Priest Rapids Hydroelectric Project (P-2114)

2020 SUMMARY RESULTS OF THE WATER QUALITY FIXED-SITE MONITORING PROGRAM WITHIN THE PRIEST RAPIDS HYDROELECTRIC PROJECT

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Executive Summary

This annual fixed-site monitoring program (FSM program) water quality summary report (summary report) provides results of the FSM program efforts that Public Utility District No. 2 of Grant County, Washington (Grant PUD) conducted in 2020 in accordance with conditions of the 401 Water Quality Certification (WQC; WDOE 2007) issued by the Washington Department of Ecology (WDOE) for the operation of the Priest Rapids Hydroelectric Project (Project) and the 2018 updated, WDOE-approved Quality Assurance Project Plan (QAPP; Grant PUD 2018).

Water quality parameters monitored in 2020 under the FSM program included:

1). total dissolved gas (TDG (millimeters of mercury) [mm Hg])),
2). water temperature (degrees Celsius [°C]),
3). dissolved oxygen (DO (milligrams per liter [mg/L])),
4). pH (units), and
5). turbidity (Nephelometric Turbidity Unit [NTU]).

Monitoring methods and quality assurance/quality control (QA/QC) procedures followed protocols outlined in the QAPP (Grant PUD 2018). Section 6.7.3 of the 401 WQC (WDOE 2007) requires Grant PUD to provide the results of the monitoring efforts as well as a summary of the results by March 1 of the year following the monitoring activities.

Water quality monitoring conducted in 2020 occurred at Grant PUD's fixed-site water quality monitoring stations (FSM stations). The purpose of monitoring water quality parameters within the Project is to provide information on water quality conditions and to verify compliance with applicable water quality standards and conditions within the 401 WQC (WDOE 2007) and QAPP (Grant PUD 2018).

In general, TDG %SAT in 2020 was at its highest during the late spring/early summer fish-spill season (mid-May to June), with some TDG values that were above 115/120 %SAT at all FSM stations for some of this time period. These high TDG events generally coincided with flows close to or above the 7Q10 levels at both Wanapum and Priest Rapids dams. After June, TDG %SAT fell below 115/120 %SAT at all FSM stations for most of the 2020 FSM program monitoring season. Additionally, water temperatures peaked during August/early September, with some daily maximum values greater than 20°C at three of the four FSM stations. Grant PUD's 2020 periodic grab-sampling efforts under the FSM program indicated DO between 10.0 and 13.0 mg/L, pH from 7.8 to 8.5 units, and turbidity between 0.1 and 6.3 NTUs.

Grant PUD will continue its hourly TDG and water temperature monitoring as well as periodic DO, pH, and turbidity monitoring at its FSM stations in 2021, according to conditions contained in the 401 WQC (WDOE 2007) and the QAPP (Grant PUD 2018).

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Terms and Abbreviations

1-DMax	maximum daily temperature
7-DADMax	7-day average of the daily maximum temperatures
°C	degrees Celsius
DCP	data collection platform
DO	dissolved oxygen
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FSM program	fixed-site monitoring program
FSM stations	fixed-site monitoring stations
Grant PUD	Public Utility District No. 2 of Grant County, Washington
kcfs	thousand cubic feet per second
MW	megawatt
mg/L	milligrams per liter
mm Hg	millimeters of mercury
multi-probe	multi-parameter water quality monitoring probe
NIST	National Institute of Standards and Technology
NTU	Nephelometric Turbidity Unit
Project	Priest Rapids Hydroelectric Project
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
TDG	total dissolved gas
TMDL	total maximum daily load
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
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 in central Washington State. The Project is authorized by the Federal Energy Regulatory Commission (FERC) under Project No. 2114[1] and includes the Wanapum and Priest Rapids developments.

A 401 Water Quality Certification (WQC) for the operation of the Project was issued by the Washington Department of Ecology (WDOE) on April 3, 2007 (WDOE 2007), amended on March 6, 2008, and directly incorporated into the FERC license to operate the Project in April of 2008 (FERC 2008). Various sections of the 401 WQC require Grant PUD to monitor total dissolved gas (TDG), water temperature, dissolved oxygen (DO), and pH throughout the Project (WDOE 2007). Section 6.7.3 of the 401 WQC (WDOE 2007) requires Grant PUD to provide WDOE with water quality monitoring results, along with a summary report, by March 1 of the year following the monitoring activities.

Water quality data were collected, analyzed, and reported for the year 2020. Additionally, instruments were maintained and calibrated as defined in Grant PUD's 2018 updated WDOE-approved Quality Assurance Project Plan (QAPP; Grant PUD 2018), which contains elements of sampling frequency, procedures, equipment, analytical methods, quality control, data handling and assessment procedures, and reporting protocols designed to meet the conditions of the 401 WQC (WDOE 2007; see Section 2.0).

The following annual fixed-site monitoring program (FSM program) water quality summary report (summary report) provides the results of Grant PUD's FSM program in 2020 in accordance with Section 6.7.3 of the 401 WQC (WDOE 2007).

2.0 Quality Assurance Project Plan

The water quality data summarized in this summary report were collected in accordance with Grant PUD's 2018 updated QAPP, titled:

> *"Quality Assurance Project Plan for Monitoring Selected Water Quality Parameters within the Priest Rapids Hydroelectric Project: 2018 Update"* (Grant PUD 2018).

The updated QAPP was approved by WDOE on February 21, 2019 and FERC on May 7, 2019.

The QAPP provides details on water quality monitoring methods that Grant PUD implements to meet conditions of the 401 WQC. Water quality parameters that are monitored under the QAPP include:

1). TDG (millimeters of mercury [mm Hg]),
2). water temperature (degrees Celsius [°C]),
3). DO (milligrams per liter [mg/L]),
4). pH (units), and
5). turbidity ((Nephelometric Turbidity Units [NTU]).

Water quality monitoring conducted under the QAPP was performed via Grant PUD's FSM program.

[1] 123FERC ¶ 61,049 (2008).

Information provided in the QAPP includes the following:

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

The purpose of Grant PUD's FSM program is to provide information on water quality conditions within the Project, as well as verify compliance with applicable water quality standards and conditions within the 401 WQC. Implementation of the QAPP assures that water quality data collected by the FSM program are of enough quality to meet the objectives of the FSM program. Adaptive management provisions in the QAPP determine potential changes to monitoring methods, locations, or other modifications that may be warranted. Updates are made to the QAPP as necessary (subject to both WDOE and FERC approval).

The current QAPP for Grant PUD's FSM program can be found here.

2.1 Priest Rapids Hydroelectric Project Description

The downstream boundary of the Project is located approximately three miles below Priest Rapids Dam (river mile [RM] 397.1) and extends upriver to the Rock Island Dam tailrace at RM 453.5 (Figure 1).

