AVISTA CORPORATION

2018

LONG LAKE HED TAILRACE

DISSOLVED OXYGEN

MONITORING REPORT

WASHINGTON 401 CERTIFICATION, SECTION 5.6(B)

Spokane River Hydroelectric Project
FERC Project No. 2545

Prepared By:

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LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
% saturation	percent of saturation
°C	degrees Celsius
7Q10	7-day average flow with a 10-year return period
AC	alternating current
Avista	Avista Corporation
BAR	barometric pressure
cfs	cubic feet per second
DO	dissolved oxygen
DO%	dissolved oxygen percent of saturation
DO TMDL	Dissolved Oxygen Total Maximum Daily Load
DO WQAP	Dissolved Oxygen Water Quality Attainment Plan
DQO	data quality objective(s)
Ecology	Washington State Department of Ecology
FERC	Federal Energy Regulatory Commission
ft amsl	feet above mean sea level
Golder	Golder Associates Inc.
HED	hydroelectric development
m	meter(s)
mg/L	milligrams per liter
mm Hg	millimeters mercury (pressure)
MQO	measurement quality objective
MS5	Hydrolab® MS5 Multiprobe®
LLFB	monitoring station at Long Lake forebay
LLTR	monitoring station at Long Lake tailrace
PDT	Pacific Daylight Time
Project	Spokane River Project
REMI	Reservoir Environmental Management, Inc.
RMSE	root mean squared error
SCCD	Stevens County Conservation District
Spokane Tribe	Spokane Tribe of Indians
TDG	total dissolved gas

1.0 INTRODUCTION

1.1 Background

Water quality monitoring results during the Spokane River Project (Project) relicensing process (HDR 2005) indicate that the Long Lake Hydroelectric Development (HED) discharged water that did not meet the applicable dissolved oxygen (DO) water quality standards at certain times of the year. To address this issue, Avista Corporation (Avista) proposed to conduct a feasibility study to identify potential mechanisms to improve DO levels at the Long Lake HED discharge, evaluate which alternatives are reasonable and feasible, and implement selected alternative(s) to improve DO in the Long Lake HED discharge. Avista initiated this process while relicensing the Project with the Long Lake HED Phase I Aeration Study (HDR 2006).

Avista and the Spokane Tribe of Indians (Spokane Tribe) entered into a non-License Agreement, which addresses DO (and other water quality issues) on the Spokane Tribe's reservation. This Agreement commits Avista to "work collaboratively [with the Spokane Tribe] to develop and carry out feasibility studies and implementation actions pertaining to the goal of meeting the DO, TDG (total dissolved gas), and Temperature requirements at the Reservation boundary."

License Article 401, Appendix B, Condition 5.6(B) of the Washington Section 401 water quality certification (Ecology 2010a) required that Avista "*submit to Ecology a Detailed Phase II Feasibility and Implementation Plan based on the Long Lake HED DO Aeration Study within one year of license issuance (by June 17, 2010), choosing one or several options to implement. The plan shall contain:*

- *Anticipated compliance schedule for conducting preliminary and final implementation plans.*
- *A monitoring plan to evaluate compliance (including avoidance of super-saturation) and coordinate results with the DO TMDL efforts.*"

Avista submitted the Detailed Dissolved Oxygen Phase II Feasibility and Implementation Plan to Washington State Department of Ecology (Ecology) as directed, and Ecology approved it on June 11, 2010 (Avista 2010). Shortly thereafter, DO enhancement testing and monitoring was conducted (HDR and REMI 2010). On December 9, 2010, the Federal Energy Regulatory Commission (FERC; 2010) modified and approved the Feasibility and Implementation Plan. Avista's implementation of the FERC-approved Feasibility and Implementation Plan is documented in the 2011, 2012, and 2013 annual reports (Golder 2012, 2013, and 2014 respectively). Avista's 2014 annual report (Golder 2015) documented 2014 DO conditions along with the Five-Year summary report required under the FERC approved Feasibility and Implementation Plan, which were submitted to Ecology, the Spokane Tribe, and FERC.

Avista has continued to implement this DO enhancement strategy, which includes documenting the 2015, 2016, and 2017 actions in an annual report (Golder and Mattax Solutions 2016, Golder and Mattax Solutions 2017, and Avista 2018 respectively). The 2016 annual report (Golder and Mattax Solutions 2017) presented the results of the 2016 DO conditions along with an analysis of the monitoring results from the past seven years (2010 through 2016). This current report presents the results of the 2018 DO monitoring immediately downstream of Long Lake Dam for the year's low-flow period and summarizes the use of draft tube aeration to boost DO levels in the river below the dam's tailrace.

1.2 Objectives

The objectives of the DO monitoring plan (Avista 2010) are to:

1. Improve the understanding of the seasonal timing and magnitude of DO levels in the Long Lake HED tailrace, particularly as they relate to the applicable water quality standards.
2. Obtain data for aeration feasibility studies for the Long Lake Dam, powerhouse, and tailrace.
3. Document the effectiveness of meeting the DO water quality standards through measure(s) implemented to increase DO levels of Long Lake HED discharges.
4. Document super-saturation caused by measure(s) implemented to increase DO levels of Long Lake HED discharges.
5. Coordinate results with DO Total Maximum Daily Load (TMDL) efforts.

2.0 METHODS

Water quality parameters that were recorded include DO concentration (milligrams per Liter [mg/L]), TDG pressure (millimeters mercury [mm Hg]), and water temperature (°C). Water depth (meters [m]) was also recorded and used in conjunction with water temperature to evaluate the timing of water quality monitoring instruments being out of water and above the minimum TDG compensation depth.

2.1 Equipment and Calibration

Solinst® barologgers were used to determine local barometric pressure. A primary barologger was deployed at the Long Lake HED pump house for the entire monitoring season. A back-up barologger was also deployed at the pump house for the entire monitoring season to provide local barometric pressure (BAR) data if the primary barologger failed. As an additional quality assurance measure, resulting site-specific barometric pressures were compared to corresponding values for the Spokane International Airport for each site visit. Spokane International Airport station sea-level barometric pressures were downloaded from the Weather Underground[1] and adjusted by subtracting 37.05 mm Hg to account for the altitude of the Long Lake HED tailrace (1,365 feet above mean sea level [ft ams]).

Hydrolab® MS5 Multiprobe® (MS5) instruments with TDG, optical DO, temperature, and depth sensors were used. A MS5 connected to an external alternating current (AC) power source was used upon initial deployment with the goal of minimizing potential issues associated with low or no power supply. In addition, a second MS5 powered solely on internal batteries was deployed for long-term monitoring and was paired with the AC-powered MS5 to obtain spot measurements of DO, TDG pressure, and temperature.

[1]On each site visit day, Spokane, WA KGEG barometric pressure data were downloaded from the History & Almanac section of https://www.wunderground.com/history/airport/KGEG/2017/4/7/DailyHistory.html?req_city=Spokane+International&req_state=WA&req_statename=&reqdb.zip=99224&reqdb.magic=3&reqdb.wmo=99999.

All Hach instruments used had undergone annual servicing by Hach and were factory calibrated before the 2018 monitoring season. Monitoring equipment was calibrated according to the manufacturer's instructions prior to deployment and on periodic site visits. Pre-deployment field verification included synchronizing the clocks, comparing each MS5's TDG pressure value with the silastic membrane removed to the ambient barometric pressure, confirming the patency of each MS5's TDG silastic membrane, and testing the barologgers to confirm that the recorded values were similar and comparable to those at the Spokane International Airport.

During service periods, each MS5 was retrieved and the pull time was recorded. Each service session included verification of logging status and downloading the data to a portable field computer. The Solinst® barologgers also were downloaded during these service periods. Patency of the original TDG membrane was confirmed by observing a rapid increase in TDG pressure while pressurizing the sensor with soda water. The manufacturer's instructions were implemented to calibrate depth, DO sensors, and to verify the temperature sensors.

2.2 Station Facilities

For this monitoring, MS5 long-term deployments were done at a water quality monitoring facility located 0.6 mile downstream of Long Lake Dam, referred to as LLTR (Table 2-1; Figure 2-1). As agreed upon with Ecology, the water quality monitoring facilities in the Long Lake HED forebay, referred to as LLFB, was not used in 2018, since water quality conditions at LLTR, not LLFB, are used to refine aeration operations at the Long Lake HED powerplant.

The permanent station at LLTR consisted of a 4-inch-diameter pipe stilling-well (standpipe), which was sealed at the pipe's submerged end to prevent the MS5 from falling out of the pipe. The standpipe had ½-inch-diameter perforations along its sides and a hole at the bottom to provide water exchange between the interior and exterior of the pipe and limit accumulation of sediment and debris in the bottom of the pipe. The standpipe's top end is protected by an enclosed box containing AC power and data communication equipment.

During periods of low tailrace water elevations, the MS5 was removed from the permanent stilling well, placed inside a perforated PVC pipe, and placed directly on the streambed, as near to the outlet of the permanent station's stilling well as possible to ensure the MS5 was consistently under water.

In 2012, Avista installed a real-time data system to transmit MS5 water quality measurements from the LLTR long-term monitoring stations to the HED control room in the powerhouse. A coordinated team of Avista staff, including the HED Operators and water resource specialists, used LLTR's real-time DO and TDG pressure values to select aeration valve openings for each Unit with the goal of meeting the 8-mg/L DO criterion at LLTR without exceeding the 110-percent of saturation TDG criterion.

2.3 Spot Measurements

As a quality assurance measure, spot measurements of DO, TDG pressure, and water temperature were made continuously throughout the sampling season by pairing a secondary MS5 with the primary MS5. The river is generally well mixed at LLTR, as was determined in 2011 based on paired spot measurements of water temperature, DO, and the percent TDG, for both sides of the river (Golder 2012). Therefore, no spot measurements were conducted across the river during the 2018 monitoring season.

2.4 Data Collection and Processing

Parameters monitored at 15-minute log intervals with the instruments described above included:

- Barometric pressure (mm Hg)
- Air Temperature (°C)
- Depth (m)
- TDG pressure (mm Hg)
- Dissolved Oxygen (mg/L)
- Water Temperature (°C)

In addition, percent of saturation for TDG and DO were computed based on measurements, as:

- TDG = TDG in mm Hg / Barometric pressure in mm Hg x 100
- DO percent of saturation (DO%) was computed using equations in the National Park Service's DO Calculator (Thoma and Mailick. n.d.)

Data downloaded to the laptop computer were transferred to an office server and checked for errors using Microsoft Excel®. Erroneous data were identified, assigned data quality codes, and omitted from the final data set.

Long Lake Dam's operations are monitored and recorded by Avista's internal plant control software which were used to output aeration operations, river discharge passing over the dam's spillway, the discharge passing through the dams units, and a total discharge on a 15 minute basis for the extent of the DO monitoring period.

2.5 Monitoring Difficulties

During retrieval of the two probes at LLTR on August 30, the secondary probe (MS5 48762) broke free from its casing and was not able to be retrieved from the water. MS5 60375 was calibrated and redeployed as the secondary probe at LLTR for the rest of the monitoring season. A diver retrieved MS5 48762 on September 14.

