Priest Rapids Hydroelectric Project (P-2114)

2019-2023 (5-Year) Total Dissolved Gas Abatement Plan

License Article 401(a)(19)

By
Public Utility District No. 2 of Grant County
P.O. Box 878
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January 2019

Executive Summary

This 2019-2023 (5-Year) total dissolved gas abatement plan (GAP; 5-Year GAP) provides details on operational and structural measures that Public Utility District No. 2 of Grant County, Washington (Grant PUD) plans to implement as part of its fish-spill program for the years' 2019 through 2023. These measures are intended to comply with Washington State's water quality standards for total dissolved gas (TDG) at the Priest Rapids Hydroelectric Project (Project). The Washington Department of Ecology (WDOE) establishes Washington state water quality standards for TDG during the non-fish and fish-spill seasons. This 5-Year GAP is being submitted consistent with WDOE's recent approval of Grant PUD's *Final Summary of Total Dissolved Gas Monitoring within the Priest Rapids Hydroelectric Project – Year 10 Report* (Year 10 Report; Grant PUD 2018a) and Section 6.4.11(f) of the 401 WQC (WDOE 2007). This compliance GAP will be updated every 5 years for the remainder of the Project license (Year 2044), and will include any applicable information on new or improved technologies and a review of any additional reasonable and feasible gas abatement options. In addition, a compliance analysis of the previous 10 years of TDG data will also be completed every 5 years concurrent with the 5-year compliance GAP, which will analyze Grant PUD's ability to consistently achieve compliance with the provisions of TDG water quality standards.

Proposed operational abatement measures described in this 5-Year GAP include minimizing involuntary spill by scheduling maintenance operations based on predicted flows and maximizing turbine flows by setting minimum generation requirements to power purchasers. Operational abatement measures also include the participation in regional operators meetings to discuss potential TDG abatement measures, coordination of regional spill amounts and locations, and implementation of preemptive spill to avoid periods of high involuntary spill. In addition, Grant PUD will consult with WDOE on any non-routine operational changes that may affect TDG, as well as manage fish-spill programs to meet TDG water quality standards through coordination with the Priest Rapids Coordinating Committee (PRCC).

Structural TDG abatement measures described in this 5-Year GAP include operation of both the Wanapum and Priest Rapids Fish Bypasses (WFB and PRFB), which are both designed to safely pass juvenile outmigrating salmonids while minimizing TDG uptake (Hendrick et. al 2009 and Keeler 2016). The installation of the advanced turbine systems at Wanapum Dam is completed, with the final unit installed in October of 2013. Additionally, in accordance with the terms and conditions contained in the 401 WQC (WDOE 2007) Grant PUD conducted TDG evaluations with all 10 advanced turbines in operation in October of 2013 in accordance with the Wanapum Dam Advanced Turbine Total Dissolved Gas Evaluation (see Keeler 2012), to determine the impact, if any, the operation has on TDG. Results from these evaluations are presented in Keeler (2014) and were submitted to the WDOE/PRCC and the FERC on December 13, 2013 and February 20, 2014, respectively.

Compliance monitoring for TDG will continue at Grant PUD's fixed-site water quality monitoring stations (FSM stations), and TDG data will be collected on an hourly basis throughout the year and will be reported to Grant PUD's water quality website at:

https://www.grantpud.org/water-quality.

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Terms and Abbreviations

2004 Biological Opinion	National Marine Fisheries Service 2004 Biological Opinion for the Priest Rapids Project
7Q10 flow	highest seven consecutive day average flow with a 10-year recurrence frequency
Biological Opinion	National Marine Fisheries Service 2008 Biological Opinion for the Priest Rapids Project
Chelan PUD	Public Utility District No. 1 of Chelan County, Washington
Corps	US Army Corps of Engineers
DO	dissolved oxygen
ESA	Endangered Species Act
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
MOA	Memorandum of Agreement
MW	megawatt
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Unit
PRFB	Priest Rapids Fish Bypass
PRCC	Priest Rapids Coordinating Committee
Project	Priest Rapids Hydroelectric Project
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RPA	Reasonable and Prudent Alternative
TDG	total dissolved gas
TMDL	total maximum daily load
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WFB	Wanapum Fish Bypass

WDOE	Washington Department of Ecology
WQC	water quality certification

1.0 Introduction

Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates the Priest Rapids Hydroelectric Project (Project; Figure 1). The Project is licensed as Project No. 2114[1] by the Federal Energy Regulatory Commission (FERC), and includes the Wanapum and Priest Rapids developments. A 401 water quality certification (WQC) for the operation of the Project was issued by the Washington Department of Ecology (WDOE) on April 3, 2007 (WDOE 2007), amended on March 6, 2008 and effective on issuance of the FERC license to operate the Project in April of 2008 (FERC 2008). Section 6.4.11(e) of the 401 WQC (WDOE 2007) requires Grant PUD to submit an annual total dissolved gas abatement plan (GAP) in accordance with WDOE's water quality standards for total dissolved gas (TDG).

On July 13, 2018 the WDOE approved Grant PUD's *Final Summary of Total Dissolved Gas Monitoring within the Priest Rapids Hydroelectric Project – Year 10 Report* (Year 10 Report; Grant PUD 2018a; Appendix A), in which Grant PUD demonstrated that it had fully implemented the conditions of the 401 WQC associated with TDG, had achieved reasonable compliance with the TDG water quality standards, and the operation of the Project is protective of the aquatic uses within the Project. The Year 10 Report included provisions consistent with Section 6.4.11(f) of the 401 WQC, which includes providing WDOE with a compliance GAP for review and approval by October 31, 2018. This deadline was extended to December 31, 2018 with an extension of time (EOT) request on October 10, 2018 and approved by WDOE on November 2, 2018 (Appendix B).

This compliance GAP will be updated every 5 years for the remainder of the Project license, and will include any applicable information on new or improved technologies and a review of any additional reasonable and feasible gas abatement options. In addition, a compliance analysis of the previous 10 years of TDG data will also be completed every 5 years concurrent with the 5-year compliance GAP, which will help demonstrate Grant PUD's ability to consistently achieve compliance with the provisions of TDG water quality standards.

This 5-Year GAP provides details on operational and structural measures Grant PUD will continue to implement during the 2019-2023 fish-spill seasons, which are intended to help ensure that Project operations continue to meet a similar level of compliance as demonstrated in the Year 10 Report.

1.1 Priest Rapids Project Description

The Wanapum development consists of a 14,680-acre reservoir and an 8,637-foot-long by 186.5-foot-high dam spanning the Columbia 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; a downstream fish passage structure (the Wanapum Fish Bypass (WFB)); and a powerhouse containing ten vertical shaft integrated Kaplan turbine/generator sets with a total authorized installed capacity (best gate) of 735 MW (Figure 2).

The Priest Rapids development consists of a 7,725-acre reservoir and a 10,103-foot-long by 179.5-foot-high dam spanning the Columbia River. The dam consists of left and right

[1] 123FERC ¶ 61,049

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; a downstream fish passage structure (the Priest Rapids Fish Bypass (PRFB)); and a powerhouse containing ten vertical shaft integrated Kaplan turbine/generator sets with a total authorized installed capacity of 675 MW (best gate) (Figure 3).

The Wanapum and Priest Rapids dam spillways were initially designed to accommodate flows that exceeded turbine (hydraulic) capacity and have more recently been used to spill water for the purpose of supplementing downstream smolt migrations. However, releasing flows over the spillways can also result in elevated TDG, which can be harmful to aquatic life. To address this issue, Grant PUD coordinates its fish-spill program to address fish migrations and comply with current water quality standards for TDG and has implemented downstream bypass measures to safely pass salmonids and/or to reduce or minimize TDG.

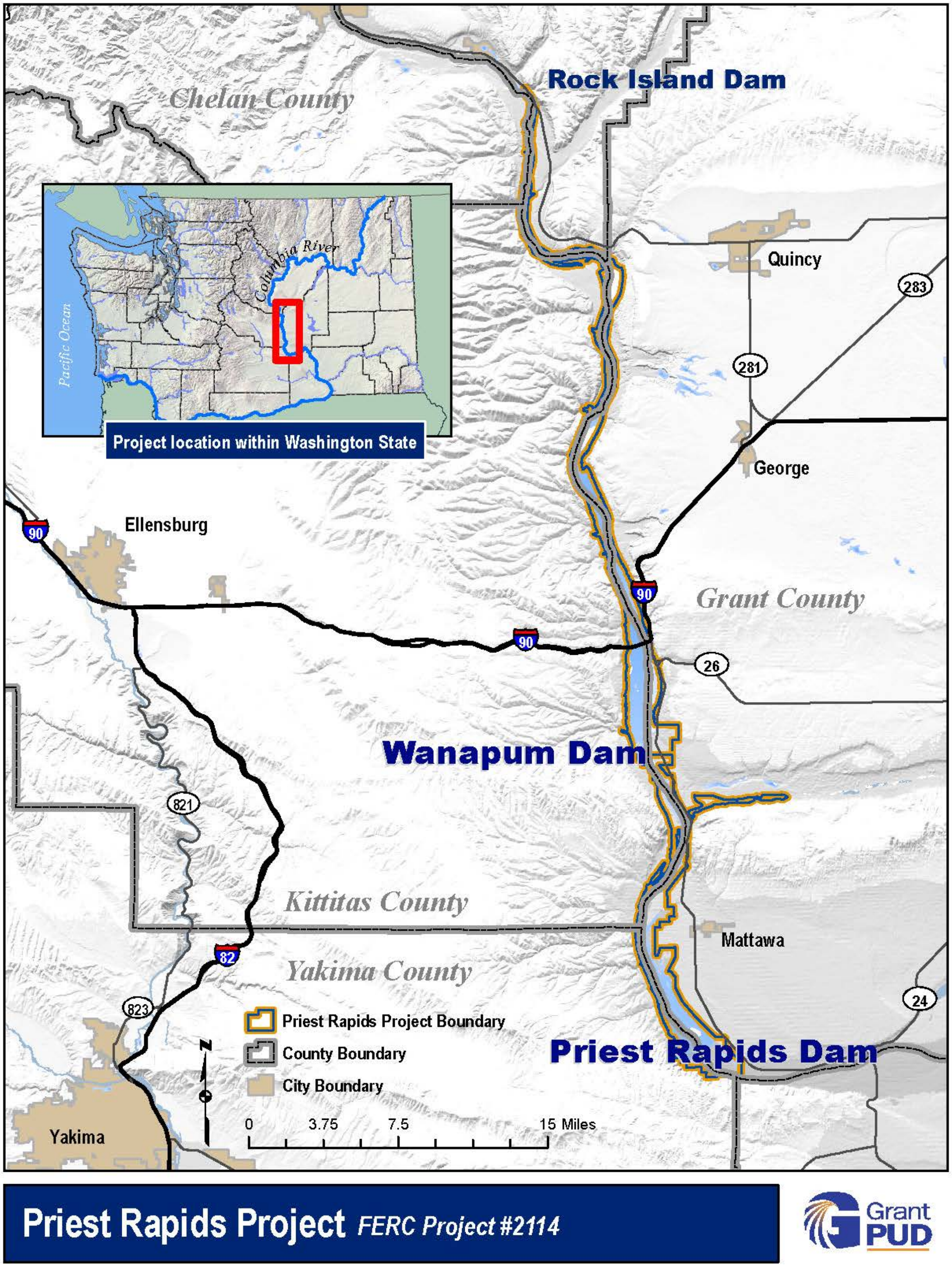

Figure 1 The Priest Rapids Project is located in central Washington State on the mid-Columbia River.

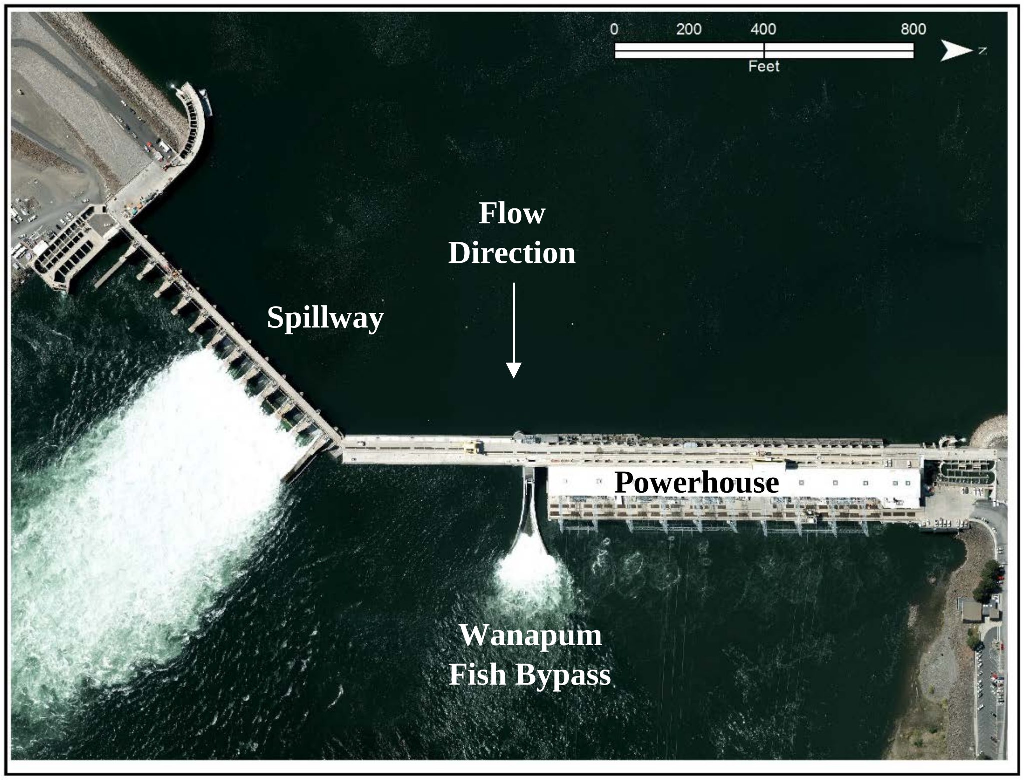

Figure 2 **Aerial photograph of Wanapum Dam, mid-Columbia River, WA.**

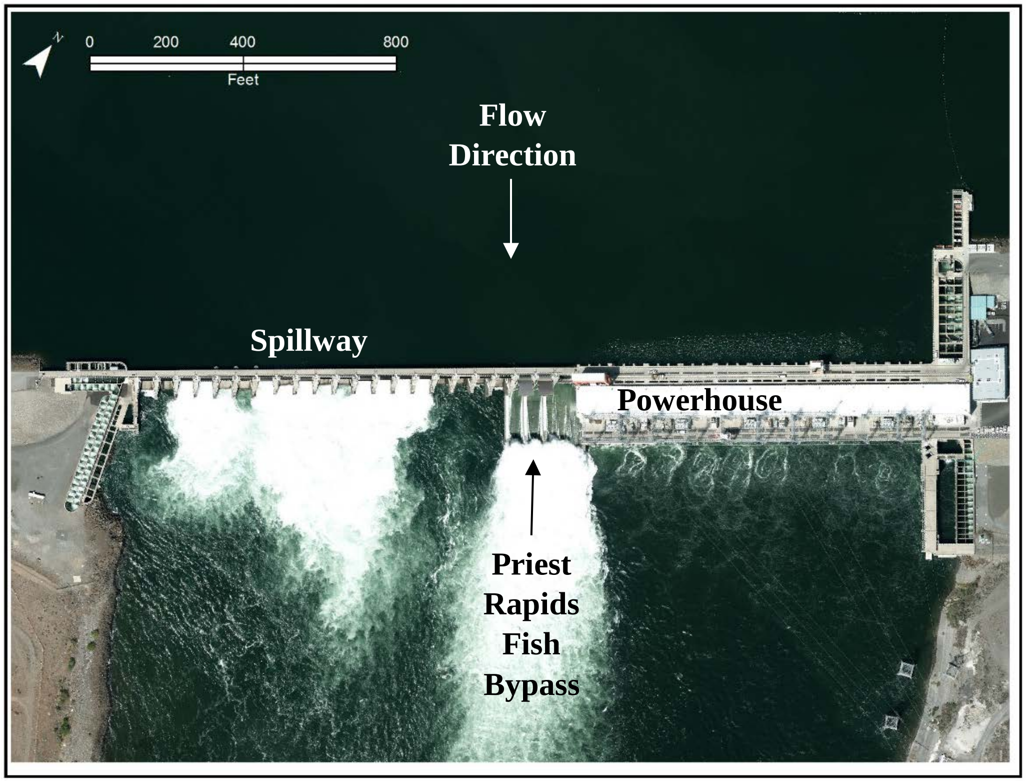

Figure 3 **Aerial photograph of Priest Rapids Dam, mid-Columbia River, WA.**

1.2 Regulatory Framework

Washington state water quality standards are established by WDOE 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 (%SAT)) during the non-fish spill season (September 1 through March 31) is 110 %SAT for any hourly measurement. The current standard for TDG (in %SAT) during the fish-spill season (April 1 through August 31) is 120 %SAT in the tailrace of the dam spilling water for fish and 115 %SAT in the forebay of the next downstream dam, based on the average of the twelve highest consecutive hourly readings in a twenty-four hour period. A one-hour, 125 %SAT maximum standard for TDG also applies throughout the Project.

It is important to note that the TDG water quality standards identified above are intended to help protect aquatic life designated uses within the Project. This includes WDOE's allowance of higher TDG levels during the fish-spill season which allow dams to spill water to help meet juvenile salmonid passage performance standards. Specific passage performance (or survival) standards for the Project are outlined in the Priest Rapids Project Salmon and Steelhead Settlement Agreement (Grant PUD 2006) and the National Marine Fisheries Service (NMFS) 2008 Biological Opinion (Biological Opinion; NMFS 2008).

Specifically, the Biological Opinion provides that Grant PUD make stable progress towards achieving a minimum 91% combined adult and juvenile salmonid survival performance standard at the Priest Rapids and Wanapum developments (i.e. each dam/reservoir). The 91% standard includes a 93% project-level (one reservoir and one dam) juvenile performance standard. Because NMFS recognizes that it is not currently possible to measure the 91% combined adult and juvenile survival standard, NMFS provides that Grant PUD continue to conduct dam and reservoir smolt survival studies, evaluating progress towards meeting a 93% juvenile development passage survival.

Structural changes (WFB and PRFB), along with changes in how the dams are operated (Fish Mode), is the approach that Grant PUD has pursued over the past decade to increase dam passage survival rates and achieve performance standards for yearling chinook, sockeye, steelhead and coho (Grant PUD 2018). This approach is supported by the NMFS and the Priest Rapids Coordinating Committee (PRCC) and has been adopted into the Priest Rapids Project license order. Achieving the survival standards as described above and in addition to meeting TDG numeric criteria as outlined in WAC 173-201A-200(1)(f), are an integral part of meeting the water quality standards (e.g. protection of designated uses) as described in the Project's 401 WQC (WDOE 2007).

1.2.1 Fish-Spill Season

The fish-spill season is defined by WDOE to occur from April 1 through August 31 of each year (Section 6.4.1(b) of the Project's 401 WQC; WDOE 2007). Actual spill for fish at Wanapum and Priest Rapids dams typically occurs from mid-April through mid-August, depending on the timing of the fish-migrations as documented at the Rock Island Dam smolt index station. Grant PUD also provides small amounts of spill for adult fallback from the end of the juvenile fish-spill season until November 15, annually.

