AVISTA CORPORATION

2018
LONG LAKE
TOTAL DISSOLVED GAS
MONITORING REPORT

WASHINGTON 401 CERTIFICATION, SECTION 5.4(D)

Spokane River Hydroelectric Project
FERC Project No. 2545

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LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
7Q10	7-day average flow with a 10-year return period
ft amsl	feet above mean sea level
Avista	Avista Corporation
BAR	barometric pressure
cfs	cubic feet per second
DO	dissolved oxygen
DQO	data quality objective(s)
Ecology	Washington State Department of Ecology
FERC	Federal Energy Regulatory Commission
Golder	Golder Associates Inc.
HED	hydroelectric development
LLFB	monitoring station at Long Lake forebay
LLGEN	monitoring station at Long Lake HED Unit 4 generation plume
LLTR	monitoring station at Long Lake tailrace
LLTRSP1	monitoring station across the river from LLTR
m	meter(s)
mg/L	milligrams per liter
mmHg	millimeters mercury (pressure)
MQO	measurement quality objective
MS5	Hydrolab® MS5 Multiprobe®
PDT	Pacific Daylight Time
RMSE	root mean squared error
Spokane Tribe	Spokane Tribe of Indians
TDG	total dissolved gas, as pressure
TDG%	total dissolved gas, as percent of saturation
WQAP	Water Quality Attainment Plan

1.0 INTRODUCTION

On June 18, 2009, the Federal Energy Regulatory Commission (FERC) issued Avista Corporation (Avista) a License for the Spokane River Project, which includes Long Lake Dam (FERC 2009). Article 401(a) of the License required Avista to develop a Total Dissolved Gas (TDG) monitoring plan and a TDG Water Quality Attainment Plan (WQAP) for Long Lake Dam.

Avista consulted with Washington State Department of Ecology (Ecology) and the Spokane Tribe of Indians (Spokane Tribe) as it developed the Washington TDG Monitoring Plan, which addresses TDG associated with spills from the Long Lake and Nine Mile hydroelectric development (HEDs) (Golder 2010a). Ecology approved this plan on March 17, 2010, and Avista filed the Ecology-approved plan with FERC on March 26, 2010. Avista filed the WQAP, with FERC on July 16, 2010, and FERC approved it, and the Washington TDG Monitoring Plan, on December 14, 2010 (FERC 2010).

Avista implemented the WQAP in 2010 and continued seasonal TDG monitoring through 2013 at Long Lake Dam. Annual reports document the TDG monitoring for 2010 (Golder 2011), 2011 (Golder 2012), 2012 (Golder 2013), and 2013 (Golder 2014). Following the approved Revised Long Lake HED TDG Compliance Schedule (Figure 1-1)[1], 2013 was the last season of monitoring TDG before structural changes to address TDG were initiated at the dam. Monitoring was to be re-initiated once the changes were completed.

In accordance with the Revised Long Lake HED TDG Compliance Schedule, Avista filled in the plunge pool below the spillway and completed construction of two spillway deflectors as part of the Long Lake Dam Spillway Modification Project in December 2016 and has completed two years of post-construction TDG monitoring in 2017 and 2018. Results of the 2017 TDG monitoring can be found in Avista's 2017 Long Lake Total Dissolved Gas Monitoring Report (Avista 2018). This report discusses the results of the TDG monitoring conducted for Long Lake Dam during 2018. A summary of the 2018 data quality is provided in Appendix A and a record of consultation with Ecology and the Spokane Tribe is provided in Appendix B.

[1] Ecology and FERC approved the Revised Long Lake HED TDG Compliance Schedule on November 21, 2014 and February 19, 2015, respectively.

2.0 LONG LAKE HED

2.1 Objectives

The overall objectives of the Long Lake HED TDG Monitoring Plan, developed as part of the Washington TDG Monitoring Plan, are to:

- Collect data to test the efficacy of using selected operational measures to reduce gas production by Long Lake Dam spillway(s)
- Collect data for modeling the effectiveness of using selected structural measures to reduce gas production by Long Lake Dam spillway(s)
- Test the effectiveness of selected operational and structural TDG abatement measures for Long Lake HED
- Confirm that Long Lake Dam does not cause exceedances of the TDG standard after implementation of selected operational and/or structural measures

2.2 Monitoring Period

The License requires Avista to monitor TDG below Long Lake Dam during flows close to the 7Q10 (32,000 total cfs) (Section 5.4(B), FERC 2009). In 2018, use of the Long Lake Dam spillway began for a short duration (30 min) on December 1 and then spilled on a more consistent basis starting on December 4th. Avista began monitoring TDG on December 20, 2017 and continued through June 11, 2018. Discharge at the Long Lake Dam was close to, but did not exceeded the 7Q10 discharge in 2018 (see section 2.4.1).

2.3 Methods

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

2.3.1 Equipment and Calibration

Hydrolab® MS5 Multiprobe® (MS5) instruments with TDG, optical DO, temperature, and depth sensors were used. When applicable, each MS5 that was deployed for extended periods was connected to an external alternating current power source throughout the entire monitoring period with the goal of reducing potential issues associated with low or no power supply.

Solinst® barologgers were used to determine local barometric pressure (BAR). A primary barologger was deployed at the Long Lake Tailrace monitoring location (LLTR) for the entire monitoring season. A back-up barologger was also deployed at the LLTR to provide BAR data if the primary barologger failed. As an additional quality assurance measure, site-specific barometric pressures were compared to corresponding values for the Spokane International Airport. The Spokane International Airport station's sea-level daily ranges for barometric pressure were downloaded from the Weather Underground[2] and adjusted by subtracting 37.05 mmHg to account for the altitude of the Long Lake Dam tailrace (1,365 feet above mean sea level [ft amsl]).

Monitoring equipment was calibrated according to the manufacturer's instructions and following the data quality objectives for the project prior to deployment and on periodic site visits. All instruments used were maintained and calibrated by the factory's service department prior to the 2018 monitoring season. Pre-deployment field verification included synchronizing the clocks, comparing the MS5s' TDG pressure value with the silastic membrane removed to the ambient barometric pressure, confirming the MS5s' patency of the TDG silastic membrane, and testing the barologgers to confirm that the recorded values were similar and comparable to the Spokane International Airport.

During service periods, each MS5 was retrieved and the pull time 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 carbonated soda water. Depth, temperature, and DO sensors were calibrated according to the manufacturer's instructions.

2.3.2 Station Facilities

To facilitate TDG and DO monitoring at Long Lake Dam, permanent water quality monitoring facilities were constructed at three locations: 1) 0.6 mile downstream of the Long Lake Dam referred to as LLTR, 2) in the Long Lake HED Unit 4 generation plume referred to as LLGEN, and 3) in the Long Lake HED forebay referred to as LLFB (Table 2-1; Figure 2-1). The long-term monitoring strategy described in the TDG monitoring plan (Golder 2010a) calls for TDG monitoring at two of the permanent monitoring stations, the downstream station, LLTR, and LLGEN. Avista voluntarily initiated monitoring at LLFB in 2017 and 2018 to substantiate the results seen at LLGEN.

Each permanent station consists of a 4-inch-diameter pipe stilling-well (standpipe), which is sealed at the pipes' submerged end to prevent the MS5 from falling out of the pipe. Each standpipe has 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. Each standpipe's top end is protected by an enclosed box containing AC power and data communication equipment.

2.3.3 Spot Measurements

Spot measurements of TDG, water temperature, and DO were made during each site visit, on one to three week intervals, starting in January. Spot measurements were taken across the river from LLTR, at LLTRSP1 (Table 2-1). Spot measurements were not conducted at LLGEN due to the extremely turbulent waters at this location, which made it unsafe to deploy a temporary MS5.

[2] On each site visit day, Spokane, Washington 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

2.3.4 Data Collection and Processing

Parameters monitored at 15-minute log intervals with the MS5s described above included:

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

In addition, TDG percent of saturation (TDG%) was computed, as:

- TDG% = TDG in mmHg / Barometric pressure in mmHg x 100

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

Long Lake Dam's operations are monitored and recorded by Avista's internal plant control software, which was used to output data including: discharge passing over the dam's spillway; discharge passing through the dams units; and total discharge on a fifteen minute basis for the extent of the TDG monitoring period.

