US Army Corps of Engineers®

Northwestern Division

2014 TOTAL DISSOLVED GAS REPORT

Spill at Bonneville Dam

Columbia Basin Water Management Division
Reservoir Control Center
Water Quality Unit

December 2014

This page is purposely left blank for duplex printing.

2014 TOTAL DISSOLVED GAS REPORT

COLUMBIA RIVER BASIN

December 2014

Water Quality Unit
Reservoir Control Center, Columbia Basin Water Management Division
U. S. Army Corps of Engineers Northwestern Division
Portland, Oregon

Including Material Provided by:
Portland District – U.S. Geological Survey (Portland Office)
Walla Walla District – U.S. Geological Survey (Kennewick Office)
Seattle District – Columbia Basin Environmental
Fish Passage Center

2014 TOTAL DISSOLVED GAS REPORT
COLUMBIA RIVER BASIN

Table of Contents

Table of Contents ..... **i**
List of Tables ..... **iii**
List of Appendices ..... **iii**
List of Acronyms ..... **iv**
Terminology ..... **v**
Part 1 Program Description **1**
1.0 Introduction 1
1.1 Clean Water Act and Endangered Species Act 2
1.1.1 General 2
1.1.2 Corps' Goals 2
1.1.3 Biological Opinions 3
1.1.3.1 Background 3
1.1.3.2 USFWS and NOAA Fisheries BiOps 3
1.1.4 TDG Standards 3
1.1.5 TDG TMDL Progress 6
1.1.5.1 Policy on Chief Joseph Spill Operations 6
1.1.6 Operating Guidelines 6
Part 2 Program Operating Conditions **7**
2.1 Water Year Runoff Conditions 7
2.1.1 Weather 7
2.1.2 Water Supply 11
2.1.3 Reservoir Operation 12
2.1.3.1 General 12
2.1.3.2 Flood Control 13
2.1.3.3 Total River Flow 13
2.1.3.4 7Q10 Flow 16
Part 3 Water Quality Monitoring **18**
3.1 Fixed Monitoring Stations 18
3.2 TDG Monitoring Plan of Action 18
3.3 Changes in the FMS 18
3.4 Malfunctioning Gauge Occurrences 19
3.5 QA/QC on FMS 19
3.5.1 Walla Walla District QA/QC 19
3.5.2 Portland District QA/QC 20
3.5.3 Seattle District QA/QC 21
Part 4 Fish Passage Spill Program **21**
4.1 Spill 21
4.1.1 Fish Operations Plans 22
4.1.2 Fish Passage Spill 22
4.1.3 BiOp Performance Standard Test Operations 23
4.1.4 Long Term Turbine Outages 23

4.1.5 Involuntary Spill 24
4.2 SYSTDG Model.....25
4.2.1 2014 Improvements Made to SYSTDG:.....25
4.3 TDG Monitoring Studies 26
Part 5 Instances of TDG Exceeding WQS.....26
5.1 TDG Instance Calculation Methods.....26
5.2 TDG Instances.....27
5.2.1 110 percent TDG Instances.....27
5.2.2 115 percent and 120 percent TDG Instances 27
5.2.3 Instances of TDG Exceeding 125 percent WQS.....28
5.2.4 TDG Instances in Oregon (Additional Information).....29
5.2.5 7Q10 Flows Days.....29
5.2.6 Comparison of Annual TDG Instances.....30
5.2.7 Types of Daily TDG Instances.....31
Part 6 Gas Bubble Trauma Monitoring 32
6.1 Biological Monitoring Highlights.....32

List of Tables

Table 1 Columbia River Basin Percent Precipitation WY 2014
Table 2 Columbia River Flow WY 2014
Table 3 Dates When 7Q10 Flows Were Exceeded in 2014
Table 4 2014 FOPs Spill Operations
Table 5 2014 Long Term Outages
Table 6 2014 Spill Season Number of TDG Instances Exceeding WQS
Table 7 2014 Spill Season Number of TDG Instances Exceeding Oregon WQS
Table 8 Number of Days When 7Q10 Flows Were Exceeded in 2014
Table 9 2014 Annual Comparison of TDG Instances Exceeding WQS
Table 10 2014 Spill Seasons Types and Number of TDG Instances

List of Figures

Figure 1 Basin Precipitation Relative to Average, October, 2013-January 2014
Figure 2 Basin Temperatures, January, 2014
Figure 3 Basin Temperatures, February 2014
Figure 4 Basin Precipitation Relative to Average, March 2014
Figure 5 2014 Water Supply Forecast at The Dalles
Figure 6 2014 Bonneville Dam Flow and Spill
Figure 7 2014 Ice Harbor Dam Flow and Spill
Figure 8 2014 Chief Joseph Dam Flow and Spill
Figure 9 2014 Lower Granite Dam Flow and Spill

List of Appendices

Appendix A Monitoring Stations
Appendix B Corps of Engineers Plan of Action for Dissolved Gas Monitoring in 2010-14
Appendix C Fish Operations Plans
Appendix D FOP Implementation Reports With Hourly Spill, Flow, and TDG
Appendix E Percent TDG Instance Tracking
Appendix F Statistical Evaluation of SYSTDG
Appendix G Walla Walla District TDG Report
Appendix H Portland District TDG Report - USGS Data Series Report
Appendix I Seattle District TDG Report
Appendix J Gas Bubble Trauma Monitoring and Data Reporting
Appendix K TDG TMDL Implementation Summary

List of Acronyms

The following acronyms are used throughout this report.

BiOp	Biological Opinion
BPA	Bonneville Power Administration
Corps	U.S. Army Corps of Engineers
CRT	Columbia River Treaty
ESA	1973 Endangered Species Act
FCOP	Flood Control Operating Plan
FCRPS	Federal Columbia River Power System
FMS	fixed monitoring station
FOP	Fish Operations Plan
GBT	gas bubble trauma
kcfs	thousand cubic feet per second
kaf	thousand acre feet
Maf	million acre-feet
MOP	minimum operating pool
NOAA Fisheries	National Oceanic and Atmospheric Administration, Fisheries
NWRFC	Northwest River Forecast Center
ODEQ	Oregon Department of Environmental Quality
PUD	Public Utility District
QA	quality assurance
QC	quality control
RCC	Reservoir Control Center
Reclamation	United States Bureau of Reclamation
RPA	Reasonable and Prudent Alternative (from the Biological Opinion)
SSARR	Streamflow Synthesis and Reservoir Regulation model
TDG	total dissolved gas
TMT	Technical Management Team
TMDLs	Total Maximum Daily Loads
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VARQ	Variable Q, a variable flow associated with Libby flood control
WDOE	Washington Department of Ecology
WQS	Water Quality Standards
WY	water year

Terminology

The U.S. Army Corps of Engineers (Corps) provides the following definitions used throughout this report.

2014 Supplemental BiOp[1]: The current governing Biological Opinion for the Federal Columbia River Power System. It recommends a comprehensive series of actions to avoid jeopardizing 13 Endangered Species Act (ESA)-listed salmon and steelhead species throughout their life cycle and adverse modification of designated critical habitat.

FCRPS Action Agencies: The three Federal agencies responsible for the operation of the Federal Columbia River Power System (FCRPS) are the Corps, Bureau of Reclamation (Reclamation), and Bonneville Power Administration (BPA).

Fish Passage Spill: The Corps affirmatively decides to spill for the benefit of juvenile fish passage at the four lower Snake River and four lower Columbia River dams, in accordance with the operative biological opinions and in a manner that is consistent with the Clean Water Act. The 2014 Supplemental BiOp RPA action 29 calls for the Action Agencies to provide spill at these dams to improve juvenile fish passage, but not to exceed applicable state water quality standards for TDG. The dates and levels for spill at each dam may be modified through the implementation planning process and adaptive management decisions. At some Corps dams, the amount of spill to aid fish passage is a specified level (i.e., flow rate or percent of total river flow), while at others, the Corps spills up to the applicable state TDG criteria, referred to as the "gas cap." The maximum spill level at a given dam that meets, but does not exceed the gas cap is referred to as the spill cap.

Gas Cap: Voluntary spill for fish passage up to the applicable state TDG criteria.

Hydraulic capacity: The maximum water flow rate that a hydro power facility can pass through the turbines. Capacity can be limited by outages, operating limits, and the carrying of mandatory power reserves by the project.

Involuntary Spill: In contrast to spilling for the benefit of juvenile fish passage at the four lower Snake River and four lower Columbia River dams, involuntary spill is driven largely by hydrologic capacity at each dam; the quantity of water that exceeds the capacity of a dam to either temporarily store the water upstream of the dam or pass the water through its turbines. In these circumstances, water must be released through the spillway. Involuntary spill occurs due to either **Lack of Load** or **Lack of Turbine**, but can also occur as a result of the management of reservoirs for flood risk[2], scheduled or unscheduled

[1] The 2014 Supplemental BiOp considered the Action Agencies' 2014-2018 Implementation Plan (2014-2018 IP) and the 2013 Comprehensive Evaluation and also incorporates both the 2008 NOAA BiOp and the 2010 Supplemental BiOp. References to the 2014 Supplemental BiOp also include, as appropriate, references to prior BiOps.