Shortly after the primary and secondary loggers were calibrated and redeployed on September 10, the DO values of the two loggers deviated from their typical paired relationship during certain periods of the day. The loggers showed the same trend of rising and falling throughout the day, but the primary logger (MS5 60376) measured lower DO values than the secondary logger. During this time, the DO values of the primary logger would change more than 1 mg/L between 15 minute logging intervals while the other water quality values of the probe (temperature, TDG) did not show a sharp change in value, leading to the conclusion that the DO change seen at these times was not representative of the water characteristics, but technical failures of the DO sensor. Therefore data from the secondary logger was used to represent water quality characteristics from September 10 to the end of the monitoring season. MS5 60376 was replaced after the October 9 calibration with MS5 48762. All MS5s were sent in for factory maintenance after the monitoring season.

3.0 RESULTS

MS5s and barologgers were set to record data for approximately 11,808 15-minute periods (referred to as "continuous" data in this report) from July 1 through October 31 (Table 3-1). Two barologgers deployed at LLTR provided a complete (100 percent of the entire continuous monitoring period) data set for local barometric pressure. Temperature, DO, and TDG data were successfully obtained for greater than 99 percent of the entire continuous monitoring period (Appendix A, Table A-4). Spot measurements collected when long-term deployment and/or instrument downloads were conducted[2] were used for the quality assurance/quality control program described in Appendix A.

3.1 Discharge

Combined Long Lake HED generation, spill discharge, and seepage for the July 1 to October 31 monitoring period ranged from approximately 210 to 6,417 cubic feet per second (cfs) (Table 3-2). The maximum discharge occurred in July, when discharge reached 6,417 cfs. Maximum discharge was 5,176 cfs, 4,735 cfs, and 6,313 cfs in August, September, and October respectively. Average discharge was greatest (2,653 cfs) in October, least (1,677 cfs) in August, and intermediate in July and September (2,584 and 1,914 cfs, respectively).

3.2 Water Temperature

Tailrace (LLTR) water temperature ranged from 17.0°C to 19.7°C in July and reached a seasonal maximum of 20.3°C on August 20 (Figure 3-1). Water temperature cooled to less than 18°C by the beginning of September and steadily cooled to around 11.2°C at the end of October (Figure 3-1).

3.3 Barometric Pressure

Site-specific barometric pressures ranged from 711 to 735 mm Hg based on the Solonist® barologgers deployed at LLTR (Table 3-1).

3.4 Dissolved Oxygen

LLTR DO concentrations (recorded during generation and non-generation) ranged from 6.4 to 10.5 mg/L with the greatest consistent DO concentrations near the end of the monitoring period, when the water was coolest and potential solubility for oxygen is greatest (Figure 3-1). Dissolved oxygen initially decreased to below 8.0 mg/L on July 6 through July 20 and then more consistently fell below 8.0 mg/L starting on August 1 (Figure 3-2). Aeration was used consistently from August 1 through October 8. Figures 3-2 through 3-5 display DO and TDG trends along with aeration operations throughout the progression of the low flow season. These figures show that the daily DO cycle at LLTR peaked in the early afternoon and was lowest in the morning, coinciding with the HED generating schedule. Additional information on the HED's operations, use of spillgates,

[2] This occurred on June 25, July 5, July 20, August 2, August 14, August 30, September 10, September 27, October 9, October 24, and October 31.

aeration operation, and the corresponding frequency of LLTR DO values less than 8.0 mg/L are presented in Table 3-3.

During periods of generation, DO values at LLTR were less than the 8.0-mg/L criterion 9.2 percent of the time during the DO monitoring season (Table 3-3 and 3-4). DO concentrations of less than 8.0 mg/L occurred 0.1 percent of the time in July and 0 percent of the time in October, with most occurring in the last two weeks of August and the first two weeks of September (Table 3-4). Of the DO concentrations below 8.0 mg/L, 35 percent were within 0.2 mg/L of 8.0 mg/L (i.e. 7.8 and 7.9 mg/L, Figure 3-6) with the minimum DO of 6.4 mg/L occurring in the first half of September (Table 3-4). The 2018 aeration operations are summarized in Section 3.6.

DO and other water quality data monitored at LLTR when neither generation nor aeration occurred are summarized in Table 3-5. LLTR's minimum DO concentration for non-generation periods was 6.5 mg/L, which occurred in the last two weeks of September. Non-generation DO values for LLTR were less than the 8.0-mg/L DO criterion for 30.3 percent of the 5,531 15-minute values (Table 3-5). Non-generation DO concentrations of less than 8.0 mg/L occurred throughout the first three months of the monitoring season, but not in October (Table 3-5). These low DO concentrations were within 0.2 mg/L of 8.0 mg/L (i.e. 7.8 and 7.9 mg/L) 36 percent of the time.

Table 3-6 includes a summary of DO values for the entire July 1 through October 31 monitoring season. The frequency for DO less than 8.0 mg/L during generation was 9.2 percent compared with 30.3 percent for non-generation, which resulted in an overall frequency of 19.2 percent (generation and non-generation).

Calculated DO% saturation values ranged from approximately 37.0 to 119.8 percent for LLTR (Table 3-1, Figure 3-7). DO% saturation for LLTR ranged from 70.6 to 119.8 percent during periods of generation (Table 3-4) and from 70.7 to 111.3 percent during non-generation (Table 3-5).

3.5 Total Dissolved Gas

The range of TDG percent was 95.5 to 112.7 percent of saturation for LLTR (Table 3-1). Percent TDG of Long Lake HED discharges monitored at LLTR were greater than the 110.0 percent criterion for 255 (4.1 percent) of the 6,211 values during generation (Table 3-3, Figure 3-6). Tables 3-3 and 3-4 provide additional insight into the HED operations coinciding with these high TDG values. These exceedances of the 110.0 percent of saturation criterion occurred from the beginning of August through mid-September (Figures 3-3 and 3-4). TDG was also greater than the 110.0 percent of saturation criterion during non-generation in this period with an overall frequency of 1.1 percent of the monitoring season (Table 3-7).

3.6 Aeration

Dissolved oxygen levels were monitored from July 1, 2018 through October 31, 2018. Avista operated the HED at varying capacities throughout this period with no spillway releases. Aeration operations were conducted consistently between August 1 and October 8, using different aeration valve openings for Units 1, 3, and 4. Unit 2 was used minimally in 2018 and aeration did not occur the limited time it was in use. Aeration was conducted for a total of 1,657 unit-hours with 0 hours for a single unit, 446 hours for two units simultaneously, and 255 hours for three units simultaneously.[3] The various generating and aeration conditions along with comparisons of DO and TDG during generation, as measured at LLTR to their applicable criteria, are summarized below and in Tables 3-3 and 3-4.

Key conclusions for the 2018 monitoring period, presented by month, are:

- **July**: Aeration was not conducted in July. The frequency of DO being less than 8.0 mg/L was 0.1 percent with a minimum DO being 7.9 mg/L. TDG did not exceed the 110 percent criterion in July.
- **August**: Aeration was conducted on all 31 days with two to three units being used simultaneously, resulting in a total of 743 unit-hours of aeration. These operations resulted in DO meeting the 8.0-mg/L criterion at a frequency of approximately 93.6 percent early in the month and 46.8 percent late in the month. These operations also resulted in elevating TDG to greater than the 110 percent criterion at a frequency of 8.7 percent early in the month and 28.2 percent late in the month, with a maximum TDG of 112.7 percent of saturation.
- **September**: Aeration was conducted daily with two to three units simultaneously, for a total of 717 unit-hours of aeration. These operations resulted in DO meeting the 8.0-mg/L criterion at a frequency of 66.7 percent early in the month and 98.0 percent late in the month. These operations also resulted in elevating TDG to greater than the 110 percent criterion early in the month at a frequency of 7.2 percent, with a maximum TDG of 111.5 percent of saturation.
- **October**: Aeration was conducted through October 8 with two to three units being used simultaneously, for a total of 197 unit-hours of aeration. These operations resulted in meeting the 8.0-mgL DO criterion at a frequency of 100 percent, and did not cause TDG of greater than the 110 percent criterion.

Results of this study demonstrate the continued work Avista puts towards meeting the DO criterion through aeration of the units at Long Lake Dam. From July 1 through October 31 of 2018, daily aeration enabled DO in powerhouse discharges to satisfy the 8.0-mg/L DO criterion approximately 91.8 percent of the time (Table 3-4) and to be within measurement accuracy (i.e., 7.8 mg/L or greater) 94.0 percent of the time (Figure 3-6). Aeration operations maintained TDG that was less than the upper limit of 110 percent of saturation criterion 95.9 percent of the time (Table 3-4). Avista will continue to refine the use of real-time DO and TDG pressure measurements for selecting aeration valve openings, with the goal of providing additional improvements in DO while limiting adverse TDG conditions.

4.0 DISCUSSION

Avista continues to refine their efforts towards addressing low DO concentrations in Long Lake HED discharges in accordance with the approved schedule (Figure 4-1). The 2018 percentage of DO concentration values greater than or equal to 8.0 mg/L were the fourth highest value during generation and third highest value when including non-generation data since monitoring began in 2011 (Table 4-1). Percent TDG was below the 110 percent criterion a remarkable 95.9 percent of

[3] 1,657 unit-hours = (1 unit x 0 hours) + (2 units x 446 hours) + (3 units x 255 hours)

the season during generation and 97.3 percent of the season overall. With these results, Avista plans to continue draft tube aeration operations with adaptive management to improve the effectiveness, using real-time water quality monitoring results.

Avista and others have also implemented measures to improve DO upstream of Long Lake dam. This includes upstream wastewater dischargers working to reduce their point source nutrient loads as well as efforts by Ecology and local conservation districts to reduce nutrient loads from non-point sources (e.g. tributaries and groundwater) in both Washington and Idaho in order to meet the goal of the Spokane River and Lake Spokane DO Total Maximum Daily Load (Ecology 2010). Additionally, Avista has been implementing its Lake Spokane DO Water Quality Attainment Plan (DO WQAP, Avista and Golder 2012) since 2012. The DO WQAP discussed nine feasible potential measures to improve DO conditions in Lake Spokane, identified a baseline monitoring program, implementation activities, and has an annual reporting component. Implementation activities completed in 2018 are summarized in the Lake Spokane DO WQAP 2018 Annual Summary Report (Avista 2019).

Based on the effectiveness of the draft tube aeration program, combined with other measures being implemented to improve DO in Lake Spokane, no new or additional enhancement measures are necessary to meet the Water Quality Standard below Long Lake HED.

4.1 Need for Additional Monitoring

In order to adequately operate the draft tube aeration system for improving DO, but not causing the TDG criterion to be exceeded, there is a continued need for monitoring DO and TDG at LLTR and using the real-time data system to transmit water quality measurements from LLTR to the HED control room in the powerhouse. LLTR monitoring will follow the same procedures used in previous monitoring seasons, as described in the Detailed Dissolved Oxygen Phase II Feasibility and Implementation Plan (Avista 2010). As in previous monitoring seasons, Avista does not plan to monitor at LLFB, since water quality data from LLFB are not used for selecting aeration operations.

Avista will continue to monitor DO and TDG at LLTR and will work with Ecology and the Spokane Tribe to determine the need for providing future annual reports of the aeration, DO and TDG monitoring results following completion of the DO critical season.

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TABLES

Table 2-1. Long Lake HED dissolved oxygen monitoring station.

Station Code	Description	Latitude / Longitude (NAD83)	Monitoring Type
LLTR	On left downstream bank, at a water pump house approximately 0.6 mile downstream from Long Lake dam	47°37'48"/ 117°31'47"	Long-term

Table 3-1. Summary of 2018 continuous water quality monitoring results.

