STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
4601 N Monroe Street • Spokane, Washington 99205-1295 • (509)329-3400

January 30, 2009

Mr. Tom Dresser
Manager, Fish, Wildlife and Water Quality
Grant County Public Utility District
P.O. Box 878
Ephrata, WA 98823

Dear Mr. Dresser:

RE: Request for Comment – Final 2009 Quality Assurance Project Plan for Monitoring Selected Water Quality Parameters within the Priest Rapids Hydroelectric Project

The Department of Ecology (Ecology) has reviewed the Final Quality Assurance Project Plan received on January 27, 2009, and APPROVES this plan. Our comments sent to Grant PUD on January 16, 2009, were incorporated into the final plan.

Please feel free to contact me at (509) 329-3450 or by email at dman461@ecy.wa.gov if you have any further questions regarding this matter.

Sincerely,

D. Marcie Mangold

D. Marcie Mangold
Water Quality Program

DMM:dw

cc: Gerry O'Keefe, Grant PUD
Ross Hendrick, Grant PUD
Bill Tweit, WDFW
Brian Faller, Ecology/ATG
James M. Bellatty, Ecology/WQP

Grant County
PUBLIC UTILITY DISTRICT
Excellence in Service and Leadership

January 26, 2009

Ms. Marcie Mangold
Washington Department of Ecology
Eastern Regional Office
N. 4601 Monroe
Spokane, WA 99205-1295

Re: **Final 2009 Quality Assurance Project Plan for monitoring selected water quality parameters within the Priest Rapids Hydroelectric Project**

Dear Ms. Mangold,

Please find enclosed Public Utility District No. 2 of Grant County, Washington's (Grant PUD's) final quality assurance project plan (QAPP) for monitoring water quality parameters within the Priest Rapids Hydroelectric Project (Project). This QAPP is consistent with the requirements of the Project [issued by the Federal Energy Regulatory Commission (FERC) April 17, 2008] and associated obligations and mandates, including the Washington State Department of Ecology (WDOE) 401 Water Quality Certification. Specifically, the water quality certification requires that the QAPP be submitted within one year of license issuance and be reviewed and updated annually based on yearly review of data and data quality, and that any changes to the QAPP required in accordance with the 401 be reviewed and approved by WDOE.

Grant PUD prepared and disseminated for comment a draft QAPP on December 19, 2008 to WDOE, the Priest Rapids Coordinating Committee, and to National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (UFWS), specifically. The draft QAPP was also posted to Grant PUD's water quality monitoring web site. Comments on the plan were due January 19, 2009. WDOE provided the only comments to the plan on January 16, 2009, which was included as Appendix C to the final QAPP. A summary table of all comments received to date on the draft QAPP and Grant PUD's responses to those comments are included in Appendix D of the final QAPP.

Article 401 of the FERC license for the Project requires that this QAPP also be approved by FERC prior to implementation. Therefore, this final QAPP will also be submitted to FERC for approval.

Note that this QAPP will also be included in the final total dissolved gas abatement plan (GAP) as Appendix C. The draft GAP underwent separate consultation, by the same parties consulted to comment on this QAPP, on October 31, 2008 with comments due December 31, 2008. The GAP is required under Section 6.4.1 1 (e) of the 401 water quality certification and the final is due February 1, 2009. This final QAPP will be included in the final GAP because it contains quality assurance methods related to monitoring and reporting total dissolved gas measurements.

Grant PUD appreciates the comments received from WDOE on the draft QAPP and look forward to working with you in the future. Please contact Ross Hendrick at 509-754-5088, ext. 2468 or rhendrl@gcpud.org if you have any questions or comments.

Sincerely,

Tom Dresser
Manager – Fish, Wildlife, and Water Quality

CC: Gerry O'Keefe
Ross Hendrick
James Bellatty – WDOE
Scott Carlon – NMFS
Bryan Nordlund – NMFS
Jim Craig – USFWS
PRCC Members
Wanapum

Priest Rapids Hydroelectric Project (P-2114)

Quality Assurance Project Plan for Monitoring Selected Water Quality Parameters Within the Priest Rapids Hydroelectric Project

License Article 401(a)(23)

By Ross Hendrick
Public Utility District No. 2 of
Grant County, Washington

January 2009

Executive Summary

This Quality Assurance Project Plan (QAPP) provides details on water quality monitoring methods that Public Utility District No. 2 of Grant County, Washington (Grant PUD) plans to implement to meet conditions of the 401 Water Quality Certification (WQC) issued by the Washington Department of Ecology (WDOE). Water quality parameters that will be monitored under this QAPP include total dissolved gas (TDG), water temperature, dissolved oxygen (DO), pH, and turbidity.

Water quality monitoring conducted under this QAPP will be done via Grant PUD's Fixed Site Water Quality Monitoring (FSM) program. Information provided in this QAPP includes the following:

- Purpose and objectives of the FSM program
- List of parameters to be monitored
- Organization and schedule
- Data quality objectives
- Descriptions and maps of the monitoring locations
- Monitoring methods, procedures, and equipment
- Analytical methods
- Quality control procedures, including descriptions of calibration, maintenance, and data handling and assessment procedures
- Reporting protocols
- Provisions for adaptive management

The purpose of Grant PUD's FSM program will be to continue to provide information on water quality conditions within the Priest Rapids Hydroelectric Project area, as well as verify compliance with applicable water quality standards and conditions within the WDOE 401 WQC. Implementation of this QAPP will help assure that water quality data collected by the FSM program will be of sufficient quality. Adaptive management provisions in this QAPP will help determine potential changes to monitoring methods, locations, etc. that may be needed, and annual updates will be made to this QAPP accordingly, subject to WDOE and Federal Energy Regulatory Commission (FERC) approval.

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Terms and Abbreviations

7Q10 flow	highest seven consecutive day average flow with a 10-year recurrence frequency
Corps	US Army Corps of Engineers
DO	dissolved oxygen
GAP	Gas Abatement Plan
GBT	gas bubble trauma
Grant PUD	Public Utility District No. 2 of Grant County, Washington
FERC	Federal Energy Regulatory Committee
FSM	fixed-site monitoring
kcfs	thousand cubic feet per second
MW	megawatt
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Unit
PRCC	Priest Rapids Coordinating Committee
PRFF	Priest Rapids Fish Forum
Project	Priest Rapids Hydroelectric Project
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
TDG	total dissolved gas
TMDL	total maximum daily load
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WFUFB	Wanapum Future Unit Fish Bypass
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
WQC	water quality certification
WDOE	Washington Department of Ecology

1.0 Introduction

Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates the Priest Rapids Hydroelectric Project (Project), located along the Columbia River in central Washington. The Project is authorized by the Federal Energy Regulatory Commission (FERC) under Project No. 2114 and includes Wanapum and Priest Rapids dams. A 401 Water Quality Certification (WQC) for the operation of the Project was issued by the Washington State Department of Ecology (WDOE) on April 3, 2007 and amended on March 6, 2008. The WQC's terms and conditions were directly incorporated in the new FERC license to operate the Project on April 17, 2008. Section 6.7.1 of the WQC requires Grant PUD to submit for WDOE approval a Quality Assurance Project Plan (QAPP) for each parameter to be monitored under the 401 WQC. Once approved by WDOE, this QAPP must also be approved by FERC per Article 401 of the Project license (FERC 2008).

Various sections of the 401 WQC require Grant PUD to monitor total dissolved gas (TDG), water temperature, dissolved oxygen (DO), and pH throughout the Project (WDOE 2007). Grant PUD plans to continue implementation of its Fixed Site Water Quality Monitoring (FSM) program to meet the 401 WQC water quality monitoring requirements. This QAPP provides details on parameters to be monitored, maps of sampling locations, and descriptions of the purpose of the monitoring; sampling frequency, sampling procedures and equipment, and analytical methods, quality control procedures, data handling and data assessment procedures, and reporting protocols of the FSM program.

This QAPP was prepared using the following publications and references as guidelines, as applicable to the goals and objectives of the Grant PUD's FSM program:

1). WDOE guideline publication for preparing QAPPs (WDOE 2004);
2). U.S. Geological Survey (USGS) National Field Manual for Collection of Water Quality Data (Gibs et. al 2007); and
3). Grant PUD's current Quality Assurance and Quality Control (QA/QC) procedures as described in Duvall and Dresser (2003).

2.0 Background

The Project is located on the Columbia River in central Washington state. From its headwaters in Canada, the Columbia River extends for 1,214 miles, with 460 miles in Canada and 754 miles in the United States. The Columbia River watershed drains an area of approximately 258,500 square miles in the Pacific Northwest. The following states and provinces comprise the majority of the Columbia River Basin: Washington, Oregon, and Idaho, the western portion of Montana, the southeastern portion of British Columbia, and small areas of Wyoming, Nevada, and Utah.

Grant County, the fourth largest county in Washington state, is located in the approximate center of the state, remote from major population areas. This part of Washington, being on the dry (east) side of the Cascade Mountain Range, is arid and receives about seven inches of rain in an average year. The Columbia River forms part of the western boundary of Grant County, and touches again at the county's most northern corner at Grand Coulee Dam (Figure 1). The Project is located on that portion of the Columbia River that makes up the western boundary of Grant County. The Project also forms partial boundaries of Benton, Yakima, Kittitas, Douglas, and Chelan counties. In all, the Project encompasses 58 miles of the Columbia River from river mile

(RM) 395 to RM 453. The Project remains in a largely undeveloped and undisturbed condition. Development along the river is limited to a few very small communities and scattered tracts of irrigated orchard land.

The Project is part of the much larger 13,600 Megawatt (MW), seven dam, mid-Columbia River hydroelectric system which extends from near the U.S./Canada border to the beginning of the Hanford Reach, a total of 351 RMs. The Project's location at the downstream end of this highly integrated system of hydropower facilities adds significantly to the complexity of Project operations.

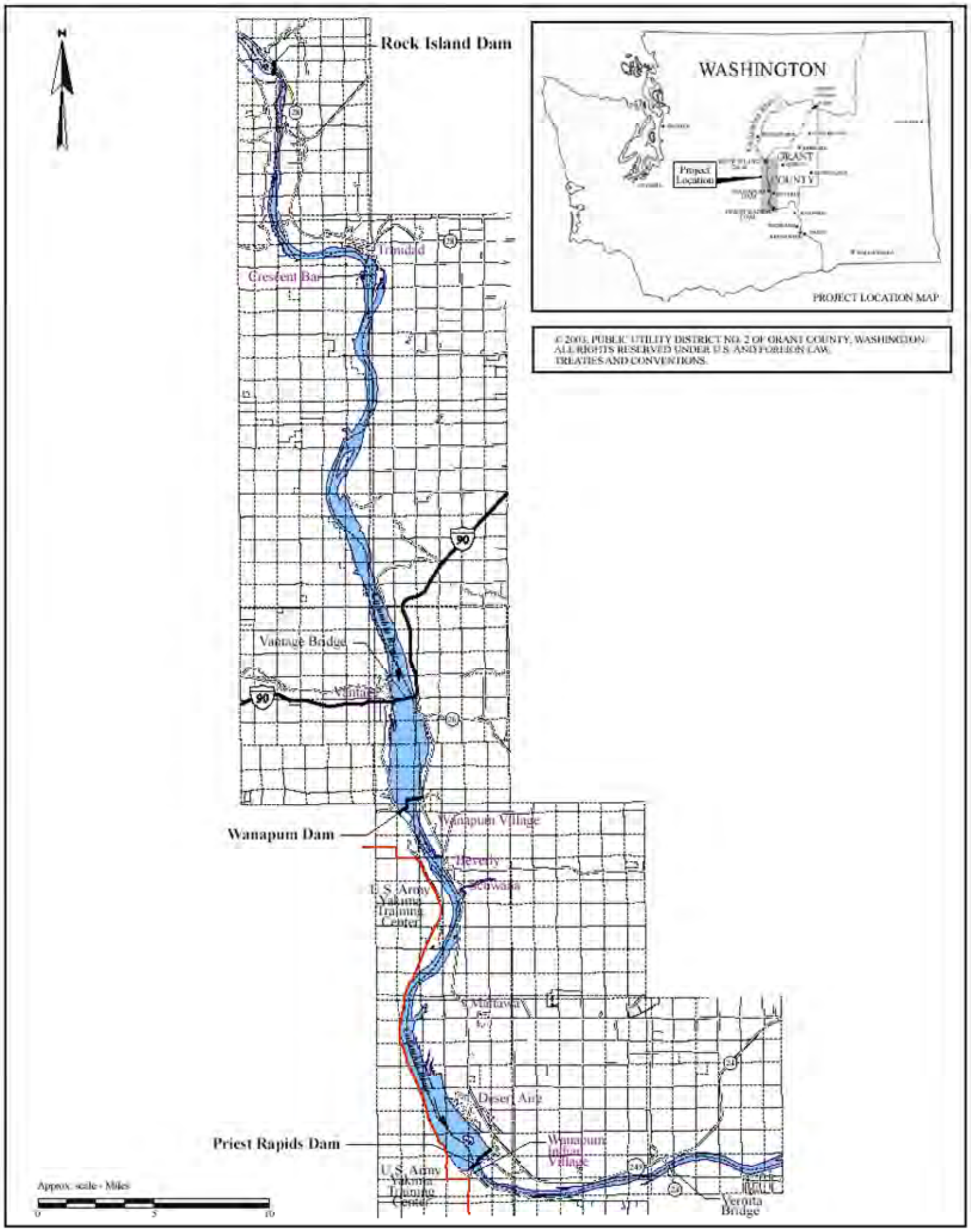

Figure 1 Location map of the Wanapum and Priest Rapids developments and nearby communities.

The first two water resource developments encountered on the Columbia River downstream of the U.S./Canada border are Grand Coulee and Chief Joseph dams, located at RM 597 and RM 544, respectively. Both of these projects are federally owned and operated and are not, therefore, subject to FERC jurisdiction. Grand Coulee, at 6,809 MW, is the largest hydroelectric generating facility in the United States. Lake Roosevelt, the reservoir formed by Grand Coulee Dam, is over 151 miles long and contains 5.2 million acre-feet (MAF) of usable water storage. The operation of the multi-purpose Grand Coulee Project generally establishes the flow and temperature regime for the entire mid-Columbia River system (Perkins 2002).

Three Washington Public Utility Districts (PUDs) own and operate the five hydroelectric projects below Chief Joseph Dam, all of which are subject to the jurisdiction of FERC. The first facility downstream of Chief Joseph Dam is the Wells Project at RM 516, owned and operated by PUD No. 1 of Douglas County. The Rocky Reach Project, at RM 474, is owned and operated by PUD No. 1 of Chelan County, as is the Rock Island Project at RM 453.5. The next dams are Grant PUD’s Wanapum (RM 415.8) and Priest Rapids (RM 397.1) developments.

The Wanapum Reservoir is 38 miles long and extends to the tailwater of Rock Island Dam. The reservoir has an approximate surface area of 14,680 acres. The drainage area of the Columbia River at the dam is 90,900 square miles. Priest Rapids Reservoir is approximately 18 miles long and extends to the tailwater of Wanapum Dam. The impoundment has an approximate surface area of 7,725 acres. Above Priest Rapids Dam, the Columbia River drains an area of nearly 96,000 square miles. The total area encompassed by the current FERC-licensed Project boundary is 34,380 acres, consisting of those lands necessary for the safe and efficient operation and maintenance of the Project and for other useful purposes, such as recreation, shoreline control, and protection of environmental resources.