[2] The Corps directs operations of storage projects in the Columbia Basin to manage flood risk. Projects' reservoir pools are drafted in the winter and early spring to provide storage space to capture part of the spring runoff, reducing peak flows in the river. This flood risk management operation may require spill from storage reservoirs (not at projects with fish passage facilities), which may result in elevated levels of TDG in the river system. The Corps and other action agencies work to manage system flood risk operations in a manner

turbine unit outages or transmission outages of various durations, passing debris, or any other operational and/or maintenance activities required to manage dam facilities for safety and authorized project uses.

(a) Lack of Load Spill: Occurs when the available market for hydropower is less than the power that could be produced by the current river flow with available turbine capacity. When BPA cannot access sufficient market to sell hydropower and there is insufficient storage capability, the river flow must be released over the spillway or through other regulating outlets. Lack-of-load spill generally occurs during times of high flows (e.g., in the spring or fall when power demands are low both in California and the Pacific Northwest). Releases from upstream storage dams during high load periods (generally morning and evening) can result in high flows at downstream dams during low load periods (e.g., middle of the night), causing lack of load spill. Lack of load spill is managed on a system-wide basis to distribute TDG levels across the Federal projects using the spill priority list.

(b) Lack of Turbine Spill: Occurs when flows exceed the hydraulic capacity of the available power generation facilities at a specific dam. Lack of turbine spill can be affected by high river flows, planned and unplanned unit outages, planned and unplanned transmission outages, and other transmission constraints. Any of these conditions physically limit the potential for hydropower production. Lack of turbine spill will generally be the amount of project outflow in excess of the maximum amount that can be released through all available generators and other outlet structures (e.g., sluiceways and fish ladders). In general, when this condition occurs, the affected project will be operating at maximum generation, but within the Fish Passage Plan turbine operating criteria capability to minimize the amount of spill.

Lack of turbine spill can also occur when turbines cannot be used because their capacity must be held in reserve to provide mandatory reserve power capacity (reserves) for contingencies and load balancing. **Reserves** (Reserve Power Capacity) are the amount of generation capacity above the amount currently in use that is immediately available to maintain system reliability. At projects that must carry reserve power capacity, these projects can only be loaded to the maximum available generation minus the reserve capacity allocated to that project. Spill for maintaining reserves primarily occurs at Grand Coulee, Chief Joseph, The Dalles, John Day, Bonneville, and occasionally McNary dams.

(c) Other Spill: Occur for the purposes of passing debris or operational and/or maintenance activities required to manage dam facilities for safety and multiple uses. These are infrequent and generally of short duration.

Percent TDG: Percent of total dissolved gas saturation (TDG) or concentration in the water-body. This may also appear as %TDG in the text or tables.

---

that reduces the need to spill at levels that exceed TDG water quality standards; however, there are conditions in which fulfilling the Corps' flood risk management authorities necessitates drafting storage reservoirs.

SSARR: The Streamflow Synthesis and Reservoir Regulation (SSARR) model is an operational hydrologic model of a river system used for flood control studies, planning studies, and daily streamflow forecasting.

Spill cap: The estimated spill rate to achieve the appropriate level of spill to meet the applicable state water quality standards (WQS), generally 115 percent in the forebay or 120 percent in the tailwater, or to meet target levels of TDG identified in the Spill Priority List. The maximum project spill level that meets but does not exceed the gas cap is referred to as the spill cap.

Spill Priority List: Identifies the order and amount of spill at the Corps' Columbia River Basin dams and Grand Coulee Dam for management of expected TDG production in the system. The Spill Priority List is primarily used to manage system-wide TDG levels throughout the year and is applicable for all spill conditions. Information from the Spill Priority List is used to guide where and to what extent BPA allocates reserves to the various projects and other actions that may limit system reserve obligations.

Spill Shift: Spill shift is the act of shifting generation from one project to another to better manage spill and TDG in the river. This is usually used at Chief Joseph Dam and Grand Coulee Dam.

TDG Instance: An instance occurs when TDG levels exceed applicable state water quality standards and applicable waivers[3] (Oregon) and criteria adjustments (Washington).

TMT: The Technical Management Team (TMT) is an interagency sovereign technical group responsible for making recommendations on operations for fish to the Federal agency with authority to operate FCRPS projects. This group is comprised of representatives from sovereign entities including five Federal agencies: BPA, Reclamation, National Oceanic and Atmospheric Administration (NOAA) Fisheries, U.S. Fish and Wildlife Service (USFWS), Corps, four states (Idaho, Oregon, Montana, and Washington), and participating Tribes.

Unit Outage: A unit outage is a period of time when a generating unit cannot be in operation because of maintenance or repairs.

[3] At the request of the Oregon Department of Environmental Quality, the term "waiver" will now be referred to as "modification".

Part 1 Program Description

1.0 Introduction

This report describes the U.S. Army Corps of Engineers' (Corps) Columbia River Basin spill and water quality monitoring program for 2014 and covers the Columbia and Snake River dams located in Washington and Oregon. This report was developed to meet the Corps' water quality program reporting responsibilities related to the Oregon Department of Environmental Quality (Oregon) Total Dissolved Gas (TDG) modification, the Washington Department of Ecology (Washington) TDG criteria adjustment and the 2002 and 2003 TDG Total Maximum Daily Loads (TMDLs) for the lower Columbia and lower Snake rivers.

This report provides information requested by Oregon and Washington including weather, flow and runoff conditions for the spill season, information regarding project operations, data from the physical and biological monitoring programs, description and results of any biological or physical studies of spillway structures and prototype fish passage devices, and progress on implementing measures contained in the lower Columbia and Snake rivers TDG TMDL documents. This report also includes documentation on the performance of the TDG monitoring system.

The following is a list of the appendices included in this report. Note: Appendices with * are provided electronically on the website at:
http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2014

- Appendix A - General overview of the monitoring system with information on the fixed monitoring stations (FMS), updated in 2014.
- Appendix B - Dissolved Gas Monitoring Plan of Action for 2010 – 2014, updated in 2013.
- Appendix C - Fish Operations Plans (FOPs) for 2014 spill season.
- Appendix D - 2014 monthly FOP implementation reports for the fish passage season. This appendix contains graphs of flow, spill and high 12-hour percent TDG average along with variance tables. They can also posted on the TMT web site.
- Appendix E - Summary of TDG instance types when TDG levels exceed state water quality standards (WQS).
- Appendix F - Detailed evaluation of the SYSTDG model performance during the 2014 spill season.
- Appendix G - Walla Walla District report on the Quality Assurance/Quality Control (QA/QC) review for TDG and temperature monitoring gauges at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary dams.
- Appendix H- Portland District report on the QA/QC review for TDG and temperature monitoring gauges at John Day, The Dalles, Bonneville, and the Warrendale and Camas/Washougal sites.
- Appendix I - Seattle District report on the QA/QC review for TDG and temperature monitoring gauges at Chief Joseph Dam.

- Appendix J - Gas Bubble Trauma (GBT) Monitoring and Data Reporting by the Fish Passage Center.
- Appendix K* - TDG TMDL implementation summary providing an overview of the status of the Corps' TDG TMDL activities.

1.1 Clean Water Act and Endangered Species Act

1.1.1 General

TDG and water temperature are the primary water quality parameters monitored by the Corps in the mainstem Columbia and Snake rivers in the states of Oregon and Washington. TDG and to some extent temperature may be influenced by dam water management operations (e.g., water released over the dam spillways, releases through the powerhouses and other facilities, and forebay and tailwater water surface elevations), as well as environmental factors including ambient temperatures and wind conditions.

The monitoring performed by the Corps is part of a larger interagency water quality monitoring system that includes the Reclamation and the Washington Public Utility District (PUD) monitoring systems (as conducted by Douglas County PUD, Chelan County PUD, and Grant County PUD).

1.1.2 Corps' Goals

The Corps' policy is to comply with applicable WQS to the extent practicable regarding nationwide operation of water resources projects. The general policy is summarized in the **Corps Digest of Water Resources Policies and Authorities**, Engineering Pamphlet 1165-2-1, Section 18-3.b, page 18-5 dated July 30, 1999, which states:

> Although water quality legislation does not require permits for discharges from reservoirs, downstream water quality standards should be met whenever possible. When releases are found to be incompatible with state standards they should be studied to establish an appropriate course of action for upgrading release quality, for the opportunity to improve water quality in support of ecosystem restoration, or for otherwise meeting their potential to best serve downstream needs. Any physical or operational modification to a project (for purposes other than water quality) shall not degrade water quality in the reservoir or project discharges.

1.1.3 Biological Opinions

1.1.3.1 Background

During the 1990s, Snake and Columbia River salmonids were listed under the Endangered Species Act (ESA). Through ESA consultations, the Corps implemented a variety of operational and structural measures that were called for in biological opinions to improve the survival of listed salmonids. The 2014 Supplemental BiOp calls for the Corps to provide spill for juvenile fish migration in the FCRPS. The Action Agencies annually develop a Fish Operations Plan (FOP) that provides detailed information on the implementation of the BiOp spill and transport operations for fish passage. For this reporting period, the FCRPS BiOps that the Corps is implementing are the 2000 U.S. Fish and Wildlife Service (USFWS) and the 2014 Supplemental BiOp.