Parameter	LLTR		
	Minimum	Maximum	Count
Date/Time (PDT)	7/1/2018 0:00	10/31/2018 23:45	11,808
Water Temperature (°C)	11.2	20.3	11,764
Dissolved Oxygen (mg/L)	6.4	10.5	11,762
BAR (mm Hg)	711	735	11,805
TDG (mm Hg)	699	815	11,734
TDG (% of saturation)	95.5	112.7	11,731
Dissolved Oxygen (% of saturation)	70.6	119.8	11,759

Table 3-2. Monthly outflow from Long Lake HED.

Month - Year	Minimum Discharge (cfs)	Maximum Discharge (cfs)	Average Discharge (cfs)
July 2018	210	6,417	2,584
August 2018	210	5,176	1,677
September 2018	210	4,735	1,914
October 2018	210	6,313	2,653
July through October 2018	210	6,417	2,210

Table 3-3. Summary of exceedances of dissolved oxygen and total dissolved gas at LLTR during generation.

Period		Operations, Spill, and Aeration Characteristics			LLTR DO					LLTR TDG			
Start	Stop	Operations	Spill	Aeration	Total Number	Number DO <8.0 mg/L	Frequency DO <8.0 mg/L	Min DO (mg/L)	Min DO (%)	Total Number	Number >110.0% [1]	Frequency >110.0% [1]	Max TDG (%)
7/1/18 0:00	7/31/18 23:45	1 to 4 units, capacity varies, generation during portion of the day	No	No units used	1,701	2	0.1%	7.9	87.9	1,695	0	0.0%	107.7
8/1/18 0:00	8/1/18 23:45	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	35	5	14.3%	7.9	90.1	35	0	0.0%	106.7
8/2/18 0:00	8/16/18 23:45	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	541	32	5.9%	7.3	81.1	538	52	9.7%	112.6
8/17/18 0:00	8/18/18 1:00	2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	55	7	12.7%	7.5	85.0	55	0	0.0%	109.9
8/18/18 1:15	9/10/18 23:30	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	870	480	55.2%	6.4	70.6	866	173	20.0%	112.7
9/10/18 23:45	9/13/18 23:45	2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	158	15	9.5%	6.8	74.4	158	10	6.3%	111.5
9/14/18 0:00	9/14/18 23:45	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	59	14	23.7%	7.2	78.0	59	0	0.0%	109.7
9/15/18 0:00	9/16/18 1:00	2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	53	3	5.7%	7.6	83.5	53	20	37.7%	110.3
9/16/18 1:15	9/17/18 1:00	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	51	1	2.0%	7.8	85.3	51	0	0.0%	109.7
9/17/18 1:15	9/23/18 23:45	1 to 2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	391	13	3.3%	7.6	81.8	391	0	0.0%	109.8
9/24/18 0:00	9/24/18 23:45	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	57	3	5.3%	7.7	81.6	57	0	0.0%	106.9
9/25/18 0:00	9/27/18 23:45	2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	180	0	0.0%	8.0	84.6	177	0	0.0%	107.5
9/28/18 0:00	10/1/18 23:45	2 units, capacity varies, generation during portion of the day	No	No units used	226	0	0.0%	8.3	88.4	226	0	0.0%	104.7
10/2/18 0:00	10/4/18 9:45	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	148	0	0.0%	8.1	84.9	148	0	0.0%	104.2
10/4/18 10:00	10/8/18 23:45	2 to 3 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	252	0	0.0%	8.3	85.0	252	0	0.0%	104.7
10/9/18 0:00	10/31/18 23:45	1 to 4 units, capacity varies, generation during portion of the day	No	No units used	1,454	0	0.0%	8.4	85.9	1,450	0	0.0%	102.6
7/1/18 0:00	10/31/18 23:45	1 to 4 units, capacity varies, generation during portion of the day	No	0 or 2 to 3 units used sometime most days	6,231	575	9.2%	6.4	70.6	6,211	255	4.1%	112.7

Notes:

1. 110% TDG criterion is not applicable when discharge exceeds the 7-day average flow with a 10-year return period, which is referred to as the 7Q10.

Table 3-4. Semi-monthly summary of water quality and operations during generation.

Period		HED Operations				LLTR Water Temperature		LLTR DO			LLTR DO%				LLTR TDG%		
Start	Stop	Generation (hours)	Spill (hours)	Average Total Discharge (cfs)	Aeration (unit-hours)	Total Number 15-Min Values	Average Water Temp (°C)	Total Number 15-Min Values	Min DO (mg/L)	Frequency <8.0 mg/L	Total Number 15-Min Values	Min DO%	Max DO%	Frequency <80.0%	Total Number 15-Min Values	Max TDG%	Frequency >110.0% [1]
7/1/18 0:00	7/15/18 23:45	252	0	4,259	0	1,006	17.8	1,006	7.9	0.1%	1,006	87.9	101.2	0.0%	1,003	105.0	0.0%
7/16/18 0:00	7/31/18 23:45	174	0	4,333	0	695	19.0	695	7.9	0.1%	695	89.0	119.8	0.0%	692	107.7	0.0%
8/1/18 0:00	8/15/18 23:45	138	0	4,080	360	545	19.1	545	7.3	6.4%	545	81.1	107.2	0.0%	542	112.6	8.7%
8/16/18 0:00	8/31/18 23:45	143	0	3,929	382	575	18.6	575	6.6	53.2%	575	73.6	105.3	0.0%	575	112.7	28.2%
9/1/18 0:00	9/15/18 23:45	161	0	3,687	398	646	17.4	646	6.4	33.3%	645	70.6	95.6	5.7%	642	111.5	7.2%
9/16/18 0:00	9/30/18 23:45	213	0	3,210	320	848	16.3	848	7.6	2.0%	847	81.6	103.2	0.0%	845	109.8	0.0%
10/1/18 0:00	10/15/18 23:45	214	0	3,590	197	851	14.4	850	8.1	0.0%	850	84.9	99.8	0.0%	846	104.7	0.0%
10/16/18 0:00	10/31/18 23:45	267	0	4,199	0	1,066	12.0	1,066	8.8	0.0%	1,066	85.9	99.4	0.0%	1,066	102.6	0.0%
7/1/18 0:00	10/31/18 23:45	1,565	0	3,917	1,657	6,232	16.4	6,231	6.4	9.2%	6,229	70.6	119.8	1.2%	6,211	112.7	4.1%

Notes:

1. 110% TDG criterion is not applicable when discharge exceeds the 7-day average flow with a 10-year return period, which is referred to as the 7Q10.

Table 3-5. Semi-monthly summary of water quality and operations during non-generation.

Period		HED Operations				LLTR Water Temperature		LLTR DO			LLTR DO%				LLTR TDG%		
Start	Stop	Non-Generation (hours)	Spill (hours)	Average Total Discharge (cfs)	Aeration (unit-hours)	Total Number 15-Min Values	Average Water Temp (°C)	Total Number 15-Min Values	Min DO (mg/L)	Frequency <8.0 mg/L	Total Number 15-Min Values	Min DO%	Max DO%	Frequency <80.0%	Total Number 15-Min Values	Max TDG%	Frequency >110.0% [1]
7/1/18 0:00	7/15/18 23:45	107	0	210	0	430	17.8	430	7.2	24.2%	430	79.8	99.1	0.2%	430	103.4	0.0%
7/16/18 0:00	7/31/18 23:45	209	0	210	0	837	18.7	837	6.8	12.5%	837	76.6	111.3	0.5%	837	106.0	0.0%
8/1/18 0:00	8/15/18 23:45	222	0	210	0	885	18.9	885	7.4	29.8%	884	82.3	99.0	0.0%	881	110.5	0.7%
8/16/18 0:00	8/31/18 23:45	240	0	210	0	956	18.5	955	6.8	66.3%	953	75.7	106.2	9.5%	951	112.3	4.6%
9/1/18 0:00	9/15/18 23:45	198	0	210	0	790	17.3	790	7.0	65.8%	790	76.6	92.5	14.9%	790	110.9	1.1%
9/16/18 0:00	9/30/18 23:45	147	0	210	0	588	16.2	588	6.5	8.8%	588	70.7	99.0	1.2%	588	109.5	0.0%
10/1/18 0:00	10/15/18 23:45	145	0	210	0	582	14.3	582	8.1	0.0%	582	83.6	96.1	0.0%	582	103.3	0.0%
10/16/18 0:00	10/31/18 23:45	116	0	210	0	464	12.1	464	8.7	0.0%	464	86.2	92.6	0.0%	460	100.3	0.0%
7/1/18 0:00	10/31/18 23:45	1,386	0	210	0	5,532	17.2	5,531	6.5	30.3%	5,528	70.7	111.3	4.0%	5,519	112.3	1.1%

Notes:

1. 110% TDG criterion is not applicable when discharge exceeds the 7-day average flow with a 10-year return period, which is referred to as the 7Q10.

Table 3-6. Summary of dissolved oxygen less than 8.0 mg/L, dissolved oxygen criterion lower limit.

Parameter	LLTR		
	Total Number	Number <8.0 mg/L DO	Frequency <8.0 mg/L DO
Generation With Spill > 200 cfs	0	0	na
Generation With Spill ≤ 200 cfs	0	0	na
Generation Without Spill [1]	6,231	575	9.2%
All Generation [1]	6,231	575	9.2%
Non-Generation [2]	5,531	1,678	30.3%
All	11,762	2,253	19.2%

Notes:

1. Of the 6,231 measurements, 371 (6.0%) were less than 7.8 mg/L.
2. Of the 5,531 measurements, 1,077 (19.5%) were less than 7.8 mg/L.

Table 3-7. Summary of total dissolved gas (%) greater than 110.0%, the total dissolved gas criterion upper limit.

Parameter	LLTR		
	Total Number	Number >110% TDG [2]	Frequency >110% TDG
Generation With Spill > 200 cfs [1]	0	0	na
Generation With Spill <200cfs	0	0	na
Generation Without Spill	6,211	255	4.1%
All Generation [2]	6,211	255	4.1%
Non-Generation [3]	5,519	59	1.1%
All	11,731	314	2.7%

Notes:

1. 110% TDG criterion is not applicable when discharge exceeds the 7-day average flow with a 10-year return period, which is referred to as the 7Q10.
2. Of the 6,211 measurements, 16 (0.3%) were greater than 112%.
3. Of the 5,519 measurements, 2 (0.0%) were greater than 112%.

Table 4-1. Aeration operations and frequency of meeting dissolved oxygen and total dissolved gas criteria.

