AVISTA CORPORATION

2017
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
LLFBSP1	monitoring station in long Lake forebay off Crescent Dam
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 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 on December 14, 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 completed construction of two spillway deflectors as part of the Long Lake Dam Spillway Modification Project in December 2016 and TDG monitoring was re-initiated in spring of 2017. This report discusses TDG monitoring conducted for Long Lake Dam during the 2017 high-flow season, after deflectors were installed on the dam's spillway. A summary of the 2017 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 (Section 5.4(B), FERC 2009). In 2017, use of the Long Lake Dam spillway began on February 12 and discharge at the dam first exceeded the 7Q10 discharge (32,000 total cfs) on March 15. Monitoring began at the Long Lake Dam Tailrace station (LLTR) and Long Lake Dam Generation station (LLGEN) on March 10 and extended through June 20. Although no longer required, monitoring was re-initiated at the Long Lake Forebay station (LLFB) on April 14 and ended June 20.

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 LLTR monitoring location 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 2017 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.

In addition, a MS5 equipped with a short power/data cable and a laptop computer was used as a portable TDG meter to obtain spot measurements at long-term and short-term TDG monitoring stations.

2.3.2 Station Facilities

To facilitate TDG and DO monitoring, 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 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 starting in April. Site visits were done at approximately one-to-three week intervals. Spot measurements were taken across the river from LLTR,

[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

at LLTRSP1 and in the dam's forebay off the Crescent Dam at LLFBSP1 (Table 2-1). The spot measurements taken at LLFBSP1 were to investigate this location to determine if water quality parameters were consistent between this location off the Crescent Dam and the permanent station at LLFB. 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 at the site.

2.3.4 Data Collection and Processing

Parameters monitored at 15-minute log intervals with the instruments 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 based on measurements, 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.

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

2.3.5 Spillway Gate Testing

Preliminary spillway gate testing was conducted in 2017 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 2017 are summarized in Table 2-2.

2.3.6 Monitoring Difficulties

Prior to the TDG monitoring season, four of Avista's MS5s were serviced and calibrated at Hach Hydromet (Hach) Technical Support & Service and additionally, each unit successfully passed the mass verification test conducted the morning of February 28, indicating they were operating correctly and providing reliable values. Logger issues were encountered at each of the three monitoring stations.

The Washington Total Dissolved Gas Monitoring Plan (Golder 2010a) states each MS5 should be downloaded and recalibrated at approximately 2 week intervals. MS5's at both LLTR and LLGEN were deployed on March 10, with the MS5 at LLGEN being redeployed on March 14. Two weeks later, an attempt was made to retrieve and recalibrate both MS5’s, but the river’s water levels had risen to a point that access to the MS5’s was not available. On April 7, it was determined that the water was at a level where the MS5s could not be removed from their stilling wells, but their data could be downloaded. On April 7, their data was downloaded but no recalibration was able to be conducted. It was not until April 14 that the MS5 was able to be accessed and recalibrated, resulting in nearly 5 weeks between calibration periods. Calibration on April 14 showed both MS5’s met the Measuring Quality Objective’s identified in the Monitoring Plan (See Appendix A, Table A-2), therefore all 5 weeks of data were deemed reliable and included in analysis.

LLTR

Starting in Mid-April, the low water level at the LLTR station left the MS5’s depth in the water slightly below the 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. Starting June 12, the water level dropped low enough that the MS5 was out of the water for varying periods of time, which resulted in various lengths of data gaps from June 12 to the end of the sampling season on June 20. In the future, when this issue is identified, the MS5 will be removed from the stilling well and placed directly on the river bottom to avoid de-watering.

On May 17, MS5 #48763 was removed from the water and recalibrated. No unusual drift was observed during recalibration and the probe was redeployed at LLTR. On May 24, unusually low and variable DO values were observed at the LLTR station. On May 26 the probe was removed and replaced with MS5 #60376. After reviewing the data since the previous calibration, it was uncertain when the DO parameter became unreliable, therefore all DO readings from May 17 to May 26 were removed from final analysis.

LLGEN

MS5 #48764 was deployed at LLGEN on March 10 at 12:00 Pacific Daylight Time (PDT) and recorded data without issue until March 10 at 19:45 PDT. At that point, the TDG reading rapidly decreased from 791 mmHg to 537 mmHg in a matter of one hour and then continued to read values that were outside typical TDG values. The MS5 could not be recalibrated to the local barometric pressure and was therefore replaced on March 14 at 12:00 PDT with MS5 #60375. MS5 #48764 was returned to Hach for repair to resolve the issue. Hach reported that the MS5 had a TDG sensor failure that caused the issue and replaced the faulty sensor.

On April 14, MS5 #60375 was removed from the stilling well at the LLGEN location for recalibration. When the MS5 was lowered back in the well after calibration, it became lodged in the well before it reached its typical depth in the well. An attempt for remove it from the well at this time was unsuccessful. It was determined that forcefully removing the MS5 may intensify damage to the sensor so it was left lodged in the well. An attempt was made on April 20 to remove the probe again, which proved unsuccessful. A third attempt was made to remove the MS5 on April 28, which was successful. After dislodging the probe, the probe was immediately dropped back down the well where is was able to reach its typical depth. It was allowed to log for 30 min as a way to assess if the readings taken at the typical depth differed from the readings taken immediately before the MS5 was dislodged from above the typical depth. The TDG value was 825 mmHg at typical depth whereas it was at 811 mmHg just 30 minutes before at the non-typical depth. The MS5's depth values showed a difference of approximately 5.5 feet between the typical and non-typical depths. Based on this information, the data from April 14 at 16:30 PDT to April 28 at 14:45 PDT was determined to be not representative of the station's typical water conditions and was therefore eliminated from the final data set.

LLFB

On April 14, MS5 #48765 was initially deployed at LLFB at 17:00 PDT. The MS5 was connected to the station's data communications hardware and left to run off the MS5's battery reserves. The power required to run the communications hardware rapidly depleted the MS5's battery reserves and the MS5 lost power and stopped logging data on April 15 at 9:00 PDT. On April 20, the batteries were replaced and the MS5 was connected to external AC power. This resulted in a data gap from April 15 at 9:15 to April 20 at 11:00 PDT.

On May 17, MS5 #48765 at LLFB was recalibrated and replaced in the stilling well. After allowing time for the TDG sensor to equilibrate from being out of the water for a period of time, it was observed that the TDG sensor was reading values drastically above typical TDG values. On May 19, the MS5 was removed from the stilling well and placed directly in the forebay water, where it began reading more typical values. The MS5 was then returned to the stilling well where is again read non-typical values, leading to the conclusion that the well was causing the non-typical values. On May 30, debris was cleaned out of the well with compressed air to ensure water was able to freely flow through the well. After cleaning the well, the MS5 was redeployed and found to be reading accurately, leaving a data gap from May 17 at 14:30 to May 30 at 10:15.

2.4 Results

The TDG monitoring season consisted of the period from March 10 at 11:30 PDT through June 20 at 3:30 PDT, which included 9,761 15-minute periods (Table 2-3). The MS5 at LLTR was deployed the entire monitoring season and recorded data for 93% of the sampling season. Data from LLGEN was recorded from March 10 at 12:00 to the end of the sampling season and recorded data for 82% of the season. Due to delayed deployment, data was recorded for 47% percent of the sampling season at LLFB. Monitoring at LLFB was not a requirement of the 2017 monitoring plan, but was voluntarily initiated partially though the sampling season 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 and LLFBSP1 on April 20, April 28, May 17, and May 30, and June 9, when long-term deployment or download of instruments was conducted (Table 2-4). Values from the spot measurement at LLFBSP1 taken on May 30 were outside the typical range of values at this location and were therefore eliminated from the data set. All other results of continuous and spot measurements are displayed in Figures 2-2 through 2-5.

2.4.1 Discharge

Combined Long Lake Dam hourly generation and spill discharge for the March 10 11:30 PDT through June 20 at 3:30 PDT monitoring period ranged from approximately 6,663 cubic feet per second (cfs) to 46,331 cfs. Spills at Long

Lake Dam reached a maximum of approximately 39,923 cfs, which was 86 percent of the total river discharge (generation plus spill discharge) of approximately 46,331 cfs on March 20. Spill from the dam occurred as late as June 20. With the exception of 3 hours on June 14, Long Lake Dam generation was near full capacity for all periods when spill occurred at the dam. Total river discharge exceeded the Ecology-designated 7Q10 for 477 hours (nearly 20 days) from mid-March to early April.

2.4.2 Water Temperature

Water temperature in the tailrace (LLTR) increased from approximately 3.7°C in early March to approximately 17.5°C near the end of June (Figure 2-2). Maximum temperatures of 17.53°C and 17.87°C at LLTR and LLGEN respectively occurred on June 7. Water temperature measured at LLFB during April 14 through June 20 reached a maximum of 17.35°C on June 15.

2.4.3 Barometric Pressure

Site-specific barometric pressures ranged from 705 to 737 mmHg based on the Solonist® barologger deployed at LLTR (Figure 2-3).

2.4.4 Total Dissolved Gas

TDG pressure for LLTR was greater than corresponding values for LLGEN from the beginning of the monitoring period until April 1 (Figure 2-3). From April 1 until the end of the monitoring period, the relationship varied with TDG pressure at LLGEN being equal to or higher than pressure at LLTR 69.9 percent of the remaining season. Once LLFB monitoring started on April 14, TDG pressure at LLFB was equal to or higher than the TDG pressure at LLTR for 89.9 percent of the remaining monitoring season (Figure 2-3). TDG pressure at LLGEN and LLFB corresponded well, trending similarly, with the largest difference seen on May 31. A two-sample t-test showed no significant difference between TDG pressure at the LLGEN and LLFB locations ($p=0.465$).

Spot values for LLTRSP1 coincided with the continuous monitoring data for LLTR, ranging in difference from 2-14 mmHg. Spot measurements at LLFBSP1 coincided with the continuous monitoring at LLFB with the difference ranging from 4 – 12 mmHg.

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. Discharge through the dam first exceeded 32,000 cfs on March 15 and remained above the 7Q10 until April 2, with the exception of one hour on March 20. Discharge again exceeded the 7Q10 on April 3 and continued to be above 32,000 until April 5.