1.1.3.2 USFWS and NOAA Fisheries BiOps

USFWS 2000 BiOp

According to the FCRPS actions addressed in the USFWS 2000 BiOp, operational and structural changes are to be made to reduce uncontrolled spill and the effects of high TDG at lower Columbia River dams if it is determined that bull trout are affected by the FCRPS.

NOAA Fisheries 2014 FCRPS BiOp

The 2014 Supplemental BiOp RPAs includes operations that have an effect on water quality: RPA Actions 4, 15, 26, 29 and 32. For the 2014 fish migration season, the Federal agencies operated the FCRPS in accordance with the 2014 FOPs, which are provided in Appendix C.

The FCRPS BiOps may be found at the following website:
http://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp.aspx

1.1.4 TDG Standards

The following are the applicable TDG WQS as currently approved by the states of Oregon and Washington.

State of Oregon:
OAR 340-041-0031:

- Waters will be free from dissolved gases, such as carbon dioxide, hydrogen sulfide, or other gases, in sufficient quantities to cause objectionable odors or to be deleterious to fish or other aquatic life, navigation, recreation, or other reasonable uses made of such water.
- Except when streamflow exceeds the ten-year, seven-day average flood, the concentration of TDG relative to atmospheric pressure at the point of sample collection may not exceed 110 percent of saturation. However, in hatchery-receiving waters and other waters of less than two feet in depth, the concentration of TDG relative to atmospheric pressure at the point of sample collection may not exceed 105 percent of saturation.

OAR 340-041-104(3): Total Dissolved Gas. The Commission may modify the total dissolved gas criteria in the Columbia River for the purpose of allowing increased spill for salmonid migration. The Commission must find that:

(a) Failure to act would result in greater harm to salmonid stock survival through in-river migration than would occur by increased spill;

(b) The modified total dissolved gas criteria associated with the increased spill provides a reasonable balance of the risk of impairment due to elevated total dissolved gas to both resident biological communities and other migrating fish and to migrating adult and juvenile salmonids when compared to other options for in-river migration of salmon;

(c) Adequate data will exist to determine compliance with the standards; and

(d) Biological monitoring is occurring to document that the migratory salmonid and resident biological communities are being protected;

(e) The Commission will give public notice and notify all known interested parties and will make provision for opportunity to be heard and comment on the evidence presented by others, except that the Director may modify the total dissolved gas criteria for emergencies for a period not exceeding 48 hours;

(f) The Commission may, at its discretion, consider alternative modes of migration.

The Corps received a TDG waiver on June 24, 2009, from the State of Oregon effective for the 2010-2014 spill seasons from April 1 – August 31. The Environmental Quality Commission approved a modification to the 110 percent total dissolved gas water quality standard for fish passage spill at McNary, John Day, The Dalles, and Bonneville dams on the lower Columbia River, subject to the nine conditions. Two operational conditions have been selected from the TDG modification list and are highlighted for the purposes of this report:

(iii) Spill must be reduced when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 120 percent of saturation in the tailraces of McNary, John Day, The Dalles, and Bonneville dams' monitoring stations.

(iv) Spill must be reduced when instantaneous TDG levels exceed 125 percent of saturation for any 2 hours during the 12 highest hourly measurements per calendar day in the tailraces of McNary, John Day, The Dalles, and Bonneville dams' monitoring stations.

State of Washington:

WAC 173-201A-200(1)(f): Aquatic life total dissolved gas criteria. TDG is measured in percent saturation. Table 200 (1)(f) lists the maximum TDG criteria for each of the aquatic life use categories.

TABLE 200 (1)(f)
Aquatic Life Total Dissolved Gas Criteria in Fresh Water

Category	Percent Saturation
Char Spawning and Rearing	Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.
Core Summer Salmonid Habitat	Same as above.
Salmonid Spawning, Rearing, and Migration	Same as above.
Salmonid Rearing and Migration Only	Same as above.
Non-anadromous Interior Redband Trout	Same as above.
Indigenous Warm Water Species	Same as above.

(i) The water quality criteria established in this chapter for TDG shall not apply when the stream flow exceeds the seven-day, ten-year frequency flood.

(ii) The TDG criteria may be adjusted to aid fish passage over hydroelectric dams when consistent with a department approved gas abatement plan. This plan must be accompanied by fisheries management and physical and biological monitoring plans. The elevated TDG levels are intended to allow increased fish passage without causing more harm to fish populations than caused by turbine fish passage. The following special fish passage exemptions for the Snake and Columbia rivers apply when spilling water at dams is necessary to aid fish passage:

- TDG must not exceed an average of 115 percent as measured in the forebays of the next downstream dams and must not exceed an average of 120 percent as measured in the tailraces of each dam (these averages are measured as an average of the twelve highest consecutive hourly readings in any one day, relative to atmospheric pressure); and
- A maximum TDG one hour average of 125 percent must not be exceeded during spillage for fish passage.

On June 30, 2010, Washington approved the gas abatement plan, submitted March 22, 2010. Two conditions are highlighted for the purpose of this report:

1) This approval shall extend through the end of February 2015 and apply to Corps' dams on the Columbia and Snake rivers in Washington State.

2) This approval allows spill to increase the dissolved gas levels above 110 percent of saturation to aid fish passage, but not to exceed 125 percent of saturate as a one-hour average. Gas saturation may not exceed 120 percent in the tailrace and 115 percent in the forebay of the next downstream dam as measured by the highest 12-hour, consecutively-averaged value in any one day.

1.1.5 TDG TMDL Progress

The Oregon modification and the Washington criteria adjustment request an update on the progress of implementing actions recommended in the "TMDL for the Lower Columbia River Total Dissolved Gas (September 2002)" and the "TMDL for the Lower Snake River Total Dissolved Gas (April 2003)" reports. Appendix K provides the status of the Corps' TDG TMDL implementation activities.

1.1.5.1 Policy on Chief Joseph Spill Operations

In 2008, 19 flow deflectors were installed at Chief Joseph Dam to reduce TDG production when spill is necessary. During testing and in actual operations, the spillway flow deflectors have successfully reduced TDG levels associated with spillway releases when inflow TDG levels approach approximately 120 percent. In addition, for lower TDG levels, Chief Joseph Dam can spill a significant amount of water without increasing downstream TDG levels. The Corps' spill management policy utilizes the spillway flow deflectors at Chief Joseph Dam as an effective means for moderating system TDG levels under involuntary spill conditions.

1.1.6 Operating Guidelines

The Corps' Reservoir Control Center (RCC) Water Quality Unit is responsible for monitoring the TDG and water temperature conditions in the forebay and the tailwater of the Columbia and Snake River dams, and selected river sites. The Corps' district water quality staff operates and maintains the water quality gauges at the FMSs. In accordance with the Corps' Northwestern Division operational water management guidelines, spill levels and spill patterns at the dams are monitored and changed so that TDG levels are consistent with the 2014 Supplemental BiOp and applicable state water quality standards (WQS).

Washington's method of calculating percent saturation TDG is "an average of the twelve highest consecutive hourly readings in any one day." For the remainder of this report, this method is referred to as the "Washington method." Oregon applies the state WQS to the tailwater gauges (below the dams in Oregon: McNary, John Day, The Dalles and Bonneville) using the average of the 12 highest hourly readings in a given day. For the remainder of this report, this method is referred to as the "Oregon method." Part 5 of this report provides detailed information on the TDG instances using the Oregon and Washington methods (ODEQ/WDOE respectively).

The Corp's four projects on the lower Columbia River share the state border. Whichever calculation method (Washington and Oregon) is the more stringent for the projects that are in both states (i.e. McNary, John Day, The Dalles, and Bonneville dams) is the one that is applied. The resulting daily averages are shown for both states in the web report

http://www.nwd-wc.usace.army.mil/ftppub/water_quality/12hr/.

The tailwater TDG values at these four projects include both states' results, the value applied is shown in black text (red text if a TDG instance occurred), and the other less stringent value has strikethrough and grey text. In addition, the states have also set forth conventions in reporting these values. Changes made to state WQS exceptions since 2006 were applied to operations in 2014, and the Corps has adjusted operations based on the most stringent (or restrictive) of the two applicable standards and calculation methods.[4] The Camas/Washougal FMS was removed from the 2014 TDG management and was not used as limiting feature of the Bonneville spill cap.

Part 2 Program Operating Conditions

2.1 Water Year Runoff Conditions

This part provides an overview of the water year runoff and reservoir operations, including a description of the weather, water supply, and reservoir operations.

2.1.1 Weather[5]

In 2014, the region's weather was typically warmer and drier than normal. August of 2013 through September of 2014 Basin-wide temperatures varied widely and were above normal (1.3ºF/0.7ºC).

