft

[1] Analyzed by UWMCL

7.1.3.1 Phosphorous

Phosphorus occurs in natural waters and in wastewaters almost solely as phosphates. These are classified as orthophosphates, condensed phosphates (pyro-, meta-, and other polyphosphates), and organically bound phosphates (American Public Health Association 2005).

While phosphorus is naturally scarce, many human activities result in phosphorus discharge to natural waters (Chapra 1997). Small amounts of orthophosphate or certain condensed phosphates are added to some water supplies during treatment (American Public Health Association 2005). Larger quantities of these compounds may be added during laundering or other cleaning as phosphates are major constituents of many commercial cleaning products. Phosphates are also used extensively in the treatment of boiler waters. Human and animal wastes both contain substantial amounts of phosphorus which may reach natural waters through point sources (e.g., municipal wastewater-treatment facilities) or non-point sources (e.g., septic drain fields, surface runoff). Orthophosphates applied to agricultural or residential cultivated land as fertilizers are carried into surface waters with storm runoff and through groundwater. Phosphorus in natural waters can be classified in several different ways (Wetzel 1975). Chapra (1997) has proposed one scheme, which is outlined below:

- **Orthophosphate**: This is also referred to as soluble inorganic phosphorus. This form of phosphate is readily available for uptake by plants; it consists of the species H_2PO4^{-1}, $HPO4^{-2}$, and $PO4^{-3}$. It is determined operationally as the inorganic phosphate in water that passes through a 0.45-µm filter and reacts with ammonium molybdate and antimony potassium tartrate under acidic conditions to form a complex.

- **Particulate organic phosphorus**: This form mainly consists of living plants, animals, and bacteria as well as organic debris. This fraction is not available for uptake by plants. Particulate phosphorus is operationally defined as the phosphorus retained on a 0.45-µm filter.

- **Nonparticulate organic phosphorus**: This fraction consists of dissolved or colloidal organic compounds containing phosphorus. Low molecular weight compounds of organic phosphorus can be excreted by microorganisms, which through polycondensation can produce high molecular weight colloidal compounds. Although some phytoplankton species are able to utilize organic phosphate esters, such as glycerophosphates and pyrophosphates, this ability is highly variable among species (Wetzel 1975). This fraction is not assumed to be available to plants for growth in the CE-QUAL-W2 model used in the Lake Chelan study; however, the model assumes that hydrolysis of dissolved organic phosphorus contributes to the soluble inorganic phosphorus fraction which is taken up by plants (Chapra et al. 2005).

- **Particulate inorganic phosphorus**: This category consists of phosphate minerals, sorbed orthophosphate (e.g., on clays), and phosphate complexed with solid matter (e.g., calcium carbonate precipitates or iron hydroxides). This fraction is not available for uptake by plants. Particulate phosphorus is operationally defined as the phosphorus retained on a 0.45-µm filter.

- **Nonparticulate inorganic phosphorus**: This category includes condensed phosphates such as those found in detergents. This fraction is not directly available for uptake by plants; it must be converted to SRP.

Total phosphorus and orthophosphate will be analyzed for this project. These compounds were selected to allow modeling of the relationship between phosphorus concentration, attached algae biomass, and pH using CE-QUAL-W2. The model inputs for phosphorus are dissolved inorganic phosphorus (assumed to equal to orthophosphate) and organic phosphorus. Organic phosphorus is determined by subtracting orthophosphate from total dissolved phosphate.

7.1.3.2 Nitrogen

Nitrogen is a complex element that can exist in seven states of oxidation. From a water quality standpoint, the forms of greatest interest in order of decreasing oxidation state are nitrate, nitrite, ammonia, and organic nitrogen. All of these forms of nitrogen, as well as nitrogen gas, are biochemically interconvertible and are components of the nitrogen cycle (American Public Health Association 2005).

Both dissolved inorganic and organic nitrogen species can be taken up by attached algal species. Total persulfate nitrogen, nitrate+nitrite, and ammonium will be analyzed for this project. These compounds were selected for comparison to previous TMDL effectiveness monitoring results and to allow modeling of the relationship between phosphorus/nitrogen nutrient concentrations, attached algae biomass, and pH using CE-QUAL-W2. The model inputs for nitrogen are ammonium, nitrate+nitrite, and organic nitrogen. Dissolved organic nitrogen is determined by subtracting the concentration of ammonia and nitrate+nitrite from total persulfate nitrogen.

7.1.3.3 Alkalinity and pH

Alkalinity is the capacity of water to neutralize acid. In nearly all natural waters the presence of carbonate, bicarbonate, and hydroxyl ions accounts for essentially all of the alkalinity (Tchobanoglous and Schroeder 1997). The equilibrium relationship between dissolved carbon dioxide, carbonic acid, bicarbonate, and carbonate controls the pH of most natural waters. The CE-QUAL-W2 model accounts for changes in alkalinity due to plant photosynthesis and respiration, nitrogen and phosphorus hydrolysis, nitrification, and denitrification (Chapra et al. 2005). Alkalinity and pH are input parameters needed to model changes in pH due to enhanced productivity of attached algal resulting from elevated nutrient concentrations.