TDG percent values for LLGEN, which is essentially unaffected by spill at Long Lake Dam, exceeded 110 percent of saturation from sometime between the days of March 10 and 14 until June 13, and had TDG percent values that ranged from 104.8 to 125.1 percent (Figure 2-4). TDG percent at LLTR, which is affected by spill at the dam, exceeded 110 percent of saturation from the beginning of monitoring on March 10, continuously until June 7, and then periodically topped and fell below 110 percent until June 11. TDG percent values at LLTR ranged from 104.8 to 126 percent. TDG percent values at LLFB followed a similar pattern to LLGEN, where it was over the 110 percent exceedance when it was deployed on April 14 and remained above the criterion until June 13, with a value range of 105.2 to 119.3 percent TDG.

The maximum TDG percent values seen in 2017 coincided with discharge above the Ecology-specified 7Q10 of 32,000 cfs. While not accountable for the TDG saturation in the river during this time, the spillway modification was designed to reduce TDG saturation at both high and low discharge values, therefore TDG saturation above 32,000 was included in the 2017 analysis. 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 8.8 to 14.7 mg/L for LLGEN, 9.3 to 13.6 mg/L for LLFB, and 8.7 to 15.4 mg/L for LLTR (Figure 2-5). The greatest DO concentrations occurred in March, although values remained above the 8.0 mg/L DO criterion throughout the entire monitoring period.

2.4.6 Spillway Gate Test

In 2017, gate testing was used to evaluate adjustments in the number of gates used and how high the gate were opened influenced TDG percent trends (Table 2-5). The number of gates open and opening height combinations were compared at relatively similar spill discharges to assess the resulting amplitude of TDG percent change at LLTR and whether that change was contrary to the trends seen at the corresponding timeframe at LLGEN and LLFB.

A gate test was conducted on March 17, where gates 3, 4, 5, and 6 were kept at constant gate heights (Figure 2-6). For the first part of the test, gate 7 was held at 8 feet, resulting in a TDG percent range of 122.5-122.7. For the second part of the test, gates 7 and 8 were each open 4 feet. Spreading out this spill resulted in a decrease in TDG percent at LLTR, decreasing from 122.7 to 121.0. LLGEN showed a slight increase from 113.6 to 114.0 during this time frame, indicating that spreading out the discharge across more gates reduced percent TDG.

Multiple gate tests were conducted from April 10 – 12 (Figure 2-7). Testing began with gates 3, 4, and 6 at heights ranging from 4.0 to 7.9 ft and gate 5 at 22.5 ft. Gate 5 was then lowered while gates 3, 4 and 6 were increased so all 4 gates were at heights ranging from 8.6 to 9 ft. This change created a slight increase in percent TDG going from 120.8 percent to 121.2 percent. After being held at these gate positions for some time, the gate configuration was again changed adding gates 7 and 8 to the configuration, leaving gates 3 - 8 at heights ranging from 5.6 – 6.4 ft. With the spill spread out over 6 gates, percent TDG was reduced from 121.2 to 119.2. From there, the spill was confined to only three gates, with gate 3 being open 3.3 ft and gates 4 and 5 being opened to 22.4 ft each. Reducing the amount of gates used and substantially increasing the height of two gates increased TDG percent from 119.2 to 120.7. The gates were then reconfigured so gates 3, 4, 5, and 6 were all at heights ranging from 6.6 – 9.9 ft. This configuration stabilized TDG percent, maintaining a value of 120.8 for the 4.5 hours of testing.

For the next group of testing, gates 3, 4, 5, and 6 started out configured at heights ranging from 6.9 – 10 ft resulting in a percent TDG of 120.8 (Figure 2-8). The gates were then reconfigured, spreading out spill between gates 3 - 8 at heights ranging from 4.7 to 6.0 ft. Spreading out the spill over these 6 gates resulted in a reduction of percent TDG from 120.8 to 118.6. Spill remained spread out over the 6 gates until they were reconfigured back to just using gates 3 – 6 all at heights ranging from 7.0 – 10.0 ft. This change increased TDG percent from 118.9 to 121.3. The gate configuration of using only gates 3 – 6 was maintained until spill was again spread out between gates 3 – 8, at height range of 5.6 to 7.9 ft. This change resulted in a decrease of percent TDG from 121.4 to 120.6.

On May 24, a short gate test was conducted to evaluate the impacts of having one gate wide open versus opening multiple gates at shorter gate heights (Figure 2-9). Gate 6 was opened to 21.9 ft resulting in a percent TDG of 115.2. Spill was then spread across gates 4 – 8 with gate heights ranging from 1.6 to 3.9 ft. Spreading out spill resulted in a decrease in TDG percent from 115.0 to 114.3.

Three gate tests were conducted to replicate the testing originally conducted in 2003. Test were considered a replicate if the 2017 spill discharge was ±600 cfs from the 2003 spill discharge value. In 2003, gate 5 was tested at a spill discharge of 6,043 cfs, resulting in a 9 percent increase in TDG when comparing LLTR to LLFB (Table 2-6). In 2017, gate 5 was again tested at a spill discharge of 6,554 cfs resulting in a decrease of 2-3 percent TDG at LLTR when compared to LLFB and LLGEN values respectively. A test on gate 6 at around 12,500 cfs spill discharge showed a 14 percent increase in TDG percent at LLTR when compared to LLFB in 2003. The same test in 2017 showed a 2 percent decrease in TDG percent when comparing LLTR to LLGEN. The final replicate test was conducted on the combination of gates 5 and 6 spilling a combined 6,000 cfs. In 2003, this test resulted in an increase of 5 percent TDG when comparing LLTR to LLFB. In 2017, the test resulted in a decrease of 3 percent TDG at LLTR when compared to LLFB and LLGEN values.

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 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,[3] 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. Following completion of the project,

[3] 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.

during 2017, Avista resumed TDG monitoring 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 plans to continue TDG monitoring to assess the effectiveness of the modifications and to evaluate spillgate operational protocols during 2018.

2.6 Discussion

Due to above average precipitation, spring of 2017 saw the 4th highest peak discharge measured in the Spokane River since measurements began in 1894. The high range of discharges seen in the river allowed for a robust evaluation of how the newly constructed spillway modification performed at and above the 7Q10 discharge, as well as at the lower discharge values seen in previous monitoring season.

Contrary to historic measurements at Long Lake Dam (Golder 2003, 2004, 2011, 2012, 2013), TDG at LLTR was less than the TDG levels at LLGEN and LLFB for much of 2017. The TDG levels at LLTR still followed the pattern of spill flows, as seen in previous monitoring seasons. While TDG percent values at LLTR exceeded the 110% criterion earlier in the season than LLGEN and LLFB, all three locations remained above 110% throughout the descending arm of the river's discharge curve with LLTR being the first monitoring location to drop below 110%.

Comparison of the TDG% at LLTR and spill discharges for 2017 indicate TDG% was greater than the 110 percent criterion 99 percent of the time when spill was at least 5,000 cfs, but it was only greater than the 110 percent criterion 59 percent of the time for spills of less than 5,000 cfs (Table 2-5). However, when comparing LLTR TDG% and LLGEN TDG% for the same time (referred to as data pairs[4]), TDG% values at LLTR were greater than at LLGEN and exceeded the 110 percent criterion for 0 percent of the 293 15-minute data pairs with spill of less than 5,000 cfs. The same relationship was seen when comparing LLTR TDG percent to that of LLFB. This is in stark contrast to historic measurement from 2011-2013 where LLTR percent TDG was greater than LLGEN or LLFB 15%, 100%, and 36% of the time respectively. In 2017, when spill ranged from 5,000 - 11,000 cfs, TDG percent values at LLTR were greater than at LLGEN and exceeded 110% 7 percent of the 15-minute data pairs and were greater than LLFB and over 110% 10 percent of the time. For periods with spills over 11,000 cfs, LLTR percent TDG values were greater than LLGEN and over 110% 57 percent of the monitoring period and greater than LLFB and over 110% 12 percent of the time (Table 2-7).

These data show that TDG% values at LLTR, which includes water that is spilled over the dam's spillway, were frequently lower than the values from LLGEN or LLFB. The longevity and frequency of LLTR values being less than LLGEN or LLFB had not been seen in previous annual monitoring, indicating the spillway modification project implemented in 2016 positively influenced TDG levels in the Long Lake Dam tailrace.

Of equal importance, the maximum TDG% at LLTR in 2017 was 126%, which signified a dramatic reduction from values seen in previous years (Table 2-8). For example, discharge flows in 2012 of 37,100 cfs had the closest peak

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

discharge flows to 2017, which were 46,331 cfs. For those years, the maximum TDG% in 2012 was 146% compared to a maximum of 126% in 2017 (Figure 2-10). The maximum 2017 TDG% was less than the maximum values for all other years besides 2004, including years when maximum discharge flows peaked at around 22,000 cfs. Collectively, this further indicates the positive influence the spillway modification project had on TDG levels downstream of the dam.

Additionally, gate testing showed that spreading out the spill discharge between multiple gates at lower gate heights decreases the percent TDG downstream. In early season gate testing, percent TDG at LLTR was greater than the values seen at LLGEN and LLFB, while later test showed the opposite relationship. This indicates that the relationship between the percent TDG at LLTR and LLGEN/LLFB may be driven more by the overall quantity of spill or other water characteristics (e.g. water temperature, etc.), than by the specific gate configuration.

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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"	Investigational
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
LLFBSP1	On left downstream bank, off Cresent Dam	47° 50'05" / 117° 50'19"	Investigational spot during spillway use

Table 2-2. Summary of spillway gate testing conducted in 2017.

