Quality Assurance Project Plan

Mid Columbia and Snake Rivers
Total Dissolved Gas
Total Maximum Daily Load Field Monitoring

by
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303(d) listings addressed in this study:
Mid Columbia River Total Dissolved Gas (Grand Coulee to Snake River)
Lower Snake River Total Dissolved Gas (Idaho Border to Columbia River)

Waterbody Number: WA-CR-1040 and WA-35-1010
Ecology EIM Number: PPIC0005

Approvals

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Abstract

This Quality Assurance (QA) Project Plan addresses total dissolved gas monitoring to be conducted at Wells Dam on the Columbia River and Lower Granite Dam on the Snake River as part of the development of total maximum daily loads on the Columbia and Snake Rivers. Data will be collected with multi-parameter data logging meters. Secondary parameters will also be monitored: dissolved oxygen, temperature, pH, and specific conductance. Monitoring is planned for the May through July spring runoff period.

Background/Problem Statement

Ecology is determining the Total Maximum Daily Load (TMDL) of total dissolved gas (TDG) in the mainstem Mid Columbia River from Grand Coulee Dam to the confluence of the Snake River and on the Lower Snake River from the Idaho border to its confluence with the Columbia River. The state of Washington has listed multiple reaches of the Columbia and Snake Rivers on its 303(d) list where TDG levels exceeded state water quality standards. All reaches of the TMDL area are considered impaired for TDG. The state of Washington will be issuing this TMDL and submitting it to the U.S. Environmental Protection Agency for its approval.

Elevated TDG levels are caused by spill events at the hydroelectric projects on the two rivers. Water pouring over the spillway of a dam and plunging into tailrace waters entrains air bubbles. When these are carried to depth in the dam's stilling basin, the higher hydrostatic pressure forces air from the bubbles into solution. The result is water supersaturated with dissolved nitrogen, oxygen, and the other constituents of air. As the bubbles rise in the aerated zone of the tailrace, some of the gas leaves solution. However, as the bubbles dissipate and the water enters the downstream reach, the remaining TDG will remain unless wind or channel-induced turbulence causes more degassing. Water that passes the dam through the powerhouse has the same TDG as upstream.

TDG may also be affected by natural phenomenon. High biological primary productivity can raise TDG by raising dissolved oxygen. For a constant TDG loading level, the percent saturation of TDG can rise if atmospheric barometric pressure drops or if the water temperature increases.

Fish in water with high TDG levels may not display signs of difficulty if the higher water pressures at depth offset high TDG pressure passing through the gills into the blood stream. However, if the fish inhabit supersaturated water for extended periods, or rise in the water column to a lower water pressure at shallower depths, TDG may come out of solution within the fish, forming bubbles in their body tissues. This gives rise to gas bubble trauma (GBT).

Spills can occur at any time for several reasons:

- Fish passage spills (voluntary spills), conducted under the Biological Opinion in compliance with the Endangered Species Act.
- Spills required when flow exceeds powerhouse capacity (involuntary spills).

There are three main reasons for involuntary spills:

- The powerhouse can't pass flood flows.
- The powerhouse is off-line due to lack of power demand.
- The powerhouse is off-line for maintenance or repair.

With the exception of Grand Coulee Dam, dams on the Mid Columbia and Lower Snake Rivers are run-of-the-river dams with very little storage capacity. Therefore, spills are often forced due to operational decisions at upstream storage reservoirs, such as Grand Coulee or Dworshak Dams.

Project Description

The overall goal of the project is to set TMDLs by evaluating the effects of dam spills on TDG in the river. Due to extensive research into TDG in the Columbia and Snake Rivers, the TMDLs will be developed almost entirely from existing and on-going data and analysis, mostly by the U.S. Army Corps of Engineers (Corps). Long-term monitoring of TDG has occurred in the forebay and tailrace of each dam at the Fixed Monitoring Station (FMS) sites. Detailed monitoring studies of TDG downstream of the dams' spillways has been conducted for most dams.

However, with respect to the development of the TMDL, a few data gaps exist. Although the FMS sites provide a long-term record of TDG levels, they do not provide information on the spatial variability of TDG or on the boundaries of the aerated zone below the spillway. It requires detailed monitoring from an intensive synoptic survey to obtain this information.