2.3.5 Spillway Gate Testing

Spillway gate testing was conducted throughout January and then from late February to early April to evaluate how combined gate usage and fluctuations in individual gate spill discharge influence TDG levels with the new modifications to the spillway. To a lesser extent, additional testing was done to replicate the spillway gate testing originally conducted on Long Lake Dam in 2003-2004 (Golder 2003, Golder 2004). The gate tests conducted in 2018 are summarized in Table 2-2.

Individual gates were tested open at 2, 4, 6, 8, and 9 foot increments. Gate combinations that sum to 4, 6, 8, and 9 feet were also tested (Table 2-2). For each gate test, the gate was left in position for a minimum of 3 hours to allow for the TDG percent to stabilize. The TDG percent value from the final 15 minute data point before the gate configuration was changed was used to represent the result of the gate test. The TDG percent value resulting from the spill of an individual gate is strongly influenced by factors outside the operations of the gate (e.g. water temperature, incoming TDG percent, etc.), therefore gate testing results were analyzed by comparing the difference in TDG percent between LLTR and LLGEN at paired data points[3].

2.3.6 Monitoring Difficulties

Prior to the TDG monitoring season, all six of Avista's MS5s were serviced and calibrated at Hach Hydromet (Hach) Technical Support & Service. Before deployment on December 20, 2017, three MS5s successfully passed the mass verification test, indicating they were operating correctly and providing reliable values. A second mass verification test was conducted on January 15, 2018, and

[3] A data pair is a set of LLTR and LLGEN TDG% values for the same time.

five of the six MS5s successfully passed the mass verification test. A final mass verification test was conducted on May 11 where five of the six MS5s successfully passed the test.

From the beginning of the monitoring season (December 20, 2017) until the morning of January 24, three units at Long Lake Dam were operational, leading to the total flow through the units being around 5,200 cfs. On January 24, the fourth unit became operational resulting in approximately 6,800 cfs being passed though the powerhouse. Having less water passing through the dam earlier in the monitoring season changed the proportion of spilled water to non-spilled water downstream at LLTR compared to later season monitoring. Sampling a higher proportion of spilled water potentially influenced the TDG percent values collected at LLTR, artificially increasing them. Since we were unable to verify the existence or quantify the magnitude of this increase, these values were ultimately included in the final dataset.

Data collection issues were also encountered at each of the three monitoring stations.

<u>LLTR</u>

MS5 #60375 was deployed at LLTR on December 20 to begin the monitoring season. At setup, the MS5 was not hooked to the external power and lost battery power by the afternoon of December 26. The MS5 was connected to external power by mid-day December 27 to resolve the issue.

At times, starting in mid-May and lasting to June 8, the water level at the LLTR station was lower than the MS5's suggested TDG compensation depth, as defined in the TDG WQAP. These TDG values were included in the final data set based on how the below-compensation-depth TDG values were comparable and fit the TDG value trends of the neighboring above-compensation-depth TDG values. On June 8, the water level dropped low enough that the MS5 was less than one meter deep in the water at times. At that point the MS5 was removed from the stilling well and placed directly on the river bottom to avoid de-watering.

<u>LLGEN</u>

MS5 #48763 was calibrated and redeployed at LLGEN on April 10. When it was pulled out of the water to calibrate on April 27, the DO sensor was not able to be calibrated. #48763 was therefore replaced with MS5 #60375 at LLGEN for the remainder of the monitoring season. DO data from April 10 through April 27 was included in the final analysis since the DO values from this period at LLGEN showed the same relationship to values at LLFB as were seen in the previous periods in the 2018 monitoring season.

From June 2 through June 10, the water level at the LLGEN station was lower than the MS5's suggested TDG compensation depth, as defined in the TDG WQAP. These TDG values were included in the final data set based on how the below-compensation-depth TDG values were comparable and fit the TDG value trends of the neighboring above-compensation-depth TDG values.

<u>LLFB</u>

MS5 #60376 was deployed at LLFB on December 20 to begin the monitoring season. After deployment, DO readings from this probe steadily decreased from 10.9 to 9.57 mg/L before the MS5 was recalibrated at 11:30 am on January 12. After recalibrating and redeploying the MS5 at

14:45 on January 12, DO readings were around 11.8 mg/l, indicating the 9.57 mg/L value seen at 11:30 may have been invalid. Further analysis of the December 20 through January 2 data showed irregular DO values when compared to DO values at LLGEN and were therefore eliminated from the final dataset. These invalid DO values were most likely the result of reduced battery voltage in the MS5. Batteries were replaced and this issue was not encountered again in subsequent data collection.

2.4 Results

The TDG monitoring season consisted of the period from December 20, 2017 at 18:00 PT through June 11, 2018 at 23:45 PT, and included 16,632 15-minute periods (Table 2-3). The MS5s at all three locations were deployed the entire monitoring season and recorded data for 99% of the sampling season. Monitoring at LLFB is not a requirement of the monitoring plan, but was voluntarily initiated to substantiate results seen at LLGEN.

The primary barologger deployed at LLTR provided local barometric pressure for 100% of the monitoring period (Appendix A, Table A-4). Spot measurements were collected at LLTRSP1 on January 15 and 30, February 12, March 1, 12, and 28, April 10 and 27, May 11 and 25, and June 8 (Table 2-4). All results of continuous and spot measurements are displayed in Figures 2-2 through 2-5.

2.4.1 Discharge

Total Long Lake Dam generation and spill discharge for the 2018 monitoring period ranged from approximately 5,157 cfs to 28,463 cfs. Spills at Long Lake Dam reached a maximum of approximately 21,736 cfs, which occurred on May 12, and spill occurred at the dam until mid-day June 11. From the beginning of the monitoring period until January 24, Long Lake Dam was generating with one unit down, averaging a little less than 5,200 cfs through the units. After January 24, generation was near full capacity for the rest of the monitoring period, except for a 30 minute period on May 26 when all four units tripped and no generation occurred. Total river discharge did not exceeded the Ecology-designated 7Q10 in 2018.

2.4.2 Water Temperature

Water temperatures at LLTR and LLGEN reached a low of 2.6°C in late February and a high of 17.5°C in early June (Figure 2-2). Water temperature measured at LLFB reached a maximum of 17.4°C in early June and a low of 2.5°C in early February. Water temperatures steadily increased from December through mid-April, and then increased more rapidly beginning in mid-April, as atmospheric temperatures began to increase and precipitation became less frequent.

2.4.3 Barometric Pressure

Site-specific barometric pressures ranged from 706 to 737 mmHg based on the Solonist® barologger deployed at LLTR (Figure 2-3). Barometric pressure in 2018 was similar to the 2017 monitoring period barometric pressure which ranged from 705 to 731 mmHg.

2.4.4 Total Dissolved Gas

TDG pressure (mmHg) for LLTR was greater than corresponding values for LLGEN and LLFB from the beginning of the monitoring period until April 24. From April 24 until the end of the monitoring period, the relationship reversed with TDG pressure at LLTR being less than pressure at LLGEN and LLFB for most of the remaining monitoring season (Figure 2-3). Spot values for LLTRSP1 coincided with the continuous monitoring data for LLTR, ranging in difference from 0-12 mmHg and an average of 3 mmHg.

TDG percent values for LLGEN, which is essentially unaffected by spill at Long Lake Dam, exceeded 110 percent of saturation at times between February 11 and February 19, and then consistently from April 15 through June 10, experiencing TDG percent values that ranged from 94.2 to 126.2 percent. TDG percent at LLTR, which is affected by spill at the dam, exceeded 110 percent of saturation first from February 5 continuously until February 22, then periodically fell below 110 percent from February 24 to April 11. From April 11 to June 10, TDG percent at LLTR exceeded 110 percent almost continuously. TDG percent values at LLTR ranged from 96.6 to 120.3 percent. TDG percent values at LLFB followed a similar pattern to LLGEN, where it was over the 110 percent exceedance at times between February 11 and February 19 and then remained consistently above 110 percent from April 15 to June 10, with a value range of 98.1 to 125.8 percent TDG (Table 2-5; Figure 2-4).

The 110 percent of saturation TDG criterion is not applicable when stream discharge exceeds the 7-day average flow with a 10-year return period (7Q10), which Ecology (2009) specified as 32,000 cfs for the Spokane River at Long Lake Dam and Nine Mile Dam. During the 2018 monitoring season, maximum total discharge (spill plus turbine discharge) was 28,463 cfs, hence the 7Q10 was not exceeded. Table 2-4 provides the specific periods where TDG saturation was greater than the 110 percent of saturation criterion when total discharge was less than the 7Q10.

