TDG FOREBAY FIXED MONITORING SYSTEM REVIEW AND EVALUATION FOR JOHN DAY DAM, 2004

(BI-OP MEASURE 132)

November 17, 2004

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For
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Contract Number: DACW68-03-D-0003 DTO1

Executive Summary

Action 132 of the 2000 Biological Opinion (BIOP 132) requests a systematic review and evaluation of the total dissolved gas (TDG) fixed monitoring system (FMS) in the forebays of all mainstem Columbia and Snake River dams. The FY04 Scope of Work for Columbia River BIOP 132 required the relocation of the John Day Dam forebay TDG FMS station, JDA, to a 10 m depth on the John Day Dam forebay navigation lock wing wall, plus the installation of an additional TDG monitoring instrument 5-7 m deeper, and a thermister string at this same location. This report will evaluate the data collected at the John Day Dam forebay TDG fixed monitoring system during the 2004 fish spill season, compare the data from the two monitoring instruments, and make comments regarding the repositioning of the monitoring stations from their original locations.

Comparisons of the 10 and 17 m instruments found a statistical difference between the TDG data measured at these two stations, however, this difference was small relative to the standard deviations of the two stations and the environmental change we observed over the study time. This difference between the two depths is likely due to high precision of measurement at each instrument, but slight differences in sampled accuracy between stations. Our findings suggest that either station will likely measure a sufficient amount of environmental variation in the river and represent good approximation of TDG in the forebay of John Day Dam. We conclude that at least one station between 10 and 17 m is necessary to accurately record the total dissolved gas patterns in the upstream forebay of John Day Dam.

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Introduction

The U. S. Corps of Engineers (COE) operates many of the hydropower projects within the Columbia River Basin. These dams, reservoirs, and associated modifications to the water resources have an impact on aquatic habitat across the entire basin. Of particular concern is hyper-aeration of the water flowing through the dam spillways, which can lead to gas bubble disease in fish and other biota. For instance, high concentrations of dissolved gases, which are associated with high spill at the dams, may contribute to gas bubble trauma in threatened or endangered juvenile salmonids. The COE has been conducting ongoing water quality monitoring to better understand the fundamental nature of dissolved gas loading and dynamics as a result of hydropower system operation.

A fixed monitoring system (FMS) was installed at the dams throughout the Columbia and Snake Rivers in 1994. These fixed monitoring stations have been used to establish a method of evaluation and management of spill practices at dams concerning water quality total dissolved gas levels. The project forebay TDG monitors are intended to represent a mixed cross section in the river just upstream of the dam and can be a fair approximation of aquatic habitat as defined by TDG and water temperature in that area of the pool.

In response to Action 132 of the 2000 Biological Opinion, a review and evaluation was developed for the forebay TDG fixed monitoring stations at the mainstem Columbia and Snake River dams. Data from the review conducted in 2003 depicted thermally induced spikes in TDG at the original forebay FMS stations, creating an unrepresentative record of river water conditions. The alternate TDG stations, positioned at the forebay navigational lock wing wall, were the least affected by the thermal related pressure spikes (Carroll 03). Results from this review recommended that the COE relocate the existing forebay TDG FMS to the navigation lock wing wall; and the set up of an additional comparable TDG monitoring instrument adjacent to but 5 meters deeper than the relocated FMS monitor.

In compliance with results from the FMS review, the FY04 Scope of Work for Columbia River BIOP 132 required the following tasks. The original FMS station JDA being moved to the upstream tip of the navigation lock wing wall and the named changed to JDY. The second task was to add an additional TDG monitoring instrument (station JDAFBNL) adjacent to and 5-7 m deeper than JDY. JDAFBNL depth, 15-17 m, should be adequate to avoid most thermal responses in the TDG readings brought about by a mixing of the warm surface layers and should approximate the average water temperature for the water column. The third task was to add a thermister string adjacent to the new FMS station.

This report will review the data collected at John Day Dam from April 7 to July 25, 2004, and will compare the data from instrument JDY positioned at a depth of 10 m to instrument JDAFBNL positioned at 17 m to determine the depth needed to accurately monitor forebay conditions. A better understanding of the relationship between instrument depth and the accuracy of instrument readings can improve project management for TDG as well as water quality compliance evaluations.

Study Design

The following tasks were conducted during FY 2004 at the John Day Dam:

- Relocate existing John Day forebay TDG FMS to the forebay navigation lock wing wall; and set up of an additional TDG monitoring instrument adjacent to and deeper than the monitor (at a depth of 17 m as compared to 10 m).
- Review and analysis of data recorded at the two FMS stations, from April 7 to July 25, 2004, for representativeness of forebay conditions, and anomalies in TDG and temperature.
- Set up of a thermister string positioned at the forebay navigation lock wing wall, and review of the data collected from April 7 to July 25, 2004.