17 March		10-12 April		24 May	
Time	**Gate Number and Height (ft)**	**Time**	**Gate Number and Height (ft)**	**Time**	**Gate Number and Height (ft)**
6:00-8:30	3@11.6, 4@12.5, 5 & 6@ 12.0, 7@8.0	4:00-8:00	3@4.0, 4@7.0, 5@22.5, 6@7.9	12:00-15:00	6@21.9
9:00-10:45	3@11.6, 4@12.5, 5 & 6@ 12.0, 7@4.1, 8@4.0	8:15-13:00	3@8.8, 4@8.6, 5@9.0, 6@8.9	15:45-20:00	4@1.6, 5@1.9, 6@3.0, 7@3.9, 8@3.9
		13:15-17:00	3@6.1, 4@6.4, 5@6.1, 6@6.1, 7@5.6, 8@5.7		
		17:15-21:00	3@3.3, 4@22.4, 5@22.4		
		1:00-4:45	3@7.7, 4@9.9, 5@9.9, 6@6.6		
		5:00-8:15	3@8.0, 4@10.0, 5@10.0, 6@6.9		
		8:45-11:15	3@5.4, 4@5.7, 5@5.5, 6@6.0, 7@4.7, 8@4.8		
		13:15-16:15	3@5.4, 4@5.7, 5@5.5, 6@6.0, 7@5.4, 8@5.4		
		17:15-0:45	3@7.7, 4@9.7, 5@10.0, 6@7.0		
		1:00-7:00	3@8.0, 4@10.0, 5@10.0, 6@7.0		
		9:15-13:00	3@7.5, 4@7.9, 5@7.5, 6@7.5, 7@5.6, 8@5.7		

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)	3/10/17 12:00	6/20/17 3:30	9,759	4/14/17 16:15	6/20/17 3:30	6,382	3/10/17 11:15	6/20/17 3:30	9,771
Water Temperature (°C)	3.69	17.87	9,587	6.45	17.35	4,589	#N/A	#N/A	9,087
Dissolved Oxygen (mg/L)	8.77	14.70	8,241	9.29	12.20	3,018	#N/A	#N/A	8,227
BAR (mm Hg)	Used LLTR BAR			Used LLTR BAR			705	731	9,762
TDG (mm Hg)	759	890	7,962	755	855	4,589	#N/A	#N/A	9,055
TDG (% saturation)[1]	#N/A	#N/A	7,962	105	119	4,589	105	126	9,055

Notes:

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

Table 2-4. LLTRSP1 and LLFBSP1 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	4/20/2017	7.5	#N/A	843	725	116.3
LLFBSP1	4/20/2017	7.6	#N/A	844	720	117.3
LLTRSP1	4/28/2017	9.0	12.4	841	726	115.9
LLFBSP1	4/28/2017	9.0	12.2	828	721	114.8
LLTRSP1	5/17/2017	11.6	11.6	834	721	115.7
LLFBSP1	5/17/2017	11.5	11.4	824	717	114.9
LLTRSP1	5/30/2017	15.2	11.1	830	718	115.6
LLTRSP1	6/9/2017	17.1	#N/A	794	717	110.8
LLFBSP1	6/9/2017	17.2	#N/A	788	712	110.6

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	6,904			6,771			3,377		
Total # of records	9,055			7,963			4,589		
Periods when TDG exceeded 110% saturation (PDT)[1,2,3]	3/10/2017 12:15	to	3/15/2017 14:45	3/14/2017 15:00	to	3/15/2017 14:45	4/14/2017 18:00	to	4/20/2017 19:30
	3/20/2017 11:00	to	3/20/2017 11:45	3/20/2017 11:00	to	3/20/2017 11:45	4/30/2017 18:45	to	4/30/2017 19:30
	4/2/2017 16:00	to	4/3/2017 11:45	4/2/2017 16:00	to	4/3/2017 11:45	5/13/2017 23:45	to	5/14/2017 19:30
	4/5/2017 9:00	to	6/7/2017 4:45	4/5/2017 9:00	to	6/12/2017 23:45	5/16/2017 16:45	to	6/13/2017 22:00
	6/7/2017 7:00	to	6/8/2017 1:15	6/13/2017 0:45	to	6/13/2017 1:15			
	6/8/2017 4:15	to	6/8/2017 22:15						
	6/9/2017 8:15	to	6/9/2017 10:30						
	6/9/2017 12:45	to	6/10/2017 22:45						
	6/11/2017 16:00	to	6/11/2017 16:30						

Notes:

1. Flows exceeded the 7Q10 from 3/15/2017 15:00 to 4/2/2017 16:00 with the exception of 1 hour and from 4/3/17 12:00 to 4/5/17 9:00.
2. Refer to Figure 2-4 and Appendix A for data gaps.
3. LLGEN had a data gap between 3/10/2017 19:45 PDT, which had a TDG% of 109.1%, and 3/14/2017 15:00 PDT, which had a TDG% of 110.7%.

Table 2-6. Comparison of 2003-2004 and 2017 spillway gate testing results.

	2003-2004						2017						
Gate Number	Gate Height (ft)	Discharge (cfs)			TDG % LLTR	TDG % LLFB	Gate Height (ft)	Discharge (cfs)			TDG % LLTR	TDG % LLGEN	TDG % LLFB
		Spill	Unit	Total				Spill	Unit	Total			
5	9.0	6,043	7,000	13,043	124	115	10.2	6,554	6,838	13,392	114	117	116
6	24.0	12,493	7,000	19,493	127	113	21.9	12,385	6,718	19,103	115	117	
5 & 6	4.5	6,043	7,000	13,043	120	115	4.0	6,033	6,867	12,900	113	116	116

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	7,457	7,457	100%	5,747	3,296	57%
5-11 kcfs spill	976	971	99%	966	70	7%
<5 kcfs spill	487	286	59%	471	0	0%
No spill	131	0	0%	131	0	0%
All spill and non-spill	9,051	8,714	96%	7,315	3,366	46%

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

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

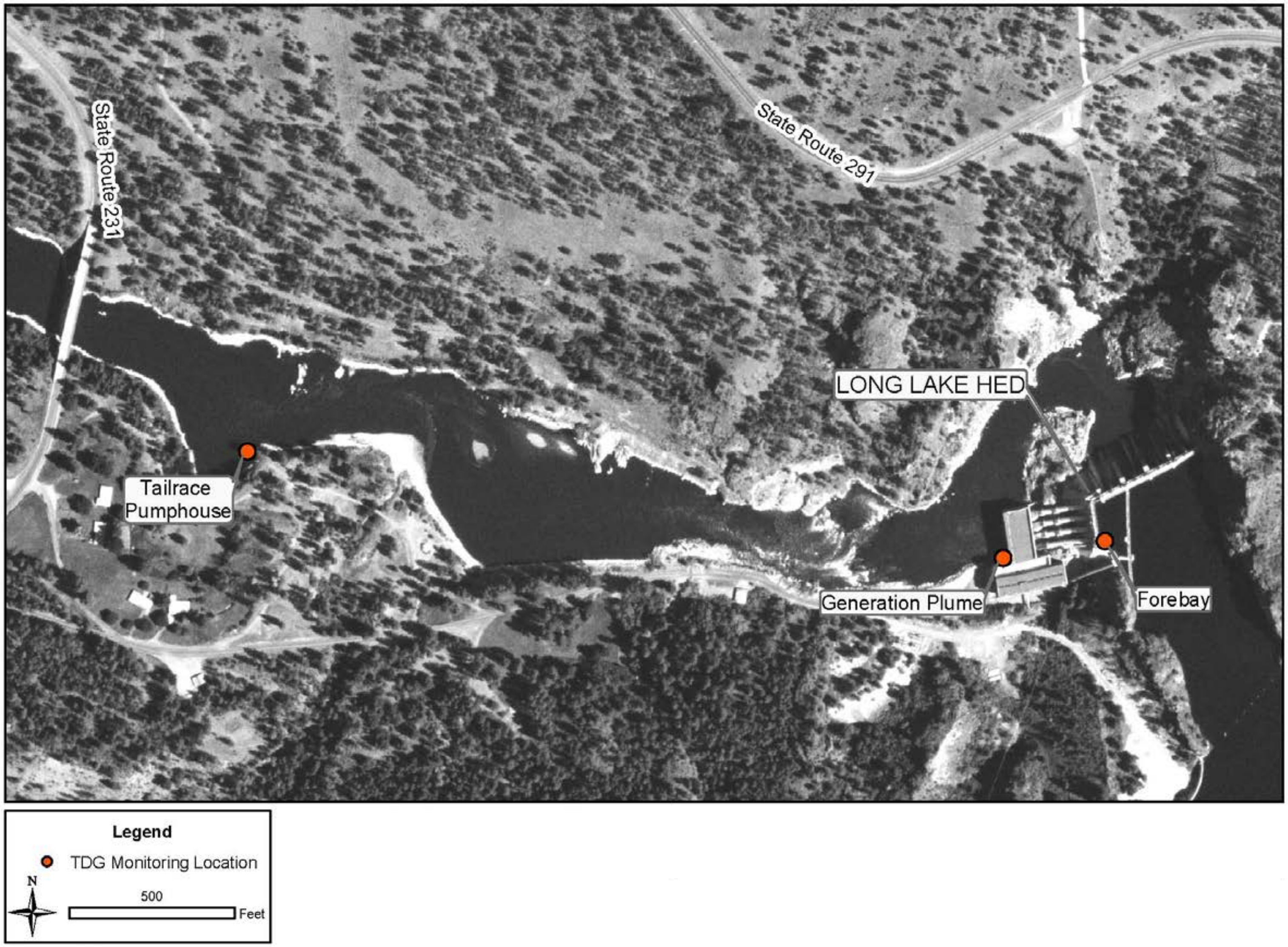
Notes

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.

