Grant County
PUBLIC UTILITY DISTRICT
Excellence in Service and Leadership

January 6, 2011

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

Re: **Final 2011 Total Dissolved Gas Abatement Plan for the Priest Rapids Project**

Dear Ms. Mangold,

Enclosed please find Public Utility District No. 2 of Grant County, Washington's (Grant PUD's) final total dissolved gas abatement plan (GAP) for Wanapum and Priest Rapids dams. This GAP for 2011 is an update to the 2010 GAP and is consistent with the requirements of the Priest Rapids Hydroelectric Project License (issued April 17, 2008) and associated obligations and mandates, including the Washington State Department of Ecology (WDOE) 401 water quality certification (WQC). Specifically, the water quality certification requires that the GAP be revised annually to reflect any changes required in accordance with the 401 WQC, that the draft GAP be submitted to WDOE annually for review, on or before October 31, and that the GAP be finalized by February 1 of the following year. The GAP requirement is also referenced in the 2008 Biological Opinion, Salmon and Steelhead Agreement, and the fishway prescriptions submitted by both the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) relating to the Priest Rapids Project License.

This document was distributed for comment to WDOE, the Priest Rapids Coordinating Committee (PRCC), NMFS, USFWS, and Wanapum Tribe on October 29, 2010. No comments were received by the requested comment due date of December 31, 2010.

Article 401(a)(19) of the Priest Rapids Project License requires that annual updates to the GAP also be approved by the Federal Energy Regulatory Commission (FERC) prior to implementation, and that these updates be submitted to FERC by March 1 of each year.

The final GAP includes several appendices, including:

- Appendix A: Summary of 2010 Fish-Spill Season and Total Dissolved Gas Monitoring report; required under section 6.4.11(c) of the 401 (submitted to WDOE October 28, 2010).
- Appendix B: 2010 Fishery Operations Plan; required under Article 404 of the FERC license (currently undergoing separate consultation with the PRCC and a final version will be available after February 15).
- Appendix C: 2009 Quality Assurance Project Plan (QAPP); required under section 6.7.1 of the 401 and Article 401 (a)(23) of the FERC license (approved by WDOE and FERC on January 30, 2009 and July 26, 2009, respectively).

Appendices A – C each underwent separate consultation processes as required per the conditions requiring those reports/plans.

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

Sincerely,

Ross Hendrick
Fisheries Program Supervisor – Res. Fish, Wildlife, and WQ Branch

CC: Jeff Grizzel
Tom Dresser
Julie Piper
Carson Keeler
James Bellatty – WDOE
PRCC Members
Wanapum

Priest Rapids Hydroelectric Project (P-2114)

2011 Total Dissolved Gas Abatement Plan

License Article 401(a)(19)

By Carson Keeler

Public Utility District No. 2 of Grant County, Washington
Priest Rapids Project
FERC Project Number 2114

January 2011

Executive Summary

This total dissolved gas abatement plan (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 year 2011. These measures are intended to result in compliance with Washington state's water quality standards for total dissolved gas (TDG) at the Priest Rapids Hydroelectric Project (Project). The Washington State Department of Ecology (WDOE) establishes Washington state water quality standards for TDG during the non-fish and fish-spill seasons. This current year's plan (2011) is an update to the 2010 GAP submitted to WDOE and the Federal Energy Regulatory Commission (FERC) on January 26, and February 25, 2010, respectively (Hendrick 2010).

Proposed operational abatement measures include minimizing involuntary spill by scheduling maintenance operations based on predicted flows and continuing to participate in the Hourly Coordination Agreement, which uses automatic control logic to maintain preset reservoir levels at the mid-Columbia River dams in order to meet load requirements and prevent involuntary spill. In addition, Grant PUD plans to consult with WDOE on 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). Grant PUD will also conduct biological monitoring for gas bubble trauma (GBT) during the fish-spill season.

Structural TDG abatement measures include operation of the Wanapum Fish Bypass (WFB), which is designed to safely pass juvenile outmigrating salmonids while minimizing TDG uptake. Research/modeling and fish-passage evaluations have been completed to support the designs of a fish-passage facility at Priest Rapids Dam that will increase fish-passage while maintaining or reducing TDG levels (Jacobs et al. 2010). Priest Rapids Coordinating Committee approval was granted to move forward with the design measures of the Priest Rapids Fish Bypass (PRFB) in May of 2010. Beginning in the fall of 2011, Grant PUD is proposing to modify three existing tainter gate spillbays to create the PRFB. The PRFB shall be designed to comply with TDG water quality standards. In accordance with the terms and conditions contained in the 401 water quality certificate (WQC; WDOE 2007), Grant PUD will conduct TDG evaluations during the first year of PRFB operation (scheduled for fish-spill season 2016) to determine any potential TDG impacts. The installation of the new advanced turbines at Wanapum Dam is on-going, with the final unit presently scheduled for installation in 2012. These new turbines are designed for greater efficiency and power output for a given volume of water, while also having an increased hydraulic capacity. This increase in hydraulic capacity allows for the potential of passing greater river volume, thus yielding the potential for less volume of spill needed during times of involuntary spill.

Compliance monitoring for TDG will continue at Grant PUD's fixed-site monitoring stations. TDG data will be collected on an hourly basis throughout the year and will be reported to Grant PUD's water quality web-site (http://www.gcpud.org/naturalResources/fishWaterWildlife/waterqualityMonitoring.html). An annual report to WDOE will summarize Grant PUD's TDG monitoring and fish-spill season results.