The FMS station data, consisting of station location, TDG, water temperature, and depth, was collected on hourly intervals and then stored on the COE Columbia River Operational Hydromet and Management System (CROHMS) database (http://www.nwd-wc.usace.army.mil/report/tdg.htm). There are two TDG stations, both located on the forebay navigation lock wing wall; station (JDY) positioned at approximately 10 m deep, and station (JDAFBNL) positioned at approximately 17 m deep. The temperature profiles were collected on 15-minute intervals using remote automated logging instruments (thermistors) spaced at appropriate depth intervals (0.5 m, 1.5 m, 3 m, 5 m, 10 m, 15 m, 20 m, 25 m, 30 m, and bottom at the forebay navigation lock wing wall. Figure 1 depicts the location of the total dissolved gas fixed monitoring stations sites, and the thermal profile station at John Day Dam during this study.

Study Results

Total dissolved gas data from two monitoring stations, and temperature data from a thermistor string was collected in the upstream forebay of John Day Dam from April 7 to July 25, 2004. Plots of the data over time illustrated a fluctuation in TDG ranging from 766 to 862 mm Hg from the 10 and 17 m station data throughout the sampling period (Figure 2). This range of TDG levels did not exceeded the state water quality fish spill waiver of approximately 874 mm Hg based on 115% saturation of TDG. The mean TDG was 809.00 mmHg (SD±20.87) at 10 m, and 806.72 mmHg (SD±19.86) at 17 m (Table 1). A statistical test between paired samples of the two stations indicated a significant difference (*t*-test, 2840df, $P < 0.0001$) in TDG between the 10 and 17 m locations, but this difference in measurement was small (Figure 3). On average, the mean difference [10 m – 17 m] between the two stations was 2.28 mmHg (SD±3.36; Figure 3)

Table 1. . Descriptive statistics for TDG (mmHg) measured at two stations in the upstream forebay of John Day Dam from April 7 to July 25, 2004

	Meter location	
Statistic	JDY (10 m)	JDAFBNL (17 m)
Mean saturation	809.00(SD± 20.87)	806.72 (SD± 19.86)
Minimum saturation	766	767
Maximum saturation	862	856
Mean temperature (°C)	15.34	15.57
Number of days recorded	106	106

Water temperature as monitored at the John Day forebay FMS, via a thermister string, ranged from 9 to 27 °C during the 2004 study period. As the season progressed, we observed a strong linear increase in temperature (r^2 = 0.97, 23243 df, P < 0.0001; Figure 4). The slope of temperature regressed on data indicated an average increase of 0.11 °C per day.

The maximum, minimum, and mean water temperatures at each thermistor depth are presented in Table 2 and Figure 5. Water temperatures from depths of 0.5 to 15 m appeared to be more affected by environmental thermal spikes than depths of 15 to 40 m. For example, minimum (8.92 to 9.21 °C) and mean (15.10 to15.89 °C) temperatures were stable among depth profiles, but maximum temperatures from 0 to 15 m (26.85 – 22.36 °C) were higher than temperatures from 15 to 40 m (21.97-21.05 °C). At depths near the reservoirs bottom, the water temperature is homogenous, and does not seem to be affected by daily cycles in solar radiation and in air temperature.

Table 2. Descriptive statistics for water temperature measured in the upstream forebay of John Day Dam from April 7 to July 25, 2004.

	Thermistor Depth Intervals (°C)									
	0.5 m	1.5 m	3 m	5 m	10 m	15 m	20 m	25 m	30 m	Bottom
Minimum	9.21	9.03	9.12	8.92	9.20	9.10	9.12	9.14	9.08	9.10
Maximum	26.85	25.74	24.63	24.42	22.95	22.36	21.97	21.75	21.58	21.09
Mean	15.89	15.66	15.65	15.55	15.45	15.29	15.22	15.25	15.18	15.11
Days recorded	106	106	106	106	106	106	106	106	106	106

Conclusions

A total dissolved gas fixed monitoring station was installed at the forebay navigation lock wing wall of John Day Dam during the 2004 fish spill season. TDG data was collected and reviewed from two different depths at this location. The data from the stations at 10 and 17 m likely represented a mixed cross section of the forebay water conditions. We found a statistical difference between TDG measured at the two stations, however, this difference was small relative to the standard deviations of the two stations and the environmental change we observed over time. It is possible that the difference we found could represent a true environmental difference, although we feel the difference between the two depths is due to high precision of measurement at each station, but slight differences in accuracy between stations. Our findings suggest that either station will likely measure a sufficient amount of environmental variation in the river and represent good approximation of TDG in the forebay of John Day Dam.

