U.S. ARMY
CORPS OF ENGINEERS

TDG MONITORING PLAN

March 2021

U.S. Army Corps of Engineers
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1.0 INTRODUCTION

This Total Dissolved Gas (TDG) Monitoring Plan (Plan) was prepared by the U.S. Army Corps of Engineers (Corps) as an update to previous TDG Monitoring Plans.[1] This TDG Monitoring Plan summarizes what, how, when, and where to take the measurements, the roles and responsibilities of the Corps and others in TDG monitoring, and identifies channels of communication with other participating agencies. This includes the Corps, the Chelan, Douglas, and Grant County Public Utility Districts (PUDs), the U.S. Bureau of Reclamation (Reclamation) and the U.S. Fish and Wildlife Service (USFWS). The following are related planning and reporting documents:

- Water Quality Plan for TDG and Temperature in the Mainstem Columbia and Snake River, Corps, Bonneville Power Administration (Bonneville) and Reclamation, last updated 2014 (available upon request), update in progress.
- TDG Management Plan, Corps, included as an appendix in the annual Water Management Plan (https://pweb.crohms.org/tmt/documents/wmp/)
- Biological Monitoring Plan, Corps, covers gas bubble trauma (GBT) monitoring, pending, will be available upon request.
- Fish Operation Plan, Corps, include as an appendix in the annual Fish Passage Plan, plan for planned spring and summer spill for juvenile fish passage, https://pweb.crohms.org/tmt/documents/fpp/
- Annual TDG Report, Corps, https://www.nwd.usace.army.mil/CRWM/Water-Quality/
- Total Dissoloved Gas Fixed Monitoring Stations, Corps, as Appendix A to the Annual TDG Report, includes site photos, exact locations, maps, etc. https://www.nwd.usace.army.mil/CRWM/Water-Quality/

The following changes are included this update:

- Forebay TDG gauges will be installed prior to summer spill. They are no longer required during spring due to the 2020 change in State of Washington criteria adjustment.
- The Camas / Washougal (CWMW) TDG gauge will be discontinued. There is no requirement for this gauge.
- The annual data quality meeting will be replaced with coordination, as needed. There is no longer a BiOp requirement for an annual meeting.

2.0 GENERAL OVERVIEW

The Plan describes the following: Corps' responsibilities; fixed monitoring stations (FMS) gauge management; data management; annual data quality control/quality assurance (QA/QC) evaluation reports; and, cooperation with participating agencies.

[1] The National Marine Fisheries Service (NMFS) 2020 Columbia River System (CRS) Biological Opinion requests that the Corps develop and implement the TDG monitoring plan (Terms and Conditions).

3.0 CORPS RESPONSIBILITIES

This TDG monitoring plan describes the following Corps' responsibilities associated with TDG monitoring. Portland, Seattle, and Walla Walla Districts will perform the activities required to ensure that the TDG monitoring sites are operating accurately, including but not limited to the following tasks:

- Assist in preparation of the TDG Monitoring Plan
- Prepare an annual QA/QC evaluation report which is included as an appendix in the Corps' Annual TDG Report
- Procure data collection/transmission instruments
- Prepare and award equipment and service contracts
- Perform initial instrument installation and testing
- Install and remove permanent FMS installations
- Evaluate existing FMS to ensure that measured TDG levels are representative of true river conditions
- Collect and transmit TDG data to the Corps' Water Management System (CWMS)
- Review data for early detection of instrument malfunction
- Conduct periodic calibration, service and maintenance calls
- Provide emergency service calls
- Perform special TDG measurements, as necessary
- Maintain records of instrument calibration and/or adjustments
- Retrieve, service, and store instruments at the end of the season
- Provide raw and revised data to the Division office
- Perform additional monitoring/studies at selected locations on an "as needed/as funded" basis
- Perform data corrections for regionally agreed upon FMS gauges in CWMS.

The Corps' Columbia Basin Water Management Division Reservoir Control Center (RCC) will be responsible for the following activities:

- Facilitate data quality discussions, as needed.
- Ensure that TDG data is disseminated to outside users which involves maintaining TDG web reports, ensuring that TDG data is coming into the Corps' CWMS database so that the web reports remain populated, contacting the Districts, the PUDs, Reclamation and USFWS when data communication to the database fails, and developing web reports to meet the region's TDG data needs.
- Perform data correction for regionally agreed upon FMS gauges in CWMS.