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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
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
PRFF	Priest Rapids Fish Forum
Project	Priest Rapids Hydroelectric Project
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RPA	Reasonable and Prudent Alternative
TG	tainter gate
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), located on the Columbia River downstream of Rock Island Dam, owned and operated by Public Utility District No. 1 of Chelan County (Chelan PUD; Figure 1). The Project is licensed as Project No. 2114[1] by the Federal Energy Regulatory Commission (FERC), and includes Wanapum and Priest Rapids developments. A 401 water quality certification (WQC) for the operation of the Project was issued by the Washington State Department of Ecology (WDOE) on April 3, 2007 and amended on March 6, 2008. The 401 WQC terms and conditions are incorporated in the FERC license to operate the Project issued on April 17, 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).

This GAP provides details on operational and structural measures Grant PUD plans to implement over the next eight years (the first of ten years began with the 2009 GAP (Hendrick 2009b)). These measures are intended to result in compliance with WDOE's water quality standards for TDG at the Project.

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; an intake section for future generating units; a downstream fish passage structure in one of the unused intake sections (unit No. 11); and a powerhouse containing ten vertical shaft integrated Kaplan turbine/generator sets with a total authorized capacity of 1,038 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 embankment sections; left and right concrete gravity dam sections; a left and right fish passage structure, each with an upstream fish ladder; a gated spillway section; and a powerhouse containing ten vertical shaft integrated Kaplan turbine/generator sets with a total authorized capacity of 955 MW (Figure 3).

[1] 123FERC¶61,049

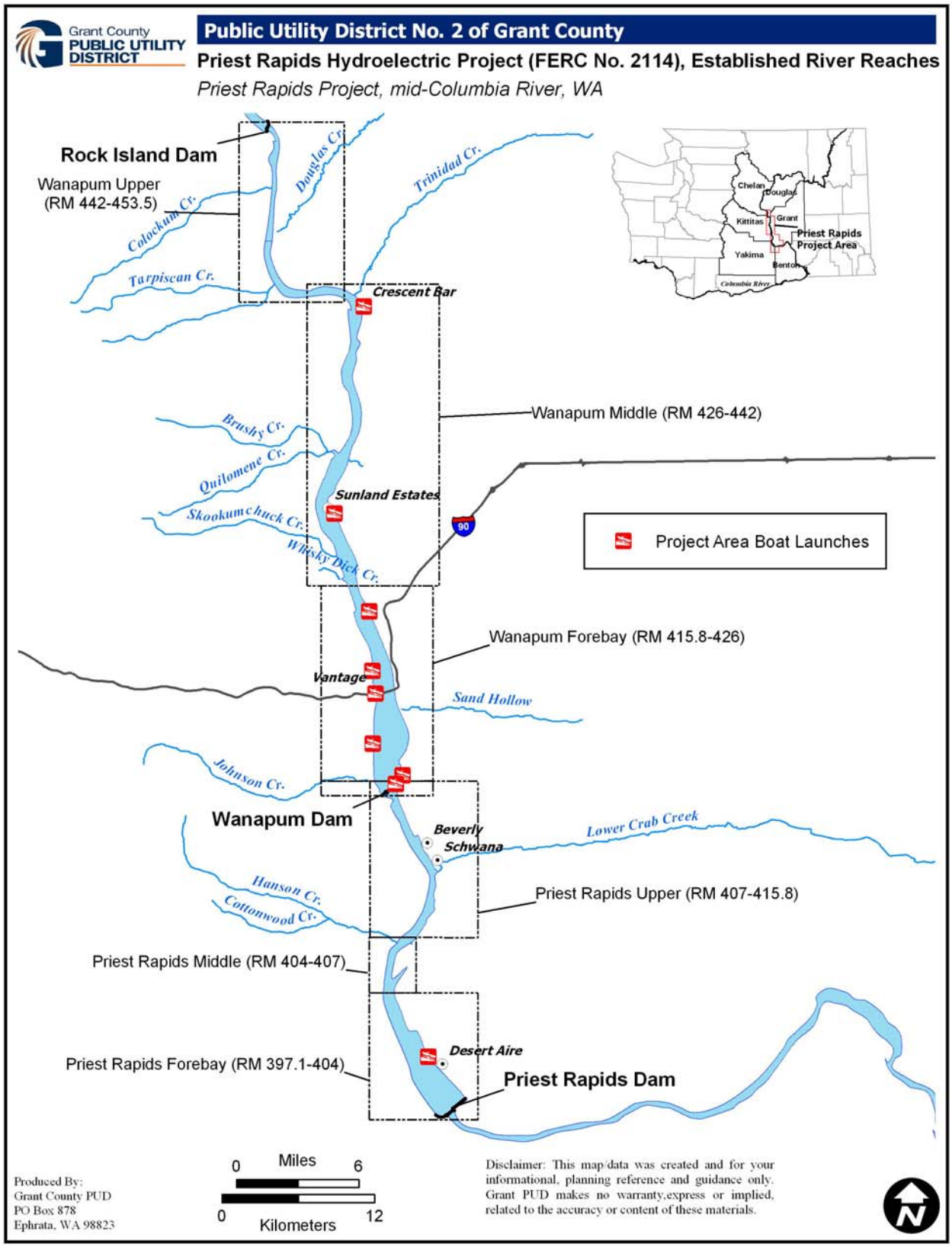

Figure 1 **Priest Rapids Hydroelectric Project and established river reaches presented by river mile (RM), mid-Columbia River, WA.**