Lower Granite Dam on the Snake River and Wells Dam on the Mid Columbia have only had limited detailed TDG data collection. Therefore, Ecology is planning to collect TDG data from these two dams to support the TMDL. The objectives of the data collection will be to assess the variability of TDG laterally and longitudinally upstream from the FMS site and to determine the end of the aerated zone based on TDG measurements.

Other data collection using the data quality protocols described herein may also be conducted if opportunities arise, such as joint sampling to evaluate data comparability during a Corps detailed study.

Responsibilities

- *Paul Pickett*: Project lead and principal investigator, responsible for overall project management, preparation of Quality Assurance (QA) Project Plan, supervision and completion of field sampling, analysis of project data, and preparation of technical content of draft and final report.

- *Will Kendra and Karol Erickson*: Manager/supervisor of the Watershed Ecology Section and the Water Quality Studies Unit, respectively, of the Environmental Assessment Program. Responsible for review and approval of the QA Project Plan and draft final report.

- *Cliff Kirchmer and Stew Lombard*: Ecology Quality Assurance Office and Lab Accreditation Officer, respectively, responsible for technical assistance on Quality Assurance, including review of the QA Project Plan.

- *Melissa Gildersleeve and Mike Herold:* Section manager and TMDL coordinator (client contact) for the Watershed Management Section of Ecology's Water Quality Program. Responsible for review of the draft QA Project Plan and draft final report.

Schedule

TDG monitoring will be targeting the spring and early summer season, since this is the period of maximum flows from spring runoff. During this period, dams will be spilling for salmon passage, and there may also possibly be involuntary spills due to the volume of snowmelt runoff. Monitoring will occur during May through July 2002. Currently, one-day field surveys are expected to occur at Wells Dam during the last week of May, June, and possibly July for a total of two to three surveys. One-day surveys at Lower Granite Dam will occur in mid-May, June and possibly July for a total of two to three surveys. The need for a third survey will be determined by the quality and quantity of data collected during the first two surveys and whether spills are still continuing in July.

Monitoring data will be analyzed for the TMDL submittal reports. A preliminary draft report for informal stakeholder review is expected by September 2002, a final draft for formal public review by December 2002, with final issuance in March 2003. Data will also be reported in a technical memorandum to the project client and EA Program files, developed in accordance with program report review guidelines. Digital archiving of data will be in the EIM database, in accordance with EA Program guidelines (all manual measurements and statistical summaries of continuously logged data). The technical memorandum and data archiving will be completed in September 2002.

Data Quality Objectives and Decision Criteria

TDG meters, like other field monitoring equipment, are subject to bias due to systematic errors introduced by calibration, equipment hardware or software functioning, or field methods. Bias will be minimized by following manufacturer's protocols for calibration and maintenance and field protocols for stabilization of meter readings (Tanner and Johnston, 2001). Bias is difficult to assess for TDG field measurements because a more accurate verification method, such as a laboratory standard, is not available. Therefore, data quality objectives (DQOs) will be set for precision, but not for bias or accuracy.

Data precision for TDG meters is evaluated by calibration methods and by comparison to other meters in the field. Most TDG measurements are expected to fall into the range of 100% to 140% saturation. State criteria are 110% saturation with special conditions during fish passage spills of 115%, 120%, and 125% saturation for the downstream forebay, 12-hour average in the tailrace, and 1-hour maximum in the tailrace, respectively. A DQO of 1% TDG saturation would be reasonable to achieve project objectives.

Measurement Quality Objectives (MQOs) will equal DQOs for this study and will be similar to those reported by the U.S. Geological Survey (USGS) for the FMS system in the lower Columbia (Tanner and Bragg, 2001). MQOs will be met if meter readings are within 1% TDG or 5 mm Hg of the expected value based on comparison to calibration values (pressurized chamber) or duplicate measurements (paired readings of Ecology meters). MQOs will also be evaluated for paired readings of the FMS and Ecology meters. If MQOs are not met for FMS-Ecology pairs, the differences will be evaluated but the data will not be qualified or discarded.

TDG percent saturation measurements are dependent upon barometric pressure readings, so MQOs are also necessary for the field barometer used. The target for this study will be a MQO of 1 mm Hg for the field barometer.