	2010[a]	2011[b]	2012[c]	2013[d]	2014[e]	2015[f]	2016[g]	2017[h]	2018
Long Lake HED Operations									
Average July - October Discharge (cfs)	nr	3,819	2,941	2,298	2,441	1,396	2,270	2,468	2,210
HED Units with Aeration	Tested aeration of Units 3 and 4	Units 3 and 4 with no more than 1 unit aerating at same time	Units 1 and 2 with up to 2 units aerating at same time	Units 1, 2, 3, and 4 with up to 3 units aerating at same time	Units 1, 2, 3, and 4 with up to 3 units aerating at same time	Units 1, 2, 3, and 4 with up to 3 units aerating at same time	Units 1, 2, 3, and 4 with up to 3 units aerating at same time	Units 1, 2, 3, and 4 with up to 3 units aerating at same time	Units 1, 2, 3, and 4 with up to 3 units aerating at same time
Aeration start and end dates, respectively	September 1 and 2	August 24 and October 19	August 2 and October 14	August 6 and October 6	July 24 and October 21	July 1 and October 31	July 7 and October 11	July 17 and October 18	August 1 and October 8
Aeration Hours	25 unit-hours within 14 hours	684 unit-hours within 684 hours	1,687 unit-hours within 1,021 hours	1,562 unit-hours within 859 hours	2,282 unit-hours within 1,045 hours	2,204 unit-hours within 1,000 hours	1,944 unit-hours within 976 hours	1,992 unit-hours within 1,002 hours	1,657 unit-hours within 701 hours
Frequency LLTR Dissolved Oxygen ≥8.0 mg/L									
During Generation without Spillgate Use[g]	Test results indicate aeration could achieve DO of 7.5 and 8 mg/L while maintaining TDG% <110%	80.8% of 6,709 values	84.7% of 8,272 values	91.5% of 6,826 values	87.4% of 6,656 values	65.1% of 4,434 values	95.6% of 7,039 values	97.4% of 7,130 values	90.8% of 6,231 values
During Generation with Spillgate Use[h]		100.0% of 1,472 values	100.0% of 484 values	zero values	100.0% of 4 values	zero values	zero values	zero values	zero values
Entire Generation Period		84.2% of 8,181 values	85.5% of 8,756 values	91.5% of 6,826 values	87.4% of 6,660 values	65.1% of 4,434 values	95.6% of 7,039 values	97.4% of 7,130 values	90.8% of 6,231 values
Entire Monitoring Period (Both Generation and non-Generation)		67.2% of 11,787	67.6% of 11,786	75.0% of 11,772 values	74.3% of 11,445 values	49.4% of 11,764 values	85.7% of 11,733 values	86.7% of 11,585 values	80.8% of 11,762 values
Frequency LLTR TDG% ≤110.0%									
During Generation without Spillgate Use[i]	Test results documented that draft-chest aeration could cause TDG% >110%	99.9% of 6,676 values	96.2% of 8,262 values	88.8% of 6,825 values	86.6% of 6,773 values	88.3% of 4,420 values	91.8 of 7,017 values	99.0% of 7,065 values	95.9% of 6,211 values
During Generation with Spillgate Use[j]		0.7% of 1,467 values	4.3% of 484 values	zero values	75.0% of 4 values	zero values	zero values	zero values	zero values
Entire Generation Period		82.0% of 8,143 values	91.1% of 8,746 values	88.8% of 6,825 values	86.6% of 6,777 values	88.3% of 4,420 values	91.8% of 7,017 values	99.0% of 7,065 values	95.9% of 6,211 values
Entire Monitoring Period (Both Generation and non-Generation)		87.6% of 11,748	93.4% of 11,773	93.9% of 11,768 values	90.5% of 11,616 values	95.1% of 11,750 values	94.2% of 11,701 values	99.3% of 11,519 values	97.3% of 11,731 values

Notes:

nr = data not analyzed

[a] September 1 and 2, 2010 aeration testing is documented in HDR and REMI (2010, Section 7.0 and Appendix C).

[b] 2011 Monitoring is documented in Golder (2012).

[c] 2012 Monitoring is documented in Golder (2013).

[d] 2013 Monitoring is documented in Golder (2014).

[e] 2014 Monitoring is documented in Golder (2015).

[f] 2015 Monitoring is documented in Golder and Mattax Solutions (2016).

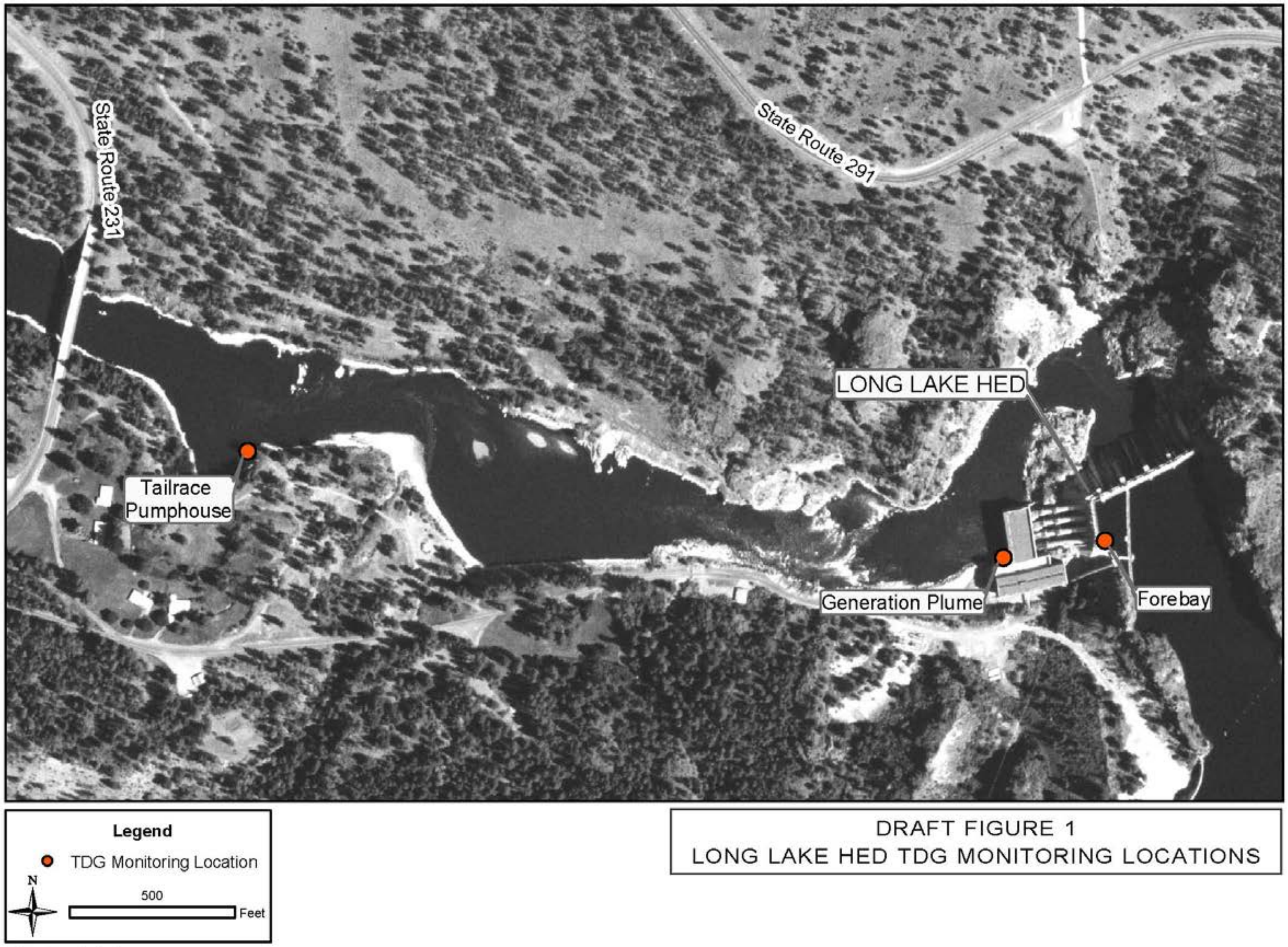
[g] 2016 Monitoring is documented in Golder and Mattax Solutions (2017).

[h] 2017 Monitoring is documented in Avista (2018).

[i] Includes periods of <200 cfs spill in 2014 and 2015.

[j] Excludes periods of <200 cfs spill in 2014 and 2015.

FIGURES



Source: Avista

Figure 2-1: Long Lake HED long-term water quality monitoring location.

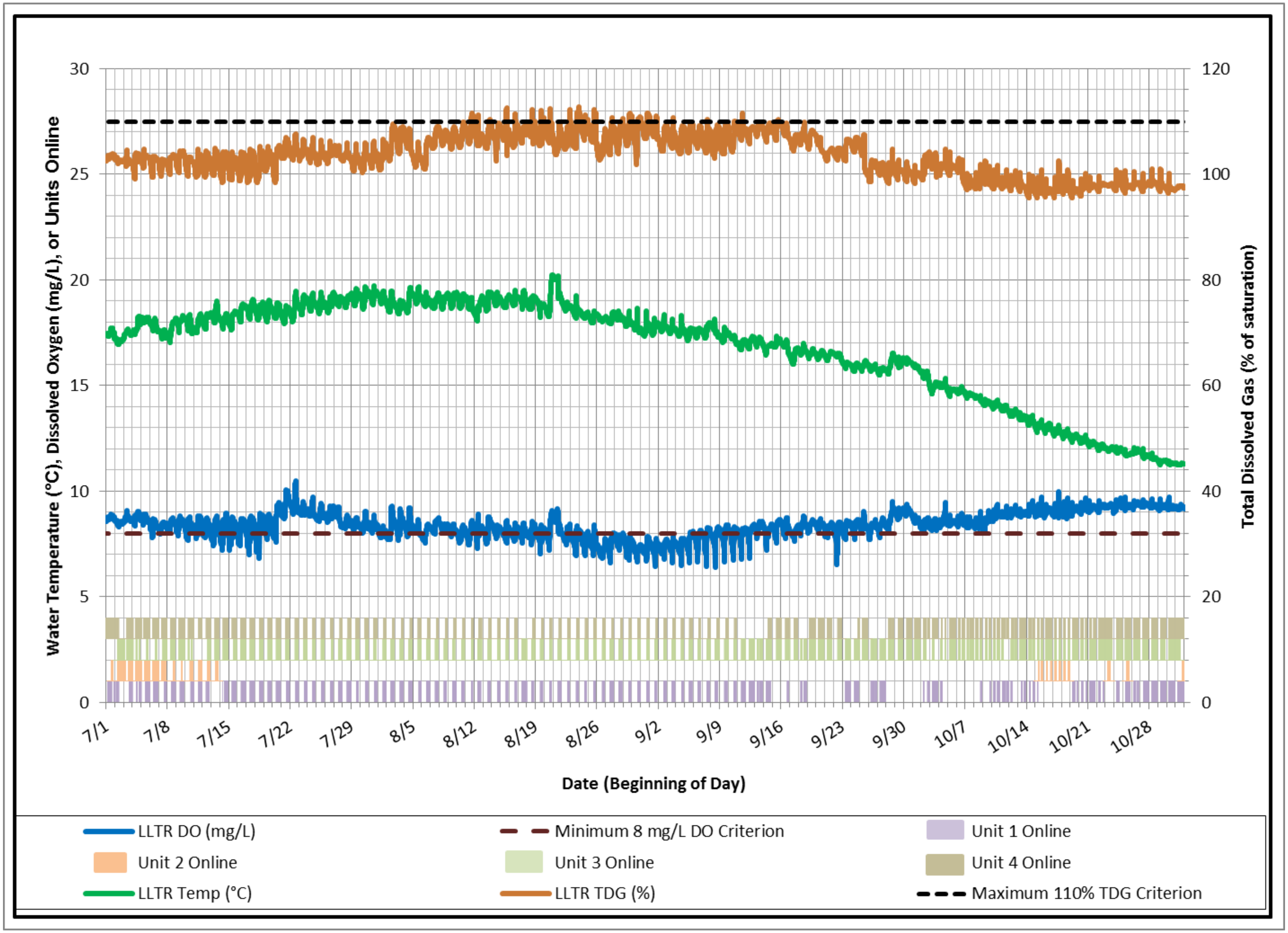


Figure 3-1: LLTR 2018 water temperature (°C), dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations.

