Appendix H

Walla Walla District TDG Report

(includes McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, and Dworshak)

Evaluation of Water-Year 2006 Fixed-Monitoring Station Data: Walla Walla District

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ABSTRACT

The U.S. Army Corps of Engineers (USACE), Walla Walla District (CENWW), operated fifteen fixed-monitoring system (FMS) stations (eight seasonal and seven year round) for total dissolved gas (TDG), barometric pressure (BP), and temperature as part of their 2006 water-quality program. These stations are located on the Columbia, Lower Snake and Clearwater Rivers. This report provides a summary of the 2006 water-year data along with the corresponding quality assurance/ quality control (QA/QC) evaluation. Field instrument calibration revealed only minor differences between the in-place and replacement sondes with overall averages of -0.03 mmHg for BP, 0.00 percent TDG saturation, and -0.03 °C. Data for seven of fifteen stations were 100 percent complete but Anatone failed to achieve 95 percent completeness for TDG measurements. Fourteen of the fifteen stations exceeded 20°C and six stations were over 20°C more than 10 percent of the time. Dworshak tailwater did not exceed the 20°C criterion. The special maintenance data study showed that monthly sondes provided better calibration data than the bi-weekly sondes.

1.0 INTRODUCTION

Six hydropower projects – McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, and Dworshak – operated by the Walla Walla District (CENWW) of the U.S. Army Corps of Engineers (USACE) are included in the basin-wide fixed-monitoring system (FMS) network. Seven of the stations (*i.e.*, two at McNary Dam, two at Ice Harbor Dam, two at Lower Granite Dam, and one at Dworshak Dam) are operated throughout the year (Figure 1; Table 1). The remaining eight stations record data from 1 April through 15 September.

Three water-quality parameters are monitored at these facilities. One is total dissolved gas (TDG). This parameter is of interest since gas supersaturation results when air is entrained as water flows over the spillways and plunges into the stilling basin where water pressure causes the air to go into solution. The river subsequently becomes shallow beyond the stilling basin and the result is water supersaturated with TDG relative to atmospheric conditions. The U.S. Environmental Protection Agency (USEPA) has established an upper limit of 110 percent saturation for protection of freshwater aquatic life. Concentrations above this level can cause gas bubble trauma in fish and adversely affect other aquatic organisms (USEPA, 1986). The State of Washington water-quality standards (WADOE, 1997) provide exemptions to this criterion when water is spilled for fish passage, as well as during high river discharge events (*i.e.*, flows greater than the 7Q10). WAC 173-201A-070 states that the averages of the twelve highest daily TDG values when water is spilled for fish passage can reach 115 percent in the forebays and 120 percent in the tailwaters. The one-hour maximum TDG measurement cannot exceed 125 percent. Two additional parameters that influence TDG saturation are barometric pressure and water temperature. As such, measurements for these two constituents are also recorded and stored in the database.

Measurements were completed hourly at all stations and transmitted via the Geostationary Operational Environmental Satellite Program (GOES) system to the Columbia River Operational Hydromet Management System (CROHMS) data base at the USACE Northwestern Division (CENWD) office in Portland, Oregon every four hours. The CENWD website is the official U.S. Government source for the entire total dissolved gas monitoring system (TDGMS) and can be accessed at http://www.nwd-wc.usace.army.mil/report/total.html.

2.0 PURPOSE AND SCOPE

The purpose of gas monitoring is to provide managers, agencies, and interested parties with near real-time data for managing stream flows and TDG levels downstream from power-producing dams. As with any data collection activity, an important component that cannot be overlooked is the quality of the data. Measurement of data quality allows determination of the usefulness and relevance of data for current and future decision processes.

This 2006 report:

- Describes the data collection methods.
- Evaluates quality assurance/ quality control (QA/QC) data for the FMS stations at McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite reservoirs. Additionally, this data-collection system provided water-quality information for the Clearwater River downstream of Dworshak Dam, the Columbia River near Pasco, and the Snake River near Anatone, Washington (Figure 1; Table 1).

The QA/QC data includes:

1. Instrument Data. This data was used to evaluate how an instrument performed as a function of the magnitude and direction that individual sensors deviated over time from their respective laboratory standards. These relationships were determined for each sensor before and after each two-week deployment.
2. Station Data: These data present comparisons between an in-place instrument that was deployed at a given station for a two-week cycle and a newly calibrated QA/QC instrument (field standard). The Honeywell® and Sutron® barometers at each station were evaluated with a hand-held barometer that served as a portable field standard for barometric pressure. Fifteen stations were visited for maintenance two times per month between 1 April and 15 September. Seven stations were maintained on the same bi-weekly schedule for the entire year.

- Provides a synopsis of the station TDG, temperature, and barometric pressure data.

3.0 METHODS

3.1 DATA COLLECTION

The instrumentation at each FMS station consisted of components provided by CENWW and the U.S. Geological Survey (USGS). A 12-volt battery charged by a solar panel and/or 120-volt alternating-current line powered each station. The Hydrolab® multi-parameter probes (*i.e.*, twenty-five Minisondes, sixteen Minisonde 4a's, and eight Datasondes), cables, and Honeywell® PPT16 electronic barometers were provided by CENWW. The sixteen Sutron® Model 8210 and two Satlink® Model data collection platforms (DCP) and associated satellite linkages were used. The Model 8210 DCPs were rented from the USGS. The DCP transmitted the most recently logged eight hours of data to the GOES system every four hours. The data were automatically decoded and transferred to the CROHMS database.

3.2 LABORATORY PROCEDURES

The TDG sensor measures the sum of the partial pressures of gaseous compounds dissolved in the water and reports the result in millimeters of mercury (mmHg). The TDG sensor requires a two-step calibration procedure (*i.e.*, adjustments are made at two points on the calibration curve) that is completed prior to and after deployment. The atmospheric pressure calibration point (Lab BP) is equal to the atmospheric pressure at the time of calibration as measured with a ParoScientific® digital barometric pressure standard that was checked quarterly against a wall-mounted mercury barometer (Princo Instruments Model 453). The differences between Lab BP and the pressure measured by the sonde [Δ(BP-PT)] were recorded before and after deployment. The slope of each sensor response was also evaluated to ensure that measurements were interpolated correctly over the full range of expected field values. To accomplish this task, a Heise™ certified pressure calibrator (primary standard) was used to apply pressure to the TDG sensor. Two hundred mmHg were added to Lab BP during the pre-deployment check and the differences between Lab BP+200 and the sondes' response were recorded as Δ[(BP+200)-PT]. Similar tests were completed post-deployment when 100 mmHg was added to Lab BP, and the resulting differences were recorded as Δ[(BP+100)-PT]. Pre-deployment pressure tests were made without a membrane installed. Post-deployment tests were made with a dry membrane in place.

Each sonde also includes a sensor for reporting water temperature in degrees Celsius (°C). Sonde thermometers are factory calibrated and cannot be adjusted. However, temperature sensor performance was evaluated pre- and post-deployment by comparing instrument readings to a National Institute of Standards and Technology (NIST)-traceable digital thermistor and NIST-traceable probe (Barnant 600-1075 thermistor and YSI 400 series probe). Both of these instruments were checked quarterly against a NIST mercury thermometer standard.

3.3 Field Procedures

The differences in barometric pressure, water temperature, and TDG between a secondary standard instrument (*i.e.,* replacement sonde) and the fixed-station monitors after two weeks of field deployment were measured and recorded as part of the field inspection and calibration procedure. These differences, defined as the secondary standard value minus the field instrument value, were used to compare and quantify the precision between two independent instruments. The Honeywell® or Sutron® barometers were checked using the Thommen® hand-held barometer. The water temperature and TDG comparisons were made *in situ* with the secondary standard (a recently calibrated Hydrolab®) positioned alongside the field Hydrolab®.

3.4 Defining Invalid and Missing Data Values

The real-time data were examined daily during the workweek by CENWW and/or USGS employees. Missing values and those that appeared to be outside the expected range were flagged. If a reasonable explanation (*e.g.*, routine maintenance, DCP failure, or defective membrane) could be attributed to the incident, then the data point, or points, was not included in the final data set used for this analysis. Outlying data points that could not be attributed to a specific cause were retained.

Several discrepancies were identified between the data in the CROHMS database and Automated Data Acquisition and Processing System (ADAPS) database operated by the USGS during the preparation of this report. Most of the inconsistencies were categorized as missing in CROHMS but present in ADAPS. The more problematic stations included Little Goose forebay, Columbia River at Pasco, McNary tailwater, Lower Granite tailwater, and the Snake River at Anatone. Data from the other stations matched to a greater degree in both databases, but there were still disagreements. To obtain at the most representative database for this report, the information stored in ADAPS was used as the foundation. The information in the CROHMS database was then cross-referenced to ADAPS and merged where necessary to arrive at a final optimized set of data.

4.0 RESULTS AND DISCUSSION

4.1 Inventory-wide Sonde QA/QC Performance

4.1.1 Pre-deployment

The pre-deployment evaluation of the sondes consisted of 321 individual checks for each parameter (Table 2). The evaluation of the sonde pressure sensors to the standard revealed a calculated mean of 0.01 mmHg, and a range of -1.10 to 1.00 mmHg. Two hundred millimeters of mercury (mmHg) was added to the TDG sensor in the laboratory using the laboratory barometer as the baseline standard. The difference between the barometer with 200 mmHg of pressure and the instrument was compared against the expected value. The calculated mean was

based on the 321 measurements. The sonde pressure differences ranged from -0.10 percent to 0.10 percent (Figure 2; Tables 2 and 3). The calculated mean was 0.00 percent and the median was 0.00 percent (Figure 2; Tables 2 and 3).

The dissimilarities between the NIST-traceable thermometer and the sonde thermistors were also quite small. The average for all the instruments was only -0.01 °C. This calculated value was based on 321 measurements, with the medians for individual sonde ranging from –0.21 °C to 0.20°C (Table 2). The instrument manufacturer's specification is ±0.2 °C for all instruments within a sample pool.

4.1.2 Post-deployment

The evaluation of the post-deployment QA/QC data also displayed favorable results. A total of 313 data points were used for the data evaluation. The difference between the laboratory barometric pressure and that recorded by the sondes ranged from, -5.0 mmHg to 3.1 mmHg, with a mean of 0.06 mmHg (Tables 2 and 4). The results of the post calibration checks using barometric pressure +100 mmHg showed a calculated mean of -0.03 percent, and a range of -0.9 to 0.4 percent (Table 2). Sonde post calibration pressure checks (+100 mmHg) ranged from 3.1 mmHg to -15.4 mmHg. The notable exception was sonde USGS#2 with a pressure of -15.4 mmHg (Figure 3). After this exception, the sonde was deployed seven other times and gave satisfactory performance for the rest of the year.

There were 314 post deployment checks for temperature evaluation. Temperature post calibration checks resulted in a range of -0.31 °C to 0.15 °C (Table 2 and 4; Figure 4). The extreme negative value was from sonde #26. With the exception of this single measurement the sonde gave satisfactory service. The overall mean and median post deployment temperature changes were -0.03 °C and -0.02 °C, respectively (Table 2).

4.2 System-wide Station QA/QC Performance

The analysis of the station QA/QC data showed that the in-place barometric air pressure, TDG, and temperature instruments performed well when compared to the secondary standards (Figures 5 through 7). A total of 331 readings were used to calculate the mean and median values (Table 5). The mean of all the differences calculated between the station barometers and the secondary standards was 0.04 mmHg (Table 5; Figure 5). The stations where individual values departed from this median to the greatest extent were Lower Granite tailwater (LGNW) at 3.8 percent saturation and Ice Harbor forebay as 0.4 mmHg (Table 6; Figure 6). The combined median for the pooled data for all stations was calculated at 0.10 mmHg (Table 5).

A total of 313 reading were used to calculate the temperature mean and median values (Table 5). Temperature differentials in the field had median and mean values of -0.01 °C and -0.01 °C respectively (Table 5). The stations where individual values departed from this median to the greatest extent were Lower Monumental tailwater (LMNA) at -0.05 °C and Lewiston (LEWI) at -0.07 °C (Table 6). The overall pooled data temperature values for individual stations ranged from 0.35 °C to -0.38 °C (Table 5). The manufacturer's specification for the temperature sensor is +/- 0.20 °C. The stations where individual values departed from this standard to the greatest extent were Little Goose tailwater (LGSW) with values ranging from 0.32 °C to -0.29 °C and Lower Granite tailwater (LGNW) with values ranging from 0.35 °C to -0.25 °C (Table 6).

The overall median for the TDG differences between the in-place and replacement sondes was -2.00 mmHg, or -0.3 % saturation (Table 5). Individual station differences typically ranged from 0.6 % saturation to -0.7 % saturation, but there were exceptions (Table 6). One notable station was Anatone (ANQW) where a total of 249 hourly values were too low as a result of inadequate water circulation (Table 8). The Ice Harbor tailwater (IDSW), as well as Little Goose tailwater (LGSA) also experienced low values during a week (as much as 3 to 6 percent of the total hourly values) of erroneous readings (Tables 8). McNary tailwater (MCPW) and Ice Harbor forebay (IHRA) both experienced data cable failures that resulted in a loss of 1 to 1½ percent of the data, respectively (Tables 8).

4.3 FMS DATA COMPLETENESS AND STATION STATISTICS

Data completeness and station statistics were evaluated for two applicable intervals. Data completeness for all three parameters was determined for the entire year for the eight annual stations, and from 1 April through 15 September for the seasonal sites (Table 9). The 1 April through 15 September interval was applied to the frequency analysis of the temperature data to make comparisons consistent.

The most common reasons for missing or anomalous data were defective DCPs, missed data transmissions, and low data values (Table 7). Field data results and site visits found the 'too low" measurements were most commonly caused by circulation problems. The existing Sutron 8210 DCPs also accounted for several faults and are scheduled for replacement.

The data set for all stations included 8,760 possible hours for the annual stations or 4,056 possible hours for the seasonal stations. Most stations met the required 95 percent with the exception of Anatone (ANQW), which achieved a data completeness percentage of 93.63 percent (Table 10). This rating was caused by low readings that were discovered through the USGS and District QA/QC analysis. Another station that was very close to not meeting the 95 percent criterion was Little Goose forebay (LGSA) (Table 10). The reasons in this case were again low readings on the TDG sensor (Table 9).

4.3.1 Temperature

Greater than 98 percent of the overall temperature data from the FMS stations were within the acceptance criteria for completeness. The Lower Granite forebay had the lowest rating with 96.68 percent completeness (Tables 9 and 10). None of the stations were 100 percent complete. Eight of the fifteen stations were 99 percent complete.

The 1 April through 15 September time period was evaluated, and several noteworthy features were identified as a result of this process, including:

- None of the hourly temperature readings exceeded 20 °C at the Dworshak tailwater station (Figure 8; Table 11).
- 99.6 percent of the values recorded at the Dworshak site were between 5 °C and 11 °C (Table 11; Figure 8). Downstream mixing with the mainstem of the Clearwater River and warming broadened the frequency distributions at Peck and Lewiston. 50.6 percent of the Peck (PEKI) values occurred between 5 and 11 °C while about 32 percent of the Lewiston (LEWI) values were in the 9 – 13 °C range (Figure 8; Table 13).

- Ten stations experienced temperatures greater than 20 °C more than 20 percent of the time (Table 11; Figures 9 through 11). Water temperatures at the Anatone (ANQW) station were above 20 °C forty-four percent of the time. The Ice Harbor tailwater (IDSW) and forebay (IHRA) stations exceeded 20 °C 40.6 percent and 40.7 percent of the time, respectively (Table 11; Figure 9). The Lower Monumental tailwater (LMNW) and forebay (LMNA) stations exceeded 20 °C 34.9 percent and 35.5 percent of the time, respectively (Table 11; Figure 9). The Little Goose tailwater (LGSW) and forebay (LGSA) stations exceeded 20 °C 26.7 percent and 29.7 percent of the time, respectively (Table 11; Figure 9).
- The lowest frequency of temperature criterion exceedances on the Lower Snake River occurred at the Lower Granite tailwater and forebay stations at 5.5 percent and 3.6 percent, respectively (Table 11; Figures 9 and 10).
- The FMS stations at the four lower Snake River projects did display the same bimodal temperature distributions that were identified in 2005 (Figure 9 and 10) (Heaton and Juul, 2005).
- The highest recorded hourly temperature was 25.2 °C at Anatone (ANQW), but values between 21°C to 22°C were not uncommon for ⅔ of the stations (Table 11).
- The 2006 data showed the same distinct downstream trend in the number of measurements exceeding the20 °C temperature criterion at the tailwater stations identified in 2005. The reason for the progression was that the cooling effects of water released from Dworshak Reservoir were more noticeable at the upstream projects.
- The McNary tailwater (MCPW) and forebay (MCNA) stations exceeded 20 Celsius 36.0 percent and 35.1 percent of the time, respectively compared to Pasco (PAQW) that exceeded, the standard 22.6 percent of the time (Table 11; Figure 9).