4.0 FMS GAUGE MANAGEMENT

This section describes the participating agencies' FMS gauge operation, TDG monitoring, repair of malfunctioning gauges, and FMS gauge removal and storage.

4.1 FMS Gauge Operation

The current FMS gauges can be found in at the following website: http://www.nwd.usace.army.mil/Missions/Water/Columbia/Water-Quality/ *(with links to Table 1 and Figure 1 under the heading of Plans and the subheading of TDG Monitoring Plan)*. All seasonal instruments are scheduled to be in place and connected to their data collection platforms (DCPs) no later than April 1. Some gauges will record year round while others will be seasonal (Table 1). Most, but not all, forebay gauges are operated seasonally from April 1 through August 31 and most, but not all, tailwater gauges operate year-around. The seasonal gauges may be installed as early as several weeks before April 1 and remain in operation for several weeks after August 31. The Corps' Districts will coordinate activation of these FMS with the Corps' RCC Water Quality Unit.

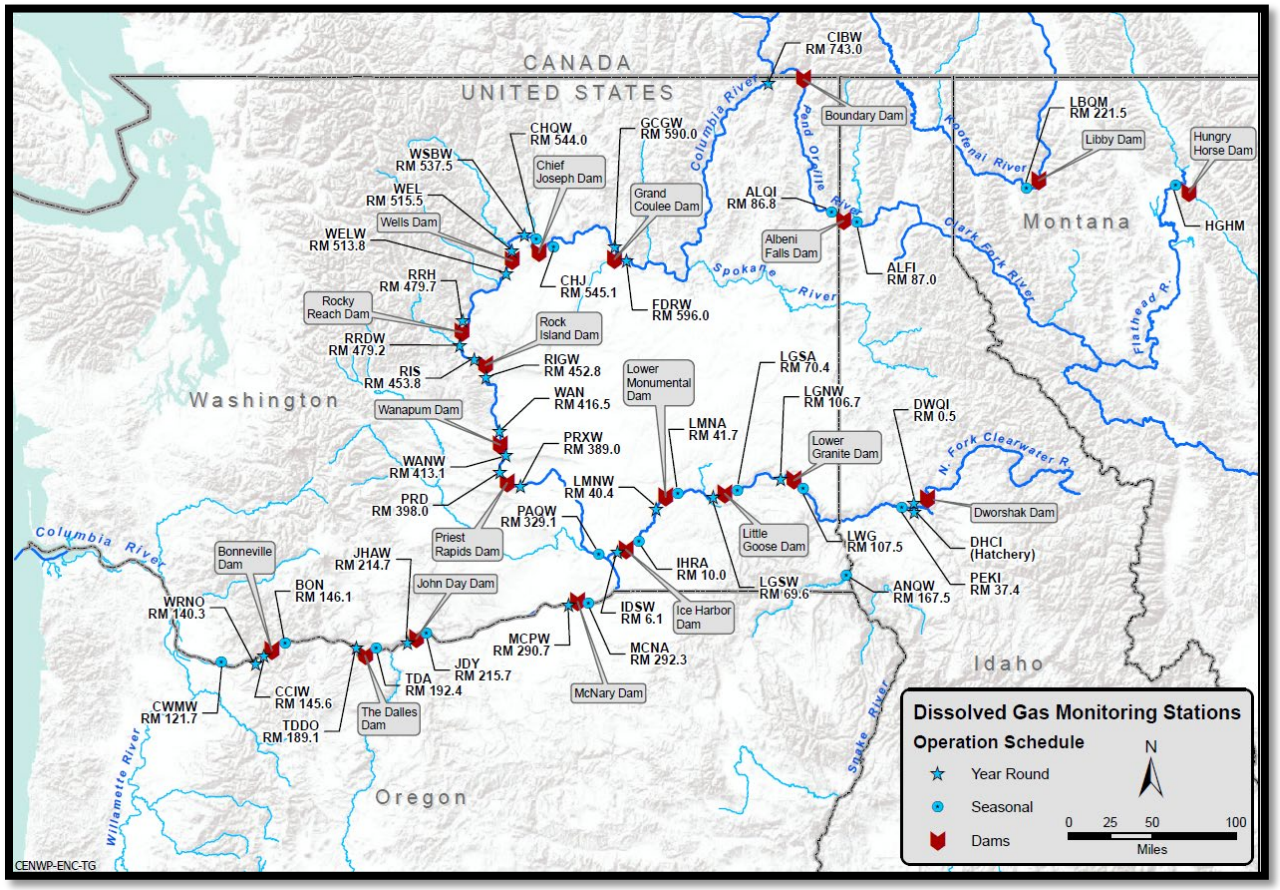

Figure 1. Map of TDG gauges.

