SUMMARY OF 2016 ANNUAL FISH-SPILL SEASON AND TOTAL DISSOLVED GAS MONITORING

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for

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Executive Summary

This report summarizes the results of the 2016 fish-spill season and associated total dissolved gas (TDG) and biological monitoring within the Priest Rapids Hydroelectric Project (Project), owned and operated by the Public Utility District No. 2 of Grant County, Washington (Grant PUD).

During the 2016 fish-spill season, Grant PUD implemented spill programs as guided by the 2008 National Marine Fisheries Service (NMFS) Biological Opinion (Biological Opinion) and the Priest Rapids Coordinating Committee (PRCC). At Wanapum Dam fish-spill was through the Wanapum Fish Bypass (WFB), which is designed to safely bypass outmigrating smolts, while minimizing TDG uptake. Depending on forebay elevations, the WFB passes up to 22 thousand cubic feet per second (kcfs). The spillway at Wanapum Dam was operated on an as-needed basis to pass involuntary spill. At Priest Rapids Dam fish-spill was through the Priest Rapids Fish Bypass (PRFB). The PRFB was designed to safely bypass outmigrating smolts, while minimizing TDG uptake. Depending on forebay elevations, the PRFB passes up to 24 kcfs. The other spillway gates at Priest Rapids Dam were operated on an as-needed basis to pass involuntary spill.

In accordance with the Washington Department of Ecology's (WDOE's) water quality standards, the fish-spill season for TDG compliance purposes occurred from April 1 through August 31, 2016 (see Washington Administrative Code (WAC) 173-201A-200(1)(f)). In accordance with the Biological Opinion, the fish-spill season began at Wanapum Dam on April 12, 2016 and concluded on August 15, 2016. The fish-spill season began at Priest Rapids Dam on April 13, 2016 and concluded on August 16, 2016. The fish-spill periods were closely matched with the juvenile migration timing, with greater than 98% of the yearling spring outmigrants passing during the spring fish-spill period between April 12 and June 14, 2016 (FPC 2016). The combined spring and summer fish-spill periods from April 12 through August 16 encompassed greater than 99% of the entire 2016 outmigration (FPC 2016).

Overall the 2016 mean daily discharges were lower than the 2006–2015 average (~16% lower on average) during the fish-spill season (April 1 through August 31). Mean daily discharge during the mid to late April time period was ~32% higher than the 10-year average. This is directly attributed to Grand Coulee drum gate maintenance operations which required a higher amount of water be discharged to maintain the elevation needed to perform the maintenance.

Exceedances of TDG standard were minimal during the 2016 fish-spill season, with a total of 17 exceedances of the 115/120 %SAT standard (based on daily average of the 12-highest consecutive hourly readings). There were no exceedances of the 1-hour 125 %SAT standard. The Priest Rapids forebay fixed-site monitoring station (FSM station) accounted for the majority of TDG exceedances (9 of 17), all of which can be attributed to river flow in excess of Wanapum Dam's current hydraulic capacity (~163 kcfs). When flows were above Wanapum Dam's hydraulic capacity, involuntary spill was required that contributed to elevated TDG levels, and because of the short distance between Wanapum and Priest Rapids dams (18 river miles (RM)), TDG levels did not have a chance to dissipate below the 115 %SAT by the time they reached the Priest Rapids Dam forebay FSM station. Additionally, of the nine exceedances recorded at the Priest Rapids Dam forebay FSM station, five corresponded with incoming TDG levels 115 %SAT or above recorded during the same time period at the Wanapum Dam forebay FSM station. Furthermore, river flow during these TDG exceedance events was approximately 32%

above the 10-year average because of drum gate maintenance operations at Grand Coulee Dam, which attributed to inadvertent spill events within the Project.

Grant PUD strives to meet TDG standards, as well achieve juvenile and adult salmonid and steelhead fish passage and survival standards for the Project, all while meeting regional energy loads and demands. Grant PUD attempted to reduce TDG when feasible by implementing operational TDG abatement measures in 2016, including attempting to maximize turbine flows by setting involuntary spill caps and minimum generation requirements (and thus maximizing turbine flows and reducing involuntary spill when feasible), participation in regional spill/project operation meetings, implementation of the regional Spill Priority List, and continuing to preemptively spill based on anticipated high flow/low power load time periods. Examples of structural abatement measures include the construction of spillway deflectors at Wanapum Dam (2000), the construction of the WFB (2008), and the PRFB (2014). Grant PUD believes that it is implementing the most current reasonable and feasible measures to reduce elevated TDG levels that occur during the fish-spill season.

Grant PUD will continue to closely monitor TDG levels during the fish-spill season in accordance with its WDOE-approved Quality Assurance Project Plan (QAPP; Hendrick 2009), and will develop its spill programs in accordance with current TDG water quality criteria as set by WDOE, adjusting spill percentages as needed to comply with current TDG standards.

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List of Abbreviations

%SAT	percent saturation
7Q10 flow	highest seven consecutive day average flow with a 10-year recurrence frequency
BPA	Bonneville Power Administration
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
DS	DataSonde
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FPC	Fish Passage Center
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
MS	MiniSonde
MW	megawatt
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Unit
PASCO	Pasco fixed-site monitoring station
PRDF	Priest Rapids forebay
PRDT	Priest Rapids tailrace
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
RM	river mile
TDG	total dissolved gas
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WANF	Wanapum forebay
WANT	Wanapum tailrace
WFB	Wanapum Fish Bypass
WDOE	Washington Department of Ecology
WQC	water quality certification

1.0 Introduction

The 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 Wanapum and Priest Rapids dams. 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, amended on March 6, 2008, and effective on issuance of the FERC license to operate the Project on April 17, 2008 (FERC 2008). Section 6.4.11(c) of the 401 WQC (WDOE 2007) requires Grant PUD to submit an annual report on fish-spill and total dissolved gas (TDG) monitoring by October 31 annually.

The following sections summarize the results of the 2016 fish-spill and TDG monitoring season.

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 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 installed capacity (best gate) of 675 MW (Figure 3).

The Wanapum and Priest Rapids dam spillways were initially designed to accommodate flows that exceeded turbine 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 fish. 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.

[1] 123FERC ¶ 61,049

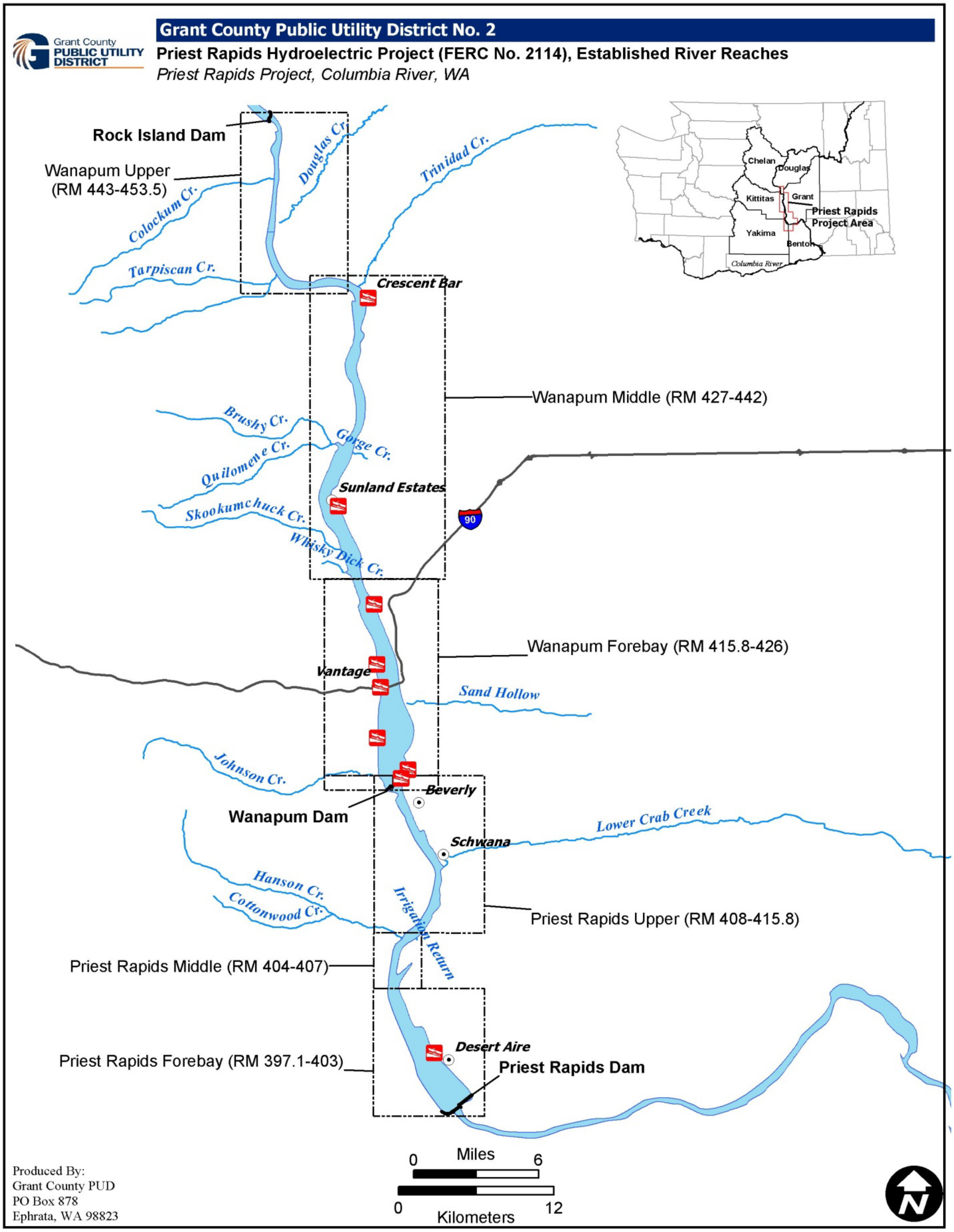

Figure 1 **The Priest Rapids Project and established river reaches presented by river mile (RM), mid-Columbia River, WA.**

