AVISTA CORPORATION

2019

LONG LAKE HED TAILRACE

DISSOLVED OXYGEN

MONITORING REPORT

WASHINGTON 401 CERTIFICATION, SECTION 5.6(B)

Spokane River Hydroelectric Project
FERC Project No. 2545

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%	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, 2017, and 2018 actions in an annual report (Golder and Mattax Solutions 2016, Golder and Mattax Solutions 2017, Avista 2018 and 2019 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 2019 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® baraloggers 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 2019 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 2019, 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 2019 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

A site visit was conducted on July 9 to calibrate the probes. During calibration, it was determined that the TDG sensor of the primary probe (#60376) had failed and was replaced with the secondary probe (#48764) for future monitoring. TDG data from the secondary probe was not able to be utilized because data logging was not enabled on the probe for this time period. Probe #48762 was incorporated as the new secondary probe and logging was enabled on both probes before re-deployment. As a result TDG data is not available from July 1 through July 9.

On September 19, the probes were attempted to be removed from the water for calibration, but got caught up on some material just below the water surface. The probes had to be left until September 23 when the proper equipment could be brought in to free the probes. For a portion of the time between September 19 and September 23, the probes were caught up and collecting data at a depth not typical of their long-term depth, therefore these data are not comparable to the other monitoring data and were eliminated from the final dataset.

During calibration of the probes on August 22, the TDG sensor of the secondary probe (#48762) was off by more than the Measurement Quality Objectives (MQOs) performance thresholds (Appendix A) set in Avista's Detailed Dissolved Oxygen Phase II Feasibility and Implementation Plan (Avista 2010) and was replaced by probe #60375. Since the secondary probe was out of calibration, there was no TDG spot measurement taken on August 22.

During calibration of the probes on October 24, it was determined that the TDG sensor of the primary probe (#48764) was off by more than the MQOs performance thresholds and because TDG data from the secondary probe (#60375) was within the calibration threshold during this time, TDG, DO, and temperature data from probe #60375 was used in the final dataset. Because there was only one properly functioning probe, no spot reading for TDG was taken during this time.

A final calibration was conducted on the two probes at the end of the sampling season where it was determined that the secondary probe (#48764) was out of calibration for TDG, therefore no TDG spot reading was taken at this time.

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 (99.9 percent of the entire continuous monitoring period) data set for local barometric pressure. Temperature and DO data were successfully obtained for nearly 97 percent of the entire continuous monitoring period, and TDG data was collected for almost 90% of the 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 6,212 cubic feet per second (cfs) (Table 3-2). The maximum discharge occurred in July, when discharge reached 6,212 cfs. Maximum discharge was 4,829 cfs, 5,131 cfs, and 5,298 cfs in August, September, and October, respectively. Average discharge was greatest (2,984 cfs) in October, least (1,583 cfs) in August, and intermediate in July and September (2,183 and 1,990 cfs, respectively).

3.2 Water Temperature

Tailrace (LLTR) water temperature ranged from 17.2°C to 19.3°C in July and reached a seasonal maximum of 19.6°C on August 23 (Figure 3-1). Water temperatures began cooling around the beginning of September and steadily cooled to less than 11°C at the end of October (Figure 3-1).

[2] This occurred on June 27, July 9, July 26, August 8, August 22, September 5, September 23, October 8, October 24, and October 31.

3.3 Barometric Pressure

Site-specific barometric pressures ranged from 713 to 738 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 6.8 to 10.3 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 2 and consistently fell below 8.0 mg/L through late September (Figure 3-1). Aeration was used sporadically from July 2 to July 9 and then consistently from July 9 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, 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 5.6 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 0.2 percent of the time in early July and 0 percent of the time in October, with most occurring in the last two weeks of August through the end of September (Table 3-4). Of the DO concentrations below 8.0 mg/L, 37 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 6.8 mg/L occurring in the first half of September (Table 3-4). The 2019 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 first two weeks of August. Non-generation DO values for LLTR were less than the 8.0-mg/L DO criterion for 49.7 percent of the 5,030 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) 58 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 5.6 percent compared with 49.7 percent for non-generation, which resulted in an overall frequency of 21.4 percent (generation and non-generation).

Calculated DO% saturation values ranged from approximately 75.6 to 108.4 percent for LLTR (Table 3-1, Figure 3-7). DO% saturation for LLTR ranged from 75.6 to 104.6 percent during periods of generation (Table 3-4) and from 75.8 to 108.4 percent during non-generation (Table 3-5).

3.5 Total Dissolved Gas

The range of TDG percent was 96.2 to 112.8 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 151 (2.7 percent) of the 5,687 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 late July 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 1.5 percent of the monitoring season (Table 3-7).

3.6 Aeration

Dissolved oxygen levels were monitored from July 1, 2019 through October 31, 2019. Avista operated the HED at varying capacities throughout this period with no spillway releases. Aeration was used sporadically from July 2 to July 9 and then consistently from July 9 through October 8, using different aeration valve openings for Units 1, 2, 3, and 4. Aeration was conducted for a total of 41 unit-hours with 0 hours for a single unit, 673 hours for two units simultaneously, and 382 hours for three units simultaneously, and 8 unit-hours for four 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 2019 monitoring period, presented by month, are:

- **July**: Aeration was used sporadically from July 2 to July 9 and then consistently from July 9 with two to four units being used simultaneously, resulting in a total of 699 unit-hours of aeration. These operations resulted in DO meeting the 8.0-mg/L criterion at a frequency of approximately 99.8 percent early in the month and 98.9 percent late in the month. These operations also resulted in elevating TDG to greater than the 110 percent criterion at a frequency of 0.0 percent early in the month and 3.1 percent late in the month, with a maximum TDG of 110.6 percent of saturation.
- **August**: Aeration was conducted on all 31 days with one to three units being used simultaneously, resulting in a total of 702 unit-hours of aeration. These operations resulted in DO meeting the 8.0-mg/L criterion at a frequency of approximately 95.8 percent early in the month and 85.8 percent late in the month. These operations also resulted in elevating TDG to greater than the 110 percent criterion at a frequency of 1.7 percent early in the month and 4.6 percent late in the month, with a maximum TDG of 112.8 percent of saturation.
- **September**: Aeration was conducted daily with one to three units simultaneously, for a total of 869 unit-hours of aeration. These operations resulted in DO meeting the 8.0-mg/L criterion at a frequency of 89.2 percent early in the month and 78.9 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 13.1

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

percent and 0.9 percent late in the month, with a maximum TDG of 111.0 percent of saturation.

- **October**: Aeration was conducted through October 8 with two to three units being used simultaneously, for a total of 293 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 2019, daily aeration enabled DO in powerhouse discharges to satisfy the 8.0-mg/L DO criterion approximately 94.4 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 96.5 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 its efforts towards addressing low DO concentrations in Long Lake HED discharges in accordance with the approved schedule (Figure 4-1). The 2019 percentage of DO concentration values greater than or equal to 8.0 mg/L represent 94.4 percent of the entire generation period and 78.6 percent of the entire monitoring period (both generation and non-generation). This represents the third highest percentage during generation and fourth highest percentage when including both generation and non-generation data since monitoring began in 2011 (Table 4-1). Percent TDG was below the 110 percent criterion 97.3 percent of the season during generation and 98.5 percent of the entire monitoring period (including both generation and non-generation). This represents the second highest percentage of TDG below the criterion during generation as well as during the entire monitoring period (both generation and non-generation) since monitoring began in 2011 (Table 4-1). 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 2019 are summarized in the Lake Spokane DO WQAP Eight-Year Report (Avista 2020).

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 2019 continuous water quality monitoring results.