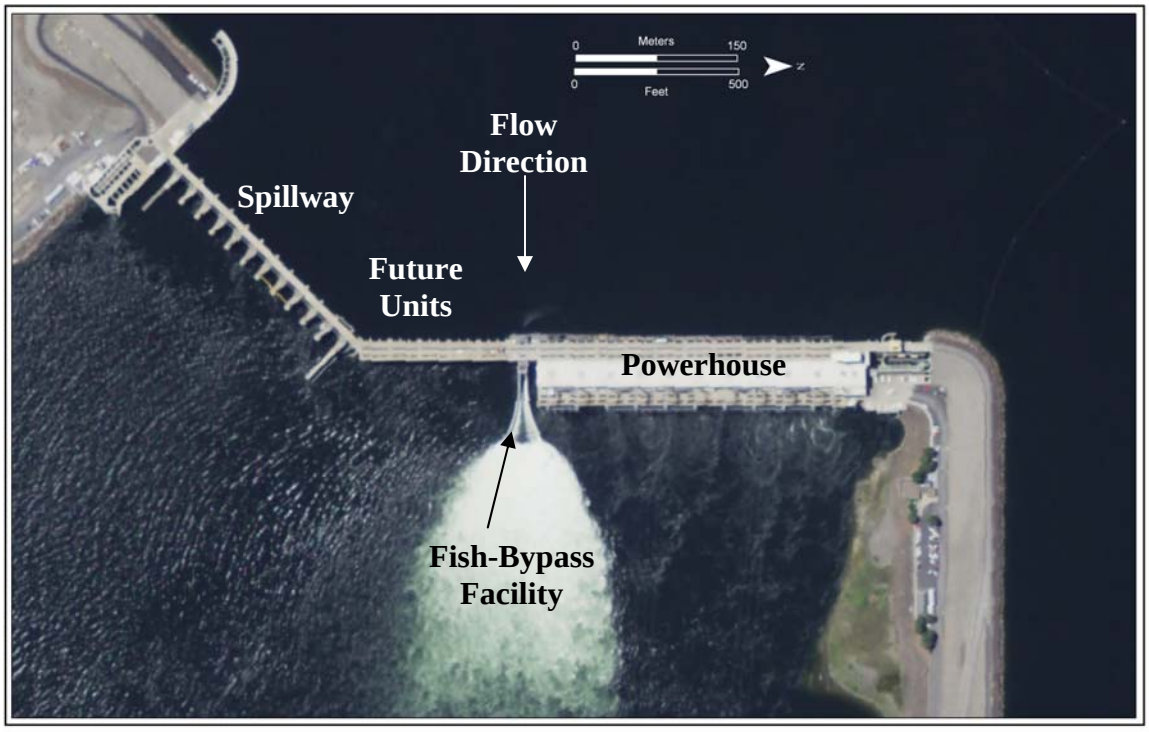

Figure 2 **Aerial photograph of Wanapum Dam, mid-Columbia River, WA.**

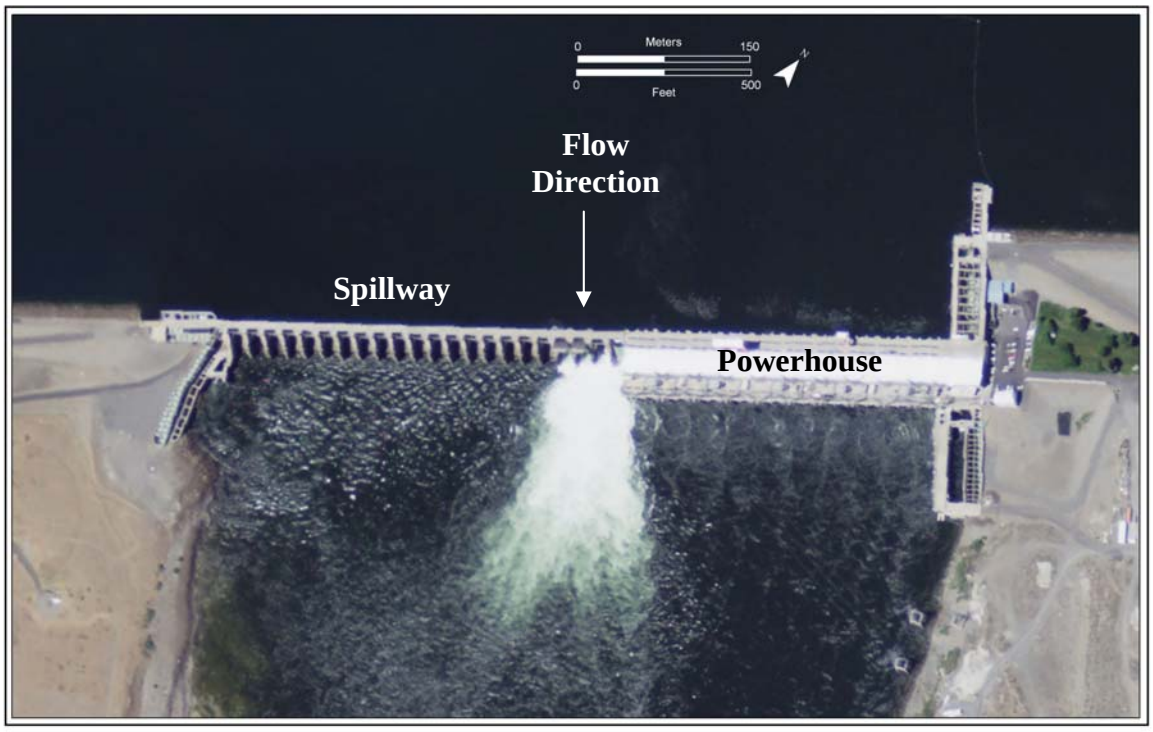

Figure 3 **Aerial photograph of Priest Rapids Dam, mid-Columbia River, WA.**

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) during the non-fish spill season (September 1 through March 31) is 110 percent for any hourly measurement. The current standard for TDG (in percent saturation) during the fish-spill season (April 1 through August 31) is 120 percent in the tailrace of the dam spilling water for fish and 115 percent in the forebay of the next downstream dam, based on the average of the twelve highest consecutive hourly readings in a twenty-four hour period. A one-hour, 125 percent 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 steady progress towards achieving a minimum ninety-one percent combined adult and juvenile salmonid survival performance standard at the Priest Rapids and Wanapum developments (i.e., each dam/reservoir). The ninety-one percent standard includes a ninety-three percent project-level (one reservoir and dam) juvenile performance standard. Because NMFS recognizes that it is not currently possible to measure the ninety-one percent 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 ninety-three percent juvenile project passage survival.