Table 1. TDG monitoring station details

STATION NAME	STATION CODE	OWNER [a]	DATES OF OPERATION [b]	CALIBRATION FREQUENCY		SERVICE LIMITATION NOTES
				FALL-WINTER	SPRING-SUMMER	
Albeni Falls Forebay	ALFI	USACE-NWS	Year Round	Monthly	2 Weeks	
Albeni Falls Tailwater	ALQI	USACE-NWS	Year Round	Monthly	2 Weeks	
Anatone	ANQW	USACE-NWW	Apr 1 – Aug 31	N/A	3 Weeks	Not accessible during flows ≥ 190 kcfs (access road is closed due to flooding). Gauge can be damaged at flows ≥ 150 kcfs and can experience siltation at flows ≤ 125 kcfs.
Bonneville Forebay	BON	USACE-NWP	Jun 15 – Aug 31	N/A	3 Weeks	
International Boundary	CIBW	Reclamation	Year Round	Monthly	2 Weeks	
Camas-Washougal	CWMW	USACE-NWP				Discontinued after 2020 spill season. Not installed in 2021.
Cascades Island	CCIW	USACE-NWP	Apr 1 – Aug 31	N/A	3 Weeks	Cannot be serviced when the tailwater elevations are ≥ 28 ft, which occurs at flows ≥ 400 kcfs. Risk of gauge failure increases at flows ≥ 490 kcfs.
Chief Joseph Forebay	CHJ	USACE-NWS	Apr 1 – Aug 31	N/A	2 Weeks	
Chief Joseph Tailwater	CHQW	USACE-NWS	Mar 1 – Sep 30	N/A	2 Weeks	
Dworshak Hatchery Collection Channel	DHCI	USFWS	Year Round	Monthly	3 Weeks	
Dworshak Tailwater	DWQI	USACE-NWW	Year Round	Monthly	3 Weeks	Cannot be serviced during high flows ≥ 55 kcfs due to safety concerns of service personnel.

STATION NAME	STATION CODE	OWNER [a]	DATES OF OPERATION [b]	CALIBRATION FREQUENCY		SERVICE LIMITATION NOTES
				FALL-WINTER	SPRING-SUMMER	
Grand Coulee Forebay	FDRW	Reclamation	Year Round	Monthly	2 Weeks	
Grand Coulee Tailwater	GCGW	Reclamation	Year Round	Monthly	2 Weeks	
Hungry Horse Tailwater	HGHM	Reclamation	Apr 1 – Aug 31	N/A	2 Weeks	
Ice Harbor Forebay	IHRA	USACE-NWW	Jun 15 – Aug 31	N/A	3 Weeks	Spring installation by NWW for study in 2021.
Ice Harbor Tailwater	IDSW	USACE-NWW	Year Round	Monthly	3 Weeks	Can be seriously damaged at high flows (>190 kcfs) and cannot be serviced during high flows due to safety concerns of service personnel. Can be accessed by boat only when flows are ≥175 kcfs. Gauge can experience siltation at flows ≤ 125 kcfs.
John Day Forebay	JDY	USACE-NWP	Jun 15 – Aug 31	N/A	3 Weeks	
John Day Tailwater	JHAW	USACE-NWP	Year Round	Monthly	3 Weeks	Cannot be serviced at hourly flows ≥ 500 kcfs due to safety concerns of service personnel. The sensor is more likely to need service in late Jul and Aug due to possible biofouling or siltation.
Libby Tailwater	LBQM	USACE-NWS	Apr 1 – Sep 30	N/A	2 Weeks	
Little Goose Forebay	LGSA	USACE-NWW	Jun 15 – Aug 31	N/A	3 Weeks	Spring installation by NWW for study in 2021.
Little Goose Tailwater	LGSW	USACE-NWW	Year Round	Monthly	3 Weeks	Can be seriously damaged at high flows (>190 kcfs) and cannot be serviced during high flows due to safety concerns of service personnel. Gauge can experience siltation at flows ≤ 125 kcfs.