7.1.3.4 Specific Conductivity, Temperature, and Dissolved Oxygen

Conductivity is a model state variable for CE-QUAL-W2 and temperature is used by the model to adjust many temperature-dependent reactions that are simulated by CE-QUAL-W2.

7.1.3.5 Chlorophyll *a*

Chlorophyll *a*, one of the photosynthetic pigments of green plants, is a measure of the portion of the pigment that is still active; that is, the portion that was still actively respiring and photosynthesizing at the time of sample collection (Ecology 1994). Chlorophyll *a* concentrations can be used to determine a lake's trophic status. Though trophic status is not related to any water quality standard, it is a mechanism for "rating" a lake's productive state. Chlorophyll *a* is a model state variable for CE-QUAL-W2.

7.1.3.6 Total Organic Carbon

Total organic carbon (TOC) in aqueous environments consists of dissolved organic carbon (DOC) and particulate organic carbon (POC). The ratio of DOC to POC approximates 6:1 to 10:1 almost universally in both lacustrine and stream systems (Wetzel 1975). Organic carbon enters aqueous environments via allochthonous (e.g., terrestrial input form leaf litter) and autochthonous (i.e., planktonic production) sources. The relative contributions of organic carbon form these sources is system dependent. Cycling of organic carbon within lacustrine systems is an essential component of lake nutrient dynamics. TOC is a model state variable for CE-QUAL-W2.

7.2 Maps or Diagrams

Figure 2 shows the sampling locations for lake and tributary stream water samples.

7.3 Assumptions Underlying Design

Lake Chelan experiences dramatic variability in seasonal conditions. The comprehensive lake study (Patmont et al. 1989) indicated that the Lucerne and Wapato Basins experience seasonal stratification and that the wind and solar heating effects induce sieches which mix water in the basins at various depths and regions depending on seasons. The lake experiences seasonal flow inputs from spring runoff and summer snow melt, and the lake level is managed at a fixed elevation during summer and purposefully drawn down in the fall and winter. These variations result in a well-mixed water column through the spring, summer and fall seasons.

The proposed sampling frequency and locations are expected to capture the range of variability in the lower Lucerne and Wapato Basins by collecting samples and measuring surface water conditions during spring, summer and fall conditions, along the central axis of the Wapato Basin where the maximum amount of water mixing will occur. It is assumed that sampling along the central axis will provide most representative samples of average lake conditions that are not biased by temporal shoreline effects, such as solar heating or concentrated biologic activities or by or human activities such as recreation or water discharge. This approach was assumed and used by the 1989 study and the TMDL effectiveness monitoring studies. Tributary stream water samples will be collected to evaluate the potential effect of tributary stream water inputs to lake quality. It is assumed that tributary stream runoff will indicate potential man-made sources of nutrients to the lower portion of Lake Chelan from agricultural regions (Stink Creek) and rural regions (First Creek).

7.4 Relation to Objectives and Site Characteristics

The frequency and number of samples is intended to provide the greatest potential range of lake conditions when temperatures and biologic activity are at their highest seasonal levels which have the greatest influence on water clarity and biologic activity. Each of the samples locations in the Wapato Basin are at or close to the narrowest sections of the Wapato Basin where water flow is expected to concentrate through these narrows, and where samples would have the greatest potential for thorough mixing and interaction with meteorological conditions. The sample in the lower Lucerne Basin are positioned at the Narrows and up-lake of the Narrows to monitor the transition area between the Lucerne and Wapato Basins. The tributary stream surface water samples are collected at the point of discharge into the lake in order to obtain samples where surface water flows are highest and where human activities have the greatest potential for introducing nutrients into Lake Chelan.

Lake stations LC-1, LC-2, LC-3, and LC-5 correspond to the locations of previous TMDL effectiveness monitoring and the initial characterization study (Patmont et al 1989) which will provide the best locations for comparison to previous monitoring results. The additional lake stations LC-4, LC-6, LC-7, and LC-8 provide greater coverage to evaluate the transition zone between the Lucerne and Wapato Basin the potential seasonal variability across the Narrows and to support the development of the water quality model with additional data in this potentially critical zone.

7.5 Characteristics of Existing Data

Publicly available reports, memoranda, and databases that present water quality data or discuss water quality conditions within WRIA 47 from 1972 to 2007 were reviewed by AMEC (2009b) A large list of conventional water quality parameters, nutrients, metals, and toxics have been measured, although relatively few parameters have been consistently measured by the various studies. Common parameters that were monitored in at least half of the studies, in order of decreasing frequency, include temperature, conductivity, pH, nitrate+nitrite, total phosphorus, total suspended solids (TSS), dissolved oxygen (DO), and turbidity. Detailed summary of historical results are provided in Anchor Environmental (2000) and Newell and Coffin (2011).