4.3.2 Total Dissolved Gas

The TDG data from fourteen of the fifteen stations were 97.2 percent complete or better after data reconstruction (Table 10). The Anatone (ANQW) was only 93.63 percent complete even after data reconstruction (Table 10). None of the stations were 100 percent complete (Table 9). Lower Monumental tailwater (LMNW), Lower Granite tailwater (LGNW), Lewiston (LEWI), Peck (PEKI), and Dworshak (DWQI) would be 100 percent complete after data reconstruction from ADAPS (Table 10). Before data reconstruction both Little Goose tailwater (LGSW) and Anatone (ANQI) failed to achieve the 95 percent completeness criterion (Table 9). Most of the data was recoverable from the USGS ADAPS database for Little Goose tailwater (LGSW) but too many of the values were too low at Anatone (ANQW). About ¼ of the stations achieved an average of 99 percent completeness (Table 9). Eleven stations would achieve 99 percent completeness with ADAPS data reconstruction (Table 10).

The TDG values recorded at the Lower Granite tailwater (LGNW) station are of additional interest. Between 1 April and 15 September there were 345 data points, or 6.6 percent of the total, that were greater than 120 percent, and 215 data points, or 5.3 percent of the total, were greater than 125 percent (Table 14). However, Lower Granite forebay (LWG) did not exceed 115 percent saturation. Additionally, Peck (PEKI) and Lewiston (LEWI) exceeded 110 percent saturation only 0.7 percent and 0.4 percent of the total measurement for the monitoring period (Table 14). There were periods of forced spill throughout the district. Forced spill is a condition

where the dam must pass water over the spill to handle inflow volumes from upstream. This observation illustrates the importance of pursuing studies to better understand in-reservoir process and their effects on gas saturation caused from forced spill operations.

There were both similarities and differences between stations with respect to the frequency distributions of the TDG data. Because spill differed by project, the following comparisons are based on 1 April through 15 September information for consistency:

- Anatone (ANQW), Peck (PEKI), and Lewsiton (LEWI) all exceeded 110 percent saturation for the hourly data, but these were less than 1 percent of the total data set. (Table 14).
- The differences between Anatone and Lewiston were, in large part, due to higher water temperatures in the Snake River and the effect of Charles Law.
- Dissolved gas exceeded 115 percent at five out of six forebay stations and exceeded 120 percent saturation at four out of five forebay stations (Table 14; Figure 11, 13, 14, and 15). Dissolved gas exceeded 120 percent at all tailwater stations and 125 percent at all Snake River tail water stations (Table 14; Figure 11, 13, 14, and 15). Dworshak tailwater exceeded 110 percent 0.4 percent of the time (Table 14).
- The frequency distributions at the lower Snake River projects are shown in Figures 13 and 14, and Tables 14 and 15. The distributions of the hourly data at Little Goose forebay and Lower Monumental forebay stations showed a distinctive bimodal distribution compared with three of the four in 2005 data (Heaton and Juul, 2005). The secondary peaks were distinguishable but not consistent between projects.
- Lower Monumental forebay (LMNA) and Lower Granite tailwater (LGNW) peaked at 130 percent saturation (Table 15 and 16). Lower Granite tailwater (LGNW) dissolved gas values were >130 percent saturation 2.3 percent of the time for the period of monitoring (Table 15).

Eleven of the fifteen stations exceeded the 110 percent, 115 percent, or 120 percent saturation for more than 12 hours per day. Seven of the fifteen stations excceded the standard for more than 20 days during their monitoring period. Lower Monumental tailwater (LMNW) and Ice Harbor forebay (IHRA) exceeded the 12-hour per day standard more than 50 days during the monitoring period.

4.4 MONTHLY VERSES BI WEEKLY MAINTENANCE CYCLE STUDY

Eight Hydrolab Datasonde 4® with TDG were deployed in pairs to evaluate the post calibration differences between sondes deployed for one month without maintenance verses sondes maintained every two weeks. The study was initiated in May and ended in September. This time period best represents the segment of the monitoring season when the greatest calibration drift would be expected. The four sites selected for the study were: the Columbia River at Pasco (Port of Pasco); the Snake River at Hood Park (near Burbank Washington); the Lower Monumental forebay; and the Clearwater River at Lewiston (river mile 3). Prior to deployment the sondes were refurbished with new membranes, O-rings, clock batteries, and upgraded with new stainless steel Luer-lok® fittings where applicable. Pre-deployment calibration data was

compared to post deployment calibration data to determine the amount of sensor drift in millimeters of mercury (mmHg).

During the study, significant differences in the amount of biological growth between the monthly and bi-weekly sondes were evident. Monthly sondes had a considerable amount of bio-fouling compared to the bi-weekly sondes (Figure 16). Differences between the test stations were expected. Clearwater River sondes and Lower Monumental forebay sondes appeared to have the greater amount of variability in the calibration data compared to the Columbia River and Snake River at Hood Park sondes (Figure 17). The Clearwater River and Lower Monumental forebay stations also showed a greater relative amount of bio-fouling compared to the Snake River at Hood Park and Columbia River stations. Pooled data from all sites showed the mean delta change in the monthly sondes was greater than that of the bi-weekly sondes (Figure 18).

Based on these results the extension of the maintenance cycles from bi-weekly to every 3 weeks on the Columbia and Snake Rivers are possible without potential degradation of data. The amount of bio-fouling on the monthly sondes in the Clearwater River and the forebay station suggests there would be some risk of data degradation if these stations were extended to more than one month in their maintenance cycle.

5.0 SUMMARY

Hourly TDG, temperature, and barometric data recorded during the 2006 water year at fifteen FMS stations were evaluated. Seven of these CENWW sites were operated throughout the year and eight were monitored from 1 April through 15 September (Figure 1; Table 9).

The USGS Pasco field office was contracted to perform routine station maintenance, complete emergency repairs, and operate the DCPs. Their pre-deployment QA/QC checks showed an average difference of 0.00 percent when the TDG sensor was compared to barometric pressure and barometric pressure plus 200 mmHg, respectively (Table 2). The post-deployment evaluations had mean differences of -0.03 mmHg and -0.03 percent when the TDG sensor was compared to barometric pressure and barometric pressure plus 100 mmHg, respectively (Table 2). The calculated mean temperature difference was -0.01 °C from pre-calibration data and -0.03 °C from the post-calibration data (Table 2).

Most of the 43 instruments used to perform this years monitoring worked within specifications (Table 3 and 4). Field checks during routine maintenance demonstrated that the air barometric pressure, percent TDG, and temperature averaged 0.04 mmHg, -0.2 percent, and -0.01 °C, respectively, when compared to the secondary standards (Table 5).

The preventative maintenance schedule provided for bi-weekly calibration and maintenance. Station performance was hampered primarily by faulty DCPs, low TDG values, defective sondes and faulty data cables (Table 7). Although low TDG readings provided for a majority of the non-correctable errors; combined missing data transmissions and DCP failures exceeded the number of erroneous values compared with those of low TDG readings (Table 7). Most of the Sutron® 8210 DCPs are scheduled for replacement by Sutron SatLink 2® DCPs in 2007.

Applicable State TDG standards were exceeded at the projects. Dworshak (DWQI), Peck (PEKI), and Lewiston (LEWI) all exceeded the Idaho State 110 percent criterion, but this occurred for 1 percent for all measurements during the monitoring period (Table 14). Five of six forebay stations exceeded the 115 percent saturation criterion (Table 14). Lower Granite forebay (LWG) did not exceed the 115 percent criterion (Table 15). Four of six forebay stations exceeded 120 percent saturation (Table 14, 15 and 16). All tailwater stations exceeded the 120 percent saturation criterion and all four exceeded 125 percent saturation during the rating period (Table 14). Lower Granite tailwater (LGNW) exceeded 130 percent saturation during 2.3 percent of the monitoring period (Table 15). Eleven of the fifteen stations exceeded the 110 percent, 115 percent, or 120 percent saturation for more than 12 hours per day. Seven of the fifteen stations excceded the standard for more than 20 days during their monitoring period. Lower Monumental tailwater (LMNW) and Ice Harbor forebay (IHRA) exceeded the 12-hour per day standard more than 50 days during the monitoring period.

Comparison of monthly and bi-weekly calibration data of the special maintenance study resulted in a pooled mean delta change of 0.4 mmHg for the monthly sondes and 0.7 mmHg for the bi-weekly sondes. This suggests there would be no degradation of data quality if the maintenance cycles were extended to three weeks during the monitoring season.

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FIGURES

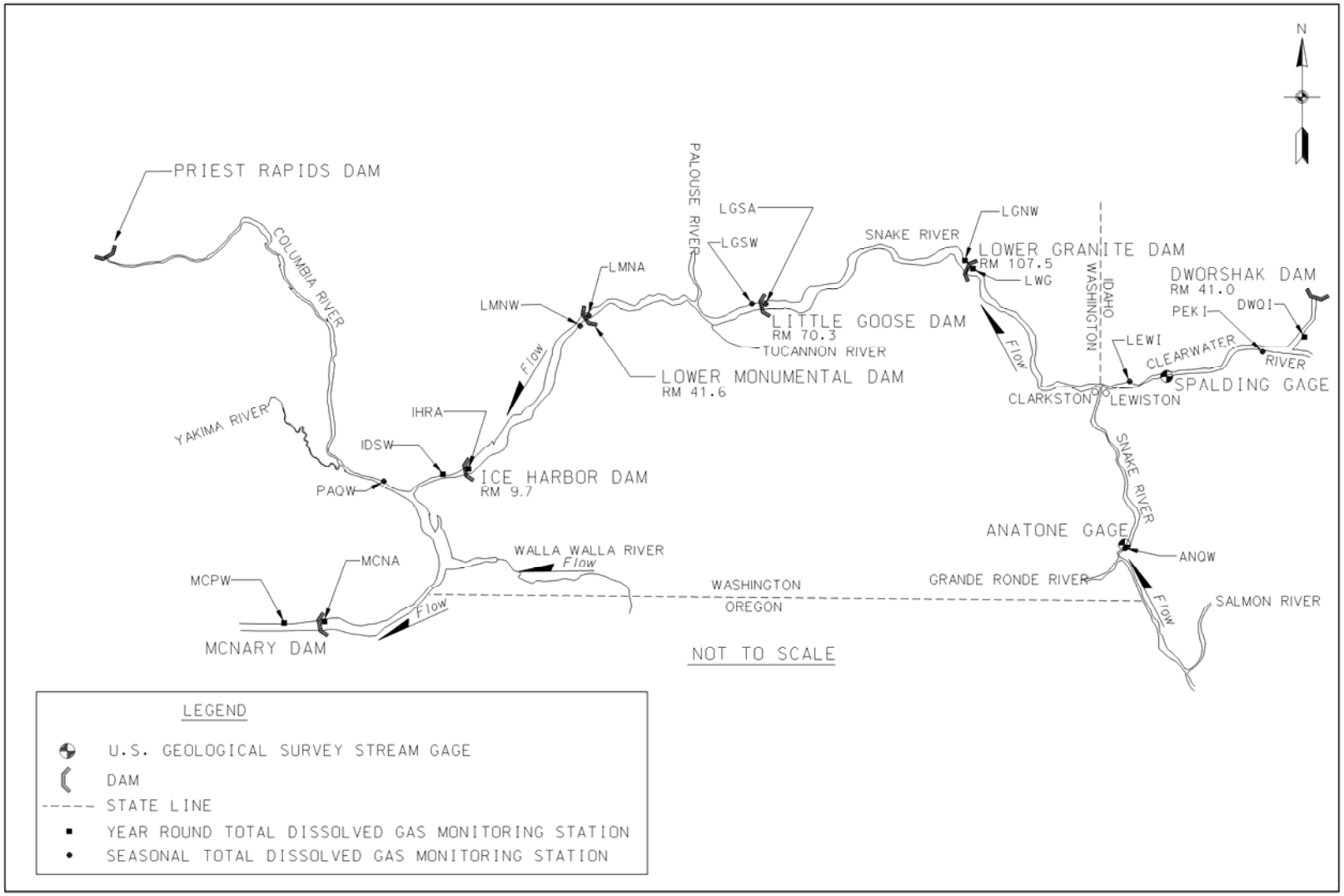


Figure 1. Locations of Walla Walla District's FMS stations.

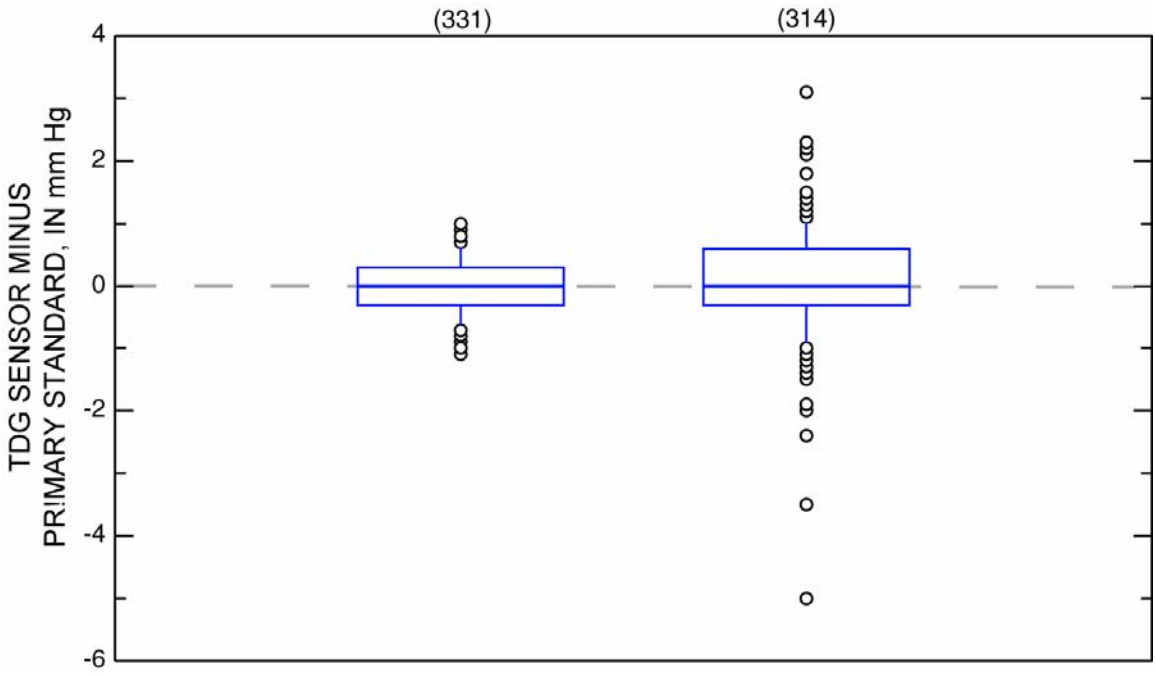


Figure 2. Summary box plots of the pre-and post-deployment check of the Hydrolab® TDG sensors.

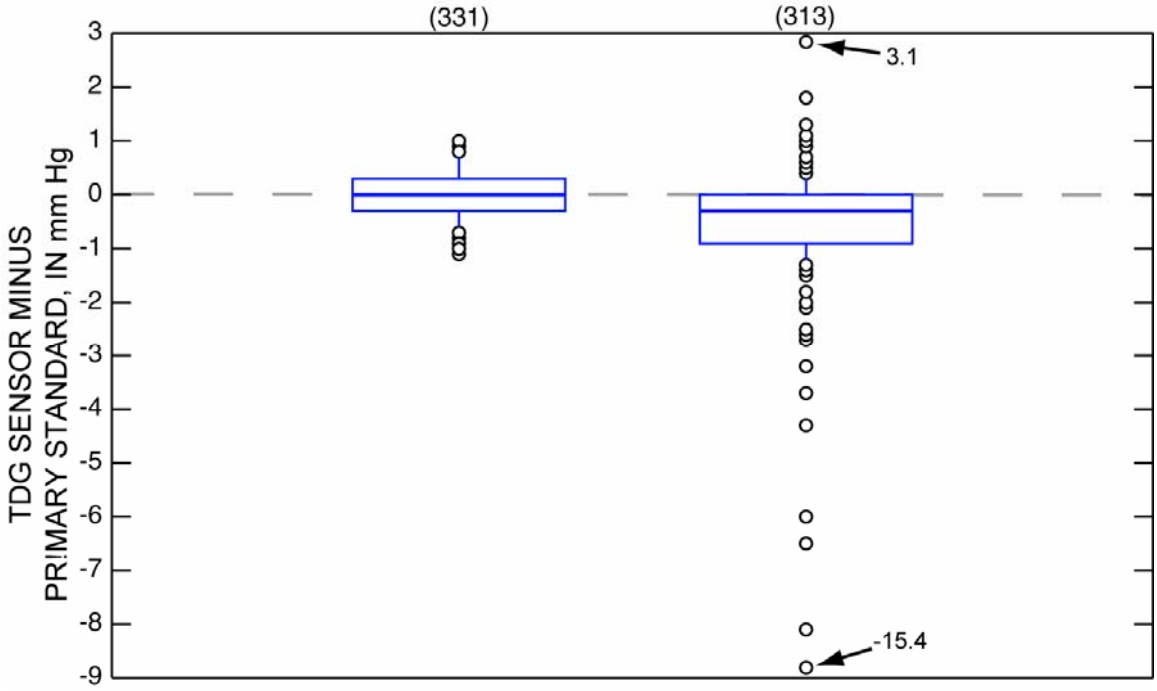


Figure 3. Summary box plots of the pre-and post-deployment check of the Hydrolab® TDG sensors with the addition of 100 and 200 psi.