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

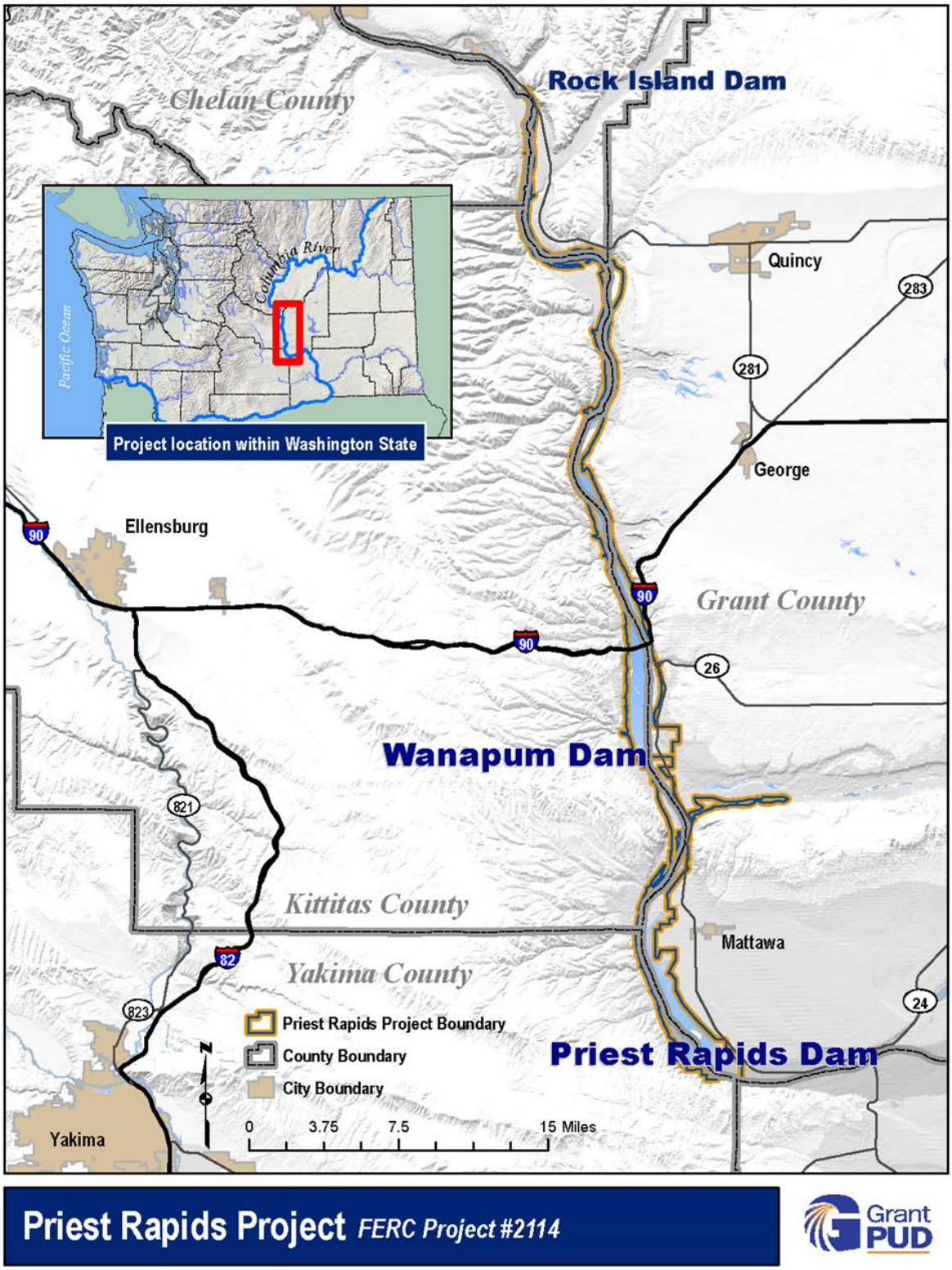

Figure 1 **The Priest Rapids Project is in central Washington State on the mid-Columbia River.**

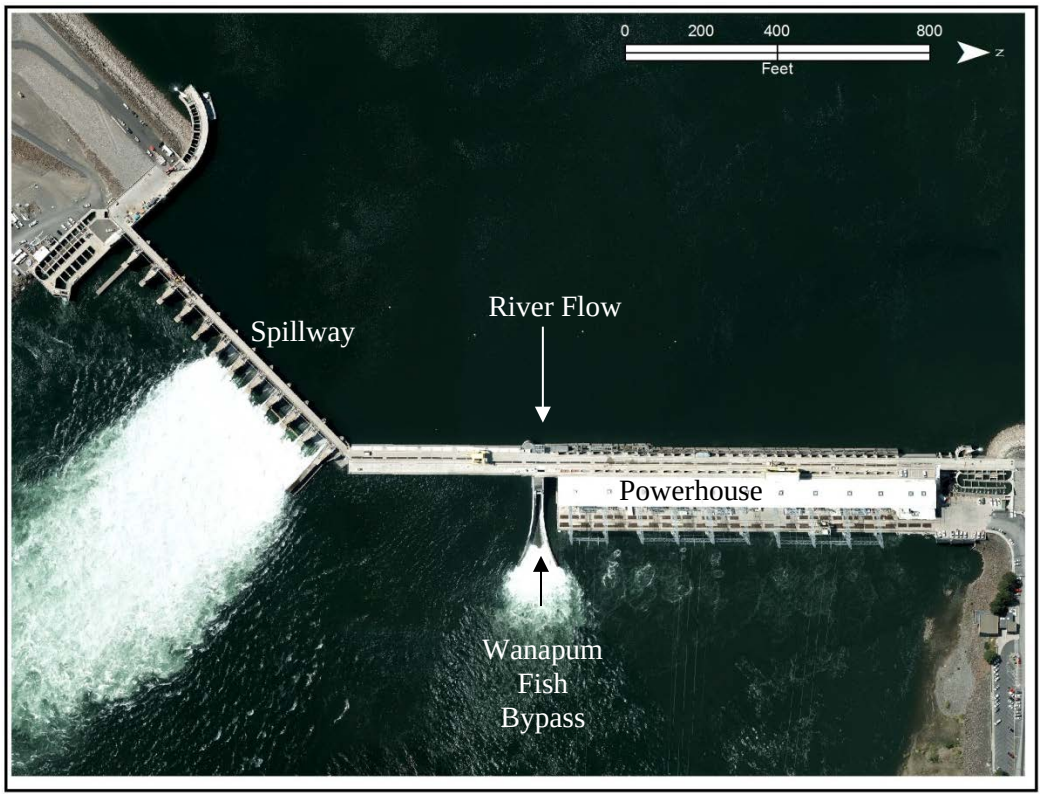

Figure 2 **Aerial photograph of Wanapum Dam, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.**

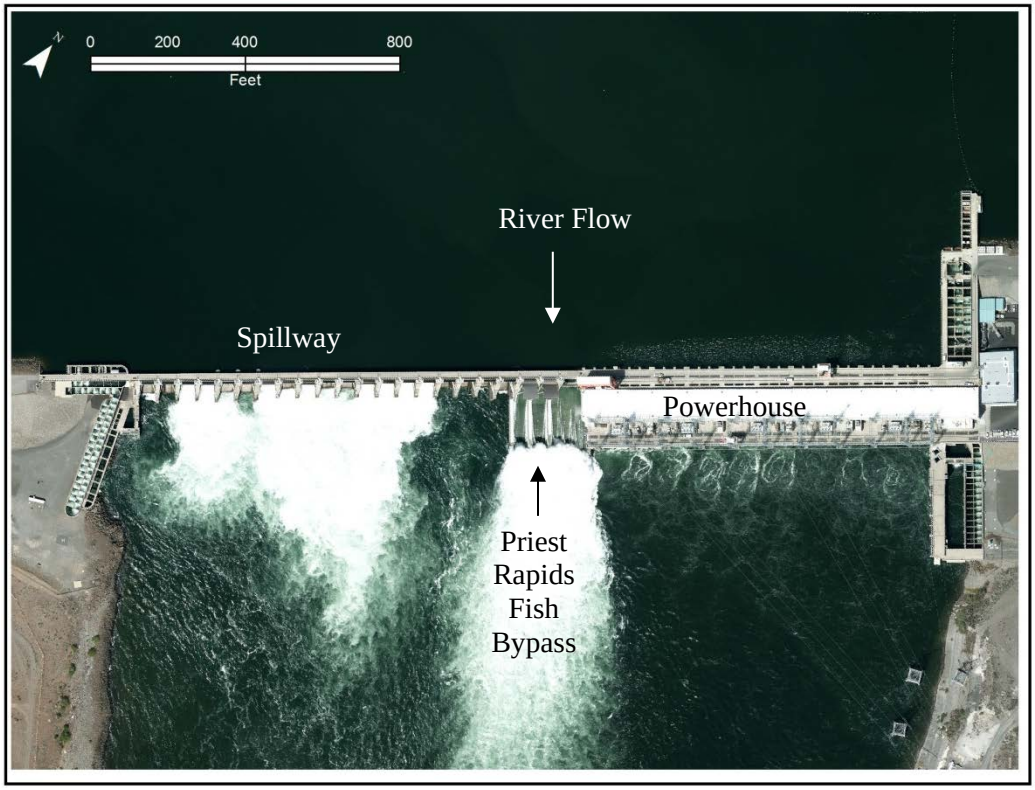

Figure 3 **Aerial photograph of Priest Rapids Dam, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.**

2.2 Regulatory Framework

Section 6.0 of the 401 WQC (WDOE 2007) contains various water quality conditions that Grant PUD complies with for the continued operation of the Project. These various conditions necessitate monitoring of TDG, water temperature, DO, and pH within the Project.