Several small streams flow into the Columbia River within the Project. Colockum, Douglas, Tarpiscan, Johnson, Skookumchuck, Tekison, Whiskey Dick, Casey, Quilomene, and Trinidad creeks and Sand Hollow Wasteway enter the Columbia River above Wanapum Dam. These are relatively small streams, some of which are dry part of the year. Crab Creek is a larger waterway that enters the Columbia River on the east shore, between Wanapum and Priest Rapids dams. Its headwaters originate just west of Spokane, Washington. Hanson Creek, which drains a large part of the U.S. Army’s Yakima Training Center (YTC), west of the Project, is the only other natural perennial stream along the Columbia River between Wanapum and Priest Rapids dams.

Wanapum Dam consists of a 14,680-acre reservoir and an 8,637-foot-long by 186.5-foot-high dam spanning the river. The dam consists of left and right embankment sections; left and right concrete gravity dam sections; a left and right fish passage structure, each with an upstream fish ladder; a gated spillway; an intake section for future generating units; a downstream fish passage structure in one of the unused intake sections (unit No. 11); and a powerhouse containing 10 vertical shaft integrated Kaplan turbine/generator sets with a total authorized capacity of 1,038 MW (Figure 2).

Priest Rapids Dam consists of a 7,725-acre reservoir and a 10,103-foot-long by 179.5-foot-high dam spanning the river. The dam consists of left and right embankment sections; left and right concrete gravity dam sections; a left and right fish passage structure each with an upstream fish ladder; a gated spillway section; and a powerhouse containing 10 vertical shaft integrated Kaplan turbine/generator sets with a total authorized capacity of 855 MW (Figure 3).

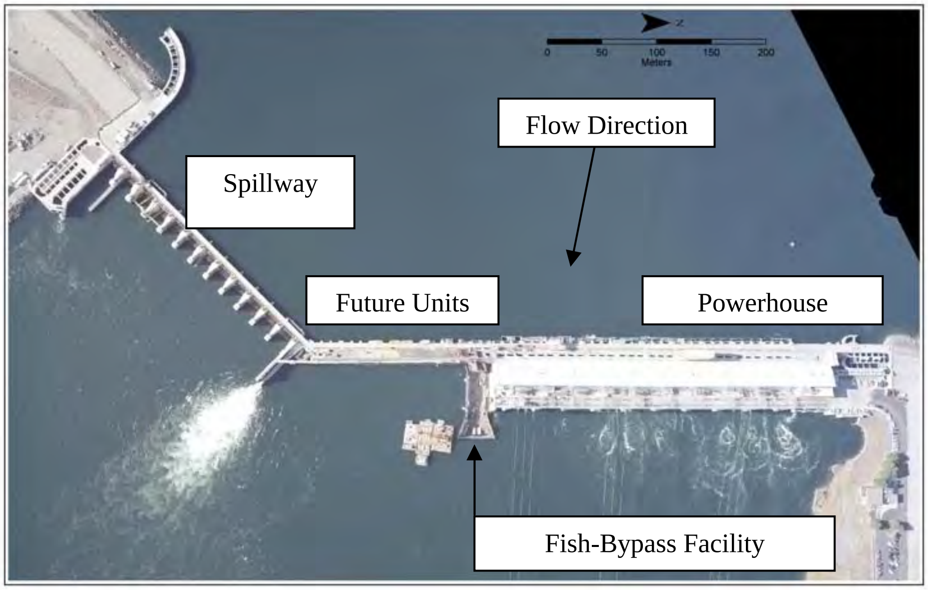

Figure 2 Aerial photograph of Wanapum Dam, mid-Columbia River, WA.

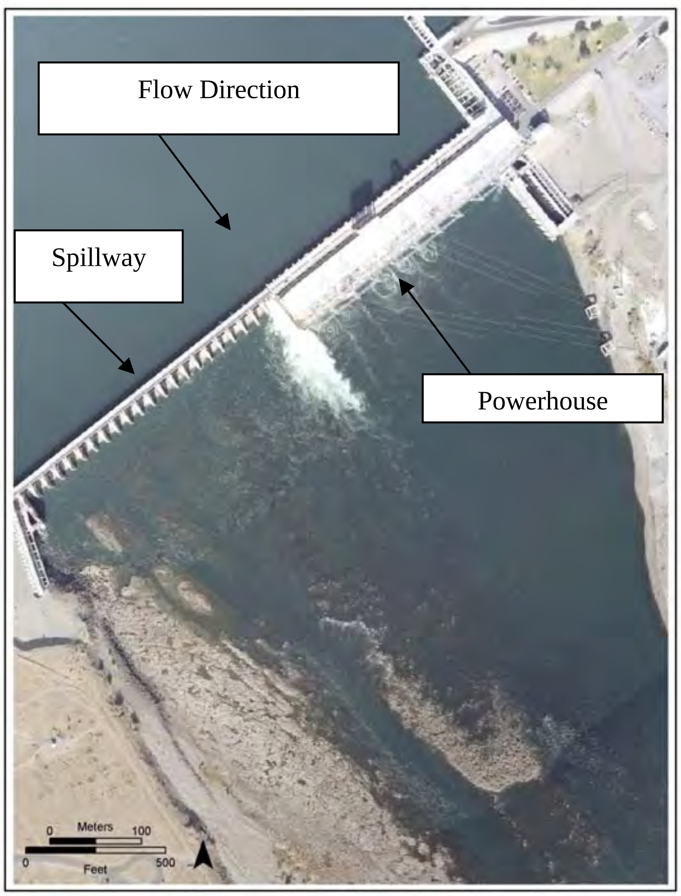

Figure 3 Aerial photograph of Priest Rapids Dam, mid-Columbia River, WA.

Several reports cover water quality issues relevant to the Columbia River within the Project. These include studies by Normandeau et al. (2000) and Juul (2003), which reviewed temperature, DO, pH, and turbidity data from 1961 to 2001. In 1999, Grant PUD prepared a limnological investigation of the reservoirs that measured over 21 parameters (Normandeau et al. 2000). Hourly temp, TDG, pH, DO, and turbidity data from five FSM stations, historical scrollcase data, thermistor arrays and water-column profile data at eight transects were examined in Juul (2003). The data in these studies were collected from 14 different sites within the Project. Perkins et al. (2002) evaluated the Project's impacts on water temperatures by developing a computer simulation of reservoir temperatures with and without the effects of the dams on the river. The Corps of Engineers Waterways Experiment Station conducted several TDG studies, including pre- and post-deflector evaluations at Wanapum Dam (COE 2001) and field work on a near field TDG study for Priest Rapids Dam (COE 2003). The results of all historical water quality studies, monitoring, etc. are summarized in Grant PUD (2003).

3.0 Regulatory Framework

Section 6.0 of the 401 WQC (WDOE 2007) contains water quality conditions that Grant PUD must follow, many of which require regular monitoring of TDG, water temperature, DO, and pH. Although turbidity monitoring is not required by the 401 WQC, Grant PUD will continue monitoring turbidity on a periodic basis as described in this QAPP. The following sections detail the water quality monitoring requirements and numeric standards for each parameter to be monitored.

3.1.1 Total Dissolved Gas

WDOE establishes Washington state water quality standards for TDG during the non-fish and fish-spill seasons (see Washington Administrative Code (WAC) 173-201A-200(1)(f)). The current standard for TDG (in percent saturation) during the non-fish spill season (September 1 through March 31) is 110 percent for any hourly measurement. The current standard for TDG (in percent saturation) during the fish-spill season (April 1 through August 31) is 120 percent in the tailrace of the dam spilling water for fish and 115 percent in the forebay of the next downstream dam, based on the average of the 12 highest consecutive hourly readings in a 24-hour period. A 1-hour, 125 percent maximum standard for TDG also applies throughout the Project during the fish-spill season.

Section 6.4.10 of the 401 WQC requires Grant PUD to maintain a TDG monitoring program at its fixed site monitoring stations (see Section 6.1 of this QAPP) throughout the year, and that TDG measurements shall occur on an hourly basis. Monitoring results shall be made available electronically to the public "…as close to the time of occurrence as technology will reasonable allow" (WDOE 2007). In addition, Grant PUD shall provide WDOE with an annual TDG summary report (see Section 6.4.11(e) of the 401 WQC).

Prior to 2008, the method used to calculate the daily TDG compliance value during the fish-spill season was based on the average of the 12 highest hourly values in a 24-hour period, starting at 0100 hrs and ending at 2359 hours. This method was based on WDOE's 1997 water quality standards. In WDOE's 2006 revision to the water quality standards (which were not approved by the Environmental Protection Agency (EPA), and thus not effective, until 2008) the method for calculating the TDG compliance value was changed. The new method provides that the TDG compliance value be determined by calculating the average of the 12 highest *consecutive* hourly values in a 24-hour period. Prior to the 2008 fish-spill season, there was some discussion amongst the Columbia and Snake river dam operators on how to properly implement this “rolling average” method, especially as it related to what time the rolling average began because of concerns related to the addition of previous day’s last 11 hours to the compliance value calculation on the next day.

On April 2, 2008 WDOE requested via letter that all Columbia and Snake river dam operators use a rolling average method for calculating the 12 highest consecutive hourly TDG readings in a 24-hour period, beginning at 0100 hours (WDOE 2008). This method is based on WDOE’s 2006 revised water quality standards, which were formally approved by EPA on February 11, 2008. Using a rolling average method that begins at 0100 hours results in counting the hours 1400 through 2359 twice: in the average calculations on the day they occur and on the next reporting day. As a result, a TDG water quality standard variance may be indicated on two separate days based on the same group of hours. On April 15, 2008 Grant PUD sent a letter to WDOE that expressed and provided an example of its concern regarding the rolling average method (Grant PUD 2008a). Grant PUD also expressed its intention to monitor this double-counting problem and report any instances in which the same block of hours create an exceedance on two different days in its annual report during two separate phone conversations with Mr. Chris Maynard and Ms. Marcie Mangold of WDOE on March 31, 2008. Appendix A of this QAPP provides an example how the rolling average method created a TDG water quality variance on two separate days based on the same grouping of hourly values, and Grant PUD’s method for accounting for those occurrences.

3.1.2 Water Temperature

WAC 173-201A-602 designates the section of the Columbia River within the Project as salmonid spawning, rearing, and migration, and therefore water temperature must remain below 17.5°C, as measured by the 7-day average of the daily maximum temperatures (7-DADMax). When a water body's temperature is warmer than the criteria (or within 0.3°C of the criteria) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C. In addition, WAC 173-201A-602 provides that temperatures below Priest Rapids Dam shall not exceed a 1-DMax of 20.0°C due to human activities. When natural conditions exceed a 1-DMax of 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed $t = 34/(T + 9)$. Portions of the Columbia River within the Project are currently classified as impaired for temperature under Section 303(d) of the Clean Water Act. Portions of the Columbia River upstream of the Project also are currently classified as impaired for temperature. WDOE has indicated that a Total Maximum Daily Load (TMDL) for temperature is expected to be developed by the EPA that will establish a final wasteload and load allocation for temperature (WDOE 2007).

3.1.3 Dissolved Oxygen, pH, and Turbidity

The water quality criteria for DO within the Project require that DO be greater than 8.0 milligrams per liter (mg/L). When DO is lower than the criteria (or within 0.2 mg/L of the criteria) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the DO of that water body to decrease more than 0.2 mg/L (WAC 173-201A-200(1)(f)).

WAC 173-201A-200(1)(g) provides that pH shall be within the range of 6.5 to 8.5 units with a human-caused variation within the above range of less than 0.5 units.

WAC 173-201A-200 (1)(e) provides that turbidity levels shall not be >5 Nephelometric Turbidity Units (NTU) over background turbidity when the background is 50 NTU or less.

4.0 Project Description

This QAPP provides details on Grant PUD’s Fixed Site Water Quality Monitoring (FSM) program. In general this QAPP provides descriptions of the following:

- Purpose and objectives of the FSM program;
- List of parameters to be monitored;
- Organization and schedule;
- Data quality objectives;
- Descriptions and maps of the monitoring locations;
- Monitoring methods, procedures, and equipment;
- Analytical methods;
- Quality control procedures, including descriptions of calibration, maintenance, and data handling and assessment procedures;
- Reporting protocols; and
- Provisions for adaptive management

4.1 Fixed Site Monitoring Program

Grant PUD currently operates and maintains four FSM stations that record water depth (m), barometric pressure (mm Hg), TDG (mm Hg), temperature (°C), DO (mg/L), pH (units), and turbidity (NTU). Barometric pressure, TDG, and temperature are monitored on an hourly basis throughout the year, while depth, DO, pH, and turbidity are monitored once every two or three weeks throughout the year. Each Grant PUD FSM station is equipped with a Hydrolab Corporation Model DS5X®, DS4A®, DS4® or Minisonde® multi-parameter water quality probe that enclosed in a submerged perforated conduit. The multi-parameter probes (multi-probes) contain individual TDG, temperature, DO, pH, and turbidity sensors that are connected to a central housing system that allows for single connections, readouts, downloads, and power supplies for up to 15 water quality sensors. At Grant PUD’s FSM stations, the multi-probes are connected to an automated system that allows Grant PUD to monitor barometric pressure, TDG, and water temperature on an hourly basis. A certified barometer located at each FSM provides the barometric pressure readings necessary to correct the partial pressure readings taken by the multi-probes (and convert TDG mm Hg to percent saturation). The multi-probes are also used to conduct periodic grab sampling of DO, pH, and turbidity.

The current (updated in the spring of 2008) data logging system at each of Grant PUD's FSM stations consist of the same basic equipment. This includes the multi-probe enclosed in a submerged perforated conduit or standpipe, which is connected to a Sutron Corporation 8210 or 9210 data collection platform (DCP). Multi-probes are interrogated hourly (on the top of the hour) and data is archived within the DCP. The DCPs are then interrogated via radio transmission into Grant PUD's fiber-optic network, which then transfers the data into a secure database (using Sutron's XConnect® database software). Duplicates of the raw data are made available to Grant PUD's water quality web-site (see Section 6.5.4).

4.2 Purpose and Objectives

The purpose of monitoring water quality parameters at the FSMs is to continue to provide information on water quality conditions within the Project, as well as verify compliance with applicable water quality standards and conditions within the WDOE 401 WQC. The following list provides the monitoring requirements of the 401 WQC (WDOE 2007) with the relevant sections of the 401 WQC shown for reference:

- Conduct hourly TDG monitoring throughout the year within the forebay and tailrace of Wanapum and Priest Rapids dams (Section 6.4.10);
    - TDG data shall be made available electronically to the public as close to the time of occurrence as technology will reasonably allow (Section 6.4.11(a)),
    - A fish-spill season TDG monitoring report shall be submitted to WDOE by October 31 of each year (Section 6.4.11 (c)),
- Grant PUD shall provide a temperature monitoring program through a QAPP (Section 6.5.1);
- Grant PUD shall continue to provide periodic monitoring of pH and DO in the Project (Section 6.6.1(a));
- Grant PUD shall provide water quality monitoring results and summary reports to WDOE by March 1 of each year (Section 6.7.3); and
- Grant PUD shall make available to the public all water quality monitoring data and results collected as part of the 401 WQC on its web-site or other readily assessable means (Section 6.1.19).