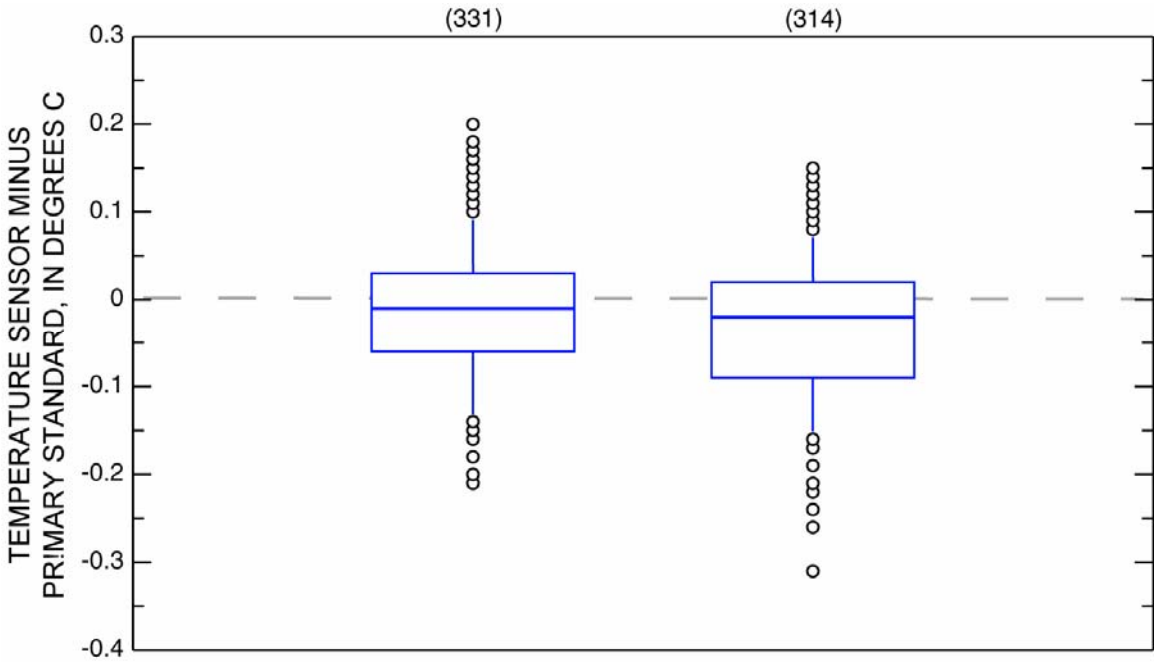


Figure 4. Summary box plots of the pre- and post-deployment check of the Hydrolab® temperature sensors.

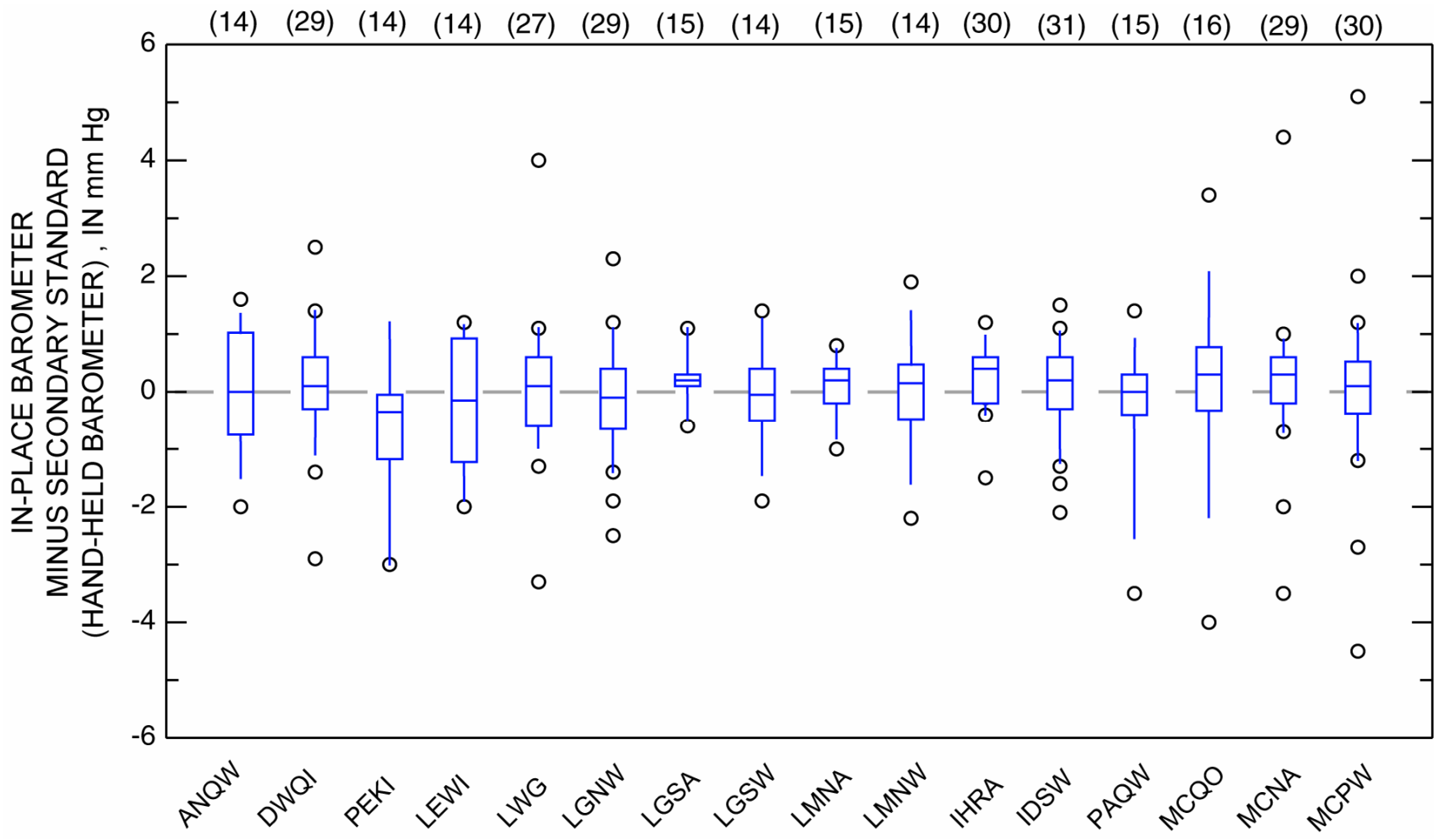


Figure 5. Box plots of the field barometric pressure check by site.

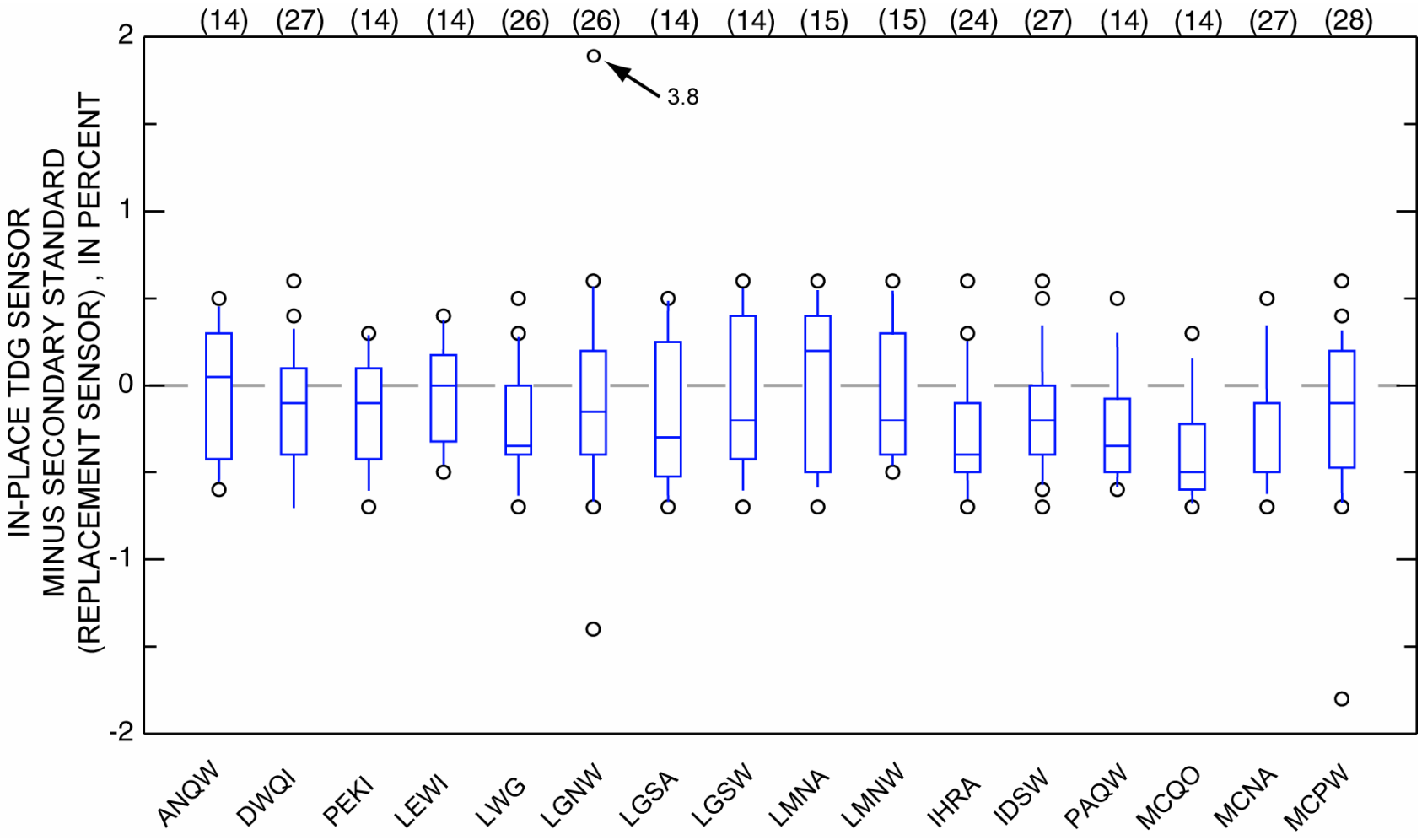
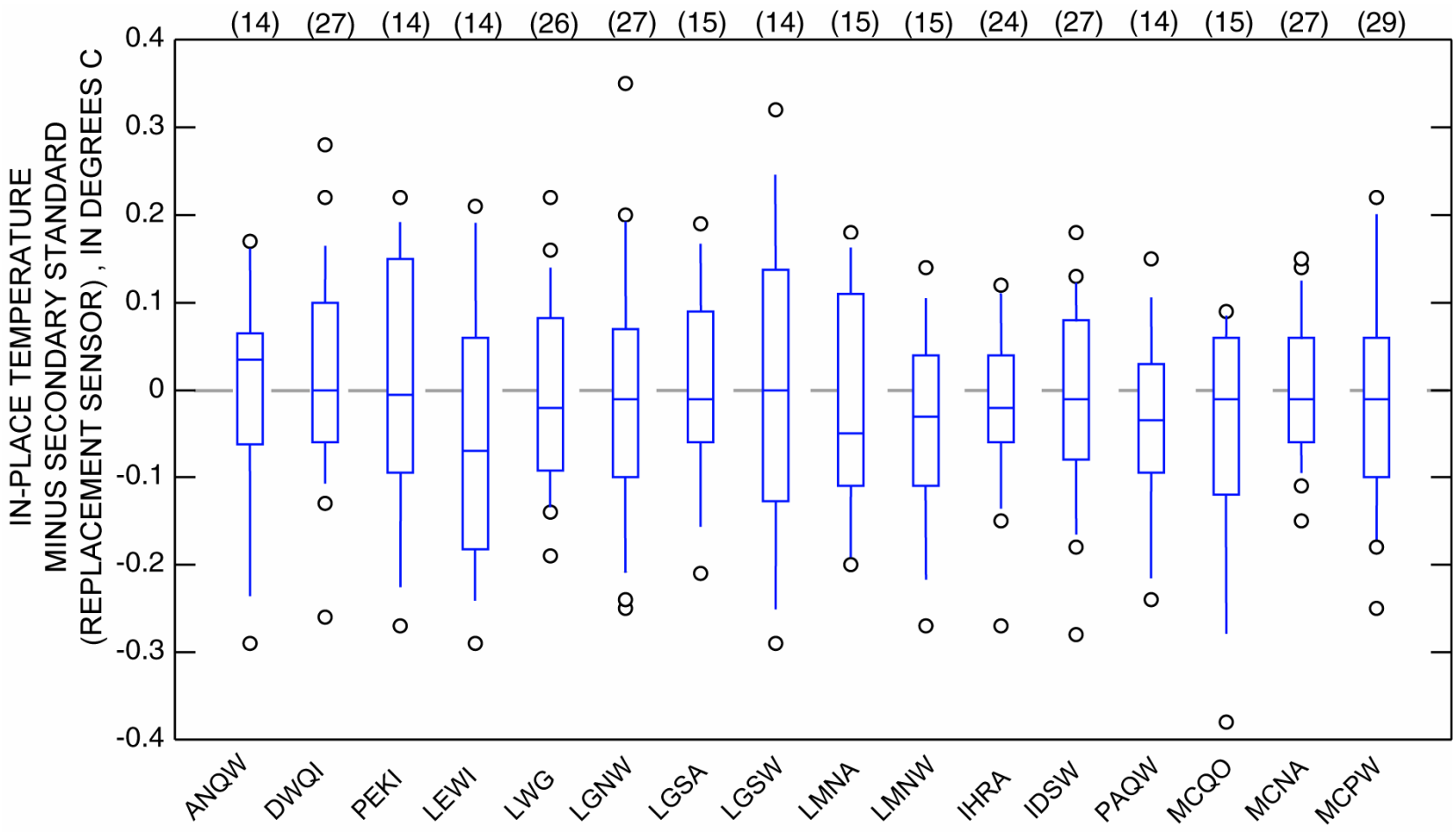


Figure 6. Box plots of the field total dissolved gas sensor check by site.