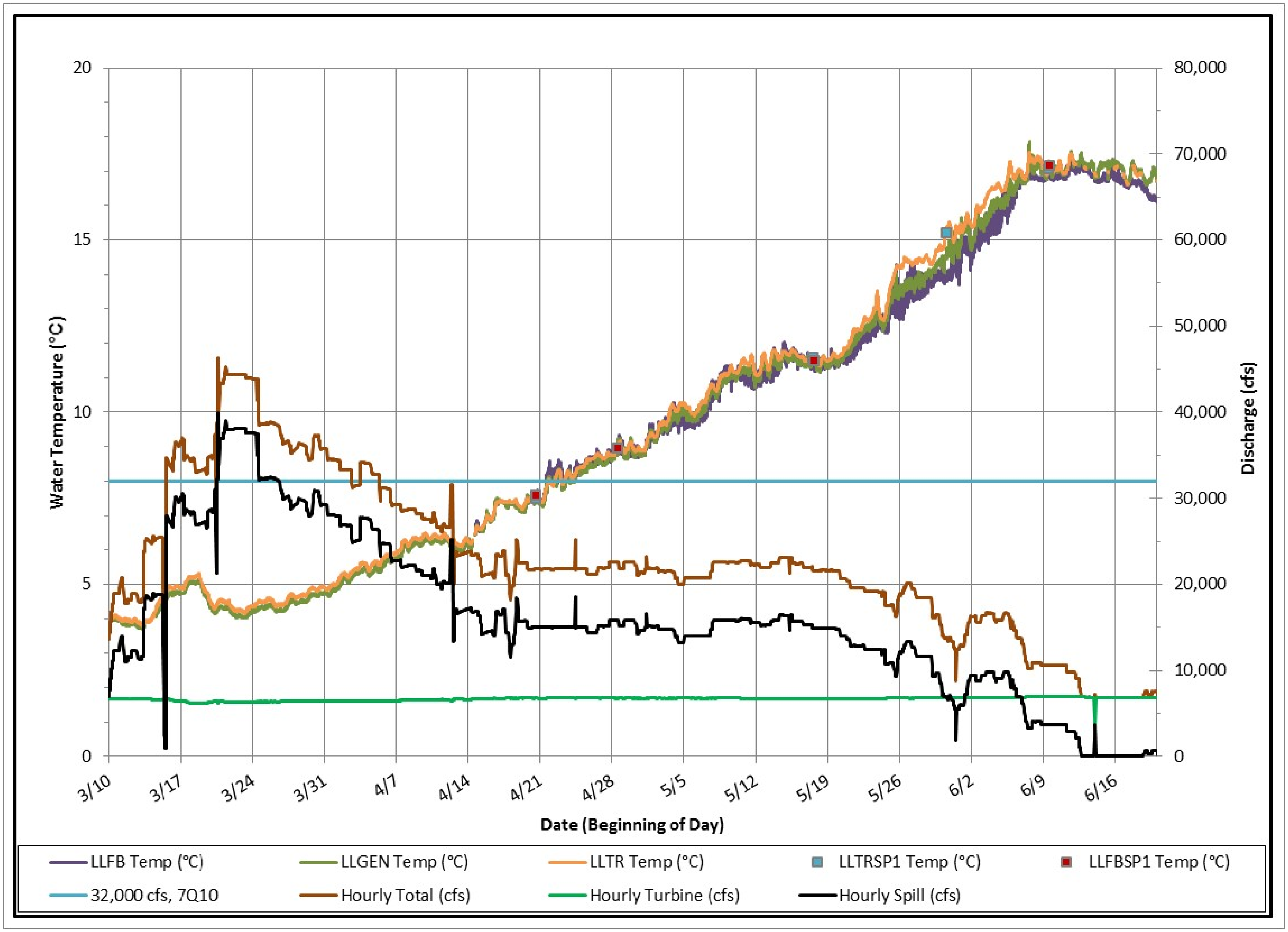


Figure 2-2: Long Lake HED 2017 water temperature (°C) and operations.

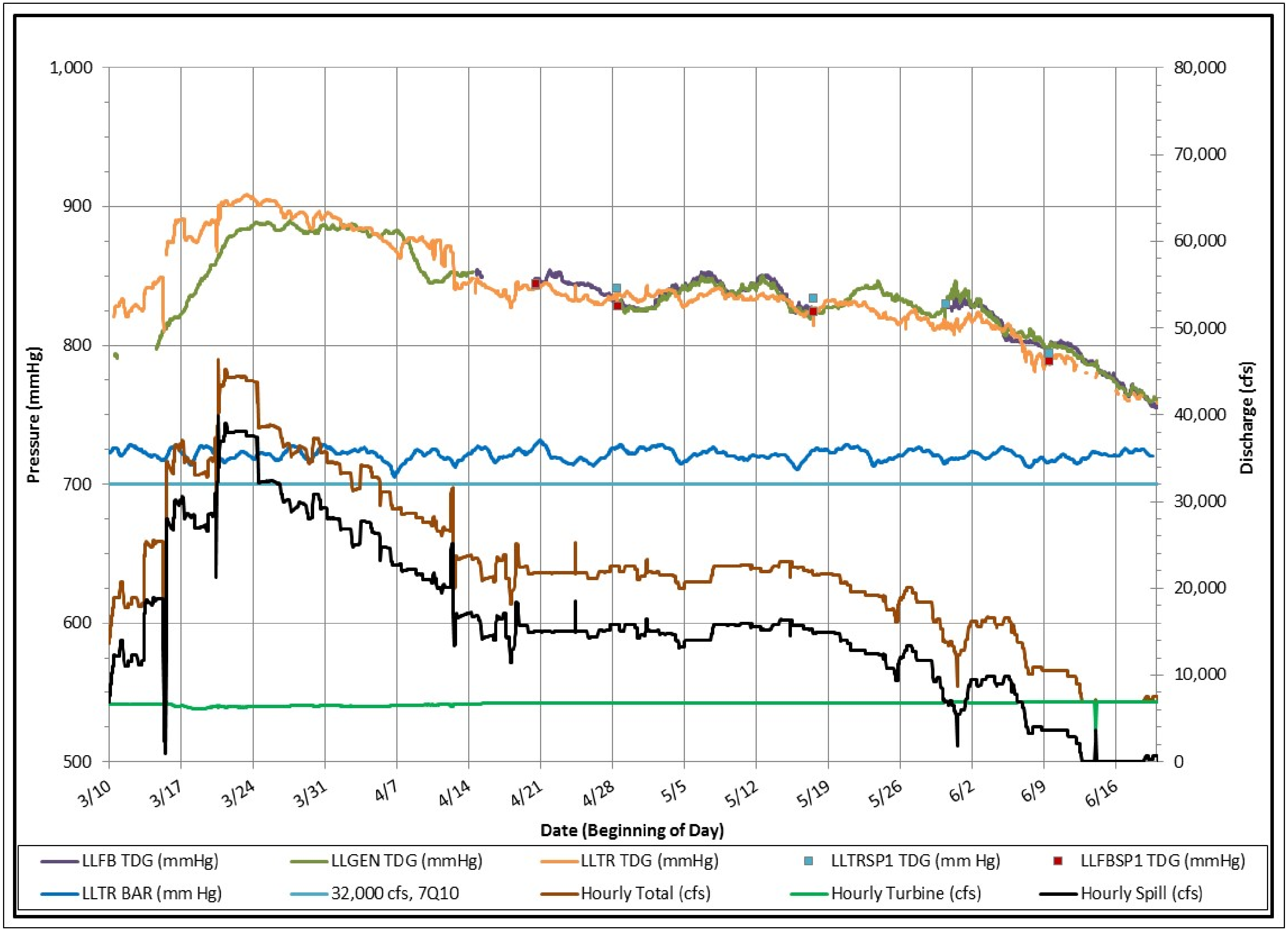


Figure 2-3: Long Lake HED 2017 barometric pressure (mmHg) and operations.

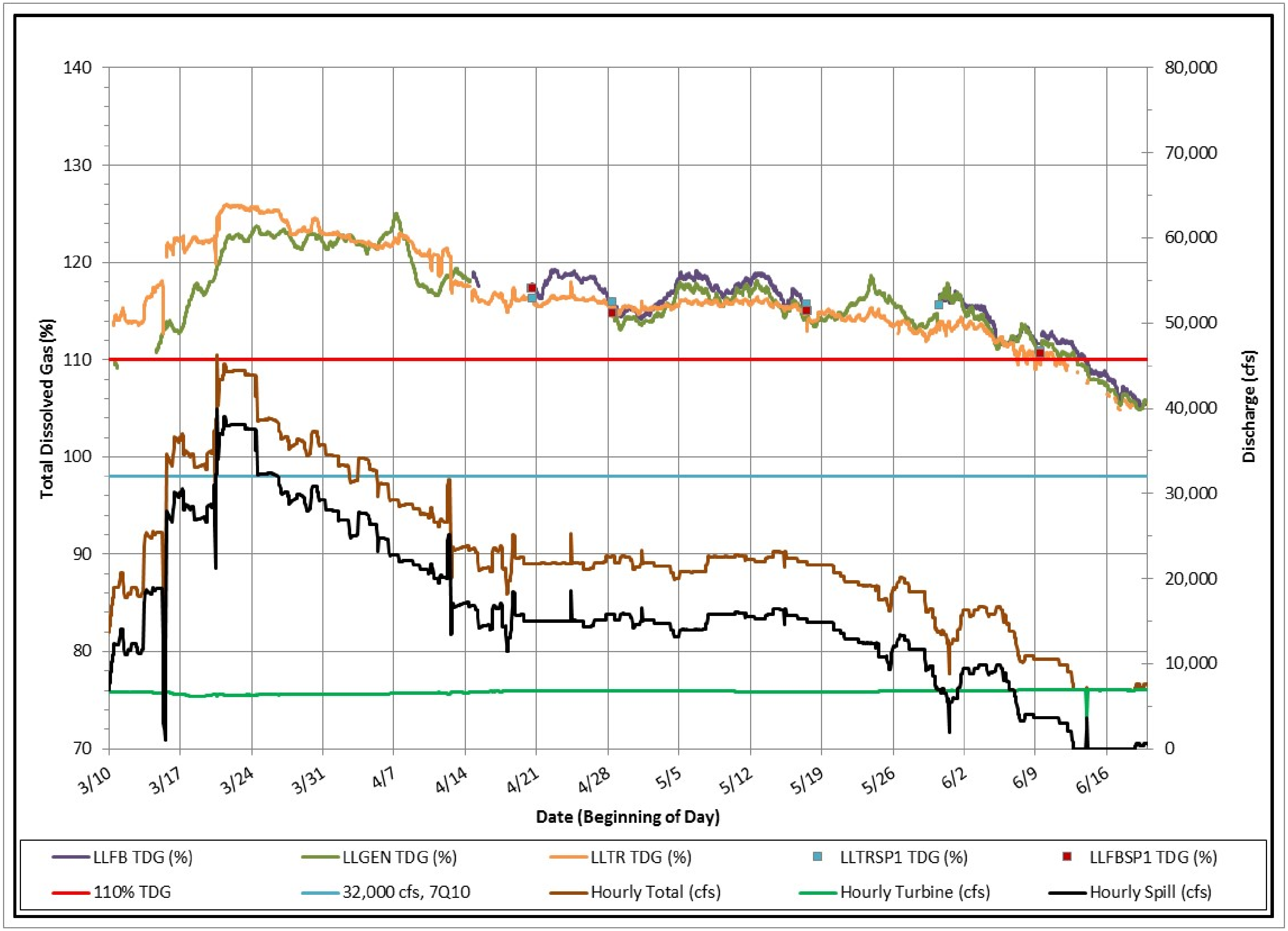


Figure 2-4: Long Lake HED 2017 total dissolved gas (%) and operations.