The following list provides a summary of the purpose and objectives of Grant PUDs FSM program:

- Continue to collect water quality data within the Project to track trends in water quality; data will be used in annual water quality summary reports;
- Post water quality monitoring data onto Grant PUD's water quality web-site, available for public use;
- Verify compliance with conditions of the Project 401 WQC and Washington's water quality standards for temperature, TDG, DO, pH, and turbidity; and
- Use TDG data collected during the fish-spill season to help make adjustments to fish-spill amounts in order to remain within water quality standards for TDG, in consultation with

appropriate fishery resource agencies and tribes according to procedures outlined in Grant PUD's Gas Abatement Plan (Grant PUD 2008b).

The purpose and objectives of the FSM program will be met using the following basic methods. Because Grant PUD's FSM program has been in place since 2001, with the most recent update to the system in the spring of 2008, no new actions are required to begin the program. The FSM program's purpose and objectives will be met by simply continuing Grant PUD's current FSM program with a few minor additions as described in this QAPP. Additional details on the program will be presented in the following sections; the generalized list below provides a summary of actions that will be continued/maintained to meet the purpose and objectives:

- Continue to use Hydrolab® (or equivalent) multi-parameter water quality probes to collect temperature, TDG, DO, pH, and turbidity data;
- Maintain current FSM locations used to continually monitor water quality parameters within the Wanapum and Priest Rapids dam forebay and tailrace areas;
- Maintain current FSM data transmission software/hardware that allows for TDG and temperature data to be transmitted to Grant PUD's water quality web-site within two hours of being collected;
- Continue to conduct periodic grab-sample monitoring of DO, pH, and turbidity data;
- Maintain current quality assurance and quality control procedures to assure data is accurate and reliable; and
- Apply the adaptive management process to the FSM monitoring program in order to allow for changes, modifications, and improvements based on monitoring results, regulatory changes, operational or structural changes to either Wanapum or Priest Rapids dams, requirements in TMDLs. etc. Grant PUD will review and update this QAPP, annually as needed, and implement any changes to the plan pending WDOE and FERC approval.

4.3 Parameters to be Monitored

In order to meet the purpose and objectives outlined above, Grant PUD will monitor TDG, temperature, DO, pH, and turbidity at its FSM stations. The following sections provide further detail on the parameters to be monitored.

4.3.1 Total Dissolved Gas

TDG will be measured on an hourly basis using a Hydrolab® TDG sensor, which uses a pressure transducer mounted behind a rigid gas-permeable silicone membrane to measure amount of total gaseous compounds dissolved in a liquid. The measurement quality objectives, range, precision, accuracy, and resolution of the TDG sensor are provided in Table 1. TDG will be measured in mm Hg and then converted to percent saturation using barometric pressure measurements recorded by a certified barometer located at each FSM station. The conversion equation is as follows:

TDG in percent saturation = (TDG mm Hg / barometric pressure mm Hg) x 100

The TDG sensor is connected to a Hydrolab® multi-probe, which transmits data to a Sutron DCP where it is then transmitted to the FSM database (see Section 4.0). Raw TDG data will be made available to Grant PUD's water quality web-site within approximately two hours of delay from time of measurement. The primary use of data will be to:

- Comply with the requirements of the 401 WQC (WDOE 2007);
- Verify compliance with WDOE's TDG water quality standards; and
- Help guide Grant PUD's fish-spill program by using TDG data collected during the fish-spill season to help make adjustments to fish-spill amounts in order to remain within water quality standards for TDG, in consultation with appropriate fishery resource agencies and tribes according to procedures outlined in Grant PUD's Gas Abatement Plan (Grant PUD 2008b).

4.3.2 Water Temperature

Water temperature will be measured on an hourly basis at each FSM station using a Hydrolab® 30k ohm variable resistance thermistor. The measurement quality objectives, metrics, range, precision, accuracy, and resolution of the temperature sensor are provided in Table 1. The sensor is connected to a Hydrolab® mulit-probe, which transmits data to a Sutron DCP where it is then transmitted to the FSM database (see Section 4.0). Raw temperature data will be made available to Grant PUD's water quality web-site within approximately two hours of delay from time of measurement. The primary use of data will be to:

- Comply with the requirements of the 401 WQC (WDOE 2007);
- Verify compliance with WDOE's water temperature standards;
- Track changes in water temperatures over time; and
- Provide input data into a temperature simulation program that will used to model the Project's ability to achieve temperature water quality standards, per section 6.6.2 of the 401 WQC (WDOE 2007).

4.3.3 Dissolved Oxygen, pH, and Turbidity

DO, pH, and turbidity data will be measured on a periodic basis at each FSM station using Hydrolab® DO, pH, and turbidity sensors. The measurement quality objectives, metrics, range, precision, accuracy, and resolution of the DO, pH, and turbidity sensors are provided in Table 1. These sensors are connected to a Hydrolab® multi-probe that will be used as the "grab-sample" probe during regular FSM station maintenance and multi-probe deployment activities, currently occurring once every two weeks during the fish-spill season (typically April through August) and every three weeks during the non-fish-spill season (typically September through March). DO, pH, and turbidity data will be made available on Grant PUD's water quality web-site after it is collected; the primary use of the data will be to:

- Comply with the requirements of the 401 WQC (WDOE 2007); and
- Track compliance with WDOE's water quality standards for DO, pH, and turbidity.

Because DO, pH, and turbidity will be measured using grab-sample methods, staff collecting the measurements will follow pre-established protocol to collect and record the measurements. The protocols include the following (see also section 6.3 of this QAPP):

- Allow the multi-probe adequate time to equilibrate to river conditions; this will be done by allowing TDG to come within 10 mm Hg of the TDG value recorded by the existing FSM station probe. This typically takes 15–30 minutes depending on TDG levels;
- Measure DO, pH, and turbidity from well mixed portions of the river. Grab-sample measurements will be taken from the FSM station standpipe, which are all located mid-channel within the main flow currents at a minimum depth of three meters;
- Collect all measurements from the same locations within the river. Because all measurements will be taken from the FSM station standpipes, each measurement will be taken from the same location within the Project and measurements will be taken from each FSM station on the same day to determine spatial and temporal variations;
- Record measurements on hand-held PDA using Hydrolab's® Hydras 3 software; date, time, personnel, multi-probe serial number, and other notes will be recorded with each measurement; and
- Five measurements will be taken every minute to make a composite measurement (average of the five measurements).

A summary of the water quality parameters to be monitored under this QAPP can be found in Table 1.

Table 1 Water quality parameters to be monitored

Parameter	**Location(s)**	**Frequency**	**Metric**	**Standards**
Total Dissolved Gas	Forebay and tailrace of each dam	Hourly	mm Hg; convert to % Saturation	non fish-spill season: <110% saturation fish-spill season: <115% in forebay, <120% in tailrace, and <125% maximum
Water Temperature	Forebay and tailrace of each dam	Hourly	˚C	If Natural <18˚C, then <2.8 ˚C increase If natural >18˚C, then >0.3˚C increase
Turbidity	Forebay and tailrace of each dam	Every two weeks (April 1-Aug 31) Every three weeks (Sept.-March)	nephelometric turbidity unit (NTU)	<5 NTU increase above background (upstream) conditions
pH	Forebay and tailrace of each dam	Every two weeks (April 1-Aug 31) Every three weeks (Sept.-March)	pH units	6.5 – 8.5 units
Dissolved Oxygen	Forebay and tailrace of each dam	Every two weeks (April 1-Aug 31) Every three weeks (Sept.-March)	milligrams per liter (mg/L)	>8.0 mg/L

4.4 Organization and Schedule

This section provides details on the organization and schedule of the FSM program. Because Grant PUD's FSM program was initiated during the relicensing period and has been operational since 2003, following the QA/QC guidelines and procedures outlined by Duvall and Dresser (2003), many of these activities are on-going and will continue pending approval of the QAPP. There are some new activities and procedures, regulatory requirements, as well as updates to the initial software/hardware that were not included in the initial QA/QC report (Duvall and Dresser 2003), and those updates and implementation schedules are reflected in this QAPP. Table 2 provides the individuals at Grant PUD with key responsibilities in the implementation of the FSM program.

Table 2 List of key personnel and responsibilities

Personnel	Title	Responsibilities	Contact information
Ross Hendrick	Limnologist; Project Manager	Program oversight, management, data analysis and QA/QC, report generation, and communication with WDOE and outside agencies/public	509-754-5088, ext. 2468; rhendr1@gcpud.org
Carson Keeler	Biologist I; Equipment and Field Manager	Field work, calibration scheduling, program oversight assistance, data collection, probe calibration and maintenance, data QA/QC	509-754-5088, ext. 2687; ckeeler1@gcpud.org
Mark Woodward	Biologist I; Equipment and Field Manager	Field work, calibration scheduling, program oversight assistance, data collection, probe calibration and maintenance, data QA/QC	509-754-5088, ext. 2692; mwoodwa@gcpud.org
Amy Jo Para	Info Ctr Analyst IV; Programming and Application Support	Data transmission software/hardware support	509-754-5088, ext. 2354; apara@gcpud.org
Allen Swenson	Webmaster	Data transmission software/hardware support; web-site support	509-754-5088, ext. 2215; ASWENSE@gcpud.org
Ted Harris	Electronic Tech IV	Data transmission support - fiber optics	509-754-5088, ext. 4004; Tharris@gcpud.org
Monhan Sunderam	Telecommunications Engineer	Data transmission support - radio transmission and communication	509-754-5088, ext. 4004; Msunder@gcpud.org
Suresh Nalla	Program Analyst V	Data transmission support - Sutron XConnect Software	509-754-5088, ext. 2413; Snalla@gcpud.org
Marcie Mangold (WDOE)	Water Quality Program – WDOE Eastern Regional Office	Grant PUD's contact for all correspondence related to the 401 Water Quality Certification	509-329-3450; dman461@ecy.wa.gov

The following table provides a summary of the schedule that will be followed for implementation of the FSM program. Additional details are provided in the relevant sections.

Table 3 Schedule of fixed site water quality monitoring activities

Activity	Purpose	Schedule	Frequency	Key Personnel (see also Table 2)
Implement FSM program per QAPP	Collect water quality data from fixed locations and time periods; comply with 401 WQC	April 2009 (pending approvals)	Continually	All (see Table 2)
Collect TDG Data	Comply with 401 WQC and help guide fish-spill program; collect trend data to compare with historical data	On-going	Hourly	Hendrick/Keeler/Woodward
Collect temperature data	Comply with 401 WQC; collect trend data to compare with historical data	On-going	Hourly	Hendrick/Keeler/Woodward
Collect DO/pH/turbidity data	Comply with 401 WQC; collect trend data to compare with historical data	On-going	Every two weeks from April 1-Aug. 31 and every 3 weeks from Sept. 1 to March 31	Hendrick/Keeler/Woodward
Conduct QA/QC checks	Comply with 401 WQC; assure that data is accurate and reliable	On-going	Varies; see relevant sections of QAPP	Hendrick/Keeler/Woodward
Post water quality data to web-site	Make data available to public per conditions of 401 WQC	On-going/April 2009	Varies; see relevant sections of QAPP	Hendrick/Keeler/Woodward
Calibrate water quality probes	Assure accurate data is being collected, prevent sensor drift, error, and/or failure	On-going	Every two weeks from April 1-Aug. 31 and every 3 weeks from Sept. 1 to March 31	Hendrick/Keeler/Woodward
Perform routine maintenance at FSM locations	Check functionality/condition of battery and solar power supply, cables, radio connections, hardware, standpipe, etc.	March 31 2009	As needed and at least once prior to April 1 and again prior to October 1 of each year	Keeler/Woodward
Conduct ice-bath checks of temperature sensors	Verify accuracy of temperature sensors against NIST thermometer	Prior to spring to April 15	Annually	Keeler/Woodward
Conduct semi-annual FSM program meetings	Continued coordination between all responsible parties, discuss trouble-shooting procedures, calibration methods, software/hardware issues, etc	March 31 2009	Prior to April 1 and again prior to October 1 of each year	All (see Table 2)
Conduct field audit of calibration, maintenance, and deployment methods	Assure proper implementation of this QAPP, determine need for adjustments to methods (through adaptive management)	By December 1 of each year	Annually	Hendrick
TDG Fish-spill monitoring report	Summarize TDG monitoring and fish-spill activities during fish-spill season and provide to WDOE per conditions of 401 WQC	October 31	Annually	Hendrick

Table 3 continued…

Activity	Purpose	Schedule	Frequency	Key Personnel
Attend regional TDG monitoring and QA/QC meeting	Present results of FSM program, discuss QA/QC methods of other dam operators	November	Annually as determined by U.S. Corps of Engineers (hosts)	Hendrick
Attend regional water quality meetings, forms, and trainings	Stay current with regionally accepted water quality monitoring methods, equipment, and QA/QC procedures; apply adaptive management to FSM program as needed	As needed	As needed	Hendrick/Keeler/Woodward
Water quality monitoring summary report	Summarize previous year's water quality monitoring results	March 1	Annual report	Hendrick
Review/Update QAPP as needed	Application of adaptive management to water quality monitoring program	April 15	QAPP shall be reviewed annually and updates made as needed	Hendrick

5.0 Data Quality Objectives

The overall purpose of monitoring the parameters discussed in this QAPP are to monitor changes or trends in water quality within the Project and to determine compliance with water quality standards, which have been established, in part, to help assure the biological objectives for the Project can be met. Making decisions on changes in water quality compared to historical data, or if water quality standards are being achieved must be made based on data that passes data quality objectives.

The WDOE (2004) indicates that when data will be used to select between two clear alternative conditions or to determine compliance with a standard, quality objectives need to be specified at two levels: Decision (or Data) quality objectives (DQOs) and measurement quality objectives (MQOs). DQOs are needed to determine the number of samples that must be taken to meet the objectives of the project. MQOs specify how good the data must be in order to meet the objectives of the project. For Grant PUD's FSM program, DQOs will be measured by the data representativeness, completeness, and comparability (described in detail below). Obtainment of MQOs will be determined by comparing data collected with specific data quality indicators such as precision, bias, and sensitivity. Following manufacturer recommendations of multi-probe use, calibration, and maintenance are also considered MQOs of the FSM program and are explained in section 6.0 of this QAPP.

5.1 Decision Quality Objectives

For this effort, data collection methods will be designed in such a manner that the results can be used to determine if the water quality criteria have been met; therefore, quality objectives at the level of the decision are required. These objectives will be met by carefully determining the number of measurements taken to represent a given condition.

The success of obtaining these objectives can be measured by ensuring that the representativeness, completeness and comparability are controlled. Each is described below.

5.1.1 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. For this investigation, representativeness is a qualitative parameter that is primarily concerned with proper design of the sampling program, and can be best satisfied by ensuring that the monitoring locations are properly located with a sufficient number of data collected. For the FSM program, data will be colleted from monitoring locations fixed within the middle of the river channel (see section 6.1) at the appropriate depth (see section 6.2.2), and will be collected at frequencies that will provide sufficient data to determine trends and if water quality standards are being met (see section 6.2.1).

5.1.2 Comparability

The comparability criterion is a qualitative characteristic that expresses the confidence with which one data set can be compared to another. Principal comparability issues are field sampling techniques, and standardized concentration units and reporting formats. Data comparability is achieved using standard field sampling techniques and measuring methods; however, comparability is limited by the other MQOs because only when precision and bias (accuracy) are known can data sets be compared with confidence. For the FSM program, water quality parameters are monitored using standard units of measurement at fixed locations, and therefore data will be comparable to both historical data collected/reported by Juul (2003) and Normandeau (2000) and in the subsequent years after this QAPP is implemented.