2.4.5 Dissolved Oxygen

Measured DO concentrations were 9.1 to 14.0 mg/L for LLGEN and LLFB, and 9.1 to 14.4 mg/L for LLTR (Figure 2-5). The greatest DO concentrations occurred during an increase in flows in mid-February, although values remained above the 8.0 mg/L DO criterion throughout the entire monitoring period at all monitoring stations.

2.4.6 Spillway Gate Test

Initial post-spillway modification project gate testing was conducted in 2017 to evaluate if adjusting the number of gates used, or how high the gate were opened influenced TDG percent trends downstream (Avista 2018). Results showed that spreading out the spill discharge between multiple gates at lower gate heights decreases the percent TDG downstream when compared to upstream values.

Based on these results, Avista implemented an experimental gate operations protocol in 2018 at Long Lake Dam where gates 3 through 8 were to be sequentially opened to a maximum of 2 feet as spill volume necessitated. Once spill increased above the capacity of the six gates open to 2 feet, gates 3 through 8 would then each be opened to 4 feet as necessary. Once spill increased above the capacity of the six gates at 4 feet open, gates 3 through 6 would be opened to 6 feet while gates 7 and 8 remained at 4 feet. The protocol called for gates 3 through 6 to continue to be opened at 2 foot increments as spill increased.

To evaluate the effectiveness of this protocol, gate testing was conducted January through April of 2018, with flows ranging from 6,565 cfs to 13,311 cfs. Results from the individual gate testing shows that gates 3 through 6 have similar influence on TDG. Although, gates 6 and 5 had the lowest difference between LLTR and LLGEN TDG percent in the 4, 6, 8, and 9 foot tests (Table 2-6). Gates 6 and 5 were the second and third lowest respectively, during the 2 foot test. Results of the combination gate testing generally shows that splitting flows between gates reduces the difference in TDG percent between LLTR and LLGEN, although the 8 foot testing shows the opposite relationship, where spreading out flows between 4 gates showed a greater difference than spilling a similar flow through one gate.

2.5 Schedule

Avista has made substantial progress toward addressing TDG loadings caused by the use of Long Lake Dam spillways in accordance with the approved revised Long Lake HED TDG Compliance Schedule (Figure 1-1). Extensive studies were conducted from the early 2000s to 2013 to identify reasonable and feasible long-term measures (i.e. structural changes) to address TDG loadings at Long Lake Dam. Concurrent with the extensive studies, Avista completed a TDG Water Quality Attainment Plan (TDG WQAP) in 2010 and in accordance with the TDG WQAP, monitored TDG and other relevant conditions during the high-flow seasons of 2010,[4] 2011, 2012, and 2013. 2013 was the last season of monitoring TDG before structural changes to address TDG were initiated at the dam.

Avista completed the Long Lake Dam Spillway Modification Project in December 2016 (Phase VI of the Revised Schedule). The 2016 project included installing two deflectors at the base of the spillway, removing a portion of a rock outcrop, and filling the 60-80 foot deep plunge pool at the base of the dam. The project was completed one year ahead of the projected end date in the Revised Schedule, therefore the General Monitoring and Reporting, and Effectiveness Monitoring schedule was moved up one year and TDG monitoring was resumed in 2017 to assess the effectiveness of the modifications and to evaluate spillgate operational protocols (Phase VII, Figure 1-1). In accordance with the approved revised schedule (Figure 1-1), Avista conducted a second year of TDG monitoring to further assess the effectiveness of the modifications and to evaluate spillgate operational protocols during 2018.

Avista has now completed two years of post-construction monitoring, reporting, and spillgate testing as required by the revised Long Lake HED TDG Compliance Schedule. During 2019, Avista will monitor TDG to fulfill the third year of effectiveness monitoring and will implement the 2018 spillgate operational protocol.

2.6 Discussion

Overall, 2018 TDG levels at LLTR, LLGEN, and LLFB increased as river flows increased. Contrary to historic measurements at Long Lake Dam (Golder 2003, 2004, 2011, 2012, 2013), but similar to 2017 TDG monitoring (Avista 2018), TDG levels in 2018 at LLTR were less than the TDG levels at LLGEN and LLFB for portions of the monitoring season. TDG percent values at LLTR exceeded the 110% criterion earlier in the season than LLGEN and LLFB, but TDG levels at LLTR did not reach the maximum values seen at LLGEN and LLFB.

[4] Avista initiated early implementation of TDG monitoring on April 18, 2010, which was after Ecology had approved the TDG monitoring Plan but prior to FERC approving the plan.

Comparison of the TDG percent at LLTR and spill discharges for 2018 indicates TDG percent was greater than the 110 percent criterion 100 percent of the time when spill was greater than 11,000 cfs, 23 percent of the time when spills were between 5,000 and 11,000 cfs, 9 percent of the time when spill was less than 5,000 cfs, and 51% of the time when no spill occurred (Table 2-5). However, when comparing LLTR TDG percent to LLGEN TDG percent for the same time interval (referred to as data pairs), TDG percent values at LLTR were greater than at LLGEN and exceeded the 110 percent criterion for 0% of the data pairs with spill of less than 5,000 cfs, 13% when spill was between 5,000 and 11,000 cfs, and 43% when spill was greater than 11,000 cfs. A similar relationship was seen when comparing LLTR TDG percent to that of LLFB (Table 2-7). These data are similar to the 2017 monitoring results but are in stark contrast to historic measurement from 2011-2013 where LLTR TDG percent was rarely lower than LLGEN or LLFB at spills greater than 11,000 cfs.

These data show that TDG percent values at LLTR, which includes water that is spilled over the dam's spillway, were frequently lower than the values from LLGEN and LLFB, at higher river flows. This relationship, seen in both 2017 and 2018, had not been seen in the pre-spillway modification annual monitoring, reinforcing the conclusion that the spillway modification project positively influences TDG percent levels downstream of Long Lake Dam.

In 2018, the maximum TDG percent at LLTR was 120%, which was the lowest maximum TDG percent value seen at LLTR since monitoring began in 2003 (Table 2-8). By comparison, discharge flows in 2003, 2004, and 2013 had lower peak discharge flows than seen in 2018, therefore TDG percent would be expected to be lower. However, for those years, the maximum TDG percent was 129%, 125%, and 126% respectively, compared to a maximum of 120% in 2018. When considering the low maximum TDG percent value seen in 2017 monitoring, the 2018 results further substantiates the positive influence the spillway modification project had on TDG levels downstream of the dam.

3.0 REFERENCES

Avista. 2018. 2017 Long Lake Total Dissolved Gas Monitoring Report, Washington 401 Certification, Section 5.4(D). April 13.

Federal Energy Regulatory Commission (FERC). 2009. Project Nos. 2545-091, 12606-000, Order Issuing New License and Approving Annual Charges for Use of Reservation Lands. Issued June 18. 167 pp.

______. 2010. Project No. 2545-118, Order Modifying and Approving Total Dissolved Gas Attainment and Monitoring Plans for the Long Lake Development – Article 401. Issued December 14. 6 pp.

______. 2015. Project No. 2545-118, Order Granting Extension of Time Under Total Dissolved Gas Attainment Plan for the Long Lake Hydroelectric Development Under Article 401. Issued February 19. 3 pp.

Golder Associates Inc. (Golder). 2010a. Washington Total Dissolved Gas Monitoring Plan. Prepared for Avista Corporation. March 26.

______. 2011. 2010 Washington Total Dissolved Gas Monitoring Report, Washington 401 Certification, Section 5.4(D). Prepared for Avista Corporation. January 21.

______. 2012. 2011 Long Lake Dam Total Dissolved Gas Monitoring Report, Washington 401 Certification, Section 5.4(D). Prepared for Avista Corporation. February 16.

______. 2013. 2012 Long Lake Total Dissolved Gas Monitoring Report, Washington 401 Certification, Section 5.4(D). Prepared for Avista Corporation. April 10.

______. 2014. 2013 Long Lake Total Dissolved Gas Monitoring Report, Washington 401 Certification, Section 5.4(D). Prepared for Avista Corporation. April 10.

______. 2003. Total Dissolved Gas Pressure (TDG) Monitoring on the Spokane River 2003 Data Report. Prepared for Avista Corporation, Spokane, WA. Prepared by Golder Associates Ltd., Castlegar, B.C. October 2003. Golder Report No. 033-1363CD: 40 p. + 1 CD Appendix.