Grant PUD is using smolt survival studies to evaluate progress toward meeting these survival standards. Structural changes at the dams are one approach that has been pursued to increase dam passage survival rates, as outlined in a fish passage alternatives study for the Project (Jacobs et. al 2003). Results of this approach have been the construction of the Wanapum Fish Bypass (WFB), the proposed modifications to three existing tainter gates at Priest Rapids Dam for the creation of a top-spill fish bypass facility (Priest Rapids Fish Bypass (PRFB)), and operation of the Wanapum and Priest Rapids dams turbines in "fish-mode" (optimal turbine operating range based on turbine fish-survival studies (Normandeau, Skalski and Townsend 2005, Normandeau and Skalski 2005)). Additional information related to these structural changes is presented in sections 2 and 3 of this GAP. 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 6.4.1.1(b), 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 Rock Island Dam. Grant PUD also provides small amounts of spill for adult fall-back from the end of the 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, see http://www.gcpud.org/prcc/PRCC.htm).

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 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

Section 6.4.1(e) of the 401 WQC (WDOE 2007) provides that even when TDG levels in the tailrace of a dam exceed 120 percent, 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 percent, 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 (Figures 4 and 5).

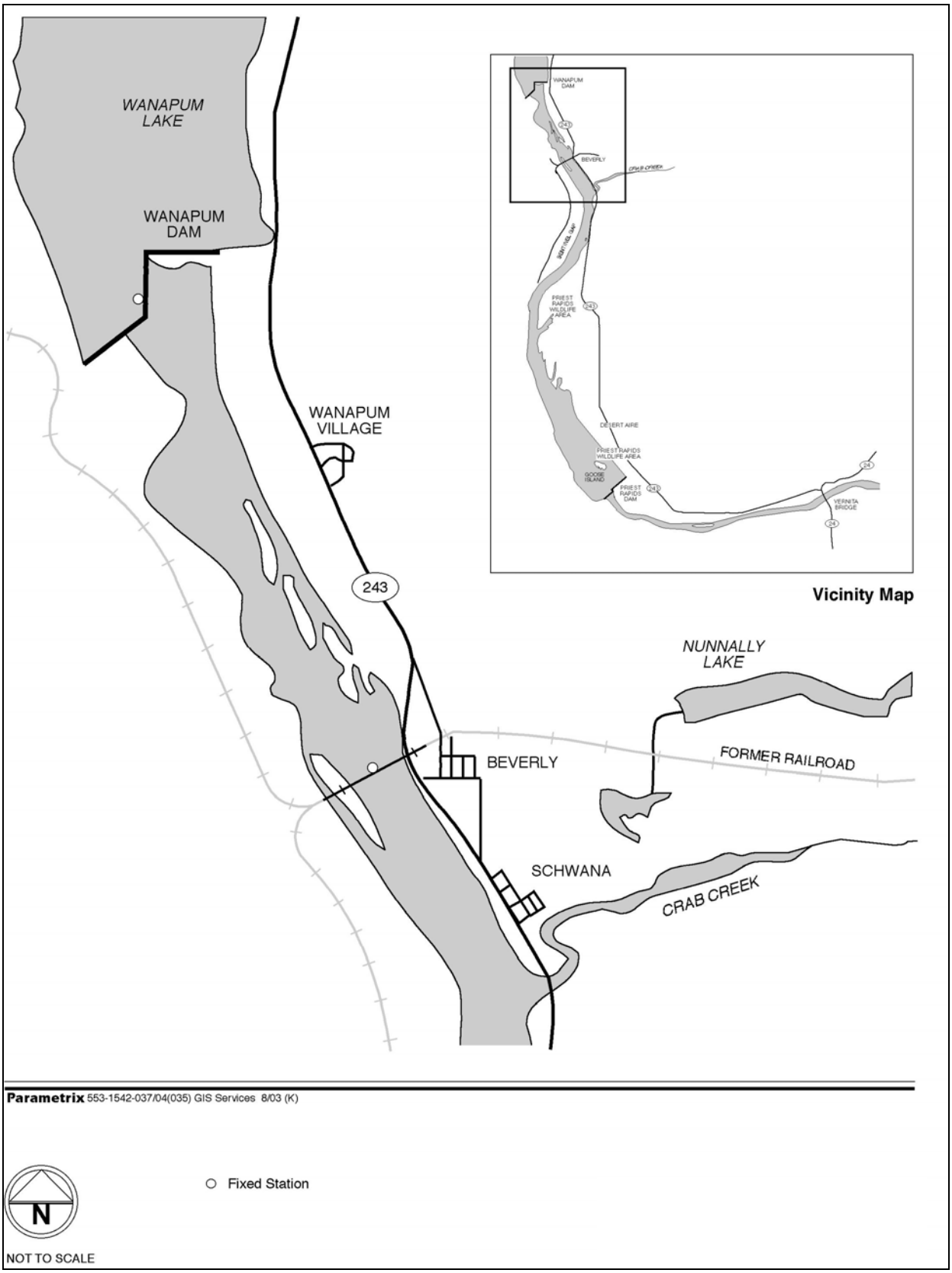

Figure 4 Location of water quality fixed-site monitoring stations for Wanapum Dam.