Parameter	LLTR		
	Minimum	Maximum	Count
Date/Time (PDT)	7/1/2019 0:00	10/31/2019 23:45	11,808
Water Temperature (°C)	10.5	19.6	11,444
Dissolved Oxygen (mg/L)	6.8	10.3	11,410
BAR (mm Hg)	713	738	11,791
TDG (mm Hg)	704	809	10,604
TDG (% of saturation)	96.2	112.8	10,594
Dissolved Oxygen (% of saturation)	75.6	108.4	11,399

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

Month - Year	Minimum Discharge (cfs)	Maximum Discharge (cfs)	Average Discharge (cfs)
July 2019	210	6,212	2,183
August 2019	210	4,829	1,581
September 2019	210	5,131	1,989
October 2019	210	5,298	2,985
July through October 2019	210	6,212	2,186

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 (%)
7/1/19 0:00	7/2/19 19:30	2 to 3 units, capacity varies, generation during portion of the day	No	No units used	112	0	0.0%	8.0	87.9	0	0	0.0%	0.0
7/2/19 19:45	7/14/19 10:30	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	647	2	0.3%	7.8	86.8	266	0	0.0%	107.9
7/14/19 10:45	7/14/19 22:15	2 to 4 units, capacity varies, generation during portion of the day	No	4 units used sometime each day	45	0	0.0%	8.1	90.6	45	0	0.0%	107.2
7/14/19 22:30	7/22/19 18:15	1 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	345	1	0.3%	7.9	88.1	345	0	0.0%	108.7
7/22/19 18:30	7/23/19 9:30	1 to 4 units, capacity varies, generation during portion of the day	No	4 units used sometime each day	21	0	0.0%	8.1	91.3	21	0	0.0%	108.2
7/23/19 9:45	8/6/19 13:30	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	499	14	2.8%	7.7	86.9	496	20	4.0%	110.6
8/6/19 13:45	8/9/19 11:00	3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	76	1	1.3%	7.9	90.1	76	8	10.5%	112.8
8/9/19 11:15	8/16/19 21:15	1 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	305	13	4.3%	7.5	84.6	305	1	0.3%	110.1
8/16/19 21:30	8/19/19 18:00	1 to 2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	83	17	20.5%	7.3	81.2	84	0	0.0%	109.5
8/19/19 18:15	8/27/19 20:30	1 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	242	29	12.0%	7.4	81.9	247	4	1.6%	111.3
8/27/19 20:45	8/29/19 14:45	1 to 2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	68	10	14.7%	7.4	82.9	68	3	4.4%	110.1
8/29/19 15:00	9/10/19 3:45	1 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	474	66	13.9%	6.8	75.7	471	108	22.9%	111.0
8/30/19 18:00	9/11/19 16:45	1 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	525	68	13.0%	6.8	75.7	522	99	19.0%	111.0
9/11/19 17:00	9/19/19 6:00	1 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	385	46	11.9%	6.9	75.6	385	0	0.0%	110.0
9/19/19 6:15	9/22/19 12:00	2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	82	7	8.5%	7.4	80.9	79	0	0.0%	109.8
9/22/19 12:15	9/22/19 20:00	3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	32	0	0.0%	8.6	94.2	32	7	21.9%	110.1
9/22/19 20:15	9/28/19 15:00	2 to 3 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	346	133	38.4%	7.4	79.2	343	0	0.0%	109.9
9/28/19 15:15	10/7/19 11:00	2 to 3 units, capacity varies, generation during portion of the day	No	3 units used sometime each day	592	0	0.0%	8.0	82.6	592	0	0.0%	105.8
10/7/19 11:15	10/8/19 10:45	2 units, capacity varies, generation during portion of the day	No	2 units used sometime each day	56	0	0.0%	8.6	88.8	53	0	0.0%	104.1
10/8/19 11:00	10/31/19 23:45	2 to 3 units, capacity varies, generation during portion of the day	No	No units used	1,681	0	0.0%	8.4	84.6	1,672	0	0.0%	102.6
7/1/19 0:00	10/31/19 23:45	1 to 4 units, capacity varies, generation during portion of the day	No	4 units used sometime each day	6,198	347	5.6%	6.8	75.6	5,687	151	2.7%	112.8

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]
7/1/19 0:00	7/15/19 23:45	213	0	4,149	281	850	18.2	850	7.8	0.2%	849	86.8	103.7	0.0%	357	108.0	0.0%
7/16/19 0:00	7/31/19 23:45	161	0	3,903	418	640	18.6	640	7.8	1.1%	640	86.9	98.4	0.0%	637	110.6	3.1%
8/1/19 0:00	8/15/19 23:45	132	0	4,076	350	529	19.1	529	7.5	4.2%	529	84.6	101.9	0.0%	529	112.8	1.7%
8/16/19 0:00	8/31/19 23:45	154	0	3,258	352	527	18.9	521	7.1	14.2%	521	78.9	104.6	0.0%	527	111.3	4.6%
9/1/19 0:00	9/15/19 23:45	174	0	3,356	390	696	18.3	696	6.8	10.8%	696	75.6	100.8	3.0%	693	111.0	13.1%
9/16/19 0:00	9/30/19 23:45	219	0	3,429	479	792	16.6	792	7.0	21.1%	789	77.0	98.4	2.2%	786	110.1	0.9%
10/1/19 0:00	10/15/19 23:45	261	0	3,734	293	1,042	13.7	1,042	8.0	0.0%	1,041	82.6	94.5	0.0%	1,038	105.8	0.0%
10/16/19 0:00	10/31/19 23:45	282	0	4,170	0	1,128	11.5	1,128	9.0	0.0%	1,126	88.5	100.5	0.0%	1,120	102.0	0.0%
7/1/19 0:00	10/31/19 23:45	1,599	0	3,779	2,563	6,204	16.2	6,198	6.8	5.6%	6,191	75.6	104.6	0.7%	5,687	112.8	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.

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]
7/1/19 0:00	7/15/19 23:45	146	0	210	0	585	18.0	585	7.5	42.4%	585	84.5	107.3	0.0%	266	106.7	0.0%
7/16/19 0:00	7/31/19 23:45	222	0	210	0	890	18.4	890	7.3	55.4%	890	80.9	100.5	0.0%	890	109.3	0.0%
8/1/19 0:00	8/15/19 23:45	227	0	210	0	907	18.7	907	6.9	66.4%	906	76.9	95.4	2.8%	902	109.1	0.0%
8/16/19 0:00	8/31/19 23:45	229	0	210	0	802	18.7	774	7.1	45.1%	773	79.9	108.4	0.1%	795	111.2	0.8%
9/1/19 0:00	9/15/19 23:45	185	0	210	0	740	18.2	740	6.8	41.1%	738	75.8	100.4	3.7%	738	110.0	0.0%
9/16/19 0:00	9/30/19 23:45	141	0	210	0	517	16.8	517	7.0	18.6%	517	77.9	97.5	1.7%	517	109.0	0.0%
10/1/19 0:00	10/15/19 23:45	98	0	210	0	394	13.8	394	7.9	0.5%	394	81.8	91.5	0.0%	394	105.0	0.0%
10/16/19 0:00	10/31/19 23:45	101	0	210	0	405	11.5	405	8.9	0.0%	405	87.5	96.9	0.0%	405	100.7	0.0%
7/1/19 0:00	10/31/19 23:45	1,352	0	210	0	5,240	17.4	5,212	6.8	40.2%	5,208	75.8	108.4	1.2%	4,907	111.2	0.1%

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]	6,198	347	5.6%
All Generation [1]	6,198	347	5.6%
Non-Generation [2]	5,212	2,094	40.2%
All	11,410	2,441	21.4%

Notes:

1. Of the 6,198 measurements, 218 (3.5%) were less than 7.8 mg/L.
2. Of the 5,212 measurements, 872 (16.7%) 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	LLTR Number >110% TDG [2]	LLTR Frequency >110% TDG
Generation With Spill > 200 cfs [1]	0	0	na
Generation With Spill <200cfs	0	0	na
Generation Without Spill	5,687	151	2.7%
All Generation [2]	5,687	151	2.7%
Non-Generation [3]	4,907	6	0.1%
All	10,594	157	1.5%

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 5,687 measurements, 3 (.1%) were greater than 112%.