STATION NAME	STATION CODE	OWNER [a]	DATES OF OPERATION [b]	CALIBRATION FREQUENCY		SERVICE LIMITATION NOTES
				FALL-WINTER	SPRING-SUMMER	
Lower Granite Forebay	LWG	USACE-NWW	Jun 15 – Aug 31	N/A	3 Weeks	
Lower Granite Tailwater	LGNW	USACE-NWW	Year Round	Monthly	3 Weeks	Can be seriously damaged at high flows (>190 kcfs) and cannot be serviced during high flows due to safety concerns of service personnel. Gauge can experience siltation at flows ≤ 125 kcfs.
Lower Monumental Forebay	LMNA	USACE-NWW	Jun 15 – Aug 31	N/A	3 Weeks	Spring installation by NWW for study in 2021.
Lower Monumental Tailwater	LMNW	USACE-NWW	Year Round	Monthly	3 Weeks	Can be seriously damaged at high flows (>190 kcfs) and cannot be serviced during high flows due to safety concerns of service personnel. Gauge can experience siltation at flows ≤ 125 kcfs.
McNary Forebay	MCNA	USACE-NWW	Jun 15 – Aug 31	N/A	3 Weeks	
McNary Tailwater	MCPW	USACE-NWW	Year Round	Monthly	3 Weeks	Gauge has limited access at flows ≥ 450 kcfs. The road to the gauge is closed but the gauge can be accessed by foot.
Pasco	PAQW	USACE-NWW	Apr 1 – Aug 31	N/A	3 Weeks	Requires regular annual cleanouts to deal with the serious siltation issues which can occur even during low flow years.
Peck	PEKI	USACE-NWW	Apr 1 – Aug 31	N/A	3 Weeks	Experiences siltation at flows ≤ 45 kcfs.
Priest Rapids Forebay	PRD	Grant County PUD	Year Round	3 Weeks	2 Weeks	
Priest Rapids Tailwater	PRXW	Grant County PUD	Year Round	3 Weeks	2 Weeks	
Rock Island Forebay	RIS	Chelan County PUD	Year Round	2 Months	Monthly	

STATION NAME	STATION CODE	OWNER [a]	DATES OF OPERATION [b]	CALIBRATION FREQUENCY		SERVICE LIMITATION NOTES
				FALL-WINTER	SPRING-SUMMER	
Rock Island Tailwater	RIGW	Chelan County PUD	Year Round	2 Months	Monthly	Cannot be serviced when flows ≥ 250 kcfs due to safety concerns of service personnel
Rocky Reach Forebay	RRH	Chelan County PUD	Year Round	2 Months	Monthly	
Rocky Reach Tailwater	RRDW	Chelan County PUD	Year Round	2 Months	Monthly	
The Dalles Forebay	TDA	USACE-NWP	Jun 15– Aug 31	N/A	3 Weeks	
The Dalles Tailwater	TDDO	USACE-NWP	Year Round	Monthly	3 Weeks	Cannot be serviced when the tailwater elevations are ≥ 85 ft, which occurs at flows ≥ 500 kcfs as measured at the USGS gauge.
Wanapum Forebay	WAN	Grant County PUD	Year Round	3 Weeks	2 Weeks	
Wanapum Tailwater	WANW	Grant County PUD	Year Round	3 Weeks	2 Weeks	
Warrendale	WRNO	USACE-NWP	Year Round	Monthly	3 Weeks	
Wells Forebay	WEL	Douglas County PUD	Year Round	Monthly	Monthly	
Wells Tailwater	WELW	Douglas County PUD	Year Round	Monthly	Monthly	
Wells Forebay– in Lake Pateros (Washburn Island)	WSBW	Douglas County PUD	Year Round	Monthly	Monthly	

a. Gauge owner abbreviations include U.S. Army Corps of Engineers (USACE), Portland District (NWP), Seattle District (NWS), Walla Walla District (NWW), U.S. Bureau of Reclamation (Reclamation), U.S. Fish and Wildlife Service (USFWS) and Public Utility District (PUD)

b. The seasonal gauges may go in several days before April 1 and remain in operation several days after August 31.

The Warrendale gauge will be kept active all year to facilitate monitoring of TDG impacts on chum redds below Bonneville Dam during the winter and as an alternative gauge to the Cascade Island TDG gauge during spill season. The Camas-Washougal gauge will not be installed in 2021. There is no requirement for this gauge. It was not used for spill management but was used to monitor TDG downstream of Bonneville Dam and to inform water quality conditions in the estuary.