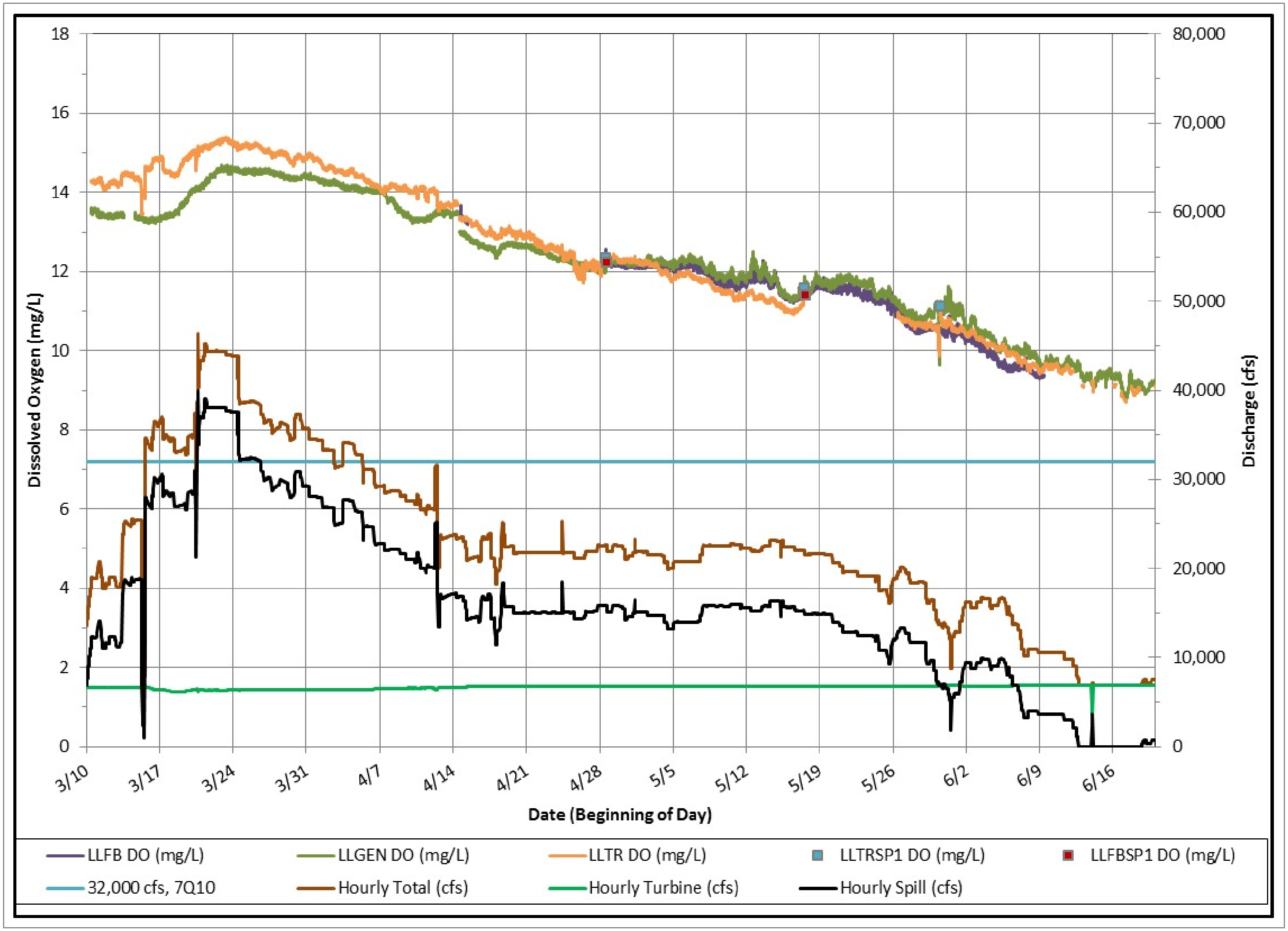


Figure 2-5: Long Lake HED 2017 dissolved oxygen (mg/l) and operations.

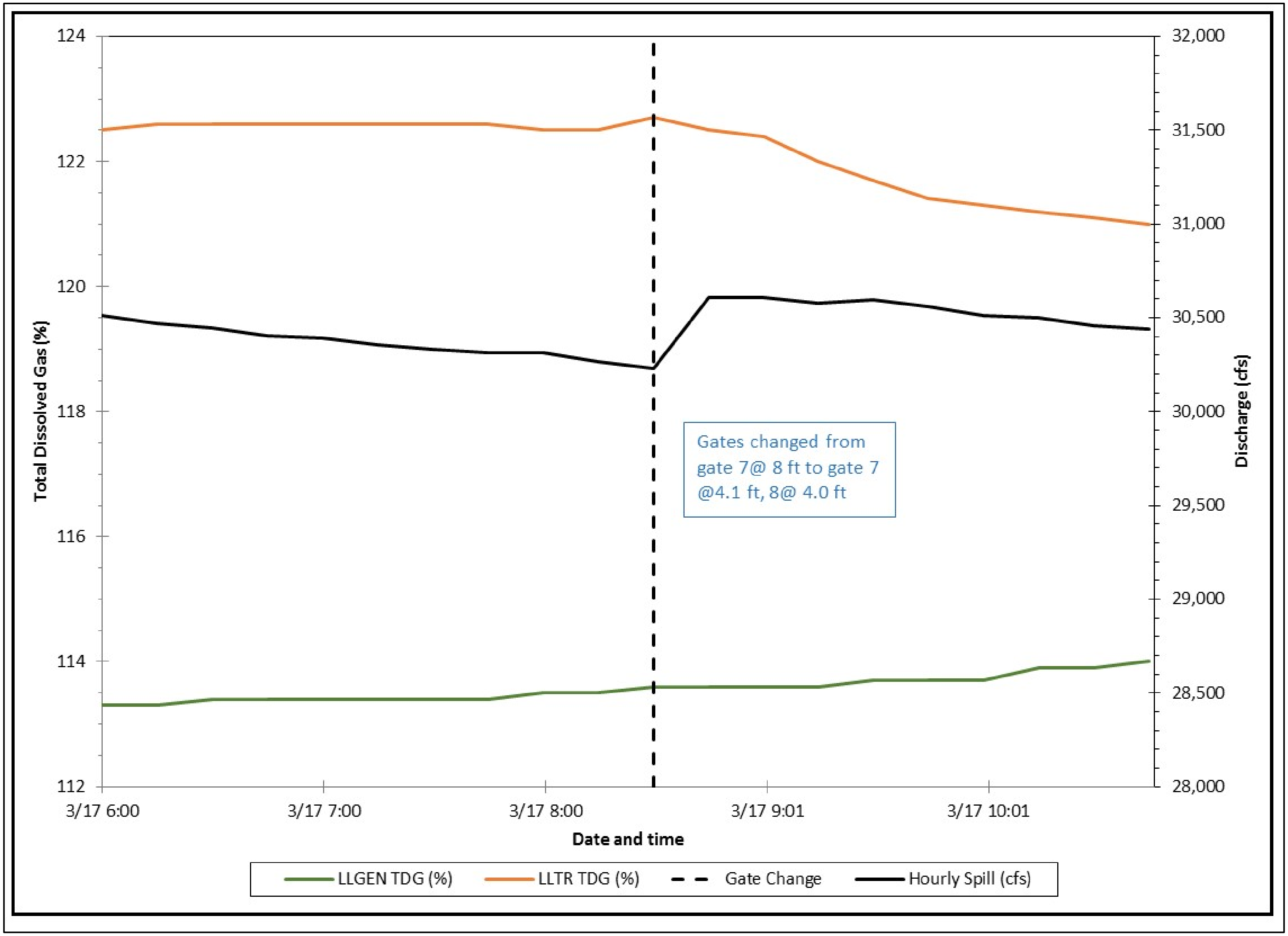


Figure 2-6: Long Lake HED March 17 gate testing.

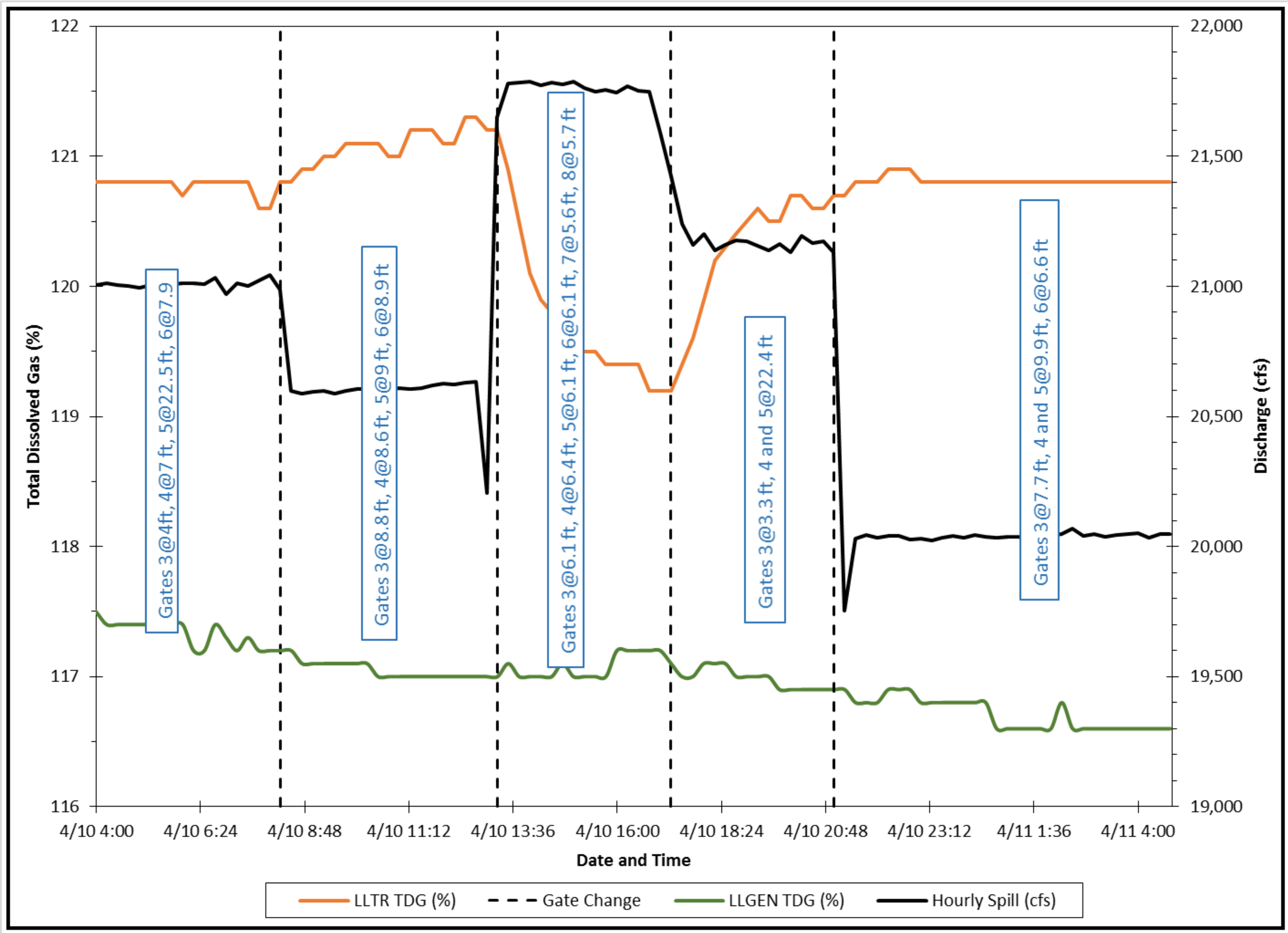


Figure 2-7: Long Lake HED April 10 - 11 gate testing.