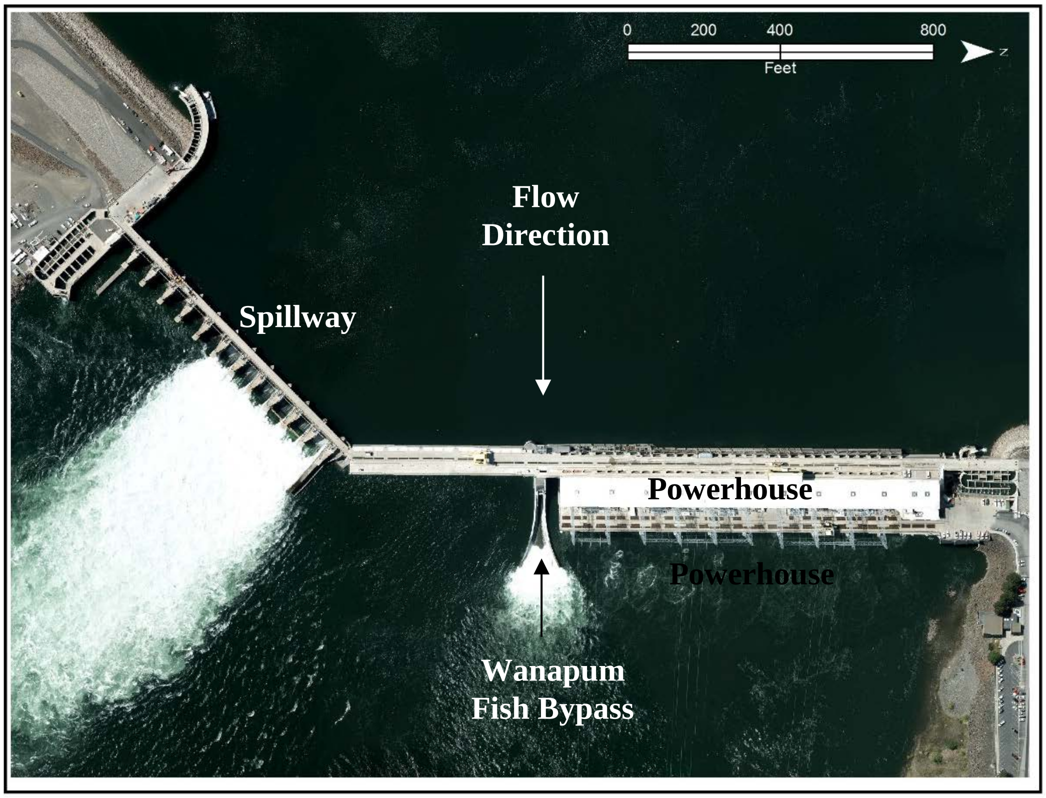

Figure 2 **Aerial photograph of Wanapum Dam, mid-Columbia River, WA.**

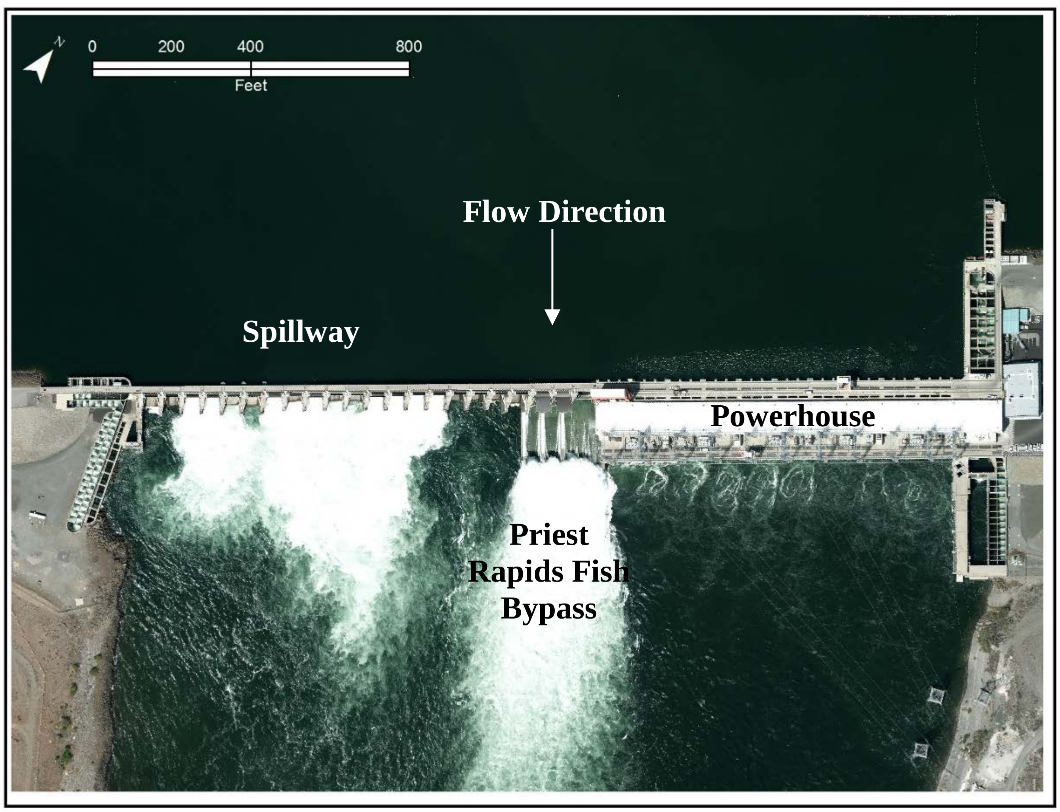

Figure 3 **Aerial photograph of Priest Rapids Dam, mid-Columbia River, WA.**

1.1.1 Fixed Site Water Quality 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 grab-samples are collected every two to three weeks throughout the year in accordance with Grant PUD's WDOE-approved Quality Assurance Project Plan (QAPP; Hendrick 2009). Grant PUD's FSM stations are located midway across the river channel in the forebay and tailrace of each dam. The Public Utility District No. 1 of Chelan County (Chelan PUD) also operates and monitors a FSM station located in the Rock Island Dam tailrace, approximately 38 river miles (RMs) upstream of Wanapum Dam, during the fish-spill season. This allows Grant PUD to monitor upstream river conditions during the fish-spill season. The Pasco FSM station located at RM 329 and owned/operated by the U.S. Army Corps of Engineers (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. This site allows Grant PUD to monitor downstream river conditions during the fish-spill season.

Each Grant PUD FSM station is equipped with a Hydrolab® Corporation DataSonde (DS) 5X, DS 5, DS4A, or MiniSonde (MS) 5 or MS4A 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 multi-probe.

For a complete description of the FSM stations see the QAPP (Hendrick 2009).

1.2 Regulatory Framework

Washington state water quality standards are established by the 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 115 %SAT in the forebay and 120 %SAT in the tailrace, 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.

1.2.1 7Q10 Flows

Section 5.0(b) of the 401 WQC (WDOE 2007) and WAC 173-201A-200(f)(i) provides 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 is calculated to be 264 kcfs for Wanapum and Priest Rapids dams.

1.2.2 Daily Total Dissolved Gas Compliance Value Calculation Method

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

On April 2, 2008 WDOE requested, via letter, that all Columbia and Snake River dam operators use a rolling average method for calculating the twelve highest consecutive hourly TDG readings in a twenty-four hour period, beginning at 0100 hours, based on WDOE's 2006 revised water quality standards (WDOE 2008b). Using a rolling average method that begins at 0100 hours results in counting the hours 1400 through 2359 twice: in the average calculations on the day they occur ***and*** on the next reporting day. As a result, a TDG water quality standard exceedance may be indicated on two separate days based on the same group of hours. On April 15, 2008 Grant PUD sent a letter to WDOE that expressed and provided an example of its concern regarding the rolling average method (Grant PUD 2008). Grant PUD also expressed its intention to monitor these "double-counting" problems and reported any instances in which the same block of hours create an exceedance on two different days in its annual report during two separate phone conversations the WDOE on March 31, 2008.

There were no "double-counting" instances of TDG during the 2016 fish-spill season. Grant PUD will continue to track and report these "double-counting" occurrences in future fish-spill years.

2.0 Data Evaluation and Analyses

Data collection, quality assurance/quality controls (QA/QC), and analyses of TDG values were conducted in accordance with the QAPP for the FSM stations (Hendrick 2009). For this report, hourly TDG data recorded during the 2016 fish-spill season were analyzed for apparent exceedances of current water quality standards.

All of the TDG sensors used during the 2016 fish-spill season were calibrated and maintained in accordance with the methods and schedules described in the QAPP (Hendrick 2009). TDG sensors that did not pass calibration tests were sent back to the manufacture for repair and/or replaced prior to deployment. Suspect or erroneous TDG values were omitted from the analysis, but are included, as well as explanation for omission, in Appendix A of this report.

The data QA/QC issues during the 2016 fish-spill season were related to probe or sensor failures at the Wanapum Dam tailrace FSM stations. Overall data loss for Grant PUD operated FSM stations during the 2016 fish-spill season were 218 hourly readings (<1.5% of the total available data collection hours), which were well within the 90% data completeness/quality objective as specified in the QAPP (Hendrick 2009).

Table 1 displays the number of TDG values that were omitted from the dataset due to QA/QC issues during the 2016 fish-spill season. Appendix B provides detailed information related to data that was omitted due to QA/QC issues.

Table 1 Overview of total dissolved gas data set during 2016 fish-spill season.

Location	Available data collection hours	Number of omitted/lost hourly readings[1]	Percent data loss (%)
WANF	3672	0	0
WANT	3672	218	5.9
PRDF	3672	0	0
PRDT	3672	0	0
Total	14688	218	1.5

Note: WANF = Wanapum forebay, WANT = Wanapum tailrace, PRDF = Priest Rapids forebay, PRDT = Priest Rapids tailrace.

[1]See Appendix B for dates, times, and circumstances relating to omitted/lost data.

3.0 Results

The following sections describe the 2016 fish-spill season flow characteristics compared to the previous ten-year average (2006-2015), the 2016 fish-spill season programs, the fish migration timing compared to fish-spill season durations, and the 2016 biological TDG monitoring results.

3.1 Description of 2016 Fish-Spill Season Flow Characteristics

Mean daily discharge during the 2016 fish-spill season were compared to the ten-year average of mean daily flows from 2006 to 2015 (Figure 4) as measured at the U.S. Geological Survey (USGS) streamflow gage #12472800 located 2.6 RMs downstream of Priest Rapids Dam (USGS 2016). Overall the 2016 mean daily discharges were lower than the 2006–2015 average (~16% lower on average) during the fish-spill season (April 1 through August 31). Mean daily discharge during the mid to late April time period was ~32% higher than the 10-year average. This is directly attributed to Grand Coulee drum gate maintenance operations which requires a higher amount of water be discharged to maintain the elevation needed to perform the maintenance. With the higher than normal discharge coming from upriver, Grant PUD was forced to use inadvertent spill at times when the hydraulic capacity was reached. This time period also coincided with a majority (16 or 17, or 94%) of the TDG exceedances recorded during the 2016 fish-spill season.

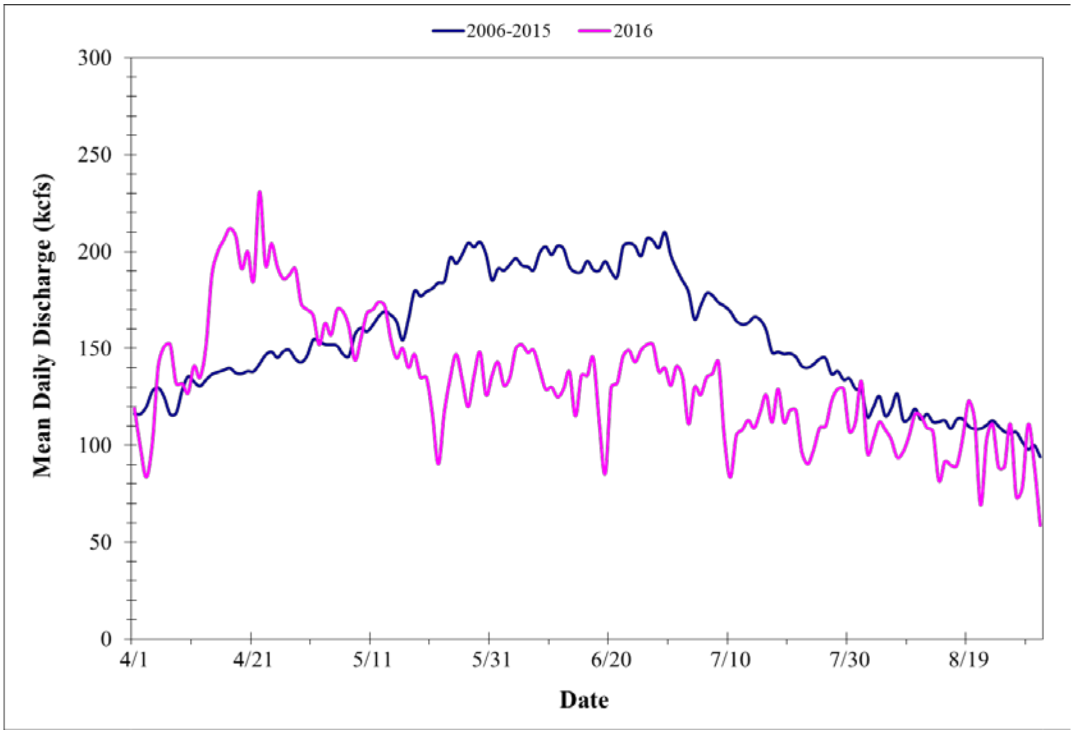

Figure 4 **Comparison of 2016 vs. previous ten-year average of mean daily discharge values as measured at the USGS streamflow gage #12472800 located below Priest Rapids Dam, mid-Columbia River, WA.**

3.2 Fish-Spill Programs

On February 1, 2008 the National Marine Fisheries Service (NMFS) issued a Biological Opinion (Biological Opinion) for the Project. The Biological Opinion includes terms and conditions related to Grant PUD's fish-spill program, and those terms and conditions are incorporated in the FERC license for operation of the Project (FERC 2008). Reasonable and Prudent Alternative (RPA) 1, and associated terms and conditions of the Biological Opinion (NMFS 2008) require Grant PUD to initiate its fish-spill programs before 2.5% of the spring migration period has passed, as documented by the smolt index counts at Rock Island Dam. The spring fish-spill program can conclude when 97.5% 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, as guided by the Priest Rapids Coordinating Committee (PRCC) and the fishway prescription set forth in the Priest Rapids Project Salmon and Steelhead Settlement Agreement (Grant PUD 2006), and continues until 95% of summer outmigrating smolts have passed. Grant PUD also provides limited spill (typically around 2 kcfs) for adult fall-back until November 15, annually.