Prior to 2008, fish-spill quantities and durations had been guided by the NMFS 2004 Biological Opinion (2004 Biological Opinion) on the effects of the proposed interim protection plan for the

Project on listed species (NMFS 2004). Yearly fish-spill programs were implemented at the guidance of the Priest Rapids Coordinated Committee (PRCC).

On February 1, 2008 NMFS issued a subsequent Biological Opinion (NMFS 2008) for the Project related to the FERC license (FERC 2008). The Biological Opinion incorporated the conditions contained in the 2004 Biological Opinion as they related to Grant PUD's fish-spill program, and those terms and conditions were incorporated in the FERC license to operate the Project issued on April 17, 2008 (FERC 2008). Reasonable and Prudent Alternatives (RPA) 1, and associated terms and conditions of the Biological Opinion require spill during the fish-spill season in order to aid in the passage of out-migrating juvenile salmonids.

1.2.2 Incoming Total Dissolved Gas Levels

According to Section 6.4.1(d) of the 401 WQC, Grant PUD may be deemed in compliance with water quality standards for TDG if both of the following apply:

- TDG levels in the dam's forebay exceed 110 %SAT during the non-fish spill season or 120 %SAT during the fish-spill season, and
- The dam does not further increase TDG levels in the tailrace

Fixed site water quality monitors are installed in both the Wanapum and Priest Rapids dams' forebays to identify incoming TDG levels (see Section 4.1).

1.2.3 7Q10 Flows

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 ten-year recurrence frequency. The 7Q10 flood flow was calculated to be 264 thousand cubic feet per second (kcfs) for both Wanapum and Priest Rapids dams.

1.2.4 Total Dissolved Gas Total Maximum Daily Load

In 2004, WDOE established a TDG Total Maximum Daily Load (TMDL) for the mid-Columbia River which set TDG allocations for each dam (WDOE 2004). According to section 6.4.1(f) of the 401 WQC, Grant PUD shall be "…deemed in compliance with the TDG TMDL…" while it remains in compliance with the 401 WQC (WDOE 2007).

1.3 Historical Conditions

The following sections provide a brief historical overview of river flows, fish-spill operations, and TDG levels and provides references to previous TDG/Fish-Spill season reports.

1.3.1 Priest Rapids Project Operations

In general terms, the hydropower system and reservoir operations of upstream development operators are coordinated through a set of complex agreements and policies to optimize the benefits and minimize the adverse effects of development operations. The Project operates within the constraints of its FERC regulatory and license requirements, Pacific Northwest Coordination Agreement, Canadian Treaty, Canadian Entitlement Agreement, Salmon and Steelhead Settlement Agreement, Biological Opinion, and Hanford Reach Fall Chinook Protection Program Agreement.

1.3.2 River Flows

Figure 4 illustrates a ten-year average of mean daily discharge values from 2008 to 2017, as measured at the U.S. Geological Survey (USGS) Stream flow gage #12472800 located 2.6 river miles downstream of Priest Rapids Dam (USGS 2018). During the fish-spill season stream flows typically peak in late May/early June and begin to recede by July.

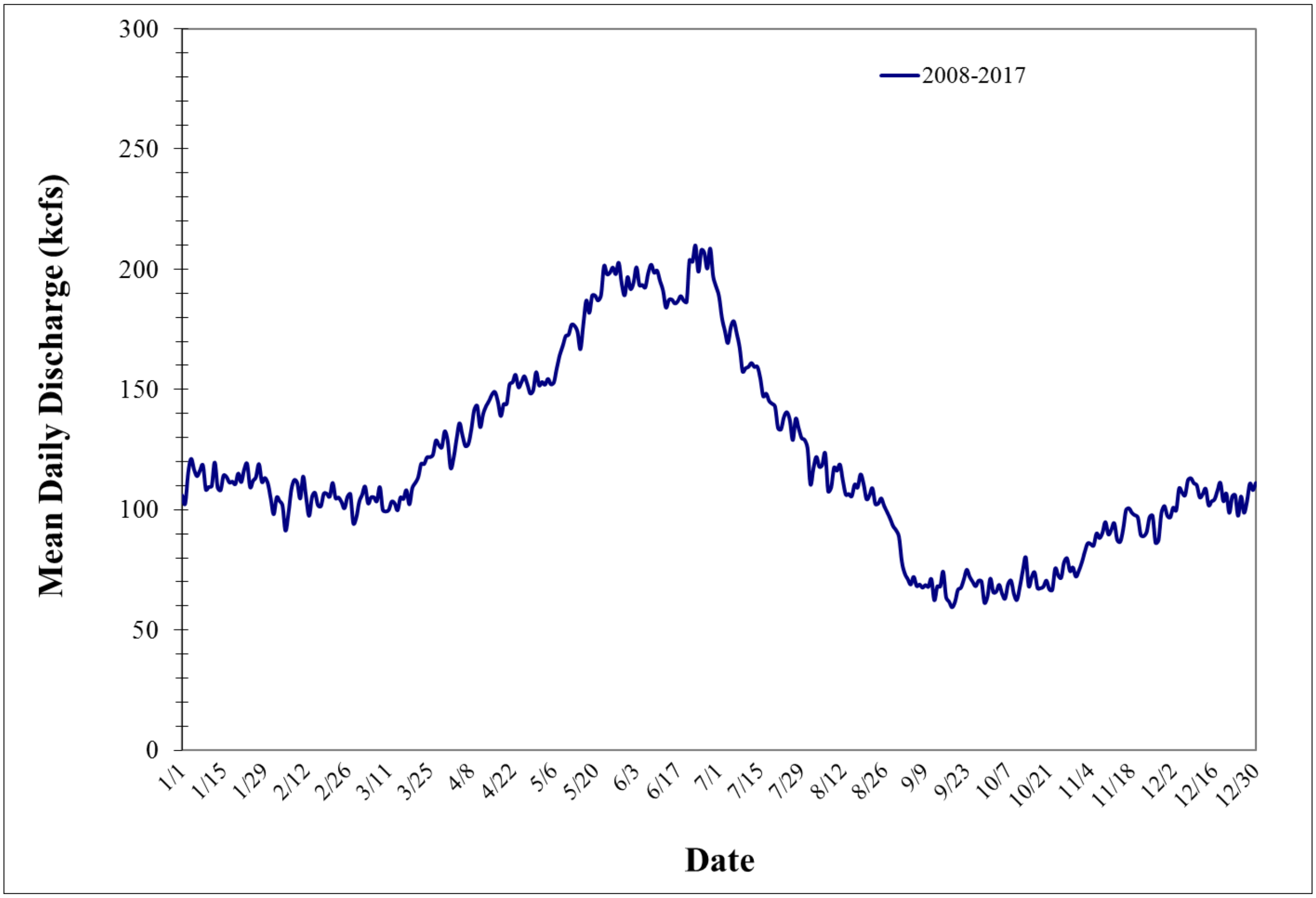

Figure 4 **Ten-year average of mean daily discharge values from 2008 to 2017 as measured at the USGS stream flow gage #12472800 located below Priest Rapids Dam, mid-Columbia River, WA (USGS 2018).**

Water is passed through Wanapum Dam either through the ten powerhouse units, 12 tainter-gates, sluiceway, and/or the WFB (Figure 2 and Figure 5). Maximum flow through each powerhouse unit ranges from 15-18 kcfs, passing 135–162 kcfs of total flow assuming 90% capacity (e.g. one unit out of operation), depending on forebay and tailwater elevations, power market conditions, and presence of out-migrating juvenile salmonids. During the fish-spill season, the turbines at Wanapum Dam are limited to approximately 15.7 kcfs in order to provide optimal passage conditions for migrating salmonids based on turbine survival studies conducted at Wanapum Dam (Normandeau, Skalski, and Townsend 2005). The 12 spillway gates and sluiceway at Wanapum Dam are designed to pass up to 1,400 kcfs, while the WFB is designed to pass an additional 20 kcfs. There are also fish-ladders on the right and left banks of Wanapum Dam, which pass up to two kcfs depending on forebay elevations.

Water is passed through Priest Rapids Dam either through the ten powerhouse units, 19 spillways, and/or the PRFB (Figure 3 and Figure 6). Maximum flow through each powerhouse unit ranges from 15-18 kcfs, passing 135–162 kcfs of total flow assuming 90% capacity (e.g. one unit out of operation), depending on forebay and tailwater elevations, power market conditions, and presence of out-migrating salmonids. During the fish-spill season, the turbines at Priest Rapids Dam are limited to 17.4 kcfs in order to provide optimal passage conditions for migrating salmonids based on turbine survival studies conducted at Priest Rapids Dam (Normandeau and Skalski 2005). The 19 spillway gates at Priest Rapids Dam are designed to pass up to 1,210 kcfs, while the PRFB is designed to pass an additional 27 kcfs, (based on forebay elevations). There are also fish-ladders on the right and left banks of Priest Rapids Dam, which pass up to two kcfs depending on forebay elevation.

1.3.3 Fish-Spill

Prior to 2005, Grant PUD's fish-spill programs were based on a Memorandum of Agreement (MOA) that called for Wanapum Dam to spill up to forty-three percent of total river flows during the spring season (from mid-April to mid-June) and forty-nine percent during summer (mid-June to mid-August). As a practical matter, TDG levels typically limited Wanapum spill to thirty-three to thirty-eight percent. Priest Rapids Dam was required to spill sixty-one percent of total river flow during the spring season (from mid-April to mid-June) and thirty-nine percent during summer (mid-June to mid-August). Again, these spill levels were typically adjusted in an effort to remain below TDG water quality standards.

On April 1, 2005, the PRCC gave concurrence to Grant PUD to implement alternative spill measures at Wanapum Dam as identified in RPA 6 of the 2004 Biological Opinion for the Project (NMFS 2004). These alternative spill methods were based on route-specific fish passage survival studies (Robichaud et al. 2005) which suggested that top-spill, powerhouse, and sluiceway passage were preferred for juvenile passage survival over passage via Wanapum spillway, and to support TDG levels within water quality criteria. Therefore, with the concurrence of the PRCC, Grant PUD moved from a tainter-gate spring fish-spill (Wanapum MOA spill) program to a "Gate 12 top-spill and sluiceway only" spill program during the 2005 fish-spill season. The PRCC also instructed Grant PUD to proceed with the spill program outlined in RPA 16 of the 2004 Biological Opinion (NMFS 2004) for Priest Rapids Dam in 2005, which is sixty-one percent of average daily total river flow, subject to TDG levels being below water quality standards, for spring migrants.

On February 1, 2008, NMFS issued a subsequent Biological Opinion (NMFS 2008) for the Project related to the FERC operating license (FERC 2008). The Biological Opinion incorporated the conditions of the 2004 Biological Opinion as they relate to Grant PUD's fish-spill program, and those terms and conditions were incorporated in the FERC license to operate the Project (FERC 2008). RPA 1, and associated terms and conditions of the Biological Opinion require Grant PUD to initiate its fish-spill programs before 2.5 percent of the spring migration period has passed, as documented by smolt index counts at Rock Island Dam. The spring fish-spill program can conclude when 97.5 percent of the spring migration period is complete, or on June 15, whichever occurs first. The summer fish-spill program begins immediately after the end of the spring fish-spill season and is guided by the PRCC and the fishway prescriptions set forth in the 2006 Priest Rapids Project Salmon and Steelhead Settlement Agreement (Grant PUD 2006) and shall continue until 95 percent of summer outmigrating fish have passed. Grant PUD also provides limited spill (typically around two kcfs) for adult fallback from the end of the fish-spill season until November 15, annually.

The 2004 through 2017 TDG-fish-spill summary reports submitted to WDOE (Hendrick 2004 – 2009 and Keeler 2010-2017) provide greater detail on the amounts and duration of fish-spill.

1.3.4 Other Types of Spill

The following sections provide a brief summary of the other types of spill that can occur at a mid-Columbia River hydroelectric developments.

1.3.4.1 Flow in Excess of Hydraulic Capacity

The limited storage and hydraulic capacity of a given project may occasionally require forced or involuntary spill past the project. This spill is required to maintain headwater elevations within the limits set by the project's FERC license, to prevent overtopping of the dam, and to maintain optimum operational conditions. With this type of release, flows up to, and in excess of the 7Q10 flood flows (264 kcfs) can be accommodated.

To reduce negative impacts of flow in excess of hydraulic capacity, Grant PUD attempts to implement pre-emptive spill so that small amounts of spill can occur if upstream flow predictions are anticipated to be higher than the predicted power-load demand, which would lead to involuntary spill. Pre-emptive spill can be initiated several hours prior to the high flows, thus making "room" to store the excess water in the reservoir until it can be passed through the turbines (e.g. when power-load demand increases). This reduces the need to involuntarily spill larger amounts of water through the tainter-gates, which typically leads to higher TDG levels. The lower, longer sustained, pre-emptive spill typically does not lead to TDG levels in excess of TDG water quality standards. Pre-emptive spill events require close coordination with upstream project operators through Grant PUD's Power Production, Power Delivery, Wholesale Marketing Supply, and Environmental Affairs departments.

1.3.4.2 Plant Load Rejection Spill

This type of spill occurs when the plant is forced off line by an electrical fault, which trips breakers, or any activity forcing the turbine units off line. This is an emergency situation and generally requires emergency involuntary spill. When the units cannot process flow, the flow must be passed by other means to avoid overtopping the dam.

1.3.4.3 Maintenance Spill

Maintenance spill is utilized for any maintenance activity that requires spill to assess the routine operation of individual spillbays and turbine units. These activities include forebay debris removal, checking gate operation, gate maintenance, and all other maintenance that would require spill. Section 2.1 provides information related to minimizing involuntary spill by scheduling maintenance operations, to the extent practicable, based on predicted flows. This will include limiting turbine maintenance during high flow and power load periods to emergency maintenance only, if possible. Any required spillgate maintenance that may necessitate spill will be coordinated in a manner that has the least effect on TDG.

1.3.4.4 Error in Communication Spill

Error in communication with the U.S. Army Corps of Engineers (Corps) Reservoir Control Center or other entities, including computer malfunctions or human error in transmitting proper data, can contribute to involuntary spill. Coordination between hydroelectric projects on the river minimizes this type of spill, but it does occur occasionally.

1.3.5 Total Dissolved Gas

The summation of the partial pressures of the individual gases in solution – primarily N_2, O_2, and CO_2 is known as TDG. As water is spilled into the tailrace air becomes entrained. This air/water mixture is then forced to the bottom of the stilling basin and the increased hydrostatic pressure forces the air into solution. The result is that water becomes supersaturated with those gases normally found in the atmosphere.

Continuous TDG has been measured within the Project since 1995. Early data collection at Grant PUD's fixed-site monitoring stations (FSM stations) focused mainly on the fish-spill season, but data is now collected hourly year-round. Intensive near-field work at Wanapum and Priest Rapids dams has also been completed to evaluate the effects of system operations (Corps 2001, 2003). Additionally, vertical TDG profiles were completed at mid-channel and near the shorelines during the 1999 synoptic study (Normandeau et al. 2000). Both Juul (2003) and Normandeau et al. (2000) provide extensive background information on TDG levels within the Project prior to 2003. Since 2004, Grant PUD has been providing WDOE with summary reports of TDG monitoring during the fish-spill season (Hendrick 2004 – 2009 and Keeler 2010-2017). These reports are mainly focused on TDG levels measured at the FSM stations during the fish-spill season. Grant PUD also provided WDOE with an annual water quality monitoring report, which covers TDG monitoring results during the non-fish spill season (Keeler 2010-2017b). In general, TDG levels are greatest during the spring fish-spill season (April-June), especially during years when incoming flow volumes exceed Wanapum Dam's hydraulic capacity (~161 kcfs), plus the WFB (~22 kcfs, for a total hydraulic capacity of ~183 kcfs).

2.0 Proposed Operational Total Dissolved Gas Abatement Measures

The following sections describe operational TDG abatement measures proposed for continued implementation to help abate TDG levels.

2.1 Minimizing Involuntary Spill

Section 6.4.1(c) of the 401 WQC (WDOE 2007) requires Grant PUD to minimize involuntary spill, as reasonable and feasible, at Wanapum and Priest Rapids dams in order to meet TDG water quality standards. This includes:

- Minimizing involuntary spill by scheduling maintenance operations, to the extent practicable, based on predicted flows. This will include limiting turbine maintenance during high flow and power load periods to emergency maintenance only, if possible. Any required spillgate maintenance that may necessitate spill will be coordinated in a manner that has the least effect on TDG.
- Minimizing involuntary spill by continuing to participate in cooperation and coordination with other Mid-Columbia operators and/or through other agreements or arrangements.
- Maximize powerhouse discharges as reasonable and feasible during periods of high flows.

Grant PUD attempts to reduce involuntary spill by maximizing powerhouse discharge during periods of high flows; however, there are other regional constraints as well as federal requirements that, at times, limits Grant PUD's ability to maximize powerhouse flows to 100% of its capacity. These constraints, considerations, and requirements include, but are not limited to the following:

- Western Electricity Coordinating Council (WECC) requirements for Grant PUD to maintain "operating reserves", which necessitates Grant PUD to hold up to 15% of the Project's powerhouse capacity in reserve to respond to changes to system load and Northwest Power Pool reserve sharing group obligations.
- Variable incoming flow estimates which can change rapidly based on upstream project operational decisions.
- Variable market conditions, which can change rapidly and impact Grant PUD's ability to respond using powerhouse discharge.
- Regional renewable energy portfolio standards and federal tax incentives that have stimulated investment in variable (e.g. alternative) energy resources. The Pacific Northwest has the highest wind production capacity in the U.S., which tends to peak during the spring runoff (e.g. higher flow) and lower energy demand periods, which can lead to limited markets for hydroelectric energy, forcing negative pricing and/or involuntary spill.

Thus both Wanapum and Priest Rapids dams are typically limited to 85% of their capacity based on the aforementioned regional constraints/considerations and federal requirements. Grant PUD attempts to operate its dams up to this capacity in order to maximize powerhouse discharge and limit involuntary spill in order to help mitigate elevated TDG levels.

Additional operational measures that will be implemented, when feasible, to minimize involuntary spill and the TDG impacts associated with involuntary spill include:

- Attempting to maximize turbine flows by setting minimum generation requirements, this includes establishing a common methodology for setting minimum generation requirements specific to Wanapum and Priest Rapids dams for the management of TDG. Mandating a high level of turbine usage during periods of high flow is a potentially effective means of limiting involuntary spill and TDG impacts; however, during periods of very high-sustained flows, there is not adequate turbine capacity to sufficiently limit spill.
- Participation in regional spill/project operation meetings. These meetings often occur prior to and during the fish spill season and include representatives from Environmental Affairs, Wholesale Marketing, and Operations from Chelan, Douglas, and Grant PUDs, as well as representatives from Bonneville Power Association (BPA) and the Corps. Discussions would likely include topics such as:
    - Each project's operational limitations, competing regulations, fish studies, and/or other environmental requirements (e.g. Hanford Reach fall Chinook flow protection requirements).
    - The possibility of shifting generation away from those projects that produce relatively low levels of TDG to those that have the propensity to produce higher TDG levels (e.g. reevaluation of the regional Spill Priority List).