The following sections detail the water quality monitoring requirements and numeric standards for each parameter monitored within the Project under the 401 WQC (WDOE 2007).

2.2.1 Total Dissolved Gas

Washington state water quality standards for TDG during the non-fish and fish-spill seasons are established by the WDOE (see Washington Administrative Code (WAC) 173-201A-200(1)(f)). The 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 standard for TDG in 2020 during the summer fish-spill season (July 1 through August 31) is 120 %SAT in the tailrace of the dam spilling water for fish and 115 %SAT in the forebay of the next downstream dam, based on the average of the twelve highest hourly readings in a day. Also, a one-hour, 125 %SAT maximum standard for TDG applied throughout the Project.

New for 2020, intended to help aid in fish passage, the WDOE implemented a short-term modification to the spring fish-spill season (April 1 to June 30) for Columbia River dam operators. This short-term modification offers the option for dam operators to increase spill during the spring fish-spill season to the following TDG levels:

- 125 %SAT in the tailrace of the dam spilling water for fish (based on the average of the twelve highest consecutive hourly readings in a day)
- 126 %SAT maximum standard in the tailrace of the dam spilling water for fish (based on the average of any two consecutive hourly readings in a day)
- The forebay compliance TDG standard for the next downstream dam is removed during the spring fish-spill season (April 1 to June 30)

To comply with the above modified TDG standards, dam operators are required to provide WDOE with an approved biological monitoring plan to measure impacts of fish (both salmonid and native species) to increased TDG conditions throughout the spring fish-spill season. Grant PUD opted into this short-term TDG modification for the spring fish-spill season in 2020 and will submit a monitoring plan for 2021 to comply with the TDG modifications set forth by the WDOE.

Section 6.4.10(d) of the 401 WQC (WDOE 2007) obligates Grant PUD to maintain a TDG monitoring program at its fixed-site monitoring stations (FSM stations) annually, and that the TDG measurements shall occur on an hourly basis. Additionally, Section 6.4.11(a) of the 401 WQC (WDOE 2007) states monitoring results shall be made available electronically to the public, "*…as close to the time of occurrence as technology will reasonable allow*."

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 not be applicable 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.

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

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

In addition, in accordance with Washington water quality standards and compliance methods, Grant PUD is only responsible for TDG levels created by operation of Wanapum and/or Priest Rapids Dams. Specifically, Chapter 90.48.422 of the Revised Code of Washington (RCW) states:

> *With respect to federal energy regulatory commission licensed hydropower projects, the department may only require a person to mitigate or remedy a water quality violation or problem to the extent there is substantial evidence such person has caused such violation or problem.*

Section 6.4 of the Project's 401 WQC outlined a 10-year compliance schedule related to TDG (Section 6.4.2(b), Table 1; WDOE 2007), which began in 2008 with the issuance of the Project license (FERC 2008). To date, Grant PUD has implemented all operational and structural TDG abatement measures, as well as completed annual monitoring and reporting requirements in accordance with Section 6.4 of the 401 WQC (WDOE 2007). Furthermore, based on the results of the TDG compliance analyses presented in Grant PUD's WDOE-approved *Final Summary of Total Dissolved Gas Monitoring with the Priest Rapids Hydroelectric Project – Year 10 Report* (Year 10 Report; Grant PUD 2018a), Grant PUD has achieved reasonable compliance of the current TDG water quality standards.

2.2.2 Water Temperature

WAC 173-201A-602 designates the segment of the Columbia River within the Project as salmonid spawning, rearing, and migration; therefore, water temperature must remain below 17.5°C, as measured by the 7-day average of the daily maximum temperatures (7-DADMax). When a water body's temperature is warmer than the criteria (or within 0.3°C of the criteria) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C. In addition, WAC 173-201A-602 provides that temperatures below Priest Rapids Dam shall not exceed a maximum daily (1-DMax) of 20.0°C due to human activities. When natural conditions exceed a 1-DMax of 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed $t = 34/(T + 9)$.

Certain sections of the Columbia River within the Project are classified as impaired for temperature under Section 303(d) of the Clean Water Act. Portions of the Columbia River upstream of the Project are also classified as impaired for temperature. On May 18, 2020 a Total Maximum Daily Load (TMDL) for temperature was issued by the Environmental Protection Agency (EPA; 2020) for review and public comment. This document is still under review at the time of this summary report.

In 2015, and in accordance with Section 6.5.2 of the 401 WQC (WDOE 2007), Grant PUD conducted temperature modeling using a CE-QUAL-W2 model to determine Grant PUD's

contribution, if any, to water temperature values recorded from 2003–2012 that were above WDOE water quality standards (NHC 2016). Results from this modeling effort were sent to the WDOE on April 14, 2016.

2.2.3 Dissolved Oxygen and pH

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

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

3.0 Fixed-Site Monitoring Program

Grant PUD currently operates and maintains four water quality FSM stations that record water depth (m), barometric pressure (mm Hg), TDG (mm Hg), water temperature (°C), DO (mg/L), pH (units), and turbidity (NTU). Barometric pressure, TDG, and water temperature are collected/reported on an hourly basis throughout the year, while DO, pH, and turbidity are noted monthly under Grant PUD's FSM program.

Each FSM station is equipped with a Hydrolab Corporation Model DS5X, DS5, DS4a, MS5, or MS4a multi-parameter water quality monitoring sonde (multi-probe) that is enclosed in a submerged perforated conduit pipe. The multi-probe contains individual TDG, water temperature, DO, pH, and turbidity sensors that are connected to a central housing system that allows for single connections, readouts, downloads, and power supplies for up to 15 water quality sensors (Hach Hydromet 2010). At the FSM stations, multi-probes are connected to an automated system that collects and records hourly monitoring of barometric pressure, TDG, and water temperature. A National Institute of Standards and Technology (NIST) certified barometer located at each FSM station provides the barometric pressure readings necessary to correct the partial pressure readings taken by the multi-probes (and convert TDG mm Hg to %SAT). The multi-probes are also used to conduct periodic grab-sampling of DO, pH, and turbidity and to collect quality assurance/quality controls (QA/QC) measurements at each FSM station.

The data logging system at each FSM station consists of the same basic equipment, which includes the multi-probe enclosed in a submerged perforated conduit or standpipe connected to a Sutron Corporation 9210 data collection platform (DCP). Multi-probes are interrogated by the DCPs every 15 minutes and the data are archived within the DCP. The DCPs are then interrogated via radio transmission into Grant PUD's fiber-optic network, which then transfers the data into a secure database (using Sutron's XConnect software). Replicas of the current year's data, along with archived data (back five years) are made available at Grant PUD's external water quality website (Grant PUD 2021).

For additional information regarding Grant PUD's FSM program/stations, see the QAPP (Grant PUD 2018).

4.0 Results

The following sections provide results and summaries of Grant PUD's FSM program for 2020. The hourly data can be attained from Grant PUD's water quality website (Grant PUD 2021).

4.1 Description of 2020 Flow Characteristics

Mean daily discharges during 2020 were compared to the previous 10-year average (Figure 4), as measured at the U.S. Geological Survey (USGS) streamflow gage #12472800 located 2.6 RM downstream of Priest Rapids Dam.

In general, 2020 mean daily discharges were slightly lower than the previous 10-year average by a little under 1% for the entire year. The most notable difference in mean daily discharge was during the early to mid-spring timeframe (March to May), where average flows were over 30% below normal. Alternatively, the period when average daily discharge was higher than the 10-year average was the late May to early July timeframe where average flows were around 16% higher than normal (Figure 4).