Bacteria were commonly analyzed in studies conducted prior to 1995, but have not been analyzed in more recent studies. Analysis of metals was conducted as part of a comprehensive water quality study of Lake Chelan conducted during 1986-1987. However, with the exception of monitoring studies conducted in the vicinity of Holden Mine, no recent data have been collected. A comprehensive examination of a large suite of organic compounds has only occurred at one site within WRIA 47. Stink Creek water samples were analyzed for 161 pesticide and pesticide degradation products as part of a statewide pesticide monitoring program.

Water quality sampling within WRIA 47 has occurred mainly within the Wapato Basin of Lake Chelan, Manson Lakes, and in the vicinity of Holden Mine in the Lucerne Basin. The historical sampling locations for surface water data is shown in Appendix A.

The Total Maximum Daily Load (TMDL) criterion for the Wapato Basin was met (not exceeded) in 1987, 1996, 1997, and 2007, based on total phosphorus concentrations measured during these events. This criterion is calculated as the summer mean total phosphorus concentration for the epilimnion. For 1987 to 2007 this mean ranged from 4.2 to 2.6 μg/L, with 95% confidence, which is lower than the TMDL criterion of 4.5 μg/L.

Weak decreasing trends in total phosphorus concentrations from 1987 to 2007 were found to be more than 95% significant at each station and depth monitored. Confirmation of good water quality in Lake Chelan was provided by low chlorophyll-*a* concentrations and high water transparency (Newell and Coffin 2011).

Meteorologic data are available from more than 10 public and privately operated weather stations around Lake Chelan and hydrologic data are available from USGS and Chelan PUD gauging stations at the lake input, output, and its major tributary (Railroad Creek). The data are publically available and stored on cloud-based servers and provide extensive continuous data that will indicate ranges, averages, and extremes of meteorologic and hydrologic data potentially useful for developing the hydrodynamic model. Locations of the monitoring stations, the period of record, and the type of data collected are summarized in Appendix C.

Bathymetric data were collected by Kendra and Singleton (1987) which developed a contour map of the lake bottom. The contour map contains sufficient topographic resolution to prepare a representative boundary for the hydrodynamic model.

8.0 Sampling Procedures

8.1 Field Measurements and Sampling SOPs

8.1.1 Lake Water Sampling and Monitoring

Prior to collecting water samples at each site for chemical analyses in the lake reaches, depth-temperature profiles of the water column will be measured at each station using multi-parameter probe to measure lake stratification. Depth-temperature data recorded by the multi-parameter probe will be downloaded to lap-top computer or other plotting device and the data used to construct a depth-temperature profile of the water column. Discrete water samples will be collected at the same three depths as previous TMDL effectiveness monitoring: 0.3 meters, 10 meters, and 20 meters (approximately 1 foot, 32 feet, and 64 feet).

In situ measurements of temperature, pH, DO, and specific conductance will be taken with a multi-parameter sonde. Prior to data collection, the multi-parameter probe will be calibrated following the manufacturer's procedures. The pH probe will be calibrated using the two-point calibration method with pH 7.0 and pH 10.0 buffer solutions. Specific conductance will be calibrated with a 100 microSiemen/centimeter (µS/cm) calibration solution.

Probes will be used per the manufacturer's instructions. Water quality parameters will be measured at each specified discrete sampling depth and at a depth of 100 feet, where possible. After stabilization of the multi-parameter probe, *in situ* measurements of temperature, specific conductivity, DO, and pH will be recorded on a project field data form (Appendix B). Quality control of the multi-parameter probe will be accomplished by measuring the 7.0 pH buffer solutions and the 100 µS/cm specific conductance calibration solution after the last station has been sampled. Replicate field measurements will be conducted at greater than 10 percent frequency using methods listed in Table 10.

UWMCL and CAI are both Ecology-accredited labs, and are tentatively identified to perform the laboratory analyses. Analysis methods are summarized in Table 5.

Secchi disk measurements will be taken to assess water transparency. To the extent possible, they will be taken on calm, sunny days to minimize interference with readings. Secchi disk measurements using a standard Secchi disk size will be taken as follows:

- The disk will be attached to a calibrated line or to a surveyor's tape.
- The disk will be lowered into the water to the point where it just disappears.
- The point where the surveyor's tape meets the water surface will be recorded on a field data form.
- The disk will be lowered a few more inches, and then slowly raised until it just becomes visible again. This point on the surveyor's tape will be recorded on the field data form.

- The point halfway between the two measurements represents the average Secchi disk reading. This point on the surveyor's tape will be marked using a clothespin or other marker.
- The average Secchi disk reading will be recorded the nearest tenth of a foot.

All lake-reach water samples will be collected with a Van Dorn 3-liter polycarbonate discrete-point water sampling bottle. Water samples will be collected from the tributaries in accordance with Ecology's SOP for collecting surface water samples (Joy 2006).

Samples will be placed in ice and cooled to ≤4 ºC immediately after collection and held to ≤4 ºC until received by the lab.

Samples for chlorophyll *a* analysis will be immediately placed into the sample cooler, and filtered within 24 hours of sample retrieval at UWMCL. The filtrate will be placed in laboratory-provided container, frozen, and within a container to minimize the filter's exposure to light.