    - Each project's planned maintenance schedules and how it may limit ability to spill water through spillways and/or pass water through turbine units.

- Preemptive spill can be used to coordinate spill sought to manage both the spill rate and the forebay elevation for better TDG management. The spill rate could be stabilized if a project's storage was used to absorb flow fluctuations from upstream projects. Generally, a target operation of one foot from the allowed maximum at each project could be used. When flows spike high, the storage could be used to lower the need for spill; when flows drop, the storage quantities could be reestablished by maintaining spill rates. Allowing a greater amount of storage to absorb variations can be an effective method in stabilizing spill flows but it can also provide adequate time for adjusting spill to meet survival study objectives and TDG requirements.
- Grant PUD will refine and use a multiple linear regression model that was developed to predict tailrace TDG by using a suite of environmental and operational predictor variables that were collected as part of the FSM program and dam operations. This predictive model will assist Grant PUD in better understanding which variables are most important to contributing to TDG, how those variables interact, and what Grant PUD can do to minimize TDG in the Project, and will provide an important aspect of Grant PUD's ongoing TDG abatement program. Additional details associated with this predictive model are provided in the Year 10 Report (Grant PUD 2018a).

2.2 Operational Changes

Per condition 6.4.1(e) of the 401 WQC (WDOE 2007), Grant PUD will provide WDOE with an opportunity to review and condition any non-routine operational change that may affect TDG which is not identified in the 401 WQC. General fishway, spillway, and turbine operation/maintenance schedules and timelines are described in the Fisheries Operation Plan (see Section 2.4).

2.3 Fish Spill

During the 2019-2023 fish-spill season, Grant PUD intends to implement spill programs at Wanapum and Priest Rapids dams as guided by the Biological Opinion (NMFS 2008) and the PRCC, which are proposed to be the same as was done in 2018. Grant PUD's fish-spill program is intended to help meet the biological objectives as defined in section 6.2.3 of the 401 WQC (WDOE 2007). The biological objectives represent important steps toward meeting the designated uses of a water body. They serve as quantifiable goals for moving toward attaining full support of designated uses, and are not intended to serve as a surrogate for the requirement to support and project designated uses of the water body. Biological objectives for Endangered Species Act (ESA) covered fish species are outlined in the Biological Opinion (NMFS 2008) and the Priest Rapids Project Salmon and Steelhead Settlement Agreement (Grant PUD 2006), while biological objectives for non-ESA covered fish species are described in the 401 WQC (WDOE 2007).

Final approval of the 2019-2023 fish-spill season programs will be obtained from the PRCC in the spring of the respective year, prior to the start of the respective fish-spill season. In general, fish-spill levels will be modified as needed to remain in compliance with TDG water quality standards, in consultation with the PRCC. WDOE will be given at least 48 hours of notification prior to the beginning of each fish-spill season initiation.

2.3.1 Wanapum Dam

The primary fish-passage route at Wanapum Dam during 2019-2023 will be the WFB, which passes up to 20 kcfs depending on forebay and tailwater elevations, and turbine passage. Results from various fish survival/behavior studies indicate that survival through the WFB is greater than 95% (Skalski et al. 2009, Timko et al. 2009, Skalski et al. 2010) and therefore the WFB was approved by the PRCC as the primary fish passage at Wanapum Dam. Results from the 2008 WFB TDG study indicate that the operation of the WFB does not negatively affect TDG levels (Hendrick et al. 2009); results from the 2009 – 2017 fish-spill season also indicate no negative impacts to TDG levels during operation of the WFB (Hendrick 2009, Keeler 2010-17).

2.3.2 Priest Rapids Dam

The primary fish-passage route at Priest Rapids Dam during 2019-2023 will be the PRFB, which passes up to 27 kcfs depending on forebay and tailwater elevations, and turbine passage. Results from various fish survival/behavior studies indicate that survival through the PRFB is greater than 95% (Hatch et al. 2015, Skalski et. al 2017) and therefore the PRFB was approved by the PRCC as the primary fish passage at Priest Rapids Dam. Results from the 2014 PRFB TDG study indicate that the operation of the PRFB does not negatively affect TDG levels (Keeler 2016); results from the 2009 – 2017 fish-spill season also indicate no negative impacts to TDG levels during operation of the WFB (Hendrick 2009, Keeler 2010-17).

2.4 Fishery Operation/Management Plan

Grant PUD's Fishery Operations Plan describes the fisheries-related operating criteria, protocols, and annual schedule of operation and inspection for the Project turbines, WFB, spillways, sluiceways, fishways, and off-ladder adult fish trapping facility. In previous GAPs, The Fishery Operations Plan was included as Appendix B; however, on May 1, 2012, Grant PUD filed a request with FERC to modify the filing protocol and deadlines for the Downstream Passage Alternatives Action Plan (401(a)(1)), Progress and Implementation Plan (401(a)(2)), Habitat Plan (401(a)(3)), Artificial Propagation, Hatchery and Genetic Management, and Monitoring and Evaluation annual reports (401(a)(4)), Priest Rapids Dam Alternative Spill Measures Evaluation Plan (401(a)(8)), and the annual Fishery Operations Plan (Article 404). FERC issued an Order modifying the filing protocol and deadlines on June 15, 2012, in which all above mentioned annual reports are to be combined into a single report, with a new annual reporting date of April 15. Because April 15th is beyond the February 1st GAP completion date as required by Section 6.4.11(e) of the 401 WQC (WDOE 2007), Grant PUD will provide WDOE with a copy of the combined report, which will include a description of Grant PUD's fishery operations plan, if requested, on or before April 15 of the corresponding year.

2.5 Biological Monitoring

Grant PUD introduced an updated biological monitoring program for future GAP's in 2018. The updated biological monitoring program consisted of two components:

1). Conduct GBT monitoring in accordance with Grant PUD's future survival studies, during which gatewell operations will be conducted that will provide a source of fish for examination. Grant PUD is currently scheduled to conduct fish survival evaluations for each anadromous fish species every 10 years, and its next studies are scheduled to occur in 2025/2026 During these studies, Grant PUD will examine up to 100

Chinook/Steelhead smolts for signs of GBT once every two weeks during the fish-spill season (~April through August).

2). Monitor the results of weekly GBT analyses from the next upstream project, Rock Island Dam, which conducts specific and regular GBT monitoring of up to 200 smolts per week in conjunction with the Fish Passage Center (FPC) at the Rock Island Bypass Trap. Results of these analyses are posted to the FPC web-site (FPC 2018). If TDG levels in the mid-Colombia River are elevated above 125 %SAT for extended periods (e.g. over four consecutive weeks), and if GBT monitoring data from Rock Island Dam shows GBT in more than 5 fish with signs above a ranking of 2, Grant PUD will consult with Ecology on possible next steps related to more specific GBT monitoring within Grant PUD's Project.

Grant PUD will continue to update this biological monitoring plan with each update to this 5-Year GAP and adaptively manage its GBT monitoring plan as needed based on updated information and/or literature, TDG data, and upstream GBT data.

2.6 Participation in Water Quality Forums

As part of this 5-Year GAP, Grant PUD will continue its participation in regional water quality related forums, including the Corps' end-of-year TDG monitoring summary meetings and other forums as applicable to TDG abatement issues. Grant PUD staff will also attend applicable trainings and/or workshops related to TDG abatement and/or monitoring methods.

3.0 Proposed Structural Total Dissolved Gas Abatement Measures

The following sections provide a summary of the structural TDG abatement measures installed to date as part of this GAP.

3.1 Wanapum Dam Spillway Deflectors

To address elevated TDG levels caused by spill, Grant PUD worked from 1996 through 2000 to develop spillway flow deflectors at Wanapum Dam. The objective of the flow deflectors is to produce a skimming flow across the water surface instead of allowing spill to plunge. After testing several designs in consultation with the agencies, tribes, and stakeholders, FERC approved construction of a full set of twelve flow deflectors (one for each spillbay) on November 15, 1999. Construction was completed in time for the 2000 fish-spill operations.

Juul (2003) and the Corps (Corps 2001) evaluated relationships between spill levels and TDG for pre- and post-deflector time periods at Wanapum Dam. Prior to the installation of the flow deflectors, gas saturation increased non-linearly with spill. After the deflectors were installed, TDG levels were reduced by as much as 10%.

While the Wanapum Dam flow deflectors appear to be effective at reducing TDG, there may be issues related to fish passage that created concern about fish passage survival. Although tests of direct mortality showed little injury to smolts, more recent evaluations suggest that skimming surface flow and edge effects associated with spill across the deflectors may expose smolts to bird predation that appears to result in lower survival rates than for smolts passing through the turbines (Robichaud et al. 2003). These evaluations led, in part; to the development of alternative fish-passage measures at Wanapum Dam.

3.2 Wanapum Fish Bypass

The WFB was completed in 2008 and was fully operational during the 2008 fish-spill season (Figure 5). Results from various fish survival/behavior studies indicate that survival through the WFB is greater than 95% (Skalski et al. 2009, Timko et al. 2009, Skalski et al. 2010) and therefore the WFB was approved by the PRCC as the primary fish passage at Wanapum Dam. Additionally, results from the TDG evaluation associated with the operation of the WFB showed no negative impacts to TDG uptake (Hendrick et. al 2009).

Figure 5 Wanapum Fish Bypass facility, mid-Columbia River, WA.

3.3 Wanapum Dam Advanced Turbines

Grant PUD completed installation of the tenth Advanced Hydro Turbine System at Wanapum Dam in September of 2013. Additionally, in accordance with the terms and conditions contained in the 401 WQC (WDOE 2007) Grant PUD conducted a TDG evaluation with all 10 advanced turbines in operation in October of 2013 in accordance with the Wanapum Dam Advanced Turbine Total Dissolved Gas Evaluation (see Keeler 2012 for more details), to determine the impact, if any, the operation has on TDG. Results from these evaluations are presented in Keeler 2014 and were submitted to the WDOE/PRCC and the FERC on December 13, 2013 and February 20, 2014, respectively. In summary, operation of all 10 units does not negatively impact TDG production.

3.4 Priest Rapids Fish Bypass

The PRFB was completed in April of 2014 and was operated as the primary means of salmonid smolt outmigration during the 2014 fish-spill season (Figure 6). The PRFB was constructed to safely pass juvenile salmonids during their outmigration and to comply with TDG water quality standards. In accordance with the terms and conditions contained in the Project's 401 water quality certificate (WQC; WDOE 2007), Grant PUD conducted TDG evaluations during the first part of August 2014 (see Hendrick and Keeler 2011 for more details) to determine any potential TDG impacts. The final evaluation was submitted to both the WDOE and FERC on March 29, 2016 showing no negative impacts to TDG from operation of the PRFB (Keeler 2016).

Figure 6 Priest Rapids Fish Bypass facility, mid-Columbia River, WA.

4.0 Compliance/Physical Monitoring

The following sections describe Grant PUD's TDG compliance monitoring program, and includes information about its fixed-site water quality monitoring program (FSM Program) and Quality Assurance Protection Plan (QAPP), which was previously approved by WDOE in 2009 (Hendrick 2009b).Concurrent with this this 5-Year GAP, Grant PUD is including an update to the QAPP, which is included as Appendix C.

4.1 Fixed-Site Monitoring Stations

Grant PUD currently operates and maintains four fixed-site water quality monitoring stations (FSM stations) that record water depth (m), barometric pressure (millimeters of mercury (mm Hg)), TDG (mm Hg), temperature (°C), dissolved oxygen (DO; milligrams per liter (mg/L)), pH (units), and turbidity (Nephelometric Turbidity Unit (NTU)). Barometric pressure, TDG, and temperature are monitored on an hourly basis throughout the year, while depth, DO, pH, and turbidity are monitored on a bi-weekly basis throughout the year. Each FSM station is equipped with a HydroLab Corporation Model DS5X, DS5A, DS4A, or Minisonde multi-probe enclosed in a submerged conduit. 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 National Institute of Standards and Technology (NIST) certified barometer located at each FSM station provides the barometric pressure readings necessary to correct the partial pressure readings taken by the HydroLab multi-probes.

Grant PUD FSM stations are located midway across the river channel in the forebay and tailrace of each dam (see Figure 7 and Figure 8). The Wanapum Dam forebay FSM station is located near Turbine Unit 10 and is affixed to a catwalk approximately mid-channel. The Wanapum Dam tailrace FSM station is located approximately 3.2 RM downstream of Wanapum Dam. The tailrace standpipe is located at mid-channel and is attached to the downstream side of Beverly Bridge. The FSM station in the forebay of Priest Rapids Dam is attached to the pier nose directly between the powerhouse and the PRFB and is located at mid-channel at approximately the center of the dam. The Priest Rapids Dam tailrace FSM station is located nine miles downstream of Priest Rapids Dam affixed to Vernita Bridge. The Pasco FSM station located at RM 329 and owned/operated by the Corps, serves as the next downstream forebay TDG compliance point for Priest Rapids Dam. This location was chosen to measure mixed river gas conditions before dilution or concentration with the waters of the Snake River. Chelan PUD also operates and monitors a FSM station located in the Rock Island Dam tailrace, approximately 38 RM upstream of Wanapum Dam, during the fish-spill season. This FSM station, along with other upstream FSM stations, allows Grant PUD to monitor upstream river conditions.

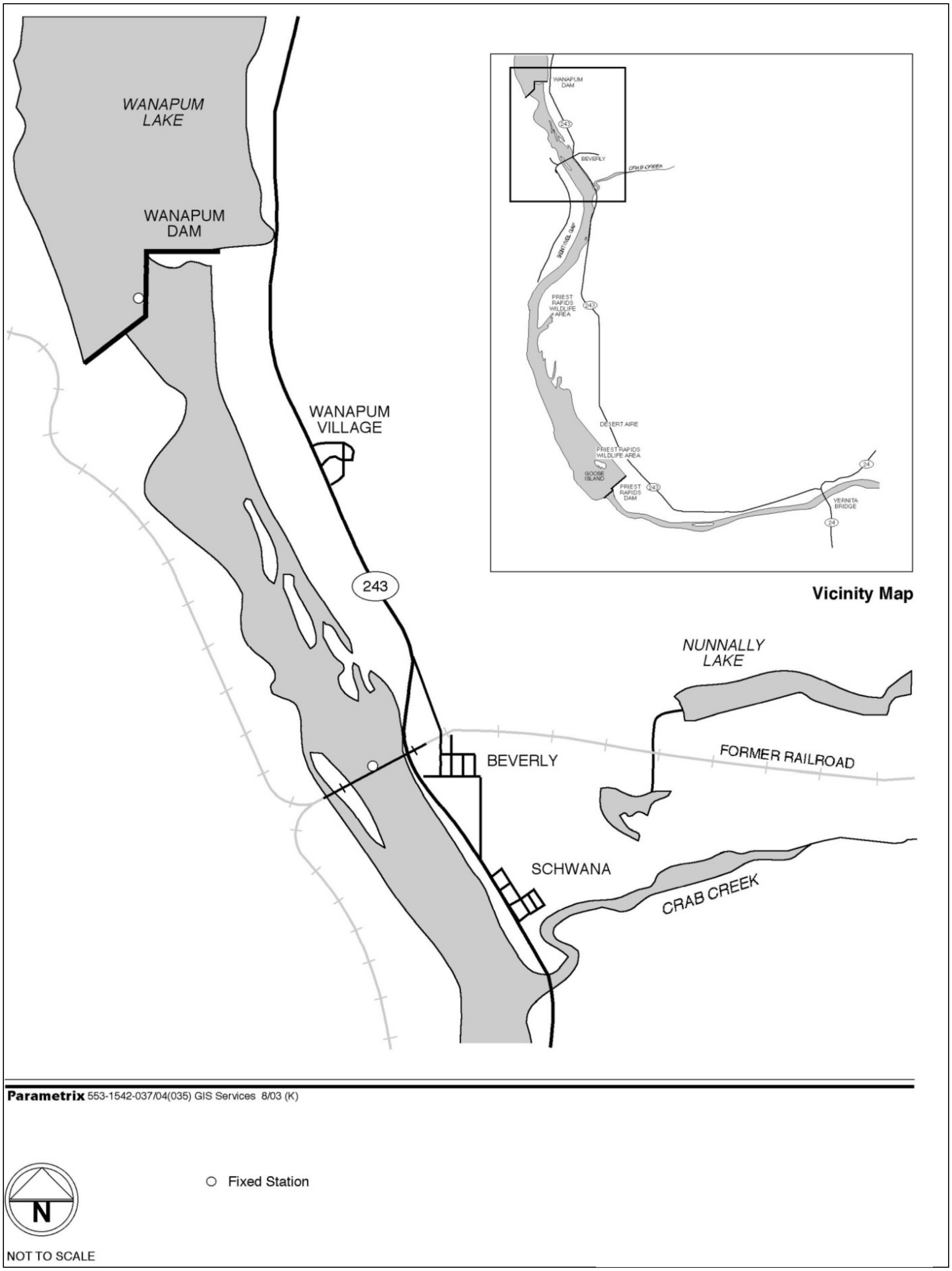

Figure 7 Location of water quality fixed-site monitoring stations for Wanapum Dam.

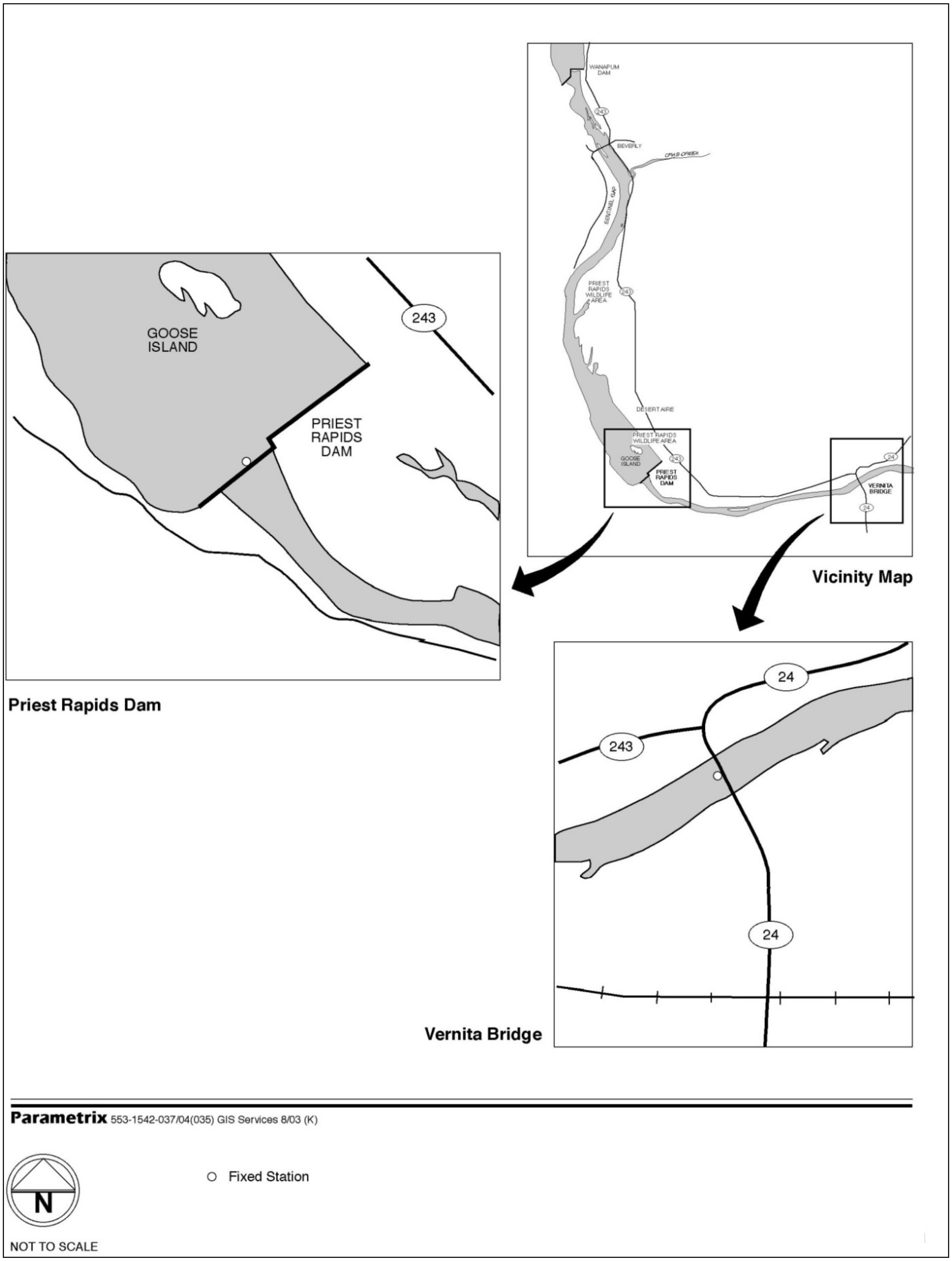

Figure 8 Location of water quality fixed-site monitoring stations for Priest Rapids Dam.