5.1.3 Completeness

Completeness is defined as the percentage of valid analytical determinations compared to the total number of determinations. Typical field or electronics problems may result in completeness of less than 100 percent, and therefore a reasonable completeness goal is 90 percent, which will be the goal of the FSM program. Completeness will be evaluated and documented throughout all monitoring, and corrective actions taken as warranted on a case-by-case basis through adaptive management (see section 7.0).

5.2 Measurement Quality Objectives

The term "data quality" refers to the level of uncertainty associated with a particular data set. Data quality associated with environmental measurement is a function of the sampling plan rationale and procedures used to collect the samples, as well as the monitoring methods and instrumentation used in making the measurements. Uncertainty cannot be eliminated entirely from environmental data. However, quality assurance programs effective in measuring uncertainty in data are employed to monitor and control deviation from the desired DQOs. Sources of uncertainty that can be traced to the sampling component are poor sampling plan design, incorrect sample handling, faulty sample transportation (if applicable), and inconsistent use of standard operating procedures (SOPs). The most common sources of uncertainty that can be traced to the analytical component of the total measurement system are calibration and contamination (i.e. equipment not "resetting" or fully equilibrating in a new sampling location). One of the primary goals of this QAPP is to ensure that the data collected are of known and documented quality and useful for the purposes for which they are intended. The procedures described are designed to obtain data quality indicators for each field procedure and analytical method. To ensure that quality data continues to be produced, systematic checks must show that test results and field procedures remain reproducible, and that the methodology employed is actually measuring the parameters in an acceptable manner. For the field measurements to be conducted under this QAPP (including TDG, temperature, DO, pH, and turbidity) many MQOs can be specified. Each of the MQOs that pertain to this QAPP is further discussed below. The goals for this effort are outlined in Table 4.

Table 4 Measurement quality objectives

Parameter	Smallest Reference Level for Decision making	Range of Instrument	Bias/Accuracy	Sensitivity/ Resolution
Total Dissolved Gas	1% Saturation	400 to 1400 mmHg	+/- 1.5 mmHg	1.0 mmHg (0.1% sat.)
Water Temperature	0.3˚C	-5 to 50˚C	+/- 0.1˚C	0.01˚C
pH	0.5 units	0 to 14 units	+/- 0.2 units	0.01 units
Turbidity	5 NTU	0 to 100 NTU	+/- 1% of range	0.1 NTU
Dissolved Oxygen	0.2 mg/L	0 to 50 mg/L	+/- 0.1 mg/L at < 8 mg/L +/- 0.2 mg/L at > 8 mg/L	0.01 mg/L

5.2.1 Precision

Precision is a measure of the reproducibility of an analysis or set of analyses under a given set of conditions and generally refers to the distribution of a set of reported values about the mean. The overall precision of a sampling event has both a sampling and an analytical component. The precision provides transparency into presence of random error such as field sampling procedures, handling, and data collection/analysis method. A reduction of precision could be introduced to this work in several ways including using equipment that is not sensitive enough (see section 5.2.3 below), collecting measurements over a large spatial or temporal regime, using a wide range of types of equipment, etc. The FSM program will use the same type of equipment to monitor water quality (Hydrolab® multi-probes) over a small spatial and temporal regime. A means of determining the precision of a measurement is to conduct duplicate sampling (e.g. making the same measurement in the same location at approximately the same time with the same type of equipment) and looking at the variability in results. As part of the FSM program, duplicate sampling will occur each time a newly calibrated multi-probe is deployed (see section 6.0).

5.2.2 Bias

Bias (otherwise known as accuracy) is the difference between the population mean and the true value of the parameter being measured. Bias in measurements obtained under this QAPP may be introduced by faults in the sampling design (e.g. all of the temperature measurements collected in one location that is not indicative of the mixed flow or strata of interest), inability to measure all forms of the parameter of interest (e.g. inability of a thermometer to reach a temperature regime needed due to physical obstacles), improper or insufficient calibration of instrumentation and/or equipment. Bias will be minimized by following standard protocols for calibration and maintenance, and by following field protocols for stabilization of the multi-probes.

5.2.3 Sensitivity

Sensitivity denotes the rate at which the analytical response varies with the concentration of the parameter being measured, or the lowest concentration of a parameter that can be detected (often referred to as “resolution” for water quality equipment). For this work, equipment must be selected that provides tight enough tolerances to ensure that the data collected are described to the necessary precision. For example, if water criterion for temperature is concerned with a temperature shift of greater than 0.3 degrees Celsius, then the equipment should be able to measure the water temperature with sensitivity less than 0.3 degrees Celsius, preferably by an order of magnitude. Often, the accuracy is much larger than the resolution. If this is the case, the accuracy is the smallest verifiable value reported by the instrument. All of the sensors used for the FMS program have sensitivities less than required to determine compliance with water quality standards (see Table 4).

6.0 Methods

The following sections provide the methods that will be used to meet the purpose and objectives of the FSM program.

6.1 Monitoring Locations

All water quality parameters discussed in this QAPP will be measured at Grant PUD’s existing FSM stations, located in the forebay and tailrace of Wanapum and Priest Rapids dams.

6.1.1 Wanapum Dam

The Wanapum Dam forebay FSM station is located near Turbine Unit 10 (N46°5229.008, W119°5817.150 - Datum WGS 84) and is affixed to the catwalk approximately mid-channel (Figures 4–5). The Wanapum tailrace FSM station is located approximately 3.2 miles downstream of Wanapum Dam. The tailrace standpipe is located at mid-channel and is attached to the downstream side of Beverly Bridge, (N46°5001.538, W119°5631.884 - Datum WGS 84; Figure 4 and Figures 6–7).

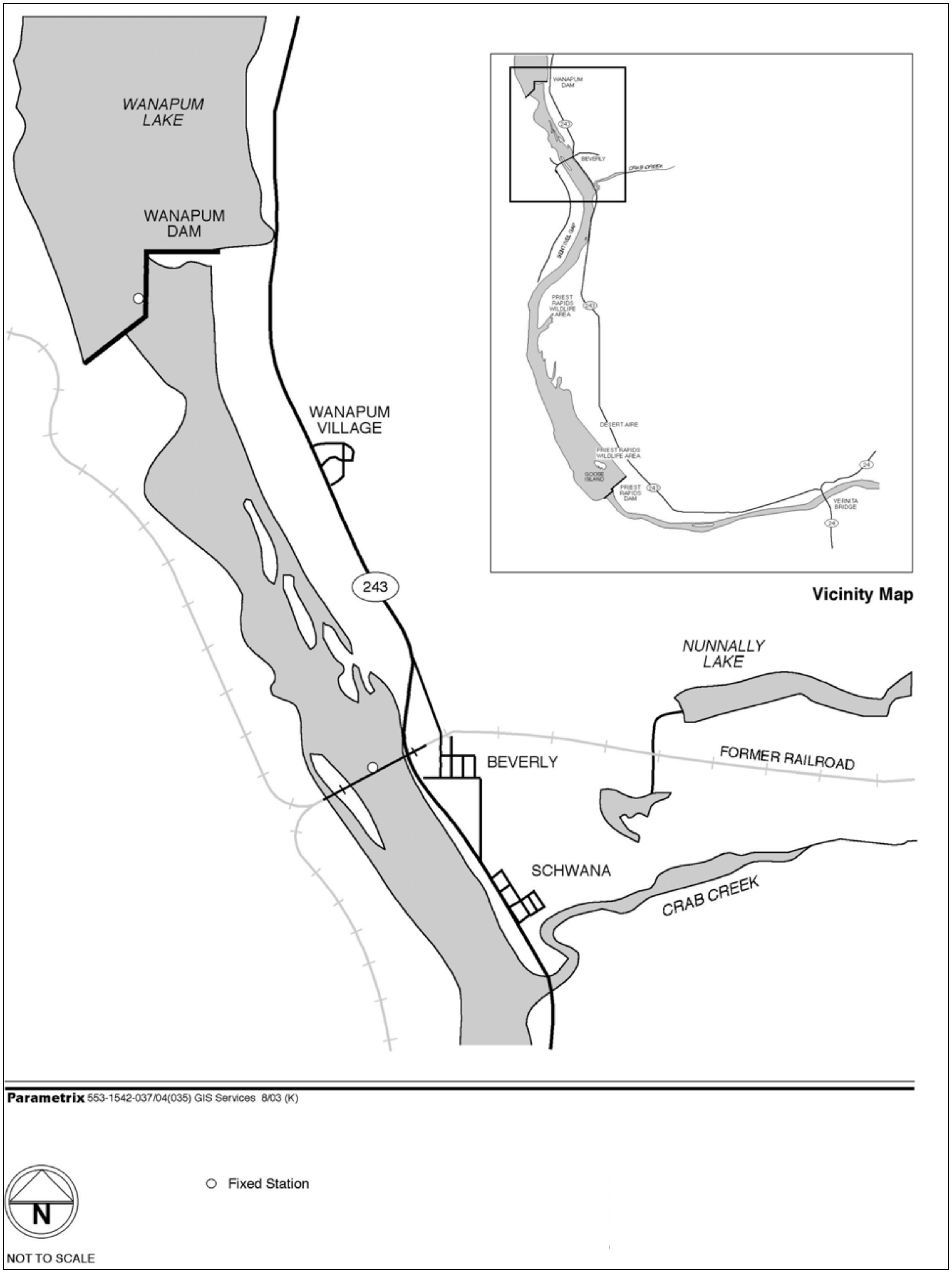

Figure 4 Location of water quality fixed site monitoring stations for Wanapum Dam.

Figure 5 **Photograph of Wanapum Dam forebay water quality fixed site monitoring station, Priest Rapids Project, mid-Columbia River.**

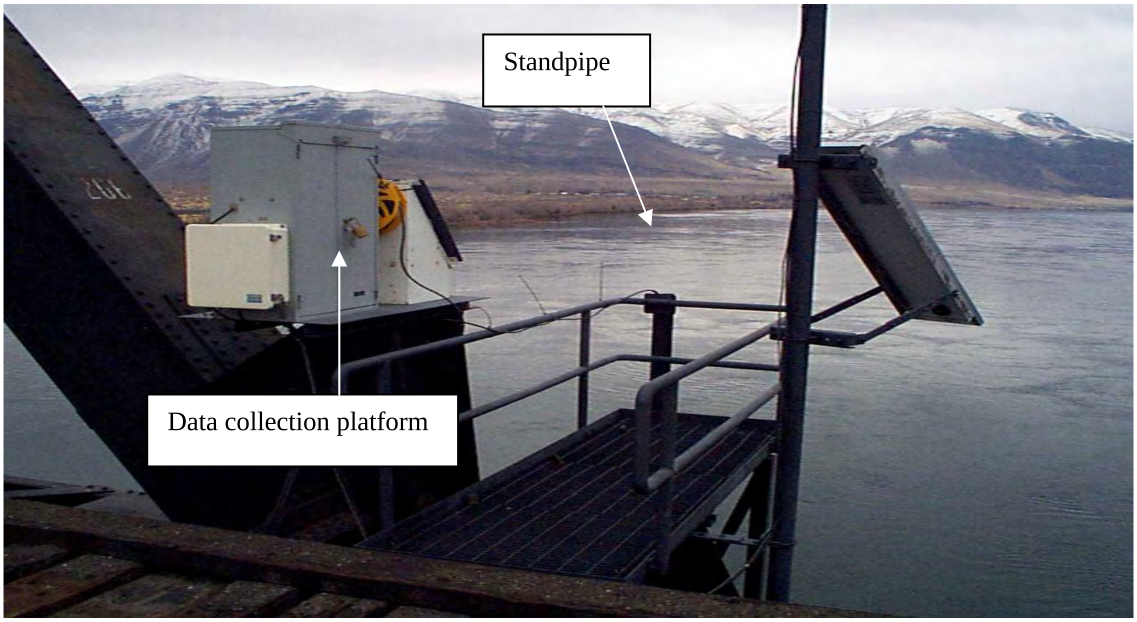

Figure 6 **Photograph of Wanapum dam tailrace water quality fixed site monitoring station, looking downstream from Beverly Bridge. Priest Rapids Project, mid-Columbia River.**

Figure 7 Photograph of Wanapum dam tailrace water quality fixed site monitoring station, looking upstream at Beverly Bridge. Priest Rapids Project, mid-Columbia River.

6.1.2 Priest Rapids Dam

The FSM station in the forebay of Priest Rapids Dam is attached to the piernose directly between the powerhouse and spillway and is located at mid-channel and approximately the center of the dam (N46°3840.324, W119°5436.633 - Datum WGS 84; Figures 8 and 9). The Priest Rapids Dam tailrace FSM station is located nine miles downstream of Priest Rapids Dam at Vernita Bridge. It is also located at mid channel and attached to a center support of the bridge (N46°3831.197, W119°4357.447 - Datum WGS 84; Figures 8 and 10).