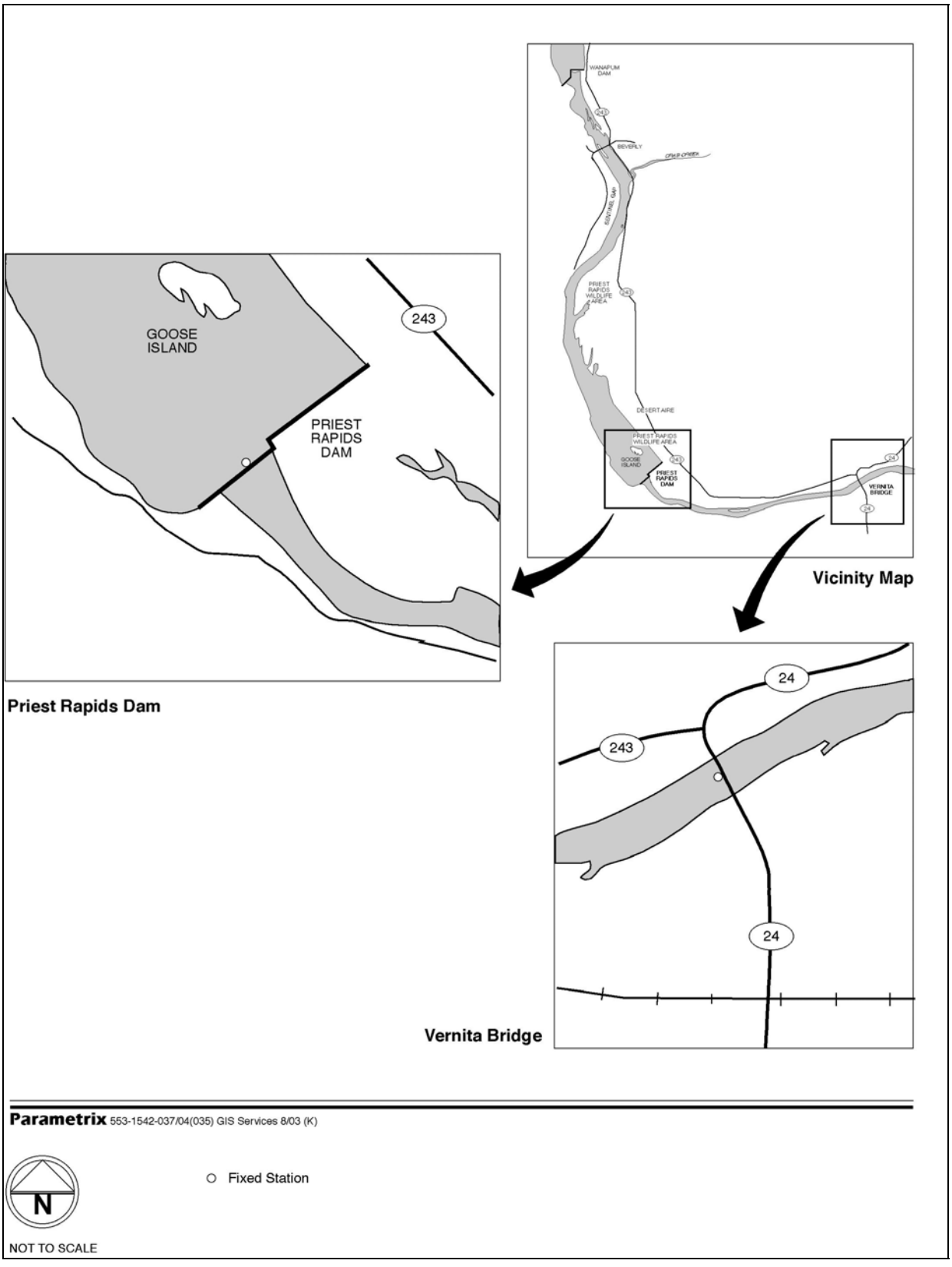

Figure 5 Location of water quality fixed-site monitoring stations for Priest Rapids Dam.

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 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 project operators are coordinated through a set of complex agreements and policies to optimize the benefits and minimize the adverse effects of project operations. The Project operates within the constraints of its FERC regulatory and license requirements, Pacific Northwest Coordination Agreement, Canadian Treaty, Canadian Entitlement Agreement, Hourly Coordination Agreement, Salmon and Steelhead Settlement Agreement, and Hanford Reach Fall Chinook Protection Program Agreement.

Under the Hourly Coordination Agreement, power operations are coordinated to meet daily load requirements through the assignment of "coordinated generation" through Central Control at Grant PUD, which establishes coordinated generation for all mid-Columbia projects. Automatic Control Logic is used to maintain preset reservoir levels in order to meet load requirements and prevent involuntary spill. These preset reservoir levels are maintained at each project through management of a positive or negative "bias" which assigns a project more or less generation depending on whether the reservoir elevation should be increased or decreased in order to maximize system benefits and minimize involuntary spill.

1.3.2 River Flows

Figure 6 illustrates a ten-year average of mean daily discharge values from 1999 to 2009, as measured at the U.S. Geological Survey (USGS) Streamflow gage #12472800 located 2.6 river miles downstream of Priest Rapids Dam (USGS 2010). During the fish-spill season streamflows typically peak in late May/early June and begin to recede in July.