4.2 Quality Assurance Project Plan

Section 6.4.10(c) of the 401 WQC (WDOE 2007) requires Grant PUD to maintain a TDG quality assurance/quality control (QA/QC) program that is at least as stringent as QA/QC procedures developed by the USGS. Grant PUD prepared a QAPP in 2009 (Hendrick 2009b), which was approved by WDOE. Concurrent with the submittal of its 5-Year GAP, Grant PUD is included an updated QAPP as Appendix C for WDOE review and approval.

4.3 Compliance Reporting

The following sections discuss Grant PUD's TDG reporting requirements, including reporting TDG data to its water quality website and notification of the start of the fish-spill season.

4.3.1 Water Quality Website

Hourly, daily summary, and monthly summary TDG and water temperature data recorded at each of Grant PUD's FSM stations, along with corresponding total river flow and spill volumes at each dam, are posted to Grant PUD's Fixed Site Water Quality Monitoring web-site, located at:

https://www.grantpud.org/water-quality

The following data is 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.
- Water Quality Monitoring Report: Link to the current year water quality monitoring report.
- Quality Assurance Project Plan: Link to the most up-to-date QAPP for the Project.
- Total Dissolved Gas Abatement Plan: Link to the most up-to-date compliance GAP for the Project.

Data from previous years' can also be accessed from the Grant PUD's water quality website.

4.3.2 Notifications

Grant PUD shall notify WDOE within 48 hours of the beginning of the fish-spill season, per section 6.4.11 (b) of the 401 WQC (WDOE 2007).

4.3.3 Reporting Schedule

This compliance GAP will be updated every 5 years for the remainder of the Project license, and will include any applicable information on new or improved technologies and a review of any additional reasonable and feasible gas abatement options, as well as the compliance analyses described in Section 4.3.4 below.

4.3.4 Compliance Analyses

As described in Section 4.1 and 4.2, Grant PUD will continue to collect TDG time-series data and, concurrent with the each 5-Year update of the compliance GAP, will perform a compliance analyses similar to the Year 10 Report, using the previous 10 years of TDG data to ensure that Project operations continue to meet a similar level of compliance demonstrated in the Year 10 Report. The compliance analysis will include a descriptive characterization of the TDG data and an overall compliance assessment for the Project with respect to the TDG water quality standards.

5.0 Conclusions

Since the issuance of the Project’s license, Grant PUD has implemented various operational and structural TDG abatement measures in accordance with the Project’s 401 WQC compliance schedule. Additionally, Grant PUD has been collecting hourly TDG data in accordance with its QAPP at the respective tailrace(s) and next downstream forebay(s) FSM stations, including the Wanapum dam forebay (to document incoming TDG). The Year 10 Report summarized TDG data collected during Grant PUD’s 10-year compliance schedule associated with the 401 WQC, which included an analysis of hourly data points evaluated for compliance with TDG water quality standards. Based on the results presented in the Year 10 Report, the Project’s overall average compliance with TDG water quality standards was over 97%. This Year 10 Report was approved by WDOE on July 13, 2018.

Grant PUD will continue to implement the remaining applicable provisions of the 401 WQC, including continued hourly monitoring of TDG data and continued implementation of TDG abatement measures noted within this 5-Year GAP (Sections 2, 3 and 4). In addition to the 5-Year GAP, a compliance analyses of the previous 10 years of data will also be completed every 5 years concurrent with the 5-year compliance GAP, which will help to ensure that Project operations continue to meet a similar level of compliance demonstrated in the Year 10 Report.

Literature Cited

Federal Energy Regulatory Commission (FERC). 2008. Order Issuing New License for Public Utility District No. 2 of Grant County, 123 FERC ¶ 61,049, Washington D.C.

Fish Passage Center (FPC). 2018. Gas Bubble Trauma Data. http://www.fpc.org/smolt/gasbubbletrauma.html. Accessed April-August 2018.

Hatch, K.B, M.A. Timko, L.S. Sullivan, J.D. Stephenson, N.L. Ogan, S.E. Rizor, C.D. Wright, C. Fitzgerald, J.R. Skalski, R.L. Townsend, and J.A. Lady. 2015. Behavior and survival analysis of juvenile steelhead and yearling Chinook salmon through Priest Rapids Project in 2014. Report prepared for Public Utility District No. 2 of Grant County, Washington by Blue Leaf Environmental, Inc., Ellensburg, Washington.

Hendrick, R. 2004-09. Summary of the annual fish-spill and total dissolved gas monitoring. Public Utility District No. 2 of Grant County, Ephrata, WA.

Hendrick, R. 2009b. Quality Assurance Project Plan for Monitoring Selected Water Quality Parameters within the Priest Rapids Hydroelectric Project. Prepared for Public Utility District No. 2 of Grant County, Washington. January, 2009. http://www.gcpud.org/resources/resLandWater/waterQuality.htm

Hendrick, R., Dotson, C., Jeske, D., Carroll, J., and Hay, D. 2009. Evaluation of Total Dissolved Gas Exchange Related to Operation of The Wanapum Dam Fish Bypass. Report prepared for Public Utility District No. 2 of Grant County, Washington. September, 2009.

Hendrick, R. and Keeler, C. 2011. Study Plan for Evaluating Total Dissolved Gas Exchange Related to Operation of the Priest Rapids Fish Bypass. Prepared for Public Utility District No. 2 of Grant County, Washington. March, 2011.

Juul, S. T. J. 2003. An assessment of selected water quality parameters for the Priest Rapids Hydroelectric Project. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, WA.

Keeler C. 2010-17. Summary of the annual fish spill and total dissolved gas monitoring. Draft Report. Public Utility District No. 2 of Grant County, Ephrata, WA. October 2010-17.

Keeler C. 2010-17b. Summary Results of the Water Quality Fixed-Site Monitoring Program within the Priest Rapids Hydroelectric Project. Prepared by the Public Utility District No. 2 of Grant County, WA. Ephrata, WA. February 2010-17.

Keeler C. 2012. Wanapum Dam Advanced Turbine Total Dissolved Gas Evaluation – Final Study Plan. Public Utility District No. 2 of Grant County, Ephrata, WA. September, 2012.

Keeler C. 2014. Evaluation of Total Dissolved Gas Related to the Operation of Advanced Turbines at Wanapum Dam. Public Utility District No. 2 of Grant County, Ephrata, WA. February 2014.

Keeler C. 2016. Evaluation of Total Dissolved Gas Related to the Operation of the Priest Rapids Fish Bypass – Final Report. Public Utility District No. 2 of Grant County, Ephrata, WA. February 2016.

National Marine Fisheries Service (NMFS). 2004. Biological Opinion and Magnuson- Stevens Fishery Conservation and Management Act Consultation. Interim Protection Plan for Operation of the Priest Rapids Hydroelectric Project FERC Project No. 2114.

NMFS. 2008. Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation for the Priest Rapids Hydroelectric Project, FERC Project No. 2114.

Normandeau Associates Inc., Washington State University and University of Idaho. 2000. An evaluation of water quality and limnology for the Priest Rapids Project Area. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, WA.

Normandeau Associates, Inc; J.R. Skalski; and R. Townsend. 2005. Performance Evaluation of the New Advanced Hydro Turbine (AHTS) at Wanapum Dam, Columbia River Washington. Prepared for Public Utility District No. 2 of Grant County, Ephrata, WA.

Normandeau Associates, Inc. and J.R. Skalski. 2005. Relationship and turbine discharge and survival of Juvenile Chinook Salmon at Priest Rapids Dam, Columbia River. Prepared for the Public Utility District No. 2 of Grant County, Ephrata, WA.

Public Utility District No. 2 of Grant County, Washington (Grant PUD). 2006. Priest Rapids Project Salmon and Steelhead Settlement Agreement, FERC Project No. 2114, (February 10, 2006).

Public Utility District No. 2 of Grant County, Washington (Grant PUD). 2018. Calendar Year 2017 - Activities under the Priest Rapids Hydroelectric Project License (FERC No. 2114). Final Report prepared by Public Utility District No. 2 of Grant County. Final. April 2018.

Public Utility District No. 2 of Grant County, Washington (Grant PUD). 2018a. Summary of Total Dissolved Gas Monitoring within the Priest Rapids Hydroelectric Project, Year 10 Report. Final. May 2018.

Robichaud, D. K. and six co-authors. 2003. Survival of Chinook Smolts during Various Spill Configurations at Wanapum and Priest Rapids Dams, 2002. Prepared for Public Utility District No. 2 of Grant County. LLG Limited, Sidney, BC.

Robichaud, D.K., Nass, B., Timko, M.A., English, K.K., and Ransom, B. 2005. Analysis of Chinook Smolt Behavior and Relative Survival at Wanapum Dam using Three-Dimensional Acoustic-Telemetry, 2004. Prepared for Public Utility District No. 2 of Grant County. LLC Limited, Sidney, BC.

Skalski, J. R., Townsend, R. L., Sullivan, L. S., Wright, C. D., Nealson, P. A., and Ransom, B. H. 2009. Survival of Acoustic-Tagged Steelhead Smolts through the Wanapum-Priest Rapids Projects in 2008. Prepared for Public Utility District No. 2 of Grant County, Washington. August 2009.

Skalski, J. R., R. L. Townsend, M. A. Timko, and L. S. Sullivan. 2010. Survival of acoustic-tagged steelhead and sockeye salmon smolts through the Wanapum – Priest Rapids Projects in 2010. Prepared for PUD No. 2 at Grant County, Ephrata, WA.

Skalski, J.R., R.L. Townsend, J.M. Lady, M.A. Timko, L.S. Sullivan, and K. Hatch. 2017. Survival of Acoustic-Tagged Steelhead Smolts Through the Priest Rapids Project in

2016. Prepared for Public Utility District No. 2 of Grant County, Washington. October 2016.

Timko, M.A., L.S. Sullivan, C.D. Wright, S.E. Rizor, R.R. O'Connor, J.R. Skalski, R.L. Townsend, C.A. Fitzgerald, M.L. Meager, T.J. Kukes, and J.D. Stephenson. 2009. Behavior and survival analysis of steelhead and sockeye through the Priest Rapids Hydroelectric Project in 2009. Draft report by Blue Leaf Environmental, Ellensburg, WA for Public Utility District No. 2 of Grant County, Ephrata, WA.

U.S. Army Corps of Engineers (Corps). 2001. Data Summary for Wanapum Dam Phase 5 Total Dissolved Gas Post-deflector Spillway Performance Test, April 26 - May 3, 2000. U.S. Army Corps of Engineers, Engineer Research and Development Center, Dallesport, WA. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, WA.

U.S. Army Corps of Engineers (Corps). 2003. Total Dissolved Gas Exchange at Priest Rapids Dam, July 21-August 4, 2002. Prepared for Public Utility District No. 2 of Grant County, Ephrata, WA.

U.S. Geological Survey (USGS). 2018. Stream flow data collected at gage #12472800: Columbia River Below Priest Rapids Dam, WA. http://waterdata.usgs.gov/wa/nwis/uv?station=12472800. Accessed November 2018.

Washington State Department of Ecology (WDOE). 2004. Total Maximum Daily Load for Total Dissolved Gas in the Mid-Columbia River and Lake Roosevelt. Submittal Report. Prepared jointly by the U.S. Environmental Protection Agency and the Washington State Department of Ecology in cooperation with the Spokane Tribe of Indians. WDOE Publication Number 04-03-002. June 2004.

Washington State Department of Ecology (WDOE). 2007. Water Quality Certification for the Priest Rapids Hydroelectric Project. Order No. 4219 dated April 2007, amended March 6, 2008 (Order 5419). http://www.ecy.wa.gov/programs/wq/ferc/existingcerts.html#G.

Appendix A

Washington Department of Ecology (WDOE) Approval Letter of Grant PUD's *Final Summary of Total Dissolved Gas Monitoring within the Priest Rapids Hydroelectric Project – Year 10 Report*

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
1250 W Alder St • Union Gap, WA 98903-0009 • (509) 575-2490

July 13, 2018

Mr. Ross Hendrick
Manager, License & Environmental Compliance
Grant County PUD
PO Box 878
Ephrata, WA 98823

RE: *Final Summary of Total Dissolved Gas Monitoring within the Priest Rapids Hydroelectric Project – Year 10 Report.* Priest Rapids Hydroelectric Project, FERC No. 2114

Dear Mr. Hendrick:

The Department of Ecology (Ecology) has reviewed the *Final Summary of Total Dissolved Gas Monitoring within the Priest Rapids Hydroelectric Project – Year 10 Report* sent via email to Ecology on May 16, 2018, with a draft report sent via email on January 8, 2018.

Based on the information provided in this report Ecology **approves** the *Final Summary of Total Dissolved Gas Monitoring within the Priest Rapids Hydroelectric Project – Year 10 Report.* Grant County Public Utility District (PUD) has demonstrated reasonable compliance as set forth in this report and as described in the 401 water quality certification (WQC).

The multipart Total Dissolved Gas (TDG) criteria requires a detailed analysis of TDG time-series data. Ecology appreciates Grant PUD's effort and collaboration with Ecology to detail best practices for evaluating compliance given the complexity of the standard. The analysis Grant County PUD performed will help Ecology to guide other hydropower projects' compliance assessment methods. Ecology also looks forward to a continuing collaboration with Grant County PUD on improvements that will further reduce instances of high TDG in which the Priest Rapids and Wanapum projects can feasibly affect.

As agreed, Grant County PUD will continue to collect TDG time-series data and provide a report every five (5) years concurrent with the 5-year compliance gas abatement plan (GAP). Each analysis will include the preceding 10 years of TDG data. This will help ensure that project operations continue to meet a similar level of compliance demonstrated in this Year 10 Report.

Please contact me at (509) 575-2808 or breean.zimmerman@ecy.wa.gov if you have any questions.

Sincerely,

Breean Zimmerman

Breean Zimmerman
Central Region Hydropower Projects Manager
Water Quality Program

cc: Debbie Firestone, Grant County PUD

Appendix B
Extension of Time Approval for Compliance GAP

From: Zimmerman, Breean (ECY)
To: Carson Keeler
Cc: NR Records; Debbie Firestone; Ross Hendrick; Jeff Grizzel
Subject: RE: EOT for compliance GAP
Date: Friday, November 02, 2018 10:07:53 AM

Please take care when opening links, attachments or responding to this email as it originated outside of Grant.

Carson,

My apologies for the very delayed response here. I appreciate you reaching out and discussing the information below with me last month.

I'm providing you this email to let you know Ecology approves of this extension for submitting the compliance GAP from October 31, 2018 to December 31, 2018, as detailed in your email below.

Please let me know if you need anything else.

Thank you,
Breean Zimmerman¦**Hydropower Projects Manager**
Water Quality Program|Central Regional Office
(509) 575-2808 (w)|(509) 406-5130 (c)|bzim461@ecy.wa.gov

From: Carson Keeler <Ckeeler@gcpud.org>
Sent: Wednesday, October 10, 2018 10:58 AM
To: Zimmerman, Breean (ECY) <bzim461@ECY.WA.GOV>
Cc: NR Records <Nrrec@gcpud.org>; Debbie Firestone <Dfirest@gcpud.org>; Ross Hendrick <Rhendr1@gcpud.org>; Jeff Grizzel <Jgrizzel@gcpud.org>
Subject: EOT for compliance GAP

Good morning Breean,

Section 9.0 of Grant PUD's Year-10 Report (10-Year TDG "check-in" report) outlined next steps. One of the bulleted items included a compliance gas abatement plan that would be updated on a 5-year basis for the remainder of the FERC license (5-Year GAP). Included below is the direct language from the Year-10 report for reference:

Consistent with Section 6.4.11(f) of the 401 WQC, Grant PUD will submit a compliance GAP by October 31, 2018 that will become effective, upon WDOE's review and approval, in 2019 (Grant PUD notes that a GAP for 2018 has already been approved by WDOE). This compliance GAP will be updated every 5 years for the remainder of the Project license, and will include any applicable information on new or improved technologies and a review of any additional reasonable and feasible gas abatement options. In addition, a compliance analysis of the previous 10 years of data will also be completed every 5 years concurrent with the 5-year compliance GAP, which will demonstrate Grant PUD's ability to continue to consistently achieve compliance with the provisions of TDG water quality standards.

Based upon the phone conversation we had early today, we'd (Grant PUD) like to request an extension of time (EOT) for the compliance GAP from October 31, 2018 to December 31, 2018 (coinciding with the due date for the updated QAPP). This should still leave time for the review period to take place before the fish-spill season is initiated. Please let me know if you have any questions.

Thanks,

Carson

Carson Keeler
Grant PUD
Office: (509) 754-5088 x2687
Cell: (509) 797-5176

Appendix C

Quality Assurance Project Plan for Monitoring Selected Water Quality Parameters within the Priest Rapids Hydroelectric Project: 2018 Update

Priest Rapids Hydroelectric Project (P-2114)

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

2018 Update

License Article 401(a)(23)

By
Public Utility District No. 2 of Grant County
P.O Box 878
Ephrata, WA 98823

December 2018

Executive Summary

This updated Quality Assurance Project Plan (QAPP) provides details on water quality monitoring methods that Public Utility District No. 2 of Grant County, Washington (Grant PUD) will implement to help meet conditions of the 401 Water Quality Certification (WQC) issued by the Washington Department of Ecology (WDOE). Water quality parameters that will continued to 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 Program (FSM Program). Information provided in this updated 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 primary purpose of Grant PUD's FSM Program is to provide information on water quality conditions within the Priest Rapids Hydroelectric Project (Project), as well as to verify compliance with applicable water quality standards and conditions within the Project's 401 WQC. Continued implementation of the QAPP will help assure that water quality data collected by the FSM Program will continue to be of sufficient quality. Adaptive management provisions in this QAPP will help determine potential changes to monitoring methods, locations, etc. that may be warranted, and updates will be made to this QAPP accordingly, subject to WDOE and Federal Energy Regulatory Commission (FERC) approval.