3.2.1 Wanapum Dam

During the 2016 fish-spill season, Grant PUD implemented the Wanapum Dam spill program as guided by the Biological Opinion and the PRCC, which called for operation of the WFB, designed to safely pass outmigrating smolts, while minimizing TDG uptake. Depending on forebay elevations, the WFB passes up to 22 kcfs. The spillway at Wanapum Dam was operated on an as-needed basis to pass involuntary spill, according to spill patterns designed for the optimal fish-passage safety and as approved by the PRCC.

3.2.2 Priest Rapids Dam

During the 2016 fish-spill season, Grant PUD implemented the Priest Rapids Dam spill program as guided by the Biological Opinion and the PRCC, which called for operation of the PRFB, designed to safely pass outmigrating smolts, while minimizing TDG uptake. Depending on forebay elevations, the PRFB passes up to 24 kcfs. The spillway at Priest Rapids Dam was operated on an as-needed basis to pass involuntary spill, according to spill patterns designed for the optimal fish-passage safety and as approved by the PRCC.

3.3 Fish-Spill Quantities and Duration

Spring fish-spill began at Wanapum Dam on April 12, 2016 at 1000 hours and ended June 14, 2016 at 2359 hours, while spring fish-spill began at Priest Rapids Dam on April 13, 2016 at 1000 hours and ended June 14, 2016 at 2359 hours. Summer fish-spill began on June 15, 2016 at 0000 hours in accordance with the Priest Rapids Project Salmon and Steelhead Agreement (Grant PUD 2006), immediately following the end of the spring fish-spill season and continued through 1700 hours on August 15, 2016 at Wanapum Dam and 1600 hours on August 16, 2016 at Priest Rapids Dam. Table 2 provides a summary of the 2016 fish-spill for both Wanapum and Priest Rapids dams.

Table 2 Summary of 2016 fish-spill operations at Wanapum and Priest Rapids dams. Priest Rapids Project, mid-Columbia River, WA.

Wanapum Dam			
Date	**Spill Program**	**Quantity[1]**	**Purpose**
April 12, 2016	***Spring Spill Initiated***		
April 12-June 14	WFB (Open 24 Hours/Day)	Up to 22 kcfs	RPA 1 and terms and conditions of the Biological Opinion and as guided/approved by the PRCC
June 15, 2016	***End of Spring Spill/ Summer Spill Initiated***		
June 15-Aug 15	WFB (Open 24 Hours/Day)	Up to 22 kcfs	Priest Rapids Project Salmon and Steelhead Settlement Agreement and as guided/approved by the PRCC
August 15, 2016	***End of Summer Spill***		
[1]Actual quantity spilled is dependent on forebay and tailwater elevations.			

Priest Rapids Dam			
Date	**Spill Program**	**Quantity[1]**	**Purpose**
April 13, 2016	***Spring Spill Initiated***		
April 13-June 14	PRFB (Open 24 Hours/Day)	Up to 24 kcfs	RPA 1 and terms and conditions of the Biological Opinion and as guided/approved by the PRCC
June 15, 2016	***End of Spring Spill/ Summer Spill Initiated***		
June 15-Aug 16	PRFB (Open 24 Hours/Day)	Up to 24 kcfs	Priest Rapids Project Salmon and Steelhead Settlement Agreement and as guided/approved by the PRCC
August 16, 2016	***End of Summer Spill***		
[1]Actual quantity spilled is dependent on forebay and tailwater elevations.			

3.4 Biological Evaluations

The following sections provide a summary of fish passage timing results as they relate to the 2016 fish-spill season at Wanapum and Priest Rapids dams and results from gas bubble trauma (GBT) monitoring.

3.4.1 Fish Passage Efficiencies

The fish-spill periods at the Project were very closely matched with the juvenile migration timing (as documented by smolt index counts at Rock Island Dam (FPC 2016)). Figure 5 illustrates that greater than 99% of the yearling spring outmigrants passed during the spring fish-spill period between April 12 and June 14 (FPC 2016). Figure 6 shows that the combined spring and summer fish-spill periods from April 12 through August 16 encompassed greater than 99% of the entire 2016 outmigration (FPC 2016), while Figure 7 shows that greater 99% of the sub-yearling Chinook passed by August 14 (FPC 2015).

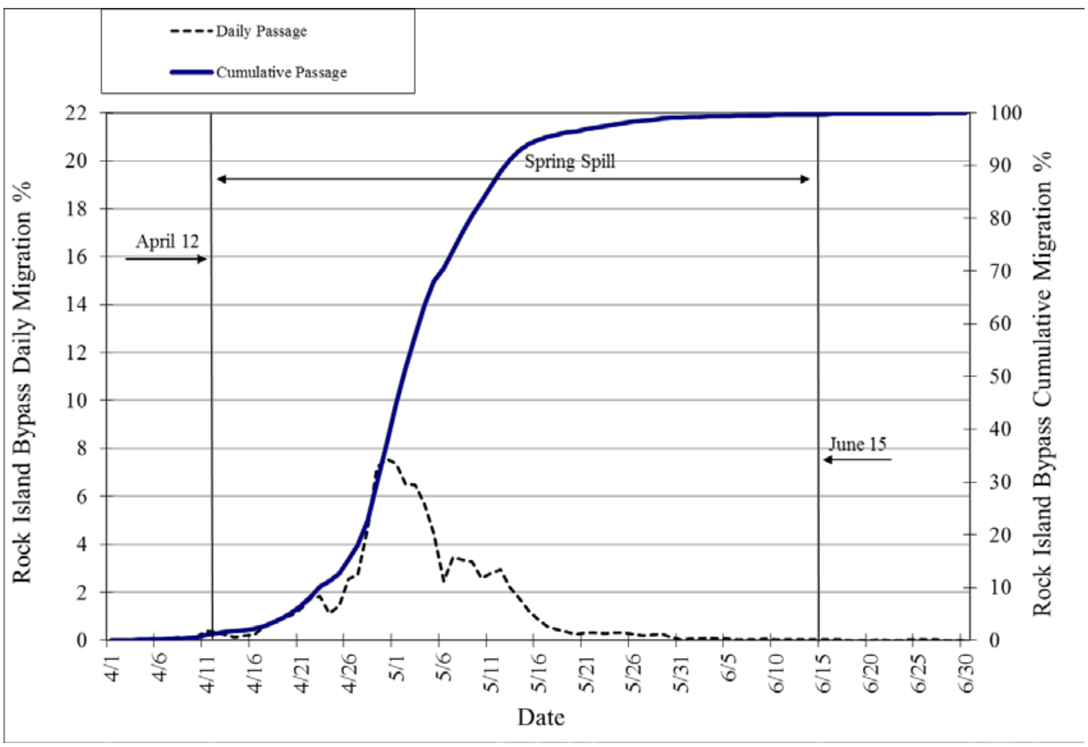

Figure 5 Fish-spill and migration timing for yearling Chinook and steelhead, spring 2016. Priest Rapids Project, mid-Columbia River, WA. Rock Island Bypass Index data courtesy of the Fish Passage Center (2016).

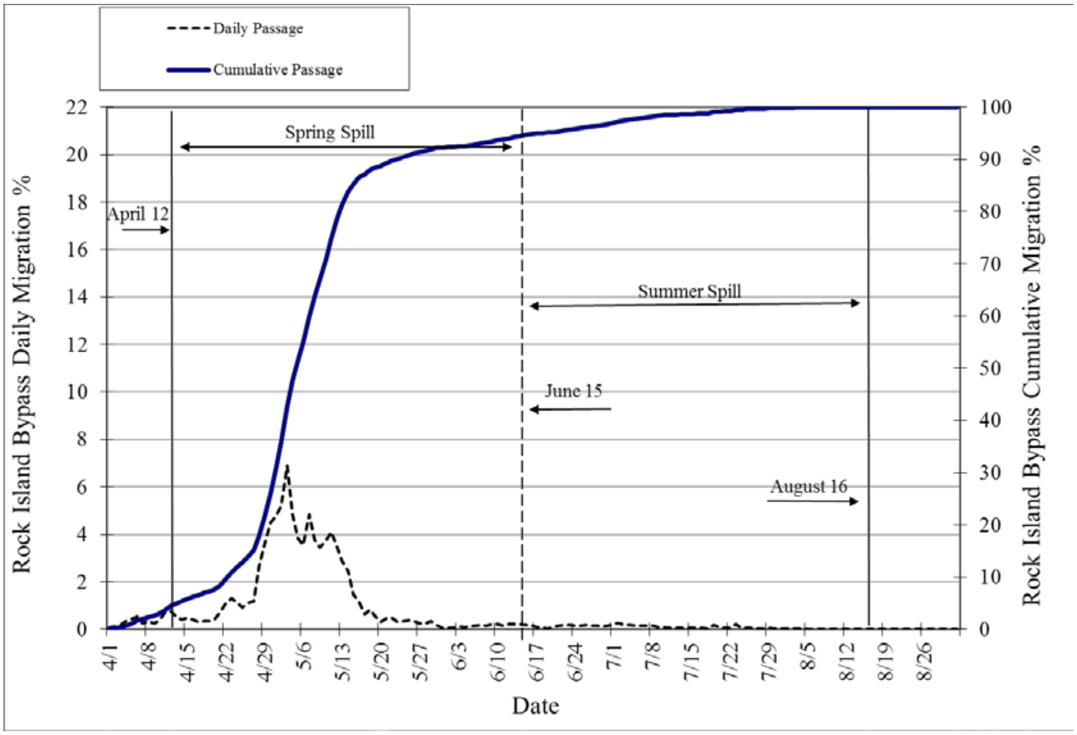

Figure 6 **Fish-spill and migration timing for all species, 2016. Priest Rapids Project, mid-Columbia River, WA. Rock Island Bypass Index data courtesy of the Fish Passage Center (2016).**