______. 2004. Total Dissolved Gas Pressure (TDG) Monitoring on the Spokane River 2004 Final Data Report. Data on CD. Prepared for Avista Corporation, Spokane, WA. Prepared by Golder Associates Ltd., Castlegar, B.C. September 2004. Golder Report No. 033-1363C2004F: 55 p. + 1 Appendix + plates.

Washington State Department of Ecology (Ecology). 2009. 401 Certification-Order Spokane River Hydroelectric Project, Certification-Order No. 5492, FERC License No. 2545, As amended May 8, 2009 by Order 6702. Prepared by Eastern Regional Office Water Quality Program staff, Spokane, WA. May 8.

TABLES

Table 2-1. Long Lake HED TDG monitoring stations.

Station Code	Description	Latitude / Longitude (NAD83)	Monitoring Type
LLFB	Long Lake Forebay between Unit 3 and 4 intakes near centerline of intake (elevation 1499 feet)	47°37'48" / 117°31'47"	Temporary
LLGEN	Long Lake HED Unit 4 generation plume	47°37'48" / 117°31'47"	Long-term
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
LLTRSP1	On right downstream bank, across river from LLTR station	47° 50'19" / 117° 51'02"	Spot during spillway use

Table 2-2. Summary of spillway gate testing conducted in 2018.

1/2/2018		1/3/2018		1/9/2018		1/10/2018		1/11/2018		1/18/2018	
Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)
3	2	7	2	3	4	3	6	7,8	3	5,6,7,8	2
4	2	8	2	4	4	3,4,5,6	2	3,6	3	3	9
5	2	1	2	5	4	7,8	4			4	9
6	2	2	2	6	4	4	6				
				7	4	5	6				
				8	4	6	6				
1/19/2018		**1/24/2018**		**1/29/2018**		**2/22/2018**		**3/16/2018**		**4/2/2018**	
Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)	Gate Number	Gate Height (ft)
5	9	3,6	4.5	3	8	3,4	4.5	3,4	2	7,8	2
6	9			4	8	4,5	4.5	3,6	2	4,8	2
				5	8			5,6	2		
				6	8						
				3,6	4						

Table 2-3. Summary of continuous monitoring results.

Parameter	LLGEN			LLFB			LLTR		
	Minimum	Maximum	Count	Minimum	Maximum	Count	Minimum	Maximum	Count
Date/Time (m/dd/yyyy PDT)	12/20/17 18:00	6/11/18 23:45	16,632	12/20/17 18:15	6/11/18 23:45	16,631	12/20/17 18:00	6/11/18 23:45	16,632
Water Temperature (°C)	2.6	17.5	16,505	2.5	17.4	16,489	2.6	17.5	16,562
Dissolved Oxygen (mg/L)	9.1	14.0	16,504	9.1	14.0	15,263	9.1	14.4	16,492
BAR (mm Hg)	Used LLTR BAR			Used LLTR BAR			706	737	16,564
TDG (mm Hg)	694	908	16,464	677	905	16,450	710	868	16,516
TDG (% saturation)[1]	94	126	16,456	92	126	16,443	97	120	16,508

Notes:

1. TDG (% saturation) calculated using site-specific barometric pressure (BAR) data collected at LLTR and corrected for altitude.

Table 2-4. LLTRSP1 spot measurement results.

Station Code	Date Time (PDT)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	TDG (mm Hg)	LLTR BAR (mm Hg)	TDG (% of saturation)[1]
LLTRSP1	1/15/18 13:00	3.9	13.0	776	728	106.6
LLTRSP1	1/30/18 11:45	4.5	13.1	781	722	108.2
LLTRSP1	2/12/18 13:15	5.0	13.2	825	728	113.3
LLTRSP1	3/1/18 13:30	2.7	13.5	776	713	108.9
LLTRSP1	3/13/18 11:45	5.0	12.3	767	719	106.7
LLTRSP1	3/28/18 14:00	6.0	11.9	775	726	106.7
LLTRSP1	4/10/18 11:45	6.4	12.5	789	719	109.8
LLTRSP1	4/27/18 12:30	8.1	12.2	838	717	116.8
LLTRSP1	5/11/18 12:00	12.4	11.5	857	724	118.3
LLTRSP1	5/25/18 13:00	15.3	10.9	839	719	116.7
LLTRSP1	6/8/18 12:00	16.9	9.9	801	722	110.9

Notes:

1. TDG (% saturation) calculated using site-specific barometric pressure (BAR) data collected at LLTR.

Table 2-5. Summary of exceedance of TDG criterion when total discharge was less than or equal to Ecology-specified 7Q10 of 32,000 cfs.

	LLTR			LLGEN			LLFB		
# of records that exceeded 110% saturation	7,424			6,127			6,184		
Total # of records	16,508			16,456			16,443		
Periods when TDG exceeded 110% saturation (PDT)[1,2]	2/5/2018 13:00	to	2/22/2018 17:00	2/11/2018 6:00	to	2/12/2018 11:45	2/11/2018 2:45	to	2/12/2018 13:00
	2/24/2018 7:15	to	2/24/2018 8:00	2/12/2018 13:00			2/12/2018 16:45	to	2/19/2018 23:30
	2/24/2018 8:30			2/12/2018 16:45	to	2/13/2018 0:00	4/15/2018 7:30	to	6/9/2018 23:30
	3/1/2018 16:00			2/13/2018 0:30	to	2/13/2018 0:45	6/10/2018 0:00		
	4/7/2018 6:45	to	4/7/2018 14:00	2/13/2018 12:00	to	2/19/2018 21:30			
	4/10/2018 13:15	to	4/10/2018 14:30	4/15/2018 10:00	to	6/10/2018 5:30			
	4/11/2018 8:30	to	6/7/2018 9:00						
	6/7/2018 10:15	to	6/10/2018 2:30						

Notes:

1. Flows did not exceeded the 7Q10 in 2018.

2. Refer to Figure 2-4 and Appendix A for data gaps.

Table 2-6. 2018 spillway gate testing results.

Date	Gate Number(s)	Gate Height (ft)	Qtotal (cfs)	Qspill (cfs)	Qgen (cfs)	TDG LLTR (%)	TDG LLGEN (%)	Difference between LLTR and LLGEN (%)
1/2/2018	3	2	6602	1454	5148	98.9	96.9	2.0
1/2/2018	6	2	6565	1413	5152	97.9	95.5	2.5
1/2/2018	5	2	6579	1433	5146	98.1	95.6	2.5
1/2/2018	4	2	6620	1464	5156	98.5	95.9	2.6
1/3/2018	7	2	6586	1433	5153	98.2	95.4	2.7
1/3/2018	8	2	6576	1426	5151	98.3	95.3	3.0
1/3/2018	1	2	6639	1460	5179	98.7	95.3	3.4
1/3/2018	2	2	6660	1460	5200	99.1	95.4	3.7
3/16/2018	5 & 6	2	9714	2819	6895	106.6	105.7	0.8
3/16/2018	3 & 6	2	9728	2852	6877	106.6	105.6	1.0
3/16/2018	3 & 4	2	9750	2884	6865	106.8	105.4	1.4
4/2/2018	4 & 8	2	9696	2824	6872	106.3	104.6	1.7
4/2/2018	7 & 8	2	9630	2757	6872	106.8	104.8	2.0
1/9/2018	6	4	8132	2953	5179	103.0	99.7	3.2
1/9/2018	5	4	8095	2923	5173	103.3	99.9	3.4
1/9/2018	7	4	8122	2942	5179	103.2	99.6	3.6
1/9/2018	3	4	8190	3014	5176	104.0	100.1	3.9
1/9/2018	4	4	7965	2787	5178	104.0	100.1	3.9
1/9/2018	8	4	8119	2947	5172	103.6	99.4	4.2
1/10/2018	6	6	9408	4216	5192	104.0	99.7	4.3
1/11/2018	3 & 6	3	7980	4448	3531	105.2	100.4	4.7
1/11/2018	7 & 8	3	9564	4367	5198	104.7	99.6	5.1
1/10/2018	5	6	9419	4216	5203	104.1	98.9	5.3
1/10/2018	3	6	9498	4296	5202	104.9	99.4	5.5
1/10/2018	4	6	9462	4257	5205	104.8	99.1	5.7
1/29/2018	6	8	12234	5343	6891	108.4	105.9	2.5
1/29/2018	3 & 6	4	12698	5851	6848	108.6	106.1	2.5
1/29/2018	5	8	12201	5342	6859	108.6	105.7	2.9
1/29/2018	3	8	12218	5395	6824	108.6	104.9	3.7
1/29/2018	4	8	12244	5386	6858	109.0	105.3	3.7
1/18/2018	5 & 6 & 7 & 8	2	10913	5689	5224	106.6	100.9	5.7
1/10/2018	7 & 8	4	11073	5873	5199	106.1	99.3	6.8
1/10/2018	3 & 4 & 5 & 6	2	10875	5681	5193	106.5	99.5	7.1
2/22/2018	4 & 5	4.5	13223	6437	6787	110.4	108.5	1.9
2/22/2018	3 & 4	4.5	13311	6475	6836	110.8	108.4	2.3
1/24/2018	3 & 6	4.5	13243	6504	6738	108.6	105.1	3.5
1/19/2018	6	9	11242	6008	5234	106.8	102.5	4.3
1/19/2018	5	9	11217	5999	5218	107.3	102.6	4.7
1/18/2018	4	9	11277	6044	5234	107.7	101.5	6.1
1/18/2018	3	9	11273	6058	5215	107.3	100.9	6.4