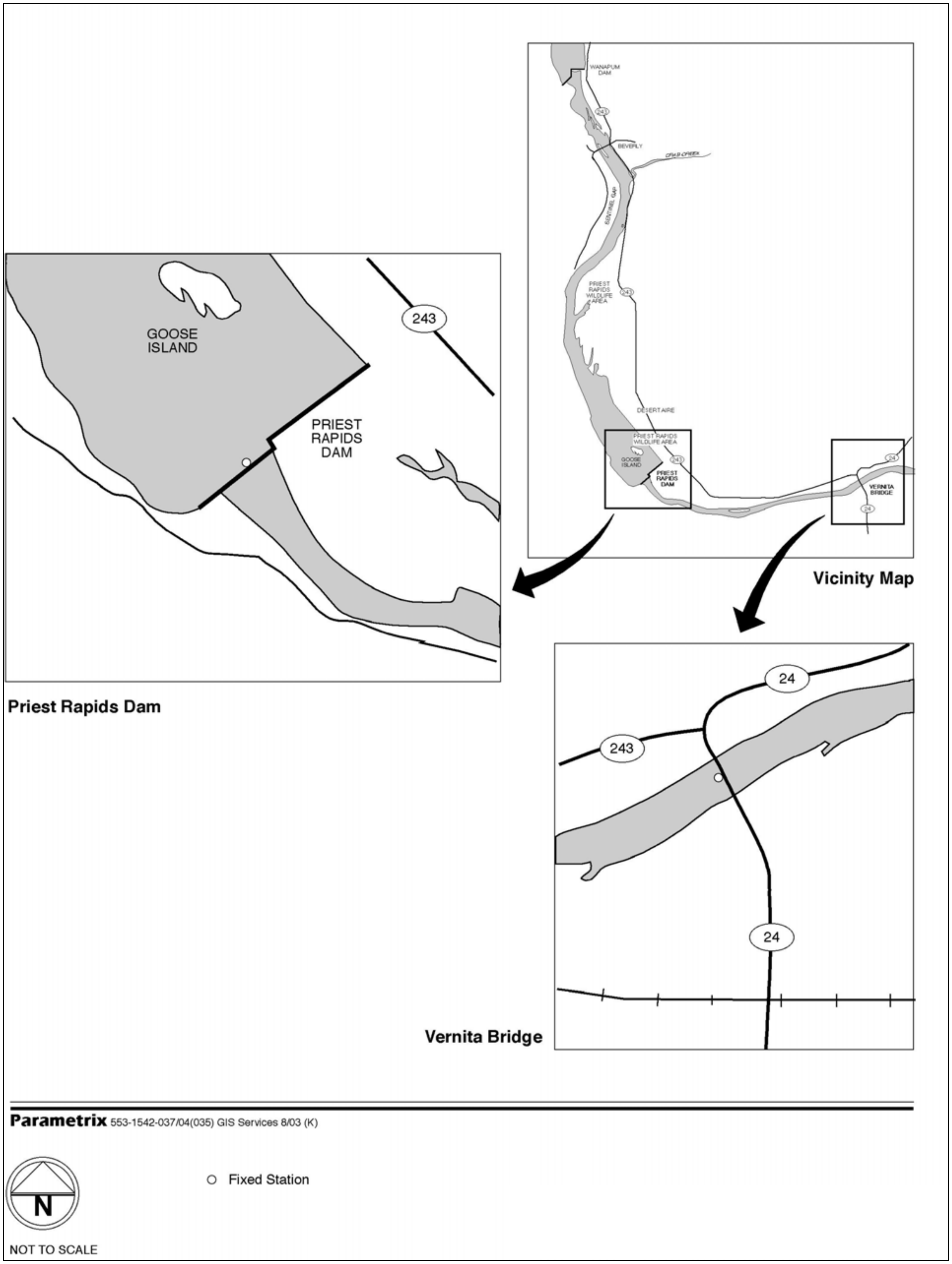

Figure 8 **Location of water quality fixed site monitoring stations for Priest Rapids Dam.**

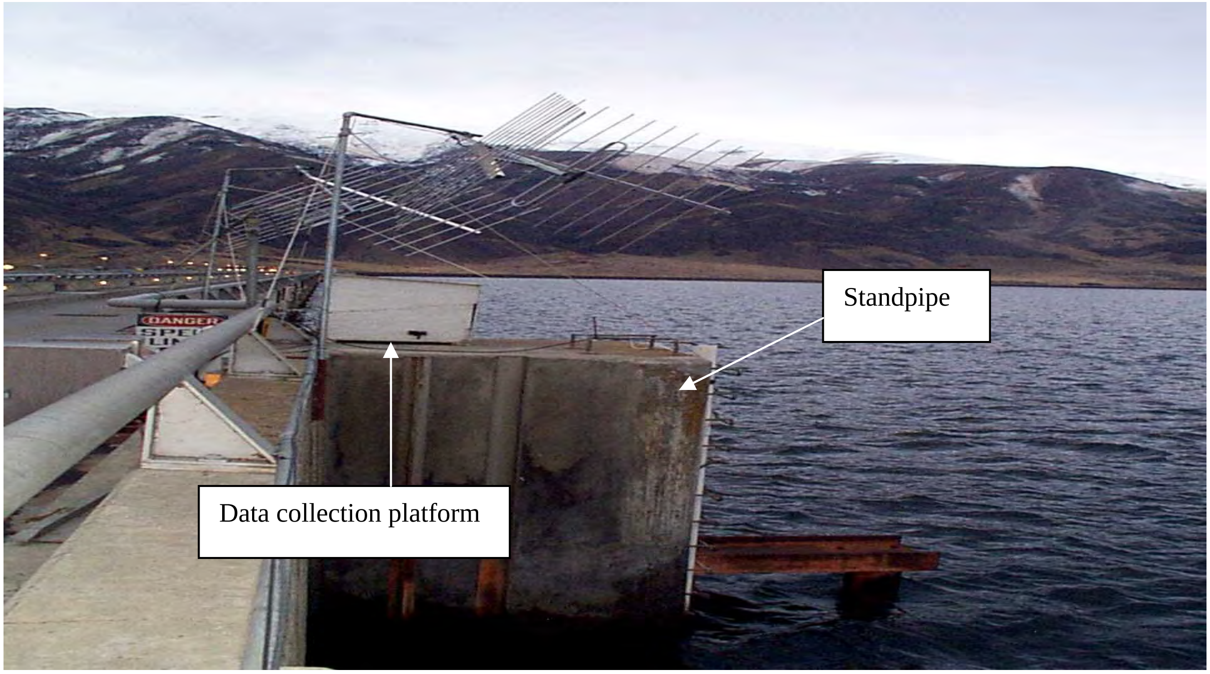

Figure 9 **Photograph of Priest Rapids Dam forebay water quality fixed site monitoring station, looking to the west. Priest Rapids Project, mid-Columbia River.**

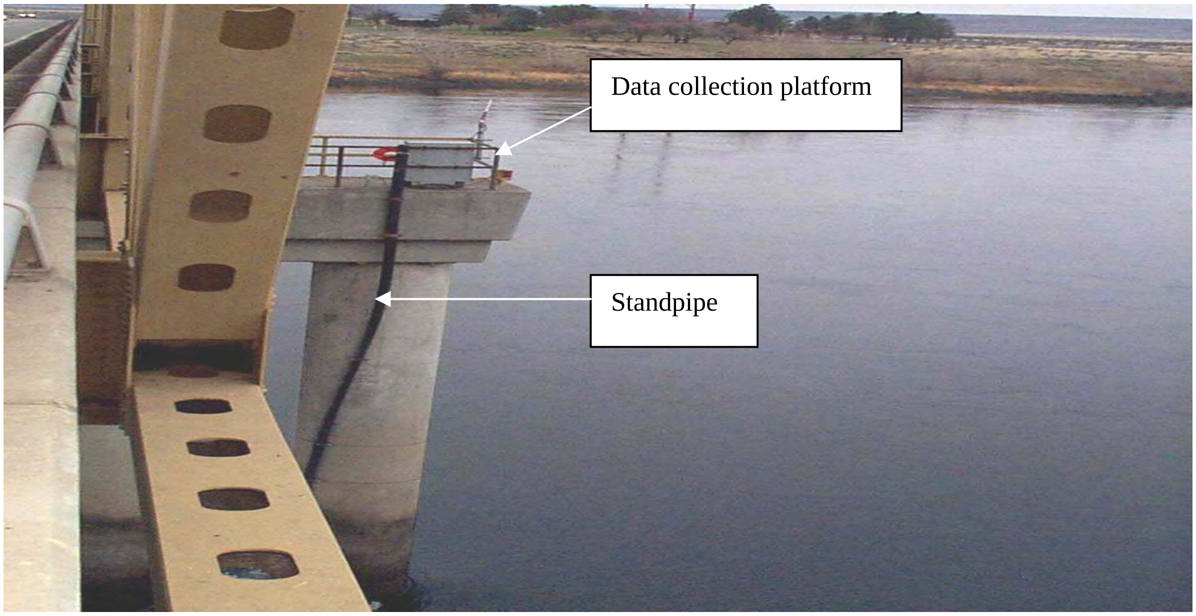

Figure 10 **Photograph of Priest Rapids Dam tailrace water quality fixed monitoring station, looking to the west from Vernita Bridge. Priest Rapids Project, mid-Columbia River.**

6.2 Monitoring Procedures

The following sections present the monitoring procedures that will be used at part of Grant PUD's FSM program, designed to meet the DQOs and MQOs.

6.2.1 Frequency

Table 1 provides the frequency that each water quality parameter will be measured. These frequencies follow the requirements of the 401 WQC (WDOE 2007), which provide that TDG and water temperature be monitored on an hourly basis, while DO and pH be monitored on a "periodic basis." Grant PUD will also continue to collect turbidity data as part of the DO and pH periodic monitoring. The once every two or three week grab-sample approach to the DO, pH, and turbidity monitoring follow Grant PUD's calibration and maintenance schedule for the water quality probes at the FSM stations, and allow for DO, pH, and turbidity measurements to be taken with the quality assurance/quality control (QA/QC) probe (see Section 6.3). The QA/QC probe is used to check accuracy and precision of newly deployed probes with those that have just been taken out, and is used at each site during probe deployment. Therefore DO, pH, and turbidity measurements will be taken from the multi-probe on the same day at each FSM station. Furthermore, measuring DO, pH, and turbidity with a newly calibrated water quality probe will reduce potential bias or sensor drift issues that can occur with DO, pH, and turbidity sensors that are left in the river for extended periods of time and are monitoring on an hourly bias. For example, pH probes can appear to calibrate satisfactorily but still not provide accurate field measurements due to the high-ionic strength of the pH buffers (typically 8,000 to 10,000 μmhos/cm) used for calibration versus the relatively low-ionic strength of the water in the Columbia River (usually 95 to 150 μmhos/cm).

6.2.2 Monitoring Depth

The monitoring depth of the hourly TDG and water temperature measurements will vary with forebay and tailrace elevations throughout the year. Given the depth of the standpipes at each FSM station, the depths should range between three and five meters. The periodic grab-samples of DO, pH, and turbidity should be measured as consistently as possible at the same depths during each monitoring event, while prioritizing the goal of capturing the condition of the mixed flow. Again, depending on forebay and tailrace elevations the depth of measurement is anticipated to be three to five meters from the surface.

6.2.3 Equipment

The equipment used for this monitoring effort will be Hydrolab® multi-probes. Appendix B provides information on Hydrolab® series 5 and 4a multi-probes. Hydrolab® probes are used throughout the Columbia River Basin, including use by other Columbia River dam operators (e.g. Chelan PUD 2007, Tanner 2003, and Corps 2008).

6.3 Calibration and Maintenance

Calibration and maintenance of the individual sensors of the Hydrolab® multi-probes will follow the manufactures recommendations and regionally accepted methods used by other resource agencies conducting similar monitoring programs, such as the USGS, U.S. Army Corps of Engineers (Corps), and other mid-Columbia River Dam operators. The general calibration, maintenance, and deployment methods (see below) for the multi-probes also follow regionally accepted methods.

To ensure accurate data collection, Grant PUD replaces multi-probes every two weeks during the fish-spill season and every three weeks during the non-spill season. Grant PUD has also established Probe Quality Assurance and Control (PQAC) SOPs to assure that data collection is accurate, reliable and consistent, and to minimize data loss. The PQAC SOPs have been modeled after USGS quality assurance and control methods (Tanner 2001 and 2003) and is updated as new techniques in maintenance and calibration are developed. In addition, Grant PUD staff routinely (at least once per year) attends Hydrolab® workshops, specialized training sessions, or regional QA/QC meetings to maintain consistency with new methodologies and techniques.

The first procedure in the PQAC SOP includes recording information regarding the FSM station location, date, time, equipment serial numbers and calibration data. The PQAC process allows Grant PUD to record data from three different instruments and compare data sets to verify precision.

The most current, real time data is recorded from the existing probe (field multi-probe) that will be removed. A recently calibrated QA/QC probe is deployed into the secondary standpipe. The QA/QC probe is allowed to fully stabilize and equilibrate after immersion. The sensor depth of all three probes is recorded to assure compensation depth has been achieved.

Once equilibration is reached by the QA/QC probe (when TDG of the QA/QC probe is within 10 mm Hg of the existing probe), the date/time and real time data for depth, water temperature, DO, pH, TDG, and turbidity are recorded once every minute for approximately five minutes, with the average of those five measurements being taken as a composite measurement. This composite measurement consists of the grab-sample needed for DO, pH, and turbidity monitoring.

After data is collected from the QA/QC probe, the newly calibrated probe (replacement probe), which will remain at the location is deployed. After sufficient time is allowed for the probe to equilibrate (to within 10 mm Hg TDG of existing probe), the real time data values are recorded using a composite average of five readings taken every minute for five minutes. The values are then compared to the QA/QC readings and the data recorded by the field-probe. If the data sets from all three probes are comparable, consistent, and reasonable, the new probe is deployed and connected to the DCP.

At the end of each FSM multi-probe removal/deployment and maintenance activity, post-calibration procedures are preformed on the removed field probe. The removed probes are then stored in the laboratory and calibrated following the maintenance and calibration procedures described above the day before it is to be re-deployed (during the next scheduled FSM site visit). If a problem was discovered during the calibration procedures; it is recorded and the multi-probe is shipped to the manufacturer for servicing or problem is discussed and solved over the phone with a Hydrolab® technician. An entry is added to the troubleshooting logbook as to what actions were made to correct the problem.

The following sections provide details on the calibration methods for each individual sensor of the water quality multi-probe.

6.3.1 Total Dissolved Gas

As discussed in the above section, calibration, maintenance, and deployment of the TDG sensors will occur every two weeks during the fish-spill season, when TDG levels are typically highest, and every three weeks during the non-fish spill season. Post-deployment maintenance methods for the TDG sensors include removing the TDG membranes from the removed multi-probes and cleaning them with a soft bristled brush and mild soap, and then allowing the membranes to air dry. TDG membranes are also visually inspected for leaks and condensation moisture trapped inside the membrane. The leaks will usually appear as large darker spots in the membrane and indicate that water has entered the silastic tubing. This can occur from either leaks through a tear in the membrane or water vapor diffusion causing condensation inside the membrane. Defective membranes are replaced before use. When not in use for extended periods of time, TDG sensors are covered with the storage cap and membranes are stored in a desiccator until future use.

To air calibrate TDG sensors, Grant PUD uses a certified mercury column barometer or portable field barometers that have been calibrated to a certified mercury column barometer. TDG is calibrated by comparing the instrument readings (in mm Hg) to those of the standard barometer at atmospheric conditions. TDG response slope checks are performed by adding known amounts of pressure, usually 200 mm Hg, directly to the transducer using a Netech Digimano 2000 digital pressure meter (certified to National Institute of Standards and Technology (NIST) traceable standard annually) to assure proper function and calibration. The membrane is bypassed during these calibrations so that the probe itself is calibrated, rather than the probe/membrane combination. Air calibrations are conducted pre- and post-deployment. If a TDG sensor does not meet post-deployment calibrations, all data collected by that sensor is considered suspect and additional review and quality checks are done to that data to determine if the sensor drifted during deployment. An inspection for leaks is performed on the membrane itself before completing calibration. One of the checks employed involves immersing the membrane in seltzer water (supersaturated with carbon dioxide). The expected result of a properly functioning membrane is an immediate jump in the TDG reading of at least 300 mm Hg above the barometer at atmospheric conditions; if the membrane fails to reach at least 300 mm Hg above the barometer reading, a new membrane is placed on the sensor and the seltzer water test is run again.

6.3.2 Water Temperature

Grant PUD follows the recommended maintenance for temperature sensors, which typically includes cleaning of the sensor to remove biological or chemical deposits. The temperature sensor is not removable and does not require any other maintenance accept to verify that the connection is securely fastened to the multi-probe. Grant PUD also conducts a visual check for damage.

Hydrolab® does not currently require a calibration method for the temperature sensor, as they calibrate the temperature sensor during construction of the multi-probes. However, per the recommendation of WDOE (2009), Grant PUD will test all Hydrolab® temperature sensors against a NIST thermometer at least once per year prior to the spring/summer monitoring period. Multi-probes and the NIST thermometer will be placed into an ice bath to verify temperature accuracy. Data collected during exposure to the ice bath will be compared to the certified thermometer to ensure that the temperature sensors of each respective multi-probe are performing properly. If inaccuracies are apparent in the Hydrolab® temperature sensors, they will not be deployed for temperature monitoring until the problem causing the inaccuracy can be identified and corrected.