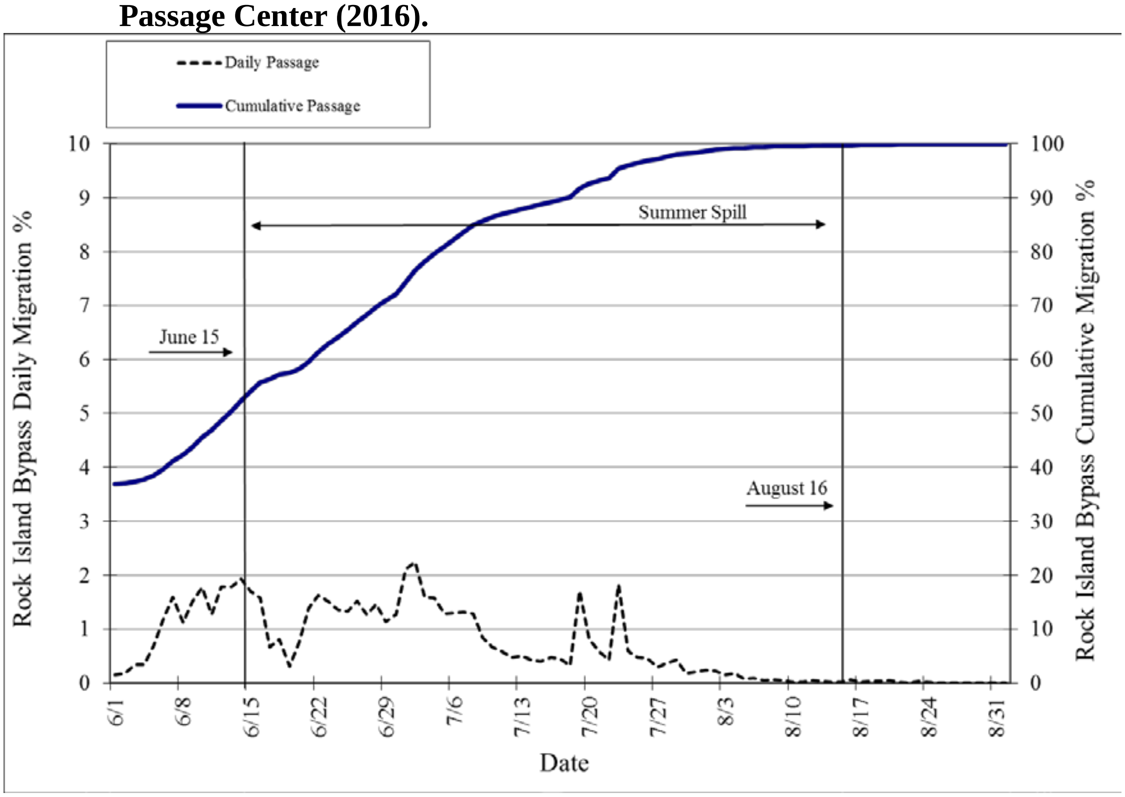

Figure 7 **Fish spill and migration timing for sub-yearling Chinook, summer 2016. Priest Rapids Project, mid-Columbia River, WA. Rock Island Bypass Index data courtesy of the Fish Passage Center (2016).**

3.4.1 Survival and Behavior Evaluation Studies

In 2016, in consultation and coordination with the PRCC, Grant PUD conducted a single species survival and behavior evaluation (using juvenile steelhead) within the Wanapum and Priest Rapids reservoir and at Wanapum and Priest Rapids dam to determine route specific survival (turbine, WFB/PRFB and spillway) and fish passage efficiency (FPE) in relationship to each passage route.

All 2016 survival estimates for the Project are still under development and not ready for distribution at the time of this 2016 TDG/Fish-Spill report.

3.4.2 Gas Bubble Trauma Monitoring

Blue Leaf Environmental (BLE) conducted GBT monitoring under contract of Grant PUD during the 2016 fish-spill season using the Smolt Gas Bubble Trauma Examination Protocol, developed by the Fish Passage Center (FPC; FPC 2009). This protocol has been used extensively throughout the Columbia and Snake River basins to standardize GBT examination practice by participating agencies within the Pacific Northwest. The principal objective was 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 passed through the collection facilities at either Priest Rapids or Wanapum dams.

During the 2016 fish-spill season, 1,197 smolts were examined for GBT, with six exhibiting signs of GBT, or approximately 0.5% of the total smolts sampled. According to the FPC (FPC 2009), a rank is assigned based upon the percent area of the fin or eye covered with bubbles. A rank 0 is assigned if no bubbles occur; rank 1 is assigned if 1-5% of the fin or eye is covered with bubbles; rank 2 is assigned for 6-25% area covered; rank 3 for 25-50% area covered; and rank 4 for >50% area covered. All of the smolts that had symptoms of GBT during the 2016 season received a rank of one.

Table 3 below provides a summary of the results of GBT monitoring during the 2016 fish-spill season recorded at either Priest Rapids or Wanapum dam.

Table 3 Gas bubble trauma monitoring results from either Priest Rapids or Wanapum dam in 2016. Priest Rapids Project, mid-Columbia River, WA.

		Number of fish with GBT Signs				
Species	Number of fish sampled	Rank 1	Rank 2	Rank 3	Rank 4	Total
Chinook	1,008	3	0	0	0	3
Steelhead	189	3	0	0	0	3
Total	***1,197***	***6***	0	0	0	***6***

3.5 Total Dissolved Gas Monitoring

The following sections discuss the results of TDG monitoring from the 2016 fish-spill season within the Project and at the Pasco compliance point location. Summary values for all hourly TDG measurements taken from each FSM station during the 2016 fish-spill season are presented in Table 4 below.

Table 4 Summary of hourly total dissolved gas measurements from each fixed-site monitor station (FSM station) during the 2016 fish-spill season. Priest Rapids Project, mid-Columbia River, WA.

Location	Data Interval	Mean	Standard Deviation	Minimum	Maximum
WANF	04/1 – 08/31	108.9	3.7	96.2	122.7
WANT	04/1 – 08/31	110.5	3.7	97.0	126.9
PRDF	04/1 – 08/31	109.6	3.1	101.1	124.8
PRDT	04/1 – 08/31	111.4	3.9	101.5	121.7
PASCO	04/1 – 08/31	107.9	3.2	97.0	117.6

Notes:
All values represent %SAT.
WANF = Wanapum forebay, WANT = Wanapum tailrace, PRDF = Priest Rapids forebay, PRDT = Priest Rapids tailrace, PASCO = Pasco Fixed-Site Monitoring Station located upstream of McNary Dam (next downstream forebay), operated by the US Army Corps of Engineers.

3.5.1 Total Dissolved Gas Averages during the Fish-Spill Season

Figure 8 through Figure 12 displays the average of the 12-highest consecutive hourly readings from each 24-hour period during the fish-spill season from each FSM station, except for days when there was no data available due to sensor membrane failure (see Sections 1.2.1 and 2.0). The average of the 12-highest consecutive hourly TDG readings from each day during the spring and summer fish-spill seasons from each FSM station, including explanation of possible causes of TDG exceedances and corrective actions taken to reduce elevated TDG levels are presented in Appendix C of this report.

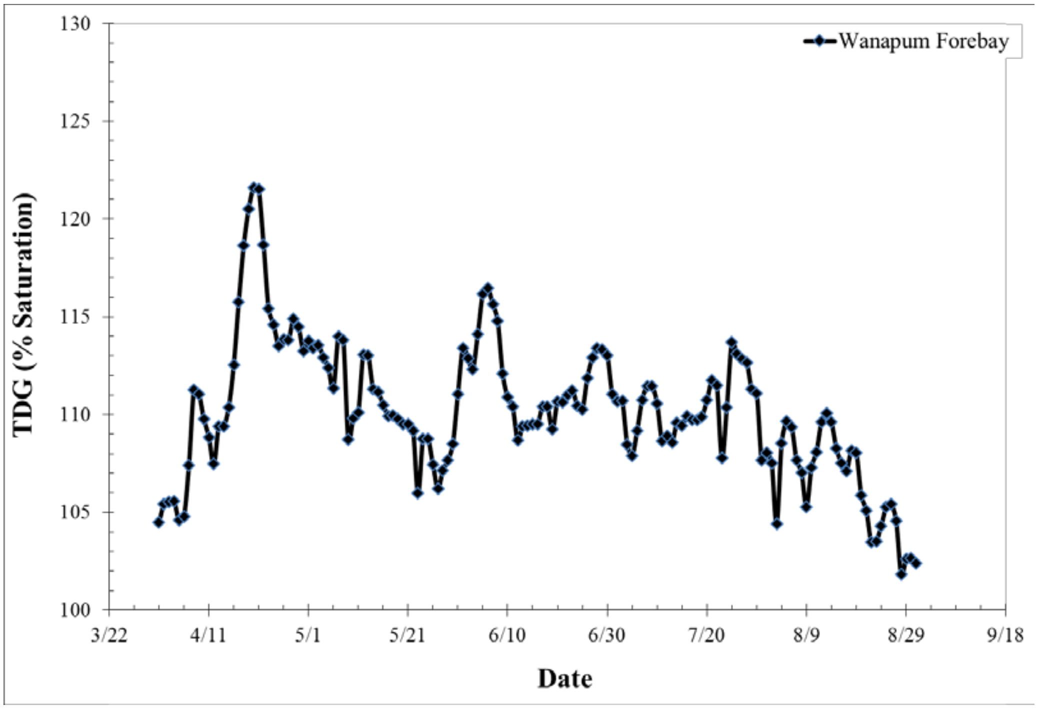

Figure 8 **Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2016 fish-spill season recorded at the Wanapum Dam forebay FSM station. Priest Rapids Project, mid-Columbia River, WA.**

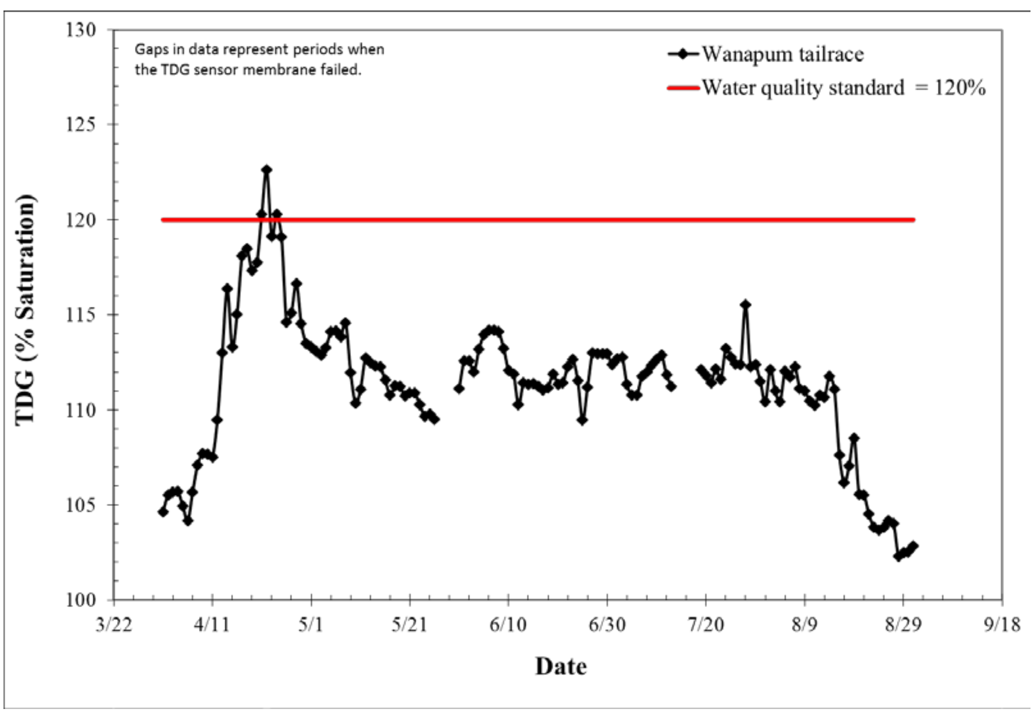

Figure 9 **Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2016 fish-spill season recorded at the Wanapum Dam tailrace FSM station. Priest Rapids Project, mid-Columbia River, WA.**