Table 2-7. Summary of LLTR TDG% by spill category and comparison with LLGEN TDG%.

Spill Category	All LLTR TDG% Values			LLTR TDG% Paired with LLGEN TDG% [1]		
	Total Count	Count >110%	% >110%	Total Count	Count >110% and >LLGEN	% >110% and >LLGEN
>11 kcfs spill	5,818	5,791	100%	5,786	2,506	43%
5-11 kcfs spill	3,395	778	23%	3,381	430	13%
<5 kcfs spill	7,043	669	9%	7,005	16	0%
No spill	187	95	51%	187	0	0%
All spill and non-spill	16,443	7,333	45%	16,359	2,952	18%

Notes:

1. TDG (% saturation) calculated using site-specific barometric pressure (BAR) data collected at LLTR and corrected for altitude.

Table 2-8. Maximum discharge flow and TDG% at LLTR, LLGEN, and LLFB.

Year	Max. Discharge (cfs)	Max. TDG%		
		LLTR	LLGEN[1]	LLFB
2003	22,310	129	-	123
2004	22,420	125	-	123
2011	34,400	138	-	123
2012	37,100	143	123	118
2013	20,480	130	116	112
2017	46,331	126	125	119
2018	28,463	120	126	126

Notes:

1. LLGEN was not monitored as a long-term monitoring station until 2012.

FIGURES

Revised January 8, 2015

Revised Long Lake HED TDG Compliance Schedule

Schedule for Operational Adjustments and Structural Modifications to Address TDG Production at Long Lake Dam

Action	Task	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
General Monitoring	Select/design permanent monitoring stations and develop monitoring plan	M	M										
	Monitor TDG and other relevant water quality conditions at the Unit 4 generation plume (LLGEN) and the tailrace (LLTR) [1]		M	M	M	M					M	M	
	Annual Monitoring Report[2]			M	M	M	M					M	M
Operational Changes - Spill Protocols	Continue historical preferential use of spill gates	O	O										
	Develop reasonable and feasible interim spill gate protocol based on the 2003/2004 spill testing		O										
	Implement selected reasonable and feasible interim spill gate protocol based on 2003/2004 spill testing			O	O	O	O	O					
	Suspend interim spill operations in 2016 and 2017 during construction								O	O			
	Implement revised spill gate protocol, which takes advantage of constructed structural modifications										O	O	O
Structural Modifications	Phase II Feasibility Study- Evaluation of Alternatives		S										
	Phase III Feasibility Study - Select Alternatives, Physical Model			S	S								
	Submit and request agency review of Phase III Recommendation					S							
	Upon FERC approval, prepare RFP for design engineering services and secure contract					S							
	Phase IV - Formulate design, plans, and specs						S						
	Phase V – Award construction bid and permit project						S	S					
	Phase VI - Construction								S	S			
	Phase VII – Testing, performance evaluation, and define spillgate protocol										S	S	
Effectiveness Monitoring	Confirm effectiveness of structural modifications and spillgate operations at reducing TDG										M	M	M

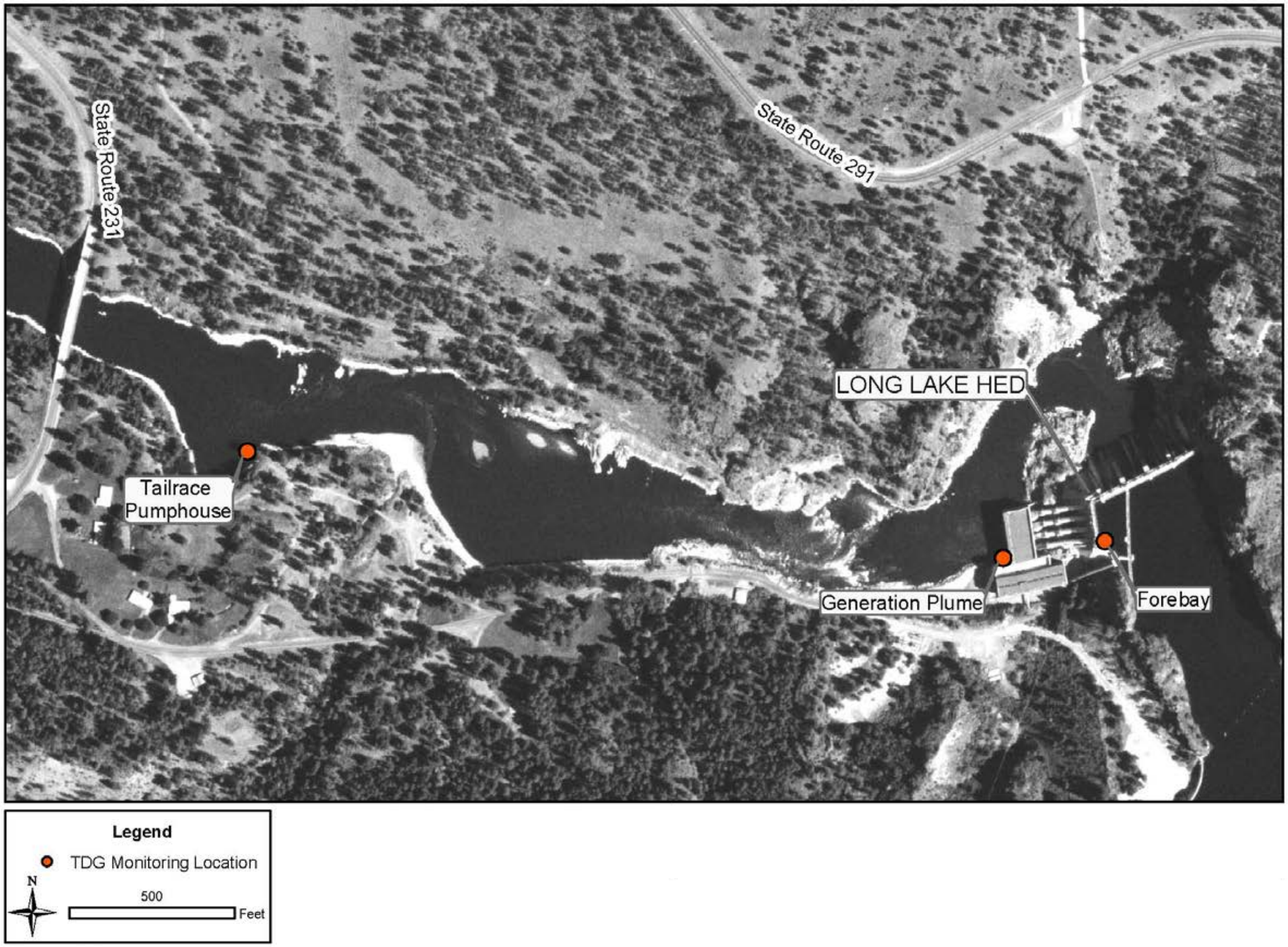
Notes

S	Structural
O	Operations
M	Monitoring

(1) Monitoring will be suspended following FERC approval of the Phase III recommendation and will resume once construction has been completed.
(2) Annual Monitoring Reports are only required following a monitoring season.