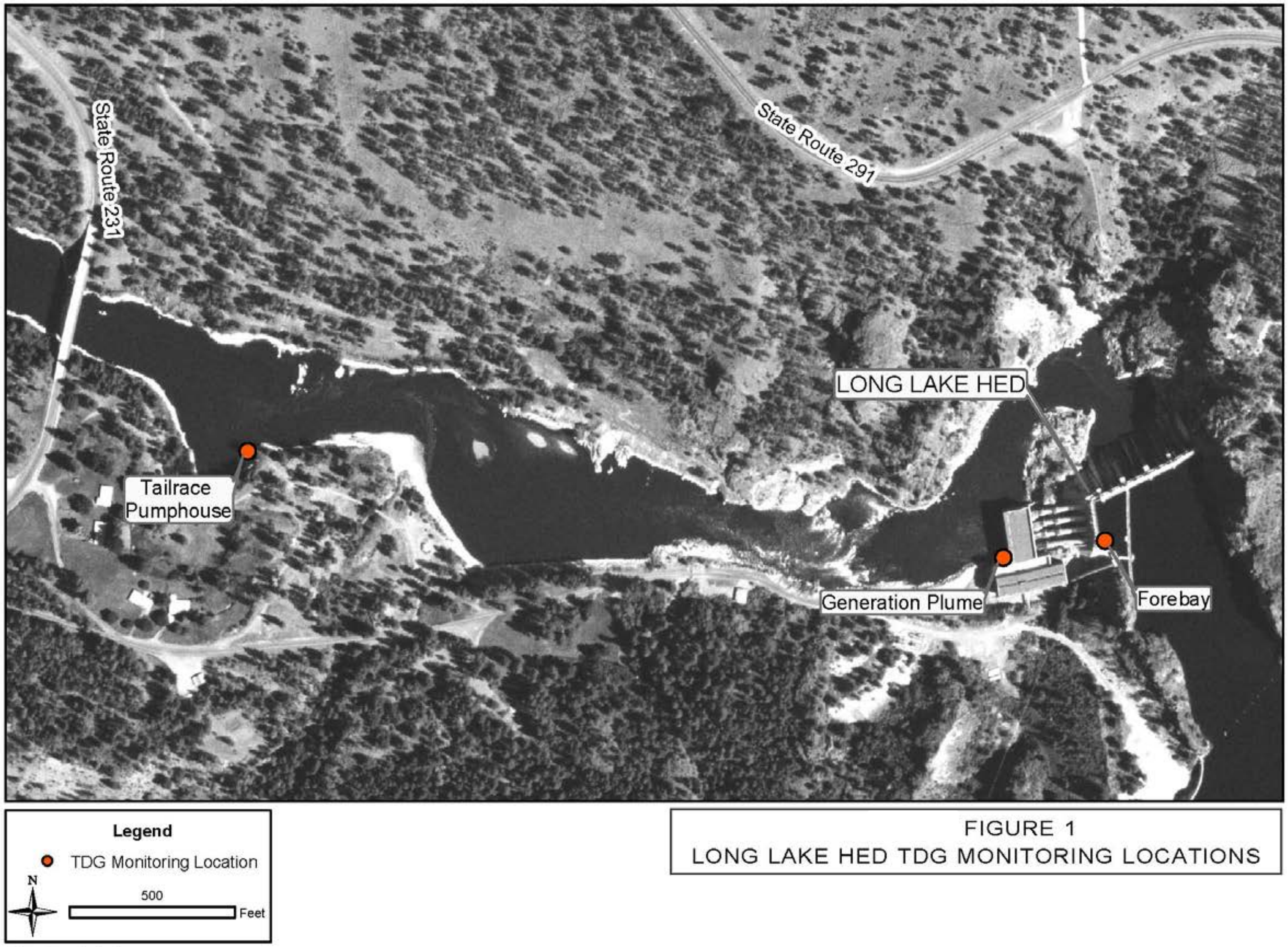
3. Of the 4,907 measurements, 0 (0.0%) were greater than 112%.

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[i]	2019
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	2,186
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	Units 1, 2, 3, and 4 with up to 4 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	July 2 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	2,565 unit-hours within 1,104 hours
Frequency LLTR Dissolved Oxygen ≥8.0 mg/L										
During Generation without Spillgate Use [j]	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	94.4% of 6,198 values
During Generation with Spillgate Use [k]		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	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	94.4% of 6,198 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	78.6% of 11,410 values
Frequency LLTR TDG% ≤110.0%										
During Generation without Spillgate Use [j]	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	97.3% of 5,687 values
During Generation with Spillgate Use [k]		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	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	97.3% of 5,687 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	98.5% of 10,594 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] 2018 Monitoring is documented in Avista (2019).
[j] Includes periods of <200 cfs spill in 2014 and 2015.
[k] Excludes periods of <200 cfs spill in 2014 and 2015.

FIGURES



Source: Avista

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

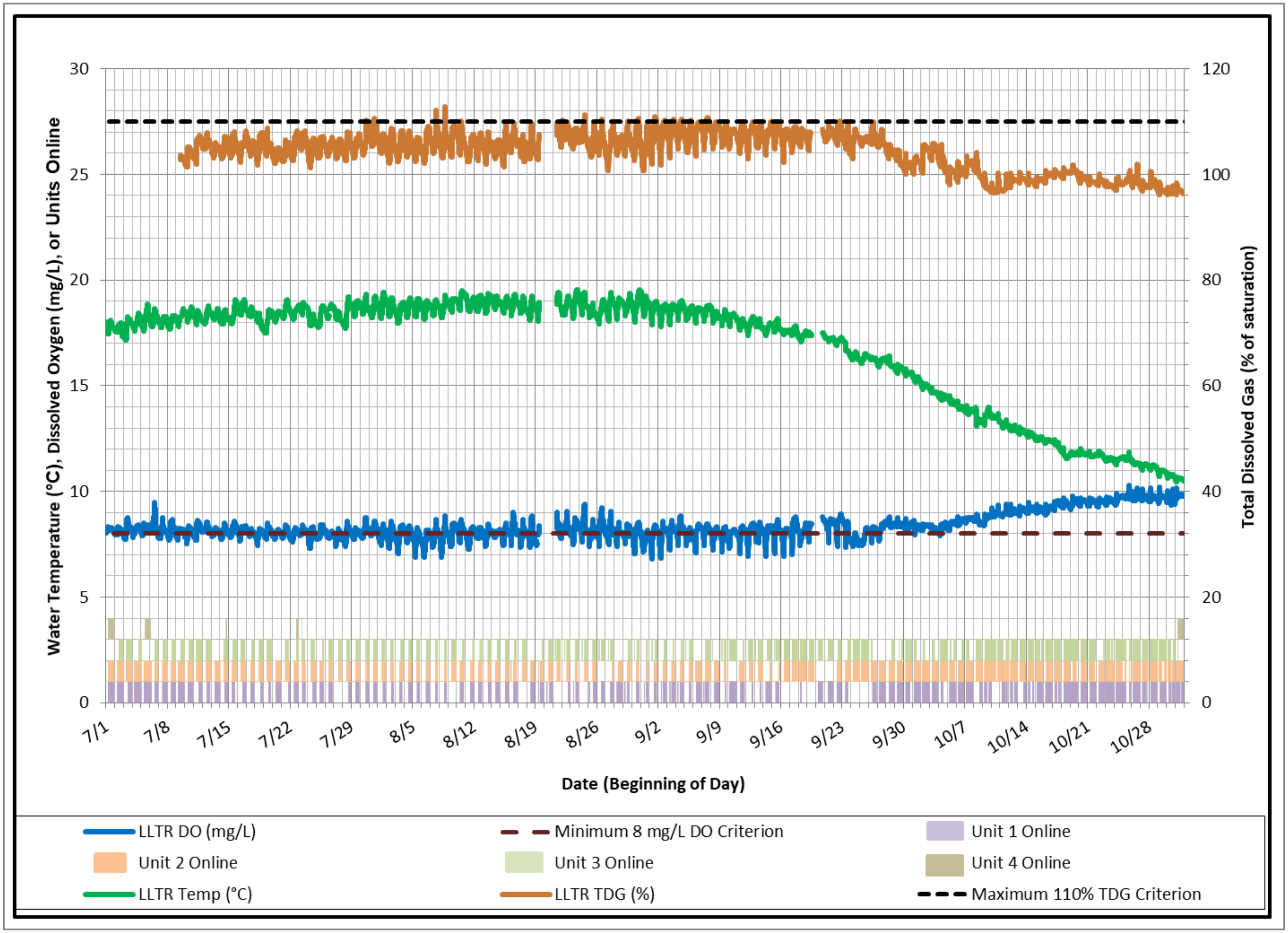


Figure 3-1: LLTR 2019 water temperature (°C), dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations.