IN-PLACE TEMPERATURE
MINUS SECONDARY STANDARD
(REPLACEMENT SENSOR) , IN DEGREES C
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
(14)
(27)
(14)
(14)
(26)
(27)
(15)
(14)
(15)
(15)
(24)
(27)
(14)
(15)
(27)
(29)
ANQW
DWQI
PEKI
LEWI
LWG
LGNW
LGSA
LGSW
LMNA
LMNW
IHRA
IDSW
PAQW
MCQO
MCNA
MCPW

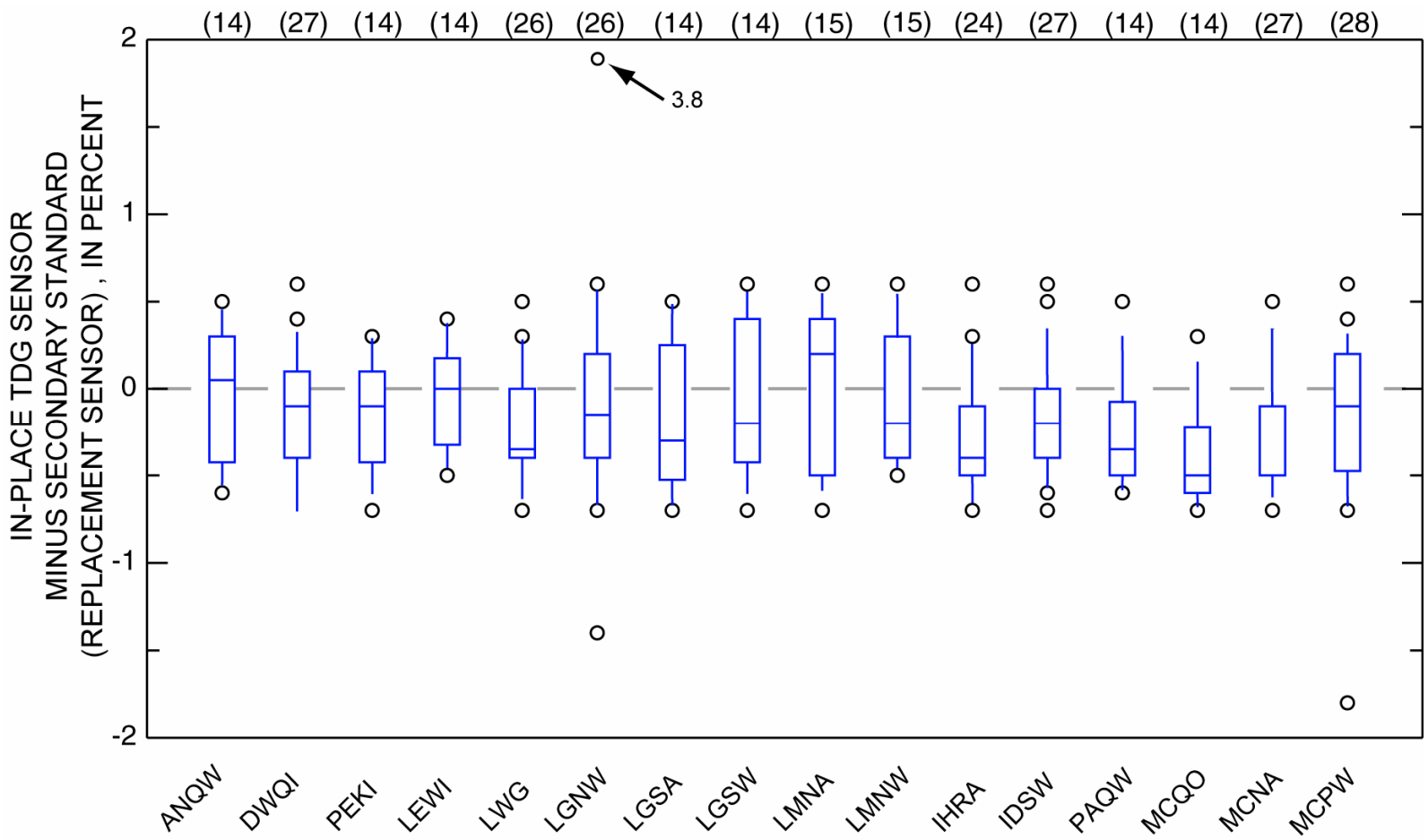


Figure 7. Box plots of the field temperature sensor check by site.

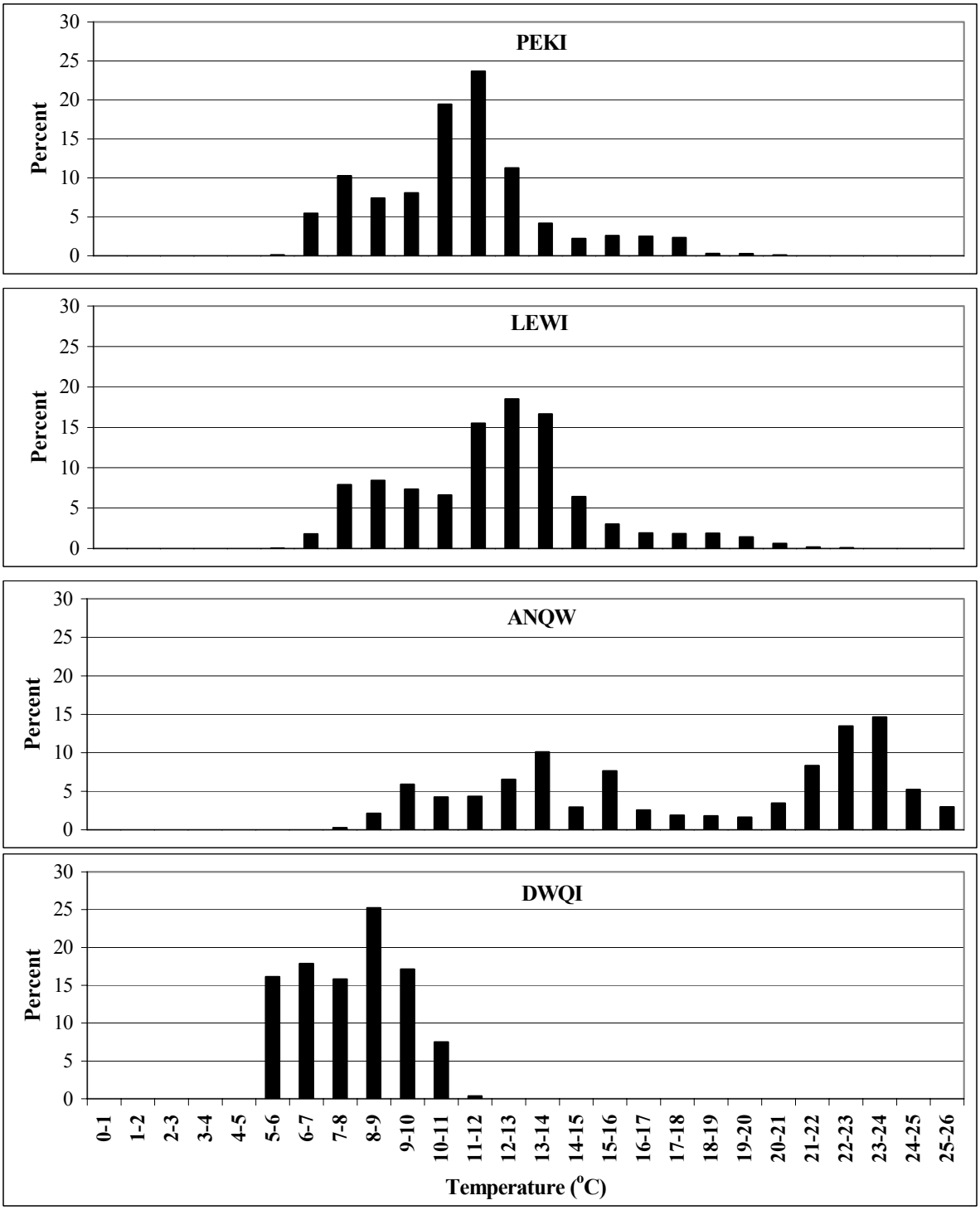


Figure 8. Frequency distributions for the 1 April – 15 September 2006 hourly temperature data recorded at the Dworshak Dam, Peck, Lewiston, Anatone, and Pasco FMS stations.

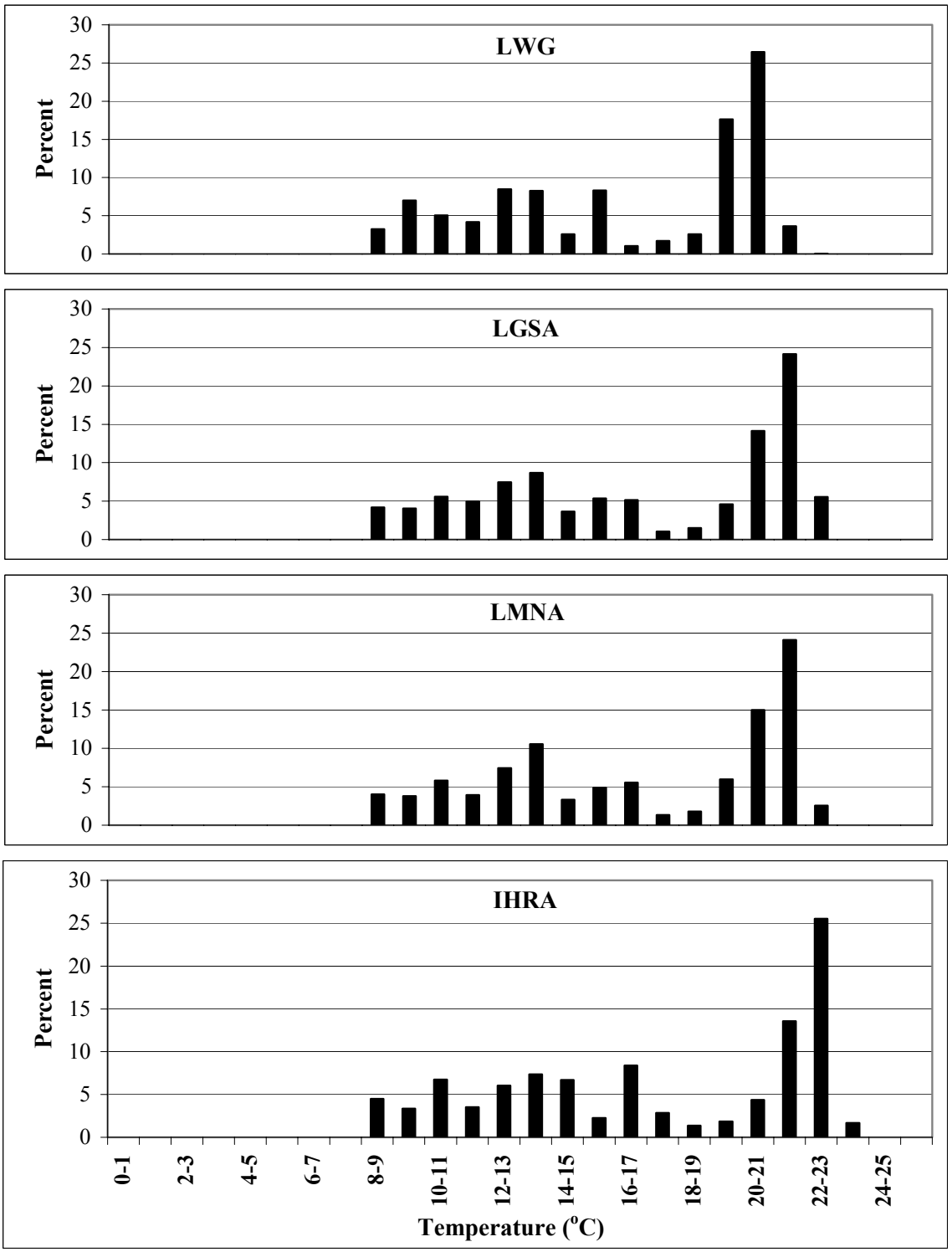


Figure 9. Frequency distributions for the 1 April – 15 September 2006 hourly temperature data recorded at the lower Snake River forebay FMS stations.

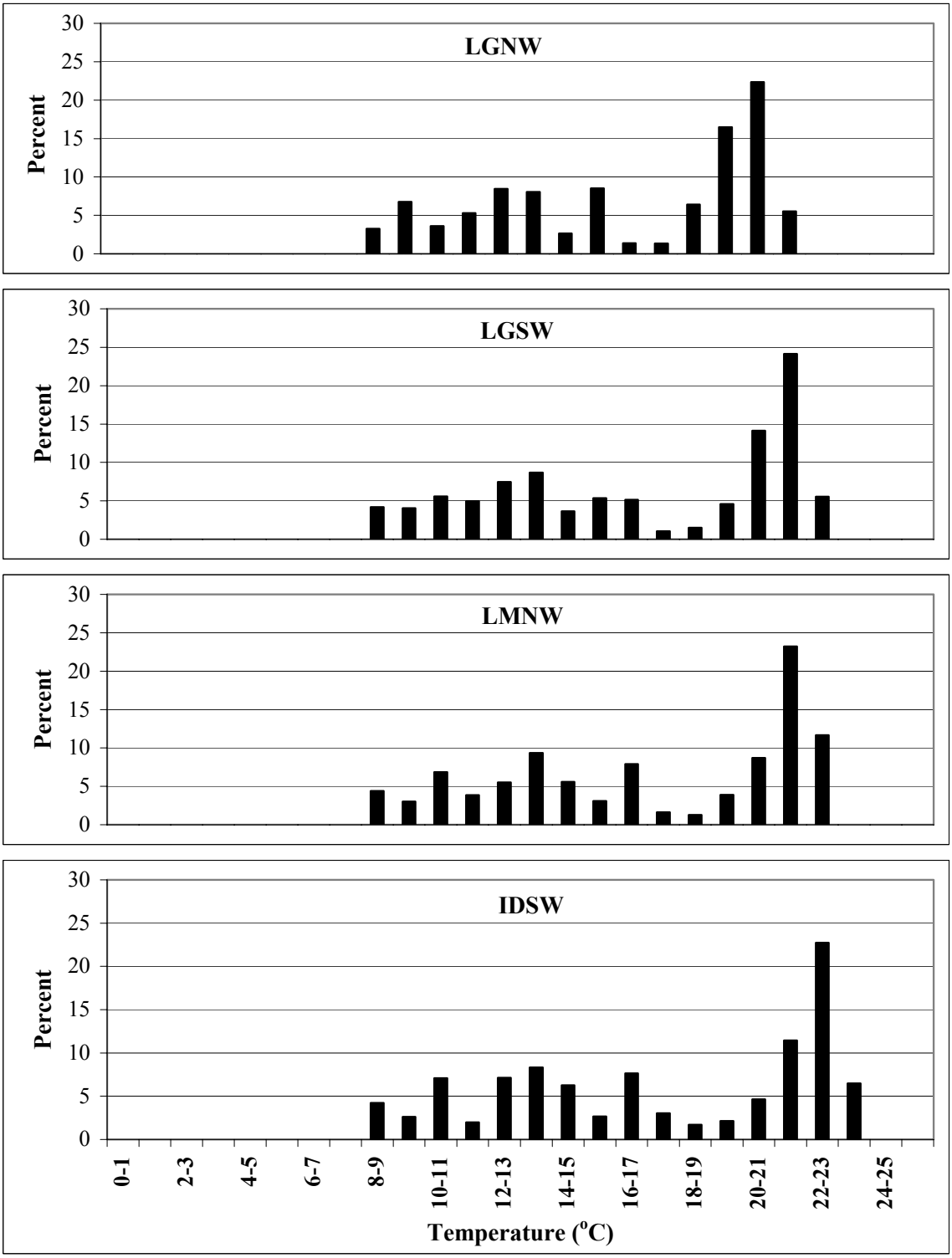


Figure 10. Frequency distributions for the 1 April – 15 September 2006 hourly temperature data recorded at the lower Snake River tailwater FMS stations.

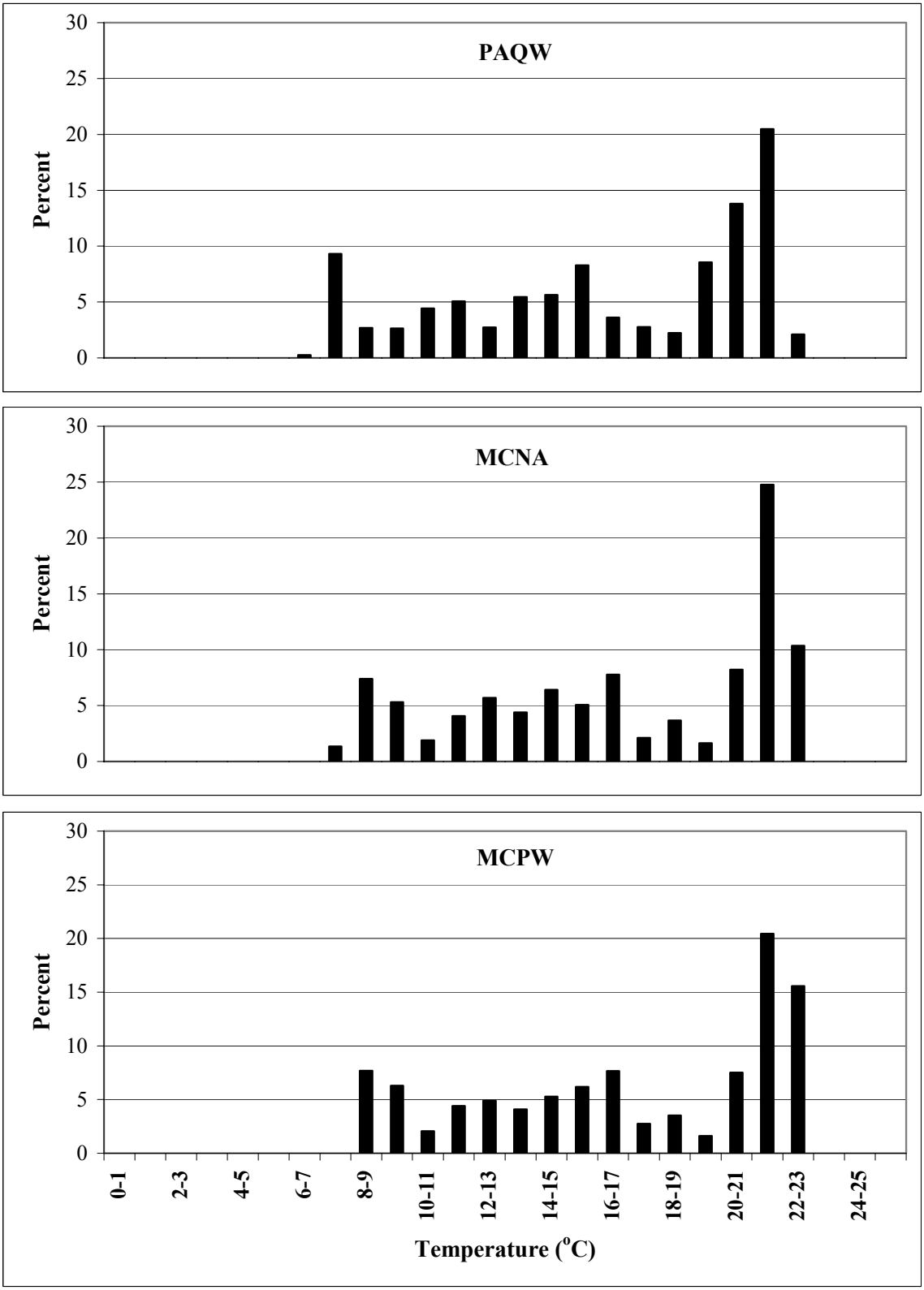

PAQW
MCNA
MCPW
Percent
30
25
20
15
10
5
0
0-1
2-3
4-5
6-7
8-9
10-11
12-13
14-15
16-17
18-19
20-21
22-23
24-25
Temperature (°C)

Figure 11. Frequency distributions for the 1 April – 15 September 2006 hourly temperature data recorded at the McNary Dam FMS stations.