Figure 6 **Ten-year average of mean daily discharge values from 1999 to 2009 as measured at the USGS streamflow gage #12472800 located below Priest Rapids Dam, mid-Columbia River, WA (USGS 2010).**

Water is passed through Wanapum Dam either through the ten powerhouse units, twelve tainter-gates, sluiceway, and/or the WFB (Figures 2 and 7). Maximum flow through each powerhouse unit ranges from fifteen to eighteen kcfs, passing 135–162 kcfs of total flow assuming ninety percent 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 current 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). New turbines are currently being installed at Wanapum Dam that are anticipated to pass up to eighteen kcfs per unit during the fish-spill season. Although six of these turbines are currently installed and operational, their exact operating range will be determined after all ten new turbines are installed (currently scheduled for 2012). The twelve spillway gates and sluice-way at Wanapum Dam are designed to pass up to 1,400 kcfs, while the WFB is designed to pass an additional twenty 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 or twenty-two spillways (Figure 3). Maximum flow through each powerhouse unit ranges from fifteen to eighteen kcfs, passing 135–162 kcfs of total flow assuming ninety percent 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 current 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 twenty-two spillway gates at Priest Rapids Dam are designed to pass up to 1,400 kcfs. There are also fish-ladders on the right and left banks of Priest Rapids Dam, which pass up to two kcfs depending on forebay elevations.

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 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 fall-back from the end of the fish-spill season until November 15, annually.

The 2004 through 2010 TDG-fish-spill summary reports submitted to WDOE (Hendrick 2004 – 2008, 2009a, Keeler 2010b) 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 project.

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 were anticipated to be higher than 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 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 Marketing, dam Operators, and Natural Recourse 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 spillways and turbine units. These activities include forebay debris flushing, 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, including computer malfunctions or human error in transmitting proper data, can contribute to involuntary spill. Hourly coordination between hydroelectric projects on the river minimizes this type of spill, but it does occur occasionally. Section 2.1 provides information related to minimizing this type of spill by continuing to participate in the Hourly Coordination Agreement.

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 Total Dissolved Gas (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 (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, Corps 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 – 2008, 2009a, Keeler 2010b). 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 for 2009, which covers TDG monitoring results during the non-fish spill season (Keeler 2010a). 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 current hydraulic capacity.

The 2010 TDG/fish-spill summary report is included in this GAP as Appendix A.

2.0 Proposed Operational Total Dissolved Gas Abatement Measures

The following sections describe operational TDG abatement measures proposed for implementation to achieve compliance with TDG water quality standards.

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 the Hourly Coordination Agreement.
- Attempting to maximize powerhouse discharge during periods of high flows.

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 in Appendix B of this GAP.

2.3 Fish Spill

During the 2011 fish-spill season, Grant PUD intends to implement spill programs at Wanapum and Priest Rapids dams as guided by the Biological Opinion and the PRCC. 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 2011 fish-spill season programs will be obtained from the PRCC in the spring of 2011, prior to the start of the 2011 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 forty-eight hours of notification prior to the beginning of the fish-spill season.

2.3.1 Wanapum Dam

The primary fish-passage route at Wanapum Dam in 2011 will be the WFB, which passes up to twenty kcfs depending on forebay and tailwater elevations, and turbine passage. 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 and 2010 fish-spill season also indicate no negative impacts to TDG levels during operation of the WFB (Hendrick 2009a, Keeler 2010b; Appendix A). In addition, results from the 2008 and 2009 fish-survival/behavior studies indicate that survival through the WFB is greater than 95% (Skalski et al. 2009, Timko et al. 2009), and therefore the WFB was approved for use by the PRCC for the 2010 fish-spill season, and is approved by the PRCC as the primary fish passage option for 2011. Additional WFB survival and three-dimensional tracking studies designed to provide relevant information and empirical evidence on survival rates and behavior were conducted in 2010 using run-of-river steelhead and sockeye as they migrate through the Project with the use of acoustic-tag technology (Dotson 2009). The 2010 WFB survival/behavior study reports are currently under development. Additional fish survival/behavior studies will be conducted in 2011 in order to evaluate overall dam passage efficiencies and survival rates (Dotson 2010); these studies will be subject to PRCC consultation prior to implementation.

2.3.2 Priest Rapids Dam

The current primary downstream passage mode at Priest Rapids Dam is tainter-gate spill. Studies conducted from 2000-2002 (English and Labelle 1999, English et al. 2001, Robichaud et al. 2003) indicate survival through the spillway at Priest Rapids Dam ranged from ninety-five to ninety-eight percent. Grant PUD is currently moving forward with plans to modify three existing

tainter gates to create the PRFB, per the Biological Opinion and in consultation with the PRCC (see also Section 3.4).

In 2011, Grant PUD will implement additional top-spill tests that will assist with the final design of the PRFB, per the requirements of the Biological Opinion (see also Section 3.4). Additional top-spill tests will be subject to PRCC consultation prior to implementation and the results of the tests will be provided to WDOE and the PRCC.

2.4 Fishery Operation/Management Plan

Grant PUD's Fishery Operations Plan is included as Appendix B of this GAP. This 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.

2.5 Biological Monitoring Plan

Grant PUD will conduct gas bubble trauma (GBT) monitoring on outmigrating salmonids smolts during the 2011 fish-spill season. Grant PUD biologists will use the Smolt Gas Bubble Trauma Examination Protocol developed by the Fish Passage Center (2009). This protocol has been used extensively throughout the Columbia and Snake river-basins to standardize the GBT examination practice by participating agencies within the Pacific Northwest. The principle objective will be to administer smolt GBT examinations and record the presence of observed GBT-related tissue damage on salmonid smolt, as a function of species, as they pass through the collection facilities at Priest Rapids Dam. GBT monitoring results will be posted weekly to Grant PUD's water quality web-site (see Section 4.3.1). The 2010 TDG/Fish-Spill summary report provides GBT monitoring results for 2010 (Keeler 2010b; Appendix A).