The Columbia River Basin WY 2014 (over the 12-month period, October 2013 – September 2014) was below average in precipitation affecting Columbia River flows and below average in the region affecting Snake River flows as shown in Table 1. The accumulative precipitation as reported by the Northwest River Forecast Center (NWRFC)

---

[4] Oregon specified these conventions in an internal management directive, "The Use of Significant Figures and Rounding Conventions in Water Quality Permitting" from 2013. http://www.deq.state.or.us/wq/pubs/imds/SigFigsIMD.pdf ; From the Oregon guidance document, Oregon DEQ would typically use 3 significant digits. When rounding calculated values to 3 significant digits if the digit that is being dropped is a 5 rounding the preceding digit up. Thus the total dissolved gas calculated level of 120.5 % would be reported as "121 %TDG", 3 significant digits and the 5 being dropped and the last digit rounding upward. Washington specified its conventions in a memo, "Clarification of WAC 201A-200(1)(f)(ii), Measuring Total Dissolved Gas (TDG) During Fish Spill on the Columbia and Snake Rivers" from 2008. http://www.nwd-wc.usace.army.mil/ftppub/water_quality/12hr/wa/WA_TDG_Calculation.pdf; From the Washington memo, it states, "Round 12 hour average to nearest whole number." Therefore, TDG would be reported as 111% or 112% per either states requirements, not 111.4% or 111.5% and TDG instances would be calculated accordingly.

[5] 2014 Annual Report of the Columbia River Treaty, Canada and United States Entities (2014 Annual Treaty Report). http://www.nwd-wc.usace.army.mil/PB/PEB_08/docEntities.htm

for WY 2014 (from October 2013 through September 2014) was 92 percent of average (1971 to 2000) in the Columbia River above Grand Coulee Dam, 83 percent of normal in the Snake River above Ice Harbor Dam, and 84 percent of normal in the Columbia River above The Dalles Dam.

TABLE 1
Columbia River Basin Percent Precipitation
WY 2014

Location	Columbia River above Grand Coulee	Snake River above Ice Harbor	Columbia River above The Dalles
October 2013	24	38	30
November 2013	86	48	63
December 2013	62	42	48
January 2014	63	50	55
February 2014	133	163	149
March 2014	211	168	182
April 2014	102	97	97
May 2014	95	48	70
June 2014	107	66	86
July 2014	57	51	56
August 2014	88	192	117
September 2014	91	108	90
WY Average	92	83	84

Note: Basin Precipitation as percentage of the 1981-2010 period

Although precipitation was slightly below average for the 2013-14 water year, the year was punctuated by one of the sharpest weather swings observed in many years. The swing, which occurred during the second half of the winter, led to rapid and sustained snowpack gains across the entire basin, and turned what was initially becoming a basinwide drought into above average spring and annual runoff in the Columbia River Basin.

For the second consecutive winter in a row, sea surface temperatures in the tropical Pacific were near the long term average. Thus, the El Niño/Southern Oscillation was not a key player in regional weather. However, an unusually persistent, intra-seasonal blocking pattern and strong polar vortex over Hudson Bay tended to lock the jet stream in place for long periods of time for much of the year. Just before the start of the water year, the evolving blocking pattern locked into a position favoring wet conditions over the Columbia basin. Flowing off the west Pacific, the jet stream guided a series of strong storm systems across the region during September, 2013. Rare September flow spikes in some headwaters in Montana, Washington, and British Columbia were observed as the Columbia Basin had its wettest September since reliable basin-average records were kept starting in 1976-77.

Then the jet stream locked into a position which would remain essentially unchanged through the last week of January, 2014. During this period, the jet stream generally flowed across Alaska and the Yukon Territory before diving south into the central and eastern United States. That left a persistent ridge along the West Coast which blocked all but the strongest Pacific frontal systems from crossing the Columbia Basin. Systems that did break through the block either weakened before crossing the Cascade mountains, or were forced over the top of the ridge and clipped the upper Columbia, Kootenay and Flathead Basins. By mid-January, concerns for a basinwide drought emerged as accumulated precipitation deficits continued to build. Only 49 percent of the usual precipitation fell between 1 October 2013 and 31 January 2014, making it the driest start to the water year since at least 1977. Temperatures initially held near or slightly below average which allowed whatever precipitation that did fall to build a modest snowpack. However, as the ridge strengthened in January, temperatures rose well above average across the Basin and began to deplete already meager lower elevation snowpacks.

Figure 1: Basin Precipitation Relative to Average, October, 2013-January 2014

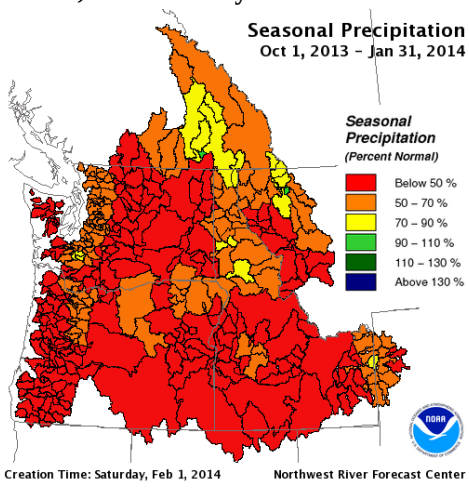
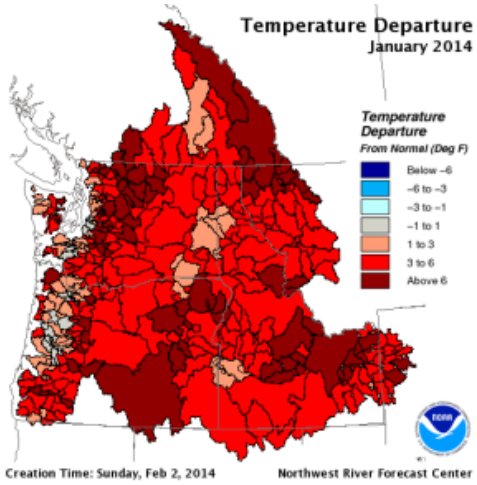


Figure 2: Basin Temperatures, January, 2014.



As February began, though, a subtle but critical pattern change commenced which resulted in one of the stormiest late-winter periods on record in the Columbia Basin. Instead of coming directly off Alaska and bypassing the region to the east, the jet stream realigned just enough to start flowing off the north Pacific. Not only did that open the door for very moist and windy storm systems to move off the Pacific, but it allowed the now intense Arctic air mass over central and southern Canada to expand into the Columbia Basin. Temperatures plummeted to record lows several times across the northern two-thirds of the basin in what became the coldest month in the region since January, 2013. Above Grand Coulee, basin average temperatures were an astounding 4.0°C/7.4°F below average for the entire month of February. Snow levels dropped to sea level twice during the first half of February, which combined with incoming Pacific storms resulted in crippling snowstorms in Vancouver, Seattle, Portland, and Spokane. Meanwhile, in the high mountains of the upper Columbia, western Montana and central Idaho, snow fell at the rate of a meter a day during three separate storms on 5-7 February, 10-12 February, and 17-19 February. While the Arctic air mass modified somewhat in March, the jet stream remained aimed at the region from the cold north Pacific, and this kept the low elevation rain falling and

mountain snows accumulating. In a stunning turn of events after such a dry start to the water year, the region experienced its second wettest February since 1977, followed by its wettest March on record – smashing the "Miracle March" basin average record in 2012 by 0.80 inches.

Figure 3: Basin Temperatures, February 2014

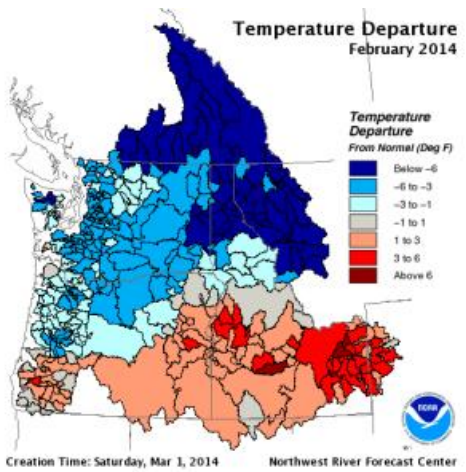
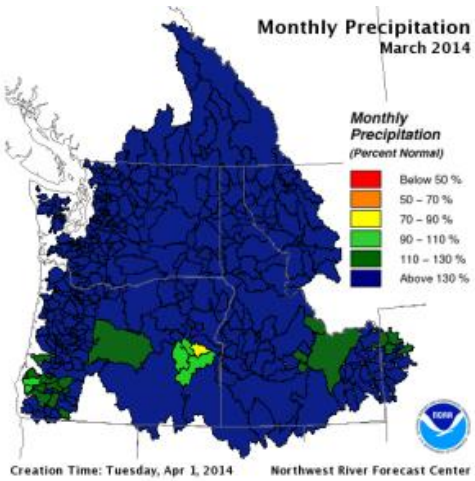


Figure 4: Basin Precipitation Relative to Average, March 2014.



As concerns about a drought were replaced by new concerns about spring flooding, the jet stream shifted back to the north by early April, and a new but weaker blocking ridge developed over California. This ridge ended any hopes of drought recovery south of the region, but it allowed cool air to hold over the Columbia Basin and allowed cold fronts to move off the Pacific. This helped to build a little more snowpack prior to the start of the spring runoff in the northern half of the basin. By May, temperatures slowly warmed and the region began to dry out as the ridge once again expanded north. The result was a very orderly spring runoff with no major flood spikes despite a snowpack which by the end of April was around 122 percent of the long-term normal in the Columbia Basin.