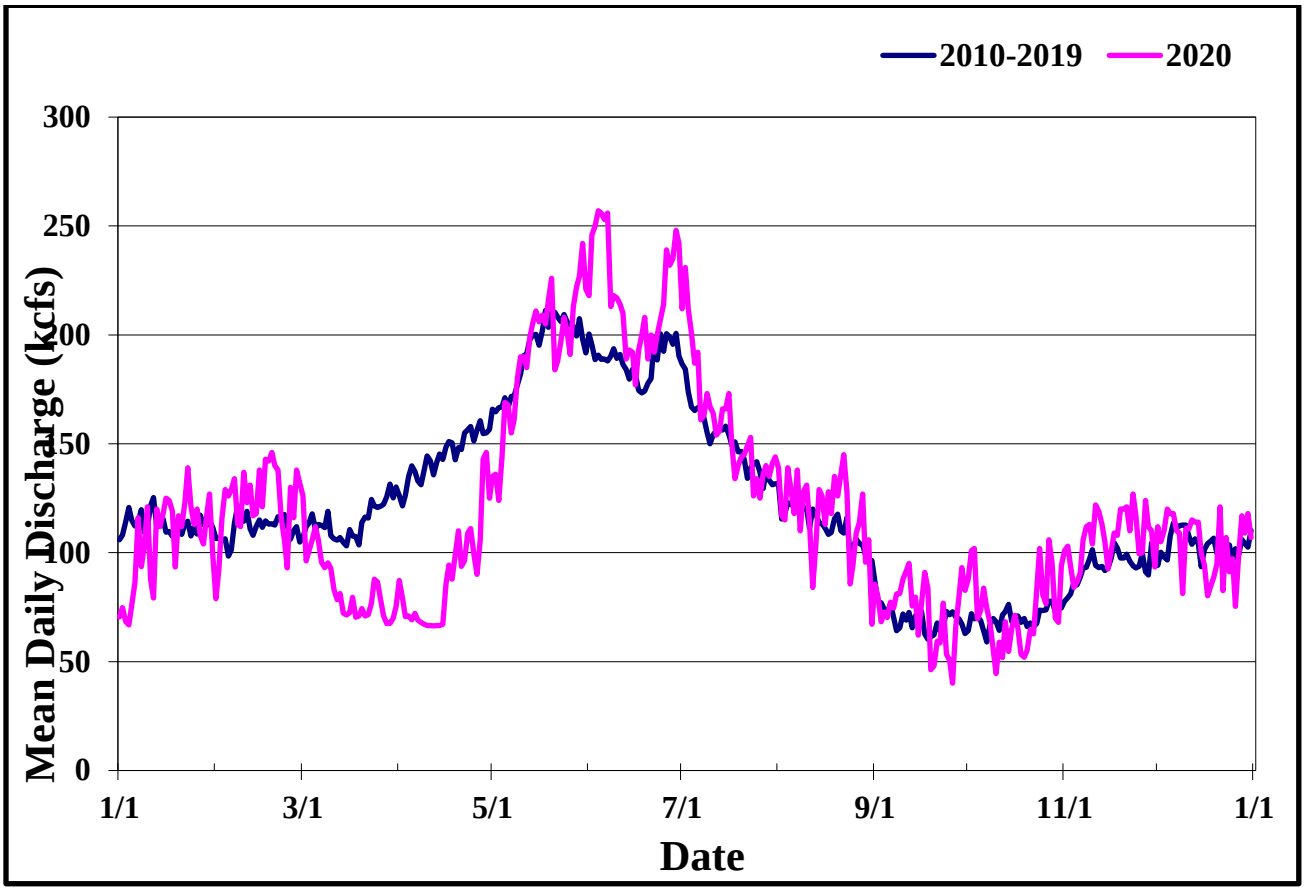

Figure 4 **Comparison of 2020 vs. previous 10-year average of mean daily discharge values measured at the U.S. Geological Survey (USGS) streamflow gage #12472800 located 2.6 river miles below Priest Rapids Dam, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.**

4.2 Total Dissolved Gas

Hourly TDG data were collected, summarized, and reported from January 1 through December 31, 2020. Data collection, QA/QC measures, and analyses of TDG values mirrored those described in the QAPP (Grant PUD 2018).

Suspect or erroneous TDG values were omitted from the analysis, but are included, as well as an explanation for omission, in Appendix A of this summary report.

The QA/QC issues during the 2020 FSM program monitoring year consisted of communication errors, probe failure, and a faulty data cable at the Priest Rapids Dam forebay FSM station. Of the 35,136 available hours from January 1 through December 31 in 2020, 875 hours were omitted/lost (approximately 2.5%). A total data completeness of 97.5% for the 2020 FSM program monitoring season was within the 90% data completeness objective as specified in the QAPP (Grant PUD 2018). Table 1 displays the number of hourly TDG values that were omitted/lost from the dataset due to various QA/QC issues. See Appendix A of this summary report for an explanation for omission from the dataset.

Table 1 Overview of Grant PUD's total dissolved gas data set during 2020, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.

Location[1]	Data Interval	Available data collection hours	Number of omitted/lost hourly readings[2]	% data loss
WANF	1/1 – 12/31	8,784	4	0.05
WANT	1/1 – 12/31	8,784	5	0.06
PRDF	1/1 – 12/31	8,784	866	9.9
PRDT	1/1 – 12/31	8,784	0	0
Total	**1/1 – 12/31**	**35,136**	**875**	**2.5**

Notes:
[1]WANF = Wanapum Dam forebay, WANT = Wanapum Dam tailrace, PRDF = Priest Rapids Dam forebay, PRDT = Priest Rapids Dam tailrace.
[2]See Appendix A for dates, times, and circumstances related to omitted/lost data.

4.2.1 Total Dissolved Gas Summary

In general, TDG %SAT in 2020 was at its highest during the late spring/early summer fish-spill season (mid-May to June), with some TDG values that were above 115/120 %SAT at all FSM stations for some of this time period. These high TDG events generally coincided with flows close to or above the 7Q10 levels at both Wanapum and Priest Rapids dams. After June, TDG %SAT fell below 115/120 %SAT at all FSM stations for most of the 2020 FSM program monitoring season. A limited amount of hourly TDG events above 120 %SAT occurred at the

Wanapum tailrace FSM station outside of the fish-spill season (September to March), primarily under reverse-load factor (RLF) operations (October to November).

The summary values (mean, standard deviation, minimum, and maximum) for all hourly TDG measurements at each FSM station during 2020 are presented in Table 2. Figures 5 through 10 below present graphical displays of the TDG values recorded during the 2020 FSM program monitoring season. The complete 2020 TDG hourly dataset can be found at Grant PUD's water quality website at: https://www.grantpud.org/water-quality.

Table 2 Summary of hourly total dissolved gas measurements from each fixed-site monitoring station (FSM station) during 2020 Non-Fish and Fish-Spill Seasons, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.

Location[1]	Season	Mean[2]	Standard Deviation	Minimum[2]	Maximum[2]
WANF	Non-Fish	98.0	3.4	92.5	109.0
	Fish-Spill	112.2	5.1	97.6	125.1
WANT	Non-Fish	100.0	3.6	94.2	124.8
	Fish-Spill	114.0	5.9	102.3	134.1
PRDF	Non-Fish	99.7	2.9	94.3	114.9
	Fish-Spill	112.7	5.4	102.2	127.2
PRDT	Non-Fish	100.4	3.3	94.5	115.7
	Fish-Spill	113.4	5.9	101.5	125.5
PASCO[3]	Fish-Spill	110.2	3.9	99.6	119.1

Notes:
[1]WANF = Wanapum Dam forebay, WANT = Wanapum Dam tailrace, PRDF = Priest Rapids Dam forebay, PRDT = Priest Rapids Dam tailrace.
[2]All values represent %SAT.
[3]The PASCO site is owned and operated by the Army Corps and only operates during the fish-spill season.