2.6 Participation in Water Quality Forms

As part of this GAP, Grant PUD will continue its participation in regional water quality related forums, including the Transboundary Gas Group, the Corps' end-of-year TDG monitoring summary meetings, Water Quality Team, and other forums as applicable to TDG abatement issues. Grant PUD staff will also attend applicable trainings and 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, or planned for installation 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 spillway) 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 quite 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 Wanapum Fish Bypass (WFB) was completed in 2008 and was fully operational during the 2008 fish-spill season (Figure 7). Results from the 2008 and 2009 fish survival/behavior studies indicate that survival through the WFB is greater than 95% (Skalski et al. 2009, Timko et al. 2009) and therefore the WFB was used as the primary fish passage option for 2010, and will also be used in 2011.

Figure 7 Photograph of Wanapum Fish Bypass facility, mid-Columbia River, WA.

3.3 Wanapum Dam Advanced Turbines

On October 2, 2003, and supplemented on April 5 and May 28, 2004, Grant PUD filed an application to amend its license for the Project seeking authorization to replace the ten turbines at the Wanapum Development. The advanced turbine replacement was proposed to provide increased power and hydraulic capacity, equal or improved survival of juvenile salmon passing through the units, and improved water quality by reducing the amount of spill over the dam during periods of high flows. The decision criteria for proceeding with the replacement of the remaining nine units over the next eight years was whether the advanced turbine testing results demonstrated equal or better survival than the existing turbines. Pursuant to FERC's July 23, 2004 Order, Grant PUD installed and tested an advanced turbine at Unit 8 consistent with the requirements of the 2004 Biological Opinion (NMFS 2004) and related FERC Order. A study was designed and conducted to test the hypothesis that survival of Chinook salmon smolts through a new advanced turbine would be equal to, or greater than, passage survival through an existing unit (Normandeau, Skalski and Townsend 2005). Results from this study demonstrated that high turbine passage survival for juvenile salmonids was achieved for both the advanced and existing turbines. Additional benefits observed included increase turbine efficiency gains for the advanced turbine design and potential increased hydraulic capacity (see below). Grant PUD also conducted a TDG study that assessed the TDG production of Unit 8 (advanced turbine) compared to Unit 4 (existing turbine); results from this study showed no increases in TDG production with the operation of the advanced turbine (Lenz and Dresser 2005). On October 11, 2005, Grant PUD filed a report on the results of biological testing of the first installed advanced turbine unit, and in December 2005, FERC authorized continued installation of the nine other advanced turbines at the Wanapum Development.

Grant PUD is currently installing the seventh Advanced Hydro Turbine System at Wanapum Dam. Installation of this seventh turbine began in April 2010 and is expected to be complete by January 2011, with continued sequential installation and completion of the Wanapum turbine upgrade by 2012.

It is currently estimated that installation of the advanced turbines will increase the total hydraulic capacity of the ten turbines at Wanapum Dam from a maximum capacity of 178 kcfs to a new maximum capacity of 188 kcfs with seventy-five feet of net head at the cavitation limit. During the fish-spill season, installation of the new turbines could have the potential to reduce spill volume by a maximum of twenty-three kcfs (and thereby the amount of TDG generated by spill). This reduction in spill volume is based upon the average maximum fish-mode capacity of the current turbines (15.7 kcfs/unit = 157 kcfs maximum capacity) and anticipated (to be verified after all ten turbines are installed) maximum fish-mode capacity of the advanced turbines (18.0 kcfs/unit = 180 kcfs maximum capacity).

3.4 Priest Rapids Dam Alternative Spill Methods

The terms and conditions of the Biological Opinion required Grant PUD to investigate alternative top-spill designs for Priest Rapids Dam; these terms and conditions also require Grant PUD to construct the PR Bypass, in consultation with NMFS and the PRCC.

Following completion of the Downstream Passage Alternatives Study (Jacobs et al. 2003), a process was initiated to develop a new passage measure for Priest Rapids Dam. In 2006, prototype surface spill passage route (top-spill bulkhead located at spillways 19 and 20) was

constructed to help evaluate fish behavior and survival under controlled operating conditions to address unknown aspects of fish passage at Priest Rapids Dam. Evaluations were undertaken in 2006, 2007 (Timko et al. 2007), 2008 (Sullivan et al. 2008), 2009 (Timko et al. 2009), and again in 2010 (Dotson 2009) under consultation with the PRCC. Additional modeling, both physical and CFD, evaluations were also undertaken during this time period. The results of these studies have led to the design of modifying the three existing tainter gates closest to the powerhouse (TG20-TG22) at Priest Rapids Dam to create the PRFB (Jacobs et. al. 2010). TDG was incorporated into the modeling evaluations so that the PRFB will have minimal or beneficial affects on TDG.

Per section 6.2.4(b) of the 401 WQC (WDOE 2007), Grant PUD convened the Priest Rapids Fish Form (PRFF, see http://www.gcpud.org/prcc/PRFF.htm) for protection of non-ESA listed fish species. Following consultation, Grant PUD finalized investigative design options, including computational and model studies, in May 2010 and installation is scheduled to begin in the fall of 2011. Within one year following construction of the PRFB (currently scheduled for the 2016 fish-spill season), Grant PUD shall complete a short-duration field study of controlled operating conditions to quantify the TDG exchange associated with the PRFB as described in sections 6.4.6(b) and 6.4.8(a) of the 401 WQC (WDOE 2007).

3.5 New Technologies

Grant PUD plans to implement the TDG abatement measures described in this GAP and required in the 401 WQC (WDOE 2007). Because these various TDG abatement measures have yet to be tested, it is premature to extensively research new or improved technologies related to TDG abatement. Should any of the TDG abatement measures identified in this GAP or 401 WQC prove to be insufficient in obtaining compliance with TDG water quality standards, Grant PUD shall, in accordance with section 6.4 of the 401 WQC (WDOE 2007) conduct feasibility studies that will attempt to identify all potentially reasonable and feasible TDG abatement measures that could be used to meet TDG water quality standards.