Positioning of data collection will be determined by Global Positioning System (GPS). Water quality data will also be collected for temperature, dissolved oxygen, pH, and conductivity. Since these are parameters of secondary importance to the study, DQOs have not been established, but MQOs will be set to determine if data are acceptable for reporting. GPS precision will be determined by taking a field measurement of position from a surveyed benchmark at the field site. The MQO will be met for GPS positioning and data will be reported if the GPS reading is within 50 meters of the benchmark. The MQO for water quality data will be met, and data will be reported, if post-calibration shows that the temperature is within 0.5°C, pH is within 0.5 standard units, DO is within 0.5 mg/L, and conductivity is within 5% or 5 μS/cm.

Table 1. Study Measurement Quality Objectives

Parameter	**Measurement Quality Objective (Maximum Deviation from True or Expected Value)**
Total Dissolved Gas Saturation	1% or 5 mm Hg
Temperature	0.5 °C
pH	0.5 s.u.
Dissolved Oxygen	0.5 mg/L
Conductivity	5% or 5 μS/cm
GPS Coordinates	50 meters
Barometric Pressure (Field)	1 mm Hg

Study Design and Field Procedures

Ecology currently has two Hydrolab® Datasonde® 4 meters with TDG sensors. The following study procedure will be followed for each survey. Upon arrival and checking in at the dam, several GPS measurements will be taken at a surveyed benchmark.

The boat will then be launched below the dam and one meter will be deployed remotely near the shore opposite and upstream of the FMS station. The exact site will be determined after field reconnaisance based on depth, current, anchorage, and other logisistical considerations. The meter will be anchored with a buoy and a line with float will be attached to the meter to aid with recovery if the deployment is swept away. The meter will be set for measurements at 5 minute intervals. GPS and ambient barometric pressure readings will be taken at the time of deployment.

The boat will then begin taking longitudinal transects in the river with the second meter. The meter will be placed in the water to equilibrate until readings appear to be stable, usually between 10 to 20 minutes. Then the meter will be stored in river water when readings are not being taken.

The boat will approach as close as possible to the dam, but at a safe distance based on the spill, wind, currents, and turbulence of the water. TDG, GPS, and ambient barometric pressure readings will be taken with the boat drifting from the upstream position down to the FMS site. If the boat approaches the shore, it will be moved a safe distance away. A minimum of one set of three transects is desired, with readings from the center and near the two banks. If readings show large lateral differences, additional transects will be taken between the initial three. If field observations suggests that the drifts are erratic, then monitoring at a fixed position (by powering the boat into the current) will be attempted. If time allows, an additional set of transects will be taken.

If time is left after at least two sets of downstream transects, the boat will be launched above the dam, and a lateral transect will be taken in the forebay with gas measurements at 1 meter intervals of depth at 5 or more points across the forebay at a safe distance from the dam.

After transects are complete, the deployed meter will be removed, and a final GPS reading will be taken from the benchmark.

Data on TDG levels from FMS monitoring sites and on spill release volumes at the dams will be obtained after the surveys from the internet or from appropriate staff.

Laboratory Procedures

No laboratory work is planned.

Quality Control Procedures

Field Quality Control

Meters will be calibrated for TDG before every survey and post-calibrated after each survey in the Ecology Headquarters laboratory. A lab sheet has been developed for TDG calibration and post-calibration of the meters (Appendix A). TDG calibration and post-calibration procedures will follow SM 2810B (APHA *et al.*, 1995), manufacturer's instructions, and USGS protocols for TDG (Tanner and Johnston, 2001).

Other water quality parameters will be calibrated before each survey if pre- or post-calibration show MQOs are not being met. Pre- and post-calibration for temperature, pH, conductivity, and DO will consist either of paired meter readings in an air-saturated water bath or comparison to a standard. Calibration for pH, conductivity, and DO (temperature is factory calibrated) will follow manufacturer's instructions and Ecology standard protocols (WDOE, 1992).

Meters will be checked for proper performance at the survey site at the beginning and end of the survey and during the survey as appropriate. The two meters will be placed side by side near one of the FMS meters and readings reviewed to ensure they are meeting MQOs. A field data sheet has been developed to check performance in the field (Appendix B).