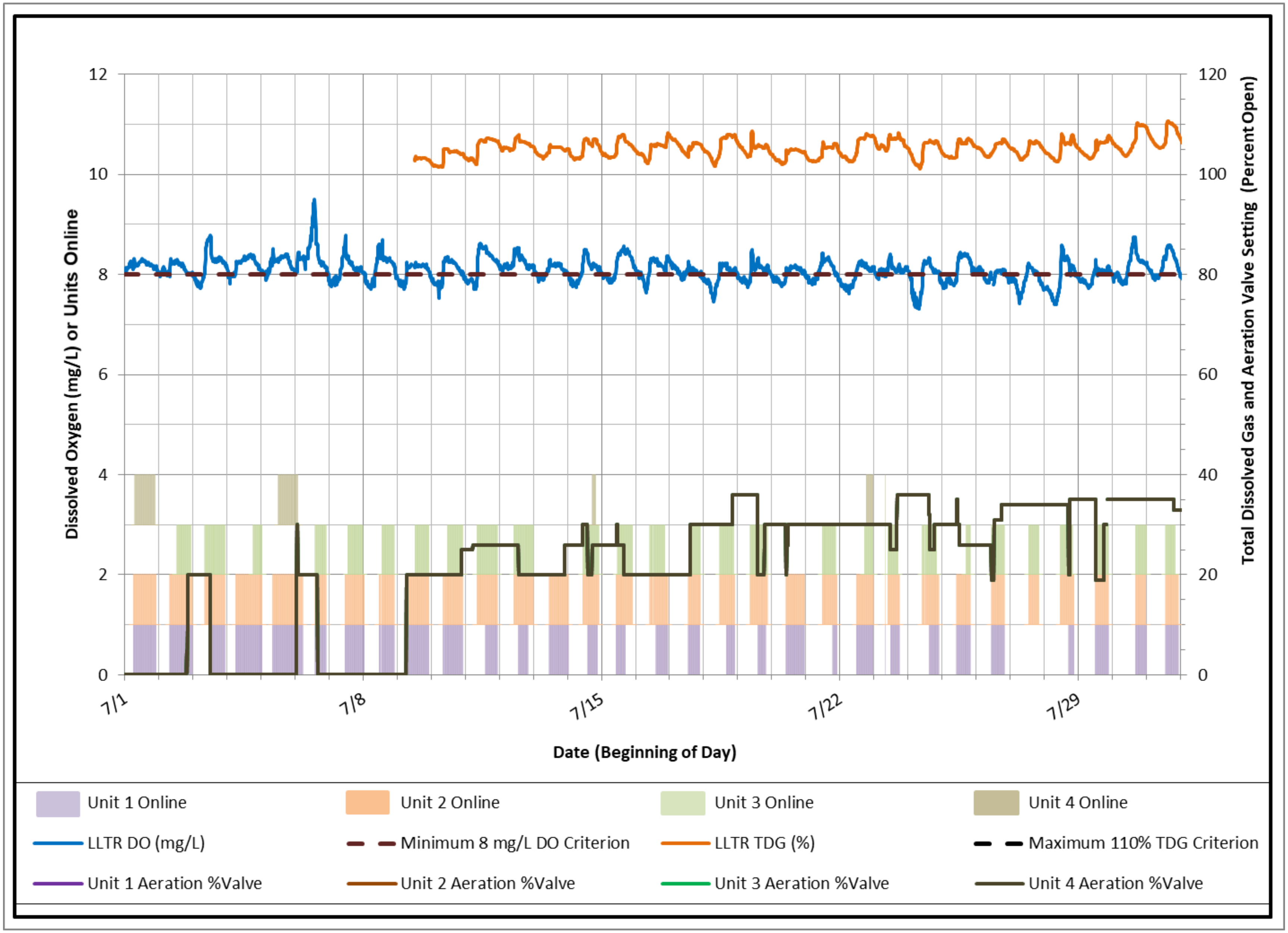


Figure 3-2: LLTR dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations, July 1 – July 31.

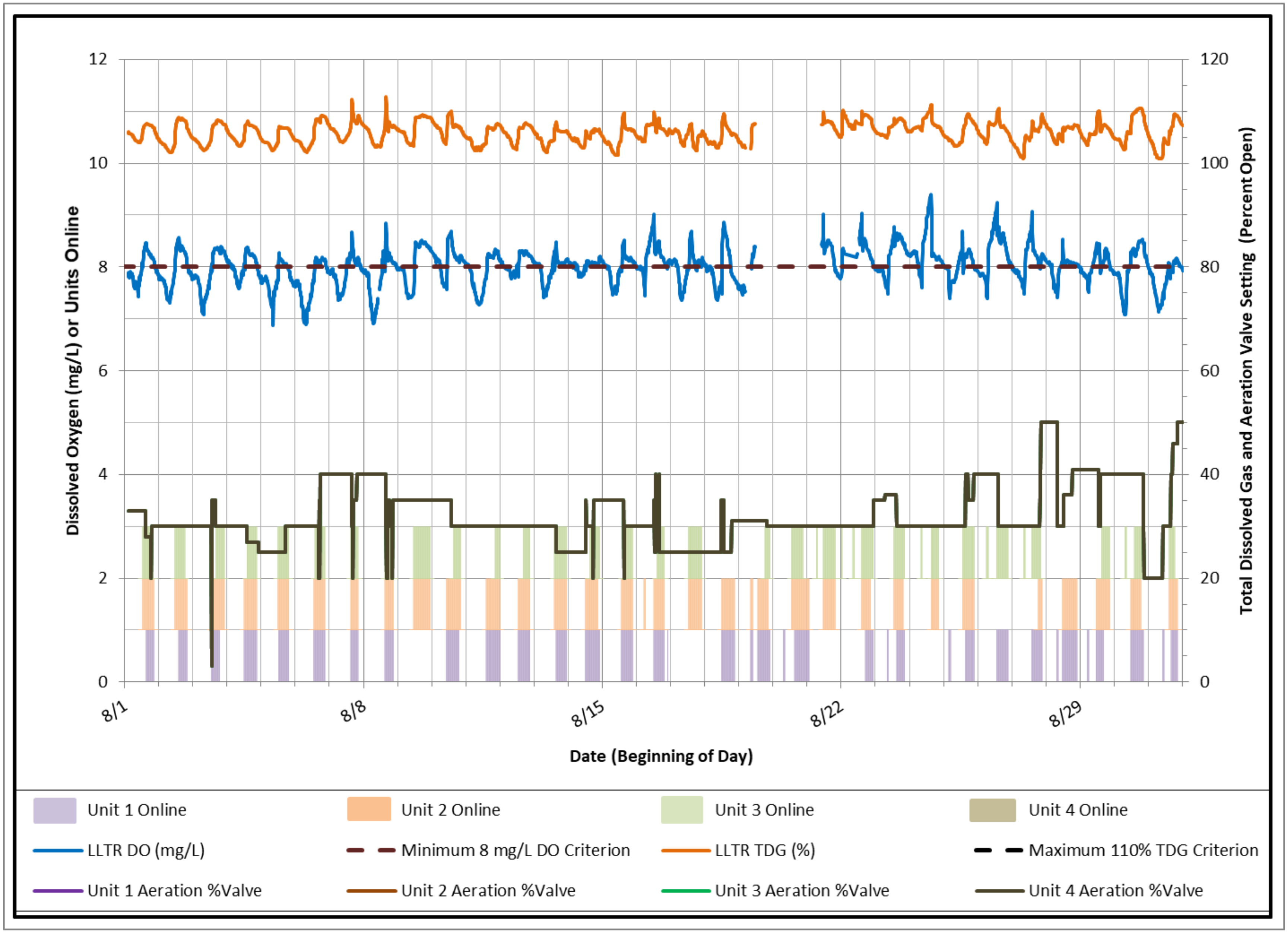


Figure 3-3: LLTR dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations, August 1 – August 31.