Figure 1-1: Long Lake HED TDG compliance schedule

Note: Approved by Ecology on November 21, 2014 and approved by FERC in an Order Granting Extension of Time Under Total Dissolved Gas Attainment Plan issued February 19, 2015 (FERC 2015).



Source: Avista

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

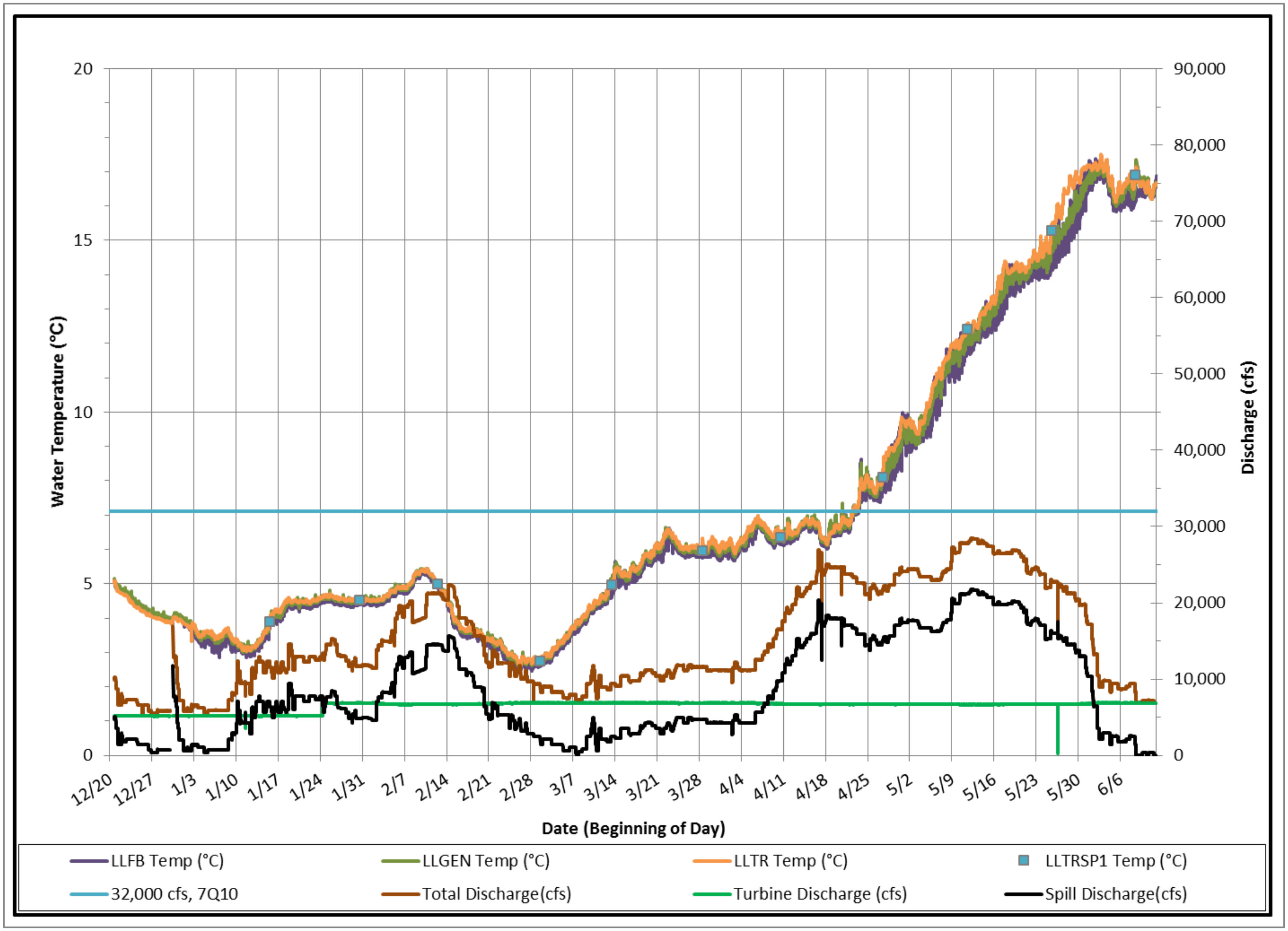


Figure 2-2: Long Lake HED 2018 water temperature (°C) and operations.

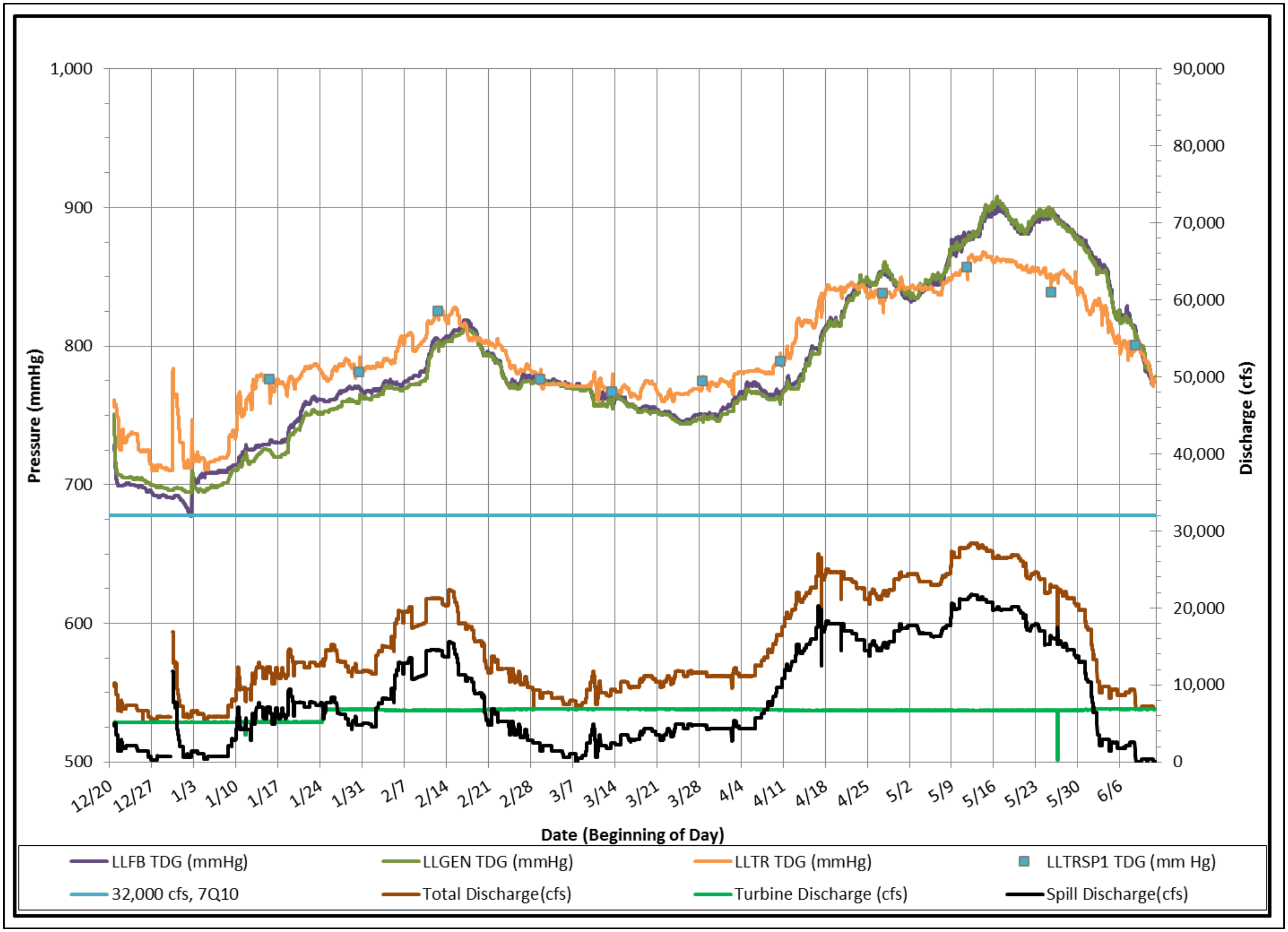


Figure 2-3: Long Lake HED 2018 barometric pressure (mmHg) and operations.