The large swings in weather conditions, though, were not quite over. The persistent ridge which developed in April and expanded north along the west coast in May strengthened and shifted inland into the heart of the basin by early July. Not only did this amplify the usual dryness across the basin, but it allowed persistent heat to take hold for much of July and August. This was enough for the some areas west of the Cascades to have one of their hottest June-August periods since the 1930s. The persistent ridge finally progressed slightly east to the Continental Divide in August, which helped draw moisture north from an unusually active North American monsoon season. That generated several rounds of strong thunderstorms in August, particularly in the U.S. portions of the basin which are normally quite dry in August. The same general trend continued in the Snake River Basin during September, while a couple of unusually early and strong fronts brought heavy rains to much of southern British Columbia and both the Oregon and Washington coasts during the second half of the month.

In the end, the weather swings between very warm and very cold canceled each other out, with annual temperatures averaging slightly above the long term normal. Basin precipitation was below average, but because heavy precipitation fell at the right time of the winter and coincided with unusually cold temperatures, the resulting above average snowpack supported above average spring and annual runoff this year.

2.1.2 Water Supply

The NWRFC April 1, 2014, forecast of January through July runoff for the Columbia River above The Dalles Dam was 92 Maf; however, the actual observed runoff volume was 108 Maf. This value is high compared to the historical average (1981-2010) January-July runoff volume of 101 Maf.

The WY 2014 total runoff volume, unregulated flow as measured at The Dalles Dam (August 2013-July 2014) was 135 Maf, which is 104 percent of the 1981-2010 average. For WY 2014, the daily average unregulated streamflow in the basin above The Dalles Dam was approximately 4 percent higher than the WY 2013 average flow (100 percent of normal). Table 2 provides WY 2014 average monthly unregulated streamflow and the percentage of the 1981-2010 average monthly flows for the Columbia River at Grand Coulee and The Dalles dams. Unregulated flows provide a general perspective on the water supply for that month or year from rainfall or snowmelt. At The Dalles Dam, the average monthly unregulated inflow during the spring runoff was highest in May, with daily flows peaking on May 30, 2014, at 594 kcfs[6].

[6] Based on the USACE Streamflow Synthesis and Reservoir Regulation (SSARR) model run

TABLE 2
Columbia River Flow in WY 2014

Time Period	At Grand Coulee		At The Dalles	
	Unregulated Flow (kcfs)	% of Average	Unregulated Flow (kcfs)	% of Average
October 2013	43	95	85	102
November 2013	37	77	78	83
December 2013	30	74	72	79
January 2014	31	78	75	77
February 2014	30	68	91	79
March 2014	71	118	190	128
April 2014	111	92	220	95
May 2014	311	123	493	120
June 2014	325	111	463	105
July 2014	196	110	256	108
August 2014	90	97	127	102
September 2014	60	107	86	99
WY Average	112	106	187	104
Note: Unregulated Flows exclude the effects of regulation provided by storage reservoirs				
Note: Runoff is an average of 1981-2010 period				

2.1.3 Reservoir Operation

The following overview of reservoir operations includes a description of flood control, streamflow, operations, and 7Q10 flows.

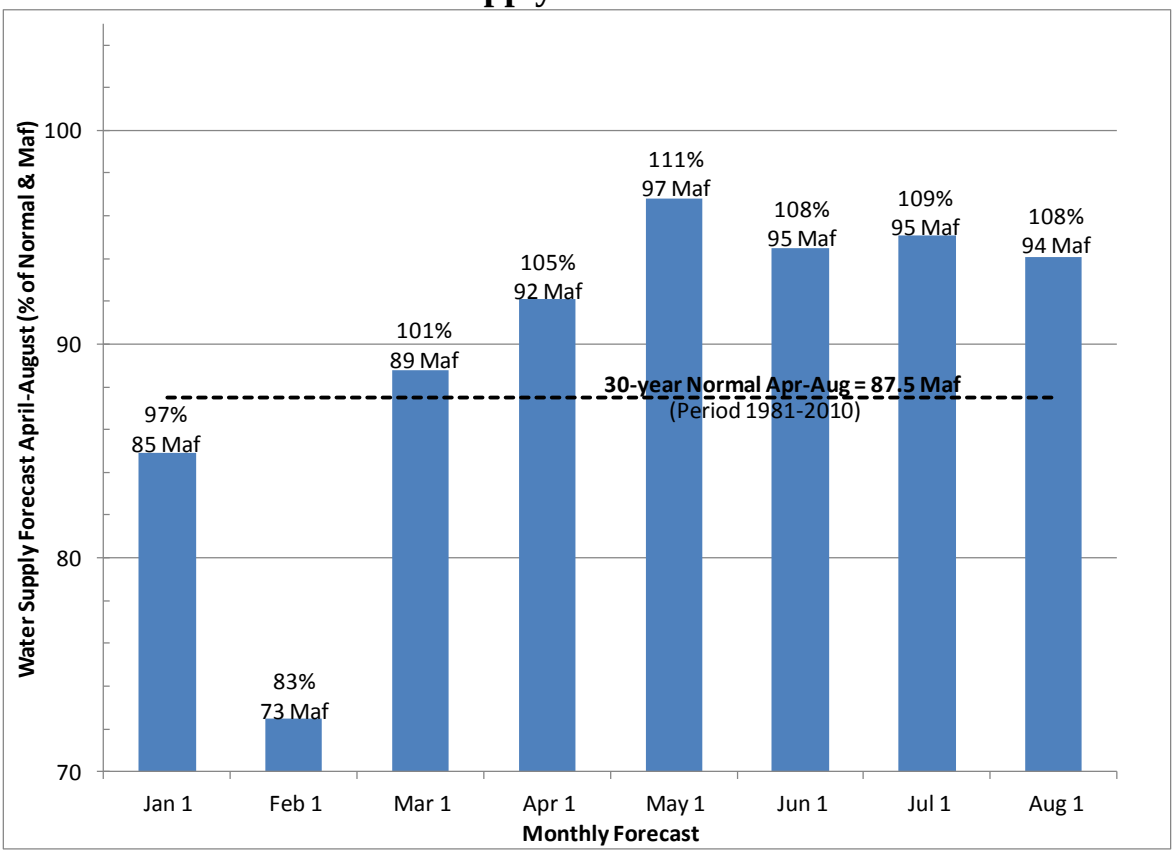
2.1.3.1 General

The WY 2014 began with Grand Coulee Dam storage at 92.1 percent full. Projected water supply forecasts for The Dalles decreased rapidly from January to February then increased back to average in March as shown in Figure 5. The shape of the runoff at Bonneville Dam resulted in generally one peak with flows above 300 kcfs from early May to early June (Figure 6).

Generally, reservoir operation objectives included: reaching the upper rule curve elevation on or about April 10 at the U.S. storage projects; refill on, or about June 30; and drafting reservoirs to summer draft limits. The spring seasonal flow objectives[7] were met at Priest Rapids (135 kcfs) and McNary Dam (260 kcfs), but not at Lower Granite Dam (100 kcfs). The summer seasonal flow objectives were not met at either McNary Dam (200 kcfs) or Lower Granite Dam (53 kcfs).

[7] The spring and summer flow objectives are defined in the 2014 Water Management Plan.

FIGURE 5
2014 Water Supply Forecast at The Dalles



2.1.3.2 Flood Control

The NWRFC 2014 water supply forecasts were initially below average but increased during the season (March and April) to somewhat above average at all the Columbia River sub-basins. Inflow forecasts and reservoir regulation modeling were performed weekly throughout the winter and spring. The FCRPS dams were operated to their specified flood control elevations based on the information available during the season. This included the treaty projects operating to the May 2003 Flood Control Operating Plan (FCOP) except for Libby Dam, which operated to Variable Flow (VARQ) drafts. The unregulated peak flow, based on the Corps' system regulation model (SSARR) at The Dalles Dam, was estimated at 594 kcfs on May 30, 2014, and a regulated peak flow of 358 kcfs occurred on May 27, 2014, as measured at the U.S. Geological Survey (USGS) gauge at The Dalles, Oregon. The unregulated peak stage at Vancouver, Washington, was calculated to be 21.3 feet on May 30, 2014, and the highest observed stage was 11.5 feet on May 28, 2014.