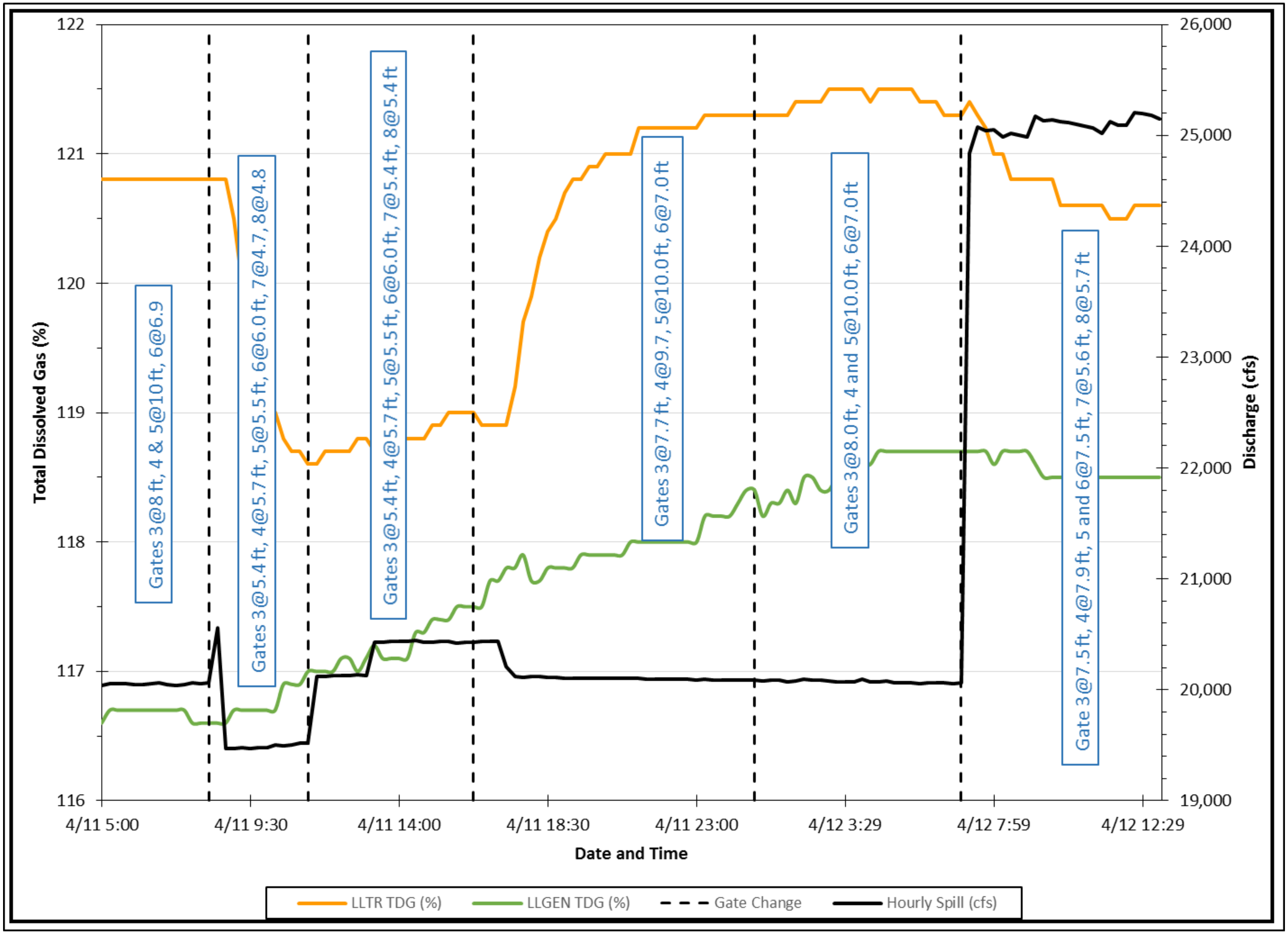


Figure 2-8: Long Lake HED April 11 - 12 gate testing.

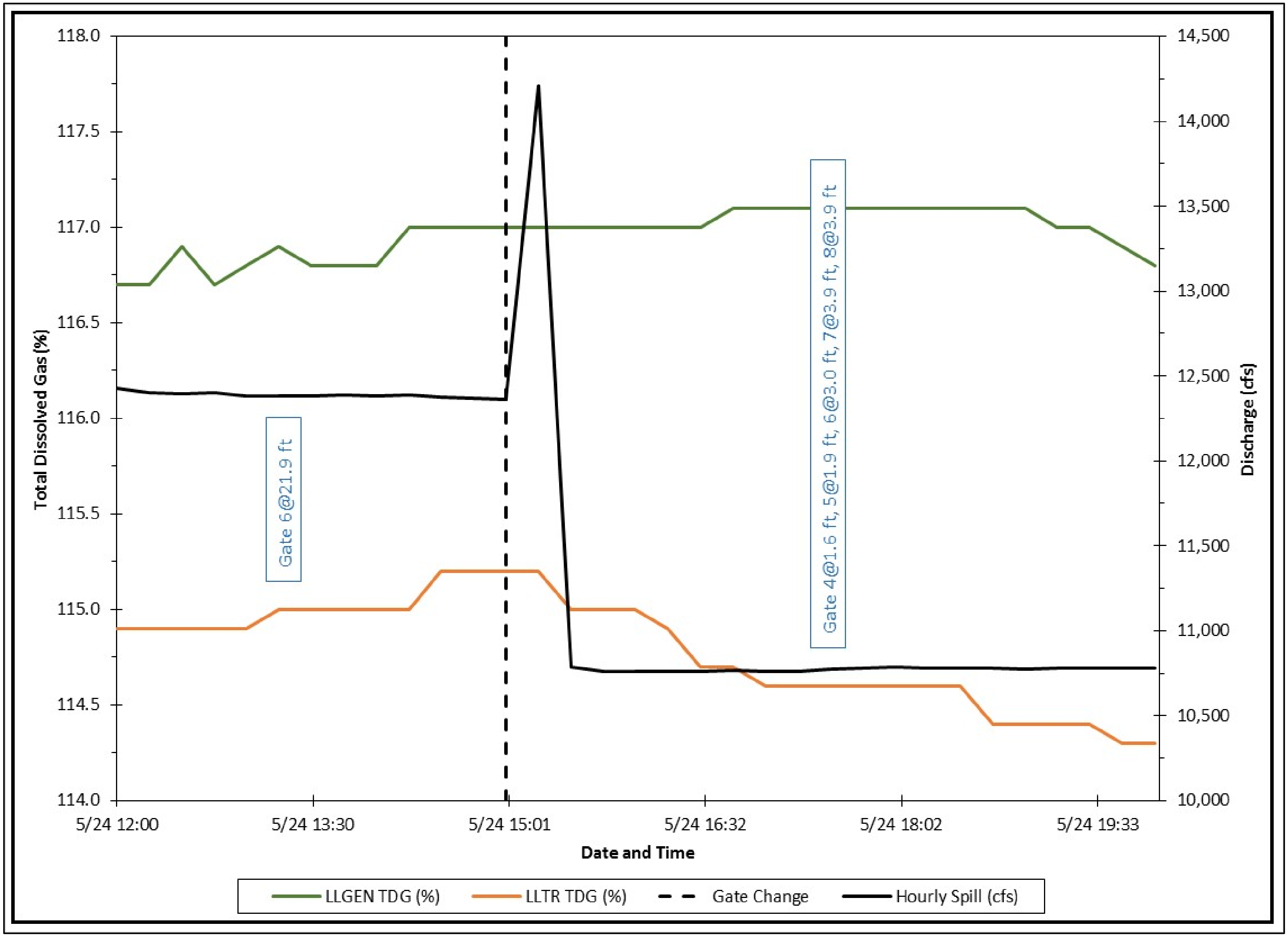


Figure 2-9: Long Lake HED May 24 gate testing.