Air temperature fluctuations to the forebay's surface layer created warming that extended beyond 10 m depths on occasions, thus a station between 10 and 17 m would be required to eliminate the minor thermal related spikes in TDG as recorded at JDY during the 2004 season.

Recommendations

Based on the 2004 sampling effort combined with the work completed in 2003 it is recommended to maintain the JDY FMS station at the upstream tip of the navigation lock wing wall at a minimum of 10 m depth for future TDG monitoring as required by the Portland District DOE. Deeper deployment to 15-17 m may be considered to further eliminate thermal spikes.

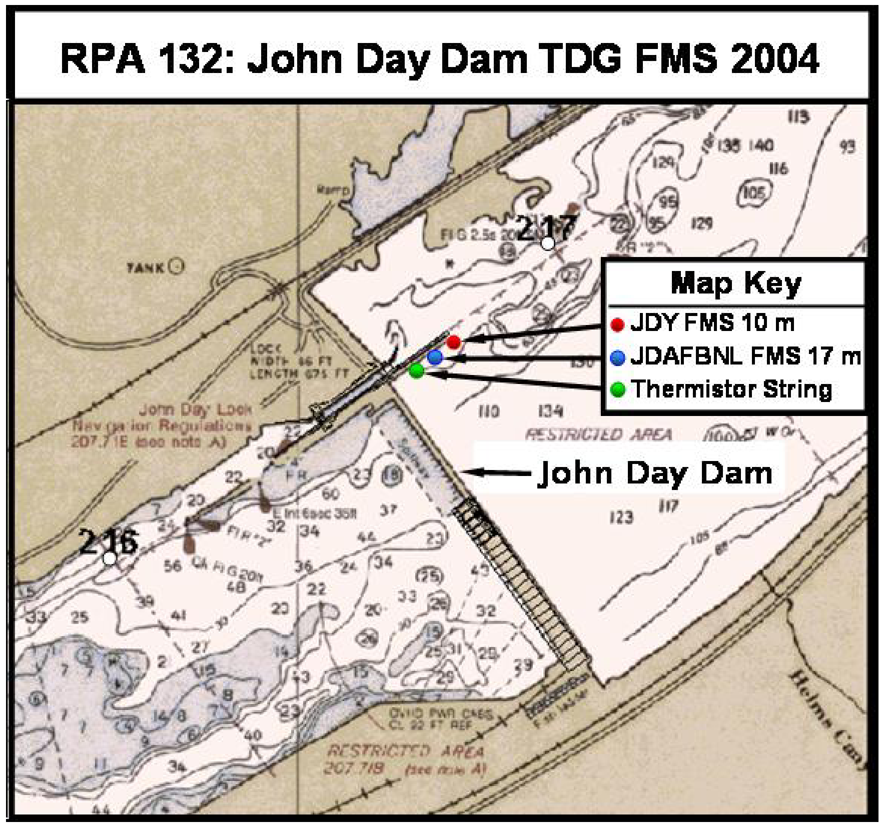

Figure 1. Total dissolved gas Fixed Monitoring Stations, and the thermal profile station locations at John Day Dam during the April 7 to July 25, 2004 study period.

Figure 2 a

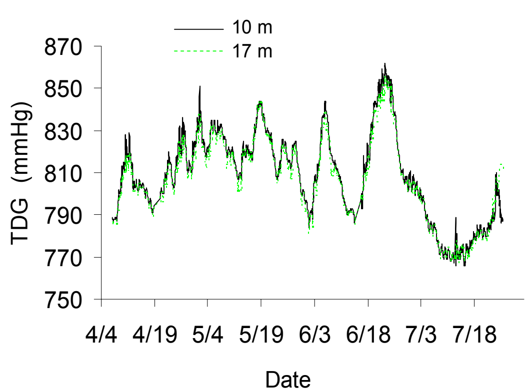

Figure 2 b

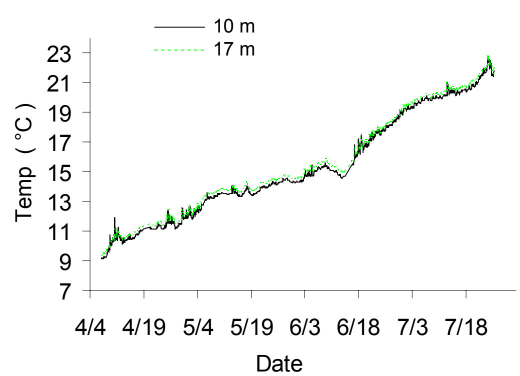

Figure 2. Hourly total dissolved gas data by date (a), and hourly water temperature data by date (b) at two stations in the upstream forebay of John Day Dam.