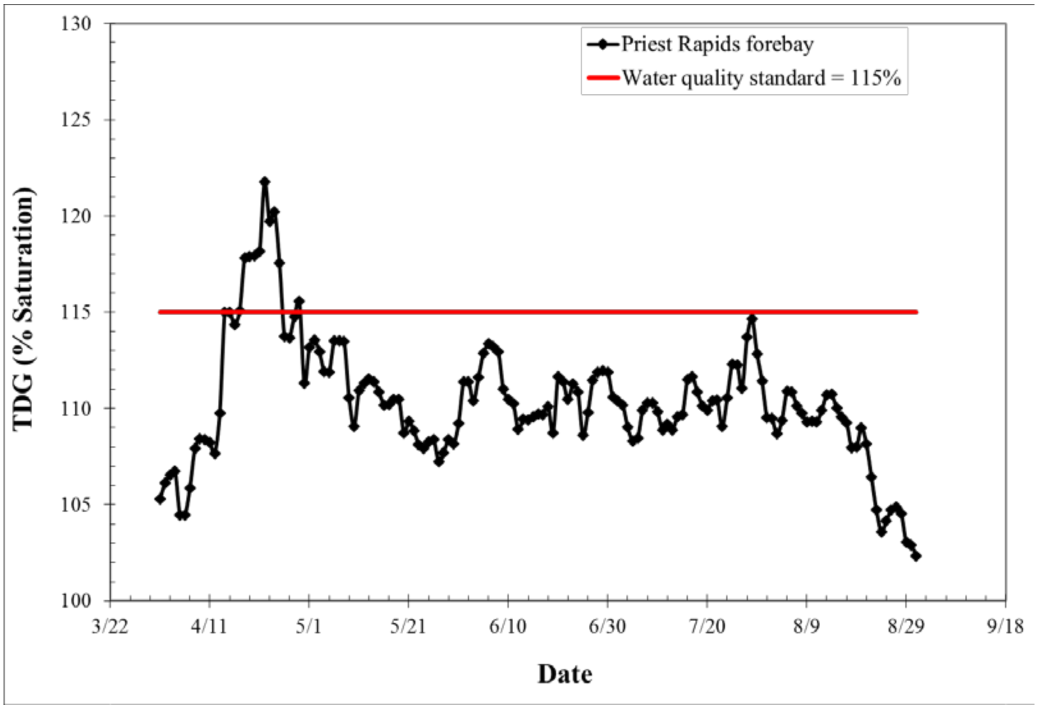

Figure 10 Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2016 fish-spill season recorded at the Priest Rapids Dam forebay FSM station. Priest Rapids Project, mid-Columbia River, WA.

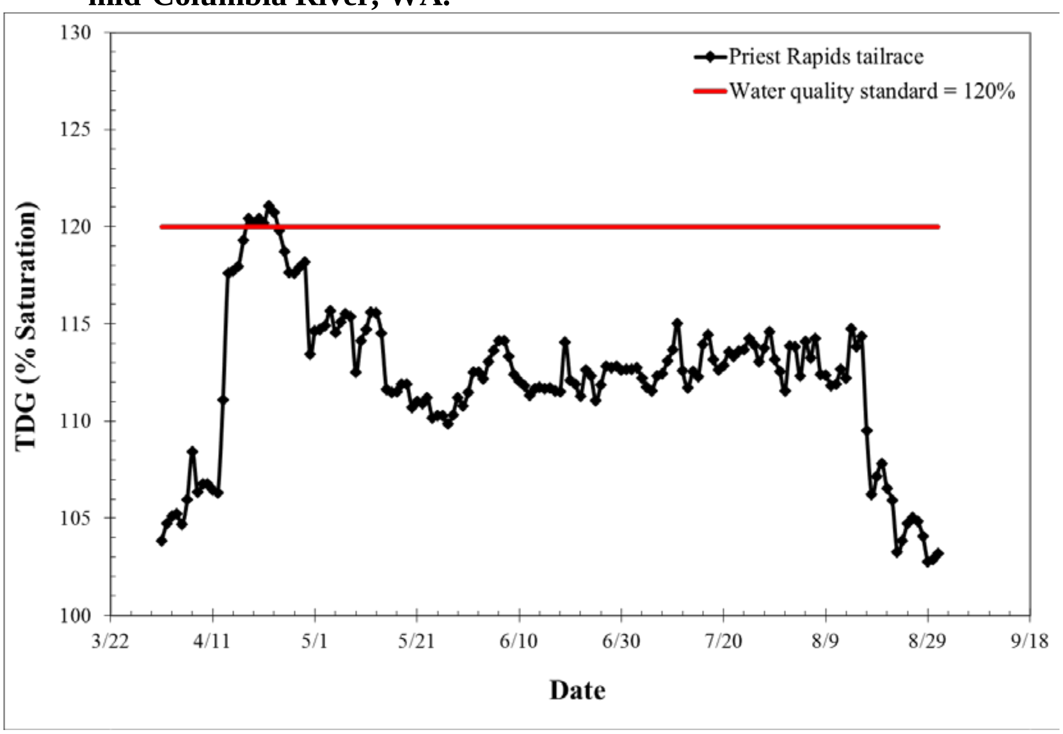

Figure 11 Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2016 fish-spill season recorded at the Priest Rapids Dam tailrace FSM station. Priest Rapids Project, mid-Columbia River, WA.

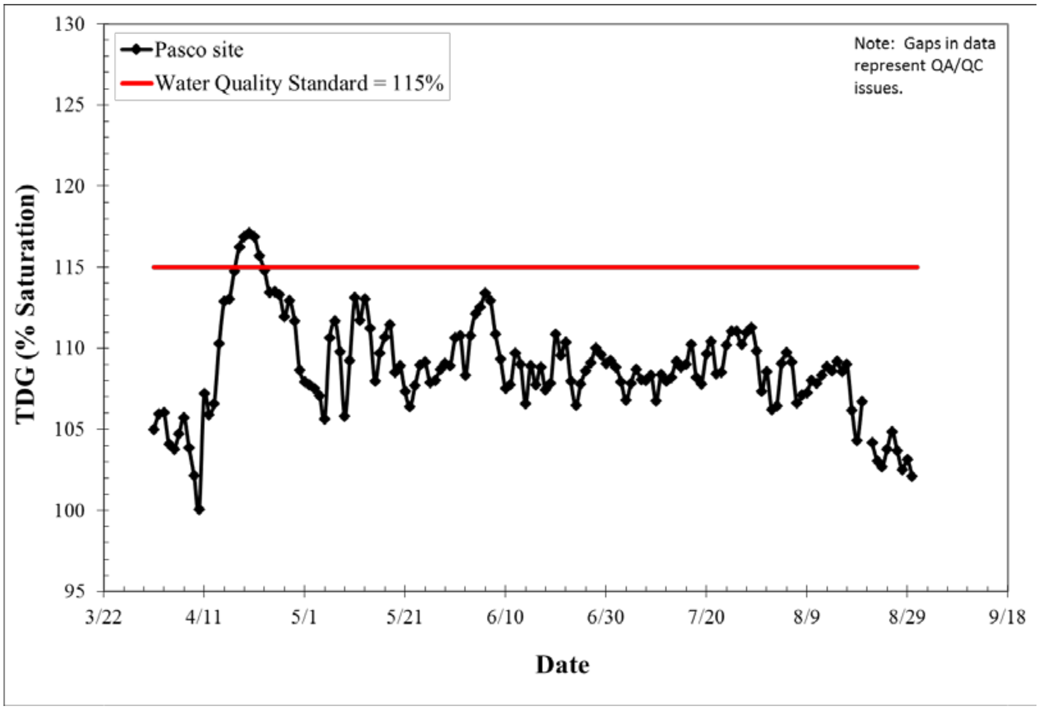

Figure 12 Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2016 fish-spill season recorded at the McNary forebay (Pasco site), mid-Columbia River, WA.

3.5.2 Total Dissolved Gas Exceedances

Table 5 displays the total number of times TDG levels exceeded the current water quality standards during the 2016 fish-spill season as measured at each of Grant PUD's FSM stations along with the Pasco compliance point (owned/operated by the Corps). Appendix A within this report presents all omitted data with explanations of why they were omitted.

Table 5 Number of 2016 fish-spill season total dissolved gas exceedances. Priest Rapids Project, mid-Columbia River, WA.

	Number of 115 %SAT/120 %SAT exceedances					Number of 125 %SAT exceedances		
Location[1]	Spring Spill	Summer Spill	Total	Total # of days[2]	% above standard	Total	Total # of hrs[2]	% above standard
WANT	1	0	1	144	<1%	0	3531	0%
PRDF	9	0	9	153	5.9%	0	3672	0%
PRDT	2	0	2	153	1.3%	0	3672	0%
PASCO	5	0	5	151	3.3%	0	3139	0%
Total	17	0	17	601	2.8%	0	14014	0%

[1]WANT = Wanapum tailrace, PRDF = Priest Rapids forebay, PRDT = Priest Rapids tailrace, PASCO = Pasco Fixed Site Monitor located upstream of McNary Dam (next downstream forebay), operated by the US Army Corps of Engineers.
[2]Based on total number of available days/hrs minus days/hrs omitted due to TDG membrane failures or other QA/QC issues.

Exceedances of the TDG standards were minimal during the 2016 fish-spill season, with a total of 17 exceedances (based on daily average of the 12-highest consecutive hourly readings), all of which occurred during the late April high flow event that is was shown in Figure 4 (and see also Section 3.5.3 below). There were no exceedances of the 1-hour 125 %SAT standard. The Priest Rapids forebay fixed-site monitoring station (FSM station) accounted for the majority of TDG exceedances (9 of 17), all of which can be attributed to river flow in excess of Wanapum Dam's current hydraulic capacity (~163 kcfs). When flows were above Wanapum Dam's hydraulic capacity, involuntary spill was required that contributed to elevated TDG levels, and because of the short distance between Wanapum and Priest Rapids dams (18 river miles (RM)), TDG levels did not have a chance to dissipate below the 115 %SAT by the time they reached the Priest Rapids Dam forebay FSM station. Additionally, of the nine exceedances recorded at the Priest Rapids Dam forebay FSM station, five (56%) corresponded with incoming TDG levels 115 %SAT or above recorded during the same time period at the Wanapum Dam forebay FSM station (see Figure 13). Furthermore, river flows during these TDG exceedance events were approximately 32% above the 10-year average because of drum gate maintenance operations at Grand Coulee Dam, which attributed to the inadvertent spill events within the Project (see Figure 4).

More specifics on exceedances and factors for the corresponding exceedance for the 2016 fish-spill season can be found in Appendix C of this report.

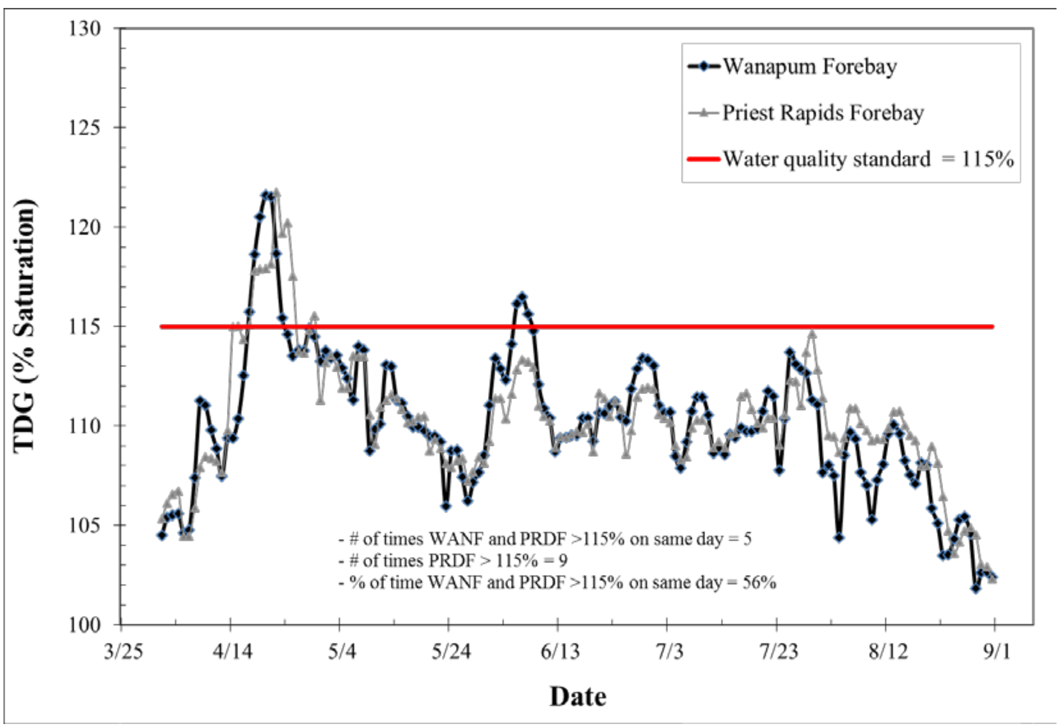

Figure 13 Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in 24-hour period) from the 2016 fish-spill season recorded at the Wanapum Dam forebay FSM station and the Priest Rapids Dam forebay FSM station. Priest Rapids Project, mid-Columbia River, WA.