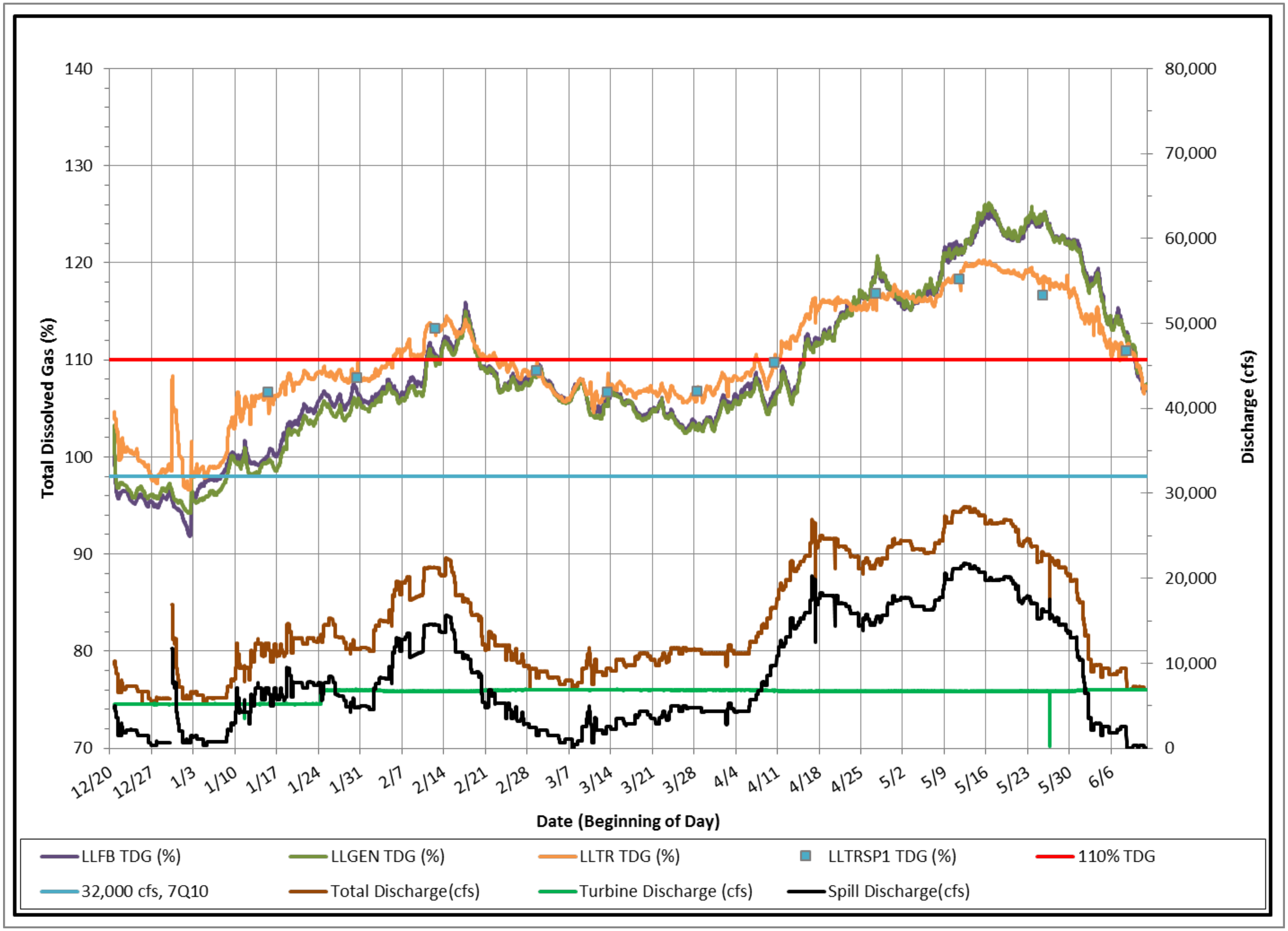


Figure 2-4: Long Lake HED 2018 total dissolved gas (%) and operations.

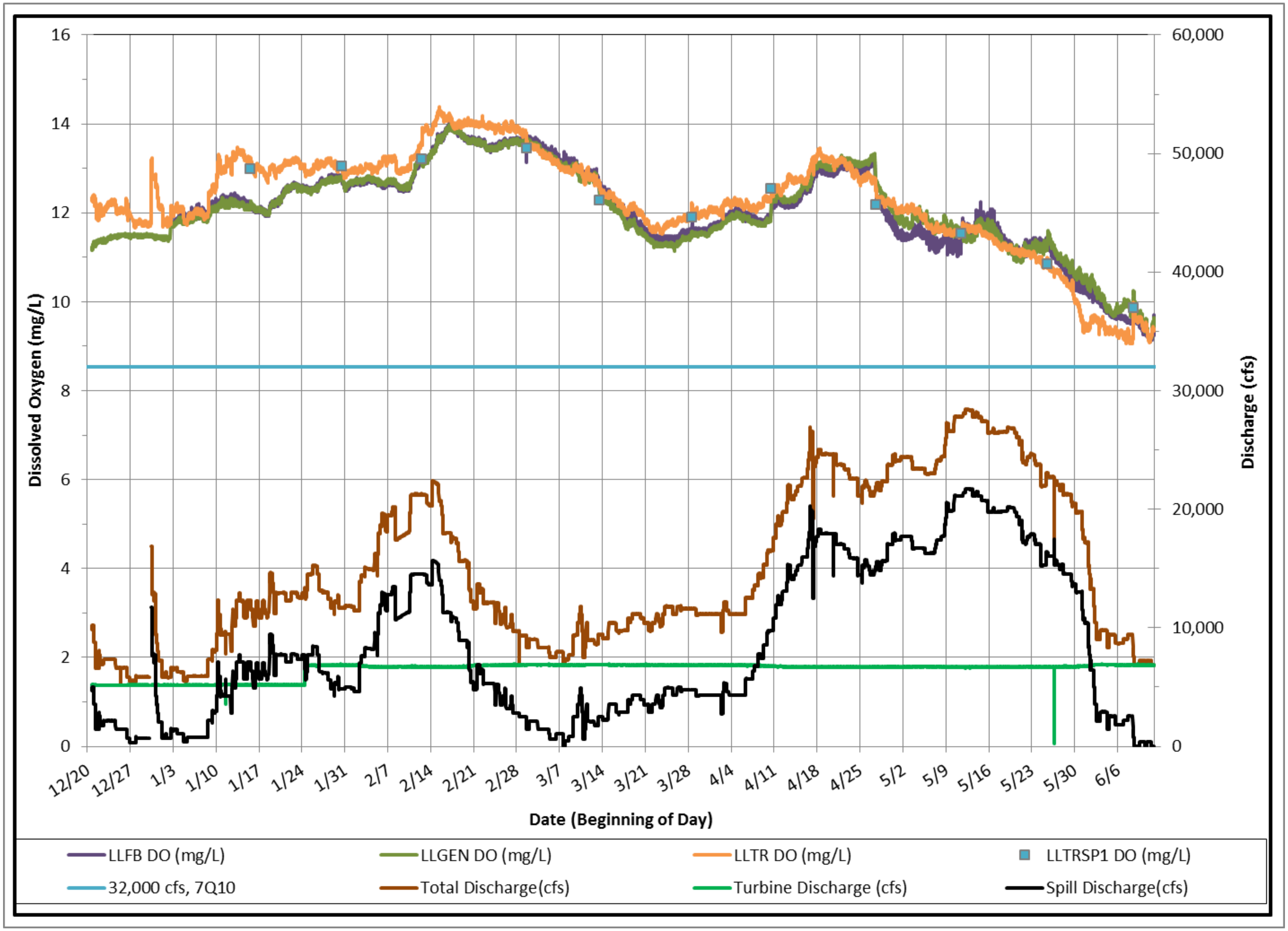


Figure 2-5: Long Lake HED 2018 dissolved oxygen (mg/l) and operations.

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

Notes: Sources: Hach MS5 User Manual and Solinist Levelogger User Guide [5]

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 Washington TDG Monitoring Plan along with the same MQO for DO as used for 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 (MQOs).