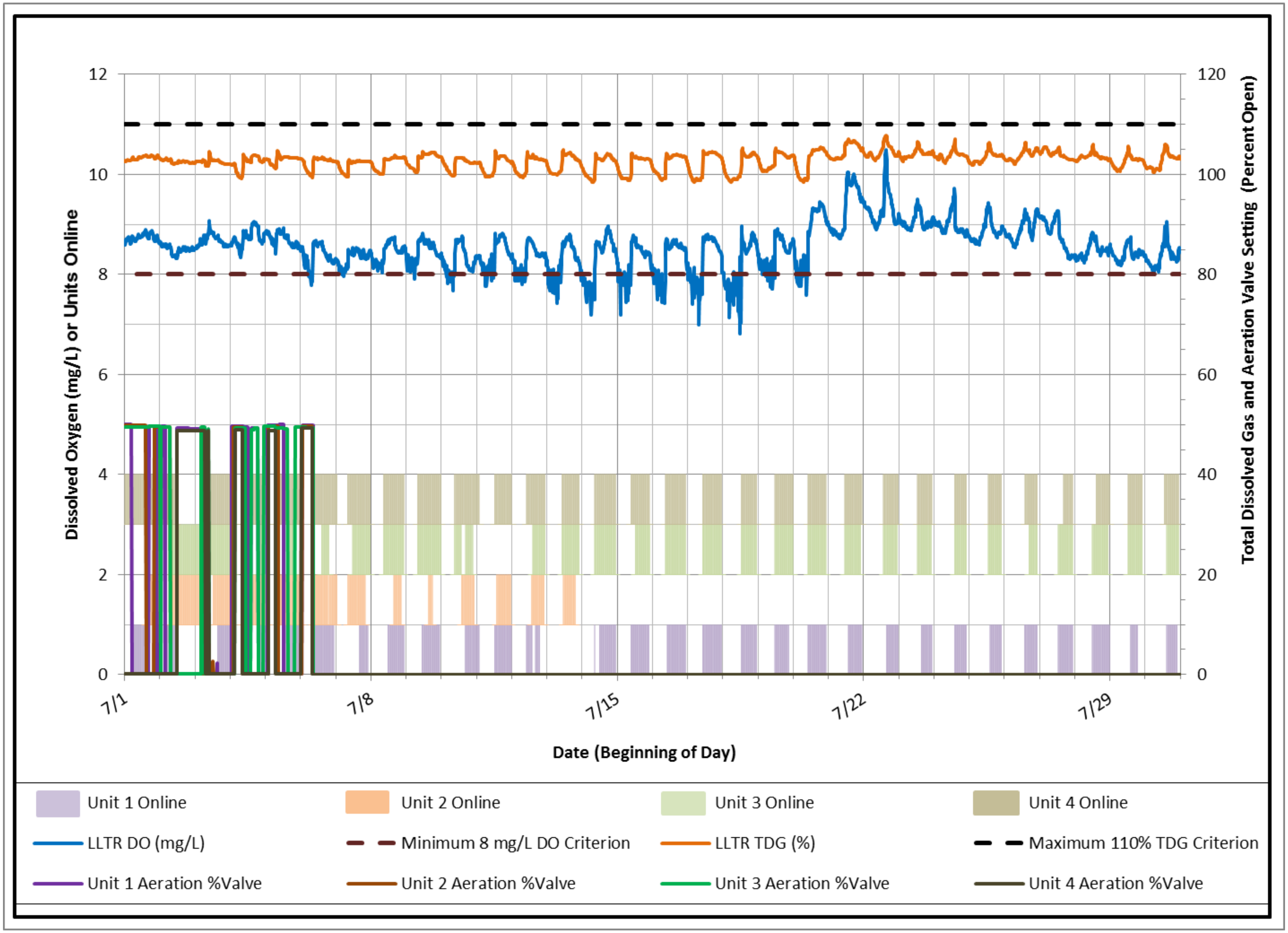


Figure 3-2: LLTR dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations, July 1 – July 31.

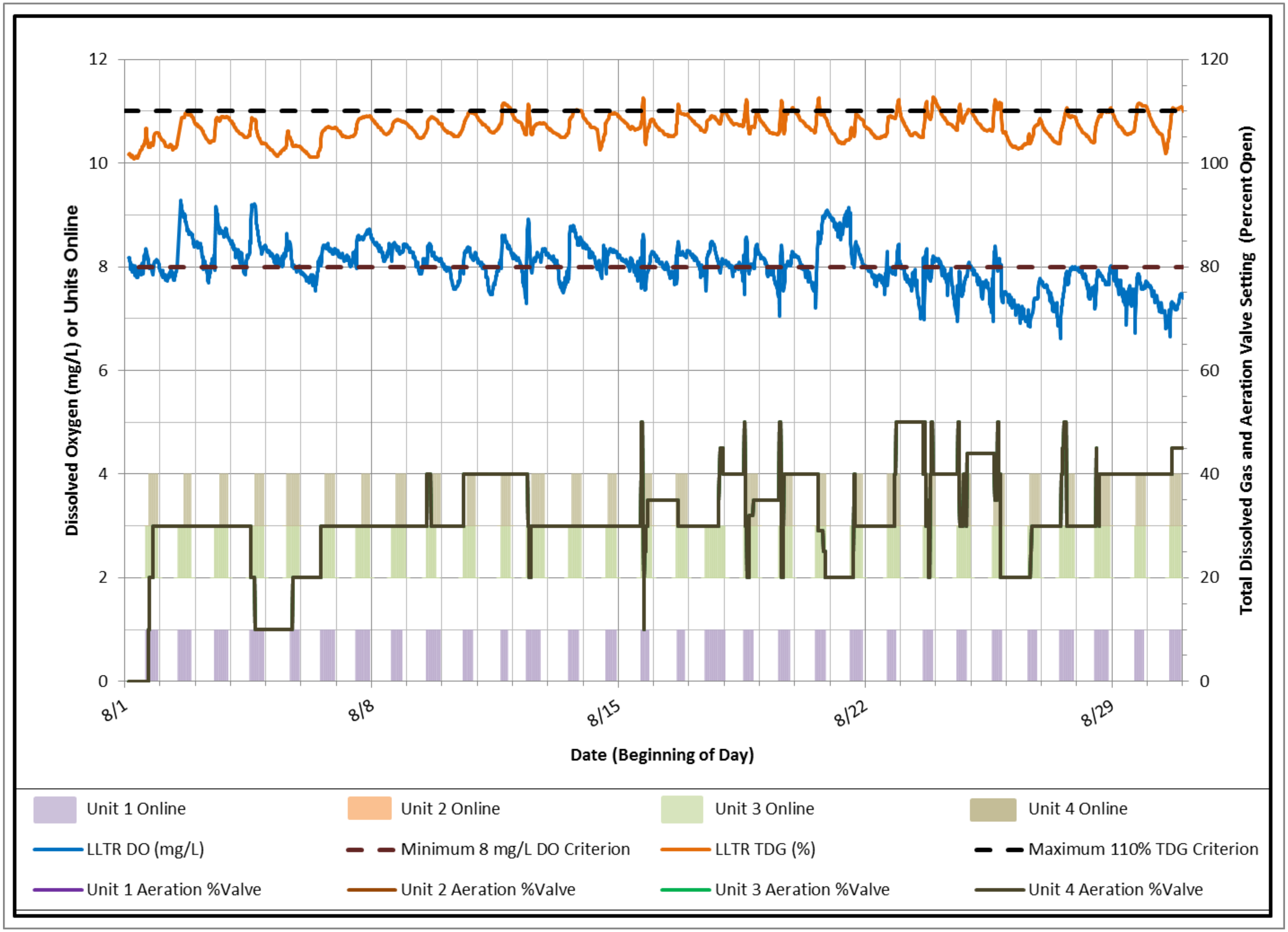


Figure 3-3: LLTR dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations, August 1 – August 31.

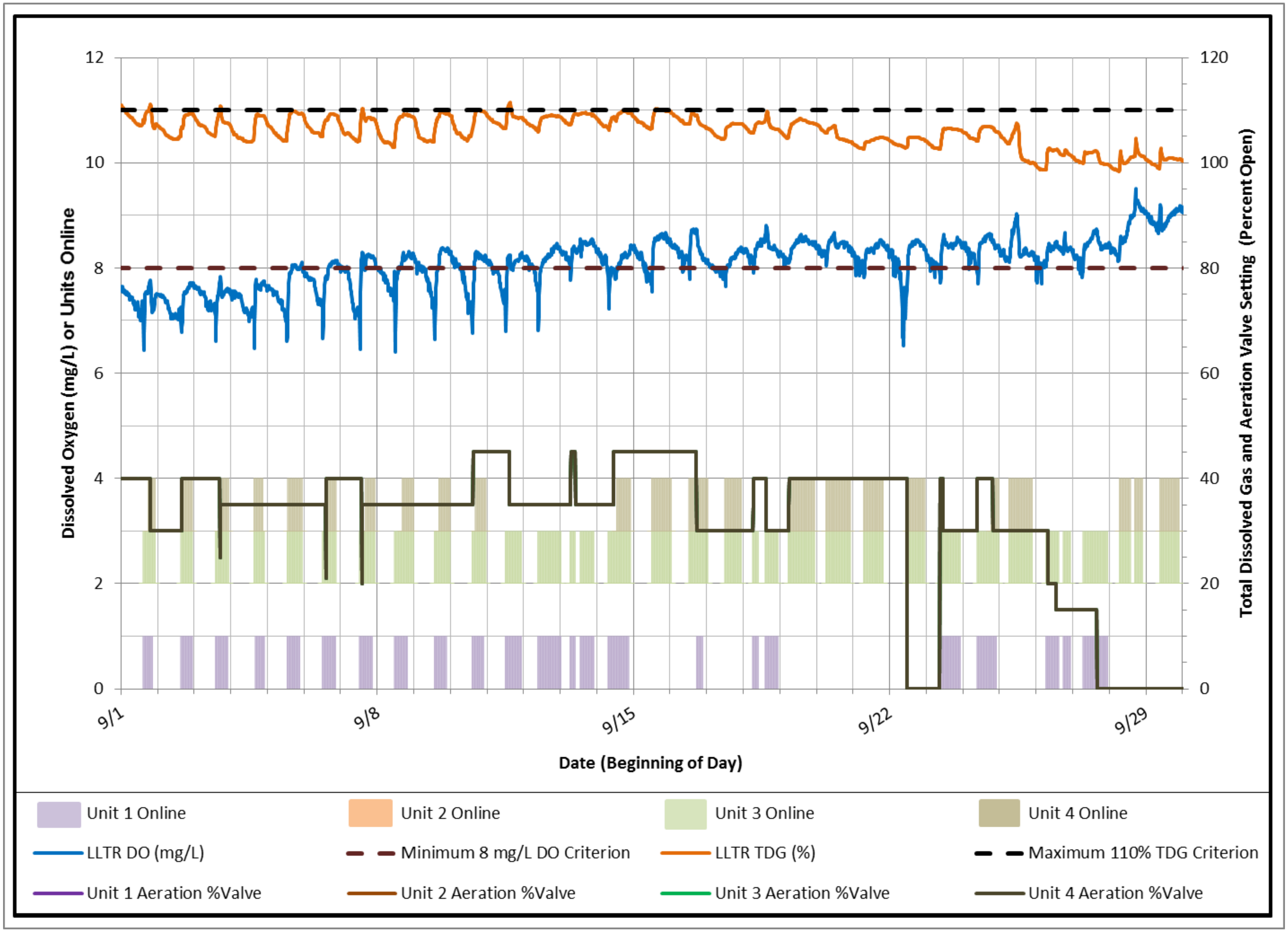


Figure 3-4: LLTR dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations, September 1 – September 30.