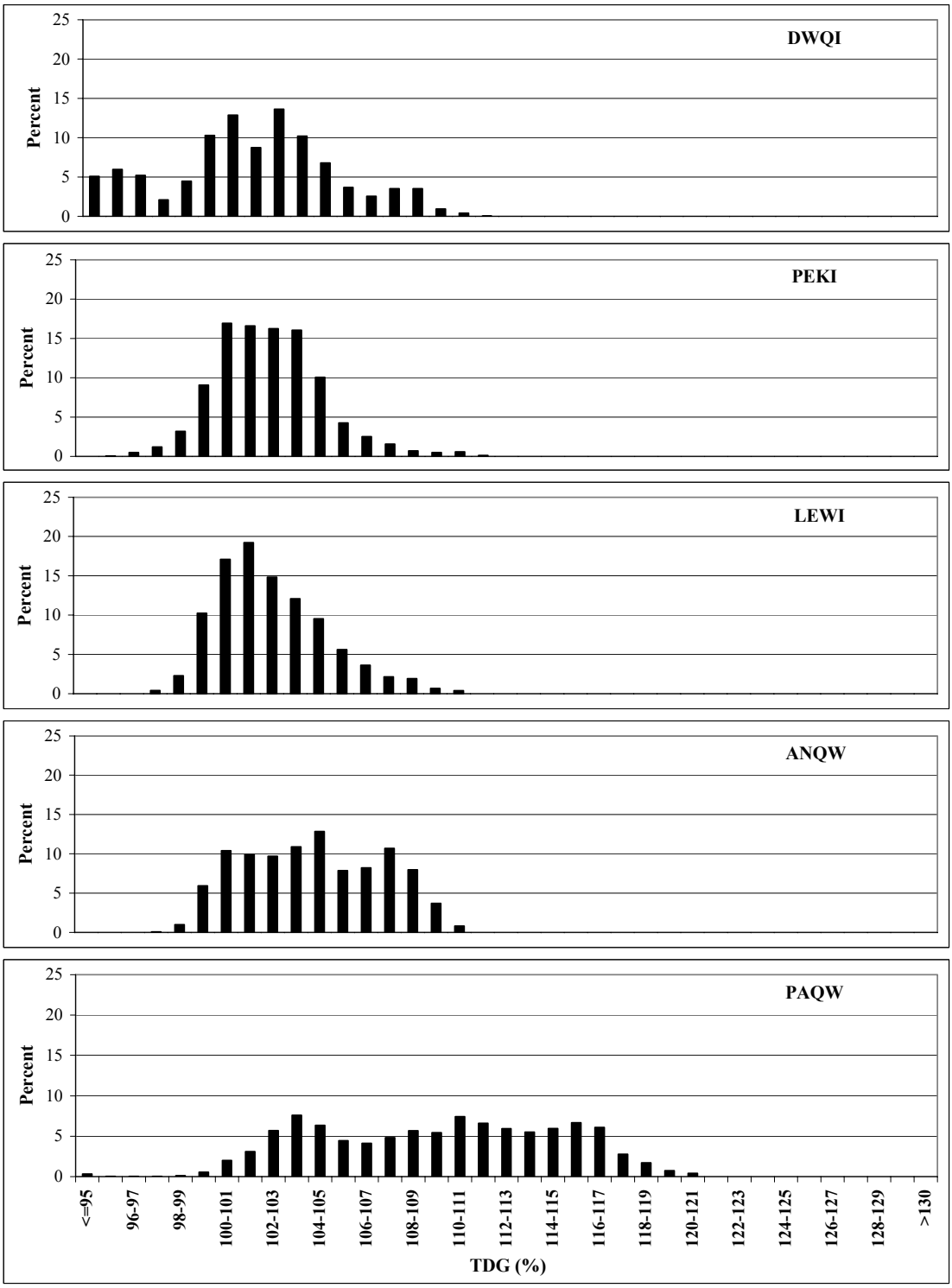


Figure 12. Frequency distributions for the 1 April – 15 September 2006 hourly TDG data recorded below Dworshak Dam, Peck, Lewiston, Anatone, and Pasco FMS stations.

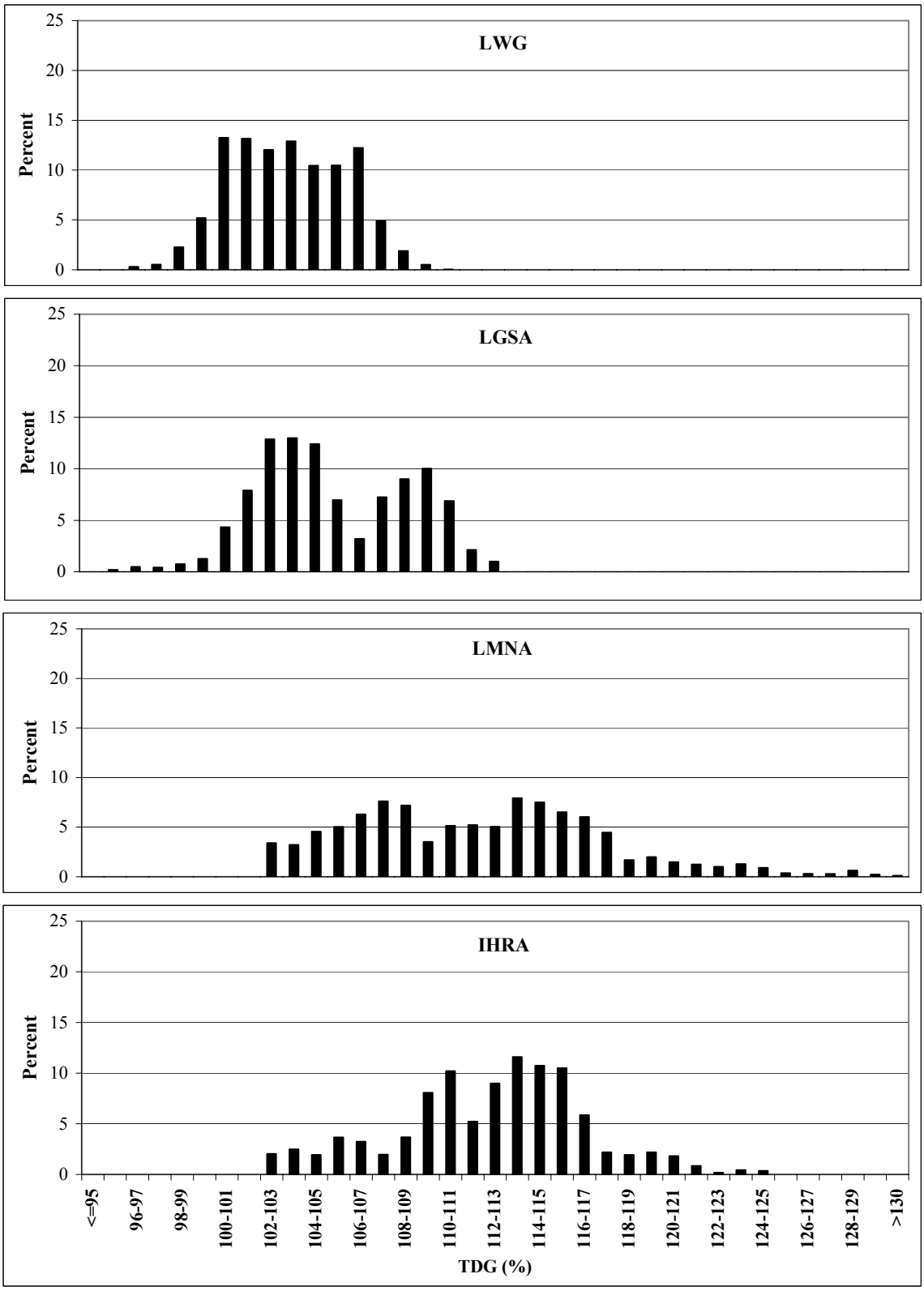


Figure 13. Frequency distributions for the 1 April – 15 September 2006 hourly TDG data recorded at the lower Snake River forebay FMS stations.

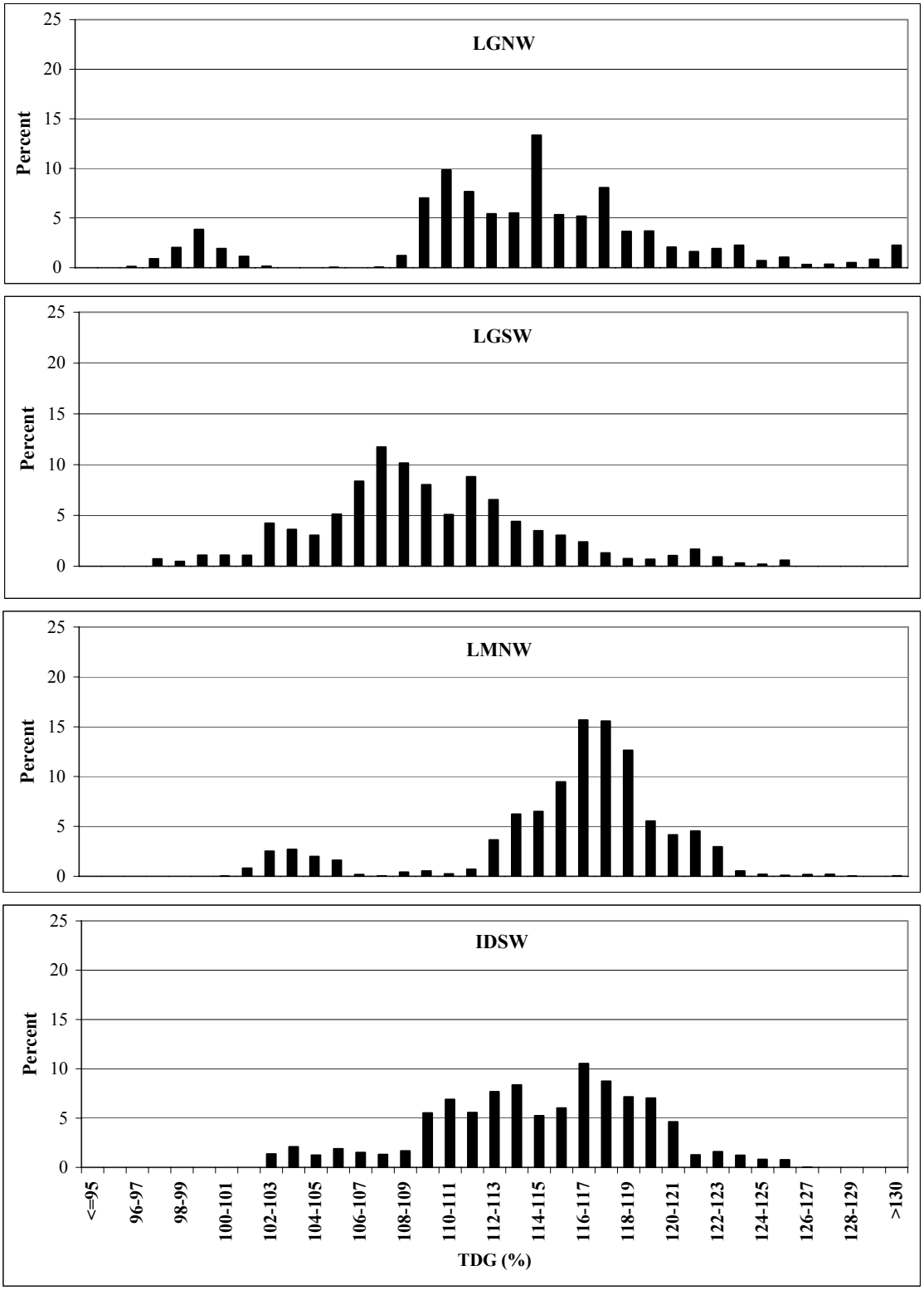


Figure 14. Frequency distributions for the 1 April – 15 September 2006 hourly TDG data recorded at the lower Snake River tailwater FMS stations.

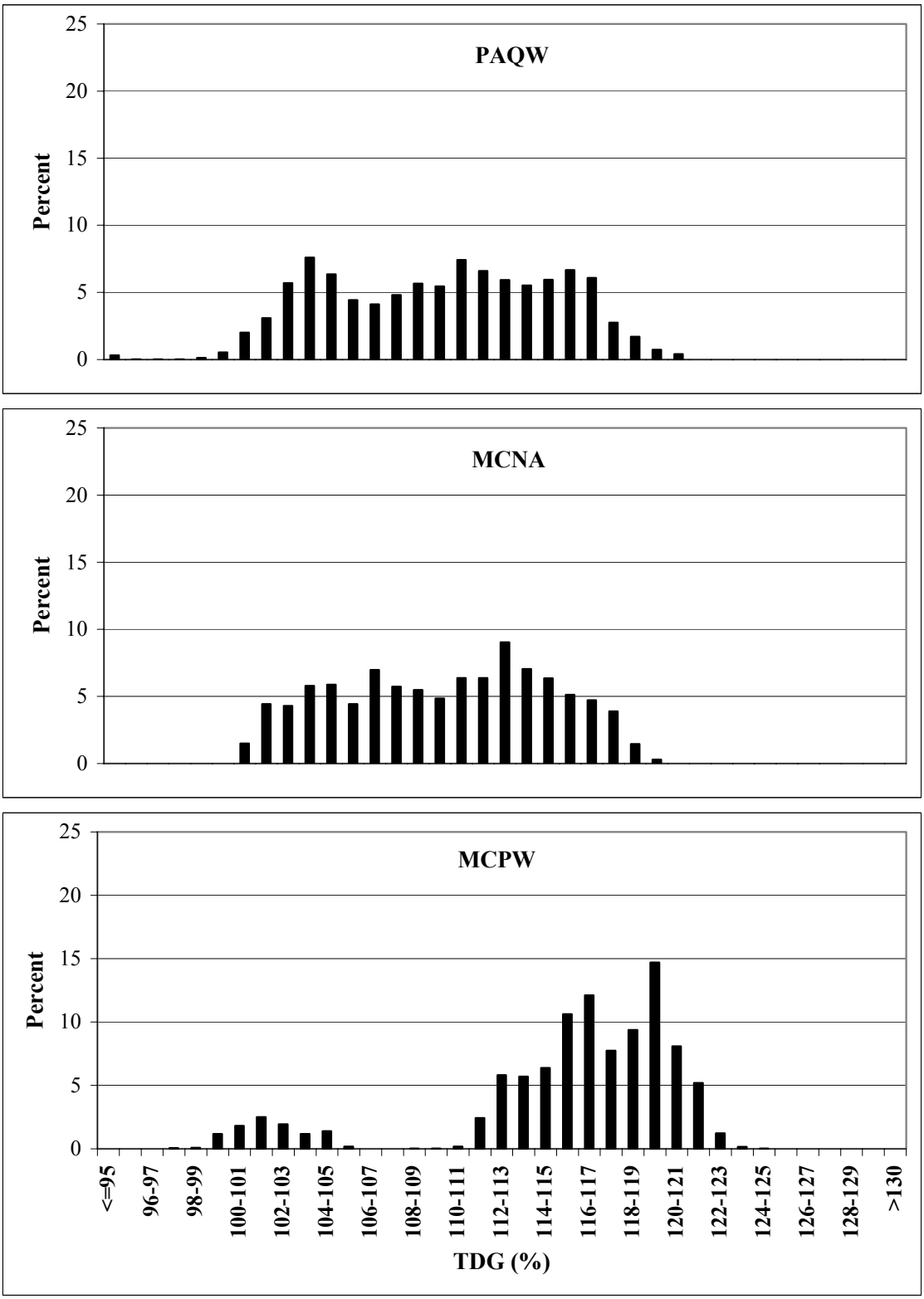
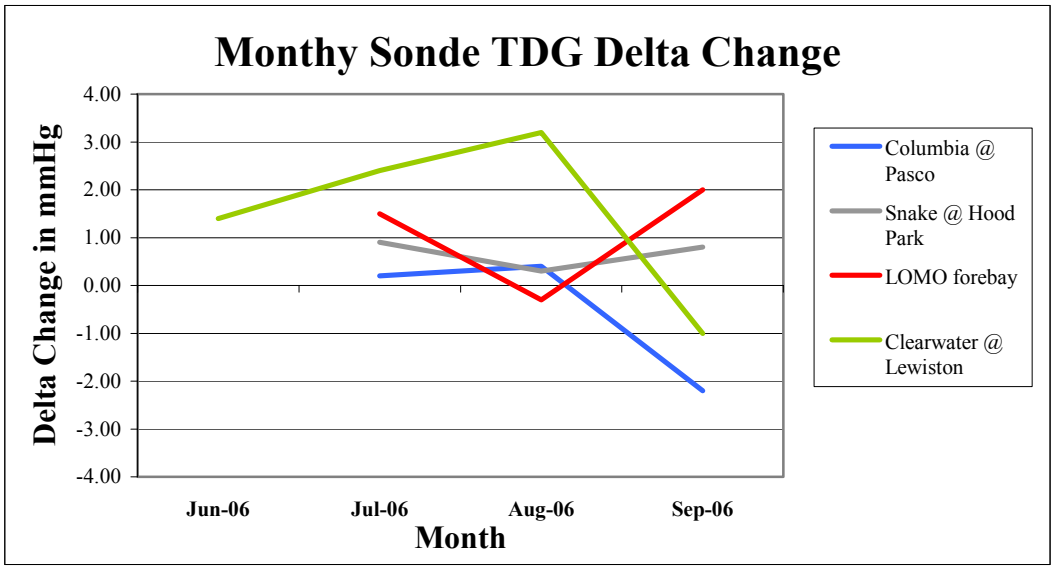