6.3.3 Dissolved Oxygen

In 2003, Hydrolab® made commercially available a new DO sensor technology. A Luminescent Dissolved Oxygen (LDO) sensor was established to reduce the maintenance and calibration needs of previous technologies, such as the Clark Cell and Winkler Titration (Mitchell 2006). This sensor offers significant enhancements in terms of accuracy and sensor life over other existing technologies used to measure DO, including optodes using intensity-based measurements and the ability to self-correct for temperature and other changes in the sensor electronics (Mitchell 2006). Maintenance of the LDO sensor is simpler than the Clark Cell, consisting of cleaning the sensor with cotton swabs and distilled water to remove any excess debris or oil and replacing the protective cap once per year (Hach Company 2006). Starting in 2005, all new Hydrolab® series 5 multi-probes were fitted with an LDO sensor for DO collection; and Grant PUD currently has five series 5 multi-probes and uses them exclusively as the QA/QC probe used to collect DO, pH, and turbidity grab-samples.

6.3.4 pH

For pH, there are two types of sensors that are used for pH on the multi-probes deployed by Grant PUD. Both incorporate a glass electrode and pH reference electrode/Teflon junction. These sensors may be used in combination or used separately.

Maintenance includes cleaning the glass bulb with methanol and then gently scrubbing it with a cotton swab. The pH reference housing is filled with pH reference solution by gently pulling the housing out or by removing the housing using a flat head screwdriver, depending on style. Care is taken to avoid leaving air or bubbles inside the housing when finished.

Calibration entails rinsing the sensor(s) with distilled water and performing a pH response slope check using known pH standards, usually 7 and 10-pH standard. The sensor(s) are then submerged in 7-pH standard and pH readings are allowed to stabilize. The multi-probe is then reprogrammed to pH 7 which removes any prior deviation of greater than 0.01 units. This step is repeated using a pH 10 standard. All sensors are rinsed with distilled water before and after calibrations (Hydrolab 1999).

6.3.5 Turbidity

The multi-probes that Grant PUD deploys at its FSM stations have one of four different turbidity sensors. This includes the standard turbidity sensor (infrared and a photodiode detector), shutter turbidity, a 4-Beam turbidity sensor, or a self-cleaning sensor. All four of these turbidity sensors incorporate similar procedures for maintenance and calibration.

Maintenance on any of the four turbidity sensors is conducted by removing biological buildup and growth with a cotton swab. Calibration entails rinsing the sensor with distilled water and performing a turbidity response slope check using known turbidity standards, usually 0 and 40 NTUs. The sensor is submerged in 0 NTU standard (within a darken chamber and lid) and turbidity readings are allowed to stabilize. The multi-probe is then programmed to 0 NTUs. This step is repeated using a 40 NTU standard. All sensors are rinsed with distilled water before and after calibrations (Hydrolab 1999).

6.4 Analytical Methods

The analytical methods for data collected under this QAPP will center on two principle objectives:

1). Verify compliance with WDOE 401 WQC (2007) and WDOE water quality standards (WDOE 2006); and
2). Track water quality trend data over the entire 44-year operating license for the Project, adaptively managing the monitoring program based on data results, changes to Columbia River chemistry, use, and flows, and changes in the state water quality standards.

Analytical methods for each parameter to be monitored are included below.

6.4.1 Total Dissolved Gas

As explained in section 3.0, there are two different water quality standards for TDG that apply to the Project, both of which require TDG to be reported as percent saturation. TDG data collected as part of Grant PUD's FSM program will be measured in mm Hg and then converted to percent saturation using barometric pressure measurements recorded by a certified barometer located at each FSM station. The conversion equation is as follows:

TDG in percent saturation = (TDG mm Hg / barometric pressure mm Hg) x 100

During the non-fish-spill season and as part of Grant PUD's daily review of the previous day's real-time TDG data, values that exceed 110 percent will be highlighted and compared to upstream (incoming conditions) and to Wanapum and Priest Rapids dam operations, as TDG does not typically exceed 110 percent saturation in the Project unless involuntary spill is required at either Wanapum or Priest Rapids dams, or at an upstream dam. Any apparent exceedances of the 110 percent saturation standard will be reported in the annual report that is due to WDOE March 1 of each year. Explanations for the exceedances will be provided, including the possible causes for the exceedance and what was done to correct/prevent additional exceedances.

During the fish-spill season and as part of Grant PUD's daily review of the previous day's real-time TDG data, values that exceed the fish-spill season TDG standards will be compared to upstream (incoming conditions) and to Wanapum and Priest Rapids dam operations. If TDG exceedances are likely being caused by fish-spill operations, Grant PUD staff will consult with fishery resource agencies and tribes to determine if reductions in fish-spill operations are needed per various conditions set forth in Grant PUD's Biological Opinion (NMFS 2008), Salmon and Steelhead Settlement Agreement (Grant PUD 2006), 401 WQC (WDOE 2007), and GAP (Grant PUD 2008b). Grant PUD will use the appropriate calculation method for the TDG compliance value as set forth in WAC 173-201A-200(f)(ii); however, adjustments will be made by Grant PUD to account for the double-counting issued discussed in Section 3.0 of this QAPP. Appendix A provides an example of the method Grant PUD will use to account for the double-counting issue.

Furthermore, section 5.0(b) of the 401 WQC (WDOE 2007) and WAC 173-201A-200(f)(i) provide that the TDG water quality standard for both Wanapum and Priest Rapids dams shall be waived if flows exceed the “7Q10 flood flow,” which is the highest seven consecutive day average flow with a 10-year recurrence frequency. The 7Q10 flood flow was calculated to be 264 thousand cubic feet per second (kcfs) for Wanapum and Priest Rapids dams. Therefore, when the average of the 12 highest consecutive hourly discharge values in a 24-hour period exceed 264 kcfs, TDG values for that 24-hour period will be omitted from the data set. In addition, hourly TDG values greater than 125 percent will be not counted as a variance of the 125 percent hourly TDG water quality standard when the hourly flow value at the relevant dam was greater than the 7Q10 flow. Any omitted data, along with explanations as to why it was omitted, will be included in the appendix of the annual water quality monitoring reports.

Any apparent exceedances of the TDG standards will be reported in the annual water quality monitoring report that is due to WDOE March 1 of each year, as well as the fish-spill and TDG monitoring report due October 31 of each year. Explanations for the exceedances will be provided, including the possible causes for the exceedance and what was done to correct/prevent additional exceedances.

As detailed in the 401 WQC (WDOE 2007) and Grant PUD’s GAP (Grant PUD 2008b), Grant PUD is actively implementing operational and structural TDG abatement measures that are anticipated to help Grant PUD obtain consistent compliance with TDG standards by 2018, with adaptive management provisions included in the event that TDG standards are not expected to be met by 2018.

Tabular and graphical displays of the mean-daily, maximum, and minimum TDG values will also be provided in the annual water quality monitoring report to WDOE, as will explanations of suspect, omitted, or lost data, and overall data completeness (based on percent of data meeting MQOs). This same type of information will also be presented in the fish-spill and TDG monitoring report due to WDOE on October 31 of each year per section 6.4.11(c) of the 401 WQC (WDOE 2007), but will be specific to the fish-spill season time-period.

Additional TDG analytical methods will be incorporated into the annual updates to this QAPP as needed based on changes to Priest Rapids Project operations, WDOE water quality standards, or other changes using adaptive management methods (see Section 7.0).

6.4.2 Water Temperature

Water temperature data collected as part of the FSM program will be analyzed on a yearly basis by calculating mean-daily, maximum, and minimum values. Calculations will also be made to determine the 7-DADMax temperatures. Tabular and graphical displays of the mean-daily, maximum, minimum, and 7-DADMax temperature values will also be provided in the annual water quality monitoring report to WDOE, as will explanations of suspect, omitted, or lost data, and overall data completeness (based on percent of data meeting MQOs). Additional analyses of the water temperature data will occur in 2013 as part of a modeling effort to determine Grant PUD’s ability to meet water temperature standards, per the conditions of section 6.5.2 of the 401 WQC (WDOE 2007).

Additional water temperature analytical methods will be incorporated into the annual updates to this QAPP as needed based on changes to Project operations, WDOE water quality standards, or other changes using adaptive management methods (see Section 7.0).

6.4.3 Dissolved Oxygen, pH, and Turbidity

DO, pH, and turbidity data collected as part of Grant PUD's FSM program will be displayed graphically with time and longitudinally downstream to the Priest Rapids Dam tailrace to determine temporal and spatial trends. Data will also be compared to historical data as reported by Juul (2003) and Normandeau (2000). Evaluations for compliance with DO, pH, and turbidity water quality criteria will also be made. Results from these analyses will be included in the annual water quality monitoring report to WDOE.

Additional DO, pH, and turbidity analytical methods will be incorporated into the annual updates to this QAPP as needed based on changes to Project operations, WDOE water quality standards, or other changes using adaptive management methods (see Section 7.0).

6.5 Data Management and Quality Assessment

The following sections provide details on the management of water quality data collected under this QAPP, as well as the methods used to determine if data quality objectives have been met.

6.5.1 Real-Time Data

The hourly TDG and water temperature data that is transferred from the multi-probe to the Sutron DCP, and then to Grant PUD's water quality database is run by Sutron's XConnect software. This database runs on a secure server located at Grant PUD's Headquarters building in Ephrata, WA, which is backed-up daily. Hourly TDG and water temperature data are then transferred to Grant PUD's water quality web-site; this process typically produces a two-hour lag between time of collection and posting to the web-site. Daily summary reports (in Microsoft Excel spreadsheet format) are created each day (for previous day's data) and posted to the web-site. The data included in the daily summary reports have passed MQOs and are considered final. Data that does not pass MQOs are deleted from the report and a description of why the data did not meet data quality objectives, any required adjustments to the TDG or water temperature sensors, or other needed adjustments are recorded in a deleted data database. These deleted data will then be presented in the annual water quality monitoring report under the QA/QC sections.

At the end of the monitoring season, real-time data will be assessed for quality based on the completeness of the data. The data quality objective for the real-time data (TDG and water temperature) will be that at least 90 percent of the real-time data meet MQOs.

6.5.2 Grab-Sample Data

The second component of data management is the grab-sample DO, pH, and turbidity data that is collected every two-to-three weeks. This data is recorded on a PDA using Hydrolab's® Hydras 3 Pocket PC software, which is then transferred to an excel spreadsheet that is backed-up daily. After each grab-sample date, the data will be posted to Grant PUD's water quality web-site and the summary results from these data will be presented in the annual water quality monitoring report.

6.5.3 Calibration and Maintenance Data

All calibration and maintenance data collected for the FSM stations, including data from the Hydrolab® sensors, BP sensors, etc. will be recorded on a PDA using Hydrolab's® Hydras 3 software, which is then transferred to an excel spreadsheet and backed-up daily. Summary calibration and maintenance data will be included in the annual water quality monitoring report.

6.5.4 Water Quality Web-Site

Currently, Grant PUD's water quality web-site provides hourly, daily summary, and monthly summary TDG and water temperature data recorded at each of Grant PUD's FSM locations, along with corresponding total river flow and spill volumes at each dam. Below is the link to Grant PUD's FSM web-site:

http://www.gcpud.org/resources/resLandWater/waterMonitoring.htm

The following data is currently available at this web-site:

- Fixed Site Monitoring - Hourly Data: Provides daily ".xls" and ".csv" files showing data that has received QA/QC review and verification; includes calculation of 24-hour averages and average of 12 highest consecutive hourly TDG values. Hourly and mean daily total river flow, spill, and spill percentages from each dam are also included.

- Fixed Site Monitoring - Monthly Summary: A ".xls" file that provides daily mean values for TDG, water temperature, and flow/spill separated by month.

- 72 Hour Water Quality Information: Previous 72 hours (~2 hour delay) of TDG, water temperature, and flow/spill data that is considered preliminary, has not received final quality QA/QC review and verification, and is subject to change based on QA/QC review.

- Priest Rapids Smolt Monitoring: ".xls" file that presents gas bubble trauma (GBT) monitoring results, including date and number of fish examined, number and percent of fish with GBT signs, and ranking of GBT sign. For more information on Grant PUD's GBT monitoring program, see Grant PUD 2008b.

Data from previous years can also be accessed from the water quality web-site. Provisions are currently underway that will provide grab-sample data, water quality monitoring reports/plans, this QAPP, and other pertinent water quality data to be posited to the web-site by the spring of 2009.

7.0 Adaptive Management

The 401 WQC (WDOE 2007) provides several adaptive management provisions that require Grant PUD to reexamine monitoring procedures, quality control, and analytical methods based on results of data (e.g. in or out of compliance with water quality standards, sudden deviations from historic trends, etc), changes in operational, or changes in WDOE water quality standards. In addition, if the overall biological objectives for the Project or Columbia River basin change, adjustments to water quality monitoring objectives in this QAPP will also change, as needed. Any changes to this QAPP will be subject to WDOE and FERC approval and included in the annual updates to this QAPP as required by section 6.7.2 of the 401 WQC (WDOE 2007).

In addition to the adaptive management provisions above, Grant PUD will also adjust this QAPP based on changes to regional water quality methodologies, new or improved water quality monitoring equipment, and/or changes to calibration and maintenance methods.

7.1 Participation in Regional Forms and Trainings

The FSM program manager will also continue to attend the Corps's year-end TDG monitoring and QA/QC meeting, at which presentations are made from the various agencies conducting TDG (and other water quality) monitoring within the Columbia River Basin. Topics include data completeness, quality, calibration results, new or improved monitoring methods, etc. Agencies typically presenting at this meeting include the USGS, Corps, other mid-Columbia River PUDs, and private consultants. The project manager of this QAPP will also make presentations to the group and participate in round-table discussions on various water quality monitoring topics. Other regional water quality forms that the project manager of this QAPP will participate include the regional water quality team and TDG TMDL adaptive management team. The project manager and field staff will also continue to seek out available trainings related to water quality monitoring equipment, monitoring methods, etc. Adjustments to this QAPP will be made, as needed, based on relevant new information obtained from these regional forms and/or trainings.

7.2 Audits

In order to assure that the proper measurement procedures are taking place and to determine if changes in the procedures are needed, two forms of audits will be conducted for the FSM program: field audits and reporting audits, each of which is discussed below.

7.2.1 Field Audits

Once per year the project manager will accompany Grant PUD water quality field staff into the field to monitor and audit all field activities including calibrations, maintenance, and multi-probe deployment methods, safety activities, and grab-sample collection methods. The auditor will focus on ensuring that all PQAC SOPs are followed, calibrations are conducted in compliance with manufacturers' specifications when applicable, and this QAPP is followed. The auditor will provide a brief write up of their observations including any deviations from QAPP and whether it should be changed or the process in the field needs to be addressed. The project manager will be responsible for ensuring that if needed, any corrective actions meet WDOE and FERC approval, and that each corrective action is implemented. A subsequent audit may be required to ensure that the change has been successfully implemented.

7.2.2 Reporting Audits

It is the responsibility of the Grant PUD to ensure that all of the reporting requirements of the 401 WQC have been met. The project manager will be responsible for keeping track of the mandated reporting and confirming that it has been met. Specifically, the project manager will access the website monthly or quarterly, as appropriate, to check that the necessary data are present, legible and correct. Additionally, the project manager will review the annual reports to make sure that the data presented are accurate, and verifiable. Any deviations from requirements will be rectified and Ecology will be notified of the deviation and corrective action.