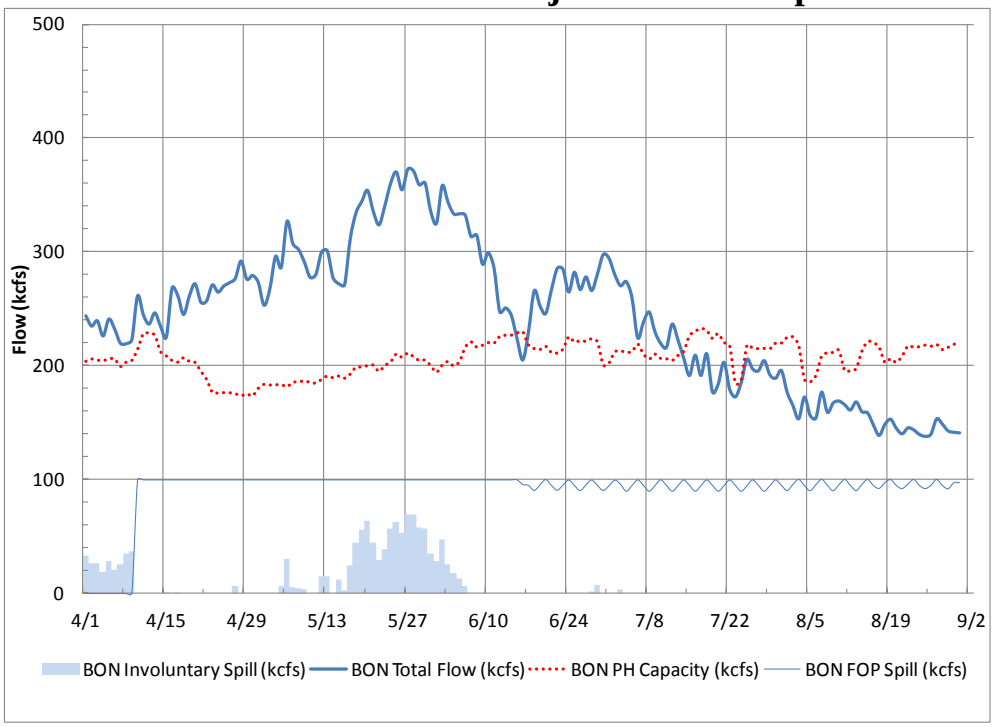
2.1.3.3 Total River Flow

Daily average observed streamflows were generally average in 2014 due to the average runoff volume (as seen at The Dalles). This resulted in average to below average releases at some of the FCRPS projects as demonstrated in the three examples shown below: Bonneville for the lower Columbia, Ice Harbor for the lower Snake and Chief Joseph for the middle Columbia reach.

Daily average total river flow on the lower Columbia River, as measured at Bonneville Dam, from April 1 through August 31, ranged from 138 kcfs to 372 kcfs, averaging 244 kcfs (Figure 6). Total river flows began to recede gradually in early June and continued a steady recession until the end of August when flows reached 141 kcfs.

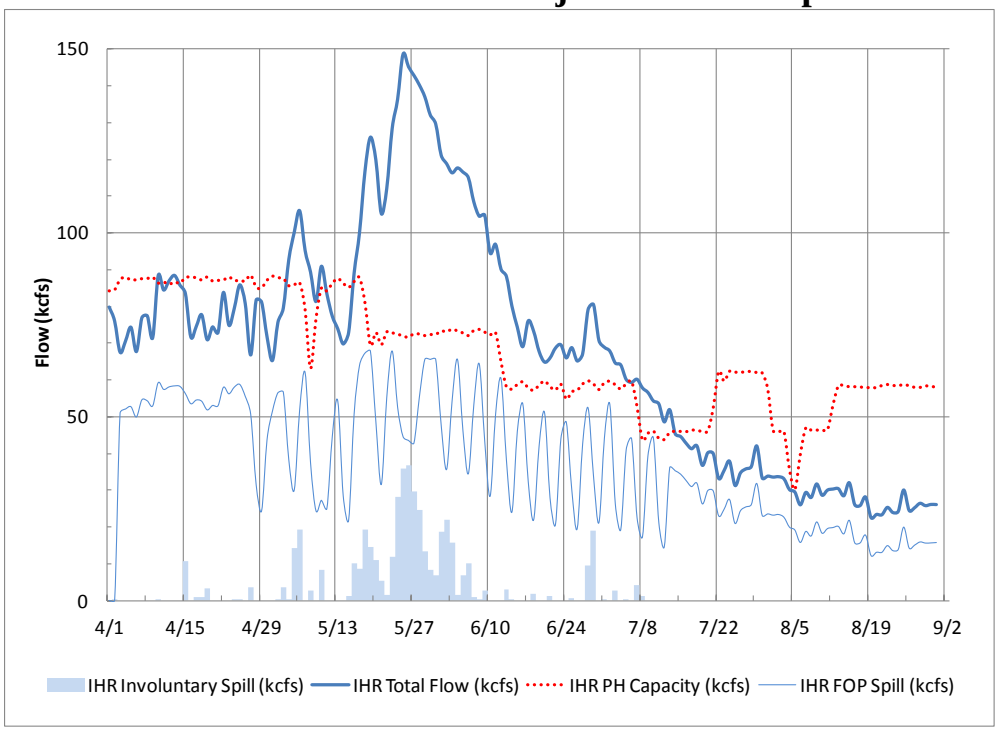
On the lower Snake River as measured at Ice Harbor Dam, daily average total river flow from April 1 through August 31 ranged from 23 kcfs to 149 kcfs, averaging 69 kcfs (Figure 7). Daily average flow peaked on May 25. Flows began to recede after the May peak with a gradual recession ending the month of August at about 26 kcfs.

FIGURE 6
2014 Bonneville Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

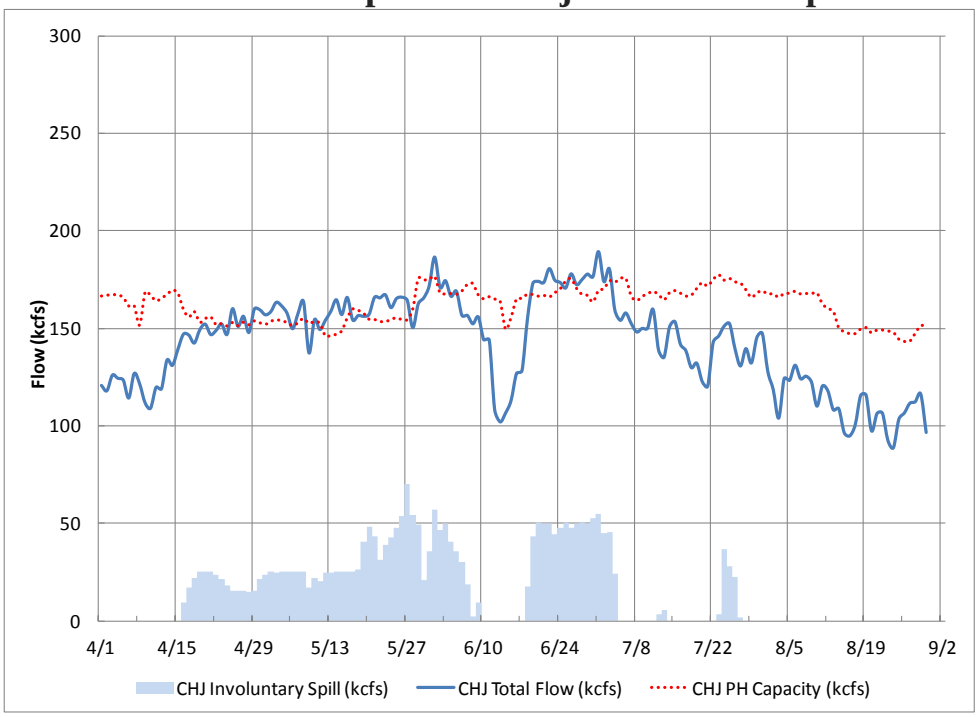
FIGURE 7
2014 Ice Harbor Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

Daily average total river flows on the mid-Columbia River, as measured at Chief Joseph Dam from April 1 through August 31, ranged from 89 kcfs to 190 kcfs, averaging 142 kcfs (Figure 8). Flows had two peaks June 1 and July 1 (the maximum) and began to decrease and continued to recede until the end of August when flows dropped to 91 kcfs on August 31.

FIGURE 8
2014 Chief Joseph Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

2.1.3.4 7Q10 Flow

When flows exceed the 7Q10 criteria (the average peak annual flow for seven consecutive days that has a recurrence interval of ten years), the Colville, Oregon, and Washington's TDG criteria do not apply. The 7Q10 flow criteria and the respective daily average flows for the Corps' Columbia River Basin dams are shown on Table 3 (the gray highlighted flows represent days when the 7Q10 flow criteria were exceeded). In 2014, river flows did not exceed the 7Q10 flow criteria.

TABLE 3
Dates When 7Q10 Flows Were Exceeded in 2014

Date	LWG (kcfs)	LGS (kcfs)	LMN (kcfs)	IHR (kcfs)	MCN (kcfs)	JDA (kcfs)	TDA (kcfs)	BON (kcfs)	CHJ (kcfs)
7Q10 Flow Criteria	**214**	**214**	**214**	**214**	**447**	**454**	**461**	**467**	**222**
5/6/2014	102	99	99	100	302	293	275	287	158
5/7/2014	104	102	101	106	320	328	313	327	150
5/8/2014	93	91	91	95	284	297	281	307	158
5/9/2014	88	86	86	89	287	291	278	302	164
5/10/2014	83	81	80	81	291	285	266	291	137
5/11/2014	87	85	88	91	263	250	231	278	154
5/12/2014	83	81	82	83	270	286	273	280	149
5/13/2014	77	75	75	77	289	293	276	300	154
5/14/2014	73	71	72	74	279	285	266	301	159
5/15/2014	70	67	68	70	262	254	241	277	165
5/16/2014	74	71	72	73	266	261	247	272	157
5/17/2014	88	84	87	89	293	281	262	271	166
5/18/2014	100	96	96	100	319	317	298	312	154
5/19/2014	118	113	114	117	331	331	313	334	157
5/20/2014	124	119	121	126	347	352	332	344	156
5/21/2014	118	113	114	120	346	349	330	354	157
5/22/2014	108	104	104	105	322	329	312	335	166
5/23/2014	115	110	107	112	322	315	293	324	166
5/24/2014	128	123	123	128	352	348	328	340	167
5/25/2014	138	132	132	137	353	355	340	360	161
5/26/2014	149	142	141	149	362	362	344	370	165
5/27/2014	146	138	140	145	360	359	337	354	166
5/28/2014	143	136	136	143	376	376	358	372	165
5/29/2014	141	133	134	140	360	365	350	371	151
5/30/2014	137	130	131	137	349	357	340	359	163
5/31/2014	133	127	128	132	356	358	338	360	166
6/1/2014	129	123	123	130	332	333	314	335	172
6/2/2014	122	116	118	121	325	328	308	325	187
6/3/2014	120	115	113	119	366	356	337	358	171
6/4/2014	117	110	113	116	334	341	322	343	175
6/5/2014	119	113	114	118	330	325	310	333	167
6/6/2014	116	112	112	117	335	330	314	333	169
6/7/2014	117	111	112	115	335	342	322	332	157
6/8/2014	110	105	105	109	307	306	290	314	157
6/9/2014	106	102	101	105	293	299	283	315	152
6/10/2014	104	99	101	105	294	286	269	289	156
Total Days	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Part 3 Water Quality Monitoring