Figure 15. Frequency distributions for the 1 April – 15 September 2006 hourly TDG data recorded at the McNary Dam FMS stations.

Figure 16. Comparison photograph of the monthly sonde (Top) and bi-weekly sonde (Bottom) showing the amount of biological growth accumulated during operational deployment.



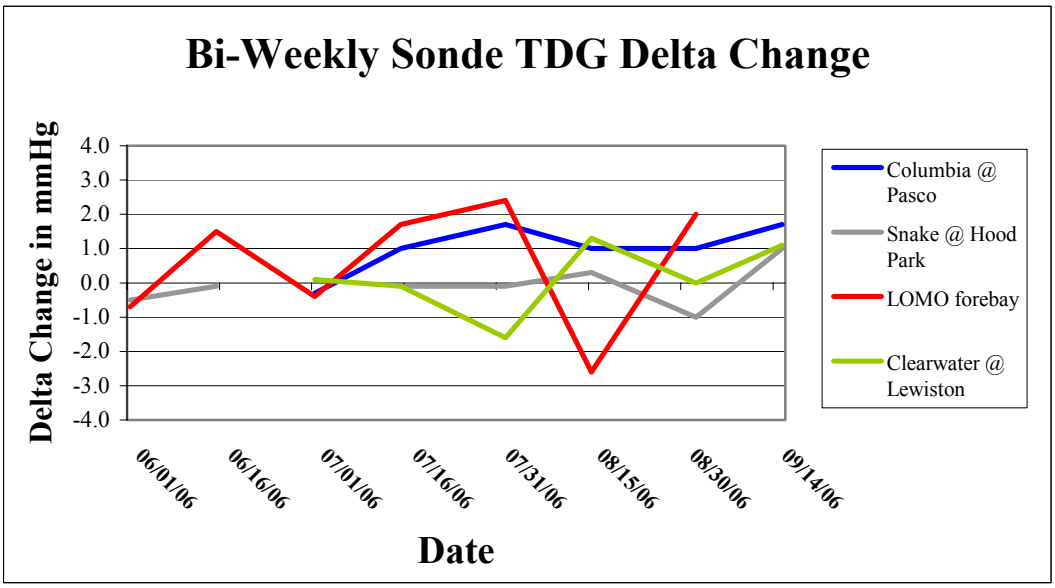


Figure 17. Summary charts comparing monthly and bi-weekly variability in instrument calibration data on the Columbia, Clearwater, and Snake Rivers during the maintenance cycle test.

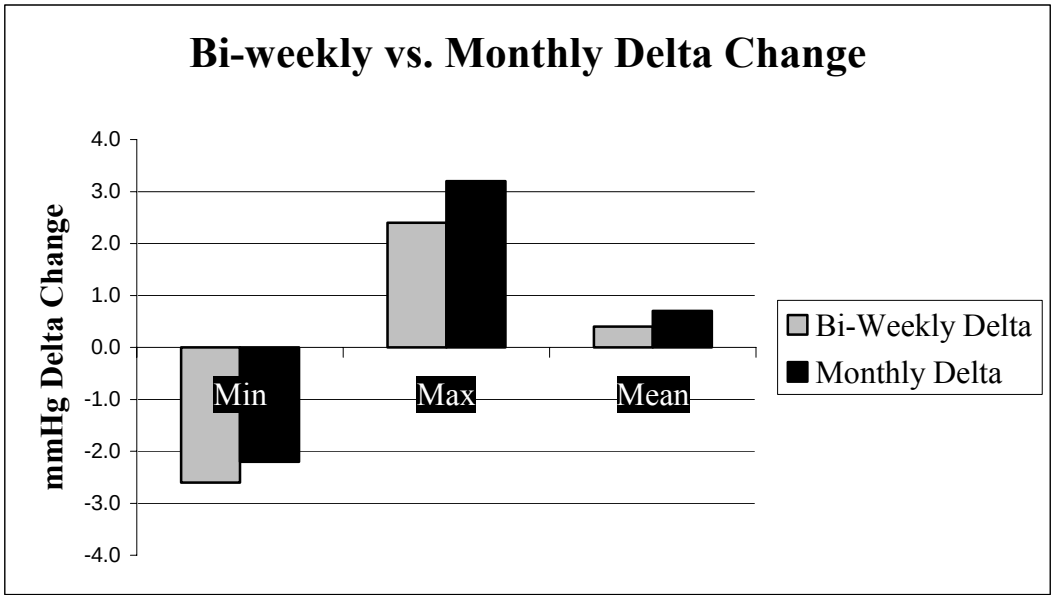


Figure 18. Minimum, Maximum, and Mean comparison between monthly and bi-weekly calibration data for all sites and instruments during the maintenance cycle test.

TABLES

Table 1. FMS station identification and location information.

Station Number	Station Name	Station ID	Latitude (NAD 83)	Longitude (NAD 83)	Elevation (NGVD 29)	River Mile	DCP ID	XMIT Time
12514400	Columbia River at Pasco, WA	PAQW	46 13 26.2851 N	119 06 57.3388 W	345	329.1	17D6E32C	0:27:10
13334300	Snake River Near Anatone, WA	ANQW	46 05 50.7579 N	116 58 41.2382 W	807	167.5	17D63544	0:16:10
13341000	N.F. Clearwater River at Dworshak Hatchery, ID	DWQI	46 30 11.6464 N	116 19 16.4090 W	1,150	0.5	17D600DE	0:13:10
13341050	Clearwater River Near Peck, ID	PEKI	46 30 00.9396 N	116 23 32.4163 W	930	37.4	17D613A8	0:14:10
13343000	Clearwater River Near Lewiston, ID	LEWI	46 25 52.0867 N	116 56 43.9589 W	750	5.0	17D62632	0:15:10
13343590	Lower Granite Dam Forebay, WA	LWG	46 39 34.1727 N	117 25 34.8564 W	738	107.5	17D643D4	0:17:10
13343595	Lower Granite Dam Tailwater, WA	LGNW	46 39 58.0726 N	117 26 19.2595 W	645	106.7	17D650A2	0:18:10
13343855	Little Goose Dam Forebay, WA	LGSA	46 34 58.3188 N	118 01 32.9831 W	638	70.3	17D66538	0:19:10
13343860	Little Goose Dam Tailwater, WA	LGSW	46 35 00.5280 N	118 02 37.4186 W	560	69.6	17D6764E	0:20:10
13352595	Lower Monumental Dam Forebay, WA	LMNA	46 33 44.6559 N	118 32 08.3477 W	540	41.6	17D686CA	0:21:10
13352600	Lower Monumental Dam Tailwater, WA	LMNW	46 33 04.5051 N	118 32 58.9500 W	445	40.4	17D695BC	0:22:10
13352950	Ice Harbor Dam Forebay, WA	IHRA	46 15 05.2792 N	118 52 43.0096 W	440	10.0	17D6A026	0:23:10
13353010	Ice Harbor Dam Tailwater, WA	IDSW	46 14 27.5868 N	118 57 13.7130 W	340	6.1	17D6B350	0:24:10
14019220	McNary Dam Forebay, WA	MCNA	45 56 28.4473 N	119 17 39.5990 W	340	292.0	17D6D6B6	0:26:10
14019240	McNary Dam Tailwater, WA	MCPW	45 56 02.7775 N	119 19 35.4628 W	240	290.7	17D5F754	0:12:10

Table 2. Summary of the laboratory results evaluating the overall differences between laboratory standards and the sondes pre- and post deployment during the 2006 water year.

Deployment	Statistic	Δ (BP) (mm Hg)	Δ [(BP+200)-PT] (%)	Δ [(BP+100)-PT] (%)	Δ T (°C)
Pre	Number	321	321	----	321
	Minimum	-1.10	-0.10	----	-0.21
	25 percentile	-0.30	-0.04	----	-0.06
	Median	0.00	0.00	----	-0.01
	75 percentile	0.30	0.04	----	0.03
	Maximum	1.00	0.10	----	0.20
	Mean	0.01	0.00	----	-0.01
Post	Number	312	----	312	312
	Minimum	-5.00	----	-0.90	-0.31
	25 percentile	-0.60	----	-0.06	-0.09
	Median	0.00	----	-0.01	-0.02
	75 percentile	0.25	----	0.03	0.02
	Maximum	3.10	----	0.40	0.15
	Mean	0.06	----	-0.03	-0.03

Table 3. Pre-deployment quality assurance data for the individual sondes utilized at the FMS stations during the 2006 water year.

Sonde ID	Δ (BP – PT) # Obs	Δ (BP – PT) Range (mm Hg)	Δ (BP – PT) Median (mm Hg)	Δ [(BP+200) – PT] # Obs	Δ [(BP+200) – PT] Range (mm Hg)	Δ [(BP+200) – PT] Median (mm Hg)	Δ (Water Temperature) # Obs	Δ (Water Temperature) Range (°C)	Δ (Water Temperature) Median (°C)
1	10	-0.60 to 0.10	-0.26	10	-0.60 to 0.10	-0.26	10	0.10 to 0.16	0.12
3	11	-0.40 to 1.0	0.20	11	-0.40 to 0.90	0.11	11	-0.13 to -0.07	-0.10
4	2	0.10 to 0.30	0.20	2	0.10 to 0.30	0.20	2	-0.13 to -0.10	-0.12
5	10	-0.50 to 0.20	-0.12	10	-0.50 to 0.20	-0.12	10	-0.02 to 0.06	0.00
6	9	-0.50 to 0.70	0.09	9	-0.50 to 1.0	0.20	9	-0.04 to 0.04	-0.02
7	6	-0.50 to 0.40	-0.03	6	-0.50 to 0.40	-0.03	6	-0.05 to 0.04	-0.02
8	7	-0.30 to 1.00	0.29	7	-0.30 to 1.00	0.29	7	-0.14 to -0.06	-0.11
10	9	-1.00 to 0.40	-0.19	9	-1.00 to 0.40	-0.19	9	-0.04 to 0.11	-0.01
11	11	0.00 to 0.90	0.45	11	0.00 to 0.90	0.45	11	-0.16 to -0.06	-0.14
12	1	-0.30	-0.30	1	-0.30	-0.30	1	0.09	0.09
13	3	0.00 to 0.10	0.03	3	0.00 to 0.10	0.03	3	0.10 to 0.12	0.11
14	5	-0.10 to 0.80	0.20	5	-0.10 to 0.80	0.20	5	-0.08 to -0.04	-0.07
15	8	0.10 to 1.00	0.39	8	0.00 to 0.60	0.26	8	-0.11 to 0.00	-0.08
16	10	-0.10 to 1.00	0.48	10	-0.10 to 1.00	0.48	10	-0.14 to 0.02	-0.10
17	2	-0.50 to -0.30	-0.40	2	-0.50 to -0.30	-0.40	2	-0.08 to -0.06	-0.07
18	7	-0.10 to 0.40	0.11	7	-0.10 to 0.40	0.11	7	-0.04 to 0.03	-0.02
19	8	-0.60 to 0.40	-0.16	8	-0.60 to 0.80	-0.04	8	-0.10 to 0.00	-0.03
20	11	-0.10 to 0.90	0.40	11	-0.10 to 0.90	0.40	11	-0.10 to -0.04	-0.07
21	7	0.00 to 1.00	0.44	7	0.00 to 1.00	0.44	7	-0.16 to -0.01	-0.12
23	11	-0.70 to 0.20	-0.18	11	-1.00 to 0.20	-0.27	11	0.00 to 0.09	0.03
25	9	-0.40 to 0.90	0.27	9	-0.40 to 0.80	0.16	9	-0.14 to 0.00	-0.06
26	7	-0.10 to 0.80	0.17	7	-1.00 to 0.80	0.03	7	-0.21 to -0.18	-0.20
27	11	-1.00 to 0.90	-0.07	11	-1.00 to -0.07	-0.07	11	-0.05 to 0.07	0.00
28	3	0.10 to 0.40	0.23	3	0.10 to 0.40	0.23	3	-0.16 to -0.14	-0.15
29	5	0.00 to 0.50	0.24	5	-0.50 to 1.00	0.24	5	0.00 to 0.03	0.00
30	11	-0.60 to 0.60	-0.15	11	-0.60 to 1.00	-0.05	11	-0.06 to 0.03	-0.02
31	9	-0.60 to 1.00	0.12	9	-0.60 to 1.00	0.12	9	-0.02 to 0.05	0.00
32	11	-1.00 to 0.30	-0.31	11	-0.70 to 0.30	-0.22	11	0.05 to 0.11	-0.01
33	5	-1.00 to 1.00	0.04	5	-1.00 to 1.00	0.04	5	-0.02 to 0.02	-0.01
34	9	-0.90 to 0.70	-0.09	9	-0.90 to 1.00	0.02	9	-0.03 to 0.07	0.01
35	10	-1.00 to 0.40	-0.24	10	-0.80 to 0.40	-0.14	10	0.02 to 0.18	0.08
37	9	-0.50 to 1.00	0.07	9	-0.50 to 1.00	0.07	9	0.00 to 0.11	0.05
38	2	0.10 to 0.80	0.45	2	0.10 to 0.80	0.45	2	-0.13 to 0,04	-0.04
39	9	-0.70 to 0.10	-0.23	9	-1.00 to 0.10	-0.34	9	-0.01 to 0.14	0.02
40	10	-0.70 to 0.50	-0.15	10	-1.00 to 0.50	-0.25	10	0.01 to 0.11	0.04
41	11	-0.40 to 0.80	0.08	11	-0.40 to 0.80	0.08	11	-0.04 to 0.08	0.01
50	2	-0.40 to -0.20	-0.30	2	-0.40 t -0.20	-0.30	2	0.08 to 0.11	0.10
USGS 1	11	-1.10 to 0.50	-0.37	11	-1.10 to 0.50	-0.28	11	0.00 to 0.17	0.04
USGS 2	8	-0.10 to 0.60	0.30	8	-0.10 to 0.60	0.30	8	-0.02 to 0.06	0.02
USGS 3	9	-0.80 to 0.00	-0.43	9	-0.80 to 0.00	-0.43	9	0.02 to 0.20	0.06
USGS 4	11	-1.00 to 0.60	-0.44	11	-1.00 to 1.00	-0.16	11	0.07 to 0.14	0.09

Table 3. Pre-deployment quality assurance data for the individual sondes utilized at the FMS stations during the 2006 water year (continued).