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%SAT	percent saturation
7Q10 flow	highest seven consecutive day average flow with a 10-year recurrence frequency
Biological Opinion	National Marine Fisheries Service's Biological Opinion for the Priest Rapids Hydroelectric Project
Chelan PUD	Public Utility District No. 1 of Chelan County, Washington
Corps	U.S. Army Corps of Engineers
DO	dissolved oxygen
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FSM station(s)	fixed-site monitoring station(s)
GAP	Gas Abatement Plan
GBT	gas bubble trauma
Grant PUD	Public Utility District No. 2 of Grant County, Washington
kcfs	thousand cubic feet per second
mg/L	milligrams per liter
mm Hg	millimeters of mercury
MW	megawatt
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Units
PRFB	Priest Rapids Juvenile Fish Bypass
PRCC	Priest Rapids Coordinating Committee
Project	Priest Rapids Hydroelectric Project
QAPP	quality assurance project plan

QA/QC	quality assurance/quality control
RM	river mile
TDG	total dissolved gas
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WFB	Wanapum Juvenile Fish Bypass
WDOE	Washington Department of Ecology
WQC	water quality certification

1.0 Introduction

Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates the Priest Rapids Hydroelectric Project (Project). The Project is licensed as Project No. 2114 by the Federal Energy Regulatory Commission (FERC), and includes the Wanapum and Priest Rapids developments. A 401 water quality certification (WQC) for the operation of the Project was issued by the Washington Department of Ecology (WDOE) on April 3, 2007 (WDOE 2007), amended on March 6, 2008 and effective on issuance of the FERC license to operate the Project in April of 2008 (FERC 2008).

Section 6.7.1 of the WQC required Grant PUD to submit for WDOE approval a Quality Assurance Project Plan (QAPP) for each parameter to be monitored under the 401 WQC. Approval of the QAPP was received by WDOE on January 30, 2009 and by FERC on July 16, 2009. This document serves as that update to the 2009 QAPP (Hendrick 2009). Updates within this QAPP include the following:

- Reporting protocols
- QA/QC controls
- Updated maps of monitoring locations
- Updated equipment
- Data collection frequency (for pH, dissolved oxygen (DO), and turbidity)
- Updated personnel and responsibilities table
- Updated calibration and maintenance procedures

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 will continue implementation of its Fixed Site Water Quality Monitoring Program (FSM Program) to continue to meet the 401 WQC water quality monitoring requirements. This QAPP update 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 updated 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, 2016 revisions);
2). U.S. Geological Survey (USGS) National Field Manual for Collection of Water Quality Data (Gibs et. al 2007, 2014 revisions); and
3). Grant PUD's Quality Assurance and Quality Control (QA/QC) procedures as described in Duvall and Dresser (2003) and additional QA/QC controls included in Grant PUD's 2009 QAPP (Hendrick 2009).

1.1 Priest Rapids Project Description

The Project is located on the mid-Columbia River in central Washington State (Figure 1). From its headwaters in Canada, the Columbia River extends 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 lie within 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 region of Washington, being on the dry (east) side of the Cascade Mountain Range, is arid and receives approximately 7 inches of precipitation 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. The Project is located on that portion of the Columbia River that makes up the western boundary of Grant County. The Project also touches Benton, Yakima, Kittitas, Douglas, and Chelan counties. In all, the Project encompasses 58 miles of the Columbia River from river mile (RM) 395 at Rock Island Dam to RM 453 two miles below Priest Rapids Dam. The Project is located in a largely undeveloped and undisturbed landscape. Development along the Project is limited to a few smaller communities and scattered tracts of irrigated farm land.

The Project is part of the much larger 13,600 Megawatt (MW), seven dam, upper/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 and also poses significant challenges with respect to managing TDG and other water quality parameters.

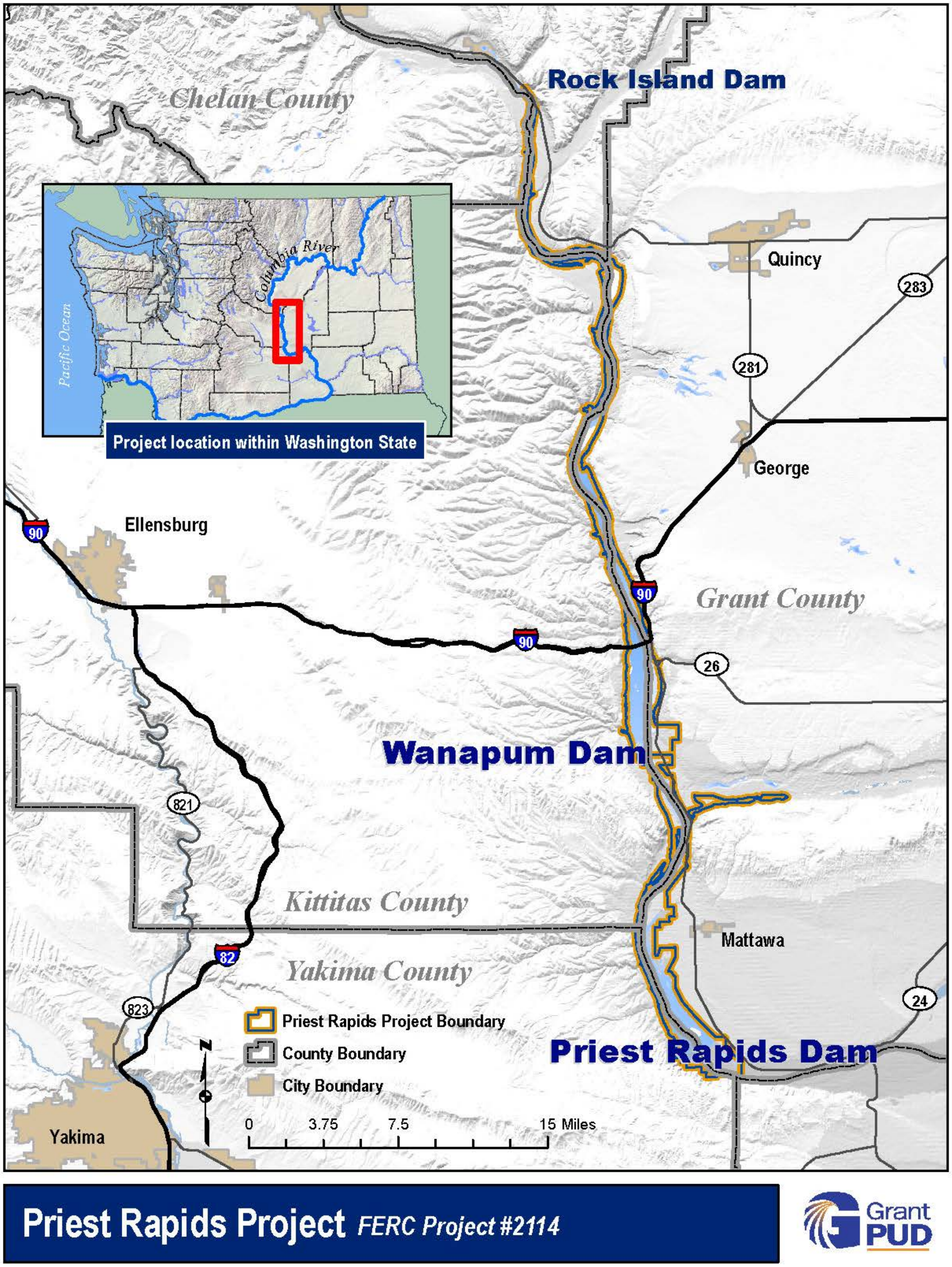

Figure 1 The Priest Rapids Project is located in central Washington State on the mid-Columbia River.

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 hydro 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 federally operated Grand Coulee and Chief Joseph Projects generally establishes the flow, TDG, and temperature regime for the entire mid-Columbia River system.

Three Public Utility Districts (PUDs) own and operate the next five hydroelectric projects below Chief Joseph Dam, all of which are subject to FERC jurisdiction. 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 (Douglas PUD). The Rocky Reach Project, at RM 474, is owned and operated by PUD No. 1 of Chelan County (Chelan PUD), 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 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.

The Wanapum development consists of a 14,680-acre reservoir (Wanapum Reservoir) and an 8,637-foot-long by 186.5-foot-high dam spanning the Columbia River (Wanapum Dam). The dam consists of left and right embankment sections; left and right concrete gravity dam sections; left and right bank fish passage structures, each with an upstream fish ladder; a gated spillway; a downstream fish passage structure (the Wanapum juvenile Fish Bypass (WFB)); and a powerhouse containing ten vertical shaft integrated Kaplan turbine/generator sets with a total authorized installed capacity (best gate) of 735 MW (Figure 2).

The Priest Rapids development consists of a 7,725-acre reservoir (Priest Rapids Reservoir) and a 10,103-foot-long by 179.5-foot-high dam spanning the Columbia River (Priest Rapids Dam). The dam consists of left and right embankment sections; left and right concrete gravity dam sections; left and right bank fish passage structures, each with an upstream fish ladder; a gated spillway section; a downstream fish passage structure (the Priest Rapids juvenile Fish Bypass (PRFB)); and a powerhouse containing ten vertical shaft integrated Kaplan turbine/generator sets with a total authorized installed capacity of 675 MW (best gate) (Figure 3).

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

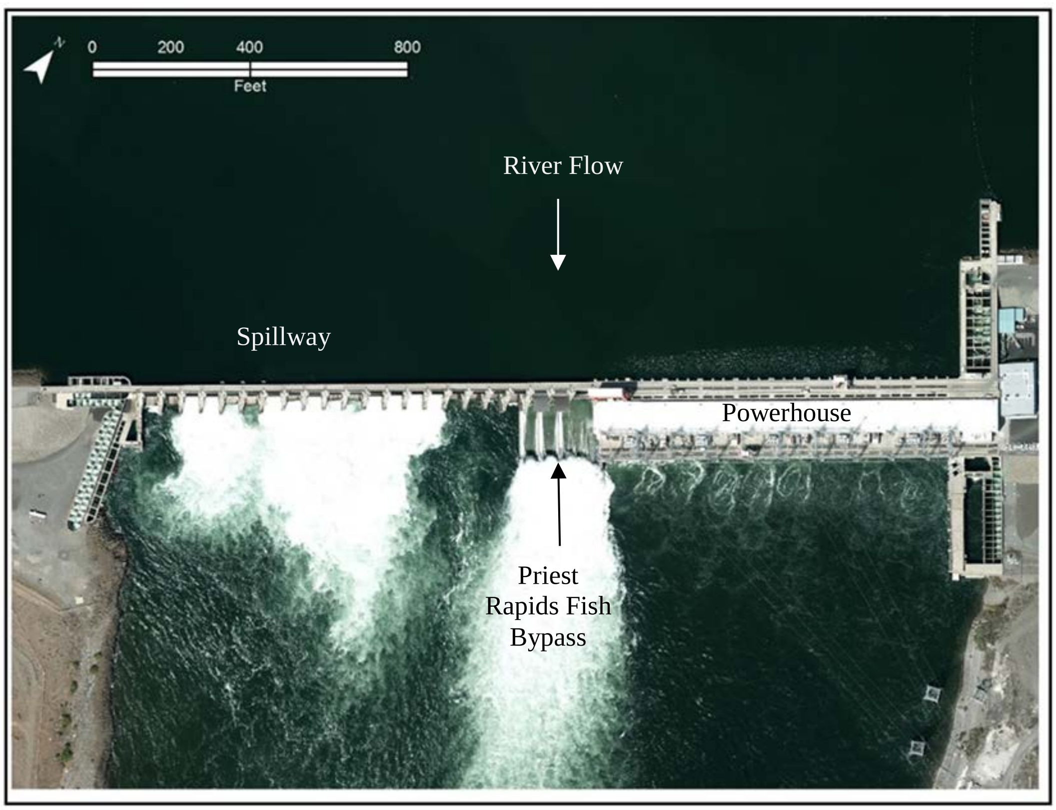

Figure 3 Aerial photograph of Priest Rapids Dam, mid-Columbia River, WA.

2.0 Regulatory Framework

Section 6.0 of the 401 WQC (WDOE 2007) contains water quality conditions that Grant PUD must comply with, 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.

2.1 Total Dissolved Gas

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

Section 6.4.1(d) of the 401 WQC (WDOE 2007) notes that even when TDG levels in the tailrace of a dam exceed 120 %SAT, that dam may be deemed in compliance with TDG water quality standards if both the following apply:

- TDG levels in the dam's forebay exceed 120 %SAT, and
- The dam does not further increase TDG levels in the tailrace

Section 5.0(b) of the 401 WQC (WDOE 2007) and WAC 173-201A-200(f)(i) provide that the TDG 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 ten-year recurrence frequency. The 7Q10 flood flow was calculated to be 264 thousand cubic feet per second (kcfs) for both Wanapum and Priest Rapids dams.

In 2004, WDOE established a TDG Total Maximum Daily Load (TMDL) for the mid-Columbia River which set TDG allocations for each dam (WDOE 2004a). According to section 6.4.1(f) of the 401 WQC, Grant PUD shall be "…deemed in compliance with the TDG TMDL…" while it remains in compliance with the 401 WQC (WDOE 2007).

Section 6.4.10 of the 401 WQC requires Grant PUD to maintain a TDG monitoring program at its fixed-site monitoring stations (FSM 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).

2.1.1 Water Temperature

WAC 173-201A-602 designates the segment of the Columbia River within the Project as salmonid spawning, rearing, and migration; 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 maximum daily (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 $t = 34/(T + 9)$.

Certain sections of the Columbia River within the Project are classified as impaired for temperature under Section 303(d) of the Clean Water Act. Portions of the Columbia River upstream of the Project are also classified as impaired for temperature. WDOE has indicated that a Total Maximum Daily Load (TMDL) for temperature is expected to be developed by the Environmental Protection Agency (EPA) that will establish a final wasteload and load allocation for temperature (WDOE 2007).

2.1.2 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.

Section 6.6.1(a) of the 401 WQC requires Grant PUD to periodically monitor both pH and DO for the term of the FERC license. Although turbidity monitoring is not required by the 401 WQC, Grant PUD will monitor turbidity on a periodic basis as described in this QAPP.

3.0 Project Description

This QAPP provides details and updates on Grant PUD's Fixed-Site Water Quality Monitoring Program (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

3.1 Fixed-Site Monitoring Program

Grant PUD operates and maintains four fixed-site water quality monitoring stations (FSM stations) that record water depth (meters (m)), barometric pressure (millimeters of mercury (mm Hg)), TDG (mm Hg), temperature (°C), dissolved oxygen (DO; milligrams per liter (mg/L)), pH (units), and turbidity (Nephelometric Turbidity Units (NTU)) as a part of its FSM Program. Barometric pressure, TDG, and temperature are monitored and reported on an hourly basis, while depth, DO, pH, and turbidity are monitored on a bi-weekly basis. TDG is measured in mm Hg at each FSM station and converted to %SAT using the barometric pressure measurements recorded by a certified barometer located at each FSM station. The conversion equation is as follows:

$$\text{TDG in \%SAT} = (\text{TDG mm Hg} / \text{barometric pressure mm Hg}) \times 100$$

Each FSM station is equipped with a HydroLab Corporation Model DS5X, DS5A, DS4A, or Minisonde multi-parameter probe (multi-probe) enclosed in a submerged conduit. Multi-probes are connected to an automated system that allows Grant PUD to monitor and report barometric pressure, TDG, and water temperature on an hourly basis. A National Institute of Standards and Technology (NIST) certified barometer located at each FSM station provides the barometric pressure readings necessary to correct the partial pressure readings taken by the multi-probes.

The 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 9210 data collection platform (DCP). Multi-probes are interrogated every 15-minutes and data is archived within the DCP. The DCPs are then interrogated via radio transmission onto 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 on Grant PUD’s water quality website (see Section 6.5.4).

3.2 Purpose and Objectives

The purpose of Grant PUD’s FSM Program is to provide information on water quality conditions within the Project, as well as to verify compliance with applicable water quality standards and conditions within the 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)),

- Conduct a TDG compliance analysis in year 2024 in accordance with Grant PUD's compliance GAP (Grant PUD 2018a);
- 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 website 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:

- 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 website, available for public use;
- Verify compliance with conditions of the Project's 401 WQC and Washington States water quality standards for temperature, TDG, DO, and pH; 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 (as reasonable and feasible), in consultation with appropriate stakeholders according to procedures outlined in Grant PUD's currently approved gas abatement plan.

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 fall of 2017, 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 existing FSM Program with a few minor additions as described in this updated QAPP. Additional details on the FSM 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 and/or update current FSM stations used to continually monitor water quality parameters within the Wanapum and Priest Rapids dam forebay and tailrace areas;
- Maintain current FSM station data transmission software/hardware that allows for TDG and temperature data to be transmitted to Grant PUD's water quality website within two hours of being collected;
- Continue to conduct periodic grab-sample monitoring of DO, pH, and turbidity data;

- Maintain current QA/QC procedures to assure data is accurate and reliable; and
- Apply the adaptive management process to the FSM 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 or as needed, and implement any changes to the plan pending WDOE and FERC approval.

3.3 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.

3.3.1 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, below. TDG will be measured in mm Hg and then converted to %SAT using barometric pressure measurements recorded by a NIST certified barometer located at each FSM station. The conversion equation is as follows:

$$\text{TDG in \%SAT} = (\text{TDG mm Hg} / \text{barometric pressure mm Hg}) \times 100$$

The TDG sensor is connected to a Hydrolab multi-probe, which transmits data to a Sutron 9210 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 website within approximately two hours of delay from the 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 (as reasonable and feasible), in consultation with appropriate stakeholders according to procedures outlined in Grant PUD's currently approved gas abatement plan.
- Concurrent with the each 5-Year update of the GAP, Grant PUD will perform a compliance analyses similar to the Year 10 Report (Grant PUD 2018), using the previous 10 years of TDG data to ensure that Project operations continue to meet a similar level of compliance demonstrated within the Year 10 Report. The compliance analysis will include a descriptive characterization of the TDG data and an overall compliance assessment for the Project with respect to the TDG water quality standards.

3.3.2 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, below. The sensor is connected to a Hydrolab multi-probe, which transmits data to a Sutron 9210 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 website 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.

3.3.3 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, below. 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 (monthly). DO, pH, and turbidity data will be made available on Grant PUD's water quality website (via the water quality monitoring report(s)) 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 and pH.

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 and time of the year;
- 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, below.