8.0 Reporting Protocols

The 401 WQC (WDOE 2007) provides detailed reporting requirements for water quality monitoring activities conducted by Grant PUD, including those activities covered under this QAPP (e.g. FSM program). Per section 6.7.3 of the 401 WQC, data collected under this QAPP will be reported to WDOE on an annual basis by March 1 of each year. In addition, per section 6.4.11(c) of the 401 WQC the TDG data collected during the fish-spill season will be included in the fish-spill and TDG monitoring report, due October 31 of each year. Finally, all real-time TDG and water temperature data, daily summary reports, and grab-sample data will be reported to Grant PUD's water quality web-site.

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Appendix A
2008 total dissolved gas compliance value calculation method

The table below presents an example of when the new WDOE TDG compliance value calculation method, which includes the last 11 hourly values from the previous day, creates a double-counting problem. On 6/7/08, this method would have created two TDG water quality variances based on the same group of hours recorded in the Wanapum Dam tailrace. The red highlighted hours indicate those which would have been counted on both days, which would have created the value of 121.5% on 6/6 AND 123.3% on 6/7 (yellow highlights), even though there were only two hourly values above 120% on 6/7. To correct this problem, during the 2008 fish-spill season Grant PUD documented double-counting events. In the example below, the compliance value on 6/7 of 123.3 was replaced by the average of the highest 12 consecutive hourly values that did NOT include the previous days last 11 hourly values (which already crated a water quality standard variance on 6/6). This resulted in a TDG compliance value on 6/7 of 116.7 (green highlight). All occurrences of this double-counting issue are documented in below.

Table A-1 Example of double counting using "rolling average" method

Date	Hour	Hourly TDG Value	Average of 12 previous hours	Highest 12-hr consecutive average for each day
6/6/2008	1400	115.7	119.4	
6/6/2008	1500	115.5	118.5	
6/6/2008	1600	115.7	117.7	
6/6/2008	1700	118.4	117.2	
6/6/2008	1800	**124.5**	117.5	
6/6/2008	1900	**125.5**	117.9	
6/6/2008	2000	**125.5**	118.5	
6/6/2008	2100	**125.4**	119.3	
6/6/2008	2200	**125.5**	**120.0**	
6/6/2008	2300	**125.4**	**120.8**	
6/6/2008	2359	**125.3**	**121.5**	**121.5**
6/7/2008	0100	**125.4**	**122.3**	**123.3**
6/7/2008	0200	**124.5**	**123.1**	
6/7/2008	0300	118.6	**123.3**	
6/7/2008	0400	116.7	**123.4**	
6/7/2008	0500	115.4	**123.1**	
6/7/2008	0600	115.3	**122.4**	
6/7/2008	0700	115.5	**121.5**	
6/7/2008	0800	114.1	**120.6**	
6/7/2008	0900	113.9	119.6	
6/7/2008	1000	113.8	118.7	
6/7/2008	1100	113.4	117.7	
6/7/2008	1200	113.5	116.7	**116.7**
6/7/2008	1300	114.1	115.7	
6/7/2008	1400	114.6	114.9	
6/7/2008	1500	114.8	114.6	
6/7/2008	1600	115.1	114.5	
6/7/2008	1700	115.2	114.4	
6/7/2008	1800	115.4	114.5	
6/7/2008	1900	115.2	114.4	
6/7/2008	2000	115.4	114.5	
6/7/2008	2100	115.3	114.7	
6/7/2008	2200	115.3	114.8	
6/7/2008	2300	114.9	114.9	
6/7/2008	2359	114.9	115.0	

Appendix B
Hydrolab® Multi-Probe specifications

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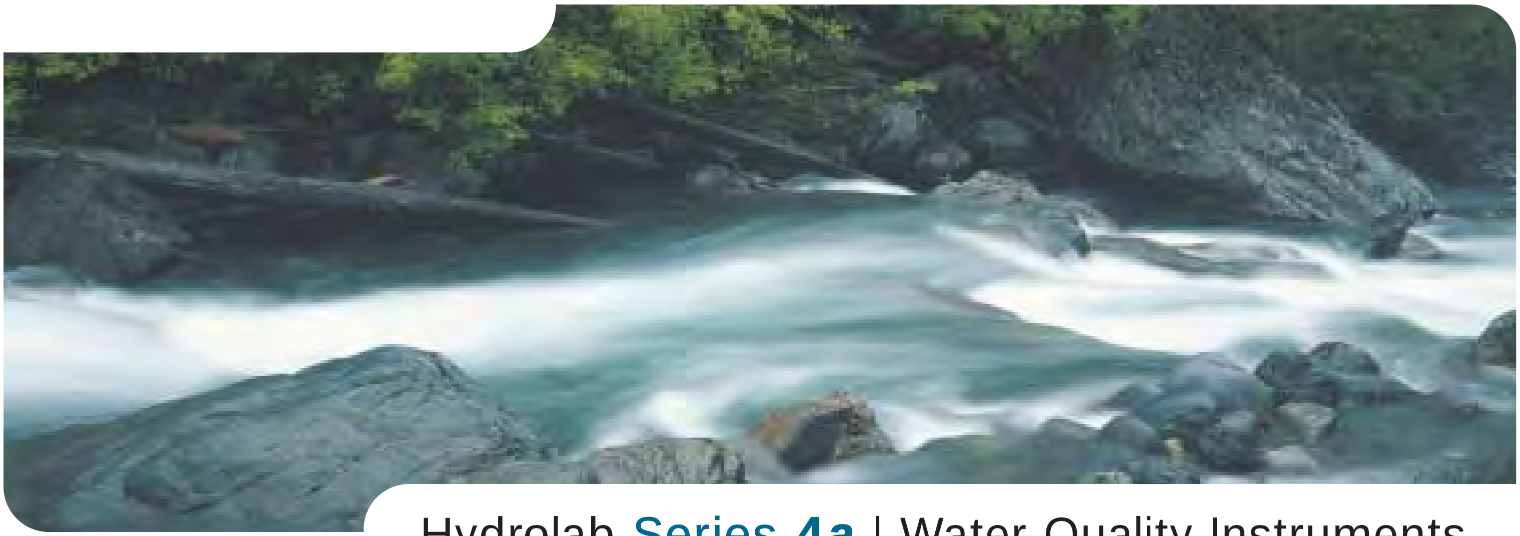

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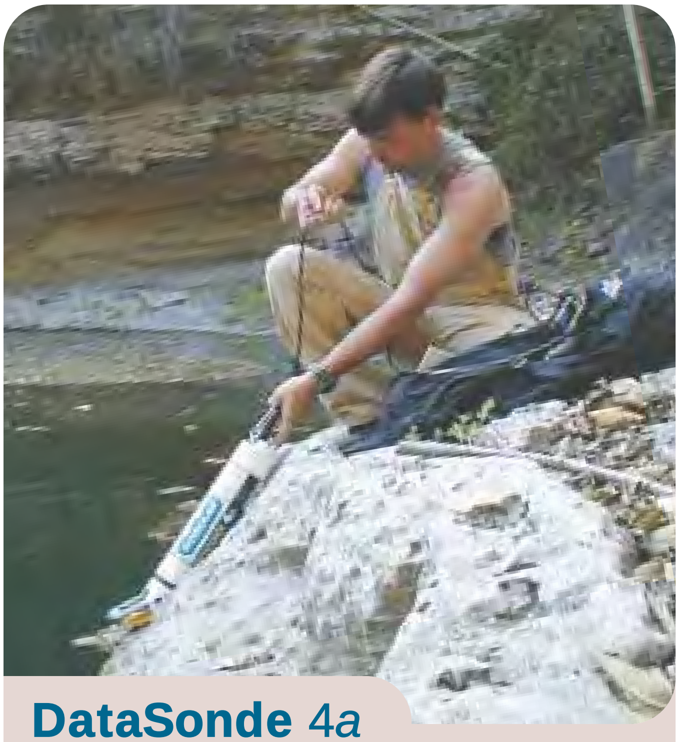

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- Excellent long-term deployment capability

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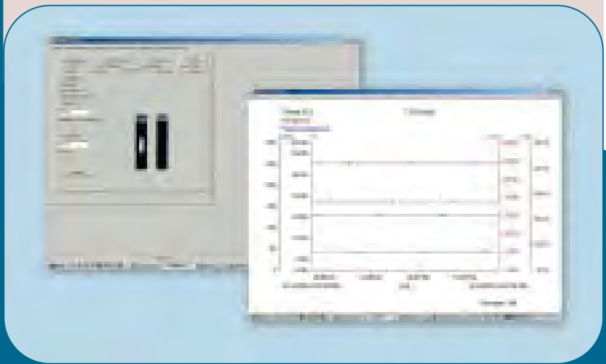

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TYPICAL PERFORMANCE SPECIFICATIONS

	RANGE	ACCURACY	RESOLUTION	AVAILABLE INSTRUMENT *
Temperature	-5 to 50° C	±0.10° C	0.01° C	D, M
Specific Conductance	0 to 100 mS/cm	±1% of reading; ±0.001 mS/cm	4 digits	D, M
pH	0 to 14 units	±0.2 units	0.01 units	D, M
Dissolved Oxygen	0 to 50 mg/L	±0.2 mg/L at ≤ 20 mg/L ±0.6 mg/L at > 20 mg/L	0.01 mg/L	D, M
ORP	-999 to 999 mV	±20 mV	1 mV	D, M
Depth Vented Level	0 to 10 m	±0.003 m	0.001 m	D, M
0-25 m	0 to 25 m	±0.05 m	0.01 m	D, M
0-100 m	0 to 100 m	±0.05 m	0.01 m	D, M
0-200 m	0 to 200 m	±0.1 m	0.1 m	D, M
Salinity	0 to 70 ppt	±0.2 ppt	0.01 ppt	D, M
4-Beam Turbidity	0 to 1000 NTU	±5% of reading; ±1 NTU	0.1 NTU (<100 NTU) 1 NTU (≥100 NTU)	D
Self-Cleaning Turbidity	0 to 3000 NTU	±1%, up to 100 NTU ±3%, 100-400 NTU ±5%, 400-3000 NTU	0.1, up to 400 NTU 1.0, 400-3000 NTU	D, M
Ammonium/Ammonia	0 to 100 mg/L-N	Greater of ±5% of reading or ±2 mg/L-N (typical)	0.01 mg/L-N	D, M
Nitrate	0 to 100 mg/L-N	Greater of ±5% of reading or ±2 mg/L-N (typical)	0.01 mg/L-N	D, M
Chloride	0.5 to 18,000 mg/L	Greater of ±5% of reading or ±2 mg/L (typical)	4 digits	D, M
Total Dissolved Gas	400 to 1300 mmHg	±0.1% of span	1.0 mmHg	D, M
Ambient Light	0 to 10,000 μmol $s^{-1}m^{-2}$	±5% of reading or ±1 μmol $s^{-1}m^{-2}$	1 μmol $s^{-1}m^{-2}$	D
Chlorophyll *a*	0 to 500 μg/L 0 to 50 μg/L 0 to 5 μg/L	±3% for signal level equivalents of 1ppb Rhodamine WT dye	0.01 μg/L	D, M
Rhodamine WT	0 to 1000 ppb 0 to 100 ppb 0 to 10 ppb	±3% for signal level equivalents of 1ppb Rhodamine WT dye	0.01 ppb	D, M
Blue-Green Algae	100 to 2,000,000 cells/mL 100 to 200,000 100 to 20,000	±3% for signal level equivalents of 1ppb Rhodamine WT dye	0.01 cells/mL	D, M
Barometric Pressure	500 to 850 mmHg	±10 mmHg	0.1 mmHg	S
Global Positioning System	-90 to 90° Latitude -18 to 180° Longitude	25 m CEP (50%) without SA and DGPS 2 m CEP (50%) with DGPS	0.1"	S

* D = DataSonde 4*a* M = MiniSonde 4*a* S = Surveyor 4*a*

INSTRUMENT SPECIFICATIONS

Computer Interface	RS-232, SDI-12
Memory	DataSonde 4*a* – 120,000 measurements MiniSonde 4*a* – 120,000 measurements Surveyor 4*a* – 375,000 measurements
Battery Supply	DataSonde 4*a* – 8 C batteries MiniSonde 4*a* – 8 AA batteries Surveyor 4*a* – rechargeable nickel metal hydride
Typical Battery Life (1-hour intervals)	DataSonde 4*a* – 313 days MiniSonde 4*a* – 114 days Surveyor 4*a* – 12-16 hours
Operating Temperature	-5 to 50° C
Maximum Depth	DataSonde 4*a* & MiniSonde 4*a* – 225 m
Size	DataSonde 4*a*: Outer diameter – 3.5"/8.9 cm; Length – 23"/58.4 cm; Weight – 7.4 lbs/3.35 kg MiniSonde 4*a*: Outer diameter – 1.75"/4.4 cm; Length – 21"/53.3 cm; Weight – 2.2 lbs/1.0 kg with extended battery pack: 29.5"/74.9 cm, Weight – 2.9 lbs/1.3 kg Surveyor 4*a*: 11x4x5"/27.9x10.2x3.8 cm, Weight – 2 lbs/0.9 kg

Hydrolab

5600 Lindbergh Drive
Loveland, CO 80539
(800) 949-3766
(970) 669-3050
fax (970) 461-3921
hydrolab.com

HYDROLAB® A HACH COMPANY BRAND

BENEFITS & SPECIFICATIONS

- Uses a pH glass sensor
- Both feature a single refillable, flowing junction reference electrode OR optional low ionic strength electrode
- Standard reference electrode is more reliable, lasts longer, is easily maintained, and refills in seconds
- Reference electrode is maintained and refilled independently of pH and/or ORP
- Two-year warranty

pH SENSOR

Range	0 to 14 pH units
Accuracy	±0.2 units
Resolution	0.01 units

ORP SENSOR

Range	-999 to 999 mV
Accuracy	±20 mV
Resolution	1 mV

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BENEFITS & SPECIFICATIONS

DISSOLVED OXYGEN SENSOR

- Uses field-proven Clark Cell technology
- Provides a continuous steady-state reading
- Low maintenance – no need to recondition the sensor
- Two-year warranty

Range	0 to 50 mg/L
Accuracy	±0.2 mg/L for 20 mg/L or less ±0.6 mg/L for over 20 mg/L
Resolution	0.01 mg/L

SPECIFIC CONDUCTANCE SENSOR

- Hydrolab uses the four graphite electrode cell methodology:
  - Increases sample exchange
  - Open cell design provides more reliable data
  - Reduces measurement error due to fouling and air bubbles (bubbles rise above the electrodes out of the way and debris and sediment fall below)
  - Easily maintained without damaging electrodes
  - Resists corrosion
- Also measures salinity, resistivity, and TDS
- Two-year warranty

Range	0 to 100 mS/cm
Accuracy	±1% of reading, ±0.001 mS/cm
Resolution	4 digits

SAMPLE CIRCULATOR

Only Hydrolab offers a sample circulator for more reliable readings. The DataSonde 4*a* and MiniSonde 4*a* integrated sample circulator facilitates fast, accurate, steady-state dissolved oxygen measurements. Other sensors receive similar benefits.