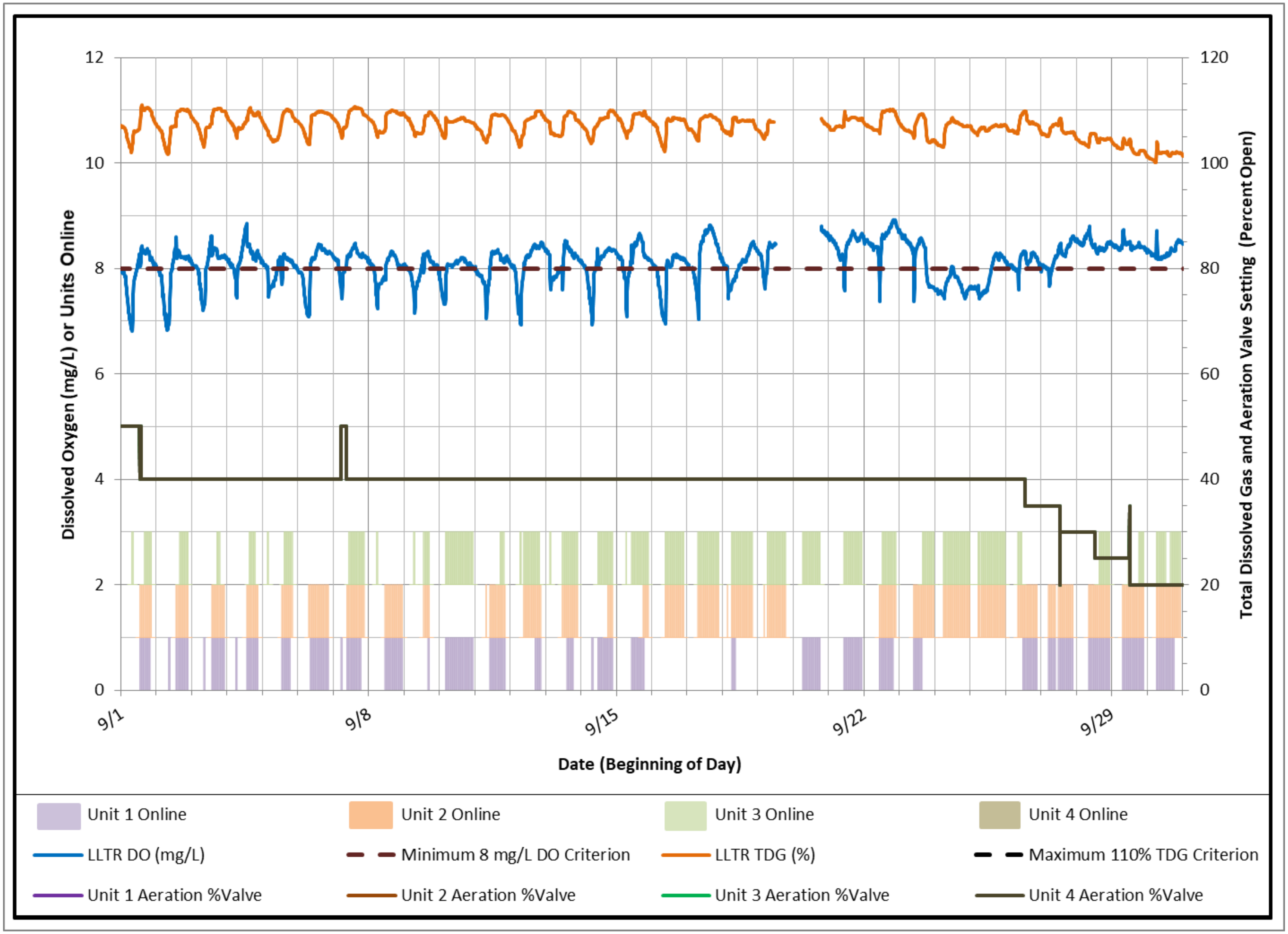


Figure 3-4: LLTR dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations, September 1 – September 30.