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; converted to %SAT	non fish-spill season: <110% saturation fish-spill season: <115% in forebay, <120% in tailrace, and <125% hourly 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	Monthly	nephelometric turbidity unit (NTU)	<5 NTU increase above background (upstream) conditions
pH	Forebay and tailrace of each dam	Monthly	pH units	6.5 – 8.5 units
Dissolved Oxygen	Forebay and tailrace of each dam	Monthly	milligrams per liter (mg/L)	>8.0 mg/L

3.4 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 2001, following the QA/QC guidelines and procedures outlined by Grant PUD's 2009 QAPP (Hendrick 2009), many of these activities are on-going and will continue for the life of the FERC license (FERC 2008). 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 QAPP (Hendrick 2009), and those updates and implementation schedules are reflected in this updated QAPP. Table 2 provides the individuals at Grant PUD with key responsibilities in the continued implementation of the FSM Program.

Table 2 List of key personnel and responsibilities.

Personnel	Title	Responsibilities	Contact information
Ross Hendrick	Manager of License and Environmental Compliance	Management, report review, and communication with WDOE and outside agencies/public	509-754-5088, ext. 2468; rhendr1@gcpud.org
Carson Keeler	Senior Biologist	Field work, calibration scheduling, program oversight, data collection, probe calibration and maintenance, data QA/QC, data analysis and QA/QC, report generation, and communication with WDOE.	509-754-5088, ext. 2687; ckeeler1@gcpud.org
Ted Harris	Electronic Tech IV	Telecommunications management – FSM station communication (both radio and fiber)	509-754-5088, ext. 4004; tharris@gcpud.org
Suresh Nalla	Program Analyst V	Data transmission support - Sutron XConnect Software	509-754-5088, ext. 2413; Snalla@gcpud.org
Breean Zimmerman (WDOE)	Hydropower Projects Manager. Water Quality Program – WDOE Central Regional Office	Grant PUD's contact for all correspondence related to the 401 Water Quality Certification	509-575-2808; bzim461@ecy.wa.gov

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

Table 3 Schedule of Fixed-Site Water Quality Monitoring Program (FSM Program) 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	On-going	Life of FERC license	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. Continue tracking reasonable compliance with TDG standards	On-going	Hourly; Life of FERC license	Hendrick/Keeler
Collect temperature data	Comply with 401 WQC; collect trend data to compare with historical data	On-going	Hourly; Life of FERC license	Keeler
Collect DO/pH/turbidity data	Comply with 401 WQC; collect trend data to compare with historical data	On-going	Monthly	Keeler
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
Post water quality data to web-site	Make data available to public per conditions of 401 WQC	On-going	Varies; see relevant sections of QAPP	Keeler
Calibrate water quality probes	Assure accurate data is being collected, prevent sensor drift, error, and/or failure	On-going	Monthly, or as needed based on QA/QC data checks	Keeler
Perform routine maintenance at FSM locations	Check functionality/condition of battery and solar power supply, cables, radio connections, hardware, standpipe, etc.	On-going	As needed and at least once prior to April 1 and again prior to October 1 of each year	Keeler/Harris
Conduct ice-bath checks of temperature sensors	Verify accuracy of temperature sensors against NIST thermometer	Prior to spring to April 15	Annually	Keeler
Conduct annual FSM Program meetings	Continued coordination between all responsible parties, discuss trouble-shooting procedures, calibration methods, software/hardware issues, etc.	On-going	Periodic, or as needed	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/Keeler
Attend regional TDG monitoring and QA/QC meeting	Present results of FSM program, discuss QA/QC methods of other dam operators	End of Year (Nov/Dec)	Annually as determined by U.S. Corps of Engineers (hosts)	Keeler

Activity	Purpose	Schedule	Frequency	Key Personnel (see also Table 2)
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
Water quality monitoring summary report	Summarize previous year's water quality monitoring results	March 1	Annual report	Keeler
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/Keeler

4.0 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 of 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, revised 2016) 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 updated QAPP.

4.1 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.

4.1.1 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 collected 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).

4.1.2 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 updated QAPP is implemented.

4.1.3 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).

4.2 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 updated 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 updated QAPP (including TDG, temperature, DO, pH, and turbidity) many MQOs can be specified. Each of the MQOs that pertain to this updated 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

4.2.1 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).

4.2.2 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 updated 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.

4.2.3 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).

5.0 Methods

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

5.1 Monitoring Locations

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

Section 6.4.10(a) of the 401 WQC (WDOE 2007) required Grant PUD to either move the TDG tailrace compliance locations to within 2,000 feet of Wanapum Dam and 1,500 feet of Priest Rapids Dam, or provide WDOE with a method and schedule for establishing new FSM stations, with indexing to the current FSM stations as needed. A Total Dissolved Gas Compliance Monitoring Location report (Grant PUD 2010) was sent to WDOE on April 16, 2010 for approval. WDOE approved the report on July 15, 2010 to use the current FSM locations during non-fish passage periods (WDOE 2010).

5.1.1 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 (Figure 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 Figure 6–7).

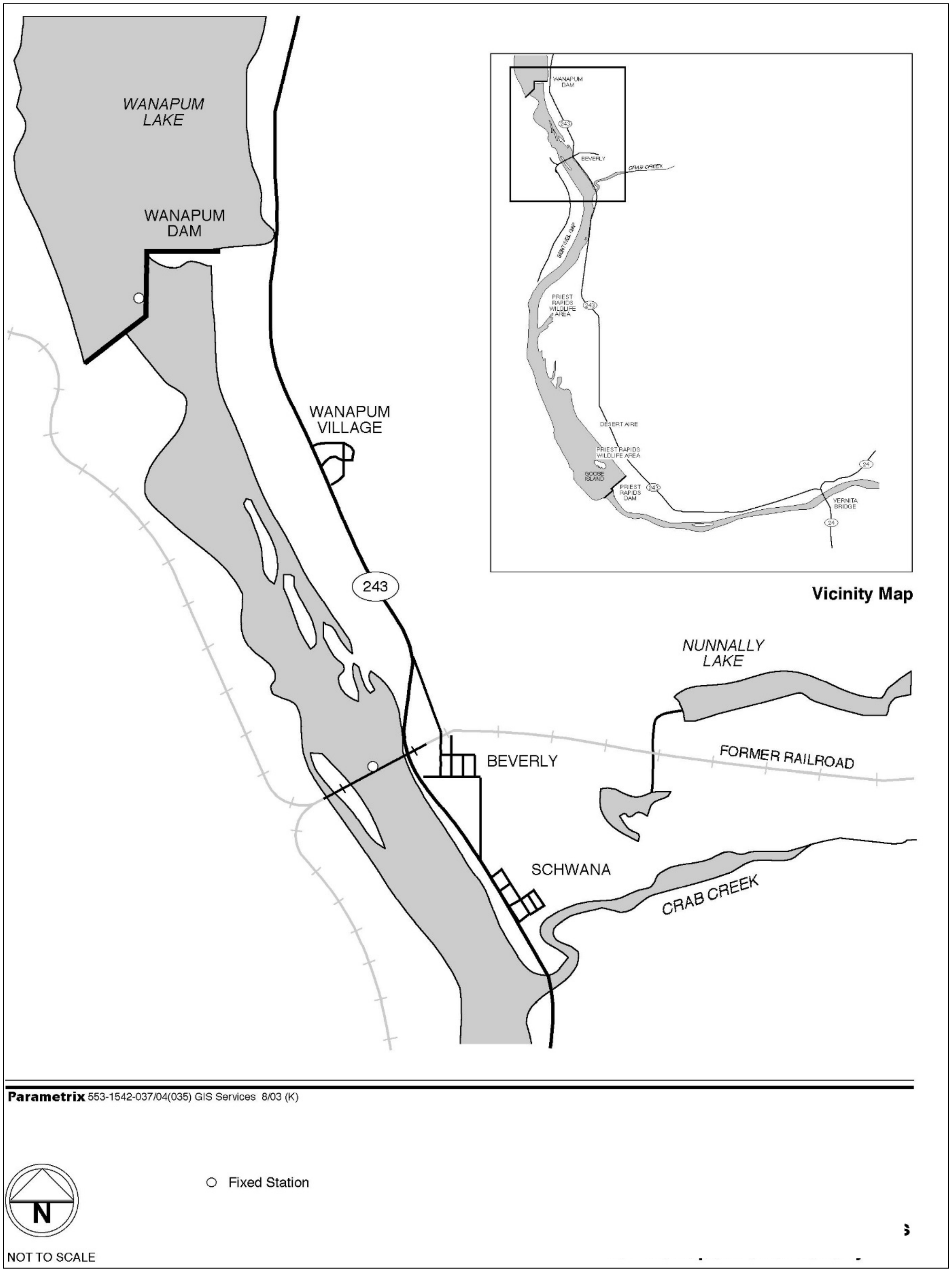

Figure 4 **Location of water quality fixed-site monitoring stations (FSM stations) for Wanapum Dam.**

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

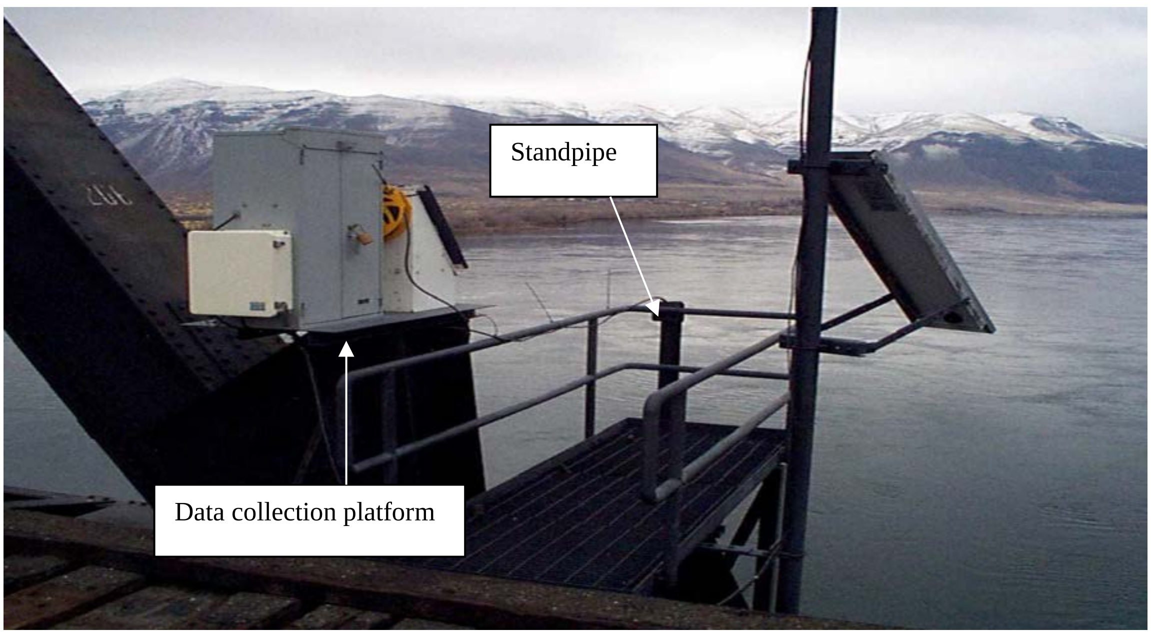

Figure 6 **Photograph of Wanapum Dam tailrace water quality fixed-site monitoring station, looking downstream from Beverly Bridge. Priest Rapids Project, mid-Columbia River.**

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

5.1.2 Priest Rapids Dam

The FSM station in the forebay of Priest Rapids Dam is attached to the pier nose 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).

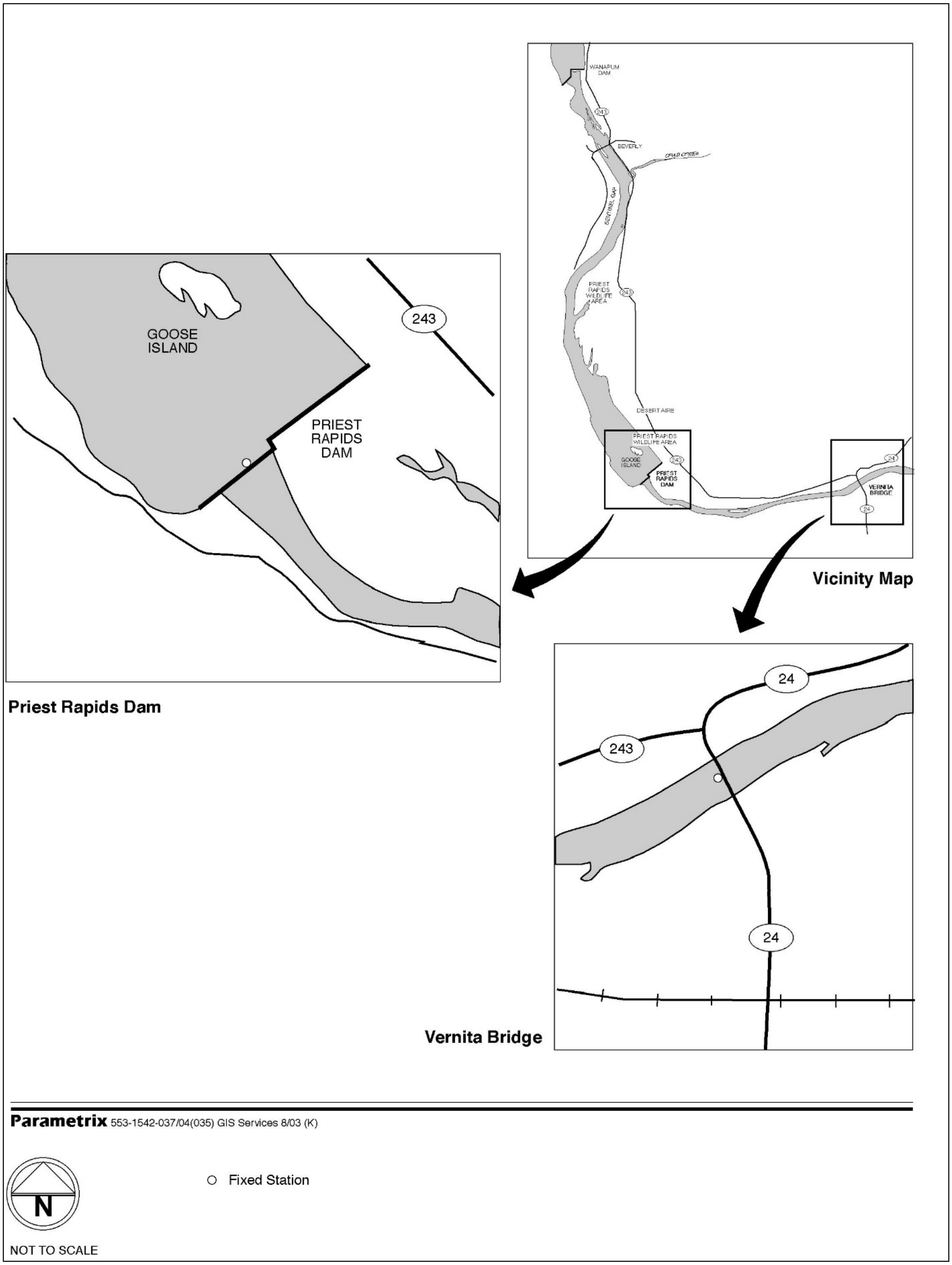
WANAPUM DAM
BEVERLY
PRIEST RAPIDS WILDLIFE AREA
DESERT AIRE
GOOSE ISLAND
PRIEST RAPIDS DAM
VERNITA BRIDGE
Vicinity Map
GOOSE ISLAND
243
PRIEST RAPIDS DAM
Priest Rapids Dam
24
243
24
Vernita Bridge
Parametrix 553-1542-037/04(035) GIS Services 8/03 (K)
N
NOT TO SCALE
Fixed Station

Figure 8 Location of water quality fixed-site monitoring stations (FSM stations) for Priest Rapids Dam.

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

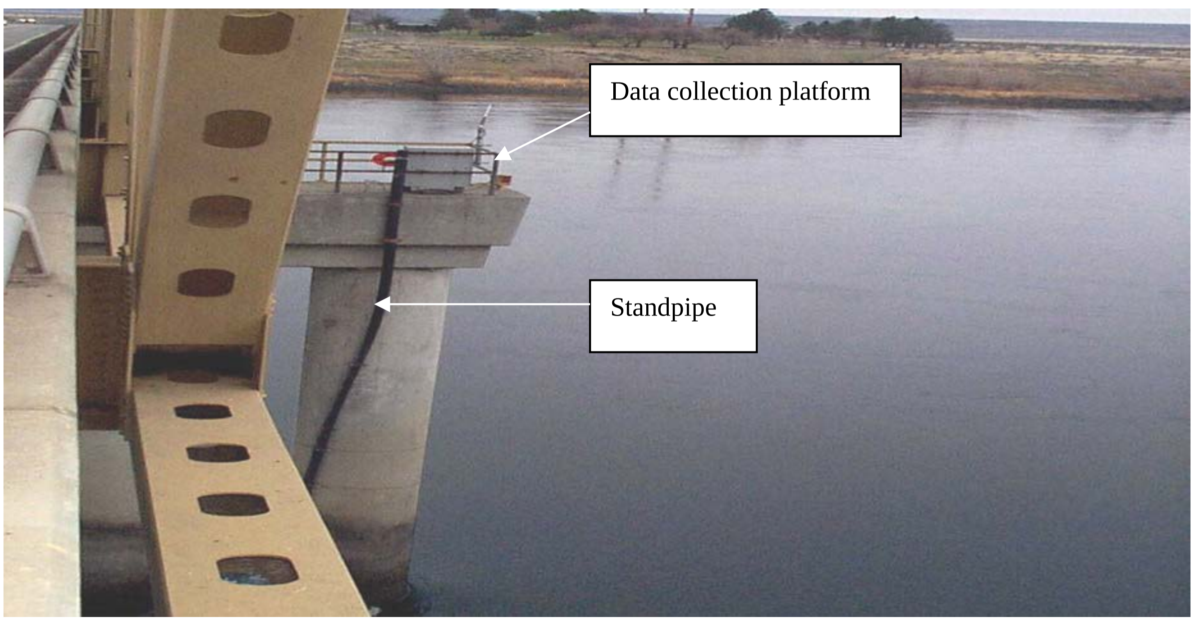

Figure 10 Photograph of Priest Rapids Dam tailrace water quality fixed-site monitoring station (FSM station), looking to the west from Vernita Bridge. Priest Rapids Project, mid-Columbia River.

5.2 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.

5.2.1 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 monthly 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).

5.2.2 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.

5.2.3 Equipment

The equipment used for this monitoring effort will be Hydrolab multi-probes. Appendix B provides information on Hydrolab DS5X, DS5A, DS4A, or Minisonde multi-parameter probe (multi-probe). 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).

5.3 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 on a monthly scale, or as needed based on daily QA/QC data review. 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 will attend Hydrolab workshops, specialized training sessions, and/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) to be removed. A 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 performed 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 station visit). If a problem is 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.

5.3.1 Total Dissolved Gas

As discussed in the above section, calibration, maintenance, and deployment of the TDG sensors will occur monthly or as needed based on daily data quality and review. 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.

5.3.2 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.

5.3.3 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 eight series 5 multi-probes and uses them exclusively as the QA/QC probe used to collect DO, pH, and turbidity grab-samples.

5.3.4 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 2006).

5.3.5 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 2006).

5.4 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 FERC license for the Project (FERC 2008), 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.