8.1.2 Collecting Water Samples from Tributary Streams

Water samples will be collected from the tributaries in accordance with Ecology's SOP for collecting surface water samples (Joy 2006) directly from streams with the laboratory- provided container. Water samples will be collected in each tributary stream for analysis of all laboratory and field parameters (Table 9 and Table 10, respectively).

Samples for chlorophyll *a* analysis will be immediately placed into the sample cooler, and filtered within 24 hours of sample retrieval. Samples will be placed in ice and cooled to ≤4 ºC immediately after collection and held to ≤4 ºC until received by the lab.

Stream flows in First Creek and Stink Creek are typically low enough to be accessible by wading. All tributary stream water samples will be collected directly from the center of the highest stream flow using the laboratory-provided sample containers and immediately sealed with the collection container.

In situ measurements of temperature, pH, DO, and specific conductance will be taken with a multi-parameter probe in each of the tributaries. Sample stations will be located just upstream of the mouths of the tributaries. *In situ* measurements will be collected at the center of the wetted channel width by placing the multi-parameter probe at mid-depth of the stream. Measurements will be recorded on the monitoring form after the instrument has stabilized.

Stream velocities will be measured using wading techniques with a Swoffer-type rod, following techniques of Nolan and Shields (2000).

Sample containers, instruments, working surfaces, technician protective gear, and other items that may come in contact with a water sample must meet high standards of cleanliness. Sample containers will be provided by UWMCL and will be pre-cleaned.

Water sampling equipment will be cleaned between each use using the procedure described below:

- Rinse with distilled water.
- Rinse with ambient water at collection site.
- Second rinse with ambient water at collection site.

8.2 Containers, Preservatio 0 n, Holding Times

Table 9 summarizes laboratory containers, preservation, and holding times.

8.3 Invasive Species Evaluation

Water sample collection will involve using equipment dedicated for use only on this project, except for field instruments, which will be decontaminated before each sampling event as part of the calibration process. No opportunities for the transfer of invasive species into or out of the study area as a result of sampling activities is expected.

8.4 Equipment Decontamination

Not applicable.

8.5 Sample Identification Scheme

Sample container labels will be prepared prior to field collection activities. The information that will be included is listed below:

- Identification number.
- Date and time.
- Samplers' initials.
- Analysis parameters.

All samples will be assigned a unique identification code on a pre-printed, waterproof label. The identification number will provide collection location information and will consist of three codes: (1) WRIA code (47); (2) lake or stream code (e.g., LC = Lake Chelan; SC = Stink Creek); and (3) station code (e.g., -1 = Station1).

8.6 Chain of Custody

Water samples will be kept in sight of the sampling crew or in a secure, locked vehicle at all times. Samples will be transported with secure custody at the end of the day to a secure location, where the samples will remain in coolers at ≤4ºC, until delivery to the laboratory the following morning. Transfer of samples from secure custody to the laboratory will be documented using a chain-of-custody form. If someone other than the sample collector transports samples to the laboratory, the collector will sign and date the chain-of-custody form and insert the name of the person or firm transporting the samples under "transported by" before sealing the container with a custody seal.

8.7 Field Log Requirements

Field log entries will include:

- Name of project and location.
- Identity of field personnel.
- Sample location and GPS coordinates.
- Site and atmospheric conditions.
- Thermal stratification depths and temperatures at lake sites.
- Date, time, location, identification, and description of each sample.
- Sample depth for lake samples.
- Field meter calibration procedures.
- Field measurement results.
- Identity of QC samples.
- Any changes to planned sampling locations and the rationale for the change.

The field log book will remain with the field staff at all times during the project activities and will be dedicated for this project.

8.8 Other Activities

No additional activities are planned.

9.0 Measurement Methods

9.1 Field Procedures Table

Table 11. Summary of field procedures.

Field Measurement	Number of samples[1]	Expected Range of Results[2]	Analytical Method[3]
pH	72	6.3 to 8.3 pH units	EPA 150.1 Multiprobe
Water temperature	72	0 to 25 °C.	SM 2550 Multiprobe
Specific conductivity	72	10 to 100 mS/cm	SM 2510 Multiprobe
Dissolved oxygen	72	0.01 to 2.0 mg/L	SM 4550 Multiprobe
Secchi depth	72	25 – 100 ft	Secchi Disk

Table 11 note: Sample matrix is water; all samples will be collected from water bodies. Sample preparation method will follow surface water sampling SOP (Joy 2006).

[1] Nine replicate measurement will also be conducted, 3 per event.

[2] AMEC (2009b) and Newell and Coffin (2011).

[3] SM indicates Standard Methods rather than an EPA method.

9.2 Laboratory Procedures Table

Table 12. Summary of laboratory procedures.