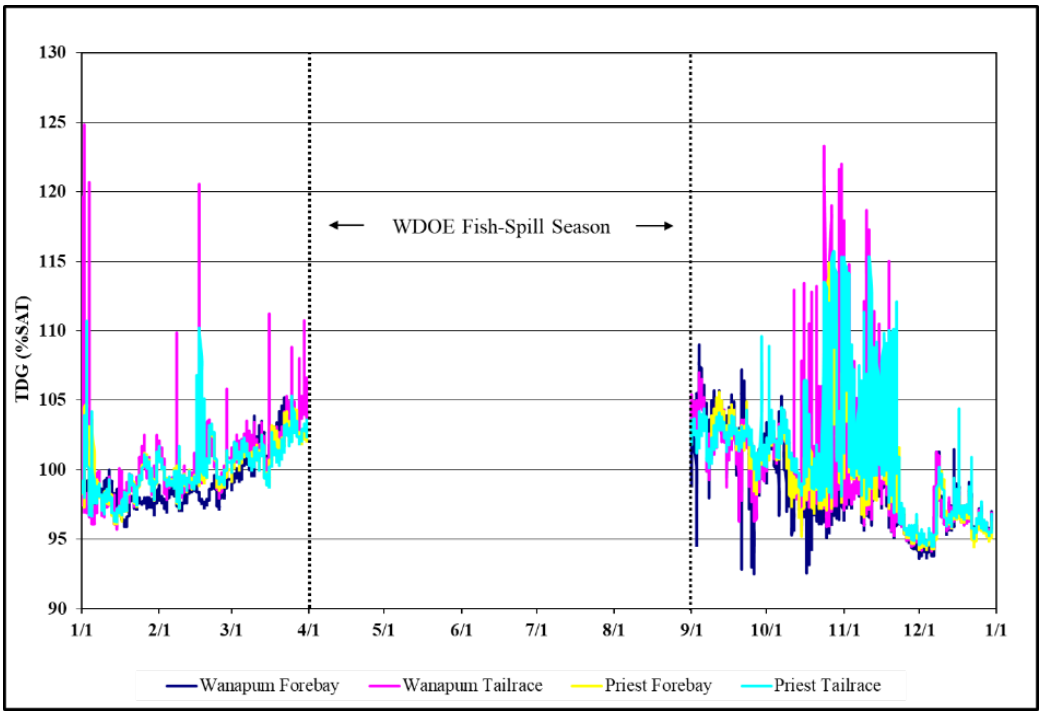

Figure 5 Hourly total dissolved gas values from the 2020 non-fish spill season, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.

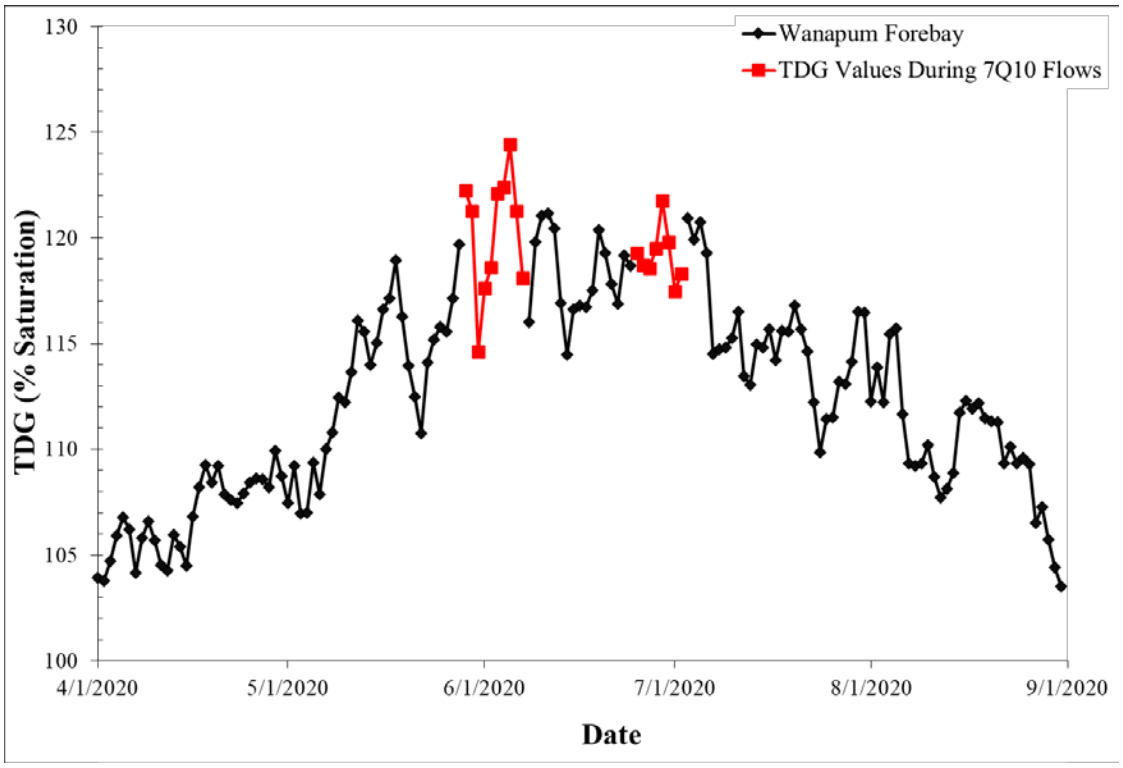

Figure 6 **Total dissolved gas values (average of the 12-highest hourly TDG values in a day) from the 2020 fish-spill season recorded at the Wanapum Dam forebay FSM station. Priest Rapids Project, mid-Columbia River, WA.**

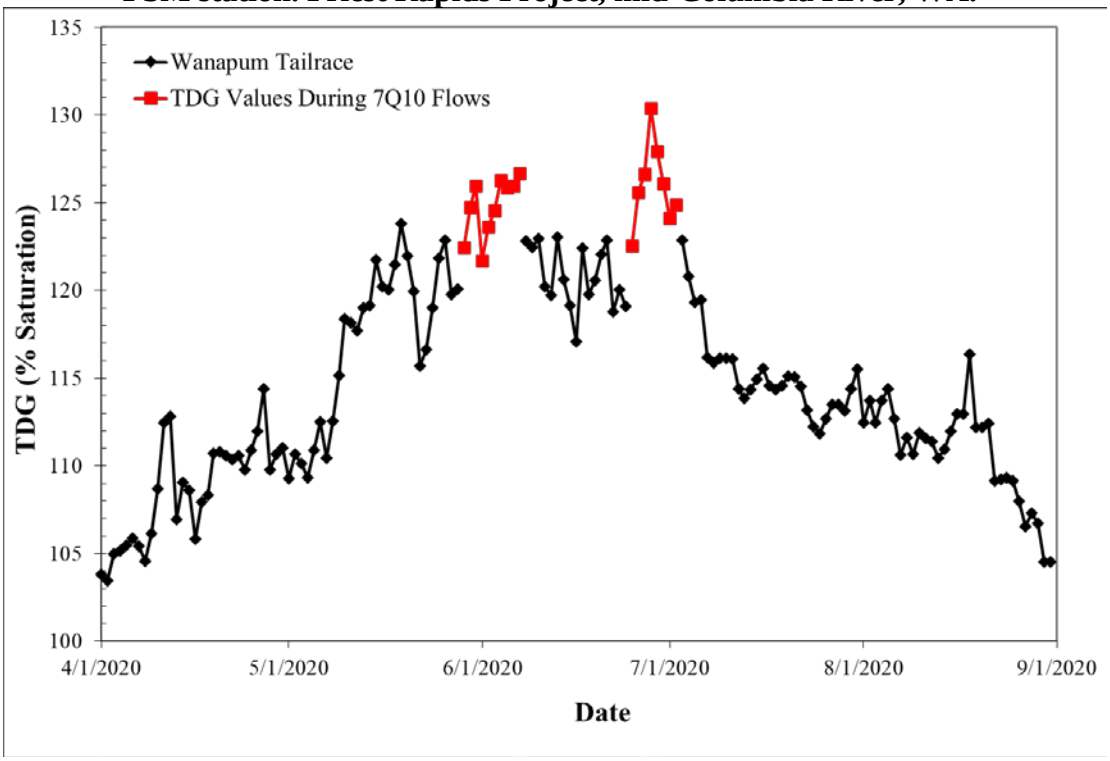

Figure 7 **Total dissolved gas values (average of the 12-highest hourly TDG values in a day) from the 2020 fish-spill season recorded at the Wanapum Dam tailrace FSM station. Priest Rapids Project, mid-Columbia River, WA.**