4.0 Compliance/Physical Monitoring

The following sections describe Grant PUD's TDG compliance monitoring program, and includes information about its fixed-site monitoring program and quality assurance protection plan (QAPP, Hendrick 2009c; Appendix C).

4.1 Fixed-Site Monitoring Stations

Grant PUD currently operates and maintains four fixed-site water quality monitoring stations (FSMs) that record water depth (m), barometric pressure (mm Hg), TDG (mm Hg), temperature (°C), dissolved oxygen (DO; mg/L), pH (units), and turbidity (NTU). Barometric pressure, TDG, and temperature are monitored on an hourly basis throughout the year, while depth, DO, pH, and turbidity are monitored on a bi-weekly basis throughout the year (Hendrick 2009c; Appendix C). 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 provides the barometric pressure readings necessary to correct the partial pressure readings taken by the HydroLab® multi-probes.

Grant PUD FSMs are located midway across the river channel in the forebay and tailrace of each dam (Figures 4 and 5). The Wanapum forebay FSM is located near Turbine Unit 10 and is affixed to the catwalk approximately mid-channel. The Wanapum tailrace FSM 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. The FSM in the forebay of Priest Rapids Dam is attached to the piernose directly between the powerhouse and spillway and is located at mid-channel at approximately the center of the dam. The Priest Rapids tailrace FSM is located nine miles downstream of Priest Rapids Dam at Vernita Bridge.

The Pasco FSM, located at river mile 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 river miles upstream of Wanapum Dam, during the fish-spill season. This allows Grant PUD to monitor upstream river conditions.

Section 6.4.10(a) of the 401 WQC (WDOE 2007) requires 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 FSMs, with indexing to the current FSMs 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 (Mangold 2010).

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. In 2003, Grant PUD developed its QA/QC protocols following established protocols by HydroLab® Corporation, the USGS, and the Corps (Duvall and Dresser, 2003). These QA/QC protocols have been updated in Grant PUD's FSM QAPP (Hendrick 2009c; Appendix C), per section 6.7.1 of the 401 WQC (WDOE 2007). The FSM QAPP is included in this GAP as Appendix C.

4.3 Compliance Reporting

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

4.3.1 Water Quality Web-Site

Hourly, daily summary, and monthly summary TDG and water temperature data recorded at each of Grant PUD's FSMs, 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:

http://www.gcpud.org/naturalResources/fishWaterWildlife/waterqualityMonitoring.html.

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 twenty-four hour averages and average of the twelve 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 seventy-two hours (~two hour delay) of TDG, water temperature, and flow/spill data that is considered preliminary, has not received final QA/QC review and verification, and is subject to change based on QA/QC review.
- Priest Rapids Smolt Monitoring: ".xls" file that presents GBT monitoring results, including date and number of fish examined, number and percentage of fish with GBT signs, and ranking of GBT sign.

Data from previous years can also be accessed from the water quality web-site (http://www.gcpud.org/naturalResources/fishWaterWildlife/waterqualityMonitoring.html).

4.3.2 Notifications

Grant PUD shall notify WDOE within forty-eight hours on the beginning of the fish-spill season, per section 6.4.11 (b) of the 401 WQC (WDOE 2007). Notification shall be given to D. Marcie Mangold of the WDOE Eastern Regional Office.

4.3.3 Annual Report

Per section 6.4.11 of the 401 WQC (WDOE 2007), Grant PUD will provide WDOE with an annual TDG monitoring report by October 31 of each year. The TDG monitoring report will include:

- flow and runoff descriptions for the fish-spill season;
- spill quantities and duration;
- quantities of water spilled for fish versus spill for other reasons for each development (Wanapum and Priest Rapids dams);
- data from the physical and biological monitoring programs, including:
    - a summary of TDG water quality exceedances of the values,
    - causes of the exceedances, and
    - a description of what was done to correct the exceedance;
- progress on implementation of TDG abatement measures (e.g. advanced turbines, PRFB, etc.); and

- monitoring and compliance for fish passage efficiency and survival under the Priest Rapids Project Salmon and Steelhead Settlement Agreement (Grant PUD 2006) and as otherwise required for non-Covered Species under the 401 WQC (WDOE 2007). Due to the complexity of the fish passage and survival studies and proper evaluation of study data, the final results were not available at the time the annual TDG report was developed. Note that Section 6.1.7 of the 401 WQC (WDOE 2007) provides WDOE the right to modify schedules and deadlines required by the 401 WQC.

The 2010 TDG monitoring report is included in Appendix A of this GAP.

5.0 Conclusions

Based on the information presented in this GAP, it is anticipated that TDG water quality standards will be met at the Project according to the implementation schedule provided in the 401 WQC for the Project. This GAP will be updated annually to reflect any changes in implementation schedules, new or improved technologies, or TDG abatement measures.

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Appendix A
Summary of 2010 Fish-Spill Season and Total Dissolved Gas Monitoring

The 2010 Fish-Spill Season and Total Dissolved Gas Monitoring Report can be found at the following URL:

http://www.gcpud.org/naturalResources/fishWaterWildlife/waterQuality.html

Appendix B
Fishery Operations Plan

The Fisheries Operations Plan is currently undergoing separate consultation and will be available on or before February 15, 2011 at the following URL:

http://www.gcpud.org/prcc/supportingdocumentation.htm

Appendix C
Quality Assurance Project Plan

The Fixed-Site Monitoring Quality Assurance Project Plan can be found at the following URL:

http://www.gcpud.org/naturalResources/fishWaterWildlife/waterQuality.html: