AVISTA CORPORATION

2011
LONG LAKE DAM
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

% saturation	percent of saturation
°C	degrees Celsius
7Q10	7-day average flow with a 10-year return period
amsl	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
m	meter(s)
mg/L	milligrams per liter
mm Hg	millimeters mercury (pressure)
MQO	measurement quality objective
MS5	Hydrolab® MS5 Multiprobe®
LLGEN	monitoring station at Long Lake HED Unit 4 generation plume
LLFB	monitoring station at Long Lake forebay
LLTR	monitoring station at Long Lake tailrace
LLTRSP1	monitoring station across the river from LLTR
LLGEN_Spot	monitoring station between Long Lake powerhouse and LLTR
PDT	Pacific Daylight Time
PME	protection, mitigation, and enhancement measure
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
WQC	Amended section 401 water quality certification

1.0 INTRODUCTION

Avista Corporation (Avista) recognizes the need to address potential negative effects of total dissolved gas (TDG) production caused by water spilling through the Long Lake Dam spillway, and as a result proposed a protection, mitigation, and enhancement measure (PME) as part of its license application to the Federal Energy Regulatory Commission (FERC) (Avista 2005). This PME, referred to as SRP-WQ-1 "Total Dissolved Gas Control and Mitigation Program", has the overall goal of reducing the project's production of elevated TDG levels to the extent necessary for project compliance with applicable water quality standards.

Washington State Department of Ecology (Ecology) issued and amended a section 401 water quality certification (WQC) for Avista's four Spokane River Project hydroelectric developments (HEDs) that are located in Washington (Ecology 2009). The WQC addresses the Upper Falls, Monroe Street, Nine Mile, and Long Lake HEDs. Section 5.4 of this WQC includes Avista's requirements to address the HEDs' effects on TDG.

On June 18, 2009, FERC issued a license for the Spokane River Project (FERC 2009). Article 401(a) of this license requires Avista to file the TDG monitoring plan required by WQC section 5.4(A) and the TDG WQAP for Long Lake Dam required by WQC section 5.4(D) for approval prior to implementation.

Avista consulted with Ecology and the Spokane Tribe of Indians (Spokane Tribe) in preparation of the required TDG monitoring plan, which addresses TDG associated with spills from the Long Lake HED (Golder 2010). Ecology approved this plan on March 17, 2010, and Avista filed this Ecology-approved plan with the FERC on March 26, 2010. Avista also filed with the FERC the Long Lake Dam Total Dissolved Gas Water Quality Attainment Plan, which includes sections of the Washington TDG Monitoring Plan that pertain to the Long Lake HED on July 16, 2010. FERC approved the monitoring plan on December 14, 2010.

During 2010, Avista implemented the plan for TDG monitoring associated with Long Lake Dam. The 2010 TDG monitoring is documented in Golder (2011).

This report discusses TDG monitoring conducted for Long Lake Dam during the 2011 high-flow season.

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 2011 monitoring period for this study was from March 24 through August 1. Use of the Long Lake Dam spillways had begun before initiation of the 2011 TDG monitoring season and extended into July 16.

2.3 Methods

Water quality parameters that were recorded include TDG (millimeters mercury [mm Hg]), dissolved oxygen (DO) concentration (milligrams per liter [mg/L]), and water temperature (°C). Water depth (meters) was also recorded and used in conjunction with water temperature to evaluate whether and when the water quality monitoring instruments emerged from the water and when they were above the minimum TDG compensation depth.

2.3.1 Equipment and Calibration

Hydrolab® MS5 Multiprobe® (MS5) instruments with TDG, optical DO, temperature, and depth sensors were used. Each deployed MS5 was connected to an external alternating current power source after the first download to reduce potential issues associated with low or no power supply.

Solinst® baraloggers were used to determine local barometric pressure. In 2011, TDG monitoring was associated with the Long Lake HED and Nine Mile HED; therefore, one barologger was deployed at the Long Lake pumphouse, and a back-up barologger deployed at the Nine Mile forebay. As an additional quality assurance measure, resulting site-specific barometric pressures were compared to corresponding values for the Spokane International Airport. Daily ranges of barometric pressure recorded at the Spokane International Airport station were downloaded from www.wunderground.com. The weather station reports the barometric pressure as it would be at sea level, so the values were adjusted by subtracting 37.05 mm Hg to account for the altitude of the Long Lake HED tailrace (1,365 feet above mean sea level [ft amsl]).

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

Monitoring equipment was calibrated according to the manufacturer's instructions prior to deployment and on periodic site visits. All instruments used were factory calibrated before the 2011 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 baraloggers 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® baraloggers also were downloaded during these service periods. Patency of the original TDG membrane was confirmed by observing a rapid increase in TDG pressure while pressurizing the sensor with soda water. Depth, temperature, and DO sensors were calibrated according to the manufacturer's instructions.

2.3.2 Station Facilities

Permanent water quality monitoring facilities are constructed at three locations associated with Long Lake HED: 1) 0.6 mile downstream of the Long Lake Dam referred to as LLTR, 2) in the Long Lake HED forebay referred to as LLFB, and 3) in the Long Lake HED Unit 4 generation plume referred to as LLGEN (Table 2-1; Figure 2-1). In 2011, the Long Lake HED forebay was used to monitor incoming TDG for this study instead of the Long Lake HED Unit 4 generation plume because of safety concerns, which were subsequently resolved.

The permanent stations consist of a 4-inch-diameter pipe stilling-well (standpipe), which is sealed at the pipe's 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. The top end of the LLTR standpipe was protected by a threaded PVC cap with a bolt and lock on it to provide security. Armored flex conduit was used to protect data power cables.

2.3.3 Spot Measurements

Spot measurements of TDG, water temperature, and DO were made at each of the TDG monitoring stations being operated during the site visits, which were done at approximately two-to three-week intervals. Spot measurements also were taken across the river from LLTR, at LLTRSP1, and between the powerhouse and LLTR, at LLGEN_Spot (Table 2-1).

2.3.4 Data Collection and Processing

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

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

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

- TDG% = TDG in mm Hg / Barometric pressure in mm Hg 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 as explained in the following section.

Long Lake HED operational logs were provided by Avista for the period of March 21 to August 2, 2011. These logs provide the HED's hourly discharges as generation and spill, along with total discharge.

2.3.5 Monitoring Difficulties

Monitoring difficulties during the 2011 TDG monitoring season are described below.

LLTR DO data varied widely (up to 6 mg/L) in early to mid-April, so the MS5 was replaced on April 27. Following calibration, the MS5 had a scale factor that was beyond limits deemed acceptable by Hach. The MS5 was sent to Hach for further evaluation. Hach indicated DO values were unreliable because of water under the DO sensor cap, and replaced the DO probe. DO data associated with this event were qualified and removed from the reliable data set.

Extreme high water limited access to the top of LLTR stilling well and thereby prevented calibration/servicing of the continuous MS5. Golder Associates Inc. (Golder) obtained HED discharges and tailwater elevations from Avista, and used this data to schedule site visits for periods when the stilling well would be accessible. Even with this effort, the stilling well was not accessible on four site visits (April 6, May 18, June 6, and June 16).

The LLTR stilling well pipe was broken when the Golder team arrived at the site on July 14. Review of depth data suggests it likely broke on July 5, and that it likely was being held above its typical elevation since the beginning of the 2011 TDG monitoring study on March 24. A new stilling well was installed on August 1.

On July 14, all of the data on the LLFB continuous MS5 could not be downloaded, even though it had been programmed correctly. The MS5 was replaced with another MS5 and sent to Hach, who also could not recover the data. This resulted in a data gap from July 3 17:15 PDT to July 14 17:00 PDT.

2.4 Results

Results of 2011 TDG monitoring season data collection activities are presented below. MS5s and baraloggers were set up to record data for nearly 12,500 15-minute periods (referred to as “continuous” data in this report) from March 24 to August 1 (Table 2-2). The barologger deployed at LLTR provided a complete data set for local barometric pressure. TDG data were successfully obtained for 99 percent of the LLTR continuous monitoring periods and 91 percent the LLFB continuous monitoring periods. Spot measurements were collected on March 24, April 6, April 27, May 18, June 5, June 16, July 1, July 14, and August 1, when long-term deployment and or download of instruments was conducted (Tables 2-3 and 2-4). Results of continuous and spot measurements are displayed in Figures 2-2 through 2-5. On April 6, May 18, June 6, and June 16 the LLTR stilling well was not accessible therefore the MS5 was not calibrated on those days.

2.4.1 Discharge

Combined Long Lake HED generation and spill discharge for the March 24 to August 1 monitoring period ranged from approximately 200 to nearly 34,400 cfs. Long Lake HED generation was at full capacity from March 24 to July 16 (Figure 2-2). Spills at Long Lake Dam reached a maximum of approximately 27,800 cfs resulting in a total river discharge (generation plus spill discharge) of up to 34,370 cfs on May 24, 2011.

2.4.2 Water Temperature

Water temperature in the forebay (LLFB) and tailrace (LLTR) increased from approximately 5°C in late March to approximately 20°C in late July (Figure 2-2). Maximum temperatures were 18.8°C at LLTR and 21.7°C at LLFB, where temperature was more variable in mid- to late July. Corresponding measurements at the two continuous stations were within 3°C of one another. LLTR temperature tended to be slightly warmer than LLFB during spill periods (Figure 2-2).

2.4.3 Barometric Pressure

Site-specific barometric pressures ranged from 711 to 733 mm Hg 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 LLFB during most of the spill period (Figure 2-3). However, this was not the case early or late in the monitoring season (Figure 2-3). Comparisons of spot and continuous data indicate TDG pressure varied substantially longitudinally below the dam and across the channel near LLTR (Figure 2-3). TDG pressure at LLGEN_Spot was similar to LLFB except during a discharge greater than 32,000 cfs on May 18.

TDG% for both LLFB and LLTR exceeded 110 percent of saturation throughout most of the monitoring period until mid-July (Figure 2-4). Exceptions to this trend occurred at LLTR on March 24 to March 30, April 21 to April 25, and on May 13.

The range of TDG% computed was 105 to 123 percent of saturation for LLFB and 102 to 138 percent of saturation for LLTR (Figure 2-4).[1] TDG% for LLTR was greater than for LLFB for most of the TDG monitoring season. However, TDG% for LLTR was less than for LLFB during spills of up to approximately 11,000 cfs, which occurred in late March, late April, early May, and mid-July (Figure 2-4).

The 110 percent of saturation TDG criterion is not applicable when stream discharge exceeds the 7Q10, which Ecology (2009) specified as 32,000 cfs for the Spokane River at Long Lake Dam and Nine Mile Dam. During the 2011 TDG monitoring study, maximum total discharge (spill plus turbine discharge) was 34,370 cfs, and the Ecology-designated 7Q10 was exceeded for 223 hours (approximately 9.3 days) in mid- to late May (Figure 2-4). Table 2-5 provides the specific periods with TDG% of greater than the 110 percent of saturation criterion when total discharge was less than or equal to the Ecology-specified 7Q10.

2.4.5 Dissolved Oxygen

Measured dissolved oxygen (DO) concentrations were 7.8 to 13.1 mg/L for LLFB and 6.4 to 15.3 mg/L for LLTR (Figure 2-5). Greatest DO concentrations occurred near the beginning of the monitoring period when temperature was near its lowest causing potential solubility for oxygen to be greatest.

2.5 Discussion

Consistent with historic measurements (Golder 2003, 2004, 2011) and expectations, TDG was greater at LLTR than LLFB and generally followed the pattern of spill flows. Comparison of the TDG% and spill discharges indicate TDG% at LLTR were greater than at LLFB and exceeded the 110 percent criterion during 97 percent of the periods with spill greater than 11,000 cfs (total discharge of greater than 17,700 cfs). In contrast, TDG% for LLTR were greater than at LLFB and exceeded the 110 percent criterion 15 percent of the periods with spill of 5,000 cfs or less and 33 percent of the periods with spill between 5,000 and 11,000 cfs time.

[1] Minimum depth for the LLFB continuous MS5 was 10 meters, indicating that the MS5s remained below the compensation depth. However, LLTR had depths of less than 1 meter, which was less than the compensation depth. Following replacement of the stilling well on July 13, the LLTR MS5 remained deeper than the compensation depth.

3.0 REFERENCES

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TABLES

Table 2-1: Long Lake Dam TDG Monitoring Stations

Station Code	Description	Latitude / Longitude (NAD83)	Monitoring Type[1]
LLFB	Long Lake Forebay between Unit 3 and 4 intakes near centerline of intake (elevation 1499 feet)	47°37'48" / 117°31'47"	Long-term
LLGEN	Long Lake HED Unit 4 generation plume	47°37'48" / 117°31'47"	None
LLTR	On left downstream bank, at a water pumphouse 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
LLGEN_Spot	On left downstream bank, approximately 330 feet downstream from Long Lake Powerhouse	47°50’11” / 117°50'32"	Supplemental spot

Notes:
1. Conducted long-term monitoring at LLFB, instead of LLGEN, because of safety concerns, and added supplemental spot measurements at LLGEN_Spot to indicate any wide fluctuations between TDG measured at LLFB from likely conditions at LLGEN. Safety concerns were subsequently resolved.

Table 2-2: Summary of Continuous Monitoring Results

Parameter	LLFB			LLTR		
	Minimum	Maximum	Count	Minimum	Maximum	Number of 15-Minute Periods
Date/Time (PDT)	3/24/2011 13:45	8/1/2011 10:45	12,469	3/24/2011 10:15	8/1/2011 8:00	12,472
Water Temperature (°C)	5.1	21.7	11,376	5.04	18.8	12,377
DO (mg/L)	7.7	12.8	11,377	6.5	15.3	11,145
BAR (mm Hg)	707	729	12,448	711	733	12,448
TDG (mm Hg)	750	880	11,357	733	1001	12,360
TDG (% saturation)[1]	104.6	123.3	11,337	101.5	138.2	12,350

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

Table 2-3: LLTRSP1 Spot Measurement Results

Date Time (PDT)	Water Temperature (°C)	DO (mg/L)	TDG (mm Hg)	LLTR BAR (mm Hg)	TDG (% of saturation)
3/24/2011 12:30	5.1	13.8	871	713	122.1
4/6/2011 12:30	6.0	13.2	864	717	120.5
4/27/2011 11:30	6.9	13.9	890	725	122.8
5/18/2011 11:45	#N/A	14.9	988	719	137.4
6/5/2011 10:45	11.9	13.1	959	722	132.7
6/16/2011 10:30	14.2	12.4	942	720	130.8
7/1/2011 13:45	15.7	11.5	864	727	118.9
7/14/2011 13:30	17.9	9.8	795	720	110.4
8/1/2011 9:00	17.8	8.5	752	Not recorded	#N/A

Table 2-4: LLGEN_SPOT Spot Measurement Results

Date Time (PDT)	Water Temperature (°C)	DO (mg/L)	TDG (mm Hg)	LLTR BAR (mm Hg)	TDG (% of saturation)
3/24/2011 16:15	5.0	12.8	800	712	112.3
4/6/2011 14:45	5.8	12.2	832	716	116.1
4/27/2011 12:45	6.9	13.1	838	724	115.7
5/18/2011 13:00	10.6	13.6	923	719	128.4
6/5/2011 11:45	11.8	12.2	891	722	123.4
6/16/2011 12:15	14.2	11.6	880	720	122.2
7/1/2011 14:30	15.5	11.4	840	727	115.6
7/14/2011 15:00	18.0	9.7	796	720	110.6
8/1/2011 10:30	18.0	8.8	767	Not recorded	#N/A

Table 2-5: Summary Of Exceedances of TDG Criterion when Total Discharge was Less Than or Equal to Ecology-Specified 7Q10 in 2011

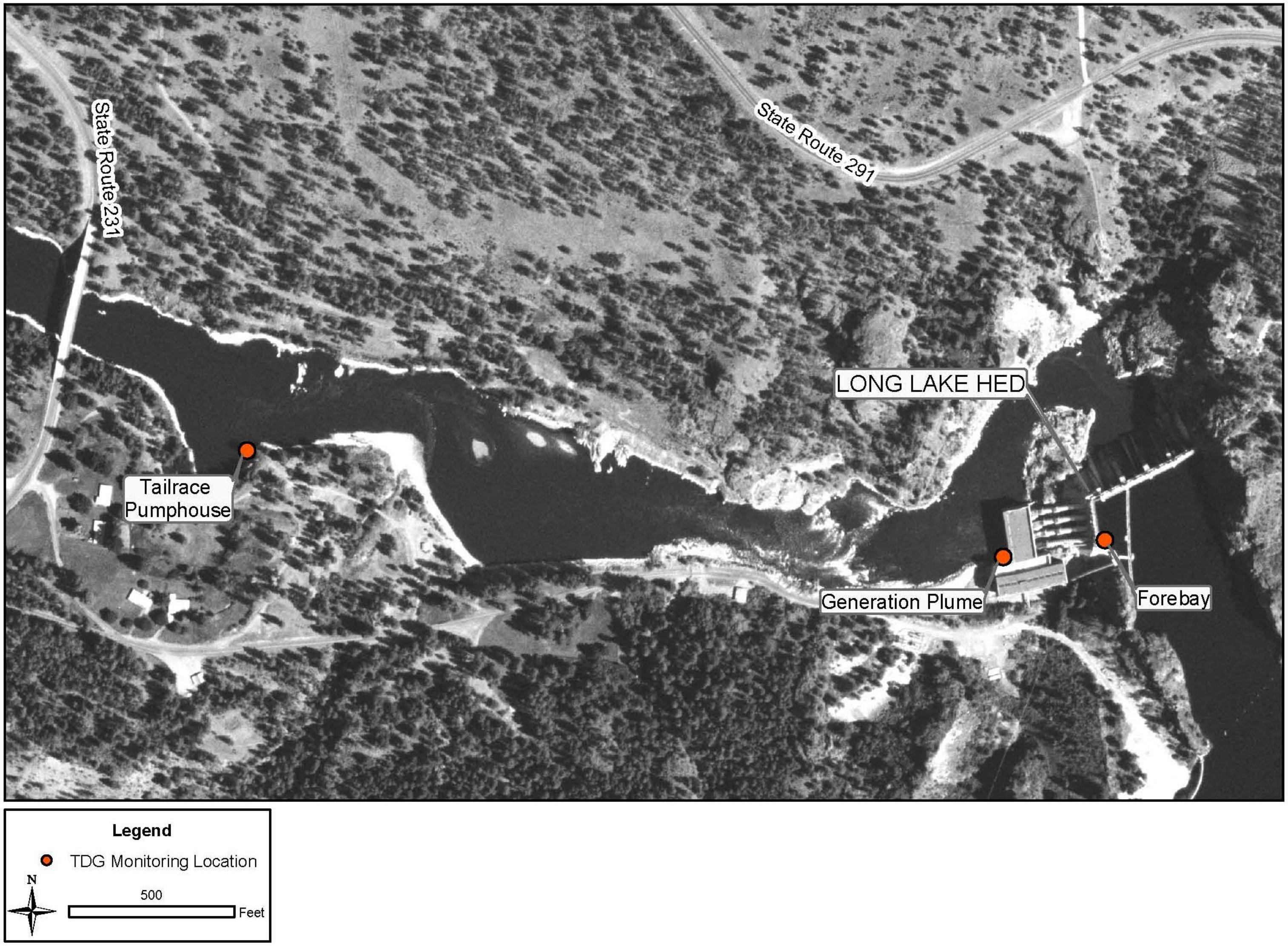
	LLFB			LLTR		
# of records that exceeded 110% of saturation	9,202			9,039		
total # of records	11,337			12,350		
Periods when TDG exceeded 110% of saturation (PDT)[1,2]	3/24 15:45	to	5/17 12:45	3/24/ 11:15	to	3/24 20:30
	5/20 9:00	to	5/24 5:45	3/26 23:00	to	3/27 3:30
	5/30 17:00	to	7/3 17:15	3/30 21:30	to	4/12 9:00
	7/14 17:15	to	7/18 7:30	4/12 15:00	to	4/13 7:00
	7/18 8:00	to	7/18 8:15	4/13 13:45	to	4/21 21:45
	7/18 9:15	to	7/18 22:00	4/24 19:00	to	4/25 6:15
	7/19 1:00	to	7/19 6:45	4/25 15:15	to	4/27 9:15
	7/21 12:30	to	7/21 13:45	4/27 16:45	to	5/8 10:30
	7/21 14:45			5/8 11:00	to	5/13 1:00
				5/13 4:15	to	5/17 12:45
				5/20 9:00	to	5/24 5:45
				5/30 17:00	to	7/16 6:15

Notes:

1. TDG data at LLFB were not available from 7/3/2011 17:30 to 7/14/2011 17:00. Data from the MS5 at LLTR indicate it was out of water from 4/12/2011 9:15 to 4/12/2011 15:00 and from 4/13/2011 7:15 to 4/13/2011 13:30, although there is not sufficient evidence to confirm this was the case.

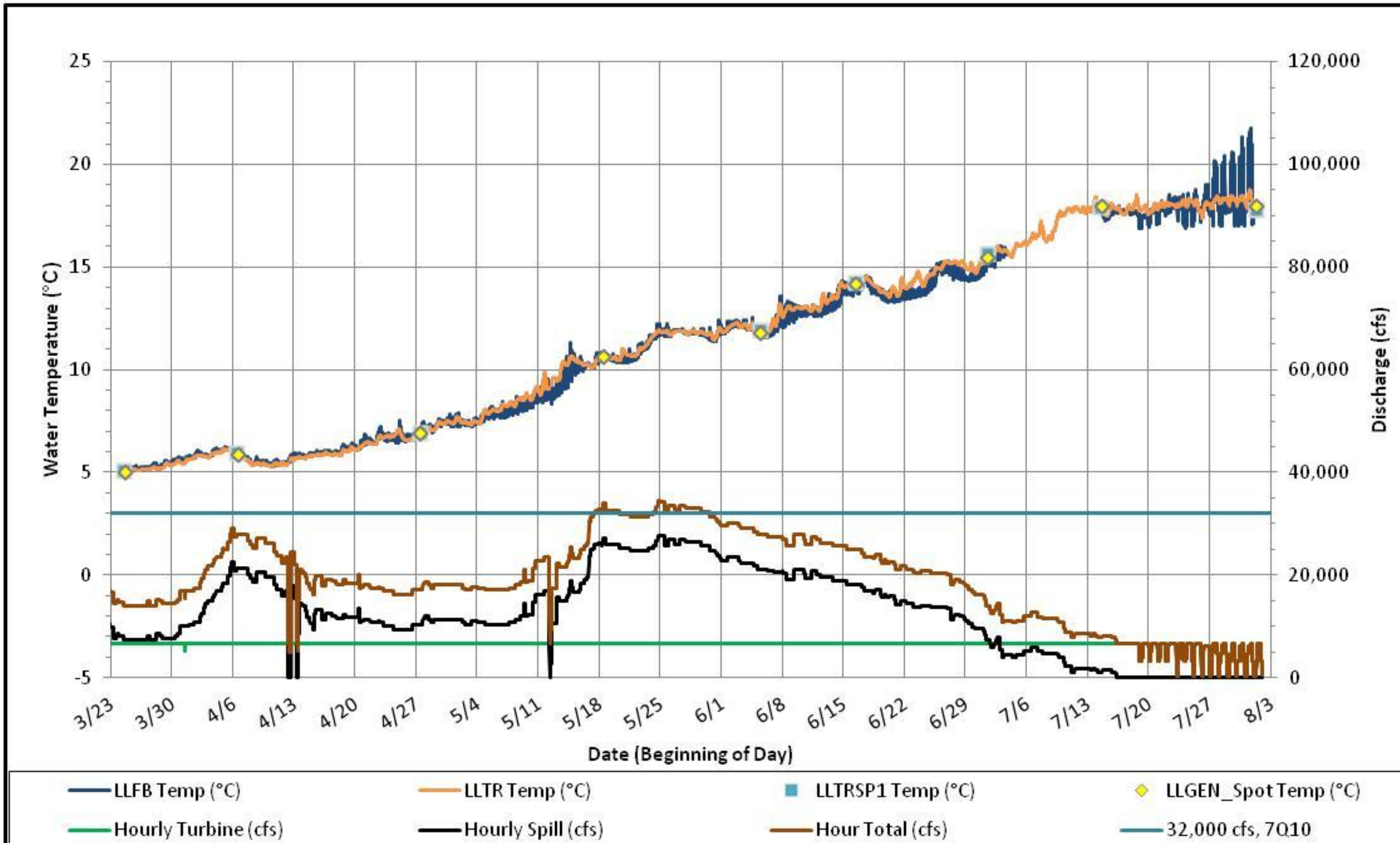
2. Flow exceeded the 7Q10 from 5/17/2011 13:00 to 5/20/2011 8:45 and 5/24/2011 6:00 to 5/30/2011 16:45.

FIGURES



Source: Avista

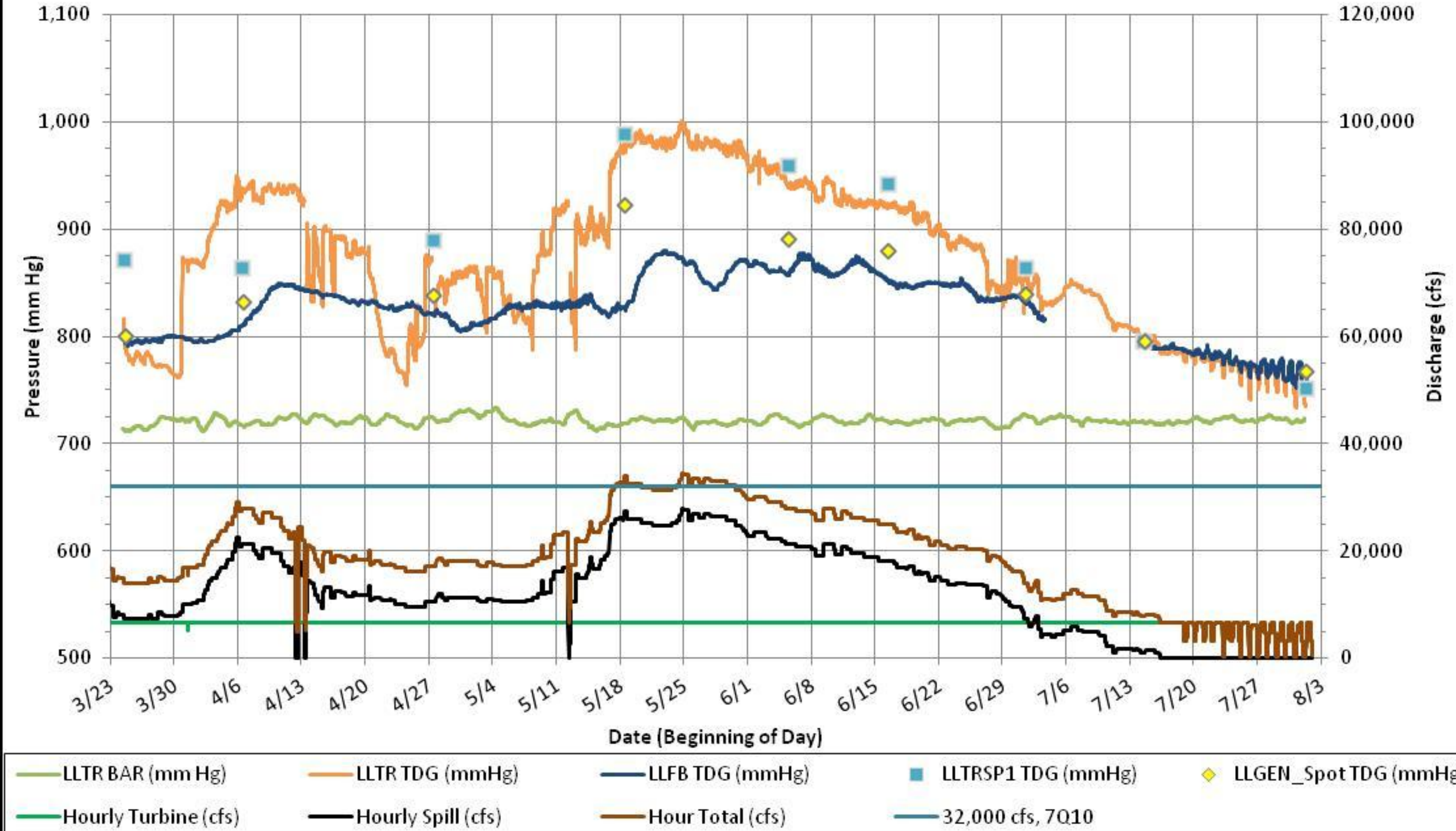
Figure 2-1: Long Lake Dam Long-Term Water Quality Monitoring Locations



Golder Associates

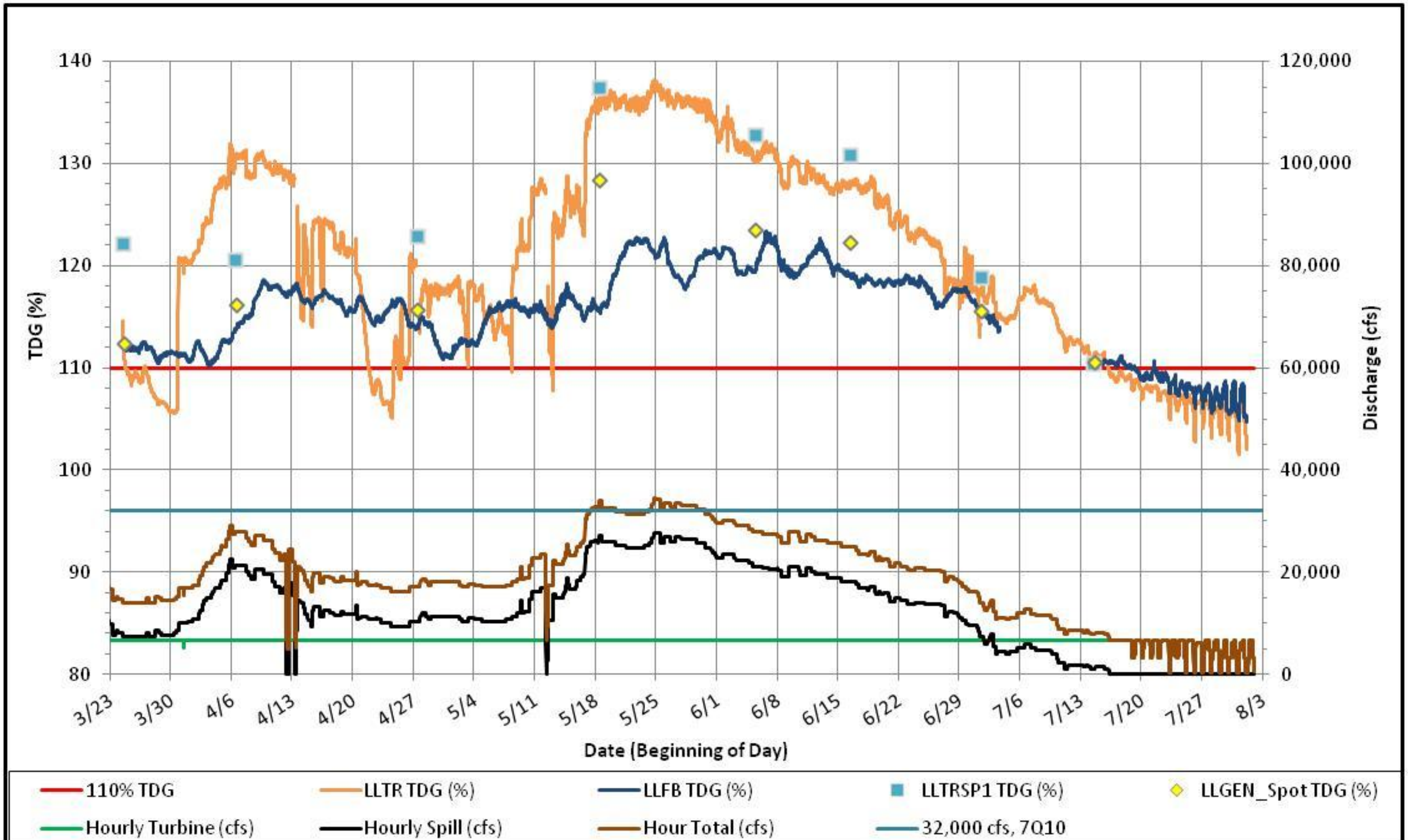
Title	Water Temperature and HED Operations		
Project Name	LL TDG Monitoring	Project No.	073-93081-02.411
Client Name	Avista	Date	February 16, 2012

FIGURE 2-2



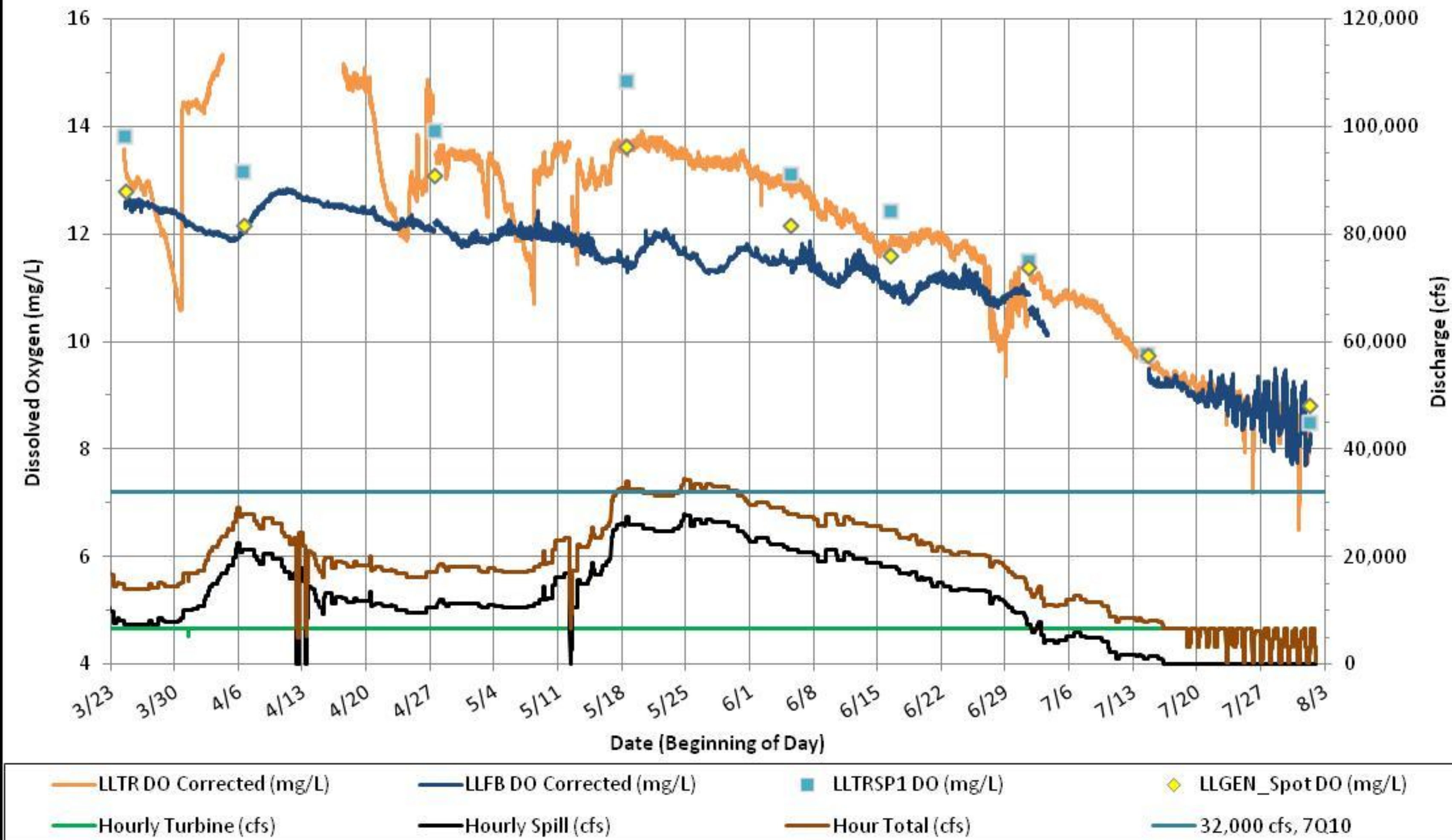
Golder Associates

Title	Total Dissolved Gas Pressure, Barometric Pressure, and HED Operations
Project Name	LL TDG Monitoring
Project No.	073-93081-02.411
Client Name	Avista
Date	February 16, 2012
FIGURE	2-3



Golder Associates

Title	Total Dissolved Gas Percent of Saturation and HED Operations		
Project Name	LL TDG Monitoring	Project No.	073-93081-02.411
Client Name	Avista	Date	February 16, 2012
FIGURE 2-4			



Golder Associates

Title	Dissolved Oxygen Concentration and HED Operations
Project Name	LL TDG Monitoring
Project No.	073-93081-02.411
Client Name	Avista
Date	February 16, 2012

FIGURE 2-5

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 mm Hg	±0.1 % of span	1.0 mm Hg
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 [2]

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 dissolved oxygen 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 mm Hg
Temperature	0.5ºC
Total Pressure	1% (5 to 8 mm Hg)
TDG%	1%
Dissolved Oxygen	0.5 mg/L

[2] 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
Part 1: Barometric Pressure (BAR), Total Pressure, and Total Dissolved Gas (TDG)

	RMSE [1]			MQO			RMSE - MQO		
Meter IDs and Locations	**BAR[2] (mm Hg)**	**Total Pressure[3] (%)**	**TDG[4] (%)**	**BAR (mm Hg)**	**Total Pressure (%)**	**TDG (%)**	**BAR (mm Hg)**	**Total Pressure (%)**	**TDG (%)**
48762 (LLTR 3/24-4/27, LLFB 7/14-8/01)	3.67	0.52	0.53	2	1	1	1.67	-0.48	-0.47
48763 (LLFB 3/24-7/14)	3.61	0.51	0.52	2	1	1	1.61	-0.49	-0.48
48764	2.24	0.31	0.31	2	1	1	0.24	-0.69	-0.69
48765	1.00	0.14	0.14	2	1	1	-1.00	-0.86	-0.86
60376 (LLTR 4/27-8/01)	3.91	0.55	0.56	2	1	1	1.91	-0.45	-0.44
Overall RMSE	3.38	0.48	0.48	2	1	1	1.38	-0.52	-0.52

Notes:
Shaded values indicate exceedance of MQO.
[1] Pooled RMSE calculated at each station during service period and removal.
[2] Pooled RMSE calculated from BAR record at station during service period and removal as compared to corresponding TDG in air new reading.
[3] Pooled RMSE calculated as the difference in TDG in air new minus the BAR, then divided by the TDG and multiplied by 100.
[4] Pooled RMSE calculated at each station during service period and removal. TDG calculated as TDG in air new divided by the BAR and multiplied by 100.
N/A - Not available, measurement not taken.

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

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

	RMSE		MQO		RMSE - MQO	
Meter IDs and Locations	**Temp[1] (°C)**	**DO[2] (mg/L)**	**Temp (°C)**	**DO (mg/L)**	**Temp[1] (°C)**	**DO[2] (mg/L)**
48762 (LLTR 3/24-4/27, LLFB 7/14-8/01)	0.14	0.59	0.5	0.5	-0.36	0.09
48763 (LLFB 3/24-7/14)	0.27	0.43	0.5	0.5	-0.23	-0.07
48764	0.17	0.76	0.5	0.5	-0.33	0.26
48765	0.00	0.73	0.5	0.5	-0.50	0.23
60376 (LLTR 4/27-8/01)	0.16	0.42	0.5	0.5	-0.34	-0.08
Overall RMSE	0.19	0.57	0.5	0.5	-0.31	0.07

Notes:
Shaded values indicate exceedance of MQO.
[1] Pooled RMSE calculated from temperature record at station during service period and removal. Temperature calibration based on the difference between the meter and calibration thermometer in a water bath.
[2] Calculated RMSE as difference of the pre-calibration measurement and 100% saturation. Initial factory calibration included in analysis.

N/A - Not available, measurement not taken

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 generally minimized by following standard protocols for calibration and maintenance, and by following field protocols for stabilization of meter readings. During the pre-deployment MS5 mass verification calibration event,[3] the TDG sensor in air was calibrated using barometric pressure that was incorrectly adjusted for altitude. Following this event, a spreadsheet was prepared and used to ensure correct calculation of barometric pressure from weather station and barologger data. Before use for this monitoring study, all MS5s were recalibrated using the correct local barometric pressure.

Precision

Precision refers to the degree of variability in replicate measurements. Instrument precision was evaluated through the calibration and maintenance activities. MQOs for total pressure and TDG% were met for all meters. However, barometric pressure, the difference between the local barometric pressure and TDG sensor in air, did not meet the MQO of 2 mm Hg for four of the five MS5s, due to using an incorrect barometric pressure for the first calibration event. TDG pressure data were corrected by adding the difference between the local barometric pressure and the corresponding value used to calibrate the TDG sensor, and data quality code assigned to track this situation.

The 0.5°C water temperature MQO was met by all MS5s; whereas, only two MS5s met the 0.5-mg/L DO MQO. The DO MQO was met by the long-term MS5s deployed at LLTR and LLFB during most of the season. The MS5s used for spot measurements and deployed at LLTR early in the season and LLFB late in the season exceeded the DO MQO.

Discharge data were obtained from Avista, which uses a well-established monitoring program. Golder reviewed the variability of discharge data to determine whether it was appropriate based on expected values. All discharge data were deemed acceptable.

Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value, or the combination of high precision and low bias. Throughout this seasonal TDG monitoring study, the MS5s

[3] The Pre-deployment MS5 mass verification calibration event was conducted at Post Falls HED.

underwent verification procedures. All differences between TDG pressure, dissolved oxygen, temperature, depth, and barometric pressure were recorded and these differences were discussed in the previous section.

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 downstream long-term monitoring station (LLTR) monitored in the past, monitoring in the LLFB stilling well constructed in 2009, 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 approximately 12,500 15-minute periods. Data completeness for all parameters except DO met the goal of at least 90 percent for both LLFB and LLTR. Completeness of DO at LLTR was slightly less than the 90-percent goal, primarily because of water under the DO cap.

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

Table A-4: Project Completeness

	LLFB		LLTR	
	Count	**Completeness (%)**	**Count**	**Completeness (%)**
Monitoring Period	12,469	--	12,472	--
Water Temperature (°C)	11,376	91%	12,377	99%
DO (mg/L)	11,377	91%	11,145	89%
BAR (mm Hg)	used LLTR BAR		12,462	100%
TDG (mm Hg)	11,357	91%	12,360	99%
TDG (% saturation)	11,337	91%	12,350	99%

Table A-5: Number of Specific DQCodes during Monitoring Period

DQ Code	DQ Code Description	LLFB					LLTR						
		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)
-211	Depth < TDG compensation depth	--	--	--	--	--	--	9,250	--	8,024	--	--	--
302	Extreme variability, water under DO cap	--	--	--	--	--	--	--	--	1,232	--	--	--
599	Suspect out of water based on depth	--	--	--	--	--	43	43	43	43	--	--	--
991	Instrument not deployed at typical long-term depth	12	12	12	12	--	22	22	22	22	--	--	--
992	Out of water/moved for downloading data	--	--	--	--	--	--	--	--	--	--	2	2
993	Out of water for calibration/servicing	31	31	31	31	23	30	30	30	30	4	--	--
996	No data reported by instrument even though programmed correctly	1,048	1,048	1,048	1,048	1,048	--	--	--	--	--	--	--
997	Suspect not yet equilibrated after deployment	2	21	1	1	--	--	17	--	--	--	--	--
	No DQ Code	11,376	11,357	11,377	11,377	11,398	12,377	3,110	12,377	3,121	12,468	12,470	12,470
	Monitoring Period[1]	12,469	12,469	12,469	12,469	12,469	12,472	12,472	12,472	12,472	12,472	12,472	12,472

Notes:

1. Monitoring period for LLFB is from 3/24/2011 13:45 to 8/1/2011 10:45. Monitoring period for LLTR is from 3/24/2011 10:15 to 8/1/2011 8:00.

APPENDIX B
CONSULTATION RECORD

2/17/2012

Marcie Mangold
Department of Ecology
4601 N Monroe Street
Spokane, WA 99205

In accordance with Avista's Federal Energy Regulatory Commission (FERC) June 18, 2009 Spokane River Project (FERC No. 2545) License Avista is submitting the following reports for your review and comment.

Annual Total Dissolved Gas Attainment and Monitoring Report for the Long Lake Development. There are two related components to this report.

A. *Annual Total Dissolved Gas Monitoring Report for 2011, Golder Associates, Dec. 2011.* As required by the Total Dissolved Gas (TDG) Water Quality Attainment Plan (WQAP) and the Washington TDG Monitoring Plan, this report provides the results of monitoring TDG at Long Lake HED and Nine Mile HED during 2011. Avista proposes to continue implementing the same monitoring plan at Long Lake HED in 2012. However, during 2011 the Nine Mile HED was plagued with numerous equipment issues which resulted in lost generation and increased spill. As a result, Avista proposed to delay monitoring until operations at the plant return to normal. Ecology agreed with this proposal and in their correspondence dated February 17, 2012 suspended TDG monitoring until the first season following completion of the Unit 1 and 2 turbine/generator replacement project and the sediment by-pass tube is again fully operational. This correspondence is attached.
B. *Long Lake Dam TDG Abatement Feasibility Phase III, Physical Model Study, 2011 Interim Report. Northwest Hydraulic Consultants, Jan. 2012.* This report documents the progress of building the physical model and hydraulic testing deflectors on the modeled Long Lake Dam spillway. Avista proposes to continue the modeling of the stepped weir alternative identified in the Phase II study during 2012. In addition, a third alternative termed the Noxon Concept (dentated spillway) will be developed including preliminary hydraulic design calculations, civil engineering, drawings, and cost estimates. Once these items are completed, Avista will be able to determine if the design should be modeled. Avista believes this effort could also be completed in 2012.

Annual Long Lake Tailrace Dissolved Oxygen Monitoring Report. This is the first annual report required under the FERC approved Dissolved Oxygen (DO) Feasibility and Implementation Plan. Monitoring DO took place from July 1st through October 31, 2011. The report illustrates the seasonal changes in DO just downstream of the dam during the low flow period of the year. In order to boost DO levels in the river, Avista installed manual aeration equipment on turbine Units 3 and 4. The results of aerating the turbine discharge water with the aeration equipment during generation are included in this report. This was Avista's first effort to implement the system, which had been tested in 2010. The results were encouraging. Avista proposes to automate the components of the system in 2012, which will allow for a more thorough, and effective aeration effort and assessment.

Avista would appreciate your review of the attached reports by March 21, 2012. This 30 day review period should allow Avista enough time to address your comments prior to submitting the reports to

FERC for their review and approval. Please feel free to call me anytime if you have questions or concerns.

Sincerely,

Hank Nelson

Hank Nelson
Environmental Coordinator

Enclosures

CC: Brian Crossley, Spokane Tribe

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

March 21, 2011

Mr. Elvin "Speed" Fitzhugh
Spokane River License Manager
Avista Corporation
1411 East Mission Ave., MSC-1
Spokane, WA 99220-3727

RE: Request for Comments – Spokane River Hydroelectric Project No. 2545 2011 Long Lake Dam Total Dissolved Gas Monitoring Report and Long Lake Dam TDG Abatement Feasibility Phase III Physical Model Study 2011 Interim Report – Washington 401 Certification, Section 5.4(D)

Dear Mr. Fitzhugh:

The Department of Ecology (Ecology) has reviewed the following documents mailed to us on February 22, 2012, and would like to provide the comments below:

2011 Long Lake Dam Total Dissolved Gas Monitoring Report

We currently do not have any comments on monitoring protocol or collection methods.

Although the data showed that often total dissolved gas (TDG) exceeded the 110% water quality standard in the tailrace, Ecology acknowledges that while you are actively working on your compliance schedule identified in your TDG abatement plan, you are in compliance with your 401 water quality certification.

Long Lake Dam TDG Abatement Feasibility Phase III Physical Model Study 2011

We would like to thank Avista for offering us the opportunity to visit the physical model on several occasions, but unfortunately our schedules did not allow the time to visit.

The study outlined and thoroughly discussed each alternative in great detail. It would be helpful if the introduction section included a recap of the TDG attainment plan as well as the compliance schedule.

According to your approved compliance schedule, Phase III was to be completed in 2012. This included hydraulic modeling for Alternative 1 (spillway deflectors) and Alternative 6 (stepped weir). Ecology understands that the modeling for the spillway deflectors has been completed, though the modeling for Alternative 6 is still ongoing, and that an additional Alternative 7 (Noxon design concept) is being developed. As such, it appears

that Phase III work will continue into 2012, which will put Avista one year behind in their compliance schedule.
We fully understand that this lapse in schedule is due to the complex challenges, including but not limited to physical constraints associated with the tailrace, of reducing TDG at Long Lake HED and agree that the additional modeling and/or assessment efforts are appropriate. Further exploration of the stepped weir and the Noxon design alternatives, as well as completion of Phase IV-Formulate Design, Plans, and Specs, should still allow Avista to meet the final deadline for TDG abatement in 2018.

We thank you for the opportunity to comment and look forward to working with you in the future. Please contact me by phone at (509) 329-3450 or by email at dman461@ecy.wa.gov if you have any further questions.

Sincerely,

D. Marcie Mangold

D. Marcie Mangold
Water Quality Program

DMM:dw
cc: Brian Crossley, Spokane Tribe of Indians
Hank Nelson, Avista
David Moore, Ecology/WQP

Nelson, Hank

From: Brian Crossley [crossley@spokanetribe.com]
Sent: Wednesday, March 21, 2012 4:23 PM
To: Nelson, Hank
Subject: TDG Long Lake and 9 mile and TDG abatement Phase III

9 mile TDG report- I agree- the data was not collected under "normal" conditions . Are the gates working good this year?

Phase III TDG abatement feasibility - I liked the idea that they constructed multiple level flip-lip that allows Avista some flexibility in managing flows and also that they are constructed across the entire spillway.

I presume the stepped model will be presented after they are done....

I have not read the DO report yet; I will get you comments on that tomorrow if I have any.

Brian