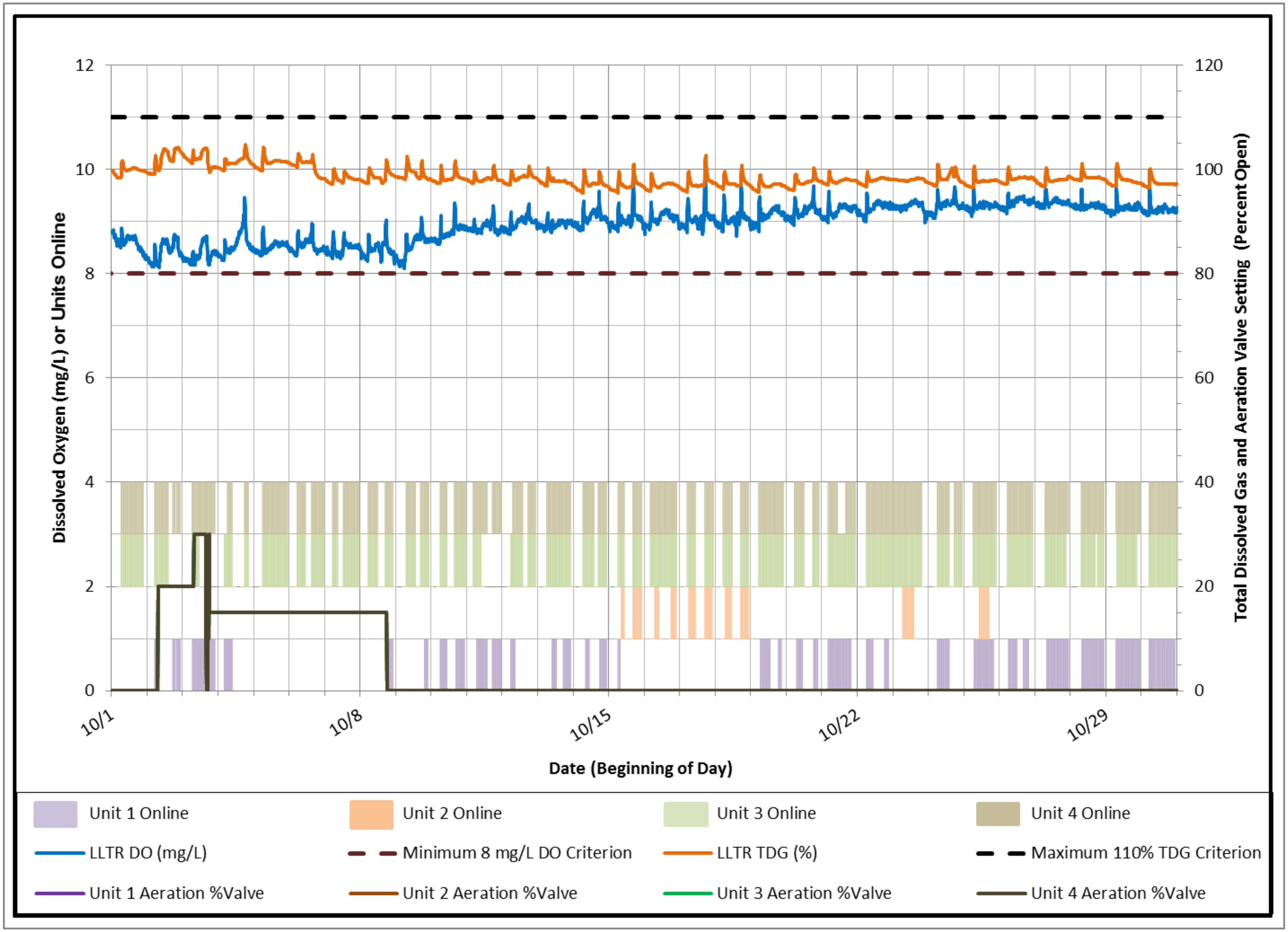


Figure 3-5: LLTR dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations, October 1 – October 31.

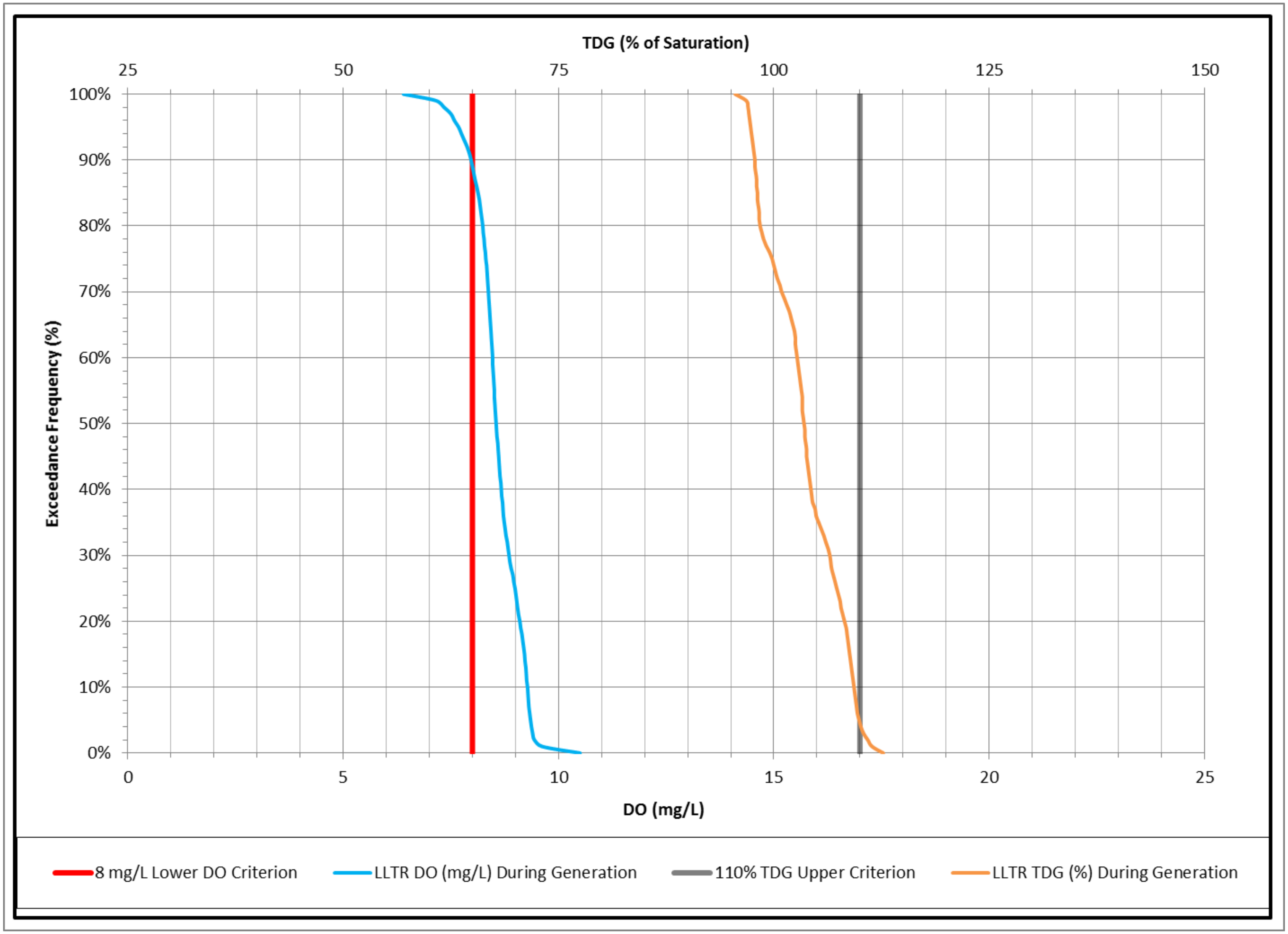


Figure 3-6: LLTR dissolved oxygen (mg/L) concentration and total dissolved gas (% of saturation) exceedance frequency during generation.

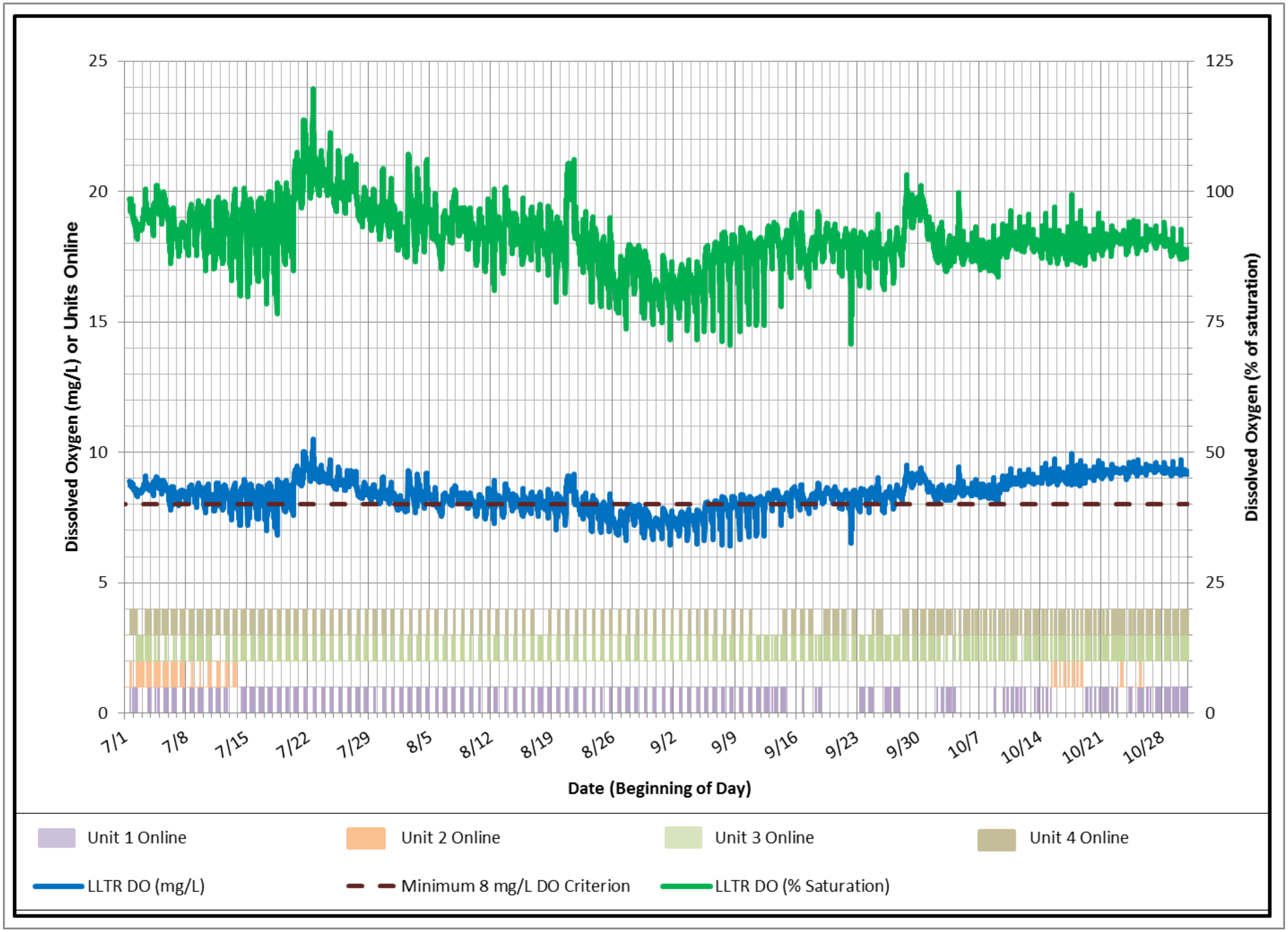


Figure 3-7: LLTR dissolved oxygen concentration (mg/L) and percent of saturation and operations.