The Corps monitors the water quality of reservoir releases at hydroprojects throughout the Columbia River Basin. This is done to manage system water quality as well as to manage fish passage spill operations at the fish passage projects in the lower Snake and lower Columbia rivers. This water quality monitoring data along with dam operating data are reviewed daily as part of the process of setting spill caps to maintain TDG levels within the 110, 115 and 120 percent TDG criteria.[8] The Corps monitors and tracks instances when TDG and temperature criteria are exceeded relative to state standards and applicable modifications and criteria adjustments; and, when feasible, adjustments are made to meet the state criteria.

3.1 Fixed Monitoring Stations

TDG and water temperature are monitored throughout the Columbia River Basin via the FMS gauges. There are a total of 42 FMSs in the U.S. portion of the Columbia River Basin and 28 are operated by the Corps. Reclamation, and Chelan and Grant County PUDs each operate four stations. Two stations are operated by the Douglas County PUD. The Corps' Portland, Seattle, and Walla Walla districts operate and maintain the FMSs in the Columbia and lower Snake River basins. Portland District is responsible for eight FMSs on the lower Columbia River from John Day Dam to Camas/Washougal. The Seattle District is responsible for two FMSs in the upper Columbia Basin at Chief Joseph. Walla Walla District is responsible for 15 FMSs in the lower Snake River and Clearwater River basins, and at McNary Dam on the Columbia River. Appendix A contains detailed information on the Corps' FMS system and a map of their locations.

3.2 TDG Monitoring Plan of Action

The 2010-2014 TDG Monitoring Plan summarizes the Corps' roles and responsibilities with dissolved gas and temperature monitoring and identifies channels of communications with other cooperating agencies and interested parties. The Plan of Action summarizes what to measure, how and when to take the measurements, and how to analyze and interpret the resulting data. The TDG Monitoring Plan is provided as Appendix B of this report.

3.3 Changes in the FMS

The Bonneville Dam tailwater (Cascade Island, CCIW) TDG gauge was not operable at the end of the 2013 fish passage season. Portland District designed the replacement in-water pipes and anchorage of the sensor pipes. Installation was complete for the start of the 2014 fish passage season in April. Two follow-up inspections occurred in the fall of 2014. During the first inspection more anchors were added to the out of water pipes. The second inspection included shooting video footage of the in-water pipe system using a ROV camera. The pipe system seems to be holding up well with the heavy gage chain intact and large

[8] See the Annual TDG Management Plan for additional information http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/2014/Appendices/Appendix_4_-_2014_TDG_Management_Plan_final2.pdf

rocks supporting the system at two points of contact in-water, plus several points further up the embankment.

3.4 Malfunctioning Gauge Occurrences

During 2014, there were four occurrences affecting 24 days where a FMS gauge malfunctioned due to various reasons as shown in Table E-7 (Appendix E).

- One occurrence at Chief Joseph tailwater gauge resulted in elevated percent TDG due to punctured membranes; therefore, the data was deleted August 13-14, 2014.
- One occurrence at Lower Monumental forebay gauge resulted in elevated percent TDG due to punctured membranes; therefore, the data was deleted August 24-25, 2014.
- One occurrence (but for 19 days) at John Day tailwater gauge resulted in low percent TDG due to a suspected membrane issue. The data changed very slowly and thus it was not readily recognized that a problem existed. Data was deleted August 7-26, 2014 (only 7 hours on August 7 so day was not included in total instances).
- One occurrence at The Dalles forebay gauge communication problems which resulted in missing or null values, which was revised, June 1, 2014.

Malfunctioning gauge TDG instances are noted as a Type 2a instance in Appendix E, Tables E-2, E-3A, and E-3B. Table E-2 (Appendix E) is based on raw data and is populated during real-time operations. Tables E-4 through E-6 (Appendix E) do not include the malfunctioning gauge data since these tables provide statistical information on hourly TDG levels.

3.5 QA/QC on FMS

The 2014 Supplemental BiOp, RPA Action 15, calls for "real-time monitoring and reporting of TDG and temperatures measured at fixed monitoring sites." The Corps' districts operate the FMS according to the TDG Monitoring Plan and prepare annual performance reports for the FMS operation. The 2014 reports are included as Appendices G, H, and I. Highlights from these reports are provided below.

3.5.1 Walla Walla District QA/QC

Walla Walla District maintains and operates the forebay and tailwater TDG FMS stations at Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary dams. This work is performed through a cooperative agreement with the Kennewick office of the USGS. The highlights of the Walla Walla District QA/QC report include:

- Data completeness for the combined barometric pressure, TDG, and temperature data received averaged 98.1 percent for the 15 monitoring sites in 2014 (nine seasonal and six year-round).
- The TDG data received from the individual sites ranged from 89.9 percent to 100.0 percent complete (Table G-7, Appendix G). The Little Goose tailwater (LGSW) FMS gauge had the highest number of unreliable TDG measurements as a result of values that were consider too low. Table G-8 (Appendix G) describes the individual causes for missing and invalid data.

- The TDG sensors from the 15 seasonal and annual FMS were removed from the field and calibrated in the laboratory every 3 weeks between April 2014 and August 2014. From September 2013 through March 2014, the six annual FMS were calibrated at four-week intervals.
- All 168 in-situ field checks of TDG sensors with the replacement probe were within ±1 percent after the deployment period.
- The calculated median for the 171 field checks for barometric pressure was 0.00 mm Hg. 167 of the individual values were within ±0.2 mm Hg of a secondary standard. Three outliers occurred at the Lewiston (LEWI) station while one was noted at the McNary tailwater (MCPW) station.
- The calculated median for the water temperature field checks was -0.02 ºC. Station medians ranged from -0.08 ºC to 0.02 ºC. 166 of the 169 individual assessments were within ±0.2°C.
- The Pasco (PAQW), Peck (PEKI), Lewiston (LEWI), and Anatone (ANQW) deployment pipes were cleaned with compressed air to remove built-up sediment. The deployment pipe at Dworshak (DWQI) was rebuilt to repair a broken coupling and the pipe was shortened to place it in an area of the river with more flow.

The full detailed QA/QC report on the Walla Walla District gauges can be found in Appendix G.

3.5.2 Portland District QA/QC

Portland District maintains and operates the forebay and tailwater gauges at John Day, The Dalles and Bonneville dams. This work is performed through a contract with the Oregon Water Science Center of the USGS. The highlights of the Portland District QA/QC report include:

- Data received from the individual monitoring sites ranged from 78.2 percent (at the Camas gauge) to 100 percent complete. See Table 2 (Appendix H) for individual gauge data completeness information. Table 3 (Appendix H) provides the causes for missing data.
- The TDG data sets were within ±1 percent TDG of the expected value on the basis of calibration data, replicate quality-control measurements in the river, and comparison to ambient river conditions at adjacent sites.
- The TDG sensors were removed from the monitoring stations and calibrated every 3 weeks, except from September 2013 through March 2014, when they were calibrated at 4-week intervals.
- Excluding the John Day tailwater gauge, all but one of the 61 in-situ field checks of TDG sensors with a secondary standard were within ±1 percent TDG. Of the 14 field checks at the John Day tailwater gauge, 8 were within ±1 percent, 2 were within ±1-2 percent and 4 were within ±2-5 percent. Periods of TDG data that appeared to be erroneously low were deleted based on 3 of the John Day tailwater field checks.

- All of the 77 field checks of barometric pressure were within ±1 mm Hg of a primary standard, and all 74 water-temperature field checks were within ±0.2°C of a secondary standard.

The full detailed QA/QC report on the Portland District gauges can be found in Appendix H.