- Creates a flow of water past the sensors
- Provides “sufficient sample flow across membrane surface” in accordance with Standard Methods Article 4500-OG
- Reduces response time – important to detect moving contaminant plumes or movement within water column
- Reduces sensor fouling – sweeps away inert debris and biological growth
- Allows deployment in any environment, even in poorly mixed areas

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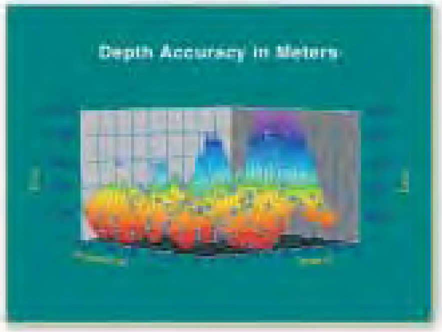
BENEFITS & SPECIFICATIONS

Hydrolab offers high-stability, custom made pressures sensors with four range options, available on both the DataSonde 4*a* and MiniSonde 4*a*.

- Exceptional accuracy for 10m, 25m, 100m, and 200m
- Two-year warranty

0 to 10 meters	Vented Level
Range	0 to 10 meters
Accuracy	±0.003 meters
Resolution	0.001 meters
0 to 25 meters	
Range	0 to 25 meters
Accuracy	±0.05 meters
Resolution	0.01 meters
0 to 100 meters	
Range	0 to 100 meters
Accuracy	±0.05 meters
Resolution	0.01 meters
0 to 200 meters	
Range	0 to 200 meters
Accuracy	±0.1 meters
Resolution	0.1 meters



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BENEFITS & SPECIFICATIONS

Hydrolab's self-cleaning turbidity offers several benefits for operators:

- ISO 7027 compliant
- Extended range with exceptional resolution
- Utilizes small aperture technique to reduce false readings from particulates and other debris
- Fixed parking position to ensure consistent data collection after each cleaning cycle
- Excellent performance in low NTU environments due to enhanced noise cancelling technique
- Two-year warranty

Range	0 to 3000 NTU
Accuracy	±1% up to 100 NTU; ±3% from 100-400 NTU; ±5% from 400-3000 NTU using StablCal®
Resolution	0.1 NTU from 0-400 NTU; 1 NTU for >400 NTU
Linearity	±1% from 0-100 NTU; ±3% from 100-400 NTU; ±5% from 400-3000 NTU
Temperature Coefficient	±0.05%/ºC

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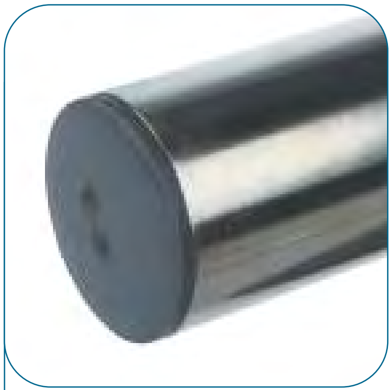
BENEFITS & SPECIFICATIONS



- Ultra-compact size designed by Turner Designs specifically for integration into the DataSonde and MiniSonde
- Turner's industry leading measurement capabilities have not been compromised – this is the highest performance submersible fluorometer available!
- Excellent turbidity rejection ensures superior detection limits in a wide range of environmental conditions
- Three auto-selected gain ranges provide a wide measurement range of 0.03 to 500 µg/L for Chlorophyll *a*, 100 to 2,000,000 cells/mL for Blue-Green Algae, and 0.04 to 1000 ppb for Rhodamine WT
- Turner's unique Secondary Standards to provide a quick and simple method to verify the sensor's stability over time
- The Secondary Standard can also be adjusted to correlate to a known chlorophyll or dye concentration
- Cost optimized for affordable price and excellent value!

OPTICAL CHARACTERISTICS:

Light Source	Light Emitting Diode
Detector	Photodiode
Excitation Wavelength	Chl 460 nm BGA (FR) 590 nm BGA (MAR) 525 nm RWT 550 nm
Emission Wavelength	Chl 685 nm BGA (FR) 650 nm BGA (MAR) 570 nm RWT 600 nm

SPECIFICATIONS:

Minimum Detection Limit

Chlorophyll *a*:	0.03 µg/L
Blue-Green Algae:	100 cells/mL
Rhodamine WT:	0.04 ppb

Dynamic Range

Chlorophyll *a*:

• Low sensitivity:	0-500 µg/L
• Medium sensitivity:	0-50 µg/L
• High sensitivity:	0-5 µg/L

Blue-Green Algae:

• Low sensitivity:	100-2,000,000 cells/mL
• Medium sensitivity:	100-200,000 cells/mL
• High sensitivity:	100-20,000 cells/mL

Rhodamine WT:

• Low sensitivity:	0-1000 ppb
• Medium sensitivity:	0-100 ppb
• High sensitivity:	0-10 ppb

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SERIES 5

Water Quality Instruments

HACH® | Environmental

Be Right. The Environment is Worth it.


HYDROLAB®
SUPERIOR SENSOR TECHNOLOGY
Hydrolab sondes are built with the industry's best sensor technology, to provide high quality data that you can trust.
UNSURPASSED RELIABILITY
Hydrolab sondes are built to withstand the harshest environmental conditions so you can be confident that your data will be correct at every site, every time.
LONG-TERM VALUE
Hydrolab sondes are built to last, easy to use, and simple to maintain—saving you time and money throughout your ownership of the instrument.
Be Right.
The Environment is Worth it.

HYDROLAB® SERIES 5

Water Quality Instruments

SONDES

MS5

- Four built-in expansion ports configured to fit your specific needs
- Measures up to 10 parameters simultaneously
- Compact and lightweight 1.75" diameter housing fits into groundwater wells
- Used for attended or unattended monitoring

DS5

- Seven built-in expansion ports configured to fit your specific needs
- Measures up to 15 parameters simultaneously
- Capable of measurements using any of Hydrolab's 15 sensors
- Used for attended or unattended monitoring

DS5X

- Ideal for "X-tended" deployments in environments where fouling and sediment are abundant
- Central cleaning system wipes away fouling from adjacent sensors to reduce the maintenance frequency
- Seven built-in expansion ports configured to fit your specific needs
- Measures up to 15 parameters simultaneously

COMMUNICATIONS

SURVEYOR

- Complete set-up capability allows users to leave their laptops in their offices
- Designed specifically for use in severe field conditions, the Surveyor can take a beating on land or in the water and still deliver your data
- Displays data in real-time or can store up to 375,000 measurements
- Oversize screen with backlight allows data to be viewed in any conditions
- Available with optional GPS and Barometric Pressure capabilities

HYDRAS 3 LT

- Real-time, multi-parameter time series graphing and vertical profiling
- Simple, point and click calibration of any parameter
- One-click download for field data collection
- User-programmable stability check on each sensor
- Included free with every Series 5 sonde

SENSORS

Hach LDO®

- Longest lasting calibrations
- Features the best accuracy available for DO measurement
- No membranes so maintenance is simple
- Clark Cell also available

Conductivity

- Open cell allows reliable measurements in any environmental condition—sediment falls to the bottom and bubbles rise to the top

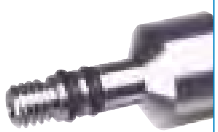
pH

- Reference electrode is easily refilled in seconds—independent of the pH sensor
- pH sensor does not need replacement when reference electrode is depleted; simply refill the reference

Turbidity: Self-Cleaning

- User-programmable self-cleaning system can perform up to 10 cleaning cycles before each reading
- 3000 NTU range allows Turbidity tracking even during rain storms or other events that could cause abnormally high readings
- 4-Beam and Standard Turbidity also available

Depth



- Optimized for depths down to 10m, 25m, 100m, or 200m

Chlorophyll a

- Ultra-compact size designed by Turner Designs specifically for integration into Hydrolab sondes
- Provides the most accurate measurement of Chlorophyll a because of electronic filtration of ambient light, efficient optical coupling, and quality optical components.

Blue-Green Algae

- Real-time measurement identifies potential algal blooms before they become problematic, allowing time for corrective action
- Ultra-compact size designed by Turner Designs specifically for integration into Hydrolab sondes
- Provides the most accurate measurement of phycocyanin or phycoerythrin because of electronic filtration of ambient light, efficient optical coupling and quality optical components

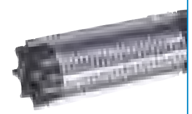
Ion-Selective Electrodes

- Available for monitoring Ammonia/Ammonium, Nitrate, or Chloride

ORP

- Uses a simple platinum band that donates or accepts electrons to monitor chemical reactions, quantify ion activity, or determine the oxidizing or reducing properties of a solution

Total Dissolved Gas



- Real-time measurement indicates water supersaturated with atmospheric gases, which can cause gas bubble gill disease in aquatic organisms

Rhodamine WT

- Ultra-compact size designed by Turner Designs specifically for integration into Hydrolab sondes
- Provides the most accurate measurement of Rhodamine WT because of electronic filtration of ambient light, efficient optical coupling, and quality optical components

PAR

- Provides a real-time measurement of sunlight intensity, which influences biota that rely on photosynthesis for nutrition

Temperature

- Provides critical compensation for Dissolved Oxygen, Conductivity, pH, and nutrient sensors
- Included with every sonde

HYDROLAB®

SPECIFICATIONS

Sondes

Size
DataSonde:
Outer diameter – 3.5"/8.9 cm
Length – 23"/58.4 cm
MiniSonde:
Outer diameter – 1.75"/4.4 cm
Length – 29.5"/74.9 cm (with battery pack)

Weight
DataSonde:
7.4 lbs/3.35 kg (typical)
MiniSonde:
2.9 lbs/1.3 kg
(typical with battery pack)

Communication Interface
RS-232, SDI-12, RS-485

Memory
Up to 120,000 measurements

Battery Supply
DataSonde: 8 C batteries
MiniSonde: 8 AA batteries

Operating Temperature
-5 to 50°C

Maximum Depth
200 m

Sensors

	Range	*Accuracy*	*Resolution*
Hach LDO™	0 to 60* mg/L *Exceeds maximum natural concentrations	± 0.1 mg/L @ ≤ 8 mg/L ± 0.2 mg/L @ > 8 mg/L ± 10% reading > 20 mg/L	0.01 mg/L
Polarographic DO	0 to 50 mg/L	± 0.2 mg/L @ ≤ 20mg/L ± 0.6 mg/L @ > 20 mg/L	0.01 mg/L
Conductivity	0 to 100 mS/cm	± (0.5% of reading + 0.001 mS/cm)	
Salinity	0 to 70 ppt	± 0.2 ppt	0.01 ppt
pH	0 to 14 pH units	± 0.2 units	0.01 units
Turbidity, Self-Cleaning	0-3000 NTU	*Compared to StablCal* ± 1% up to 100 NTU ± 3% from 100-400 NTU ± 5% from 400-3000 NTU	0.1 NTU from 0-400 NTU; 1 NTU for >400 NTU
Turbidity, 4-Beam	0-1000 NTU	± (5% of reading + 1 NTU)	0.1 NTU from 0-100 NTU; 1 NTU for >100 NTU
Depth	0 to 10m (Vented Level) 0 to 25m 0 to 100m 0 to 200m	± 0.003 meters ± 0.05 meters ± 0.05 meters ± 0.1 meters	0.001 meters 0.01 meters 0.01 meters 0.1 meters
Chlorophyll a	*Dynamic Range* Low sensitivity: 0.03-500 µg/L Med. sensitivity: 0.03-50 µg/L High sensitivity: 0.03-5 µg/L	± 3% for signal level equivalents of 1 ppb rhodamine WT dye or higher using a rhodamine sensor	0.01 µg/L
Blue-Green Algae (fresh water or marine)	*Dynamic Range* Low sensitivity: 150-2,000,000 cells/mL Med. sensitivity: 150-200,000 cells/mL High sensitivity: 150-20,000 cells/mL	± 3% for signal level equivalents of 1 ppb rhodamine WT dye or higher using a rhodamine sensor	20 cells/mL
Rhodamine WT	*Dynamic Range* Low sensitivity: 0.04-1000 ppb Med. sensitivity: 0.04-100 ppb High sensitivity: 0.04-10 ppb	± 3% for signal level equivalents of 1 ppb rhodamine WT dye or higher using a rhodamine sensor	0.01 ppb
Ion Selective Electrodes			
Ammonia Max Depth: 15 meters	0 to 100 mg/L-N	Greater of ± 5% of reading, or ± 2 mg/L-N	0.01 mg/L-N
Nitrate Max Depth: 15 meters	0 to 100 mg/L-N	Greater of ± 5% of reading, or ± 2 mg/L-N	0.01 mg/L-N
Chloride Max Depth: 15 meters	0.5 to 18000 mg/L	Greater of ± 5% of reading, or ± 2 mg/L	4 digits
TDG (Total Dissolved Gas)	400 to 1400 mmHg	± 1.5 mmHg	1.0 mmHg
ORP	-999 to 999 mV	± 20 mV	1 mV
PAR	0 to 10,000 µmol $s^{-1}m^{-2}$	± 5% of reading	1 µmol $s^{-1}m^{-2}$
Temperature	-5 to 50°C	± 0.10°C	0.01°C

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Appendix C
Consultation Comment Letters

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
4601 N Monroe Street • Spokane, Washington 99205-1295 • (509)329-3400

January 16, 2009

Mr. Tom Dresser
Manager, Fish, Wildlife and Water Quality
Grant County Public Utility District
P.O. Box 878
Ephrata, Washington 98823

Dear Mr. Dresser:

RE: Request for Comment – Draft 2009 Quality Assurance Project Plan for Monitoring Selected Water Quality Parameters within the Priest Rapids Hydroelectric Project

The Department of Ecology (Ecology) has reviewed the Quality Assurance Project Plan received on December 19, 2008, and has the following comments to offer.

1. Even though it is not required, an acronym list would be helpful as a reference.

2. Section 6.3.2 Water Temperature

   Even though Hydrolab® does not currently require a calibration method for the temperature sensor, Ecology recommends that temperature recorded values be verified with a National Institute of Standards and Technology (NIST) thermometer before each deployment season.

Please feel free to contact me at (509) 329-3450 or by email at dman461@ecy.wa.gov if you have any further questions regarding this matter.

Sincerely,

D. Marcie Mangold

D. Marcie Mangold
Water Quality Program

DMM:dw
cc: Gerry O'Keefe, Grant PUD
Ross Hendrick, Grant PUD
Bill Tweit, WDFW
Brian Faller, Ecology/ATG
James M. Bellatty, Ecology/WQP

Appendix D
Summary Table of Agency Comments to Grant PUD's Draft Quality Assurance Project Plan

SUMMARY TABLE OF AGENCY COMMENTS AND GRANT PUD RESPONSES FOR THE QUALITY ASSURANCE PROJECT PLAN (LA 401).

Submitting Entity	Date Received	Paragraph #	Agency Comment	Grant PUD Response
WDOE	16-Jan-2009	1	Even though it is not required, an acronym list would be helpful as a reference.	Comment noted. A list of abbreviations was added after the table of contents.
		2	Even though Hydrolab does not currently require a calibration method for the temperature sensor, Ecology recommends that at temperature recorded values be verified with a National Institute of Standards and Technology (NIST) thermometer before each deployment season.	Comment noted. Grant PUD will begin verifying the Hydrolab temperature sensor with a NIST thermometer. Although Grant PUD monitors for temperature throughout the year, it will perform the verification of the sensors prior to each spring. Section 6.3.2 and Table 3 were updated to reflect this calibration and maintenance step.