Action	Task	2009	2010	2011	2012	2013	2014	2015
Structural Modifications	Phase II – Apply modeling tools to determine alternatives most likely to be effective		S	S	S			
	Phase II – Identify highest priority alternative to be field tested		S					
	Phase II – Prepare Work Plan to test effectiveness of highest priority alternative		S					
	Phase II – Implement Work Plan and prepare summary report		S					
	Phase II – Determine if additional aeration measures are necessary, and prepare/implement corresponding Work Plans for testing effectiveness of additional high priority aeration measures			(S)	(S)			
	Phase III - Construct permanent modifications for preferred alternative			S	S			
	Phase IV - Evaluate need for any additional DO enhancement measures					S	S	
Monitoring	Select/design permanent monitoring stations and develop monitoring plan	M	M					
	Prepare and implement Phase II water quality monitoring plan(s) for testing of high priority alternatives		M	(M)	(M)			
	Monitor DO and other relevant water quality conditions at the 0.6 mile downstream of Long Lake Dam (LLTR)		M	M	M	M	M	
	Annual Monitoring Report			M	M	M	M	
	Five-Year Report							M

Legend

S	Structural
M	Monitoring

() Only done if testing demonstrates need for additional Long Lake HED discharge aeration measures.

Figure 4-1. Approved Long Lake HED DO feasibility and implementation schedule.

APPENDIX A
DATA QUALITY ANALYSIS

DATA QUALITY SUMMARY

Data quality objectives (DQOs) and Measurement Quality Objectives (MQOs) are the quantitative and qualitative terms used to specify how good the data need to be to meet the project's specific monitoring objectives. DQOs for measurement data, also referred to as data quality indicators, include measurement range, accuracy, precision, representativeness, completeness, and comparability. The range, accuracy, and resolution for each measured parameter are provided in Table A-1.

Table A-1. Range, accuracy and resolution of parameters recorded.

Instrument and Parameter	Range	Accuracy	Resolution
MS5 Total Dissolved Gas	400 to 1300 mmHg	±0.1% of span	1.0 mmHg
MS5 Dissolved Oxygen	0 to 30 mg/L	± 0.01 mg/L for 0 to 8 mg/L ± 0.02 mg/L for >8mg/L	0.01 mg/L
MS5 Temperature	-5 to 50°C	±0.10°C	0.01°C
MS5 Depth (0-25 meters)	0 to 25 meters	±0.05 meter	0.01 meter
Barologger Relative Barometric Pressure	1.5 meter of water	± 0.1 cm of water	0.002% of full scale
Barologger Temperature	-10 to 40°C	± 0.05°C	0.003°C

Note: Sources: Hach MS5 User Manual and Solinist Levelogger User Guide [4]

MQOs are the performance or acceptance thresholds or goals for the project's data, based primarily on the data quality indicators precision, bias, and sensitivity. Table A-2 presents MQOs selected during preparation of the Long Lake HED tailrace DO monitoring plan. The meter-specific root mean squared error (RMSE) of the calibration corrections applied after each calibration, and an overall RMSE for all meters compared to MQOs are shown in Table A-3.

Table A-2. Measurement quality objectives.

Parameter	MQOs
Barometric Pressure	2 mmHg
Temperature	0.5ºC
Total Pressure	1% (5 to 8 mmHg)
TDG%	1%
Dissolved Oxygen	0.5 mg/L

[4]Hach Corporation. 2006. Hydrolab DS5X, DS5, and MS5 Water Quality Multiprobes User Manual. February 2006, Edition 3. Catalog Number 003078HY and Solinist. 2010. Levelogger Series (Levelogger Gold, Barologger Gold, Levelogger Junior, LTC Levelogger Junior and Rainlogger) User Guide - Software Version 3.4.0. August 17, 2010.

Table A-3. Difference between RMSE and MQOs by MS5.
Table Part 1: Barometric Pressure (BAR), Total Pressure, Total Dissolved Gas (TDG)

LLHED TDG Monitoring	RMSE [1]				MQO				RMSE - MQO (positive shaded values denote exceedance of MQO)			
Meter and Site IDs	BAR[2]	Total Pressure[3]	TDG-cal[4]	TDG-spot	BAR	Total Pressure	TDG	TDG	BAR	Total Pressure	TDG-cal	TDG-spot
	mm Hg	%	%	mm Hg	mm Hg	%	%	mmHg	mm Hg	%	%	mm Hg
60375	0.77	0.11	0.11	2.83	2	1	1	5	-1.23	-0.89	-0.89	-2.17
60376	0.71	0.10	0.10	3.56	2	1	1	5	-1.29	-0.90	-0.90	-1.44
48762	0.93	0.13	0.13	3.02	2	1	1	5	-1.07	-0.87	-0.87	-1.98
Overall RMSE	0.81	0.11	0.11	3.13	2	1	1	5	-1.19	-0.89	-0.89	-1.87

[1] RMSE calculated for each meter during calibration checks while in use and between spot measurements from multiple meters.

[2] RMSE calculated from BAR measured during calibration compared to the TDG in air uncorrected reading.

[3] RMSE calculated as the difference in TDG in air uncorrected measured during calibration minus the BAR, then divided by the TDG and multiplied by 100%.

[4] RMSE calculated as TDG in air uncorrected measured during calibrations divided by the BAR and multiplied by 100%

N/A - No value reported or not applicable.

Table A-3 (Continued). Difference between RMSE and MQOs by MS5
Table Part 2: Temperature and Dissolved Oxygen (DO)

LLHED DO Monitoring	RMSE				MQO		RMSE - MQO (positive shaded values denote exceedance of MQO)			
Meter and Site IDs	Temperature[1]		Dissolved Oxygen[2]		Temp	DO	Temperature[1]		Dissolved Oxygen[2]	
	Calibration	Spot	Calibration	Spot			Calibration	Spot	Calibration	Spot
	ºC	ºC	mg/L	mg/L	ºC	mg/L	ºC	ºC	mg/L	mg/L
60375	0.04	0.02	0.02	0.09	0.5	0.5	-0.46	-0.48	-0.48	-0.41
60376	0.14	0.03	0.07	0.07	0.5	0.5	-0.36	-0.47	-0.43	-0.43
48762	0.09	0.03	0.05	0.07	0.5	0.5	-0.41	-0.47	-0.45	-0.43
Overall RMSE	0.10	0.03	0.05	0.08	0.5	0.5	-0.40	-0.47	-0.45	-0.42

[1] For Calibration, RMSE calculated from the difference between the meter and calibration thermometer at all calibration checks while the meter was in use. Spot differences are average differences between measured values from group average.

[2] Calibration RMSE as difference of the calculated pre-calibration and post-calibration measurement. Spot RMSE calculated as average difference between measured values from group average.

N/A - No value reported or not applicable

Root mean squared error (RMSE) = $\sqrt{\frac{\sum_{i=1}^{n}(x_{1,i}-x_{2,i})^2}{n}}.$

Measurement Range

The measurement range, range of reliable readings of an instrument or measuring device, specified by the manufacturer is displayed in Table A-1 for each measured parameter. Maintenance of field sampling equipment was conducted in a manner consistent with the corresponding manufacturer's recommendations to provide reliable readings within each instrument's reported measurement range.

Bias

TDG meters, like other field monitoring instruments, are subject to bias due to systematic errors introduced by calibration, equipment hardware or software functioning, or field methods. Bias was minimized by following standard protocols for calibration and maintenance, and by following field protocols for stabilization of meter readings.

Precision

Precision refers to the degree of variability in replicate measurements and is typically defined by the instrument's manufacturer. Manufacturer values for the MS5 and barologger (Table A-1) were within MQOs.

Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value (low bias). Throughout this seasonal DO monitoring study, the MS5s underwent calibration and verification procedures.

Instrument accuracy was evaluated through the calibration and maintenance activities along with paired spot measurements (Table A-3). MQOs for all parameters (i.e., DO, temperature, BAR, total pressure, and TDG) were met for all three meters used in the 2018 low-flow monitoring season.

Discharge data were obtained from Avista's internal plant control software and is found to be accurate and reliable.

Representativeness

Representativeness qualitatively reflects the extent to which sample data represent a characteristic of actual environmental conditions. For this project, representativeness was addressed through proper design of the sampling program to ensure that the monitoring locations were properly located and sufficient data were collected to characterize DO at that location.

Comparability

Comparability is the degree to which data can be compared directly to previously collected data. Comparability was achieved by consistently monitoring the same downstream long-term monitoring station (LLTR) monitored in the past.

Completeness

Completeness is the comparison between the quantity of data planned to be collected and how much usable data was actually collected, expressed as a percentage (Table A-4). The DO data collection period consisted of 11,808 15-minute periods. DO and all remaining parameters had completeness of greater than 99 percent, which exceeded the goal of 90 percent completeness. Table A-5 summarizes the number of specific DQ Codes applied to LLTR data.

Table A-4. Project completeness.

	LLTR	
	Count	**Completeness (%)**
Monitoring Period	11,808	--
Water Temperature (°C)	11,764	99.6%
Dissolved Oxygen (mg/L)	11,762	99.6%
BAR (mm Hg)	11,805	100.0%
TDG (mm Hg)	11,734	99.4%
TDG (% of saturation)	11,731	99.3%
Dissolved Oxygen (% of saturation)	11,759	99.6%

Table A-5. Number of Specific DQ Codes during the Monitoring Period, July 1 at 0:00 PT through October 31 at 23:45 PT of 2018.

DQ Code	DQ Code Description	LLTR						
		Temp (°C)	TDG (mmHg)	Depth (meters)	DO (mg/L)	Batt (volts)	Level (m H2O)	ATemp (°C)
999	Instrument logging data before deployment at monitoring station	11	11	11	11	11	0	0
998	Out of water after recovery	7	7	7	7	7	0	0
997	Equilibrating after deployment	0	30	0	0	0	0	0
993	Calibration/servicing	24	24	24	24	24	0	0
991	Instrument not deployed at typical long-term depth	2	2	2	2	2	0	0
666	Unknown	0	0	0	0	0	3	3
304	Suspect DO value to be inaccurate	0	0	0	1	0	0	0
0	No data qualifiers	11,755	11,725	11,755	11,754	11,755	11,805	11,805
-1000	Spot Measurement	3	3	3	3	3	0	0
-1002	Corresponds with spot measurement	6	6	6	6	6	0	0
	Monitoring Period[1]	11,808	11,808	11,808	11,808	11,808	11,808	11,808

Notes:

1. Monitoring period was from July 1, 2018 at 0:00 PT to October 31, 2018 at 23:45 PT.
2. Mass verifications were conducted on June 25, 2018 at 14:30 PT.