3.5.3 Total Dissolved Gas and Involuntary Spill

Figure 14 and Figure 15, and Table 6 show that mean daily flow values recorded at Wanapum Dam exceeded the current Wanapum Dam Powerhouse capacity of 141 kcfs 44% of the time over the entire fish-spill season. In addition, mean daily flow values recorded at Wanapum Dam were in excess of the current Wanapum Dam Powerhouse capacity plus voluntary (fish-spill) amounts (~163 kcfs) 17% of the time during the entire fish-spill season. As a result of higher flows in the mid-late April time frame, which were above Wanapum Dam's current hydraulic capacity (163 kcfs) involuntary spill was required for part of the fish-spill season, and all of the TDG exceedances occurred during these periods of involuntary spill (see Figures 14 and 15).

Table 6 Amount of time mean daily flow values exceeded Wanapum Dam's powerhouse capacity and/or powerhouse capacity plus fish-spill amounts. Priest Rapids Project, mid-Columbia River, WA.

Season (total # of days)	Number of days >141[1]	Percent of days >141	Number of days >163[2]	Percent of days >163
Spring Spill (75)	54	72%	26	35%
Summer Spill (78)	14	18%	0	0%
Entire Season (153)	68	44%	26	17%

Notes:
[1]The current powerhouse capacity at Wanapum Dam is limited to 141 kcfs during the fish spill season.
[2]Fish-spill amounts at Wanapum Dam during the 2016 fish-spill season were up to 22 kcfs, therefore powerhouse capacity plus fish-spill amounts were equal to ~163 kcfs.

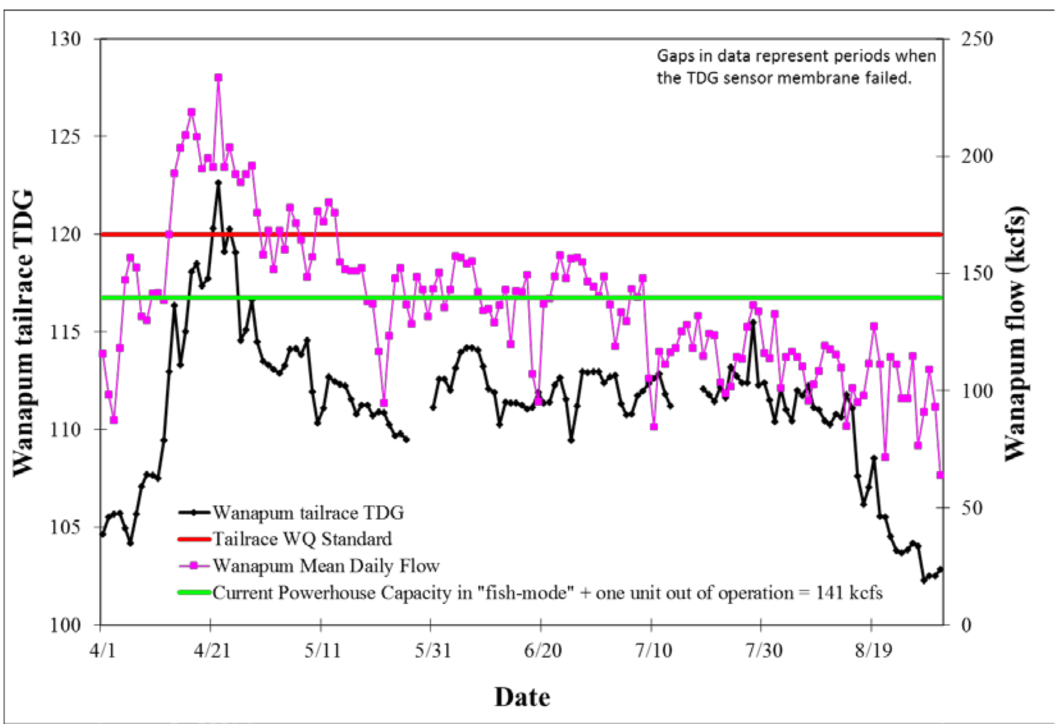

Figure 14 Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2016 fish-spill season recorded at the Wanapum Dam tailrace FSM station vs. Wanapum Dam mean daily flow values. Priest Rapids Project, mid-Columbia River, WA.

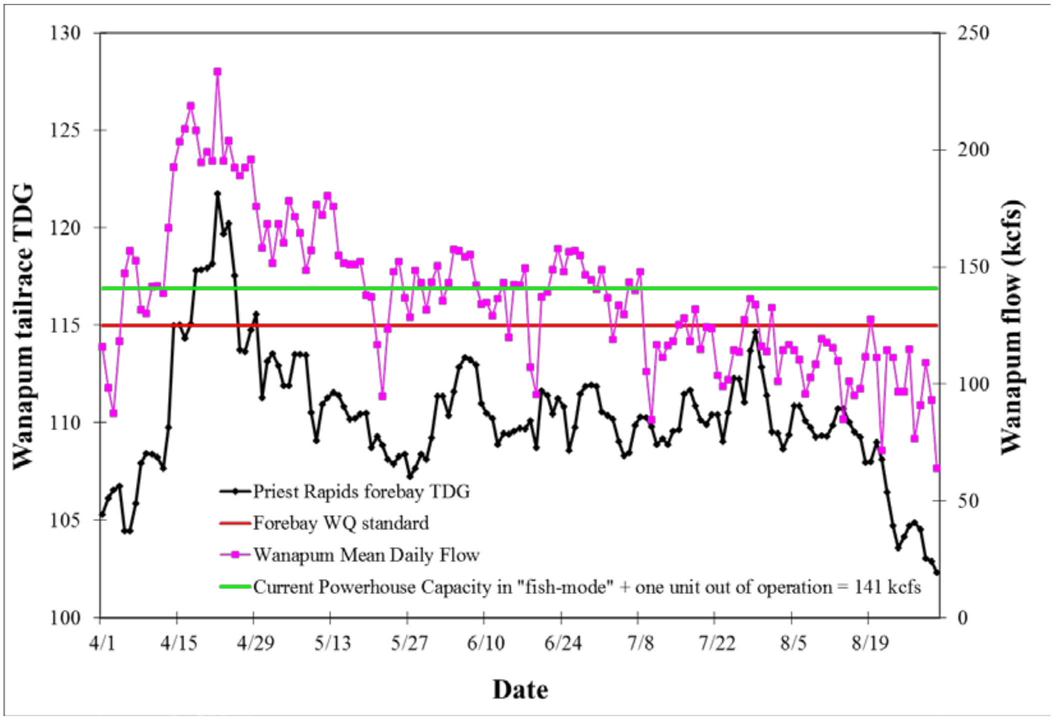

Figure 15 Total dissolved gas measurements (average of the 12-highest consecutive hourly TDG readings in a 24-hour period) from the 2016 fish-spill season recorded at the Priest Rapids Dam forebay FSM station vs. Wanapum Dam mean daily flow values. Priest Rapids Project, mid-Columbia River, WA.

Because all of the TDG exceedances during the 2016 fish-spill season occurred when mean daily flows exceeded powerhouse capacities, modifications to the fish-spill program were not a feasible TDG reduction option. Note that Grant PUD is also limited to how “full” it can run its powerhouse due to regional and federal constraints, and thus in general the combination of both Wanapum and Priest Rapids dams are limited to 85% of their full capacity (Section 4.1 provides additional detail). When possible, Grant PUD attempted to maximize powerhouse discharge (up to the aforementioned 85% capacity) and minimize involuntary spill, and Section 4.1 below provides a summary of the TDG abatement measures taken during the 2016 fish-spill season.

The dates of each TDG exceedance and the corrective measures taken to reduce the elevated values are shown in Appendix C.

4.0 Total Dissolved Gas Abatement Measures

The following sections describe some of the TDG abatement measures that Grant PUD undertook during the 2016 fish-spill season, as well as those it intends to take in the future as part of its WDOE-approved Gas Abatement Plan (GAP; Keeler 2016).

4.1 Total Dissolved Gas Abatement Measures in 2016

During the 2016 fish-spill season, Grant PUD continued to implement TDG abatement measures per its GAP (Keeler 2016), including the following:

Operational measures that were implemented, when feasible, to minimize involuntary spill and the TDG impacts associated with involuntary spill included:

- Attempting to maximize turbine flows by setting minimum generation requirements, this included establishing a common methodology for setting minimum generation requirements specific to Wanapum and Priest Rapids dam for the management of TDG. Each dam's minimum generation requirements were then allocated to power purchasers that receive a percentage of the projects' output.

  It is important to note that while attempting to maximize powerhouse flows, there are other regional constraints and considerations, as well as federal requirements that limit Grant PUD's ability to maximize powerhouse flows to 100% of its capacity. These constraints, considerations, and requirements include, but are not limited to:

  1. Variable market conditions, which can change rapidly and impact Grant PUD's ability to sell energy that will maximize powerhouse discharge.
  2. Variable incoming flow estimates (which is used, in part, to guide energy sales), which can change rapidly based on upstream project operational decisions and can impact Grant PUD's ability to maximize powerhouse discharge. For example if a given incoming flow estimate provided by upstream operators is changed, operators of projects below must attempt to account for the additional water that was not anticipated and based on the variable market conditions described above, can limit Grant PUD's ability to maximize powerhouse discharge.
  3. Regional renewable energy portfolio standards and federal tax incentives have stimulated investment in variable energy resources. The Pacific Northwest has the highest wind production capacity in the country, 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.
  4. Requirements for Grant PUD to maintain "operating reserves", which requires that Grant PUD hold up to 7% of its powerhouse capacity in reserve to respond to changes to system load and Northwest Power Pool reserve sharing group obligations.

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

- Participation in regional spill/project operation meeting on March 23, 2016. This meeting brought together representatives from Natural Resources, Marketing, and Operations from Chelan, Douglas, and Grant PUDs, as well as representatives from Bonneville Power Association (BPA) and the Corps. Discussions included topics such as:
  - Each project's operational limitations, competing regulations, fish studies, and/or other natural resources requirements (e.g. Hanford Reach fall Chinook flow protection requirements).
  - Each project's planned maintenance schedules and how it may limit ability to spill water through spillways and/or pass water through turbine units.

- Grant PUD Natural Resources Department participation in Grant PUD operational and power management scheduling meetings, which allowed Grant PUD staff with expertise in TDG management to provide input to operational planning decisions (e.g. request for turbine outages, power and river flow forecasting and subsequent operational strategy decisions, etc.).
- Preemptive spill was used as feasible to coordinate spill sought to manage both the spill rate and the forebay elevation for better TDG management. For example, 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 was 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.