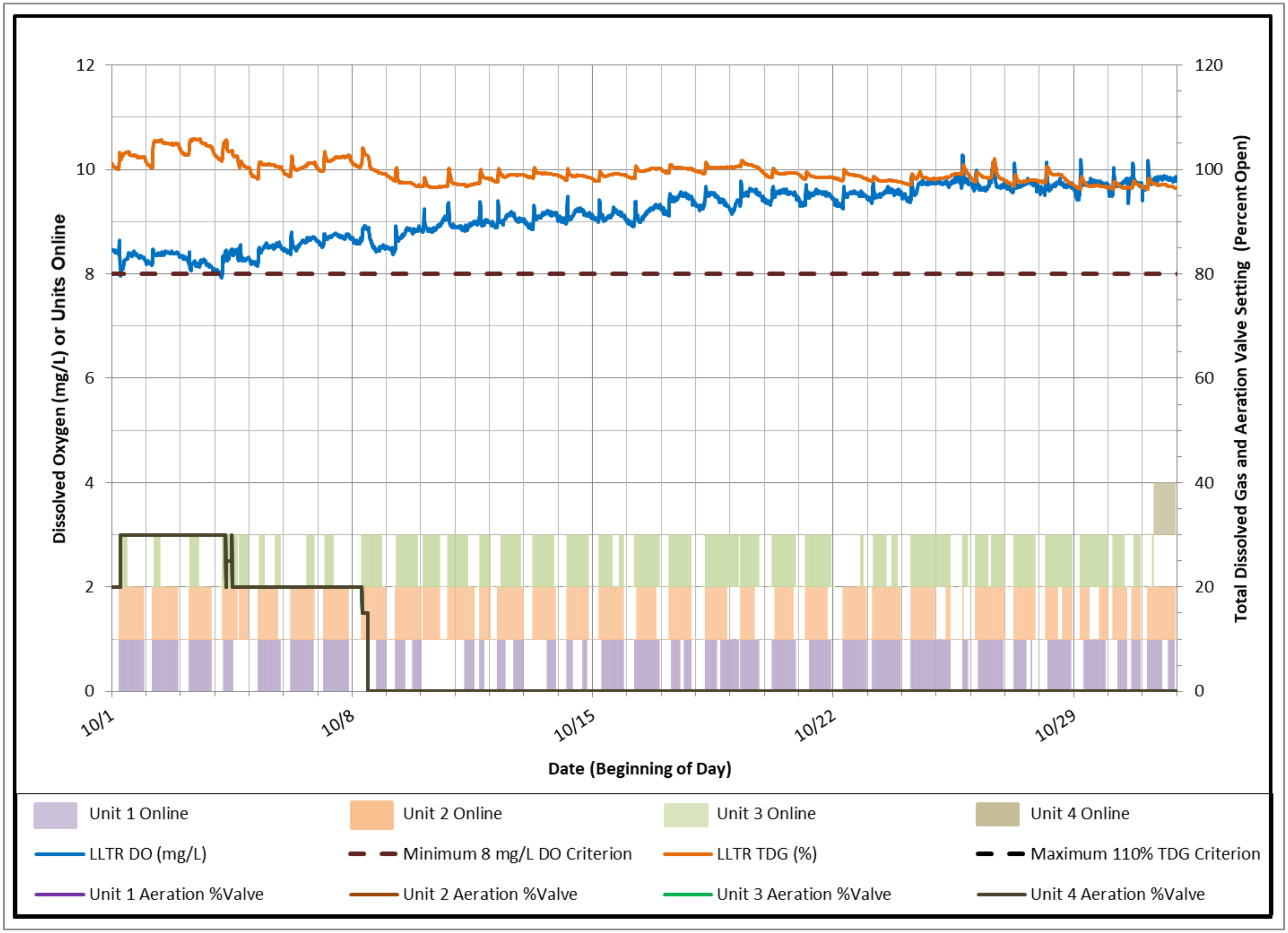


Figure 3-5: LLTR dissolved oxygen (mg/L), total dissolved gas (% of saturation), and operations, October 1 – October 31.

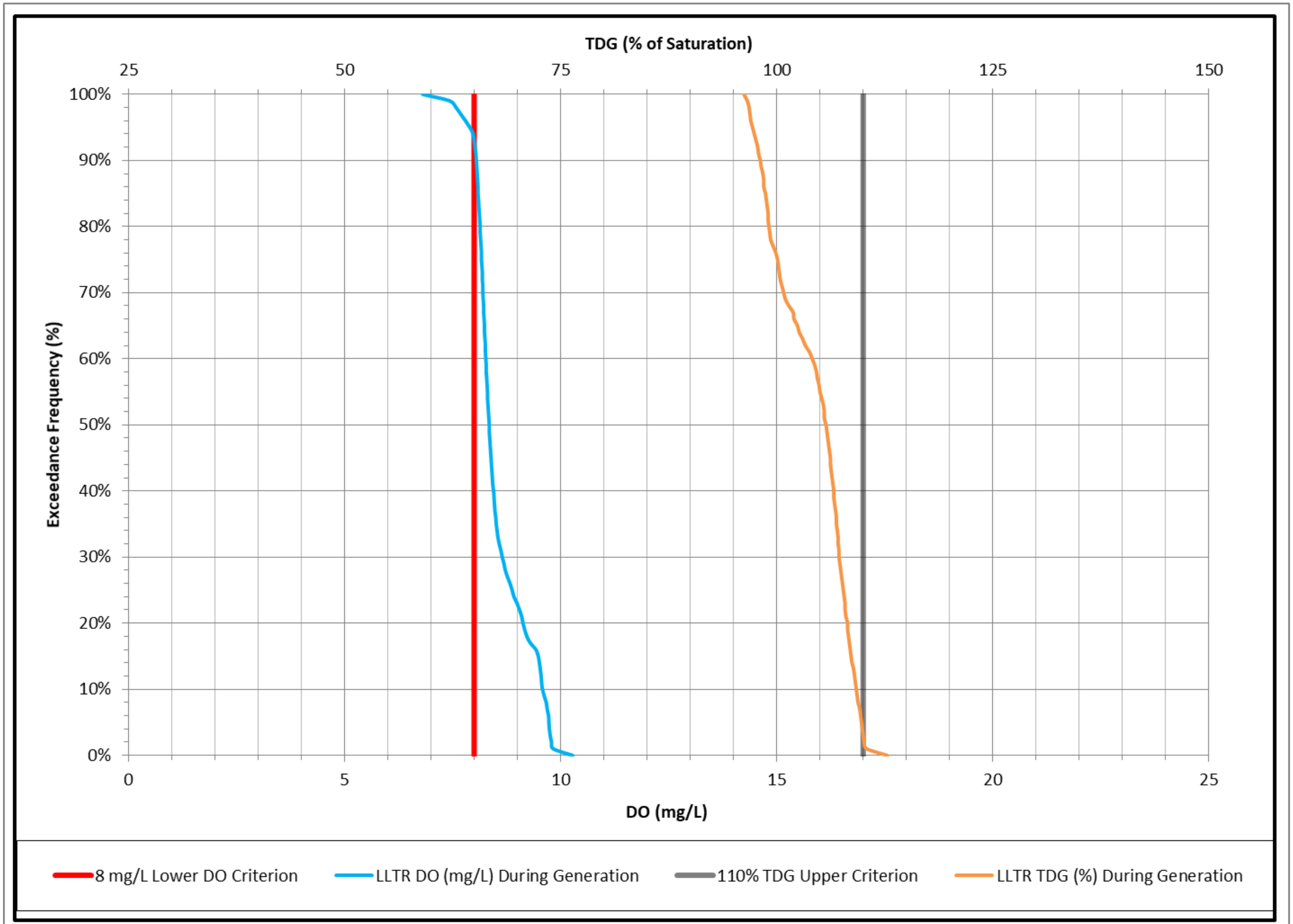


Figure 3-6: LLTR dissolved oxygen (mg/L) concentration and total dissolved gas (% of saturation) exceedance frequency during generation.