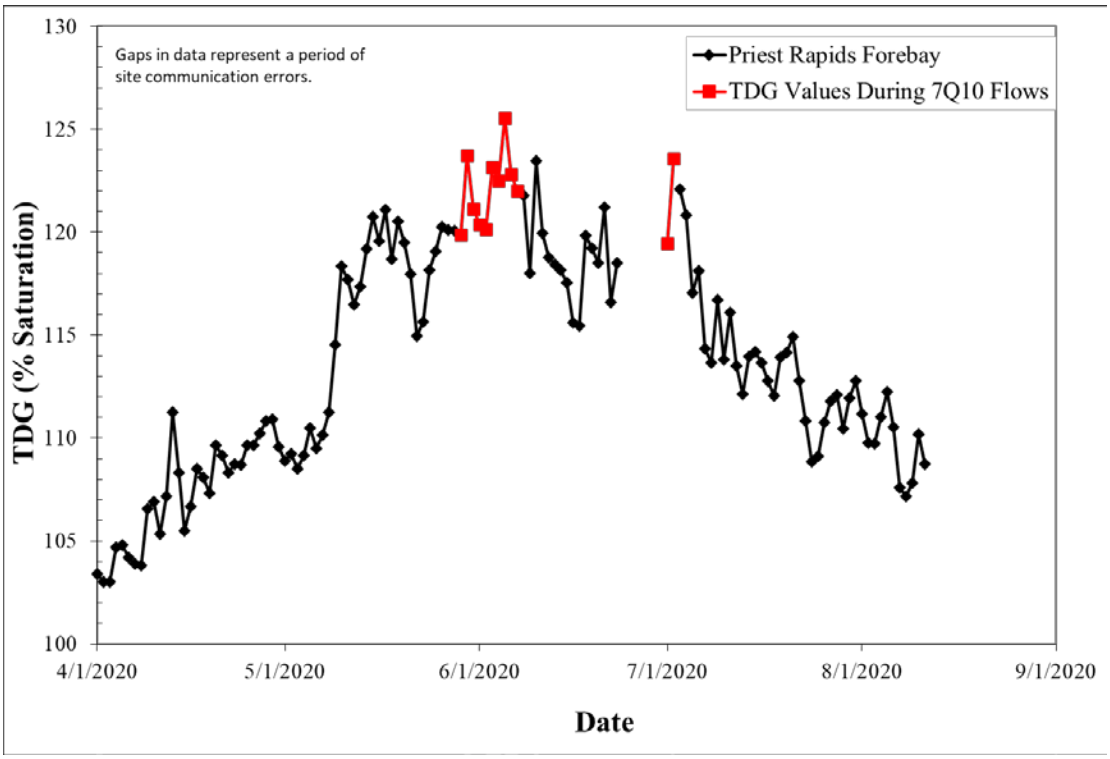

Figure 8 **Total dissolved gas values (average of the 12-highest hourly TDG values in a day) from the 2020 fish-spill season recorded at the Priest Rapids Dam forebay FSM station. Priest Rapids Project, mid-Columbia River, WA.**

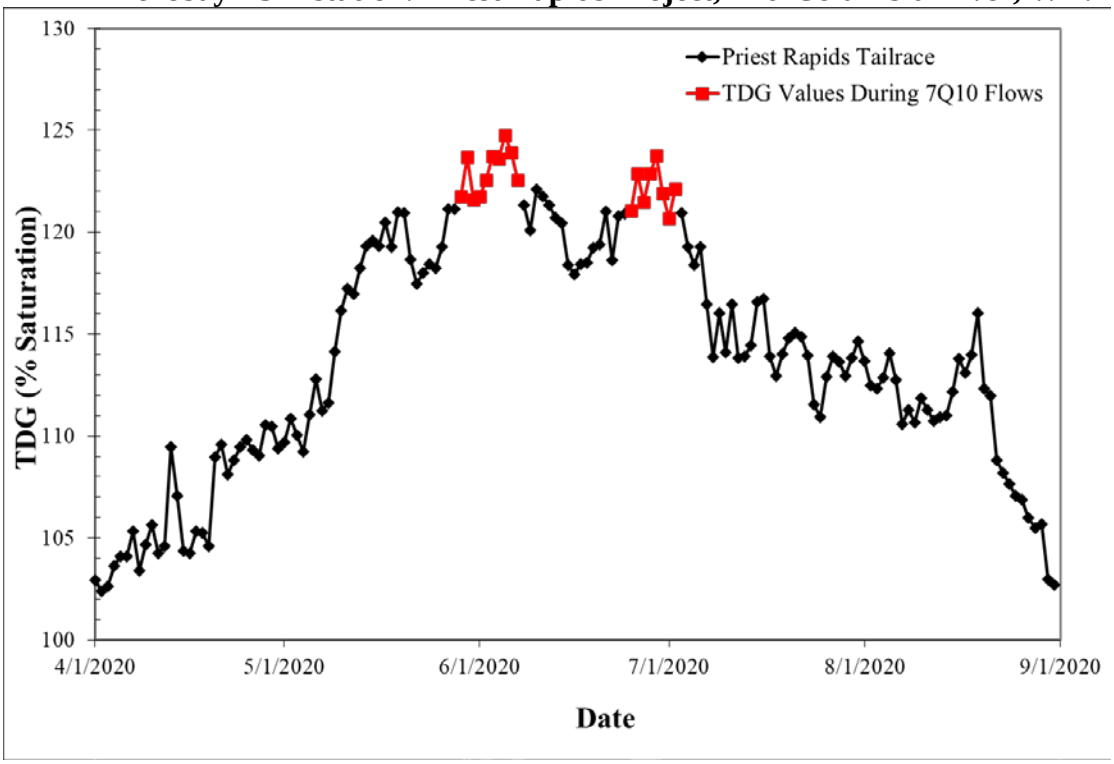

Figure 9 **Total dissolved gas values (average of the 12-highest hourly TDG values in a day) from the 2020 fish-spill season recorded at the Priest Rapids Dam tailrace FSM station. Priest Rapids Project, mid-Columbia River, WA.**

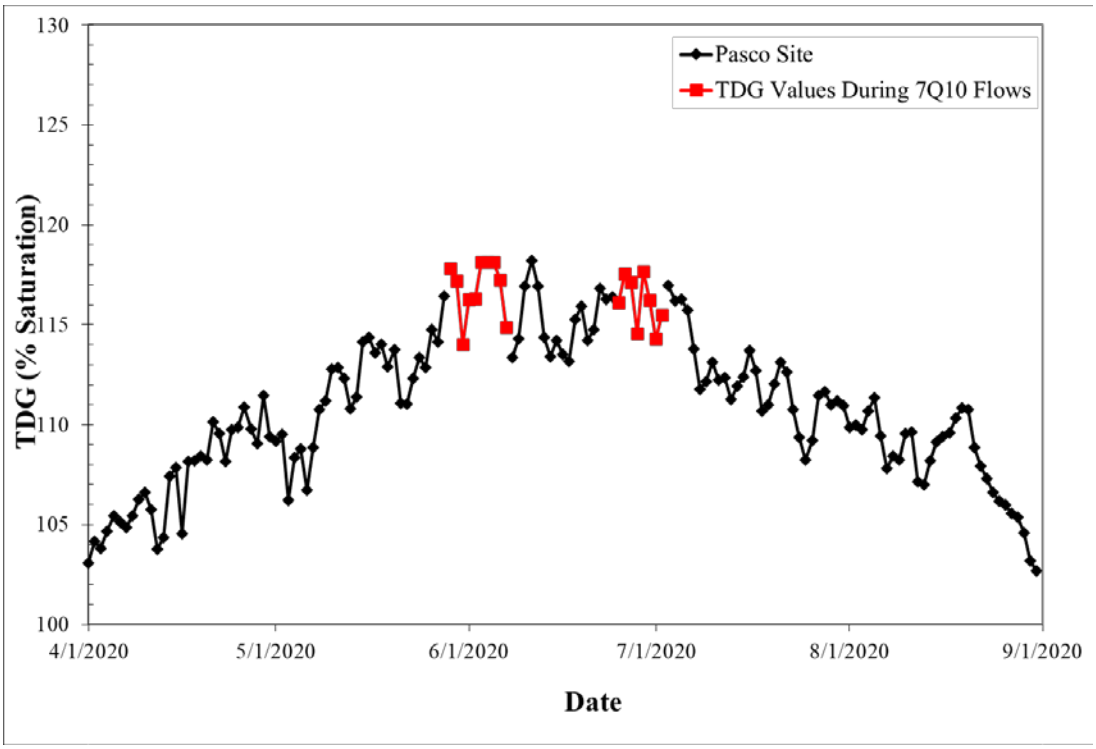

Figure 10 **Total dissolved gas values (average of the 12-highest hourly TDG values in a day) from the 2020 fish-spill season recorded at the Pasco FSM station, mid-Columbia River, WA.**

4.2.2 Total Dissolved Gas Compliance Analyses

Grant PUD will continue to collect hourly TDG time-series data and, concurrent with each 5-Year update of its compliance gas abatement plan (GAP), perform a compliance analyses similar to the Year 10 Report (Grant PUD 2018a), using the previous 10 years of TDG data to ensure that Project operations continue to meet a similar level of compliance demonstrated in the Year 10 Report. The compliance analysis will include a descriptive characterization of the TDG data and an overall compliance assessment for the Project with respect to the TDG water quality standards.