4.2 Future Total Dissolved Gas Abatement Measures

Per requirements contained in the 401 WQC, Grant PUD's GAP will be updated annually to reflect any changes in implementation schedules, new or improved technologies, or new TDG abatement measures. The 2017 draft GAP provides a summary of the proposed operational and structural abatement measures that Grant PUD plans to implement for the 2017 fish-spill season (Keeler 2016). Operational abatement measures include minimizing involuntary spill by scheduling maintenance operations based on predicted flows and active participation in regional coordination efforts to help combat involuntary spill. In addition, Grant PUD plans to 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 PRCC. Finally, Grant PUD plans to continue implementation of the TDG abatement measures described in Section 4.1 above that were conducted in 2016, including attempting to maximize turbine flows by setting minimum generation requirements, participation in regional spill/project operation meetings, and continuing to preemptively spill based on anticipated high flow/low power load time periods. Structural abatement measures have been completed and include the WFB, the PRFB, and the advanced hydropower turbines at Wanapum Dam.

TDG compliance monitoring will continue at Grant PUD's FSM stations. TDG and water temperature 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.grantpud.org/environment/water-quality/monitoring-data). An annual report to WDOE will summarize Grant PUD's TDG monitoring and fish-spill season results.

5.0 Conclusions

During the 2016 fish-spill season, all TDG exceedances occurred when river flow volumes were greater than the hydraulic capacity at Wanapum Dam (see Figure 15, and Table 7), which resulted in involuntary spill. Grant PUD implemented abatement measures intended to help moderate high TDG levels (see Section 4.1), including attempting to maximize powerhouse flows (up to its capacity that is available after accounting for regional and federal constraints) and reducing involuntary spill by selling power at reduced costs, participating in regional efforts to reduce TDG at each mid-Columbia River dam, and closely monitoring TDG and incoming flows.

As described in Section 4.0 and in the 2017 draft GAP (Keeler 2016), continuing and upcoming TDG abatement measures will be implemented by Grant PUD over the next two years (as part of the ten-year compliance schedule that began in 2008) to mitigate for elevated TDG values that may occur during the fish-spill season.

Grant PUD will continue to closely monitor TDG levels during the fish-spill season in accordance with the QAPP (Hendrick 2009), and will develop its spill programs in accordance with current TDG water quality criteria as set by WDOE, adjusting spill percentages as needed to comply with current TDG standards.

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Appendix A
Data omitted from the 2016 fixed-site monitoring total dissolved gas dataset because of QA/QC issues (Table A-1)

Table A-1 Hourly data points/sections omitted from the fixed site monitoring total dissolved monitoring dataset

Location	Date(s)	hr(s)	Problem/reason for omission	Comments/action taken to correct problem
WANT	7/13-7/19	1900-0700	Faulty TDG membrane	Replaced probe
PASCO	8/21-8/22	2000-1100	Faulty TDG membrane	Replaced probe
Note: WANT = Wanapum tailrace, PASCO = Pasco Fixed Site Monitoring Station, operated by the U.S. Army Corps of Engineers.				

Appendix B
2016 Fish-Spill Season Memoranda

Grant County
PUBLIC UTILITY DISTRICT
Innovation & Excellence...Yesterday, Today and Tomorrow

MEMORANDUM

April 11, 2016

TO: Dispatch
Wanapum Dam Control Room
Priest Rapids Dam Control Room
Planning and Scheduling

VIA: Tom Dresser, Fish, Wildlife, and Water Quality Manager

FROM: Curt Dotson

Purpose: Start of 2016 Spring Fish-Spill

Background: On April 17, 2008 FERC issued a new 44 year license to the Public Utility District No. 2 of Grant County (Grant PUD) for the operation of the Priest Rapids Project (Project No. 2114-116). Incorporated into this license are the fishway prescriptions set forth in the Biological Opinion that National Marine Fisheries Service (NOAA Fisheries) issued to Grant PUD on February 1, 2008.

Under Section 2.9.6 (Terms and Conditions) of the Biological Opinion, Action 1.5 states that the primary juvenile salmonid passage at Wanapum Dam will be 20 kcfs spill through the Wanapum Future Unit Fish Bypass (WFB) and that spill will commence before more than 2.5 percent of the spring migration have passed. Action 1.8, under that same Section, states that the Wanapum turbines will be operated in "fish mode" for 95 percent of the juvenile spring migration, and that turbine operation in "fish mode" will commence before 2.5 percent of the spring migrants have passed.

For juvenile fish passage at Priest Rapids Dam, Section 2.9.6, Action 1.12 states that the primary juvenile salmonid passage can be through an alternative top-spill facility; this is the Priest Rapids Fish Bypass (TG 20-22). This spill will also commence before 2.5 percent of the spring migrants have passed Priest Rapids Dam. Action 1.16 states that the Priest Rapids turbines will be operated in "fish mode" for 95 percent of the juvenile spring migration, and that turbine operation in "fish mode" will also commence before 2.5 percent of the spring migrants have passed the dam.

Discussion: The Rock Island Dam smolt index numbers indicate that the spring out-migration has begun. Based on the Biological Opinion, spring fish-spill at Wanapum and Priest Rapids dams will commence as indicated below and continue until further notice.

Fish Spill at Wanapum and Priest Rapids Dams:

Hydro Project	Start Date	Start Time	Spill Rate	Duration
Wanapum Dam	April 12, 2016	1000 hrs.	Wanapum Fish Bypass – 20 kcfs	24 hours/day
Priest Rapids Dam	April 13, 2016	1000 hrs.	PR Fish Bypass (Bays 20-22)	24 hours/day

In the case of any inadvertent spill (excess of powerhouse capacity) is needed at Wanapum Dam, that spill shall be discharged through the spill bay(s) as indicated in the "2016 Wanapum Dam Inadvertent Spill Pattern during Fish Spill" spread sheet.

In case of any inadvertent spill needed at Priest Rapids Dam, please follow the inadvertent spill pattern give in the "2016 Priest Rapids Dam Inadvertent Spill Pattern during Fish Spill".

Operation of the Wanapum and Priest Rapids turbines in "Fish-Mode" will commence on the same date and at the same time that "fish-spill" starts for each associated dam. For a listing of unit priority of turbine operations, please refer to the "First On / Last Off" List that was sent to each of the associated control rooms.

The Fish-Spill Representatives will monitor TDG levels and make spill changes to ensure TDG levels remain within Washington Department of Ecology's water standards.

Please give Curt Dotson a call (509-750-1999) if you have any questions.

Grant County
PUBLIC UTILITY DISTRICT
Innovation & Excellence...Yesterday, Today and Tomorrow

MEMORANDUM

June 13, 2016

TO: Dispatch
Wanapum Dam Control Room
Priest Rapids Dam Control Room
Planning and Scheduling

VIA: Tom Dresser, Fish, Wildlife, and Water Quality Manager

FROM: Curt Dotson, Fisheries Project Specialist

Purpose: Start of 2016 Summer Fish Spill

Background: On April 17, 2008 FERC issued a new 44 year license to the Public Utility District No. 2 of Grant County (Grant PUD) for the operation of the Priest Rapids Project (Project No. 2114-116). Incorporated into this license are the fishway prescriptions set forth in the Priest Rapids Salmon and Steelhead Settlement Agreement (SSA) that Grant PUD entered into with Governmental and Tribal (Fishery) Parties on February 10, 2006. This document addresses summer fish spill (Section 9.3) by establishing spill levels that are intended to pass 95% of the summer juvenile migrants (fall and summer Chinook). This calls for 49% summer spill at Wanapum Dam and 39% summer spill at Priest Rapids Dam. The summer migration season begins when summer/fall Chinook smolts are present in the river or June 15th, whichever occurs first. The Priest Rapids Salmon and Steelhead Settlement Agreement also provided the latitude for Grant PUD, in consultation with the PRCC, to implement operational measures for the Project to protect that portion of the run that passes the Project in order to improve downstream passage survival at the Project and contribute to achieving the overall no net impact (NNI) objective for summer/fall Chinook in the program area.

Action 9 & 18 of the SSA states that the Wanapum and Priest Rapids turbines will be operated in “fish mode” for the juvenile migration. Action 13 allows Grant PUD to evaluate alternative top-spill concepts for juvenile fish passage at Priest Rapids Dam.

Discussion: At Wanapum Dam, Spring Fish Spill will continue until 2359 hr. of June 14th, 2016 at which time Summer Fish Spill will begin. The 2016 Summer Fish Spill program for Wanapum Dam will be the same as the 2016 Wanapum Spring Fish Spill program – operation of the Wanapum Fish Bypass (WFB) and the Wanapum powerhouse operating within the Fish-Mode Program.

At Priest Rapids Dam, Spring Fish Spill will continue until 2359 hr. of June 15th, 2016 at which time Summer Fish Spill will begin. The 2016 Summer Fish Spill program for Priest Rapids Dam will be the same as the 2016 Priest Rapids Spring Fish Spill program – operation of the Priest Rapids Fish Bypass (TG 20-22) and the Priest Rapids powerhouse operating within the Fish-Mode Program.

Fish Spill at Wanapum and Priest Rapids Dams:

Hydro Project	Start Date	Start Time	Spill Rate	Duration
Wanapum Dam	June 14, 2015	2359 hrs.	WFB	24 hours/day
Priest Rapids Dam	June 15, 2015	2359 hrs.	PRFB (TG 20-22)	24 hours/day

Wanapum Dam should follow the spill pattern titled, "2016 Wanapum Dam Spill Gate Operations for Inadvertent Spill during Fish Spill" if inadvertent spill is needed.

Priest Rapids Dam should follow the spill pattern titled "Inadvertent Spill Pattern 2016 Priest Rapids Dam", if inadvertent spill is needed.

Operation of the Wanapum and Priest Rapids turbines in "Fish-Mode" will commence at the same date and time that "Summer Fish Spill" starts for each associated dam.

The Fish Spill Representatives will monitor TDG levels and make spill changes to ensure TDG levels remain within Washington Department of Ecology's water standards.

Please give Curt Dotson a call (509-750-1999) if you have any questions.

Grant County
PUBLIC UTILITY DISTRICT
Innovation & Excellence... Yesterday, Today and Tomorrow

MEMORANDUM August 15, 2016

TO: Grant Dispatch
Wanapum Dam Control Room
Priest Rapids Dam Control Room

VIA: Tom Dresser, Fish, Wildlife, and Water Quality Manager

FROM: Curt Dotson, Fisheries Project Specialist

Purpose: 2016 Summer Fish Spill - Ending

Discussion: The 2016 Summer Fish Spill Program began at Wanapum and Priest Rapids dams on June 14 (at 2359 hr), immediately following the end of spring fish spill. The 2016 Summer Fish Spill program for Wanapum Dam was the same as the 2016 Wanapum Spring Fish Spill program – operation of the Wanapum Fish Bypass (WFB). The 2016 Summer Fish Spill program for Priest Rapids Dam was the same as the 2016 Priest Rapids Spring Fish Spill program – operation of Priest Rapids Fish Bypass (bays 22, 21, & 20) 24/7.

The Priest Rapids Project Salmon and Steelhead Settlement Agreement states that '....*summer spill ends after 95% of the summer and fall Chinook juvenile migrants have passed Wanapum and Priest Rapids dams.*'

Summer fish-spill at Wanapum Dam will end on August 15, 2016 at 1700 hr. and at Priest Rapids Dam on August 16, 2016 at 1600 hr.

For adult fall-back, the ice/trash sluiceway at Wanapum will be opened and remain open to pass water 24/7, until November 15, 2016. For adult fall-back operations at Priest Rapids Dam, the ice/trash sluice gate at bay 22 will be opened to the full-open position and pass water 24/7 until November 15, 2016. Operation of the Wanapum and Priest Rapids turbines have been in "fish mode" for the duration of the summer fish-spill season, and upon reaching the respected date and time for each dam's "end of summer fish-spill", those turbines may return to standard turbine operations.

Conclusion: Based upon agreed criteria and in-season information, Grant PUD, in consultation with the PRCC fish-spill representatives, believes that the goal of assuring fish spill through 95% of the summer juvenile salmon out-migration through the Priest Rapids Project has been achieved. Therefore, Grant PUD will end summer fish spill at

1700 hr. on August 15, 2016 at Wanapum Dam and at 1600 hr. on August 16, 2016 at Priest Rapids Dam (Table 1).