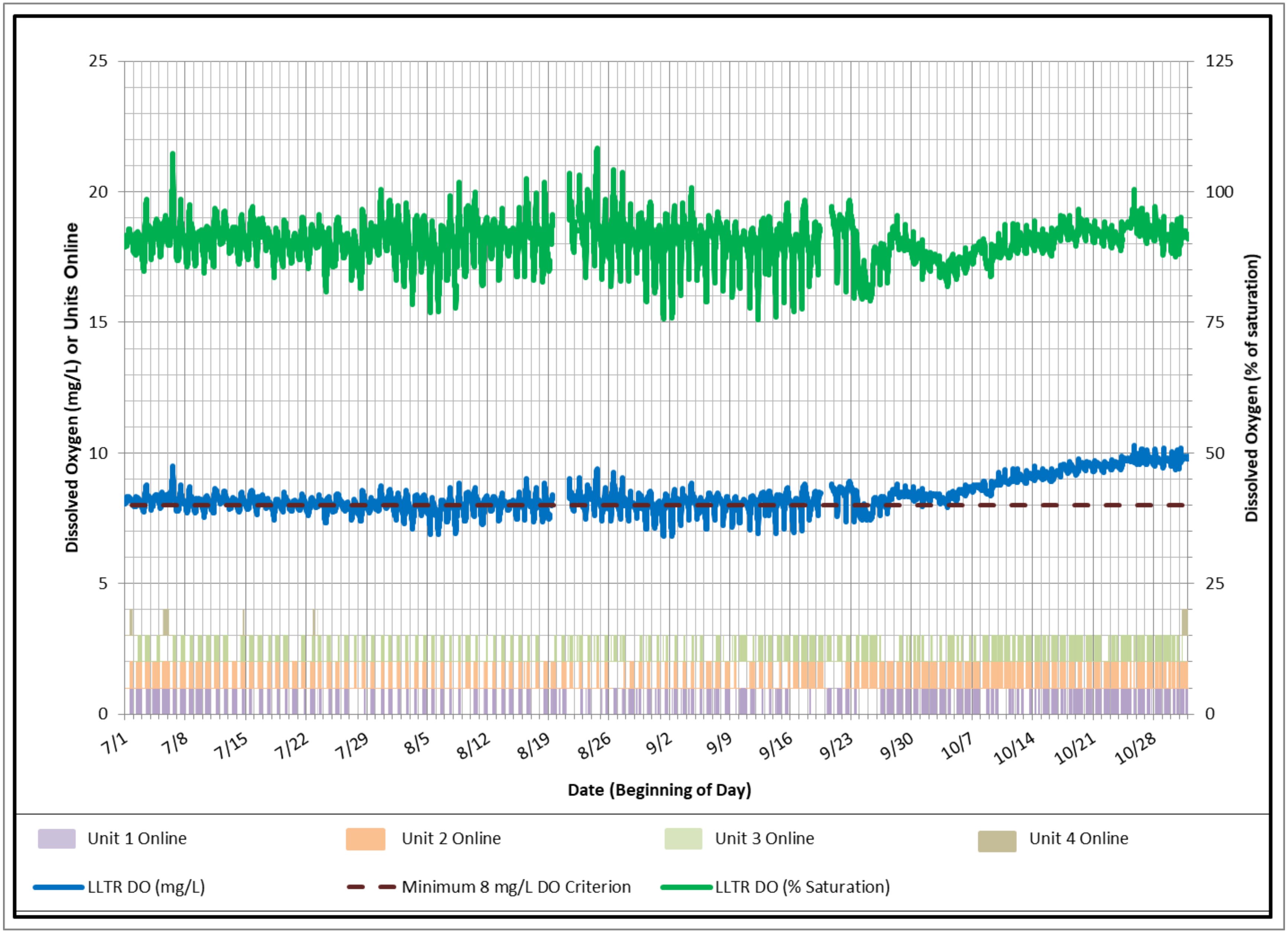


Figure 3-7: LLTR dissolved oxygen concentration (mg/L) and percent of saturation and operations.

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	1.26	0.00	0.00	2.45	2	1	1	5	-0.74	-1.00	-1.00	-2.55
60376	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48764	2.20	0.31	0.31	2.60	2	1	1	5	0.20	-0.69	-0.69	-2.40
48762	0.00	0.00	0.00	3.00	2	1	1	5	-2.00	-1.00	-1.00	-2.00
Overall RMSE	1.80	0.06	0.06	2.68	2	1	1	5	-0.20	-0.94	-0.94	-2.32

[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	0.06	0.06	0.07	0.09	0.5	0.5	-0.44	-0.44	-0.43	-0.41
60376	0.06	0.01	0.01	0.03	0.5	0.5	-0.44	-0.49	-0.49	-0.47
48764	0.12	0.05	0.04	0.08	0.5	0.5	-0.38	-0.45	-0.46	-0.42
48762	0.09	0.02	0.09	0.09	0.5	0.5	-0.41	-0.48	-0.41	-0.41
Overall RMSE	0.10	0.03	0.05	0.07	0.5	0.5	-0.40	-0.47	-0.45	-0.43

[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 DO, temperature, total pressure, and TDG percent were met for all meters used in the 2019 monitoring season. The MQO for BAR met for all meters except #48764, which exceeded the MQO by 0.2 mm Hg. The exceedance was driven by the last two calibrations where the meters had drifted 4 mm Hg each calibration period. This meter was not used for TDG readings after the second 4 mm Hg drift was identified.

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 temperature parameters had completeness of greater than 96 percent, and all parameters met or 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)	11,444	97%
Dissolved Oxygen (mg/L)	11,410	97%
BAR (mm Hg)	11,791	100%
TDG (mm Hg)	10,604	90%
TDG (% of saturation)	10,594	90%
Dissolved Oxygen (% of saturation)	11,399	97%

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 2019.

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	10	10	10	10	10	10	10
998	Out of water after recovery	11	11	11	11	11	11	11
997	Equilibrating after deployment	0	28	0	0	0	0	0
993	Calibration/servicing	17	17	17	17	17	17	17
991	Instrument not deployed at typical long-term depth	124	124	124	124	124	124	124
888	Power loss	190	190	190	190	190	190	190
666	Unknown	11	11	11	11	11	11	11
497	Faulty TDG sensor	0	812	0	0	0	0	0
101	Less than "minimum operating voltage" (<7 volts) and other data do not appear reliable	0	0	0	34	34	34	34
0	No data qualifiers	11,390	10,550	11,390	11,390	11,390	11,390	11,390
-101	Less than "minimum operating voltage" (<7 volts), but other data appear reliable	46	46	46	12	12	12	12
-102	Between "minimum operating voltage" (<9 volts) and 7 volts, but other data appear reliable	2	2	2	2	2	2	2
-1002	Corresponds with spot measurement	7	7	7	7	7	7	7
	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, 2019 at 23:45 PT.
2. Mass verifications were conducted on June 27, 2019.

APPENDIX B

CONSULTATION RECORD

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

February 28, 2020

Chad Atkins, 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 Mr. Atkins:

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:

- *2019 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 spillway gate operational protocols. The enclosed 2019 Long Lake TDG Monitoring Report (LL TDG Report) provides the results of TDG monitoring completed during 2019.

  Additionally, Avista proposes to conduct annual TDG monitoring at Long Lake Dam for another three years (2020 through 2022), following the same Long Lake HED TDG Monitoring Plan and reporting structure used in previous annual monitoring. As the additional monitoring data is collected, Avista will work with Ecology to evaluate Long Lake HED's compliance to the requirements of the License.

- *2019 Nine Mile HED Total Dissolved Gas Monitoring Report*
  In February 2012, Ecology approved Avista's request to delay the required TDG monitoring at Nine Mile Dam until Avista completed the turbine units 1 and 2 replacement project and the sediment bypass system upgrade and associated intake deck and trashrack cleaning system. Ecology required TDG monitoring to resume the first season following the completion of these projects.

  Avista has completed one year of TDG monitoring following the completion of these projects. The enclosed 2019 Nine Mile HED Total Dissolved Gas Monitoring Report (NM TDG Report) provides the results of TDG monitoring completed during 2019. Monitoring results demonstrate that Nine Mile Dam added no TDG compared to upstream levels at flows up to 25,489 cfs (as measured at Nine Mile Dam on April 14).

  Avista will monitor TDG in 2020 assuming snowpack and runoff forecasts result in flows reaching the 7Q10 flow.

Section 5.6.B: Dissolved Oxygen
The enclosed 2019 Long Lake HED Tailrace Dissolved Oxygen (DO) Monitoring Report (LL DO Report) provides the results of the 2019 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 2020, and to continue monitoring DO and TDG at the Long Lake Dam Tailrace Station.

With this, Avista is submitting the LL TDG Report, the NM TDG Report, and the LL DO Report for Ecology's review and approval. We would like to receive any comments or recommendations that you may have by **March 31, 2020**, which will allow us time to file the Report with FERC by April 15, 2020.

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 (3)

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

From: Bauer, Jordan (ECY) <jbau461@ECY.WA.GOV>

Sent: Friday, April 3, 2020 4:19 PM

To: Moan, Chris

Cc: Lunney, Meghan; Atkins, Chad (ECY)

Subject: [External] RE: Request for Ecology Review and Approval – Avista 2019 Long Lake HED Dissolved Oxygen Tailrace Monitoring Report – Section 5.6(B) Spokane River Hydroelectric Project No. 2545

Dear Chris Moan,

The Department of Ecology (Ecology) has reviewed Avista's submittal of the *2019 Long Lake HED Dissolved Oxygen Tailrace Monitoring Report*. This report was received by Ecology on February 28, 2020. The report is required in accordance with Section 5.6 (B) of Ecology's 401 Certification (Certification) and consistent with Spokane River Hydroelectric Project No. 2545 (License).

The purpose of this e-mail is to inform you that Ecology ***approves*** this report as meeting all the requirements of reporting defined in Section 5.6 of the Certification. We acknowledge monitoring should continue at the tailrace of the Long Lake Hydroelectric Development (HED) for dissolved oxygen while capturing aeration applications. We see it beneficial to meet and discuss options to improve the data inconsistencies observed in 2019 to ensure future data acquisition improves.

Ecology looks forward to future discussions as we continue to work together to evaluate dissolved oxygen in the tailrace and its' relationship with ongoing implementation projects in Lake Spokane. Please feel free to contact me with any questions.