Corps' stations that remain in service during the fall-winter season continue their operation with minimum interruption into the spring, following the necessary instrument service, maintenance check-up, and site equipment upgrades (e.g., deployment conduits). These stations include the tailwater monitors at each lower Columbia and lower Snake River project.

An assessment of monitoring site integrity will be conducted; any damages that may have occurred over the fall-winter will be repaired before proceeding on to calibration and testing. Fall-winter monitoring of TDG will be consistent with what was recommended in the TDG Total Maximum Daily Load (TMDL) for the lower Columbia and the lower Snake rivers.

4.2 PUDs, Reclamation and USFWS TDG Monitoring

The Corps expects that the following entities will continue to operate their FMS monitoring stations:

- U.S. Bureau of Reclamation: Reclamation will continue to operate FMS monitoring stations below Hungry Horse Dam, at the International Boundary and in the forebay and tailwater of Grand Coulee Dam. Hourly data transmission to the Corps' CWMS database will continue via the GOES satellite.
- U.S. Fish and Wildlife Service: USFWS will continue to operate FMS monitoring station in the collection channel of the Dworshak Hatchery. Hourly data transmission to the Corps' CWMS database will continue via the GOES satellite.
- Douglas County Public Utility District: Douglas County PUD will continue to operate FMS's in the forebay and tailwater of Wells Dam and at Washburn Island gauge (7.5 miles below Chief Joseph Dam). The year round hourly data from these stations will continue to be sent to the Corps' CWMS database. Data for this TDG station is available at http://douglaspud.org/wells-project/total-dissolved-gas-and-temperature-monitoring.
- Chelan County Public Utility District: Chelan County PUD will continue to operate FMS monitoring stations in the forebay and tailwater of Rocky Reach Dam and Rock Island Dam. Hourly data from these four stations will continue to be posted in the Corps' CWMS database.
- Grant County Public Utility District: Grant County PUD will continue to operate FMS monitoring stations in the forebay and tailwater of Wanapum and Priest Rapids dams. Hourly data from these four stations will continue to be posted in the Corps' CWMS database.

4.3 Repair of Malfunctioning Gauges

The participating agencies will endeavor to have an adequate inventory of spare instruments that will be maintained to ensure that at least one backup monitor is available for deployment as necessary. Instruments needing repairs that are beyond the staff's capability will be shipped to the manufacturer. In-house water quality and information management staff will do repairs of communication network systems. Service and repair of the data collection platforms will be performed by the manufacturer or by a contractor.

To help reduce response time in determining whether an emergency field visit is needed, the following guidelines were developed through regional discussions:

- High priority will be placed on fixing a faulty instrument when TDG data is used for real-time spill decisions during spill season (April 3 through August 31).
- During spill season, if a FMS gauge malfunctions, a repair team will visit the site to perform repairs within 2 days (3 days if a weekend and 4 days if a holiday weekend) of the malfunction or District notification unless the instrument location or high flow conditions create a safety concern. Typically, the repairs will be performed on the next day during the week and on Monday or Tuesday (if Monday is a holiday) if observed over the weekend. A gauge malfunction that occurs during a weekend or holiday may require a longer response time depending upon when the malfunction is detected and the availability of capable technicians/equipment. High priority will be placed on fixing a faulty instrument when TDG levels are, or are expected to be, in excess of the current state standards.
- No emergency trips are made for the parameter of temperature.
- During September through March, if a non-seasonal FMS gauge malfunctions, a repair team will visit the site within three calendar days (4 days if a holiday weekend) of the time of malfunction or District notification.
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- There are limitations to the access and service of gauges during high flows and low flows. These conditions are summarized in Table 1. In these cases, sensors are serviced as soon as safe conditions return.

5.0 DATA MANAGEMENT

TDG data from the Corps' FMS will be collected and transmitted systematically and without interruption to CWMS. The CWMS database is a data management system incorporating the acquisition, transformation, verification, storage, display, analysis, and dissemination of information using a relational database (ORACLE) to store the data. Other agencies transmit their data into the CWMS database via the Geostationary Operational Environmental Satellite (GOES) system or send the data to the Corps' File Transfer Protocol (FTP) server (café) where it is posted and entered into the CWMS databases.

5.1 Data Collected

Actual data collection and transmission will cover the period of planned spill for juvenile fish, typically April through August, adjusted for specific forebay and tailwater monitoring

requirements in the water quality standards. The exact start date will be coordinated with the Corps' RCC project biologists and cooperating agencies, based on runoff, spill and fish migration conditions. The following data will be collected:

- Water temperature
- Barometric pressure
- TDG pressure
- Sensor depth

Temperature, barometric pressure, and TDG pressure will be collected on a first priority basis since they are used in BiOp spill management. Thermistor strings that monitor temperature at several depths throughout the year and report data hourly have been placed at Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary Reservoir forebays.