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

[5] 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	1.75	0.24	0.24	0.00	2	1	1	5	-0.25	-0.76	-0.76	-5.00
60376	1.21	0.17	0.17	2.26	2	1	1	5	-0.79	-0.83	-0.83	-2.74
48762	0.58	0.08	0.26	3.70	2	1	1	5	-1.42	-0.92	-0.74	-1.30
48763	1.65	0.23	0.23	N/A	2	1	1	5	-0.35	-0.77	-0.77	N/A
48764	1.71	0.23	0.24	1.12	2	1	1	5	-0.29	-0.77	-0.76	-3.88
48765	1.91	0.26	0.26	N/A	2	1	1	5	-0.09	-0.74	-0.74	N/A
Overall RMSE	1.56	0.22	0.22	1.77	2	1	1	5	-0.44	-0.78	-0.78	-3.23

[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	0.17	0.00	0.10	0.09	0.5	0.5	-0.33	-0.50	-0.40	-0.41
60376	0.16	0.03	0.14	0.18	0.5	0.5	-0.34	-0.47	-0.36	-0.32
48762	0.14	0.03	0.04	0.18	0.5	0.5	-0.36	-0.47	-0.46	-0.32
48763	0.16	N/A	0.14	N/A	0.5	0.5	-0.34	N/A	-0.36	N/A
48764[3]	0.24	0.03	0.16	0.15	0.5	0.5	-0.26	-0.47	-0.34	-0.35
48765	0.34	N/A	0.07	N/A	0.5	0.5	-0.16	N/A	-0.43	N/A
Overall RMSE	0.20	0.02	0.13	0.15	0.5	0.5	-0.30	-0.48	-0.37	-0.35

[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 the average of a series of replicate measurements is to the "true" value (low bias). Throughout this seasonal TDG monitoring study, the MS5s underwent calibration and verification procedures.

Instrument accuracy was evaluated through the calibration and maintenance activities. MQOs for total pressure and pre-calibration TDG% were met for all meters (Table A-3). All six MS5s also met the 0.5°C water temperature MQO and 0.5 mg/L DO MQO both for pre-calibration measurements.

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 TDG 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 long-term monitoring stations as in the past, and conducting spot measurements at the same location across the river from LLTR as in past years.

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 TDG data collection period consisted of 16,632 15-minute periods at LLTR and LLGEN, and 16,631 at LLFB. Data completeness was 99 percent for all parameters at each monitoring station except DO at LLFB was 92 percent.

Table A-5 summarizes the number of specific DQCodes applied to LLTR, LLGEN, and LLFB data.

Table A-4. Project completeness.

	LLGEN		LLFB		LLTR	
Parameter	**Count**	**Completeness (%)**	**Count**	**Completeness (%)**	**Count**	**Completeness (%)**
Monitoring Period	16,632	--	16,631	--	16,632	--
Water Temperature (°C)	16,505	99%	16,489	99%	16,562	100%
Dissolved Oxygen (mg/L)	16,504	99%	15,263	92%	16,492	99%
BAR (mm Hg)	Used LLTR BAR		Used LLTR BAR		16,564	100%
TDG (mm Hg)	16,464	99%	16,450	99%	16,516	99%
TDG (% saturation)	16,456	99%	16,443	99%	16,508	99%

Table A-5. Number of specific DQ Codes during the monitoring period.

DQ Code	DQ Code Description	LLGEN					LLFB					LLTR						
		Temp (°C)	TDG (mmHg)	Depth (meters)	DO (mg/L)	Batt (volts)	Temp (°C)	TDG (mmHg)	Depth (meters)	DO (mg/L)	Batt (volts)	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	40	40	40	40	34	36	36	36	36	36	3	10	3	3	3	0	0
998	Out of water after recovery	19	22	19	19	11	47	47	47	47	45	1	1	1	1	0	0	0
997	Equilibrating after deployment	0	38	0	0	0	0	39	0	0	0	0	39	0	0	0	0	0
993	Out of water for calibration/servicing	65	65	65	65	62	60	60	60	60	60	37	37	37	37	34	0	0
888	Power loss	0	0	0	0	0	0	0	0	0	0	28	28	28	29	28	0	0
666	Unknown	3	3	3	4	0	0	0	0	0	0	0	0	0	0	0	8	11
303	Unrealistic DO value, suspect erratic or low voltage	0	0	0	0	0	0	0	0	1,226	0	0	0	0	0	0	0	0
101	Less than "minimum operating voltage" (<7 volts) and other data do not appear reliable	0	0	0	0	0	0	0	0	0	0	1	1	1	70	1	0	0
-101	Less than "minimum operating voltage" (<7 volts), but other data appear reliable	0	0	0	0	0	39	39	39	0	39	148	148	148	79	148	0	0
-102	Between "minimum operating voltage" (<9 volts) and 7 volts, but other data appear reliable	1	1	1	1	1	528	528	528	219	528	330	330	330	330	330	0	0
-211	Depth < TDG compensation depth, but data appear reliable	0	253	0	0	0	0	0	0	0	0	0	1,379	0	0	0	0	0
-888	Power loss, but data appear reliable	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0
-1002	Corresponds with spot measurement	0	0	0	0	0	0	0	0	0	0	11	9	11	11	11	0	0
0	No data qualifiers	16,504	16,210	16,504	16,503	16,524	15,921	15,882	15,921	15,043	15,923	16,072	14,649	16,072	16,072	16,076	16,624	16,621
	Monitoring Period[1]	16,632	16,632	16,632	16,632	16,632	16,631	16,631	16,631	16,631	16,631	16,632	16,632	16,632	16,632	16,632	16,632	16,632

Notes:

1. Monitoring periods consisted of 12/20/2017 18:00 PDT to 6/11/2018 11:45 PDT for LLTR and LLGEN and 12/20/2017 18:15 PDT to 6/11/2018 11:45 PDT for LLFB.

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 Approval – *2018 Long Lake Total Dissolved Gas Monitoring Report.*
Spokane River Hydroelectric Project, No. P-2545

Dear Chris Moan:

The Department of Ecology (Ecology) has reviewed the *2018 Long Lake Total Dissolved Gas Monitoring Report* sent to Ecology on February 28, 2019.

Ecology APPROVES the *2018 Long Lake Total Dissolved Gas Monitoring Report* as submitted. The report meets the 401 Water Quality Certification conditions and requirements for Section 5.4.D of the Ecology 401 Certification.

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

Sincerely,

Pat McGuire

Patrick McGuire
Eastern Region FERC License Coordinator
Water Quality Program

PDM:red

cc: Meghan Lunney, Avista

ECOLOGY COMMENTS AND AVISTA RESPONSES

Ecology Comment
Ecology approves the *2018 Long Lake Total Dissolved Gas Monitoring Report* as submitted.

Avista Response
Avista appreciates Ecology's approval of the *2018 Long Lake Total Dissolved Gas Monitoring Report.*

Ecology Comment
Ecology acknowledged that the information provided in the *2018 Long Lake Total Dissolved Gas Monitoring Report* meets Avista's 401 Water Quality Certification conditions and requirements for Section 5.4D of the Ecology 401 Certification.

Avista Response
Comment noted.

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*
  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 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

After reviewing the TDG Report, here are our comments. The tribe continues to support Avista in their ongoing efforts to reduce total dissolved gas below Long Lake Dam.

Avista Response

Avista appreciates the support.

Spokane Tribe Comment

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 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.

Avista Response

Avista plans to continue collecting TDG data during the 2019 high flow season. Based upon the 2017 and 2018 seasons, data demonstrates the spillway deflectors are most effective at stripping TDG at higher river flows. It is important to note that incoming TDG levels are highly influenced by seasonal and environmental conditions beyond Avista's control. Avista anticipates learning more about this following the 2019 monitoring season. Avista looks forward to working with the Spokane Tribe to review the TDG data that it collects in the downstream river to assist in gaining a better understanding of downstream conditions.

Avista tested 40 different spillgate scenarios, which included single and multiple gate configurations in accordance with the Revised Long Lake HED TDG Compliance Schedule during 2017 and 2018. Test results during these two years were consistent, and demonstrated spreading flows across multiple gates reduces the spillway's influence on TDG downstream. The 40 spillgate configurations exhausted the feasible scenarios that the spillgates would encounter while discharging during the 7Q10 (32,000 cfs). Based on the consistent results of the two years of spillgate testing, and because the potential spillgate scenarios have been exhausted, Avista does not plan to conduct further spillway gate testing.

Avista's ability to refine spill protocols during high flows is not similar to aeration at Long Lake Dam during low flows. During the low flow, summer season, Avista has greater ability to control flows passing downstream of the dam. During high flows, Avista does not have this ability.