4.3 Water Temperature

Water temperature data were collected on an hourly basis during the 2020 FSM program monitoring season at each FSM station within the Project. Data collection, QA/QC, and analyses of water temperature data followed those described in the QAPP (Grant PUD 2018).

Overall data loss in 2020 was 870 of the combined 35,136 available hours, or approximately 2.5% data loss, which was well within the 90% completeness data quality objective as specified in the QAPP (Grant PUD 2018).

Table 3 displays the number of 1-DMax and 7-DADMax values that were omitted/lost from the dataset due to QA/QC issues compared to the total number of available hours. In 2020, the QA/QC issues for the water temperature dataset had to do with communication errors between the probe and DCP device, primarily at the Priest Rapids forebay FSM station (related to a faulty cable connection).

Table 3 Overview of the water temperature data set during 2020, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.

Location[1]	Available hours	Number of hours omitted/lost[2]	% data loss
WANF	8,784	4	0.05
WANT	8,784	0	0
PRDF	8,784	866	9.9
PRDT	8,784	0	0
Total	**35,136**	**870**	**2.5**

Notes:
[1]WANF = Wanapum Dam forebay, WANT = Wanapum Dam tailrace, PRDF = Priest Rapids Dam forebay, PRDT = Priest Rapids Dam tailrace.
[2]See Appendix A for dates, times, and circumstances relating to omitted/lost data.

4.3.1 Water Temperature Summary

In general, water temperatures were highest during early-August to mid-September, with some daily maximum values greater than 20°C. The summary values (mean, standard deviation, minimum, and maximum) for all hourly temperature measurements taken from each FSM station are presented in Table 4; Figure 11 and Figure 12 present graphical displays of the 1-DMax and 7-DADMax values for the 2020 FSM program monitoring season. The complete 2020 water temperature hourly dataset can be found at Grant PUD's water quality website at: Grant PUD: Water Quality.

Table 4 Summary of hourly temperature measurements from each fixed-site monitor during 2020, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.

Location[1]	Data Interval	Mean[2]	Standard Deviation	Minimum[2]	Maximum[2]
WANF	01/01 – 12/31	11.4	5.6	3.2	21.9
WANT	01/01 – 12/31	11.2	5.5	3.3	19.8
PRDF[3]	01/01 – 12/31	10.5	5.2	3.1	19.8
PRDT	01/01 – 12/31	11.4	5.5	3.3	20.0

Notes:
[1]WANF = Wanapum Dam forebay, WANT = Wanapum Dam tailrace, PRDF = Priest Rapids Dam forebay, PRDT = Priest Rapids Dam tailrace.
[2]All values represent degrees Celsius.
[3]Temperature data not recorded/collected during the normal peak temperature period (mid-August to early September) in the 2020 water temperature dataset.

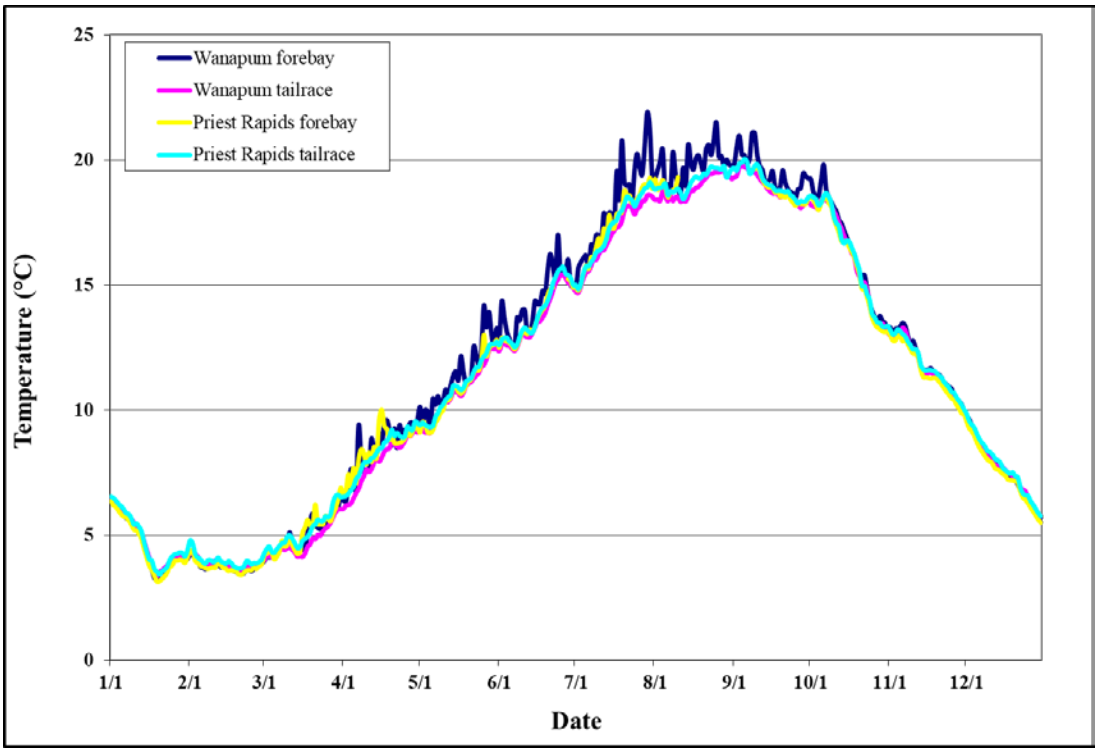

Figure 11 **Daily maximum (1-DMax) water temperature values recorded at each fixed-site monitoring station (FSM station) in 2020, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.**

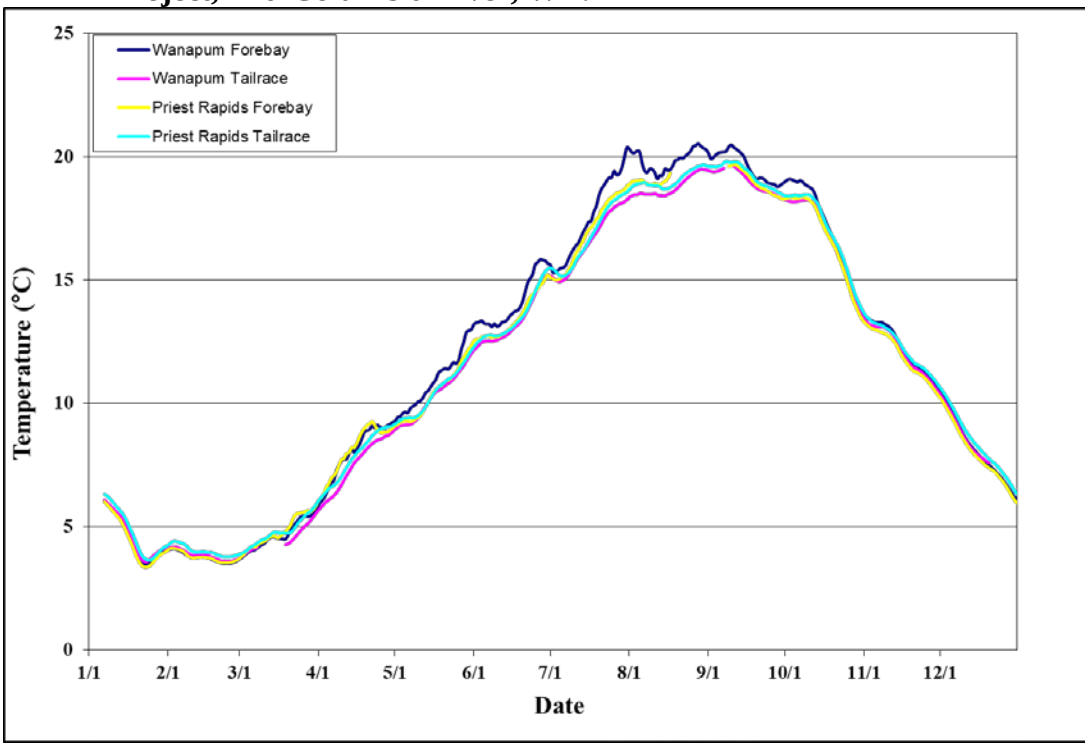

Figure 12 **Seven-day rolling average of daily maximum temperatures (7-DADMax) recorded at each fixed-site monitoring station (FSM station) in 2020, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.**