5.2 Data Quality Criteria

In 2002, the Corps, in cooperation with the regional Water Quality Team established the following data quality criteria (DQC) for FMS:

1. Each site will have two dedicated TDG probes (one installed and one spare being calibrated in the lab).
2. For Corps' TDG gauge probes, rotation and calibration will occur at least once every three weeks during the spill season and monthly during the non-spill season. The frequency of probe rotation and calibration will vary with the different PUDs and other agencies as shown in Table 1.
3. Responsible FMS owners will field check the TDG probes once they are deployed.
4. The data from the FMS is sent to the Corps' CWMS database.
5. There is a goal of 95 percent data completeness. This goal incorporates the requirement to repair a malfunctioning gauge as soon as possible as described in section 4.3.
6. If a FMS malfunctions, then a site visit is made to fix the gauge.
7. The FMS will be assessed at the end of the monitoring season against these criteria and the Districts will generate a performance QA/QC report that will be included in the annual TDG Report.
8. Adjustments will be made to the individual FMS that do not perform to the objectives described.

A more detailed description of the probes, lab and field calibration procedures, field checks and other details of the DQC are provided annually in the TDG Reports (specifically in the District's TDG reports included as appendices) which are posted at:
http://pweb.crohms.org/tmt/wqnew/tdg_and_temp/

The PUDs, Reclamation and USFWS use the same data quality criteria for FMS with the additional allowance for operator safety during extreme flow conditions. At Wells Dam, probes are recalibrated once a month rather than once every three weeks. A redundant sensor is deployed in the Wells Dam tailrace, which serves as a backup in the event that the primary probe fails.

Chelan County PUD calibrates probes once a month during the fish spill season and every other month during the non-fish spill season.

Grant County PUD is obligated by its Washington Department of Ecology (WDOE) approved Quality Assurance Project Plan (QAPP; Hendrick 2009[2]) to calibrate and deploy instrument probes every two weeks during the spill season (April through August) and every three weeks during the non-spill season (September through March).

5.3 Data Transmission and Distribution

Data will be collected and transmitted hourly. For most gauges, data transmission is sent via the GOES Satellite to the Corps' CWMS database. FMS data for the Corps' Portland and Walla Walla Districts will also be sent to the U.S. Geological Survey (USGS) internal Aquarius database simultaneously. Data transmission from Chief Joseph, Libby and Albeni Falls Dams will be transmitted via radio to the Corps' CWMS database by the Corps' Seattle District.

Daily reports summarizing TDG and related information will be posted on the Technical Management Team's (TMT). Information provided on the TMT homepage includes, but is not limited to, the following data reports:

- High 12-hour average TDG readings
- Water temperature, barometric pressure, TDG pressure
- Calculated percent TDG
- Project hourly spill (in kcfs and percent of total outflow)
- Project total hourly outflow (total river flow)
- Instrument probe depth

6.0 ANNUAL DATA QA/QC EVALUATION REPORT

An annual QA/QC report will be prepared after the end of each spill season to summarize the yearly highlights of the TDG monitoring program. The Corps' QA/QC reports will include a summary of the data quality received from each FMS. Information on the performance of the instruments (including accuracy, precision and bias associated with each parameter) and the nature and extent of instrument failures will be documented. These summaries should include statistics on data confidence limits. The Corps' QA/QC reports will be included as appendices in the Corps' Annual TDG Report which is submitted to Oregon Department of Environmental Quality and WDOE as part of the Oregon TDG standard modification and Washington TDG criteria adjustment conditions.

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[2] Hendrick, R. 2009. Quality Assurance Project Plan for Monitoring Selected Water Quality Parameters within the Priest Rapids Hydroelectric Project. Prepared for Public Utility District No. 2 of Grant County, Washington. January, 2009. http://www.gcpud.org/resources/resLandWater/waterQuality.htm

7.0 COOPERATION WITH PARTICIPATING AGENCIES

The USFWS, Reclamation, Douglas, Chelan and Grant County PUDs currently monitor for TDG at their mainstem projects or hatchery and have maintained a cooperative effort with the Corps in collecting and reporting TDG and related water quality parameters. This cooperation is expected to continue.