Table 1. Fish Spill at Wanapum and Priest Rapids Dams.

Hydro Project	Start Date	Start Time	Spill Rate	Duration
Wanapum Dam	August 15, 2016	1700 hr.	Sluice gate open	24 hours/day.
Priest Rapids Dam	August 16, 2016	1600 hr.	Sluice gate open	24 hours/day

The Wanapum and the Priest Rapids dams' sluice gate will remain fully opened until November 15, 2016 to provide a fall-back route for adult salmonids.

Please call Curt Dotson if you have any questions (509-750-1999).

Appendix C
Daily averages of the 12-highest hourly total dissolved gas readings during the 2016 fish-spill season

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
1-Apr	104.5	104.6	105.3	103.9	103.9	
2-Apr	105.4	105.5	106.1	104.7	105.0	
3-Apr	105.5	105.7	106.6	105.1	106.0	
4-Apr	105.6	105.7	106.7	105.2	106.0	
5-Apr	104.6	105.0	104.5	104.7	104.1	
6-Apr	104.8	104.2	104.5	106.0	103.8	
7-Apr	107.4	105.7	105.9	108.4	104.7	
8-Apr	111.3	107.1	107.9	106.3	105.7	
9-Apr	111.0	107.7	108.4	106.8	103.9	
10-Apr	109.8	107.7	108.4	106.8	102.1	
11-Apr	108.8	107.5	108.2	106.5	100.1	
12-Apr	107.5	109.5	107.7	106.3	107.2	
13-Apr	109.4	113.0	109.8	111.1	105.9	
14-Apr	109.4	116.4	115.0	117.6	106.6	
15-Apr	110.4	113.3	115.0	117.7	110.3	
16-Apr	112.5	115.0	114.3	117.9	112.9	
17-Apr	**115.7**	118.1	115.1	119.3	113.0	High incoming flows into the system (Grand Coulee Dam drum gate maintenance operations); powerhouse flows increased so that powerhouse was operating at 85% capacity. Flows in excess of hydraulic capacity, inadvertent spill was warranted.
18-Apr	**118.6**	118.5	**117.8**	120.4	114.8	
19-Apr	**120.5**	117.3	**117.9**	120.2	**116.3**	
20-Apr	**121.6**	117.7	**117.9**	120.4	**116.9**	
21-Apr	**121.5**	120.3	**118.2**	120.2	**117.1**	
22-Apr	**118.7**	**122.6**	**121.8**	**121.1**	**116.9**	
23-Apr	115.4	119.1	**119.7**	**120.7**	**115.7**	
24-Apr	114.6	120.3	**120.2**	119.8	114.8	
25-Apr	113.5	119.1	**117.5**	118.7	113.4	
26-Apr	113.8	114.6	113.7	117.7	113.5	
27-Apr	113.8	115.1	113.7	117.6	113.3	
28-Apr	114.9	116.6	114.8	117.9	112.0	
29-Apr	114.5	114.5	**115.6**	118.2	112.9	
30-Apr	113.3	113.5	111.3	113.5	111.7	
1-May	113.8	113.3	113.2	114.6	108.7	
2-May	113.4	113.1	113.6	114.7	107.9	

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
3-May	113.6	112.9	113.0	114.9	107.8	
4-May	112.9	113.3	111.9	115.7	107.5	
5-May	112.4	114.1	111.9	114.6	107.1	
6-May	111.3	114.2	113.5	115.1	105.6	
7-May	114.0	113.8	113.5	115.5	110.7	
8-May	113.8	114.6	113.5	115.4	111.7	
9-May	108.7	112.0	110.5	112.5	109.8	
10-May	109.8	110.3	109.1	114.1	105.8	
11-May	110.1	111.1	110.9	114.7	109.3	
12-May	113.1	112.7	111.3	115.6	113.1	
13-May	113.0	112.5	111.5	115.6	111.7	
14-May	111.3	112.3	111.4	114.5	113.1	
15-May	111.1	112.3	110.9	111.6	111.2	
16-May	110.5	111.6	110.2	111.5	108.0	
17-May	109.9	110.8	110.2	111.5	109.7	
18-May	110.0	111.3	110.5	111.9	110.7	
19-May	109.8	111.2	110.5	111.9	111.5	
20-May	109.5	110.7	108.7	110.7	108.5	
21-May	109.5	110.9	109.3	111.0	108.9	
22-May	109.2	110.9	108.8	110.9	107.3	
23-May	106.0	110.3	108.1	111.2	106.4	
24-May	108.7	109.7	107.9	110.2	107.7	
25-May	108.8	109.8	108.3	110.3	109.0	
26-May	107.4	109.5	108.4	110.3	109.1	
27-May	106.2	n/d	107.2	109.8	107.9	
28-May	107.2	n/d	107.7	110.3	108.0	
29-May	107.7	n/d	108.4	111.2	108.7	
30-May	108.5	n/d	108.1	110.8	109.0	
31-May	111.0	111.1	109.2	111.5	108.9	
1-Jun	113.4	112.6	111.4	112.5	110.6	
2-Jun	112.9	112.6	111.4	112.5	110.8	
3-Jun	112.3	112.0	110.4	112.2	108.3	
4-Jun	114.1	113.2	111.6	113.0	110.8	
5-Jun	**116.2**	113.9	112.9	113.7	112.2	
6-Jun	**116.5**	114.2	113.4	114.1	112.5	

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
7-Jun	**115.6**	114.2	113.2	114.1	113.4	
8-Jun	114.8	114.1	113.0	113.3	113.0	
9-Jun	112.1	113.2	111.0	112.4	110.9	
10-Jun	110.9	112.1	110.5	112.1	109.3	
11-Jun	110.4	111.9	110.2	111.8	107.5	
12-Jun	108.7	110.3	108.9	111.3	107.8	
13-Jun	109.4	111.4	109.4	111.7	109.7	
14-Jun	109.4	111.4	109.4	111.8	109.0	
15-Jun	109.5	111.4	109.6	111.7	106.6	
16-Jun	109.5	111.2	109.7	111.7	108.9	
17-Jun	110.4	111.0	109.7	111.5	107.8	
18-Jun	110.4	111.2	110.1	111.5	108.8	
19-Jun	109.2	111.9	108.7	114.0	107.4	
20-Jun	110.7	111.4	111.7	112.1	107.8	
21-Jun	110.6	111.4	111.4	111.9	110.9	
22-Jun	111.0	112.3	110.5	111.3	109.6	
23-Jun	111.2	112.7	111.3	112.6	110.4	
24-Jun	110.4	111.6	110.8	112.3	108.0	
25-Jun	110.2	109.5	108.6	111.1	106.5	
26-Jun	111.9	111.2	109.8	111.9	107.8	
27-Jun	112.9	113.0	111.5	112.8	108.6	
28-Jun	113.4	112.9	111.9	112.8	109.1	
29-Jun	113.3	113.0	111.9	112.8	110.0	
30-Jun	113.0	113.0	111.9	112.6	109.6	
1-Jul	111.0	112.4	110.6	112.7	109.1	
2-Jul	110.7	112.7	110.4	112.7	109.2	
3-Jul	110.7	112.8	110.2	112.8	108.8	
4-Jul	108.5	111.3	109.0	112.2	108.0	
5-Jul	107.9	110.8	108.3	111.8	106.8	
6-Jul	109.2	110.8	108.4	111.6	107.8	
7-Jul	110.7	111.8	109.9	112.3	108.7	
8-Jul	111.5	112.0	110.3	112.4	108.1	
9-Jul	111.5	112.4	110.3	113.1	108.0	
10-Jul	110.6	112.6	109.8	113.7	108.3	
11-Jul	108.6	112.9	108.9	115.0	106.8	

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
12-Jul	108.9	111.8	109.2	112.6	108.4	
13-Jul	108.6	111.2	108.9	111.7	108.0	
14-Jul	109.6	n/d	109.6	112.6	108.2	
15-Jul	109.4	n/d	109.7	112.3	109.2	
16-Jul	109.9	n/d	111.5	113.9	108.9	
17-Jul	109.7	n/d	111.7	114.5	109.0	
18-Jul	109.7	n/d	110.9	113.2	110.2	
19-Jul	109.9	112.1	110.1	112.6	108.2	
20-Jul	110.7	111.8	109.9	112.9	107.8	
21-Jul	111.7	111.4	110.4	113.6	109.7	
22-Jul	111.5	112.2	110.4	113.3	110.4	
23-Jul	107.8	111.6	109.1	113.6	108.5	
24-Jul	110.4	113.2	110.5	113.7	108.5	
25-Jul	113.7	112.8	112.3	114.3	110.2	
26-Jul	113.1	112.4	112.3	113.9	111.0	
27-Jul	112.9	112.4	111.1	113.0	111.0	
28-Jul	112.6	115.5	113.7	113.8	110.2	
29-Jul	111.3	112.3	114.7	114.6	110.9	
30-Jul	111.1	112.4	112.8	113.2	111.3	
31-Jul	107.7	111.5	111.4	112.6	109.8	
1-Aug	108.0	110.4	109.5	111.5	107.4	
2-Aug	107.5	112.1	109.5	113.9	108.6	
3-Aug	104.4	111.0	108.7	113.8	106.2	
4-Aug	108.5	110.4	109.4	112.3	106.5	
5-Aug	109.7	112.0	110.9	114.1	109.0	
6-Aug	109.4	111.7	110.9	113.3	109.7	
7-Aug	107.7	112.3	110.1	114.2	109.2	
8-Aug	107.0	111.1	109.8	112.4	106.6	
9-Aug	105.3	111.0	109.3	112.4	107.1	
10-Aug	107.3	110.5	109.3	111.8	107.3	
11-Aug	108.1	110.2	109.3	111.9	108.0	
12-Aug	109.6	110.8	109.9	112.7	107.9	
13-Aug	110.1	110.7	110.7	112.2	108.3	
14-Aug	109.6	111.8	110.7	114.8	108.9	
15-Aug	108.3	111.1	110.0	113.8	108.6	

Date	WANF	WANT	PRDF	PRDT	Pasco	Comments/Corrective Action Taken
16-Aug	107.5	107.6	109.5	114.4	109.2	
17-Aug	107.1	106.2	109.3	109.5	108.6	
18-Aug	108.2	107.1	108.0	106.2	109.0	
19-Aug	108.0	108.5	108.0	107.2	106.2	
20-Aug	105.9	105.6	109.0	107.8	104.3	
21-Aug	105.1	105.5	108.1	106.5	106.7	
22-Aug	103.5	104.5	106.4	105.9	n/d	
23-Aug	103.5	103.8	104.7	103.3	104.2	
24-Aug	104.3	103.7	103.6	103.8	103.1	
25-Aug	105.3	103.9	104.2	104.7	102.7	
26-Aug	105.4	104.2	104.7	105.1	103.8	
27-Aug	104.6	104.0	104.9	104.8	104.9	
28-Aug	101.8	102.3	104.5	104.1	103.7	
29-Aug	102.6	102.5	103.0	102.8	102.5	
30-Aug	102.7	102.5	102.9	102.9	103.1	
31-Aug	102.4	102.8	102.3	103.2	102.1	

Notes:

1. WANF = Wanapum forebay; WANT = Wanapum tailrace; PRDF = Priest Rapids forebay; PRDT = Priest Rapids tailrace; Pasco = Pasco Fixed Site Monitor located upstream of McNary Dam (next downstream forebay), operated by the US Army Corps of Engineers; n/d. = No data; see Appendix B for an explanation of why data was omitted.
2. Orange highlighted values represent values that are above current water quality standards.
3. Both Wanapum and Priest Rapids dams are, in general, limited to 85% powerhouse capacity due to regional and federal constrains, which were described in Section 3.5.3 and 4.1 of the report.