5.4.1 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 %SAT. TDG data collected as part of Grant PUD's FSM Program will be measured in mm Hg and then converted to %SAT using barometric pressure measurements recorded by a certified barometer located at each FSM station. The conversion equation is as follows:

$$\text{TDG in \%SAT} = (\text{TDG mm Hg} / \text{barometric pressure mm Hg}) \times 100$$

During the non-fish-spill season, values that exceed 110 %SAT will be analyzed and compared to upstream (incoming conditions) and to Wanapum and Priest Rapids dam operations, as TDG does not typically exceed 110 %SAT in the Project unless involuntary spill is required at either Wanapum or Priest Rapids dams, or at an upstream dam.

During the fish-spill season, 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 values are above fish-spill season standards and are likely being caused by fish-spill operations, Grant PUD staff will consult with stakeholders and/or internal Grant PUD staff 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 5-Year GAP (Grant PUD 2018a).

All TDG data will be reported in the annual water quality monitoring report that is due to WDOE March 1 of each year.

As detailed in the 401 WQC (WDOE 2007), the Year 10 Report (Grant PUD 2018), and 5-Year GAP (Grant PUD 2018a), Grant PUD has implemented both operational and structural TDG abatement measures that have helped Grant PUD obtain consistent compliance with TDG standards. A compliance analysis of the previous 10 years of TDG data will be completed every 5 years concurrent with the 5-year compliance GAP, which will help to ensure that Project operations continue to meet a similar level of compliance demonstrated in the Year 10 Report.

Additional TDG analytical methods will be incorporated as needed based on changes to Project operations, WDOE water quality standards, or other changes using adaptive management methods (see Section 7.0).

5.4.2 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).

In 2015, and in accordance with Section 6.5.2 of the 401 WQC (WDOE 2007), Grant PUD conducted temperature modeling using a CE-QUAL-W2 model to determine Grant PUD's contribution, if any, to water temperature values recorded from 2003–2012 that were above WDOE water quality standards (NHC 2016). Final results from this modeling effort were sent to the WDOE on April 14, 2016.

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).

5.4.3 Dissolved Oxygen, pH, and Turbidity

DO, pH, and turbidity data collected as part of Grant PUD's FSM program will be reported within Grant PUD's annual water quality monitoring report to WDOE. Data will be evaluated and compared with the standards noted within Table 1 above (see Section 3.3.3).

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).

5.5 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.

5.5.1 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 website; this process typically produces a one to two-hour lag between time of collection and posting to the website. Daily summary reports (in Microsoft Excel spreadsheet format) are created each day (for previous day's data) and posted to the website. 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 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.

5.5.2 Grab-Sample Data

The second component of data management is the grab-sample DO, pH, and turbidity data that is collected monthly. 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. The summary results from these data will be presented in the annual water quality monitoring report.

5.5.3 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.

5.5.4 Water Quality Website

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

https://www.grantpud.org/water-quality

The following data and information is currently available at this website:

- 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 3hourly 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 2018.

- Water Quality Monitoring Report: Link to the current year water quality monitoring report.
- Quality Assurance Project Plan: Link to the most up-to-date QAPP for the Project.
- Total Dissolved Gas Abatement Plan: Link to the most up-to-date compliance GAP for the Project.

Data from previous years' can also be accessed from the Grant PUD's water quality website.

6.0 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.

6.1 Participation in Regional Forms and Trainings

Individual(s) responsible for the FSM Program oversight (see Table 2 in Section 3.4) will attend/participate at the Corps's year-end TDG monitoring and QA/QC meeting, at which presentations are made from the various agencies conducting TDG 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 FSM Program oversight individual responsible for carrying out the duties outlined within this QAPP will also make presentations to the groups and participate in round-table discussions at various water quality monitoring workshops, if available. They will also continue 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, or by other means.

6.2 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.

6.2.1 Field Audits

Once per year the FSM Program oversight individual 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 FSM Program oversight individual 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.

6.2.2 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 individual responsible for the FSM Program oversight will also be responsible for keeping track of the mandated reporting and confirming that it has been met. Specifically, they will access the website as needed, to check that the necessary data are present, legible and correct. Additionally, they will review the annual reports to make sure that the data presented are accurate, and verifiable. Any deviations from requirements will be rectified and WDOE will be notified of the deviation and corrective action.

7.0 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. Additionally, all real-time TDG and water temperature data, daily summary reports, or other applicable information will be reported to Grant PUD's water quality website.

Literature Cited

Chelan PUD (Public Utility District No. 1 of Chelan County). 2007. Quality assurance Project plan for Lake Chelan water quality monitoring and reporting. Lake Chelan Hydroelectric Project, FERC Project No. 637. Wenatchee, Washington.

Corps (U.S. Army Corps of Engineers). 2008. U.S. Army Corps of Engineers plan of action for dissolved gas monitoring in 2009.

Duvall, D., M. and T. J. Dresser. 2003. Fixed-site Water Quality Monitors, Maintenance and Calibration Procedures, and Quality Assurance Methods. Public Utility No. 2 Grant County, Ephrata, Washington.

FERC (Federal Energy Regulatory Commission). 2008. Order Issuing New License for Public Utility District No. 2 of Grant County, 123 FERC ¶ 61,049, Washington D.C.

Gibs, J., Wilde, F.D., and Heckathorn, H.A. 2007. Use of multiparameter instruments for routine field measurements (ver. 1.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, section 6.8, August, available only online at http://water.usgs.gov/owq/FieldManual/Chapter6/6.8.html.

Grant PUD (Public Utility District No. 2 of Grant County, Washington). 2006. Priest Rapids Project Salmon and Steelhead Settlement Agreement, FERC Project No. 2114, Ephrata, Washington.

Grant PUD. 2010. Evaluation of Tailrace Total Dissolved Gas Fixed-Site Monitoring Station Locations for Wanapum and Priest Rapids Dam During Non-Fish Passage Periods. April 2010.

Grant PUD. 2018. Final Summary of Total Dissolved Gas Monitoring within the Priest Rapids Hydroelectric Project – Year 10 Report. May 16, 2018. Ephrata, Washington.

Grant PUD. 2018a. 5-Year Total Dissolved Gas Abatement Plan for the Priest Rapids Hydroelectric Project, December 31, 2018. Ephrata, Washington.

Hach Company. 2006. Hydrolab DS5X, DS5, and MS5 Water Quality Multiprobes. User Manual. February 2006, Edition 3. Hach Company, Loveland, Colorado. https://www.ott.com/download/user-manual-hydrolab-ds5x-ds5-and-ms5-water-quality-multiprobes/

Juul, S. T. J. 2003. An assessment of selected water quality parameters for the Priest Rapids Hydroelectric Project. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington.

Mitchell, D.O. 2006. Luminescence based measurement of dissolved oxygen in natural waters. Hach Company, Loveland, Colorado. http://www.hydrolab.com/products/ldo_sensor.asp.

NMFS (National Marine Fisheries Service). 2008. Endangered Species Act – Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and

Management Act Consultation for the New License for the Priest Rapids Hydroelectric Project, FERC Project No. 2114, Portland, Oregon.

Normandeau Associates Inc., Washington State University and University of Idaho. 2000. An evaluation of water quality and limnology for the Priest Rapids Project Area. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington.

Tanner, D.Q. U.S. Geological Survey. 2003. Personal Communication.

Tanner, D.Q., and M.W. Johnston. 2001. Data collection methods, quality-assurance data, and site considerations for total dissolved gas monitoring, Lower Columbia River, Oregon and Washington, 2000. U.S. Geological Survey, Portland Oregon.

WDOE (Washington State Department of Ecology). 2004. Guidelines for preparing quality assurance project plans for environmental studies. Publication No. 04-03-030. Revised December 2016. https://fortress.wa.gov/ecy/publications/summarypages/0403030.html

WDOE. 2004a. Total Maximum Daily Load for Total Dissolved Gas in the Mid-Columbia River and Lake Roosevelt. Submittal Report. Prepared jointly by the U.S. Environmental Protection Agency and the Washington State Department of Ecology in cooperation with the Spokane Tribe of Indians. WDOE Publication Number 04-03-002. June 2004.

WDOE. 2006. Water quality standards for surface waters of the State of Washington. Chapter 173-201A Washington Administrative Code. Amended November 20, 2006.

WDOE. 2007. Section 401 Water Quality Certification Terms and Conditions for the Priest Rapids Hydroelectric Project, FERC Project No. 2114, Spokane, Washington.

WDOE. 2010. Letter. RE: Request for Approval – Priest Rapids Hydroelectric Project No. 2114 Section 6.4.10(a) – Total Dissolved Gas Compliance Monitoring Locations. Drafted to Public Utility District No. 2 of Grant County, Ephrata, WA. July, 15, 2010.

Appendix A
Hydrolab Multi-Probe specifications

Minisonde Multiparameter Water Quality Sensor

Compact, lightweight 1.75" diameter housing fits into groundwater wells & boreholes

For maximum deployment life and minimum maintenance, this multiparameter water quality sonde offers Hydrolab's superior sensor technology on a multi-parameter platform. Their optimized combinations of sensors and accessories suit water quality monitoring applications in all environmental water sources, such as rivers, streams, lakes, reservoirs, oceans, bays, estuaries, and groundwater aquifers. Sensors are available to provide data for

Temperature	Depth	Conductivity	Salinity
Specific Conductance	TDS	Total Dissolved Gas	Turbidity
Dissolved Oxygen	pH	Chlorophyll	Blue Green Algae
Rhodamine WT	ORP	Ammonium	Chloride
Ambient Light (PAR)	Nitrate		

8 AA batteries: Long-term unattended operation can be achieved by paring the MS5 with the internal battery pack option.

Features & Benefits

- Optimized selection of parameters: Temperature, DO, Conductivity, pH plus >2 additional sensors
- 4 built-in expansion ports configured to fit your specific needs
- Measures up to 12 parameters simultaneously
- Field Tested Durability
- Available with Hach LDO optical dissolved oxygen sensor
- Capable of measurements using any of Hydrolab's 17 sensors
- Redundant data logging memory & internal power supply included
- Improved Power Management (minimal power consumption)
- 4 built-in expansion ports configured to fit your specific needs
- Measures up to 12 parameters simultaneously
- Optimized for long-term deployments in harsh environments
- Fits into wells & boreholes as small as 2 inches in diameter

SPECIFICATIONS for DS5, DS5X, & MINISONDE
(Subject to change without notice)

Dimensions DS5 & DS5X	Dimensions MiniSonde	Weight	Battery Supply
Diameter 3.5"/8.9 cm Length – 23"/58.4 cm	Diameter – 1.75"/4.4 cm Length – 29.5"/74.9 cm (w/battery pack)	DS5/DS5X: 7.4 lbs/3.35 kg (typical) MiniSonde: 2.9 lbs/1.3 kg (typ. w/battery pack)	DS5/DS5X: 8 C batteries MiniSonde: 8 AA batteries
Operating Temperature	**Maximum Depth**	**Communications Interfaces**	**Memory (all)**
-5.0° C to +50° C (all)	200 m (all)	RS-232, SDI-12, RS-485	>120,000 readings
SENSOR	**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)	0.1%
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	3 (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 0 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
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
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

Hach LDO® Dissolved Oxygen

NEW! 2nd generation Hach LDO sensor technology. Hach - the premier provider of luminescent dissolved oxygen (LDO) technology since 2002

Only Hydrolab Series 5 sondes feature Hach LDO technology.

Features:

- No membranes = no air bubbles, no membrane relaxation, no maintenance
- Calibrations last without drift therefore deployments last longer, reducing frequency of maintenance trips to the field, saving time & money
- Highest accuracy & widest monitoring range available
- Compact housing allows complete integration into DS5X, DS5, or MS5
- Does not consume oxygen so passive fouling will not affect DO readings
- Rust design for long-lasting performance
- Manufactured& supported by Hach Hydromet, the experts in LDO technology

Specifications:

- Range: 0 - 60 mg/L
- Resolution: 0.01 mg/L
- Accuracy: +/- 0.1 mg/L at <8 mg/L
  +/- 10% reading >20 mg/L
  +/- 0.2 mg/L at >8 mg/L

pH Sensor

Hydrolab pH sensor uses glass bulb & refillable reference electrode for easily-maintained, long-lasting operation.

Features:

- KCl impregnated glass bulb is permeable to hydrogen ions; reference filled with 3M KCl and has a porous Teflon junction. Salt bridge is formed between the two, and a potential is measured.
- Choice of standard or integrated refillable reference
- Optionally paired with ORP sensor
- Reference electrode is easily refilled in seconds – independent of pH sensor
- pH sensor does not need replacement when reference electrode is depleted; simply refill the reference for years of sensor life

Specifications:

- Range: 0 to 14 pH units
- Resolution: 0.01 units
- Accuracy: +/- 0.2 units

Chlorophyll a (by Turner Designs)

The most accurate Chlorophyll a Sensor on a Multiprobe.

Features:

- Ultra-compact size designed for integration into t DS5X, DS5, & MS5
- Available with solid Secondary Standards to provide a quick, simple method to verify sensor's stability
- Secondary Standard can be adjusted to a known chlorophyll concentration
- 3 auto-selected gain ranges for a range of 0.03 to 500 Qg/l
- Electronic filtration of ambient light, efficient optical coupling, & quality optical components provide the most accurate measurement of Chlorophyll a.
- Incredibly fast response time through electronic filtration of ambient light
- Excellent turbidity rejection (small sample volume & quality optical filters)
- Cost optimized for affordability & value

Optical Characteristics:

- Light Source: Light Emitting Diode
- Detector: Photodiode
- Excitation Wavelength: Chl 460nm
- Emission Wavelength: Chl 685nm

Specifications:

- Minimum Detection Limit: 0.03 Qg/l
- Dynamic Range: Low sensitivity: 0.03-500Qg/L
- Med. sensitivity: 0.03-50Qg/L
- High sensitivity: 0.03-5Qg/L
- Resolution: 0.01 Qg/L
- Accuracy: +/- 3% for signal level equivalents of 1 ppb rhodamine WT dye or higher using a rhodamine sensor
- Sensor housing:
  Stainless steel: Standard housing for typical fresh water applications.
  Titanium option: Corrosion-resistant housing for use in aggressive saline environments such as oceans, bays and estuaries.

Rhodamine WT (by Turner Designs)

Hydrolab's Rhodamine WT sensor is the most accurate available on a multiprobe

Features:

- Ultra-compact design specifically for integration into DS5X, DS5, & MS5
- Secondary Standards Option for quick, simple verification of sensor's stability
- Secondary Standard can correlate to a known dye concentration.
- 3 auto-selected gain ranges provide measurements from 0.04 to 1000 ppb
- Electronic filtration of ambient light, efficient optical coupling & quality components produce the most accurate measurement of Rhodamine WT.
- Incredibly fast response time through electronic filtration of ambient light
- Excellent turbidity rejection (small sample volume & quality optical filters
- Cost-optimized for affordability & value

Optical Characteristics:

- Light Source: Light Emitting Diode
- Detector: Photodiode
- Excitation Wavelength: RWT 550 nm
- Emission Wavelength: RWT 600 nm

Specifications:

- Minimum Detection Limit: 0.04 ppb
- Dynamic Range: Low sensitivity: 0.04-1000 ppb
- Med. sensitivity: 0.04-100 ppb
- High sensitivity: 0.04-10 ppb
- Resolution: 0.01 ppb

- Accuracy: +/- 3% for signal level equivalents of 1 ppb rhodamine WT dye or higher using a rhodamine sensor
- Sensor housing:

  Stainless steel: Standard housing for typical fresh water applications.

  Titanium option: Corrosion-resistant housing for use in aggressive saline environments such as oceans, bays and estuaries.

Total Dissolved Gas (TDG)

Total Dissolved Gas (TDG) sensor uses a pressure transducer mounted behind a rigid gas-permeable silicone membrane to measure total gaseous compounds dissolved in a liquid.

Features:

- TDG is measured in units of pressure (mmHg)
- Pressure includes the partial pressure of all gas species dissolved in the water.

Benefits:

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

Specifications

- Range: 400 to 1400 mmHg
- Accuracy: ± 1.5 mmHg
- Resolution: 1.0 mmHg

Dissolved Oxygen

Based on a standard EPA-approved Clark Cell design, trusted for over 30 years.

Features:

- Design based on a standard Clark Cell design, and paired with a sample circulator
- Measures the current resulting from the electrochemical reduction of oxygen diffusing through a selective membrane
- Provides a continuous, steady-state reading

Benefits:

- Low maintenance – no need to "recondition" the sensor
- Complies with Standard Methods Article 4500-OG & EPA article 360.1 that require sufficient sample flow across the membrane.
- Circulator improves response time & helps sweep away traces of pH electrolyte.

Specifications:

- Range: 0 to 50 mg/L
- Accuracy: +/- 0.2 mg/L for 20mg/L or less

  +/- 0.6 mg/L for over 20 mg/L
- Resolution: 0.01 mg/L

Li-Cor Ambient Light

The Photosynthetically Active Radiation (PAR) sensor measures sunlight intensity at a specified point in the water column.

Features:

- Single-PAR or dual-PAR sensor when a surface light sensor is needed.
- Available in flat or spherical form depending on desired light measurements.

- Measures real-time sunlight intensity (influences biota reliant on photosynthesis).
- Applications:

  Drinking water reservoir management (Algae bloom remediation is very expensive.).

  Primary production monitoring (organism growth - lower end of the food chain)

  General aquatic habitat study (submerged grasses & other plants)
- The DataSonde multiprobe measures PAR from the water column & the surface & integrates measurements with the rest of the data stream or logging record.

Specifications:

- Range: 0 to 10,000 Qmol s-1m-2
- Accuracy: ± 5% of reading
- Resolution: 1 Qmol s-1m-2

Turbidity: 4-Beam

Compliant with 4B-GLI Method 2 & perfect for profiling or spot-check turbidity measurements.

Features:

- 4B-GLI Method 2 compliant
- 4-beam sensor uses standard ba scatter, yet has multiple beams/references checking and rechecking accuracy

Benefits:

- Patented technology is immune to ambient light references; therefore, it is perfect for profiling in shallow rivers and streams
- Offers a unique, patented Quick-Cal Cube for calibration verification

Specifications:

- Range: 0-1000 NTU
- Accuracy: ± (5% of reading + 1 NTU)
- Resolution: NTU for 0-100 NTU;

  NTU for 100 NTU and greater

Turbidity (Self-cleaning)

Measures from 0 to 3000 NTU & includes a user-programmable cleaning system to remove any fouling or debris that could otherwise affect readings.

Features:

- ISO 7027 compliant
- User-programmable self-cleaning system can perform up to 10 cleaning cycles before each reading
- Accurately measures up to 3000 NTU

Benefits:

- Fixed parking position ensures consistent data collection after each cleaning cycle
- 3000 NTU range allows Turbidity tracking even during rain storms or other events that could cause abnormally high readings
- Exceptional linearity even in high NTU environments
- Utilizes small aperture technique to reduce false readings from particulates and other debris

Specifications:

- Range: 0-3000 NTU
- Accuracy (compared to StablCal):
  ± 1% up to 100 NTU,
  ± 3% from 100-400 NTU
  ± 5% from 400-3000 NTU
- Resolution: NTU from 0-400 NTU;
  NTU for >400 NTU
- Temperature Coefficient: 0.05%/C
- Sensor housing:
  Stainless steel: Standard housing for fresh water applications & depths to 200 M.
  Plastic: Corrosion-resistant for aggressive saline environments such as oceans, bays & estuaries. Rated to depths of 50 M.