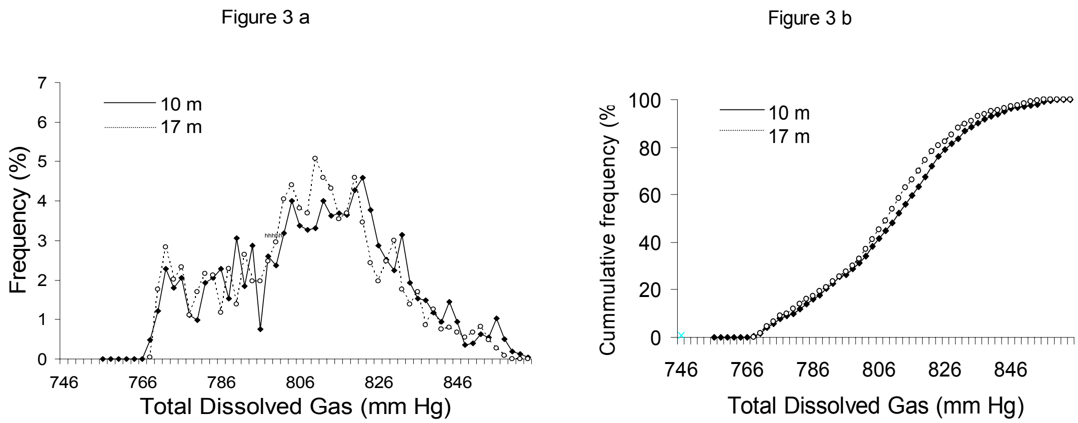

Figure 3. Frequency distribution (a) and cumulative frequency distribution (b) of TDG data at two stations in the upstream forebay of John Day Dam, 2004

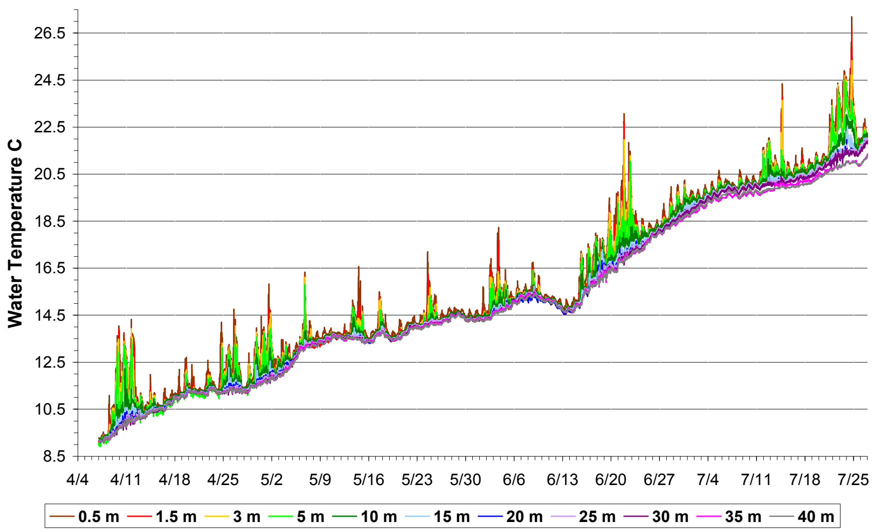

Figure 4. Thermistor string data measured in the forebay of John Day Dam, 2004

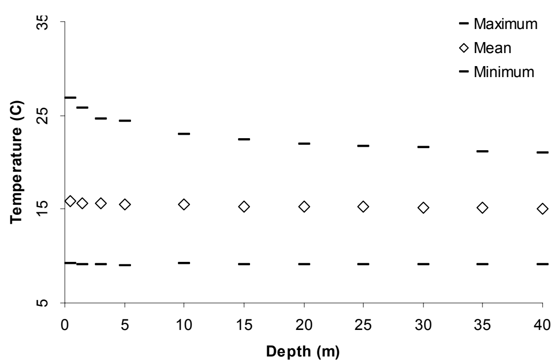

Figure 5. Maximum, minimum, and mean water temperatures at each Thermistor, 2004