Sincerely,

Jordan Bauer
Hydropower Compliance Coordinator
Washington Department of Ecology
Water Quality Program
(509) 590-5486

ECOLOGY COMMENTS AND AVISTA RESPONSES

Ecology Comment
Ecology acknowledged that the 2019 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report is required in accordance with Section 5.6 (B) of Ecology's 401 Certification (Certification) and consistent with Spokane River Hydroelectric Project No. 2545 (License).

Avista Response
Comment noted.

Ecology Comment
Ecology approves the 2019 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report as meeting all the requirements of reporting defined in Section 5.6 of the Certification.

Avista Response
Avista appreciates Ecology's approval of the 2019 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report.

Ecology Comment
We acknowledge monitoring should continue at the tailrace of the Long Lake Hydroelectric Development (HED) for dissolved oxygen while capturing aeration applications. We see it beneficial to meet and discuss options to improve the data inconsistencies observed in 2019 to ensure future data acquisition improves.

Avista Response
Avista will continue monitoring DO at Long Lake HED annually while capturing aeration applications and 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. Avista is open to discussing options to improve data collection inconsistencies encountered in 2019 and steps taken in 2020 to remedy those issues.

Ecology Comment
Ecology looks forward to future discussions as we continue to work together to evaluate dissolved oxygen in the tailrace and its relationship with ongoing implementation projects in Lake Spokane.

Avista Response
Avista looks forward to continued collaboration and discussions with Ecology in evaluating dissolved oxygen at Long Lake HED.

AVISTA

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

February 28, 2020

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 Mr. Crossley:

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 providing the following updates.

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

- *2019 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 spillway gate operational protocols. The enclosed 2019 Long Lake TDG Monitoring Report (LL TDG Report) provides the results of TDG monitoring completed during 2019.

  Additionally, Avista proposes to conduct annual TDG monitoring at Long Lake Dam for another three years (2020 through 2022), following the same Long Lake HED TDG Monitoring Plan and reporting structure used in previous annual monitoring. As the additional monitoring data is collected, Avista will work with Ecology to evaluate Long Lake HED's compliance to the requirements of the License.

- *2019 Nine Mile HED Total Dissolved Gas Monitoring Report*
  In February 2012, Ecology approved Avista's request to delay the required TDG monitoring at Nine Mile Dam until Avista completed the turbine units 1 and 2 replacement project and the sediment bypass system upgrade and associated intake deck and trashrack cleaning system. Ecology required TDG monitoring to resume the first season following the completion of these projects.

  During 2019, Avista completed one year of TDG monitoring following the completion of these projects. Avista plans to monitor TDG in 2020 assuming snowpack and runoff forecasts result in flows reaching the 7Q10 flow.

Section 5.6.B: Dissolved Oxygen
The enclosed 2019 Long Lake HED Tailrace Dissolved Oxygen (DO) Monitoring Report (LL DO Report) provides the results of the 2019 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 2020, and to continue monitoring DO and TDG at the Long Lake Dam Tailrace Station.

Attached, please find the LL TDG Report and the LL DO Report for the Spokane Tribe's review and comment. We would like to receive any comments or recommendations that you may have by **March 31, 2020**, which will allow us time to file the Report with FERC by April 15, 2020.

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
Meghan Lunney, Avista

Spokane Tribal Natural Resources

P.O. Box 480 • Wellpinit, WA 99040 • (509) 626 - 4400 • fax 258 - 9600

3/31/2020

Chris Moan, Avista Corp.
1411 East Mission Avenue
PO Box 3727 MSC-25
Spokane WA 99220

Dear Chris:

Casey Flanagan, my staff Project Manager, and I have reviewed the 2019 total dissolved gas, dissolved oxygen and temperature monitoring reports. These reports focus on Long Lake Dam and its effects on dissolved oxygen, total dissolved gas and temperature.

The dissolved oxygen (DO) mitigation continues to improve below the dam by an increased quantity of fish sampled. Non-generation dissolved oxygen levels are not adequately characterized and in the last paragraph of the results section it talks about only meeting the DO criteria during generation, whereas the 1st paragraph in the Discussion includes non-aeration times in the determination of success in meeting the 110% criterion. Naturally there would not have been high levels at the site during these time periods. DO was less than the 8 mg/L 49.7% of the non-generation hours and was measured as low as 6.5 mg/L in August.

With respect to Total Dissolved Gas (TDG) the spill deflectors reduce the TDG however the range of TDG measurements was not provided. Reporting TDG similar to DO would be helpful in showing the exceedences of the standards by the percentage of the study period.

Temperature in the Spokane River continues to exceed standards through the summer and fall, which can be detrimental to native salmonid species living within Little Falls Pool and within the Spokane Arm of Lake Roosevelt. During the monitoring period Avista tracked trout in Lake Spokane but no water quality data is provided. An interflow layer exists in Lake Spokane where temperatures are conducive to salmonid rearing however is there enough oxygen within that layer to support their normal activities.

Sincerely,

Brian Crossley
Water & Fish Program Manager
crossley@spokanetribe.com

cc: Patrick McGuire, Dept. of Ecology
BJ Kieffer, Director Dept. of Natural Resources
Danny Kieffer, Tribal Council

SPOKANE TRIBE OF INDIANS COMMENTS AND AVISTA RESPONSES

Spokane Tribe of Indians (STOI) Comment
The dissolved oxygen (DO) mitigation continues to improve below the dam by an increased quantity of fish sampled.

Avista Response
Avista appreciates recognition that its mitigation efforts, along with the efforts of a number of upstream partners, have led to an increased quantity of fish downstream of Long Lake HED.

STOI Comment
Non-generation dissolved oxygen levels are not adequately characterized and in the last paragraph of the results section it talks about only meeting the DO criteria during generation, whereas the 1st paragraph in the Discussion includes non-aeration times in the determination of success in meeting the 110% criterion. Naturally there would not have been high levels at the site during these time periods. DO was less than 8 mg/L 49.7% of the non-generation hours and was measured as low as 6.5 mg/L in August.

Avista Response
The last paragraph of Results section (3.0), falls within Section 3.6, and is titled "Aeration," and expresses the results of DO monitoring specific to times when Avista is aerating outflow water. Avista is only capable of aerating water when it is generating, therefore non-generation data is not applicable to this section of the results. Section 3.4 of the Results, titled "Dissolved Oxygen," includes three paragraphs that express the results of DO monitoring during non-generation times. The third paragraph of Section 3.4 and Table 3-5 are specific to DO values during non-generation. The fourth and fifth paragraphs of Section 3.4 and Table 3-6 compare DO monitoring results for both generation and non-generation times.

The first paragraph of the Discussion, Section 4.0, presents a general overview of DO and TDG values seen over the entire DO monitoring period and includes analysis of DO and TDG during times when Avista is aerating (and generating) and during the entire monitoring period (including both generation and non-generation). This paragraph is meant to summarize the results of sections 3.4, 3.5, and 3.6 into language that provides the reader with an overview of the DO and TDG values expressed by means of frequency of compliance with the DO and TDG criterion, experienced downstream of the Dam during the entire DO monitoring period.

The third paragraph in Section 3.4 indicates that non-generation DO was less than 8 mg/L 49.7% of the time, but that paragraph also states that DO was within 0.2 mg/L (i.e. 7.8 or 7.9 mg/L) of 8 mg/L 58% of the time, indicating that while DO reached a minimum of 6.5 mg/L during non-generation, values where more frequently closer to 8.0 mg/L. Independent of whether Avista was generating or not generating, Table 4-1 shows DO was above 8 mg/L 78.6% of the time at Avista's downstream monitoring location from July 1 through October 31, 2019.

Avista appreciates the feedback on how the characterization of non-generation data can be further incorporated into the report and modified Section 4.0 (Discussion) to better represent the frequency of compliance with the DO and TDG criterion during generation and the entire monitoring period.