Conductivity

Uses 4 graphite electrodes in an open cell design to provide extremely accurate & reliable data with virtually no maintenance.

Features:

- Design based on 4 graphite electrodes in an open cell design
- Measures current between 2 electrodes held at a fixed potential; additional electrodes are used to compensate for any fouling of the electrode surfaces.
- Sensor measurements used to derive Salinity, Total Dissolved Solids, and Resistivity

Benefits:

- Reduces measurement error from environment – sediment falls to the bottom of the cell & bubbles rise to the top. Reliable measurements in any condition.
- Easily maintained between deployments by cleaning with a Q-tip or cotton swab

Specifications:

- Range: 0-100 mS/cm
- Accuracy: ± (0.5% of reading + 0.001 mS/cm)
- Resolution: 0.001

Depth/Vented Level

High-stability, custom pressure sensor w/4 range options.

Features:

- Depth measures absolute hydrostatic pressure from an internal diaphragm
- Optimized for depths down to 10m, 25m, 100m, or 200m

Benefits:

- Vented level (0-10 m) uses a sealed dryer attached to a fixed cable that provides compensation for changes in barometric pressure.

Specifications:

- Range: 0 to 10m (Vented Level)
- Accuracy: +/- 0.003 meters
- Resolution: 0.001 meters
- Range: 0 to 25m
- Accuracy: +/- 0.05 meters
- Resolution: 0.01 meters
- Range: 0 to 100m
- Accuracy: +/- 0.05 meters
- Resolution: 0.01 meters
- Range: 0 to 200m
- Accuracy: +/- 0.1 meters
- Resolution: 0.1 meters

Blue-Green Algae (by Turner Designs)

Most accurate Blue-Green Algae sensor available on a multiprobe.

Features:

- Available in two forms, one for detecting phycocyanin (fresh water), and one for detecting phycoerythrin (marine water)
- Ultra-compact size design specifically for integration into DS5X, DS5, & MS5
- Secondary Standards provide quick & simple verification of sensor's stability
- Secondary Standard can correlate to a known Blue-Green Algae concentration.
- 3 auto-selected gain ranges: measurement range of 100 to 2,000,000 cells/mL for either phycocyanin or phycoerythrin.

Benefits:

- Real-time measurement identifies potential algal blooms before they become problematic, allowing time for corrective action
- Less expensive and more timely than cell counting or visual inspection
- Electronic ambient light filtration, efficient optical coupling & quality components provide the most accurate measurement of phycocyanin or phycoerythrin
- Incredibly fast response time through electronic filtration of ambient light
- Excellent turbidity rejection (small sample volume design & quality optical filters)
- Cost-optimized for affordability & value

Optical Characteristics:

- Light Source: Light Emitting Diode
- Detector: Photodiode
- Excitation Wavelength: Phycocyanin 590 nm
- Phycoerythrin 525 nm
- Emission Wavelength: Phycocyanin 650 nm
- Phycoerythrin 570 nm

Specifications:

- Minimum Detection Limit: 100 cells/mL
- Dynamic Range:
  Low sensitivity: 150-2,000,000 cells/mL
  Med. sensitivity: 150-200,000 cells/mL
  High sensitivity: 150-20,000 cells/mL
- Accuracy: +/- 3% for signal level equivalents of 1 ppb rhodamine WT dye or higher using a rhodamine sensor
- Resolution: 20 cells/mL
- Sensor housing:
  Stainless steel - Standard housing for typical fresh water applications.
  Titanium option - Corrosion-resistant housing for use in aggressive saline environments such as oceans, bays and estuaries.

Ion-Specific Electrodes

To measure Ammonia, Nitrate, or Chloride.

Features:

- ISE is a reference electrode immersed in a solution of fixed ion concentration separated by a membrane containing a chemical compound that reacts with the ion of interest, measuring electrical potential that varies with concentration.

Applications:

- Ammonia & Nitrate: Tracing movement of point or non-point source pollutants (i.e., runoff from agricultural operations), monitoring aquaculture for excessive waste concentrations, surveying nutrient levels in natural water bodies
- Chloride: Monitoring landfills for leaks, tracing movement of point or non-point source pollutants (i.e., storm water runoff) within a natural water body, monitoring estuaries for salinity changes, & salt water intrusion into ground or surface waters).

Benefits:

- Ammonia: High levels of accessible nitrogen (total ammonia is one form) can lead to an overabundance of microorganisms, resulting in mortality to higher organisms (such as fish and shrimp) because of depleted dissolved oxygen
- Nitrate: Small changes in biologically available nitrogen levels can dramatically affect the levels of microbiological, plant, and eventually, animal life.
- Chloride: Does not react with, or adsorb to, most components of rocks & soils, and so is easily transported through water columns; therefore, it is an effective tracer for pollution from chemicals moving from man-made sources into natural water bodies, or for salt water intrusion.

Specifications:

Ammonia

- Range: 0 to 100 mg/L-N
- Accuracy: Greater of +/- 5% of reading, or +/- 2 mg/L-N
- Resolution: 0.01 mg/L-N
- Max Depth: 15 meters

Nitrate

- Range: 0 to 100 mg/L-N
- Accuracy: Greater of +/- 5% of reading, or +/- 2 mg/L-N
- Resolution: 0.01 mg/L-N
- Max Depth: 15 meters

Chloride

- Range: 0.5 to 18,000 mg/L
- Accuracy: Greater of +/- 5% of reading, or +/- 2 mg/L-N
- Resolution: 4 digits
- Max Depth: 15 meters

ORP

Hydrolab's ORP sensor 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.

Features:

- The state of the reaction is measured by the potential developed between and inert noble metal electrode (platinum) and a reference electrode (same reference for pH)
- Compliant with SM2580 B

Benefits:

- The ORP is greatly influenced by the presence or absence of molecular oxygen. Low redox potentials may be caused by extensive growth of heterotrophic microorganisms. Such is often the case in developing or polluted ecosystems where microorganisms utilize the available oxygen. Low ORP is another relative measure for biological oxygen demand.

Specifications:

- Range: -999 to 999 mV
- Accuracy: +/- 20 mV
- Resolution: 1 mV

Temperature

The Hydrolab temperature sensor is a 30k ohm variable resistance thermistor. The temperature sensor is included with every Hydrolab sonde.

Features:

- 316 Stainless Steel, 30k ohm thermistor
- Variable resistor

Benefits:

- Provides critical compensation for Dissolved Oxygen, Conductivity, pH, and nutrient sensors
- Compliant with EPA170.1 and SM2550B

Specifications:

- Range: -5 to 50 ° C
- Accuracy: +/- 0.10 ° C
- Resolution: 0.01 degrees ° C

SBE 56 Temperature Logger

The Sea-Bird Electronics (SBE) 56 is a compact, lightweight battery-powered temperature logger for use in depths down to 1500m. The SBE 56 also logs time and samples at user-programmable intervals from 0.5 seconds to 9 hours.

Features of the SBE 56

- Long-term deployment capabilities in fresh, estuarine, and saltwater environments
- High accuracy and low drift rate with no in-field calibrations required, reducing field costs
- Low power consumption: can be deployed for 31 days at 0.5-second intervals or almost 2-years at 15-second intervals
- USB interface for fast data upload and rapid redeployment
- Easy attachment to trawl nets for fisheries and aquaculture operations

Ordering

Cabling and mounting accessories are determined by the application and installation site.

The type and number of water quality sensors you include in your multi-parameter sonde determine pricing and ordering details.

For ordering information, please contact your Sutron Sales Manager or the Sales Administrator, (703) 406-2800.

Appendix D
Consultation record for the draft 5-Year GAP and update QAPP, which included comments from Ecology and Grant PUD's responses to those comments.

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To:	Bob Rose rosb@yakamafish-nsn.gov; Chad Jackson (chad.jackson@dfw.wa.gov); Curtis Dotson; Denny Rohr (drohr5@aol.com); Erin Harris; Jim Craig (jim_l_craig@fws.gov); Justin Yeager (justin.yeager@noaa.gov); Kirk Truscott (Kirk.Truscott@colvilletribes.com); murk@yakamafish-nsn.gov; Patrick Verhey (Patrick.Verhey@dfw.wa.gov); Peter Graf; Scott Carlon (scott.carlon@noaa.gov); Tom Dresser; Tom Skiles (SKIT@critfc.org)
Cc:	Ross Hendrick; Carson Keeler
Subject:	Grant PUD"s Draft 5 year Total Dissolved Gas Abatement Plan & Updated Quality Assurance Project Plan
Date:	Tuesday, December 11, 2018 2:17:00 PM
Attachments:	2018_12_11 GCPUD 5_Year_GAP_Draft.pdf 2018_12_11 GCPUD Updated_QAPP_Draft.pdf

Good afternoon,

Attached for your review and comment are Grant County PUD's updated Quality Assurance Project Plan (QAPP) and the 2019-2023 (5 Year) Total Dissolved Gas Abatement Plan (GAP).

Grant County PUD appreciates receiving your comments **no later than January 11, 2019**.

Please contact Carson Keeler at 509-754-5088 ext. 2687 or ckeeler@gcpud.org if you have any questions.

Thank you!

Deb Firestone
Regulatory Specialist II
Grant County PUD
P.O. Box 878
Ephrata, WA 98823
509-793-1583

Grant PUD

From:	Debbie Firestone
To:	"breean.zimmerman@ecy.wa.gov"
Cc:	Tom Dresser; Ross Hendrick; Carson Keeler; Peter Graf
Subject:	Grant PUD"s Draft 5 year Total Dissolved Gas Abatement Plan & Updated Quality Assurance Project Plan
Date:	Tuesday, December 11, 2018 2:26:00 PM
Attachments:	2018_12_11 GCPUD 5_Year_GAP_Draft.pdf 2018_12_11 GCPUD Updated_QAPP_Draft.pdf

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Regulatory Specialist II
Grant County PUD
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Ephrata, WA 98823
509-793-1583

Carson Keeler

From: Carson Keeler
Sent: Monday, January 28, 2019 7:24 AM
To: 'Zimmerman, Breean (ECY)'
Cc: Ross Hendrick; Tom Dresser
Subject: RE: Grant PUD response comments

Good morning Breean,

We (Grant PUD) appreciates the additional feedback from Ecology on the 5-Year GAP. All modifications as noted below will be incorporated into Grant PUD's updated 5-Year GAP. You should see it coming your way either later today, or early tomorrow. Thanks again for your help with this matter.

Carson

From: Zimmerman, Breean (ECY) [mailto:bzim461@ECY.WA.GOV]
Sent: Friday, January 25, 2019 1:05 PM
To: Carson Keeler <Ckeeler@gcpud.org>
Cc: Ross Hendrick <Rhendr1@gcpud.org>; Tom Dresser <TDresse@gcpud.org>
Subject: RE: Grant PUD response comments

Thank you Carson for your email and our phone conversation this week, it is much appreciated. Below is Ecology's feedback to your responses below (with the exception to the response to Comment 1 which has already been addressed by Grant PUD):

Response to Comment 2: We're okay with the language as it exists in the subject Draft 5-year GAP with no need to use exact language from the 401 water quality certification. By Grant PUD meeting the TDG water quality standard insinuates aquatic life will be protected.

Response to Comment 3: We appreciate the additional detail. In short, we would recommend dropping the word "attempting" from the sentence. The word "attempting" in reference to maximizing turbine flows is not necessary when the prior sentence discusses that operational measures will be implemented, when feasible, to minimize involuntary spill. The key word is "**when feasible**," provides Grant County flexibility in regards to other constraints and thereby does not necessitate the need for the qualifying word "attempting."

Please let me know if you have questions or concerns. Otherwise, again, thank you for working through these comments with me. I greatly appreciate the collaboration.

Breean Zimmerman | **Hydropower Projects Manager**
Water Quality Program | Central Regional Office
(509) 575-2808 (w) | (509) 406-5130 (c) | bzim461@ecy.wa.gov

From: Carson Keeler <Ckeeler@gcpud.org>
Sent: Wednesday, January 23, 2019 10:28 AM
To: Zimmerman, Breean (ECY) <bzim461@ECY.WA.GOV>
Cc: Ross Hendrick <Rhendr1@gcpud.org>; Tom Dresser <TDresse@gcpud.org>
Subject: Grant PUD response comments

Good morning,

Grant PUD appreciates Ecology's willingness to provide comments and to collaborate with Grant PUD on the drafting of its 5-Year total dissolved gas (TDG) abatement plan (5-Year GAP) for the Priest Rapids Project (Project).

Grant PUD has the following responses to Ecology's comments provided below for the 5-Year GAP:

Overall response for each comment: Grant PUD understands and acknowledges that each of the three (3) comments provided by Ecology are to incorporate the exact language from the Project's 401 water quality certification (WQC) into the applicable section of the 5-Year GAP. However, the language in the 5-Year GAP is specific to Grant PUD's plan to comply with the TDG waiver for fish-spill operations, the 401 WQC, and WQ standards and feels that is does not have to include exact, verbatim, language from the 401 WQC.

Comment 1: Comment noted and Section 1.2.2 of the 5-Year GAP has been updated to reflect Ecology's comment.

Comment 2: Although Grant PUD understands this language is from the 401 WQC, it also believes that using the language "*and without further damaging aquatic life*" is confusing, and it is unclear how minimizing involuntary spill in order to meet water quality standards would correlate with harming aquatic life. As written, this section describes Grant PUD's plan to minimize involuntary spill, as reasonable and feasible, in order to meet water quality standards, which is assumed to provide benefits to aquatic life.

Comment 3: The words "attempting" and "reasonable and feasible" were added to this bullet by Grant PUD to better describe and demonstrate how Grant PUD attempts to maximize powerhouse discharge during periods of high flow, but that there are other regional constraints and/or federal requirements that, at times, can limit Grant PUD's ability to maximize powerhouse flows to 100% of its capacity. Grant PUD then goes on to describe what these regional constraints and/or federal requirements are in more detail.

Thanks again for Ecology's willingness to participate during the consultation period for the 5-Year GAP. Please let me know if there are any additional questions or concerns.

Thanks,

Carson

Carson Keeler
Senior Biologist
Grant PUD
Office: (509) 754-5088 x2687
Cell: (509) 797-5176

Carson Keeler

From: Zimmerman, Breean (ECY) <bzim461@ECY.WA.GOV>
Sent: Thursday, January 17, 2019 10:29 AM
To: Debbie Firestone; Carson Keeler
Cc: Tom Dresser; Ross Hendrick; Peter Graf
Subject: RE: Grant PUD's Draft 5 year Total Dissolved Gas Abatement Plan & Updated Quality Assurance Project Plan

Please take care when opening links, attachments or responding to this email as it originated outside of Grant.

Good morning,

Ecology appreciates the opportunity to comment on the subject plan. We also appreciate the extra time provided for our review. Ecology has the following three comments:

1. Section 1.2.2 Incoming TDG on page 6: it is recommended Grant County PUD replace the first sentence and the two associated bullet points with the exact language provided in the 401 WQC, which states:

   According to Section 6.4.1(d) of the 401 WQC, Grant PUD may be deemed in compliance with water quality standards for TDG if both of the following apply:

   TDG levels in the dam's forebay exceed 110 %SAT during the non-fish spill season or 120 %SAT during the fish-spill season, and

   The dam does not further increase TDG levels in the tailrace.

2. Section 2.1 Minimizing Involuntary Spill on page 10: it is recommended Grant County PUD add "and without further damaging aquatic life" at the end of the first sentence in this section, so the sentence will state:

   Section 6.4.1(c) of the 401 WQC (WDOE 2007 requires Grant PUD to minimize involuntary spill, as reasonable and feasible, at Wanapum and Priest Rapids dams in order to meet TDG water quality standards, ***and without further damaging aquatic life****, as follows:*

3. Also in Section 2.1 Minimizing Involuntary Spill on page 10: it is recommended Grant County PUD delete the third bullet which states, "Attempting to maximize powerhouse discharge during periods of high flows" and replace it with "Maximize powerhouse discharge, especially during periods of high river flows."

Please let me know if you have questions or concerns.

Thank you,

Breean Zimmerman | **Hydropower Projects Manager**
Water Quality Program | Central Regional Office
(509) 575-2808 (w) | (509) 406-5130 (c) | bzim461@ecy.wa.gov

From: Debbie Firestone <Dfirest@gcpud.org>
Sent: Tuesday, December 11, 2018 2:26 PM
To: Zimmerman, Breean (ECY) <bzim461@ECY.WA.GOV>
Cc: Tom Dresser <TDresse@gcpud.org>; Ross Hendrick <Rhendr1@gcpud.org>; Carson Keeler <Ckeeler@gcpud.org>; Peter Graf <Pgraf@gcpud.org>
Subject: Grant PUD's Draft 5 year Total Dissolved Gas Abatement Plan & Updated Quality Assurance Project Plan

Good afternoon,

Attached for your review and comment are Grant County PUD's updated Quality Assurance Project Plan (QAPP) and the 2019-2023 (5 Year) Total Dissolved Gas Abatement Plan (GAP).

Grant County PUD appreciates receiving your comments **no later than January 11, 2019**.

Please contact Carson Keeler at 509-754-5088 ext. 2687 or ckeeler@gcpud.org if you have any questions.

Thanks!
Deb Firestone
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Grant County PUD
P.O. Box 878
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509-793-1583

Grant PUD

Appendix E
Ecology Approval of the Final 5-Year GAP and Update QAPP

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
1250 W Alder St • Union Gap, WA 98903-0009 • (509) 575-2490

February 21, 2019

Mr. Ross Hendrick
Manager, License & Environmental Compliance
Grant County PUD
PO Box 878
Ephrata, WA 98823

RE: Request for Ecology Review – *Updated Quality Assurance Project Plan (QAPP) & the 2019-2023 (5 Year) Total Dissolved Gas Abatement Plan (GAP).*
Priest Rapids Hydroelectric Project No. 2114

Dear Ross Hendrick:

The Department of Ecology (Ecology) has reviewed and approves the *Updated Quality Assurance Project Plan (QAPP) & the 2019-2023 (5 Year) Total Dissolved Gas Abatement Plan (GAP)* sent via email to Ecology on December 11, 2018.

Ecology provided comments on January 17, 2019, and on January 25, 2019. Grant County addressed these comments (please see attached). These plans fulfill the requirements in Section 6.7.2 and Section 6.4.11(f), respectively, of the 401 Water Quality Certification.

Please contact me at (509) 575-2808 or breean.zimmerman@ecy.wa.gov if you have any questions.

Sincerely,

Breean Zimmerman

Breean Zimmerman
Hydropower Projects Manager
Water Quality Program, Central Region

cc: Tom Dresser, Grant County PUD
Carson Keeler, Grant County PUD

Attachment: email correspondence

Espinoza, Joy (ECY)

From: Zimmerman, Breean (ECY)
Sent: Thursday, January 17, 2019 10:29 AM
To: Debbie Firestone; Carson Keeler
Cc: Tom Dresser; Ross Hendrick; Peter Graf
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