4.3.2 Water Temperature Modeling

In 2002, Grant PUD funded a water temperature simulation study that examined the effects of the Project on water temperatures using the MASS1 model (Perkins et al. 2002). Results from this study found that the Project does not negatively impact water temperatures and that the Columbia River temperatures are naturally greater than WDOE water quality standards and the Project does not create increases greater than 0.3°C (Perkins et al. 2002).

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

4.3.3 Temperature QA/QC

Per the conditions of the QAPP (Grant PUD 2018), Grant PUD performed QA/QC measurements of all currently operational Hydrolab® multi-probes against an NIST-certified thermometer. Multi-probes and the NIST-certified thermometer were placed into an ice bath to verify temperature accuracy and reliability. Data collected by the multi-probes during exposure to the ice bath were compared to the NIST-certified thermometer to ensure that the temperature sensor of each multi-probe were accurate and reliable. Results from this analysis are displayed in Table 5. As discussed in the QAPP, the accuracy/bias of the temperature sensor is ±0.1°C and thus the results of the ice bath test suggest that all the sensors were within measurement quality objectives as defined by the QAPP (Grant PUD 2018) for the 2020 FSM program season.

Table 5 Temperature QA/QC data collected during 2020.

Date	Model	Serial #	Probe Temp[1]	Digital Thermometer[1]	Difference
3/11/20	DS5	46027	1.07	1.05	**0.02**
3/11/20	DS4a	37428	1.05	1.04	**0.01**
3/11/20	DS4a	39420	1.06	1.03	**0.03**
3/11/20	MS4a	40839	1.08	1.05	**0.03**
3/11/20	DS5x	43947	1.09	1.07	**0.02**
3/11/20	DS4a	37535	1.08	1.07	**0.01**
3/11/20	MS4a	40928	1.08	1.05	**0.03**
3/11/20	DS4a	37517	1.09	1.08	**0.01**
3/11/20	MS5	44768	1.10	1.07	**0.03**
3/11/20	MS4a	42195	1.06	1.06	**0.00**
3/11/20	DS5	46021	1.05	1.03	**0.02**
3/11/20	MS4a	42187	1.06	1.07	**-0.01**
3/11/20	DS5	46043	1.04	1.06	**-0.02**

Notes:
[1]All values represent degrees Celsius.

4.4 Dissolved Oxygen, pH, and Turbidity

Summary results and values (mean, standard deviation, minimum, and maximum) from the periodic grab-sample monitoring of DO, pH, and turbidity values are presented in Table 6. Data collection, QA/QC, and analyses of DO, pH, and turbidity followed those described in the QAPP (Grant PUD 2018). For 2020, some monthly grab sample(s) were not performed due to human

health and safety issues stemming from the Covid-19 pandemic response and other pandemic-related restrictions.

Of the data collected, no DO samples were below 10.0 mg/L, pH values were between 6.5 and 8.5 units, and turbidity ranged from 0.0 to 6.3 NTUs at all FSM stations within the Project during the 2020 FSM program season.

Table 6 Dissolved oxygen, pH, and turbidity grab-sample results in 2020, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.

	WANF[1]			WANT[1]			PRDF[1]			PRDT[1]		
Date	**DO[2]**	**pH[3]**	**Turb[4]**	**DO[2]**	**pH[3]**	**Turb[4]**	**DO[2]**	**pH[3]**	**Turb[4]**	**DO[2]**	**pH[3]**	**Turb[4]**
1/23/2020	11.8	8.4	2.7	12.1	8.4	5.6	11.8	7.8	6.2	11.1	8.0	3.1
2/25/2020	10.2	8.3	3.3	12.5	8.0	2.5	11.6	7.9	1.0	12.4	8.5	1.4
3/17/2020	12.1	8.1	0.1	10.1	8.2	4.4	10.9	7.8	6.3	12.7	8.5	0.5
8/11/2020	11.8	8.3	5.4	11.9	8.0	2.0	10.0	8.2	2.5	13.0	8.0	1.8
9/09/2020	11.1	8.5	3.6	10.4	8.5	4.9	12.5	8.4	0.2	12.6	8.2	0.2
10/22/2020	10.4	8.2	2.5	12.4	8.0	2.5	12.3	8.1	3.4	11.2	7.9	6.1
11/25/2020	11.0	8.5	5.8	10.6	8.3	4.2	10.9	7.9	2.9	11.5	8.4	1.7
12/15/2020	11.9	8.0	6.2	12.0	8.0	4.1	12.8	8.1	2.4	13.0	8.4	5.1
Mean	11.3	8.3	3.7	11.5	8.1	3.8	11.6	8.0	3.1	12.2	8.2	2.5
Min.	10.2	8.0	0.1	10.1	8.0	2.0	10.0	7.8	0.2	11.1	7.9	0.2
Max.	12.1	8.5	6.2	12.5	8.5	5.6	12.8	8.4	6.3	13.0	8.5	6.1
Stdev.	0.7	0.2	1.9	0.9	0.2	1.2	0.9	0.2	2.0	0.8	0.2	2.0

Notes:
[1]WANF = Wanapum Dam forebay, WANT = Wanapum Dam tailrace, PRDF = Priest Rapids Dam forebay, PRDT = Priest Rapids Dam tailrace.
[2]DO values represent mg/L, [3]pH values represent units, and [4]Turbidity values represent NTUs.

5.0 Conclusions

Water quality data collected in 2020 at Grant PUD's FSM stations included hourly TDG and water temperature data and periodic grab-samples of DO, pH, and turbidity. Grant PUD will continue its hourly TDG and water temperature monitoring as well as periodic grab-sampling of DO, pH, and turbidity at its FSM stations in 2021, in accordance with conditions contained in the 401 WQC (WDOE 2007) and the updated QAPP (Grant PUD 2018). Grant PUD will also continue its efforts in 2021 to assure minimal data losses at its FSM stations. These efforts include following the updated QAPP, which outlines standardized equipment calibration/maintenance, data collection, and data management procedures that are meant to achieve data completeness targets of greater than 90% (Grant PUD 2018).

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Appendix A
Omitted/Lost Data Explanations for 2020

Table A-1 Hourly data points omitted/lost from the fixed-site monitoring (FSM) data set during 2020, Priest Rapids Hydroelectric Project, mid-Columbia River, WA.

Location[1]	Date(s)	hr.(s)	Total hr.(s) lost/omitted	Problem/reason for omission	Comments/action taken to correct problem
WANF	11/20	20:00-23:00	4	Communication failure	WQ server rebooted
WANT	9/26	01:00-05:00	5	Communication failure	WQ server rebooted.
PRDF	6/23-7/1	16:00-06:00	180	Probe failure	Replaced with new Probe
PRDF	8/11-9/9	20:00-9:00	686	Cable failure	Replaced with new Cable. Coordinating access to site was difficult during Covid-19 response at Priest Rapids Dam.

Notes:
[1]WANF = Wanapum Dam forebay, WANT= Wanapum Dam tailrace, PRDT= Priest Rapids Dam tailrace