Laboratory Analyte	Number of Samples[1]	Expected Range of Results[2]	Analytical Method[3]
Alkalinity	72	1.0 to 10 mg $CaCO_3$/L	EPA 310.1
Total Organic Carbon	72	<0.250 to 2.0 mg/L	SM 5310 B
Total phosphorus	72	0.002 to 0.05 mg/L	SM 4500 B
Orthophosphate	72	0.001 to 0.2 mg/L	EPA 365.5
Ammonia	72	0.010 to 0.5 mg/L	EPA 349
Nitrate+Nitrite	72	0.010 to 0.1 mg/L	EPA 353.4
Total Persulfate Nitrogen	72	0.050 to 0.15 mg/L	SM 4500-NO_3^-B
Chlorophyll *a*	72	0.1 to 2.0 mg/L	EPA 445

Table 12 note: Sample matrix is water; all samples will be collected from water bodies. Sample preparation method will follow SOPs of the analytical method.

[1] Nine field replicate and nine field blank samples will also be collected, 3 each per event.

[1] AMEC (2009b) and Newell and Coffin (2011).

[2] SM indicates Standard Methods rather than an EPA method mg/L = milligrams/liter, µg/L = micrograms/liter.

9.3 Sample Preparation Method(s)

Lake water and tributary stream water samples will be collected and managed following SOP (Joy 2006). Samples will be prepared by the analytical laboratories following laboratory SOPs for each particular analytical method (see Table 9).

9.4 Special Method Requirements

No special method requirements are necessary for sample analysis; all laboratory methods are standardized.

9.5 Lab(s) Accredited For Method(s)

UW Marine Chemistry Laboratory of Seattle, Washington and Cascade Analytical, Inc., are Ecology-accredited laboratories. Cascade Analytical will perform analysis of total alkalinity. UW Marine Laboratory will perform all other analyses.

10.0 Quality Control Procedures

10.1 Laboratory and Field Quality Control

Total variation for field sampling and analytical variation will be assessed by collecting field replicate samples in addition to lab duplicates. Three replicate samples will be collected during each event, at a rate of 12.5% of all samples, and submitted for analysis of all parameters. Three field blanks will be collected in the field during each event and analyzed for each laboratory parameter (Table 6).

Laboratory samples will be analyzed at UWMCL and at CAI. The laboratory's data quality objectives and quality control procedures are documented in the Lab QA/QC Manual including the use of low-level analytical spikes prepared in the laboratory for total phosphorus to determine analytical performance at low levels. The results of the laboratory quality control sample analyses will be used to determine if measurement quality objectives have been met. Field sampling measurements will follow quality control protocols described in Ecology (1993).

All meters used to measure water quality field parameters will be checked and calibrated as appropriate against known standards at the start and end of each sampling day. Meter calibration will be done in accordance with the manufacturer's directions.

10.2 Correction Action Process

Correction actions will be considered if laboratory analyses and/or field measurements do not meet MQOs. Correction actions may include revising/updating the QAPP and adjusting field and/or laboratory procedures and documenting the changes and rationale for the correction actions.

11.0 Data Management Procedures

11.1 Data Recording / Reporting Requirements

Data and log forms produced in the field will be reviewed daily by the person recording the data, so that any errors or omissions can be corrected. All completed data sheets will be removed daily from the field clipboard and photocopied; the original data sheets will be filed in a fireproof file cabinet and the photocopies stored in the project file. All data transcribed from field forms into electronic forms and tables will be checked for accuracy and transcription errors. Electronically recorded data from water quality sonde will be downloaded daily and stored on a cloud-based server. Electronic data will include date and time stamps to record the data recording history.

11.2 Laboratory Data Package Requirements

The laboratory data package will include a case narrative discussing any problems with the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers.

The laboratory data package will also include all QC results associated with the data. This will include results for all method blanks, field blanks, check standards, matrix spikes, as well as the results for laboratory split samples and field replicates, which will be submitted "blind" to the laboratory for analysis.

11.3 Electronic Transfer Requirements

Field and laboratory data will be transferred into an Excel spreadsheet with a format consistent with Ecology's Environmental Information Management (EIM) system. All data entries will be verified for accuracy by the Project Manager prior to data submittal. Rejected data will not be submitted to the EIM system, but their presence in the data set to confirm proof of sample effort will be noted to Ecology in EIM transmittal communications. EIM data will be uploaded by Ecology following EIM procedures.

11.4 Acceptance Criteria for Existing Data

Data from previous investigations have been obtained from various methods, timelines and locations, and as such, are not expected to be strictly compatible with data collected for the LTMP. However, the LTMP data will be qualitatively compared to existing data for general indications of trends and consistency. Historic water quality data will be reviewed for general characteristics of the range of values different seasons and locations to support the water quality model development.

Meteorologic data and hydrologic data used to develop the hydrodynamic model will be inspected for consistency with historical trends and data from stations will be compared for general uniformity of seasonal, annual, and decadal trends. Data from stations that show uncharacteristic outliers, gaps, or trends from general characteristics will not be used in development of the model.