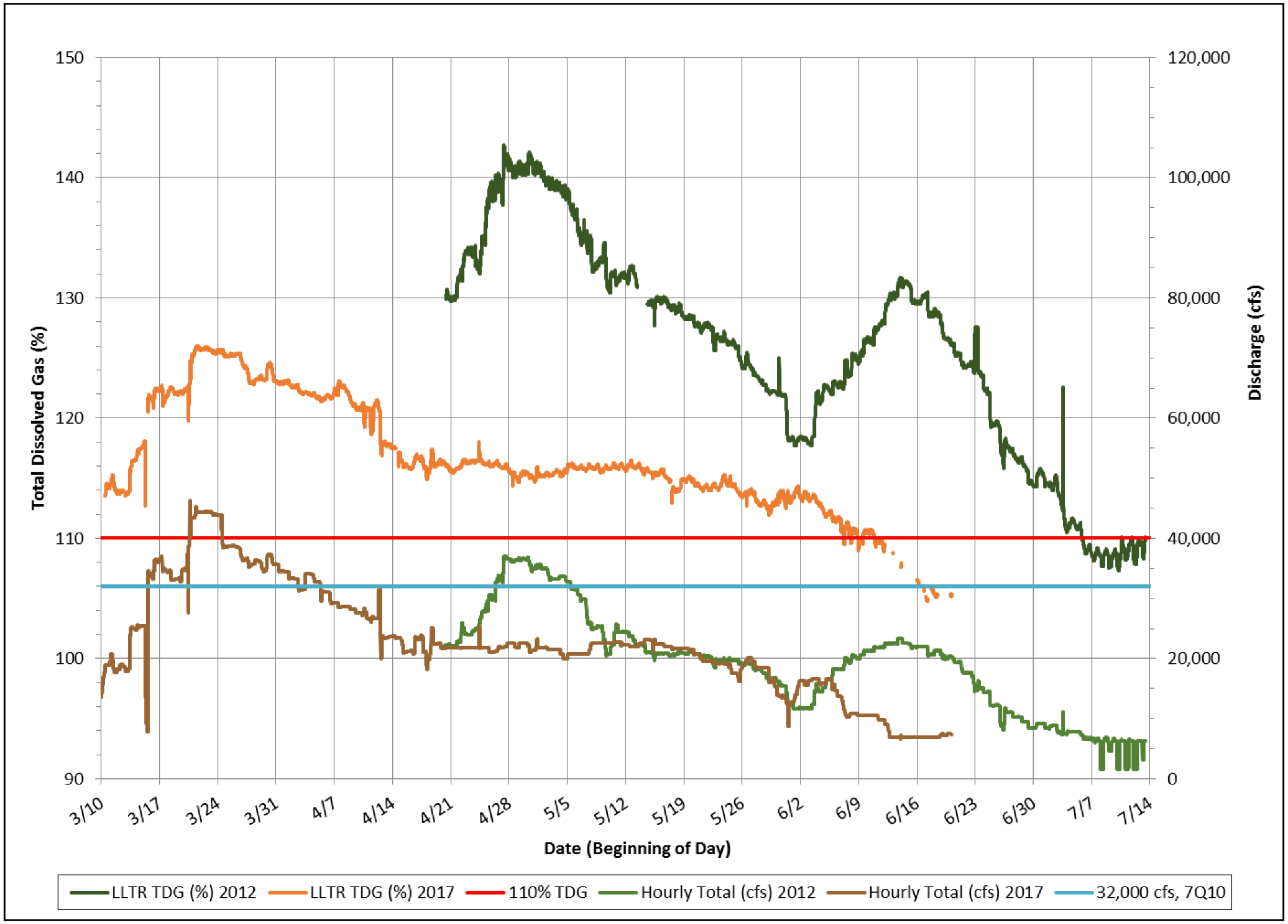


Figure 2-10: Comparison of 2012 and 2017 TDG% and total discharge (cfs).

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[5]	BAR	Total Pressure	TDG	TDG	BAR	Total Pressure	TDG-cal	TDG-spot
	mm Hg	%	%	mm Hg	mm Hg	%	%	mmHg	mm Hg	%	%	mm Hg
60375	1.67	0.23	0.23	N/A	2	1	1	5	-0.33	-0.77	-0.77	N/A
60376	1.08	0.15	0.15	2.22	2	1	1	5	-0.92	-0.85	-0.85	-2.78
48763	0.63	0.09	0.09	3.38	2	1	1	5	-1.37	-0.91	-0.91	-1.63
48764[5]	0.00	0.00	0.00	3.25	2	1	1	5	-2.00	-1.00	-1.00	-1.75
48765	1.41	0.20	0.20	2.13	2	1	1	5	-0.59	-0.80	-0.80	-2.88
Overall RMSE	1.23	0.17	0.17	2.74	2	1	1	5	-0.77	-0.83	-0.83	-2.26

[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%

[5] 48764 was used once during the TDG sampling season. The RMSE calculation is the result of one calibration measurement. Spot values are the average of two spot measurement readings.

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[3]	Calibration	Spot[3]			Calibration	Spot[3]	Calibration	Spot[3]
	ºC	ºC	mg/L	mg/L	ºC	mg/L	ºC	ºC	mg/L	mg/L
60375	0.12	N/A	0.05	N/A	0.5	0.5	-0.38	N/A	-0.45	N/A
60376	0.11	0.04	0.02	0.14	0.5	0.5	-0.39	-0.46	-0.48	-0.37
48763	0.17	0.04	0.08	0.23	0.5	0.5	-0.33	-0.46	-0.42	-0.28
48764[3]	0.06	0.13	0.89	N/A	0.5	0.5	-0.44	-0.37	0.39	N/A
48765	0.07	0.07	0.05	N/A	0.5	0.5	-0.43	-0.43	-0.45	N/A
Overall RMSE	0.12	0.07	0.25	0.18	0.5	0.5	-0.38	-0.43	-0.25	-0.32

[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.

[3] 48764 was used once during the TDG sampling season. The RMSE calculation is the result of one calibration measurement. Spot values are the average of two spot measurement readings.

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 five 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 9,771 15-minute periods at LLTR, with shorter periods for both LLGEN and LLFB. Data completeness was at least 93 percent for all parameters at LLTR except DO (84%). LLFB had data completeness of 47 percent for DO and 72 percent for all other parameters. Completeness at LLGEN was 82 percent for TDG and 98 percent for temperature and DO.

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	9,759	--	6,382	--	9,771	--
Water Temperature (°C)	9,587	98%	4,589	72%	9,087	93%
Dissolved Oxygen (mg/L)	8,241	84%	3,018	47%	8,227	84%
BAR (mm Hg)	Used LLTR BAR		Used LLTR BAR		9,762	100%
TDG (mm Hg)	7,962	82%	4,589	72%	9,055	93%
TDG (% saturation)	7,962	82%	4,589	72%	9,055	93%

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	36	36	36	36	23	14	14	14	14	10	12	12	12	12	11	0	0
998	Out of water after recovery	19	19	19	19	16	11	11	11	11	4	6	6	6	6	6	0	0
997	Equilibrating after deployment	0	18	0	0	0	0	17	0	0	0	2	34	2	2	1	0	0
995	No instrument deployed	0	0	0	0	0	0	0	0	776	0	0	0	0	0	0	0	0
993	Out of water for calibration/servicing	128	128	128	128	128	32	32	32	32	32	24	24	24	24	24	0	0
991	Instrument not deployed at typical long-term depth	0	1,335	1,335	1,335	0	0	1,232	0	0	0	0	0	0	0	0	0	0
990	Depth <0.25 meter	0	0	0	0	0	4	0	4	4	0	260	260	260	260	0	0	0
888	Power loss	0	0	0	0	0	487	487	487	487	487	0	0	0	0	0	0	0
599	Suspect out of water based on depth	0	0	0	0	0	0	0	0	0	0	379	379	379	379	0	0	0
497	Faulty TDG sensor	0	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
304	Suspect DO value not accurate	0	0	0	0	0	0	0	0	1,013	0	0	0	0	0	0	0	0
301	Unrealistic DO value, suspect bad sensor or water under the cap	0	0	0	0	0	0	0	0	0	0	0	0	0	860	0	0	0
211	Depth < TDG compensation depth	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
-101	Less than "minimum operating voltage" (<7 volts), but other data appear reliable	0	0	0	0	71	4	4	4	4	4	0	0	0	0	0	0	0
-102	Between "minimum operating voltage" (<9 volts) and 7 volts, but other data appear reliable	0	0	0	0	46	342	342	342	342	342	0	0	0	0	0	0	0
-211	Depth < TDG compensation depth, but data appear reliable	0	0	0	0	0	0	0	0	0	0	0	5,277	0	0	0	0	0
-1002	Corresponds with spot measurement	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0
0	No data qualifiers	9,588	7,975	8,253	8,253	9,487	5,488	4,243	5,488	3,699	5,503	9,085	3,776	9,087	8,227	9,729	9,771	9,771
	Monitoring Period[1]	9,759	9,759	9,759	9,759	9,759	6,382	6,382	6,382	6,382	6,382	9,771	9,771	9,771	9,771	9,771	9,771	9,771

[1]Monitoring periods consisted of 3/10/2017 11:15 PDT to 6/20/2017 3:30 PDT for LLTR, 3/10/2017 12:00 PDT to 6/20/2017 3:30 PDT for LLGEN, and 4/14/2017 16:15 PDT to 6/20/2017 3:30 PDT for LLFB.

APPENDIX B

CONSULTATION RECORD

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

February 28, 2018

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:

- *2017 Long Lake Total Dissolved Gas Monitoring Report, Avista 2018.*
  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 2017 Long Lake TDG Monitoring Report provides the results the TDG monitoring and spillgate operational protocol evaluation completed during 2017.

  In accordance with the revised Long Lake Hydroelectric Development (HED) TDG Compliance Schedule (approved in 2015), Avista will continue to monitor TDG and to evaluate the spillgate operational protocol during 2018.

- *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 2017. Per our August 30, 2017 letter to Ecology, Avista completed the turbine units 1 and 2 replacement project in 2016 and plans to resume TDG monitoring in 2019, once the sediment bypass system upgrade, and associated intake deck and trashrack cleaning system are completed. Avista will continue providing annual updates on the TDG monitoring schedule by September 1, 2018 to both Ecology and FERC.

Section 5.6.B: Dissolved Oxygen
The enclosed 2017 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report provides the results of the 2017 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 2018, and to continue monitoring DO and TDG at the Long Lake Dam Tailrace Station.

With this, Avista is submitting the 2017 Long Lake TDG Monitoring Report and the 2017 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 30, 2018**, which will allow us time to file the Report with FERC by April 15, 2018.

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 Brown, Ecology
Brian Crossley, Spokane Tribe
Speed Fitzhugh, Avista
Meghan Lunney, Avista

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
4601 N Monroe Street • Spokane, Washington 99205-1295 • (509)329-3400

March 30, 2018

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

RE: Request for Ecology Review and Approval – *2017 Long Lake Total Dissolved Gas Monitoring Report*
Spokane River Hydroelectric Project, No. P-2545

Dear Mr. Moan:

The Department of Ecology (Ecology) has reviewed the *2017 Long Lake Total Dissolved Gas Monitoring Report* sent to Ecology on February 28, 2018.