Sonde ID	Δ (BP – PT) # Obs	Δ (BP – PT) Range (mm Hg)	Δ (BP – PT) Median (mm Hg)	Δ [(BP+200) – PT] # Obs	Δ [(BP+200) – PT] Range (mm Hg)	Δ [(BP+200) – PT] Median (mm Hg)	Δ (Water Temperature) # Obs	Δ (Water Temperature) Range (°C)	Δ (Water Temperature) Median (°C)
USGS 5	10	-0.70 to 0.30	-0.09	10	-0.70 to 0.30	-0.09	10	-0.06 to 0.15	0.04
32393	1	-0.40	-0.40	1	-0.40	-0.40	1	-0.04	-0.04

Table 4. Post-deployment quality assurance data for the individual sondes utilized at the FMS stations during the 2006 water year.

Sonde ID	Δ (BP – PT) # Obs	Range (mm Hg)	Median (mm Hg)	Δ [(BP+100) – PT] # Obs	Range (mm Hg)	Median (mm Hg)	Δ (Water Temperature) # Obs	Range (°C)	Median (°C)
1	10	-1.00 to 1.50	0.07	10	-1.00 to 0.40	-0.33	10	0.10 to 0.15	0.12
3	10	-0.50 to 0.90	0.09	10	-1.40 to 0.10	-0.31	10	-0.15 to 0.05	-0.11
4	1	0.80	0.80	1	-0.20	-0.02	1	-0.13	-0.13
5	10	-0.80 to 1.00	-0.75	10	-1.20 to 0.00	-0.75	10	-0.09 to 0.00	-0.03
6	8	-0.20 to 1.00	0.35	8	-0.80 to 0.20	-0.15	8	-0.04 to -0.03	-0.04
7	4	-0.50 to 0.30	-0.05	4	-0.80 to -0.50	-0.68	8	-0.07 to -0.05	-0.06
8	7	-0.90 to 1.00	0.14	7	-1.00 to 0.00	-0.71	7	-0.16 to -0.09	-0.13
10	10	-1.10 to 0.70	-0.20	10	-1.50 to 1.00	-0.30	10	-0.05 to 0.07	-0.03
11	11	-0.10 to 1.10	0.59	11	-1.00 to 0.70	-0.05	11	-0.19 to -0.14	-0.16
12	2	-3.00 to 1.40	-0.80	2	-8.00 t 0.40	-3.80	2	0.05 to 0.06	0.06
13	3	-0.30 to 1.00	0.23	3	-1.30 to 0.00	-0.43	3	0.09 to 0.10	0.09
14	5	-0.10 to 1.00	0.46	5	-0.30 to 0.00	-0.14	5	-0.09 to -0.07	-0.08
15	7	-1.20 to 2.10	0.63	7	-1.30 to 1.10	-0.51	7	-0.13 to -0.11	-0.11
16	10	-0.10 to 1.30	0.45	10	-0.40 to 1.30	0.25	10	-0.16 to -0.07	-0.12
17	3	-0.40 to 0.30	0.03	3	-1.40 to -0.70	-0.97	3	-0.10 to -0.07	-0.09
18	5	0.00 to 1.30	0.72	5	-0.20 to 0.30	0.12	5	-0.04 to -0.03	-0.04
19	8	-5.00 to 3.10	-0.15	8	-6.00 to 3.10	-0.78	8	-0.10 to -0.01	-0.03
20	10	-0.20 to 0.90	0.39	10	-0.60 to 0.70	-0.11	10	-0.12 to -0.07	-0.09
21	6	-0.10 to 1.10	0.58	6	-0.90 to -0.10	-0.42	6	-0.17 to -0.13	-0.16
23	10	-1.90 to 0.70	-0.26	10	-4.30 to 0.10	-0.96	10	-0.05 to 0.02	0.00
25	9	-1.40 to 1.20	0.09	9	-8.10 to 0.20	-1.58	9	-0.16 to -0.12	-0.15
26	6	-0.90 to 1.50	0.45	6	-3.70 to 0.10	-0.72	6	-0.31 to 0.06	-0.20
27	11	-0.60 to 1.00	0.22	11	-1.30 to 1.00	-0.69	11	-0.09 to 0.00	-0.05
28	4	0.00 to 1.40	0.65	4	-0.60 to 1.00	0.15	4	-0.15 to -0.12	-0.13
29	4	0.00 to 0.60	0.28	4	-0.40 to 0.40	0.03	4	0.00 to 0.02	0.01
30	11	-1.00 to 2.20	-0.06	11	-6.50 to 0.20	-0.97	1	-0.1o to -0.06	-0.08
31	10	-0.50 to 1.10	0.34	10	-0.90 to 0.10	-0.26	10	-0.03 to 0.00	-0.01
32	11	-1.40 to 0.60	-0.25	11	-1.40 to 0.00	-0.53	11	-0.07 to 0.09	-0.02
33	5	-1.50 to 1.00	-0.26	5	-1.50 to 0.90	-0.66	5	-0.02 to 0.02	0.00
34	9	-3.50 to 1.20	-0.50	9	-2.50 to 0.50	-0.72	9	-0.05 to 0.07	-0.01
35	10	-1.00 to 0.90	-0.45	10	-1.00 to 0.00	-0.45	10	-0.01 to 0.15	0.06
37	10	-2.00 to 0.50	-0.34	10	-2.00 to 4.30	-0.04	10	-0.08 to 0.05	0.02
38	1	0.00	0.00	1	0.00	0.00	1	-0.15	-0.15
39	10	-1.00 to 0.80	-0.44	10	-1.10 to 0.00	-0.44	10	-0.01 to 0.12	0.03
40	10	-2.40 to 1.00	-0.04	10	-1.40 to 1.00	-0.24	10	-0.13 to 0.15	0.02
41	11	-0.70 to 1.20	0.21	11	-0.80 to 1.00	0.03	11	-0.03 to 0.04	0.00
50	1	0.50	0.50	1	-0.50	-0.50	1	0.09	0.09
USGS 1	9	-1.30 to 0.50	-0.48	9	-1.3 to 0.50	-0.70	9	0.00 to 0.07	0.03
USGS 2	8	-0.10 to 1.10	0.58	8	-15.40 to 0.20	-2.05	8	-0.03 to 0.06	0.00
USGS 3	9	-1.10 to 0.40	-0.31	9	-3.20 to 0.40	-0.87	9	0.01 to 0.05	0.04
USGS 4	11	-1.20 to 2.30	-0.10	11	-2.70 to 2.30	-0.10	11	0.07 to 0.14	0.08

Table 4. Post-deployment quality assurance data for the individual sondes utilized at the FMS stations during the 2006 water year (continued).

Sonde ID	Δ (BP – PT) # Obs	Range (mm Hg)	Median (mm Hg)	Δ [(BP+100) – PT] # Obs	Range (mm Hg)	Median (mm Hg)	Δ (Water Temperature) # Obs	Range (°C)	Median (°C)
USGS 5	10	-1.00 to 0.40	-0.05	10	-1.00 to 0.40	-0.45	10	0.00 to 0.04	0.02
32393	1	-0.40	-0.40	1	-0.40	-0.40	1	-0.04	-0.04

Table 5. Summary of the field results for the differences between the in-place and replacement sondes during 2006 water year.

Statistic	Δ BP **(mm Hg)**	Δ TDG (mm Hg)	Δ TDG (% Sat)	Δ T (^{o}C)
Number	336	313	312	317
Minimum	5.1	33.0	4.4%	0.35
Maximum	-4.50	-14.0	-1.9%	-0.38
Mean	0.04	-1.20	-0.2%	-0.01
Median	0.10	-2.00	-0.3%	-0.01

Table 6. Summary of the field results for the differences between the in-place and replacement sondes by station during 2006 water year.

	Δ Barometric Air Pressure			Δ Total Dissolved Gas					Δ Water Temperature		
Station ID	**# Obs**	**Range (mm Hg)**	**Median (mm Hg)**	**# Obs**	**Range (mm Hg)**	**Median (mm Hg)**	**Range (% Sat)**	**Median (% Sat)**	**# Obs**	**Range (°C)**	**Median (°C)**
MCPW	30	5.1 to -4.5	0.1	28	5.0 to -14.0	-1.0	0.6 to -1.8	-0.1	29	0.22 to -0.25	-0.01
MCNA	29	4.4 to -3.5	0.3	27	4.0 to -5.0	-4.0	0.5 to -0.7	-0.5	27	0.15 to -0.15	-0.01
PAQW	15	1.4 to -3.5	0.0	14	4.0 to -5.0	-3.0	0.5 to -0.6	-0.3	14	0.15 to -0.24	-0.04
IDSW	31	1.5 to -2.1	0.2	27	5.0 to -5.0	-1.5	0.6 to -0.7	-0.2	27	0.18 to -0.28	-0.01
IHRA	30	1.2 to -1.5	0.4	24	5.0 to -5.0	-3.0	0.6 to -0.7	-0.4	24	0.12 to -0.15	-0.01
LMNW	14	1.9 to -2.2	0.15	15	5.0 to -4.0	-2.0	0.6 to -0.5	-0.2	15	0.14 to -0.27	-0.03
LMNA	15	0.8 to -1.0	0.2	15	5.0 to -5.0	2.0	0.6 to -0.7	0.2	15	0.18 to -0.20	-0.05
LGSW	14	1.4 to -1.9	-0.05	14	5.0 to -6.0	-2.0	0.6 to -0.7	-0.2	14	0.32 to -0.29	0.00
LGSA	15	1.1 to -0.6	0.2	15	4.0 to -5.0	-2.5	0.5 to -0.7	-0.3	15	0.19 to -0.21	-0.01
LGNW	29	2.3 to -2.5	0.0	26	33.0 to -10.0	-1.0	3.8 to -1.4	-0.1	27	0.35 to -0.25	-0.01
LWG	27	4.0 to -3.3	0.1	26	4.0 to -5.0	-2.5	0.5 to -0.7	-0.3	26	0.22 to -0.19	-0.02
ANQW	14	1.6 to -2.0	0.0	14	4.0 to -5.0	0.5	0.5 to -0.6	0.1	14	0.17 to -0.29	0.04
LEWI	14	1.2 to -2.0	-0.15	14	3.0 to -4.0	0.0	0.4 to -0.5	0.0	14	0.21 to -0.29	-0.07
PEKI	14	1.2 to -3.0	-0.35	14	2.0 to -5.0	-1.0	0.3 to -0.7	-0.1	14	0.22 to -0.27	0.00
DWQI	29	2.5 to -2.9	0.10	27	4.0 to -5.0	-1.0	0.6 to -0.7	-0.1	27	0.28 to -0.26	0.00

Table 7. Summary of the total hours of barometric pressure, total dissolved gas, and temperature data that were missing or considered invalid in the 2006 water-year data set.

Hours	Percent	Reason
227	0.23 %	Defective sonde
232	0.24 %	Missed transmission (After data reconstruction)
95	0.10 %	Defective membrane
23	0.02 %	Routine maintenance
480	0.49 %	DCP failure
557	0.57 %	Too Low value
119	0.12 %	Missing Data
68	0.07 %	Spike

Table 8. Number and percent of all missing or invalid data points for each FMS station during the 2006 water year, along with the reasons for those designations.

Station ID	Cable Failure		Missed Transmission		Too Low Value		Spike		Routine Maintenance		Defective Membrane		Defective Sonde		DCP Failure	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
MCPW	**92**	**1.05**	**8**	**0.09**	0	0	**1**	**0.01**	**3**	**0.03**	**28**	**0.32**	0	0.00	0	0.00
MCNA	0	0.00	**27**	**0.31**	0	0.00	**2**	**0.02**	0	0.00	0	0.00	0	0.00	**23**	**0.26**
PAQW	0	0.00	0	0.00	0	0.00	**1**	**0.02**	0	0.00	0	0.00	0	0.00	**78**	**1.93**
IDSW	0	0.00	**4**	**0.05**	**121**	**1.38**	**6**	**0.07**	**7**	**0.08**	0	0.00	**86**	**0.98**	0	0.00
IHRA	**130**	**1.48**	**8**	**0.09**	0	0.00	**1**	**0.01**	0	0.00	0	0.00	0	0.00	**59**	**0.67**
LMNW	0	0.00	0	0.00	0	0.00	**1**	**0.02**	**1**	**0.02**	0	0.00	0	0.00	0	0.00
LMN	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
LGSW	0	0.00	0	0.00	0	0.00	**1**	**0.02**	**1**	**0.02**	0	0.00	0	0.00	0	0.00
LGSA	0	0.00	0	0.00	**140**	**3.47**	0	0.00	**1**	**0.02**	0	0.00	0	0.00	0	0.00
LGNW	0	0.00	**4**	**0.05**	0	0.00	**6**	**0.07**	**1**	**0.01**	**39**	**0.44**	**14**	**0.16**	0	0.00
LWG	0	0.00	**4**	**0.05**	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ANQW	0	0.00	0	0.00	**249**	**6.17**	**2**	**0.05**	**5**	**0.05**	0	0.00	0	0.00	0	0.00
LEWI	0	0.00	0	0.00	0	0.00	**2**	**0.05**	0	0.00	0	0.00	0	0.00	0	0.00
PEKI	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
DWQI	0	0.00	**19**	**0.22**	0	0.00	**3**	**0.03**	0	0.00	0	0.00	**27**	**0.31**	0	0.00

Table 9. Number and percent of all missing or invalid barometric pressure, total dissolved gas, and temperature data points for each FMS stations during the 2006 water year.

		Barometric Pressure			Total Dissolved Gas			Temperature		
Station ID	Monitoring Period	**Number Missing/ Anomalous**	**% Missing**	**% Complete**	**Number Missing/ Anomalous**	**% Missing**	**% Complete**	**Number Missing/ Anomalous**	**% Missing**	**% Complete**
MCPW	1 Oct – 30 Sep	5	0.06	99.94	202	2.31	97.69	102	1.64	98.36
MCPA	1 Oct – 30 Sep	164	1.87	98.13	212	2.42	97.58	174	1.99	98.01
PAQW	1 Apr – 15 Sep	99	1.13	98.87	149	3.70	96.30	99	1.13	98.87
IDSW	1 Oct – 30 Sep	27	0.31	99.69	239	2.73	97.27	58	0.66	99.34
IHRA	1 Oct – 30 Sep	94	1.07	98.93	163	1.86	98.12	127	1.44	98.56
LMNW	1 Apr – 15 Sep	2	0.05	99.95	47	1.17	98.83	3	0.07	99.93
LMNA	1 Apr – 15 Sep	5	1.29	98.71	84	2.08	97.92	52	1.29	98.71
LGSW	1 Apr – 15 Sep	1	0.02	99.98	46	1.14	98.86	2	0.05	99.95
LGSA	1 Apr – 15 Sep	5	0.12	99.88	**284**	**7.04**	**92.96**	2	0.05	99.95
LGNW	1 Oct – 30 Sep	8	0.09	99.91	112	1.28	98.72	21	0.23	99.77
LWG	1 Oct – 30 Sep	265	3.03	96.97	291	3.32	96.68	291	3.32	96.68
ANQW	1 Apr – 15 Sep	6	0.14	99.86	**303**	**7.51**	**92.49**	14	0.35	99.65
LEWI	1 Apr – 15 Sep	2	0.05	99.95	38	0.94	99.06	3	0.07	99.93
PEKI	1 Apr – 15 Sep	1	0.02	99.98	35	0.87	99.13	1	0.02	99.98
DWQI	1 Oct – 30 Oct	3	0.03	99.97	77	0.87	99.13	82	0.94	99.06

Table 10. Database completeness with the number and percent of all missing or invalid barometric pressure, total dissolved gas, and temperature data points for each FMS stations during the 2006 water year.