12.0 Audits and Reports

12.1 Number, Frequency, Type, and Schedule of Audits

The Project Manager will be responsible for conducting quality assurance review during the length of the project and for initiating corrective actions as needed. At the end of the first monitoring event and at the end of the first year of monitoring, the QAPP will be reviewed and revised if necessary. Additionally, the QA manager will receive necessary approvals for any revisions/updates and communicate the updates to the project team

Ecology staff may coordinate with the QA manager to conduct external audits of the LTMP. These audits will be conducted to confirm compliance with this QAPP and address questions that may arise during the project. The audits may include side-by-side sampling, observation of field methods and chain-of-custody procedures, and review of field notes, calibration records, and laboratory results, and other QAPP procedures. For these audits Ecology staff may need to accompany CCNR staff in CCNR vehicles during field activities. During field audits Ecology staff will observe all safety protocols outlined in this QAPP and in Ecology's Environmental Assessment Program Safety Manual (Ecology 2015).

12.2 Responsible Personnel

Steve Nelson is the QA manager, and will communicate the QAPP to field staff, conduct internal audits of the LTMP, and coordinate any revisions, updates, and external audits with CCNR and Ecology.

12.3 Frequency and Distribution of Reports

Interim monitoring reports summarizing field activities and observations, laboratory results, and any deviations from the QAPP or need for updates/revisions to the QAPP will be prepared after validation of each monitoring event.

Regular reporting will be conducted as required by Ecology agreement, WQC-2016-ChCoNR-00247, and are as follows.

Quarterly grant progress reports will be completed in the Ecology's Administration of Grants & Loans (EAGL) for the following schedule:

- January 1 through March 31
- April 1 through June 30
- July 1 through September 30
- October 1 through December 31

A final report will be submitted to the Ecology grant manager at least 45 days before the grant end date and a final, approved report will be uploaded to EAGL by the grant end date.

12.4 Responsibility for Reports

The interim monitoring report will be prepared by RH2 and submitted to CCNR for distribution to Ecology. A draft and final data report summarizing the results of the first year of monitoring will be prepared for submittal to CCNR, the LCWPU, and Ecology. This report will include a narrative of the following:

- Field activities.
- Chain-of-custody records.
- A Level 1 data review (see 13.2).
- Data tables and maps for sample locations.
- Data tables and maps summarizing the results of the analytical analyses.
- Electronic data tables including an Ecology EIM-compatible data deliverable.

13.0 Data Verification

This section describes procedures for data validation, verification, and usability.

13.1 Field Data Verification, Requirements, and Responsibilities

Field data records will be reviewed by the Principal and Supporting Investigators immediately after conclusion of a field event. Data review will include the following steps to verify:

- That the field methods and measurements followed specific SOPs.
- That field instrument calibration was conducted and recorded.
- That the field measurement data are legible and complete.
- That noted field conditions appropriately qualify field or laboratory results.

13.2 Data Lab Verification

Data received from the laboratory will be validated including the following steps to verify:

- That the lab utilized the specified extract, analysis, and cleanup methods.
- Sample holding time.
- That sample numbers and analyses match those requested on the chain-of-custody form.
- That the required reporting limits have been achieved.
- That field duplicates, matrix spikes, and laboratory control samples were run at the proper frequency and have met QC criteria.
- That the surrogate compound analyses have been performed and have met QC criteria.
- That initial and continuing calibrations were run at the proper frequency and have met acceptance criteria.
- That the field and lab blanks are free of contaminants.

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14.0 Data Quality Assessment

14.1 Process for Determining Whether Project Objectives Have Been Met

The Principal and Supporting Investigators will assess the quality of the data, based on case narratives and data packages, to determine whether MQOs were met for this study. The Principal and Supporting Investigators will determine whether the data should be accepted, accepted with additional qualification, or rejected and re-analysis considered. If any issues arise, data quality and usability will be discussed in the final report.

14.2 Data Analysis and Presentation Methods

Data from the study will be presented in tables summarizing the detected concentrations and any necessary data qualifiers. The data qualifiers will indicate whether sample results met MQOs and footnotes in the table or the report text will summarize the significance of any result outside the MQOs and whether corrective action was taken to remedy the non-compliance with the MQOs.

14.3 Treatment of Non-Detects

Decision-making is not part of the study, and non-detects will not be relied upon for any actions or decisions in the study outcomes. Non-detects will be used to indicate whether laboratory reporting limits are sufficient for the project objectives and whether an alternate laboratory method with lower laboratory reporting limits would be appropriate for subsequent monitoring events.

14.4 Sampling Design Evaluation

Following completion of the study, review of the initial year of monitoring data and initial development of the model, CCNR and the LCWPU will review the findings of the study and consider whether additional or fewer analytes are needed or whether there could be value in modifying the frequency or location of monitoring. CCNR and LCWPU will solicit input from Ecology project manager and technical reviewers to consider the need and approach for any improvements in the sampling design.

14.5 Documentation of Assessment

After the project data have been reviewed, verified, and validated, the Principal and Supporting Investigators will determine if the data are of sufficient quality to meet project goals and objectives. The project QC procedures and MQOs will provide information to determine if the project data quality objectives have been met. If the MQOs do not meet the project requirements, the data may be discarded. This decision will be made by the Project Manager. If the failure is traced to the analytical laboratory (e.g., sample handling, extraction, or instrument calibration and maintenance), the techniques will be reassessed prior to reanalysis.

The project report will discuss data quality and whether the project objectives can be met. If limitations in the data are identified, they will be noted.