APPENDIX B

CONSULTATION RECORD

AVISTA
1411 East Mission Avenue
PO Box 3727
Spokane, WA 99220-3727

February 28, 2019

Patrick McGuire, Water Quality Program
Washington Department of Ecology
Eastern Regional Office
4601 N Monroe Street
Spokane, WA 99205-1295

Subject: Federal Energy Regulatory Commission's Spokane River Hydroelectric Project License, Appendix B, Sections 5.4 and 5.6.B, TDG and DO Reporting Requirements

Dear Pat:

Ordering Paragraph E of the Federal Energy Regulatory Commission (FERC) Spokane River Hydroelectric Project License incorporated the Washington Department of Ecology (Ecology) Certification Conditions under Section 401 of the Federal Clean Water Act Water Quality Certification (Certification) as Appendix B of the License. In accordance with Section 5.4 and Section 5.6 of the Certification, Avista is submitting the following project status and reports for your review and approval.

Section 5.4: Total Dissolved Gas
There are two components related to Total Dissolved Gas (TDG), which include the following:

- *2018 Long Lake Total Dissolved Gas Monitoring Report*
  Avista completed the Long Lake Dam Spillway Modification Project in December 2016. Following completion of the project, Avista monitored TDG to assess the effectiveness of the modifications and to evaluate spillgate operational protocols. The enclosed 2018 Long Lake TDG Monitoring Report provides the results of the TDG monitoring and spillgate operational protocol evaluation completed during 2018.

  In accordance with the revised Long Lake Hydroelectric Development (HED) TDG Compliance Schedule (approved in 2015), Avista has now completed two years of post-construction monitoring, reporting, and spillgate testing. During 2019, Avista will monitor TDG to fulfill the third year of effectiveness monitoring and will implement the 2018 spillgate operational protocol.

- *Nine Mile TDG Monitoring*
  In accordance with Ecology's February 17, 2012 letter, Avista did not conduct TDG monitoring at its Nine Mile HED during 2018. As described in our August 30, 2018 letter to Ecology, Avista completed the turbine units 1 and 2 replacement project in 2016 and the sediment bypass system upgrade and associated intake deck and trashrack cleaning system were completed in 2018. With these projects completed, Avista plans to resume TDG monitoring in 2019.

Per Section 5.4(C), Avista shall collect TDG data for two years when flows occur during the 7Q10 median flow. With the resumption of TDG monitoring, Avista will no longer provide the required annual updates on the TDG monitoring schedule by September 1 to both Ecology and FERC and will instead submit a TDG monitoring summary report to Ecology and FERC, following the season the data is collected.

Section 5.6.B: Dissolved Oxygen
The enclosed 2018 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report provides the results of the 2018 Dissolved Oxygen (DO) monitoring immediately downstream of Long Lake Dam for the low-flow period of the year and summarizes the use of draft tube aeration to increase DO levels in the river below the dam's tailrace. Avista plans to continue with the aeration program in 2019, and to continue monitoring DO and TDG at the Long Lake Dam Tailrace Station.

With this, Avista is submitting the 2018 Long Lake TDG Monitoring Report and the 2018 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report for Ecology's review and approval. We would like to receive any comments or recommendations that you may have by **March 29, 2019**, which will allow us time to file these reports with FERC by April 15, 2019.

Please feel free to contact me at (509) 495-4084 or Meghan Lunney at (509) 495-4643 if you have any questions or wish to discuss the report.

Sincerely,

Chris Moan
Fisheries Habitat Biologist

Enclosures (2)

cc: Chad Atkins, Ecology
Chad Brown, Ecology
Brian Crossley, Spokane Tribe
Meghan Lunney, Avista

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

4601 N Monroe Street • Spokane, WA 99205-1295 • 509-329-3400

March 27, 2019

Chris Moan
Fisheries Habitat Biologist
Avista Corporation
1411 East Mission Avenue, MSC-1
Spokane, WA 99220-3727

RE: Request for Ecology Review and Comments – *2018 Long Lake Tailrace Dissolved Oxygen Monitoring Report.*
Spokane River Hydroelectric Project, No. P-2545

Dear Chris Moan:

The Department of Ecology (Ecology) has reviewed the *2018 Long Lake Tailrace Dissolved Oxygen Monitoring Report* sent to Ecology on February 28, 2019. The Report is a requirement of Section 5.6.B of the 401 Certification.

Ecology APPROVES the report and has no comments.

Please contact me at (509) 329-3567 or pmcg461@ecy.wa.gov if you have any questions.

Sincerely,

Pat McGuire

Patrick McGuire
Eastern Region Hydropower Projects 401 Certification Manager
Water Quality Program

PDM:red

cc: Meghan Lunney, Avista

ECOLOGY COMMENTS AND AVISTA RESPONSES

Ecology Comment

Ecology has no comments and approves the *2018 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report* as submitted.

Avista Response

Avista appreciates Ecology's review and approval of the *2018 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report.*

AVISTA

1411 East Mission Avenue
PO Box 3727
Spokane, WA 99220-3727

February 28, 2019

Brian Crossley
Water & Fish Program Manager
Spokane Tribe Natural Resources
P.O. Box 480
Wellpinit, WA 99040

Subject: Federal Energy Regulatory Commission's Spokane River Hydroelectric Project License, Appendix B, Sections 5.4 and 5.6.B, TDG and DO Reporting Requirements

Dear Brian:

Ordering Paragraph E of the Federal Energy Regulatory Commission (FERC) Spokane River Hydroelectric Project License incorporated the Washington Department of Ecology (Ecology) Certification Conditions under Section 401 of the Federal Clean Water Act Water Quality Certification (Certification) as Appendix B of the License. Per Sections 5.4 and 5.6.B of the Certification, and the October 2008 Settlement Agreement between Avista and the Spokane Tribe, Avista is submitting the following project status and reports for your review and comment.

Section 5.4: Total Dissolved Gas
There are two components related to Total Dissolved Gas (TDG), which include the following:

- *2018 Long Lake Total Dissolved Gas Monitoring Report.*
  Avista completed the Long Lake Dam Spillway Modification Project in December 2016. Following completion of the project, Avista monitored TDG to assess the effectiveness of the modifications and to evaluate spillgate operational protocols. The enclosed 2018 Long Lake TDG Monitoring Report provides the results of the TDG monitoring and spillgate operational protocol evaluation completed during 2018.

  In accordance with the revised Long Lake Hydroelectric Development (HED) TDG Compliance Schedule (approved in 2015), Avista has now completed two years of post-construction monitoring, reporting, and spillgate testing. During 2019, Avista will monitor TDG to fulfill the third year of effectiveness monitoring and will implement the 2018 spillgate operational protocol.

- *Nine Mile TDG Monitoring*
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Per Section 5.4(C), Avista shall collect TDG data for two years when flows occur during the 7Q10 median flow. With the resumption of TDG monitoring, Avista will no longer provide the required annual updates on the TDG monitoring schedule by September 1 to both Ecology and FERC and will instead submit a TDG monitoring summary report to Ecology and FERC, following the season the data is collected.

Section 5.6.B: Dissolved Oxygen
The enclosed 2018 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report provides the results of the 2018 Dissolved Oxygen (DO) monitoring immediately downstream of Long Lake Dam for the low-flow period of the year and summarizes the use of draft tube aeration to increase DO levels in the river below the dam's tailrace. Avista plans to continue with the aeration program in 2019, and to continue monitoring DO and TDG at the Long Lake Dam Tailrace Station.

With this, Avista is submitting the 2018 Long Lake TDG Monitoring Report and the 2018 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report for Ecology's review and comment. We would like to receive any comments or recommendations that you may have by **March 29, 2019**, which will allow us time to file these reports with FERC by April 15, 2019.

Please feel free to contact me at (509) 495-4084 or Meghan Lunney at (509) 495-4643 if you have any questions or wish to discuss the report.

Sincerely,

Chris Moan
Fisheries Habitat Biologist

Enclosures (2)

cc: Patrick McGuire, Ecology
Meghan Lunney, Avista

From: Casey Flanagan
To: Lunney, Meghan
Cc: Moan, Chris; Brian Crossley
Subject: [External] RE: Comments on TDG, DO, and Temp reports
Date: Thursday, April 11, 2019 9:52:42 AM
Attachments: image001.png

Hello Meghan and Chris,

Sorry for the delay in getting back to you both; Brian and I have taken on some new duties in DNR and are both super busy with field work and meetings. I have read over both the DO and the TDG report and am happy to see ongoing improvements in water quality within the Spokane River below Long Lake Dam.

In terms of the DO Report, the comments we have are similar to last years comments:

- The tribe is encouraged to see continued improvements in dissolved oxygen in the Spokane River below Long Lake Dam. Data collected by Avista and by the Tribe show there are still issues with meeting 8mg/L during non-generation hours. The tribe suggests researching ways to improve dissolved oxygen levels during non-generation hours.

After reviewing the TDG Report, here are our comments:

- The tribe continues to support Avista in their ongoing efforts to reduce total dissolved gases below Long Lake Dam. After two years of surveying the river during high flows, there are improvements seen in total dissolved gas levels, but there are continued exceedances of TDG below Long Lake Dam. Another year of hydrolab data collection alongside of analyzing spillgate usage is suggested by the Tribe in order to make spillgate usage as efficient as possible to reduce total dissolved gases in the Spokane River. This is similar to the aeration at Long Lake Dam; where multiple years of adjusting the aeration and analysis of the produced DO and TDG levels made the aeration as efficient as currently possible.

Let me know if you have any questions regarding our comments.

Casey Flanagan
Spokane Tribe of Indians
Water and Fish Project Manager
6290 D. Ford Wellpinit Hwy
Wellpinit, Wa 99040
(509)626-4408
caseyf@spokanetribe.com

From: Lunney, Meghan
Sent: Wednesday, April 3, 2019 1:05 PM
To: Brian Crossley; Casey Flanagan
Cc: Moan, Chris
Subject: Comments on TDG, DO, and Temp reports
Importance: High

Brian,
Just wanted to check to see if you guys had an comments on the following reports that Chris Moan sent out at the end of February.

- 2018 Long Lake Total Dissolved Gas Monitoring Report
- 2018 Long Lake HED Tailrace Dissolved Oxygen Report
- 2018 Long Lake HED Temperature Monitoring Report

Sorry to bug you, we just need to file them with FERC by April 15.

Thanks and hope all is well!
-Meghan.

Meghan Lunney, Spokane River License Manager
1411 E Mission Ave MSC-1, Spokane, WA, 99202
P 509.495.4643 | C 509.842.6133
www.myavista.com

myavista

SPOKANE TRIBE COMMENTS AND AVISTA RESPONSES

Spokane Tribe Comment

In terms of the DO Report, the comments we have are similar to last year's comments. The tribe is encouraged to see continued improvements in dissolved oxygen in the Spokane River below Long Lake Dam.

Avista Response

Comment noted, Avista continues to refine its operations to enhance DO in the Spokane River below Long Lake Dam.

Spokane Tribe Comment

Data collected by Avista and by the Tribe show there are still issues with meeting 8 mg/L during non-generation hours. The tribe suggests researching ways to improve dissolved oxygen levels during non-generation hours.

Avista Response

LLTR's minimum DO concentration for non-generation periods was 6.5 mg/L, which occurred in the last two weeks of September 2018. This coincided with low incoming DO levels. Avista looks forward to working with the Spokane Tribe to review the DO data that it collected in the downstream river.