		Total Dissolved Gas		Temperature		Barometric Pressure	
Station ID	Monitoring Period	**% CROHMS Missing/ Anomalous**	**% Optimized Missing/ Anomalous**	**% CROHMS Missing/ Anomalous**	**% Optimized Missing/ Anomalous**	**% CROHMS Missing/ Anomalous**	**% Optimized Missing/ Anomalous**
MCPW	1 Oct – 30 Sep	97.69	**99.53**	98.36	**100.00**	99.94	**100.00**
MCNA	1 Oct – 30 Sep	97.58	**98.78**	98.01	**98.78**	98.13	**98.50**
PAQW	1 Apr – 15 Sep	96.30	**98.93**	98.87	**98.90**	98.87	**98.87**
IDSW	1 Oct – 30 Sep	97.27	**99.52**	99.34	**99.69**	99.69	**100.00**
IHRA	1 Oct – 30 Sep	98.12	**98.12**	98.56	**98.93**	98.93	**99.01**
LMNW	1 Apr – 15 Sep	98.83	**100.00**	99.93	**100.00**	99.95	**100.00**
LMNA	1 Apr – 15 Sep	97.92	**98.78**	98.71	**98.71**	98.71	**100.00**
LGSW	1 Apr – 15 Sep	98.86	**99.95**	99.95	**100.00**	99.98	**100.00**
LGSA	1 Apr – 15 Sep	**92.96**	**97.20**	99.95	**100.00**	99.88	**100.00**
LGNW	1 Oct – 30 Sep	98.72	**100.00**	99.77	**100.00**	99.91	**100.00**
LWG	1 Oct – 30 Sep	96.68	**97.54**	96.68	**97.54**	96.97	**97.54**
ANQW	1 Apr – 15 Sep	**92.49**	**93.63**	99.65	**100.00**	99.86	**99.98**
LEWI	1 Apr – 15 Sep	99.06	**100.00**	99.93	**100.00**	99.95	**100.00**
PEKI	1 Apr – 15 Sep	99.13	**100.00**	99.98	**99.98**	99.98	**100.00**
DWQI	1 Oct – 30 Oct	99.13	**100.00**	99.06	**100.00**	99.97	**99.97**

Table 11. Summary of temperature data statistics recorded at the FMS sites from available data, April 1, 2006 to September 15, 2006.

Station ID	Min (^oC)	Max (^oC)	Mean (^oC)	>20^oC (%)
MCPW	7.3	21.7	16.0	36.0
MCNA	6.8	21.8	15.9	35.1
IDSW	7.4	22.7	16.5	40.6
IHRA	7.4	22.4	16.4	40.7
LGNW	7.3	20.8	15.4	5.5
LWG	7.1	21.0	15.3	3.6
DWQI	4.1	10.2	6.8	0.0
PAQW	5.9	21.4	15.3	22.6
LMNW	7.4	21.4	16.0	34.9
LMNA	7.2	21.7	16.1	35.5
LGSW	7.3	21.5	15.8	26.7
LGSA	7.3	21.8	15.9	29.7
ANQW	6.6	25.2	16.9	44.7
LEWI	5.0	21.2	11.0	0.3
PEKI	4.9	19.2	9.9	0.0

Table 12. Summary of dissolved gas percent saturation data statistics recorded at the FMS sites from available data, April 1, 2006 to September 15, 2006.

Station ID	Min (%)	Max (%)	Mean (%)	>120 % (%)
MCPW	97.6	124.1	115.6	14.6
MCNA	100.2	119.8	109.7	0.0
IDSW	102.1	126.3	114.5	10.3
IHRA	102.2	124.9	112.3	3.5
LGNW	96.7	134.5	113.9	13.9
LWG	96.1	110.0	103.3	0.0
DWQI	93.7	111.0	101.4	0.0
PAQW	90.0	120.6	109.5	0.4
LMNW	100.8	133.0	115.8	12.8
LMNA	102.1	130.6	111.8	7.8
LGSW	97.2	139.2	113.3	6.5
LGSA	97.3	125.7	109.6	4.7
ANQW	97.9	110.9	104.3	0.0
LEWI	97.1	110.7	102.5	0.0
PEKI	96.0	111.2	102.3	0.0

Table 13. Percent distributions for the 1 April – 15 September 2006 hourly temperature data from the FMS stations.

°C	DWQI	PEKI	LEWI	ANQW	LWG	LGNW	LGSA	LGSW	LMNA	LMNW	IHRA	IDSW	PAQW	MCNA	MCPW
0-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-6	**16.1**	**0.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-7	**17.9**	**5.5**	**1.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.3**	0.0	0.0
7-8	**15.8**	**10.2**	**7.9**	**0.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**9.3**	**1.3**	0.0
8-9	**25.2**	**7.4**	**8.4**	**2.1**	**3.2**	**3.2**	**4.2**	**4.0**	**4.9**	**4.4**	**4.5**	**4.2**	**2.7**	**7.4**	**7.7**
9-10	**17.1**	**8.0**	**7.3**	**5.9**	**7.0**	**6.7**	**4.0**	**3.8**	**2.6**	**3.0**	**3.3**	**2.6**	**2.6**	**5.3**	**6.3**
10-11	**7.5**	**19.4**	**6.6**	**4.2**	**5.0**	**3.6**	**5.6**	**5.8**	**5.6**	**6.9**	**6.7**	**7.1**	**4.4**	**1.9**	**2.1**
11-12	**0.4**	**23.7**	**15.5**	**4.3**	**4.2**	**5.3**	**5.0**	**3.9**	**4.1**	**3.8**	**3.5**	**2.0**	**5.1**	**4.1**	**4.4**
12-13	0.0	**11.3**	**18.5**	**6.5**	**8.5**	**8.5**	**7.5**	**7.4**	**5.9**	**5.5**	**6.0**	**7.1**	**2.7**	**5.7**	**4.9**
13-14	0.0	**4.1**	**16.6**	**10.1**	**8.3**	**8.0**	**8.7**	**10.5**	**9.4**	**9.4**	**7.3**	**8.3**	**5.4**	**4.4**	**4.1**
14-15	0.0	**2.2**	**6.4**	**2.9**	**2.6**	**2.7**	**3.6**	**3.3**	**5.7**	**5.6**	**6.7**	**6.3**	**5.6**	**6.4**	**5.3**
15-16	0.0	**2.6**	**3.0**	**7.6**	**8.3**	**8.5**	**5.4**	**4.9**	**3.8**	**3.1**	**2.3**	**2.7**	**8.3**	**5.1**	**6.2**
16-17	0.0	**2.5**	**1.9**	**2.6**	**1.0**	**1.4**	**5.1**	**5.6**	**6.9**	**7.9**	**8.4**	**7.6**	**3.6**	**7.8**	**7.7**
17-18	0.0	**2.3**	**1.8**	**1.9**	**1.7**	**1.3**	**1.0**	**1.3**	**1.8**	**1.6**	**2.9**	**3.0**	**2.8**	**2.1**	**2.8**
18-19	0.0	**0.3**	**1.9**	**1.8**	**2.6**	**6.4**	**1.5**	**1.8**	**1.5**	**1.3**	**1.4**	**1.7**	**2.2**	**3.7**	**3.5**
19-20	0.0	**0.2**	**1.4**	**1.6**	**17.6**	**16.5**	**4.6**	**6.0**	**2.4**	**3.9**	**1.9**	**2.1**	**8.6**	**1.6**	**1.6**
20-21	0.0	**0.1**	**0.6**	**3.4**	**26.4**	**22.3**	**14.1**	**15.0**	**10.0**	**8.7**	**4.4**	**4.6**	**13.8**	**8.2**	**7.5**
21-22	0.0	0.0	**0.2**	**8.3**	**3.6**	**5.5**	**24.1**	**24.1**	**24.2**	**23.2**	**13.5**	**11.4**	**20.5**	**24.8**	**20.5**
22-23	0.0	0.0	**0.1**	**13.5**	0.0	0.0	**5.6**	**2.6**	**11.3**	**11.7**	**25.5**	**22.7**	**2.1**	**10.3**	**15.6**
23-24	0.0	0.0	0.0	**14.6**	0.0	0.0	0.0	0.0	0.0	0.0	**1.7**	**6.5**	0.0	0.0	0.0
24-25	0.0	0.0	0.0	**5.2**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-26	0.0	0.0	0.0	**3.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 14. Number and percent of FMS station total dissolved gas data that surpassed the 110 percent, 115 percent, 120 percent, and 125 percent criteria during the 2006 water year.

Station Type	Station ID	Interval	>110% # Obs	>110% %	>115% # Obs	>115% %	>120% # Obs	>120% %	>125% # Obs	>125% %
Idaho	DWQI	1 Oct – 30 Sept	38	0.4	----	----	----	----	----	----
	PEKI	1 April – 15 Sept	28	0.7	----	----	----	----	----	----
	LEWI	1 April – 15 Sept	15	0.4	----	----	----	----	----	----
Free-flowing	ANQW	1 April – 15 Sept	31	0.8	----	----	----	----	----	----
Forebay	LWG	1 April – 15 Sept	----	----	0	0.0	0	0.0	----	----
	LGSA	1 April – 15 Sept	----	----	320	8.1	183	4.7	----	----
	LMNA	1 April – 15 Sept	----	----	822	20.6	310	7.8	----	----
	IHRA	1 April – 15 Sept	----	----	913	22.7	145	3.5	----	----
	PAQW	1 April – 15 Sept	----	----	716	18.0	16	0.4	----	----
	MCNA	1 April – 15 Sept	----	----	625	15.5	0	0.0	----	----
Tailwater	LGNW	1 April – 15 Sept	----	----	----	----	345	8.6	215	5.3
	LGSW	1 April – 15 Sept	----	----	----	----	250	5.3	49	1.2
	LMNW	1 April – 15 Sept	----	----	----	----	499	12.3	22	0.5
	IDSW	1 April – 15 Sept	----	----	----	----	382	9.5	32	0.8
	MCPW	1 April – 15 Sept	----	----	----	----	591	14.6	0	0.0

Table 15. Percent distributions for the 1 April – 15 September 2006 hourly TDG data from the stations that were monitored annually.

% TDG	DWQI	LWG	LGNW	IHRA	IDSW	MCNA	MCPW
<95	5.1	0.0	0.0	0.0	0.0	0.0	0.0
95-96	6.0	0.0	0.0	0.0	0.0	0.0	0.0
96-97	5.2	0.3	0.1	0.0	0.0	0.0	0.0
97-98	2.1	0.5	0.9	0.0	0.0	0.0	0.0
98-99	4.5	2.3	2.0	0.0	0.0	0.0	0.1
99-100	10.3	5.2	3.8	0.0	0.0	0.0	1.2
100-101	12.9	13.2	1.9	0.0	0.0	1.5	1.8
101-102	8.7	13.1	1.1	0.0	0.0	4.4	2.5
102-103	13.6	12.0	0.1	2.0	1.4	4.3	1.9
103-104	10.2	12.9	0.0	2.5	2.1	5.8	1.2
104-105	6.8	10.4	0.0	1.9	1.2	5.9	1.4
105-106	3.7	10.5	0.0	3.6	1.9	4.4	0.2
106-107	2.5	12.2	0.0	3.2	1.5	7.0	0.0
107-108	3.5	4.9	0.0	2.0	1.3	5.7	0.0
108-109	3.5	1.9	1.2	3.7	1.7	5.5	0.0
109-110	0.9	0.5	7.0	8.1	5.5	4.8	0.0
110-111	0.4	0.0	9.8	10.2	6.9	6.4	0.2
111-112	0.0	0.0	7.7	5.2	5.6	6.4	2.4
112-113	0.0	0.0	5.4	9.0	7.7	9.0	5.8
113-114	0.0	0.0	5.5	11.6	8.4	7.0	5.7
114-115	0.0	0.0	13.3	10.7	5.2	6.3	6.4
115-116	0.0	0.0	5.3	10.5	6.0	5.1	10.6
116-117	0.0	0.0	5.2	5.9	10.5	4.7	12.1
117-118	0.0	0.0	8.1	2.2	8.7	3.9	7.7
118-119	0.0	0.0	3.6	1.9	7.1	1.5	9.4
119-120	0.0	0.0	3.7	2.2	7.0	0.3	14.7
120-121	0.0	0.0	2.1	1.8	4.6	0.0	8.1
121-122	0.0	0.0	1.6	0.8	1.3	0.0	5.2
122-123	0.0	0.0	1.9	0.2	1.6	0.0	1.2
123-124	0.0	0.0	2.3	0.4	1.2	0.0	0.1
124-125	0.0	0.0	0.7	0.3	0.8	0.0	0.0
125-126	0.0	0.0	1.1	0.0	0.8	0.0	0.0
126-127	0.0	0.0	0.3	0.0	0.0	0.0	0.0
127-128	0.0	0.0	0.3	0.0	0.0	0.0	0.0
128-129	0.0	0.0	0.5	0.0	0.0	0.0	0.0
129-130	0.0	0.0	0.8	0.0	0.0	0.0	0.0
>130	0.0	0.0	2.3	0.0	0.0	0.0	0.0

Table 16. Percent distributions for the 1 April – 15 September 2006 hourly TDG data from the stations that were monitored seasonally.

% TDG	ANQW	PEKI	LEWI	LGSA	LGSW	LMNA	LMNW	PAQW
<95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
95-96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96-97	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
97-98	0.1	1.2	0.4	0.7	0.7	0.0	0.0	0.0
98-99	1.0	3.2	2.3	0.5	1.4	0.0	0.0	0.1
99-100	5.9	9.1	10.2	1.1	0.6	0.0	0.0	0.5
100-101	10.4	16.9	17.1	1.1	0.8	0.0	0.0	2.0
101-102	9.9	16.6	19.2	1.1	0.8	0.0	0.8	3.1
102-103	9.7	16.2	14.8	4.2	1.7	3.4	2.5	5.7
103-104	10.9	16.0	12.1	3.6	1.1	3.2	2.7	7.6
104-105	12.8	10.0	9.5	3.0	0.7	4.5	2.0	6.3
105-106	7.9	4.2	5.6	5.1	0.5	5.0	1.6	4.4
106-107	8.2	2.5	3.6	8.4	0.9	6.3	0.2	4.1
107-108	10.7	1.6	2.2	11.7	0.5	7.6	0.0	4.8
108-109	8.0	0.7	1.9	10.2	0.9	7.2	0.4	5.7
109-110	3.7	0.5	0.7	8.0	3.7	3.5	0.5	5.4
110-111	0.8	0.6	0.4	5.1	9.9	5.1	0.2	7.4
111-112	0.0	0.1	0.0	8.8	11.6	5.2	0.7	6.6
112-113	0.0	0.0	0.0	6.6	8.9	5.0	3.6	5.9
113-114	0.0	0.0	0.0	4.4	9.8	7.9	6.2	5.5
114-115	0.0	0.0	0.0	3.5	12.3	7.5	6.5	5.9
115-116	0.0	0.0	0.0	3.0	10.3	6.5	9.5	6.7
116-117	0.0	0.0	0.0	2.4	4.9	6.0	15.7	6.1
117-118	0.0	0.0	0.0	1.3	6.7	4.4	15.6	2.8
118-119	0.0	0.0	0.0	0.7	2.9	1.7	12.6	1.7
119-120	0.0	0.0	0.0	0.7	0.8	2.0	5.5	0.7
120-121	0.0	0.0	0.0	1.0	0.9	1.5	4.1	0.4
121-122	0.0	0.0	0.0	1.7	0.8	1.2	4.5	0.0
122-123	0.0	0.0	0.0	0.9	0.9	1.0	3.0	0.0
123-124	0.0	0.0	0.0	0.3	1.7	1.3	0.5	0.0
124-125	0.0	0.0	0.0	0.2	1.9	0.9	0.2	0.0
125-126	0.0	0.0	0.0	0.6	0.5	0.4	0.1	0.0
126-127	0.0	0.0	0.0	0.0	0.3	0.3	0.2	0.0
127-128	0.0	0.0	0.0	0.0	0.4	0.3	0.2	0.0
128-129	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
129-130	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
>130	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0

Table 17. Number of days FMS stations exceeded 110 percent, 115 percent, 120 percent, total dissolved gas for 12 hours or more during the 2006 water year.

	LWG	LGNW	LGSA	LGSW	LMNA	LMNW	IHRA	IDSW	MCNA	MCPW	DWQI	PAQW	ANQI	LEWI	PEKI
January-06	0	0	-	-	-	-	0	0	0	0	0	-	-	-	-
February-06	0	0	-	-	-	-	0	0	0	0	0	-	-	-	-
March-06	0	0	-	-	-	-	0	0	0	0	0	-	-	-	-
April-06	0	7	2	0	15	4	11	5	5	6	2	4	0	0	0
May-06	0	16	17	12	25	15	23	12	9	14	0	4	0	0	0
June-06	0	5	5	7	15	10	16	5	17	12	0	23	0	0	0
July-06	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
August-06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September-06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October-06	0	0	-	-	-	-	0	0	0	0	0	-	-	-	-
November-06	0	0	-	-	-	-	0	0	0	0	0	-	-	-	-
December-06															
# of Days	0	28	24	19	55	29	51	22	31	32	2	31	0	0	0
possible days	311	311	168	168	168	168	311	311	311	311	311	168	168	168	168
% days out	0.0%	9.0%	14.3%	11.3%	32.7%	17.3%	16.4%	7.1%	10.0%	10.3%	0.6%	18.5%	0.0%	0.0%	0.0%
%day in comp	100.0%	91.0%	85.7%	88.7%	67.3%	82.7%	83.6%	92.9%	90.0%	89.7%	99.4%	81.5%	100.0%	100.0%	100.0%