Ecology APPROVES the *2017 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: Elvin "Speed" Fitzhugh, Avista
Meghan Lunney, Avista
Chad Atkins, Ecology

ECOLOGY COMMENTS AND AVISTA RESPONSES

Ecology Comment
Ecology approves the *2017 Long Lake Total Dissolved Gas Monitoring Report* as submitted.

Avista Response
Avista appreciates Ecology's review and approval of the *2017 Long Lake Total Dissolved Gas Monitoring Report.*

Personal communication between Chris Moan of Avista and Pat McGuire of Ecology on April 5, 2018.

Chris Moan called Pat McGuire at 8:45 on April 5 to ensure Ecology received Avista's response, via email, to the Spokane Tribe's comments on the 2017 Long Lake Total Dissolved Gas Monitoring Report. Pat acknowledged that Ecology received the email and that Ecology approved of the edits made in response to the Spokane's Tribe's comments.

AVISTA

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

February 28, 2018

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:

- *2017 Long Lake Total Dissolved Gas Monitoring Report, Avista 2018.*
  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 2017 Long Lake TDG Monitoring Report provides the results the TDG monitoring and spillgate operational protocol evaluation completed during 2017.

  In accordance with the revised Long Lake Hydroelectric Development (HED) TDG Compliance Schedule (approved in 2015), Avista will continue to monitor TDG and to evaluate the spillgate operational protocol during 2018.

- *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 2017. Per our August 30, 2017 letter to Ecology, Avista completed the turbine units 1 and 2 replacement project in 2016 and plans to resume TDG monitoring in 2019, once the sediment bypass system upgrade, and associated intake deck and trashrack cleaning system are completed. Avista will continue providing annual updates on the TDG monitoring schedule by September 1, 2018 to both Ecology and FERC.

Section 5.6.B: Dissolved Oxygen
The enclosed 2017 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report provides the results of the 2017 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 2018, and to continue monitoring DO and TDG at the Long Lake Dam Tailrace Station.

With this, Avista is submitting the 2017 Long Lake TDG Monitoring Report and the 2017 Long Lake HED Tailrace Dissolved Oxygen Monitoring Report for your review and comment. We would like to receive any comments that you may have by **March 30, 2018**, which will allow us time to file the Report with FERC by April 15, 2018.

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
Speed Fitzhugh, Avista
Meghan Lunney, Avista

SPOKANE TRIBE COMMENTS AND AVISTA RESPONSES

Personal communication between Chris Moan of Avista and Casey Flanagan of the Spokane Tribe on March 26, 2018.

On March 26, 2018 Chris Moan of Avista received verbal comments from Casey Flanagan of the Spokane Tribe in regards to the *2017 Long Lake Total Dissolved Gas Monitoring Report*.

Spokane Tribe Comment
The last sentence of the text at the top of page 9, reads "LLGEN showed at slight increase from 133.6 to 114.0 …" Please correct the sentence.

Avista Response
The sentence was corrected to read "LLGEN showed ***a*** slight increase from ***113.6*** to 114.0 …"

Spokane Tribe Comment
At the top of page 11, it is unclear what timeframe the 5,000 cfs – 11,000 cfs information is referring to, 2017 data or the historical 2011-2013 data referred to in the sentence immediately before the sentence in question.

Avista Response
The sentence refers to the 2017 timeframe and was edited in the document to read: "***In 2017,*** when spill ranged from 5,000 – 11,000 cfs, …"

Spokane Tribe Comment
Please emphasize the improvements in TDG, from a historical context, by comparing 2017 TDG% data to other years.

Avista Response
An additional paragraph, along with a table and figure, was added to the Discussion Section comparing 2017's maximum TDG% to all previous monitoring years TDG%. The paragraph was added to page 11 and reads:

"Of equal importance, the maximum TDG% at LLTR in 2017 was 126%, which signified a dramatic reduction from values seen in previous years (Table 2-8). For example, discharge flows in 2012 of 37,100 cfs had the closest peak discharge flows to 2017, which were 46,331 cfs. For those years, the maximum TDG% in 2012 was 146% compared to a maximum of 126% in 2017 (Figure 2-10). The maximum 2017 TDG% was less than the maximum values for all other years besides 2004, including years when maximum discharge flows peaked at around 22,000 cfs. Collectively, this further indicates the positive influence the spillway modification project had on TDG levels downstream of the dam."

Table 2-8 was added as the last table in the Tables section and Figure 2-10 was added as the last figure in the Figures section. They appear in the report as follows:

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

Notes:

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

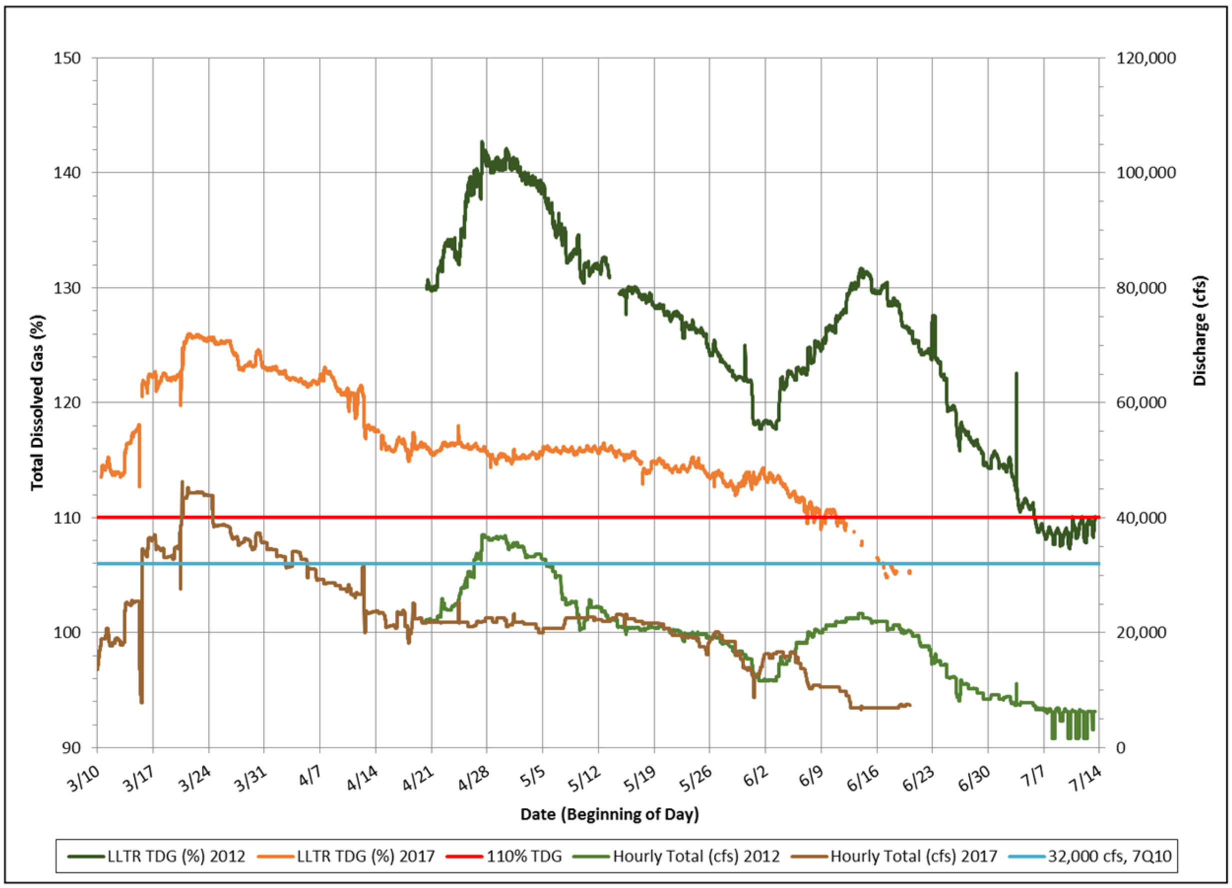


Figure 2-10: Comparison of 2012 and 2017 TDG% and total discharge (cfs).

Email correspondence from Avista to the Spokane Tribe

From:	Moan, Chris
Sent:	Wednesday, April 04, 2018 4:35 PM
To:	'Brian Crossley (crossley@spokanetribe.com)'; Casey Flanagan (caseyf@spokanetribe.com)
Cc:	Fitzhugh, Speed (Elvin); Lunney, Meghan; 'PMCG461@ECY.WA.GOV'
Subject:	Response to Spokane Tribe comments for 2017 Long Lake Total Dissolved Gas Monitoring Report
Attachments:	Avista Response to Spokane Tribe Comments_TDG_4-4-18.docx
Importance:	High

Brian and Casey,

Attached is a synopsis of the telephone conversation, in the form of comments and responses that we can include with the long Lake TDG Report, that I had with Casey on March 26. Please review Avista's response to comments and provide any feedback by Friday, April 6. If I do not hear back from you by April 6, I will go ahead and include them in the consultation record. Thanks again for your help on this, we really appreciate it.

Chris Moan
Fisheries Habitat Biologist

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This email (including any attachments) may contain confidential and privileged information, and unauthorized disclosure or use is prohibited. If you are not an intended recipient, please notify the sender and delete this email from your system. Thank you.

Note: The attachment referenced in this email is the "Spokane Tribe Comments and Avista Response" document on page B-8 and B-9 of this report.

Email correspondence from the Spokane Tribe to Avista

From:	Casey Flanagan <caseyf@SpokaneTribe.com>
Sent:	Thursday, April 05, 2018 6:47 AM
To:	Moan, Chris
Subject:	[External] RE: Response to Spokane Tribe comments for 2017 Long Lake Total Dissolved Gas Monitoring Report

Good morning Chris,
I read over the document you sent me and it reads well to me. I don't have any problems with attaching this to the report. Did Brian also send you the Tribe's memo with 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

Personal communication between Speed Fitzhugh of Avista and Brian Crossley of the Spokane Tribe on April 5, 2018.

Speed Fitzhugh called Brian Crossley on April 5 to ask if the Spokane Tribe planned to submit written comments on the 2017 Long Lake HED Total Dissolved Gas Monitoring Report (TDG report). Brian indicated the Spokane Tribe is not submitting written comments and is comfortable with Avista's modifications to the TDG report made in response to the Spokane Tribes March 26, 2018 verbal comments.