Data Review, Quality Assessment, and Validation

Data Review and Validation

Data will be downloaded from the meters to a spreadsheet and reviewed for outliers and values exceeding MQOs. Outliers and data that exceed the MQOs will be evaluated for the cause of the problem. Slight exceedances will be tolerated with the data qualified and the poorer precision taken into account in data analysis. Exceedances that can be traced to membrane or other equipment failure will result in rejection of the data.

Data completeness will be adequate if at least two sets of transects are completed with data meeting the MQOs at each of two surveys. Each set of transects should include longitudinal transects from at least the middle and right and left sides of the channel, covering most of the distance from the closest approach to the dam downstream to the FMS site.

References

APHA, AWWA, and WEF, 1995. Standard Methods for the Examination of Water and Wastewater, Nineteenth Edition. American Public Health Association, American Water Works Association, and Water Environment Federation. Washington, D.C.

Tanner, D. Q. and H. M. Bragg, 2001. Quality-Assurance Data, Comparison to Water-Quality Standards, and Site Considerations for Total Dissolved Gas and Water Temperature, Lower Columbia River, Oregon and Washington, 2001. Water Resources Investigations Report 01-4273, U.S. Geological Survey, Portland, OR.

Tanner, D. Q., and Johnston, M. W., 2001. Data-Collection Methods, Quality-Assurance Data, and Site Considerations for Total Dissolved Gas Monitoring, Lower Columbia River, Oregon and Washington, 2000. Water-Resources Investigations Report 01–4005, U.S. Geological Survey, Portland, OR.

WDOE, 1992. Field Sampling and Measurement Protocols for the Watershed Assessments Section. Washington State Department of Ecology, Olympia, WA.

Appendix A

Hydrolab Calibration Procedure
Hydrolab TDG Post-Calibration Procedures

HYDROLAB CALIBRATION PROCEDURES (To be Done Prior to Survey)

Hyrolab #______________ Lab barometer ID ___________
TDG sensor #___________ Date barometer last calib. ___________
Survey location _______ Today's date ___________
Survey Date _________ Checked by ___________

1. CALIBRATE TDG WITH DIGITAL PRESSURE GAUGE (MEMBRANE OFF).

Lab BP ________ mm Hydrolab ambient pressure ________ mm Time __________
Baro+100mm: expected/measured ________ /________
Baro+200mm: expected/ measured ________ /________
Baro+300mm: expected/ measured ________ /________

If any readings are >2 mm off, do a 2-point calibration at BP and BP+200 mm and note below.
Calibration BP: calibrated/measured ________ /________
BP+200mm: calibrated/ measured ________ /________

2. INSTALL DRY MEMBRANE AND TEST HYDROLAB WITH PRESSURE GAGE AND CHAMBER.

Lab BP + 200mm = ______ mm
Before applying 200 mm pressure Hydrolab Pressure ________ mm Time _______
After applying pressure Hydrolab Pressure ________ mm Time _______

3. INSTALL SENSOR GUARD AND TEST HYDROLAB WITH CLUB SODA.

Before soda test Hydrolab Pressure ________ mm Time _______
High pressure, soda test Hydrolab Pressure ________ mm Time _______
Low pressure, after soda test Hydrolab Pressure ________ mm Time _______

5. CHECK MEMBRANE FOR INTERNAL MOISTURE AFTER THE OUTSIDE HAS HAD TIME TO DRY

HYDROLAB TDG POST-CALIBRATION PROCEDURES (To be Done at the Conclusion of a Survey)

Today's date ___________ Checked by ___________

1. TEST LOW CALIBRATION WITH MEMBRANE ATTACHED.

Lab BP _________ mm Hydrolab Pressure ________ mm Time _______

2. TEST HYDROLAB WITH DIGITAL PRESSURE GAGE AND PRESSURE CHAMBER.

Lab BP + 200mm = ______ mm
Before applying 200 mm pressure Hydrolab Pressure ________ mm Time _______
After applying pressure Hydrolab Pressure ________ mm Time _______

3. TEST HYDROLAB WITH CLUB SODA.

Before soda test Hydrolab Pressure ________ mm Time _______
High pressure, soda test Hydrolab Pressure ________ mm Time _______
Low pressure, after soda test Hydrolab Pressure ________ mm Time _______

(If the unit does not perform well on #1-3 above, re-evaluate the corresponding site record.)
Remove TDG membrane, clean the membrane, air dry, store with dessicator.
Allow TDG sensor to air dry for at least 24 hours.