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Appendix A. Historical Summary of Existing Data

TABLE 1

WATER QUALITY PARAMETERS ANALYZED WITHIN WRIA 47

Chelan County, Washington

Data Collection Period		1969-1980	1972	1982	1983	1986	1986-1987	1990	1991	1994	1994	1995	1996	1996	1999	2002-2003	2003	2006
SOURCE [1]		1	2	3	4	5	6	7	8	9	10	24	12	13	14	15	17	22
Water Quality Parameter	**Units**																	
Conventionals																		
Alkalinity	mg CaCO3/L	●					●							●		●		
Ammonia	µg N/L	●			●	●	●		●	●								
Bicarbonate	µg/L						●											
Biological Oxygen Demand	mg/L		●															
Chemical Oxygen Demand	mg/L	●	●		●													
Chloride	mg/L						●											
Chlorophyll a	µg/L	●					●					●	●		●	●		
Cyanide	mg/L													●				
Dissolved Oxygen	mg/L			●			●	●	●	●		●	●		●	●		
Dissolved Oxygen Saturation	%						●						●					
Fluorine	µg/L						●											
Light Extinction Coefficient	1/meter						●											
Nitrogen - Nitrite+Nitrate N	µg N/L	●		●	●	●	●		●	●	●	●	●	●	●	●		
Nitrogen - Total N	µg N/L	●			●		●			●					●			
Nitrogen - Total Persulfate N	ng/L											●	●					
Nitrogen - Total Soluble N	µg N/L						●											
pH		●	●	●	●		●	●	●	●	●	●	●	●	●	●		
Phaeophytin	µg/L						●					●	●					
Phosphorus - Orthophosphate	mg/L				●				●							●		
Phosphorus - Soluble Reactive P	µg P/L						●			●								
Phosphorus -Total P	µg P/L	●		●	●	●	●		●	●		●	●	●	●	●		
Phosphorus - Total Soluble P	µg P/L						●											
Secchi Disk Depth	meters			●			●	●				●	●					
Specific Conductance	µmho/cm	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
Sulfate	mg/L													●				
Temperature	°C		●	●	●		●	●	●	●	●	●	●	●	●	●	●	●
Total Chlorine Residual	mg/L				●													

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AMEC Geomatrix, Inc.
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Figure 4. Summary of existing data for Lake Chelan (AMEC Geomatrix Inc. 2009b).

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TABLE 1

WATER QUALITY PARAMETERS ANALYZED WITHIN WRIA 47

Chelan County, Washington

Data Collection Period		1969-1980	1972	1982	1983	1986	1986-1987	1990	1991	1994	1994	1995	1996	1996	1999	2002-2003	2003	2006
SOURCE [1]		1	2	3	4	5	6	7	8	9	10	24	12	13	14	15	17	22
Water Quality Parameter	**Units**																	
Conventionals (continued)																		
Total Dissolved Gas	%														●			
Total Hardness	mg/L													●				
Total Nonvolatile Suspended Solids	mg/L		●															
Total Organic Carbon	mg/L										●						●	
Total Solids	mg/L		●															
Total Settleable Solids	mg/L		●															
Total Suspended Solids	mg/L		●		●		●		●	●	●			●	●	●	●	
Total Nonvolatile Suspended Solids	mg/L		●															
Transparency															●			
Turbidity	NTU		●		●		●		●	●				●		●	●	
Bacteria																		
Fecal Streptococci	#/100 mL						●											
Fecal Coliform	#/100 mL		●		●	●	●		●	●		●						
Total Coliform	#/100 mL			●			●											
Metals																		
Aluminum	µg/L						●							●				
Arsenic	µg/L						●							●				
Cadmium	µg/L													●				
Calcium	µg/L						●											
Copper	µg/L													●				
Iron	mg/L						●							●				
Lead	µg/L													●				
Managanese	µg/L													●				
Mercury	µg/L													●				
Nickel	µg/L													●				
Silver	µg/L													●				
Zinc	µg/L													●				

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Figure 5. Summary of existing data for Lake Chelan (AMEC Geomatrix Inc. 2009b).

TABLE 1

WATER QUALITY PARAMETERS ANALYZED WITHIN WRIA 47

Chelan County, Washington

Data Collection Period		1969-1980	1972	1982	1983	1986	1986-1987	1990	1991	1994	1994	1995	1996	1996	1999	2002-2003	2003	2006
SOURCE [1]		1	2	3	4	5	6	7	8	9	10	24	12	13	14	15	17	22
Water Quality Parameter	**Units**																	
Herbicides																		
2,4-D	µg/L										○							
Atrazine	µg/L										○							
Bromacil	µg/L										○							
Bromoxynil	µg/L										●							
Dacthal	µg/L										○							
Dichlorobenil	µg/L										●							
Dichlofop-methyl	µg/L										○							
MCPA	µg/L										○							
MCPP	µg/L										○							
Norflurzaon	µg/L										●							
Norflurazon Desmethyl	µg/L										●							
Simazine	µg/L										●							
Trillate	µg/L										○							
Insecticides																		
Carbaryl	µg/L										○							
Chlorpyrifos	µg/L										●							
4,4'DDD	ng/L															●	●	●
4,4'DDE	ng/L										○					●	●	●
4,4'DDT	ng/L										●					●	●	●
Total DDT	ng/L										●					●	●	●
Diazinon	µg/L										●							
Diuron	µg/L																	
Hexazinone	µg/L																	
3-hydroxycarbofuran	µg/L										●							
Malathion	µg/L										○							
Ozinphos-methyl (Guthion)	µg/L										●							
Terbacil	µg/L																	

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Figure 6. Summary of existing data for Lake Chelan (AMEC Geomatrix Inc. 2009b).