Appendix B

Hydrolab TDG Field Inspection/Calibration Sheet

HYDROLAB TDG FIELD INSPECTION/CALIBRATION SHEET

Site ID: ___________ Date: ___________ Arrive time:__________ Personnel: __________________
Weather: ______________________________ Air temperature: ______ °C
Observed spill conditions: _______________________________________
Lab Hydrolab #_______________________ Date last cal._____________
Lab Barometer ID _____ Date last cal.__________ GPS ID ________________

1. Check GPS at benchmark. Time:__________ Bar Press:____________
GPS reading: ____°____'____"N ____°____'____"W Data code:_______________
Benchmark: ____°____'____"N ____°____'____"W ID:__________________

2. Take readings with both meters at Forebay FMS site. Start time:______ Bar Press:____________
DS#:____; Depth:___m; TDG:___mmHg; DO:___mg/L; pH:____; Cond:___uS/cm; Temp:____; Time:____
DS#:____; Depth:___m; TDG:___mmHg; DO:___mg/L; pH:____; Cond:___uS/cm; Temp:____; Time:____
End time:__________ Bar Press:___________

3. After a minimum of 15 minutes, if both Hydrolab readings have not changed 1 mm./2 min, or if meters are changing but difference is constant:
___________ mm (DS#____) - ____________ mm (DS#____) = ___________ mm Time: ________
IF Difference is > 10 mm, do A and B
A. Test both Datasondes with club soda:
DS#____ ; TDG:___________ mm Time: ________
DS#____; TDG:___________ mm Time: ________
B. Test both Datasondes with pressure gage and chamber:
DS#____: ambient___________ mm; plus 200mm__________ mm Time: ________
DS#____: ambient___________ mm; plus 200mm__________ mm Time: ________
IF DATASONDE FAILS EITHER TEST, REPLACE MEMBRANE AND RETEST, OR DO NOT USE.

4. Take reading at Tailwater FMS site Start time:______ Bar Press:____________
DS#:____; Depth:___m; TDG:___mmHg; DO:___mg/L; pH:____; Cond:___uS/cm; Temp:____; Time:____
DS#:____; Depth:___m; TDG:___mmHg; DO:___mg/L; pH:____; Cond:___uS/cm; Temp:____; Time:____
End time:__________ Bar Press:___________

5. Calculate minimum sensor compensation depth (MSCD)
(Meter PT________ - Field BP________) / 23 = _________ m.

6. Deploy moored Datasonde at or below MSCD across river and upstream from FMS.
Take reading with Surveyor side by side with moored Datasonde Bar Press:____________
Depth: _____ m; TDG: ____mmHg; DO: ____mg/L; pH: _____; Cond: ____uS/cm; Temp:_____ Time: ____

7. Conduct transects below dam.

8. Conduct transect above dam.

9. Take reading at Tailwater FMS site Bar Press:____________
Depth: _____ m; TDG: ____mmHg; DO: ____mg/L; pH: _____; Cond: ____uS/cm; Temp:_____ Time: ____

10. Take reading with Surveyor side by side with moored Datasonde. Bar Press:____________
DS#:____; Depth:___m; TDG:___mmHg; DO:___mg/L; pH:____; Cond:___uS/cm; Temp:____; Time:____

11. Take readings at Forebay FMS site Start time:______ Bar Press:____________
DS#:____; Depth:___m; TDG:___mmHg; DO:___mg/L; pH:____; Cond:___uS/cm; Temp:____; Time:____
DS#:____; Depth:___m; TDG:___mmHg; DO:___mg/L; pH:____; Cond:___uS/cm; Temp:____; Time:____
End time:__________ Bar Press:___________

12. Check GPS at benchmark. Time:__________
GPS reading: ____°____'____"N ____°____'____"W Benchmark: ____°____'____"N ____°____'____"W