TABLE 1

WATER QUALITY PARAMETERS ANALYZED WITHIN WRIA 47
Chelan County, Washington

Data Collection Period		1969-1980	1972	1982	1983	1986	1986-1987	1990	1991	1994	1994	1995	1996	1996	1999	2002-2003	2003	2006
SOURCE [1]		1	2	3	4	5	6	7	8	9	10	24	12	13	14	15	17	22
Water Quality Parameter	**Units**																	
Other Organics																		
Bromodichloromethane	µg/L						●											
Chlorodibromomethane	µg/L						●											
Pentachlorophenol	µg/L										●							
PCB Aroclors	µg/L																●	
PCB Congeners	µg/L																	
Tribromomethane	µg/L						●											
Trichloromethane	µg/L						●											

Note(s)
1. See Attachment A for Source references.
● Analyzed Parameter
○ Analyzed parameter but not detected

Figure 7. Summary of existing data for Lake Chelan (AMEC Geomatrix Inc. 2009b).

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Appendix B. Field Sampling Data Sheet and QA/QC Form

FIELD SAMPLING and QA/QC DATA SHEET

Lake Chelan
Long Term Monitoring Plan

Sample Location:	Lat:	Long:

Sample ID: Project #:

Weather:	Air Temperature: °C

FIELD PARAMETERS

Time	Depth	pH	Temp (°C)	DO (mg/l)	SP Cond (µS)	Secchi	Method

Sonde Brand and Model:

WATER SAMPLING DATA

Parameter	Time	Method	# Bottles	Volume (ml)	Type	Ice	Preservative	Filter
Alkalinity								
Total Organic Carbon								
TP								
Orthophosphate								
TN								
NO3/NO2								
NH3								
Chlorophyll a								

Total Bottles (include duplicate count):

Duplicate ID: Time:

Water Characterization			Calibration Record	
Color	Clarity	Odor	Date	Adjustment ?

Notes:

SAMPLER:

(PRINTED NAME) (SIGNATURE)

Figure 8. Field sampling and QA/QC data sheet.

Appendix C. Meteorologic and Hydrologic Station Data

Meteorolorologic Station Name	Station Code	Latitude	Longitude	Elevation	Date Final	Date Initial	Temp	Dewpt	Hum	Ppt	Wind	Direc	Baro	Solar
Stehekin	MSTRW1	48.347	-120.72	1229	2016	2007	X	X	X	X	X	X	X	-
Methow	MCMFW1	48.026	-120.241	3156	2016	2007	X	X	X	X	X	X	X	-
Bear Run	KWACHELA9	47.913	-120.217	1365	2016	2014	X	X	X	X	X	X	X	X
Manson	MMASW	47.917	-120.124	1972	2016	2007	X	X	X	X	X	X	X	
Chelan Ridge	KWACHELA10	47.865	-120.188	1490	2016	2014	X	X	X	X	X	X	X	X
Echo Ridge	KWACHELA16	47.874	-120.073	1818	2016	2015	X	X	X	X	X	X	X	X
Chelan Area	KWACHELA2	47.84	-120.009	1169	2016	2008	X	X	X	X	X	X	X	-
Manson 2	ME5811	47.917	-120.177	1282	2016	2007	X	X	X	X	X	X	X	X
S Lakeshore Rd	KWACHELA7	47.895	-120.215	1122	2016	2014	X	X	X	X	X	X	X	-
Chelan	MD9139	47.863	-120.089	1148	2016	2007	X	X	X	X	X	X	X	X
Highlands	KWACHELA4	47.858	-120.041	1610	2016	2012	X	X	X	X	X	X	X	-
S Lakeshore Rd 2	KWACHELA13	47.899	-120.214	1131	2016	2015	X	X	X	X	X	X	X	-
Apple Blossom	KWACHELA12	47.838	-119.991	1263	2016	2015	X	X	X	X	X	X	X	-
Woodland	KWACHELA6	47.910	-120.212	1106	2016	2014	X	X	X	X	X	X	X	X

Hydrologic Station Name	Station Code	Latitude	Longitude	Elevation	Date Final	Date Initial	Gauge	Flow
Railroad Creek	12451500	48.196	-120.597	1250	1910	1977	X	-
Stehekin River	12451000	48.330	-120.691	1099	1910	2016	X	X
Chelan River	12455200	47.835	-120.012	1097	1903	2016	X	X

Figure 9. Meteorologic and hydrologic station data.