3.5.3 Seattle District QA/QC

Seattle District maintains and operates the forebay and tailwater TDG FMS stations at Chief Joseph Dam. The highlights of the Seattle District QA/QC report are:

- Data completeness for TDG and temperature data received at both the forebay station (CHJ) and the tailwater station (CHQW) were 99.9 percent. Missing TDG and temperature data at both stations were largely due to DCP malfunctions and programming problems.
- For TDG data, at the tailwater station (CHQW) a total of 11 hours were rejected due to slow probe response time after recalibration, while 21 hours were rejected due to TDG membrane issues. At the forebay station (CHJ) a total of 5 hours were rejected due to slow probe response time after recalibration. No temperature data were rejected at stations CHJ and CHQW.
- Laboratory calibration data were good and within 0.1°C for temperature and 1 percent saturation for TDG. Field calibration data were good and generally within 2mm Hg of the secondary standard barometer, 0.1ºC of the secondary standard thermometer, and 2 percent saturation of the secondary standard TDG instrument.
- The TDG sensors were removed from the field after 2 weeks of deployment and calibrated in the laboratory.
- A total of 25 out of 27 (93%) in-situ field checks of total-dissolved-gas sensors with a secondary standard were within ± 2 percent after 2 weeks of deployment in the river.
- A total of 30 out of 30 (100%) in-situ field checks of barometric pressure were within ±2 mm Hg of a secondary standard, and 27 out of 27 (100%) water temperature field checks were all within ±0.2°C.

The full detailed QA/QC report on the Seattle District gauges can be found in Appendix I.

Part 4 Fish Passage Spill Program

4.1 Spill

Operation of the FCRPS to meet multiple authorized purposes can result in instances of percent TDG exceeding the state water quality standards. Part 4 provides detailed information on the implementation of fish passage spill as well as involuntary spill (e.g., lack of turbine, lack of load, transmission constraints, etc.).

4.1.1 Fish Operations Plans

The 2014 Supplemental BiOp calls for the Corps to provide spill for juvenile fish migration in the FCRPS. The Corps in coordination with other Action Agencies and NOAA Fisheries annually develop a Fish Operations Plan (FOP) that provides detailed information on the implementation of the BiOp spill and transport operations at the four lower Snake River and four lower Columbia River dams. The spring and summer FOPs were developed in collaboration with regional sovereigns and is consistent with spill operations specified for juvenile fish passage in the 2014 Supplemental BiOp.

At some Corps' projects, the amount of fish passage spill is a specified level, and, at others, the Corps is to spill up to the applicable state TDG criteria -- referred to as the "gas cap." The maximum project spill level that meets but does not exceed the gas cap is referred to as the spill cap. The 2014 spring and summer FOPs, provided in Appendix C, describes specific fish operations implemented this year and are summarized in Table 4.

TABLE 4
2014 FOPs Spill Operations

Project	Planning Dates	Time	Spill Amount (Not to Exceed the Spill Cap)
Lower Granite	April 3 - June 20	24 hours per day	20 kcfs
Lower Granite	June 21-August 31	24 hours per day	18 kcfs
Little Goose	April 3 - August 31	24 hours per day	30% of project outflow
Little Goose	During flows < 32 kcfs	24 hours per day	Constant spill of 7-11 kcfs
Lower Monumental	April 3 - June 20	24 hours per day	Spill cap
Lower Monumental	June 21-August 31	24 hours per day	17 kcfs
Ice Harbor	April 3 - April 28	0500-1800	45 kcfs during the day
Ice Harbor	April 3 - April 28	1800-0500	Spill cap at night
Ice Harbor	April 28 - July 13	24 hours per day	Alternating between 2-day blocks of 30% of project outflow vs. 45 kcfs during the day/spill cap at night
Ice Harbor	July 13 - August 31	0500-1800	45 kcfs during the day
Ice Harbor	July 13 - August 31	1800-0500	Spill cap at night
McNary	April 10 - June 15	24 hours per day	40% of project outflow
McNary	June 16-August 31	24 hours per day	50% of project outflow
John Day	April 10 - April 27	24 hours per day	30% of project outflow
John Day	April 27 - July 20	24 hours per day	Alternate between 2-day blocks of 30% vs. 40% of project outflow
John Day	July 21 - August 31	24 hours per day	30% of project outflow
John Day	April 10 - August 31	24 hours per day	Minimum spill is 25% of project outflow
The Dalles	April 10 - August 31	24 hours per day	40% of project outflow
Bonneville	April 10 - June 16	24 hours per day	100 kcfs
Bonneville	June 16 - August 31	24 hours per day	Alternating between 2-day blocks of 95 kcfs vs. 85 kcfs during the day/121 kcfs at night
Bonneville	April 10 - August 31	24 hours per day	Minimum spill is 50 kcfs

4.1.2 Fish Passage Spill

Fish-passage spill, also referred to as voluntary spill, occurs for the benefit of juvenile fish migration in accordance with the operative biological opinions. The 2014 FOPs established spill levels for juvenile fish passage at the four lower Snake and four lower

Columbia River dams during the juvenile fish migration season. The fish passage spill called for in the 2014 FOPs was to occur from April 3 to August 31 at the lower Snake River dams, and from April 10 to August 31 at the lower Columbia River dams. However, because total river flows were somewhat high, continuous involuntary spill began on March 7 at McNary (see Part 4.1.5 for more details). As coordinated with Oregon and Washington, tracking TDG instances for this report starts on April 1.

The amount of fish passage spill for the 2014 spill season at each dam is shown in weekly graphs that show the flow, FOP spill, and percent TDG for April through August are included in the monthly FOP implementation reports (Appendix D) which can be found at: http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2014/.

4.1.3 BiOp Performance Standard Test Operations

In 2014, juvenile dam passage performance tests were conducted at McNary and John Day dams, but did not alter current spill operations. The intent of these studies is to assess the juvenile performance following modifications to fish facilities or operational changes at the dams. These research studies are developed and coordinated through the Anadromous Fish Evaluation Program Studies Review Work Group with NOAA Fisheries providing concurrence on the final study plan. For more information on all planned fish tests, see Appendix A of the annual Fish Passage Plan at: http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/.

4.1.4 Long Term Turbine Outages

Unit outages can affect the spill volume at the dams by causing additional involuntary spill. Table 5 summarizes the long term unit outages during the 2014 Fish Passage Season and identifies outages outside of the reporting period. Not all outages actually have or will result in spill or elevated TDG levels, but are included for informational purposes. There were a total of 27 long term outages during the Fish Passage Season. There were three long-term (greater than one month) unit outages on the lower Snake River, 13 long-term unit outages on the lower Columbia River, and eleven unit outages on the middle Columbia River.

TABLE 5
2014 Long Term Outages

Project	Unit	Start Date	Finish Date	Reason
Lower Granite	6	5/12/13	8/31/14	Repair turbine blades, annual maintenance
Little Goose	3	7/7/14	8/31/14	6 Yr Overhaul / Cavitation Repair
Ice Harbor	3	8/1/14	8/31/14	Forced-bushing failure, overhaul
McNary	4	3/27/14	8/31/14	Forced - Thrust bearing overheat
McNary	11	6/28/13	8/31/14	Rewind
John Day	2	5/1/14	8/31/14	Forced - Oil in the tailrace, Blade Seal Replacement/ Blade Linkage Inspection
John Day	3	2/6/14	8/31/14	Forced - Ground fault
John Day	6	1/7/13	8/31/14	MU-6 Overhaul / Coolers - Replace Thrust Bearing
The Dalles	13	7/21/14	8/28/14	Annual, ground mat diagnosis,broken isophase insulator
The Dalles	14	7/21/14	8/31/14	5 Yr Overhaul
The Dalles	22	3/24/14	6/12/14	5 Yr Overhaul
Bonneville	2	7/7/14	8/31/14	5 Yr Overhaul / Incl. T1/2 work during this time. Air Gap Installation / ZW106 Disconnect Maintenance
Bonneville	4	4/21/14	7/1/14	Clean stator windings
Bonneville	6	3/17/14	4/30/14	5 Yr Overhaul
Bonneville	11	9/25/12	8/31/14	forced out, damaged bearing
Bonneville	13	4/14/14	5/21/14	Digital Governor Replacement
Chief Joseph	7	4/21/14	8/31/14	Turbine Replacement and Quad Services
Chief Joseph	10	12/8/13	8/31/14	Alstom Turbine Replacement and CJD Quad Services Phase 1,2, & 3
Chief Joseph	19	7/7/14	8/31/14	Digital Governor Replacement
Chief Joseph	25	6/2/14	7/17/14	Digital Governor Replacement
Grand Coulee	5	7/11/12	8/31/14	K5A Transformer Replacement, WECC Testing, SF-6 Breaker Annual, Stator Warranty Inspection, Bypass Valve Repacement
Grand Coulee	7	3/18/14	8/31/14	5 Yr Overhaul / WECC Testing /SF-6 Breaker Annual / Stator Warranty Inspection
Grand Coulee	10	3/9/13	8/31/14	Forced - Line circuit 3 fire / K10A Isophase Bus Fire/ WECC Model Testing/ Pre-Quin/ Quin
Grand Coulee	11	2/6/14	8/31/14	Forced - line 3 trip, transformer fault
Grand Coulee	12	11/8/13	6/5/14	5 Yr Overhaul
Grand Coulee	22	1/26/14	8/29/14	3-Yr Maint. / Cav Repair / Relay Replacement
Grand Coulee	24	3/5/13	8/31/14	Overhaul Transformer/fixed wheel gate testing
TOTAL OUTAGES = 27				

4.1.5 Involuntary Spill

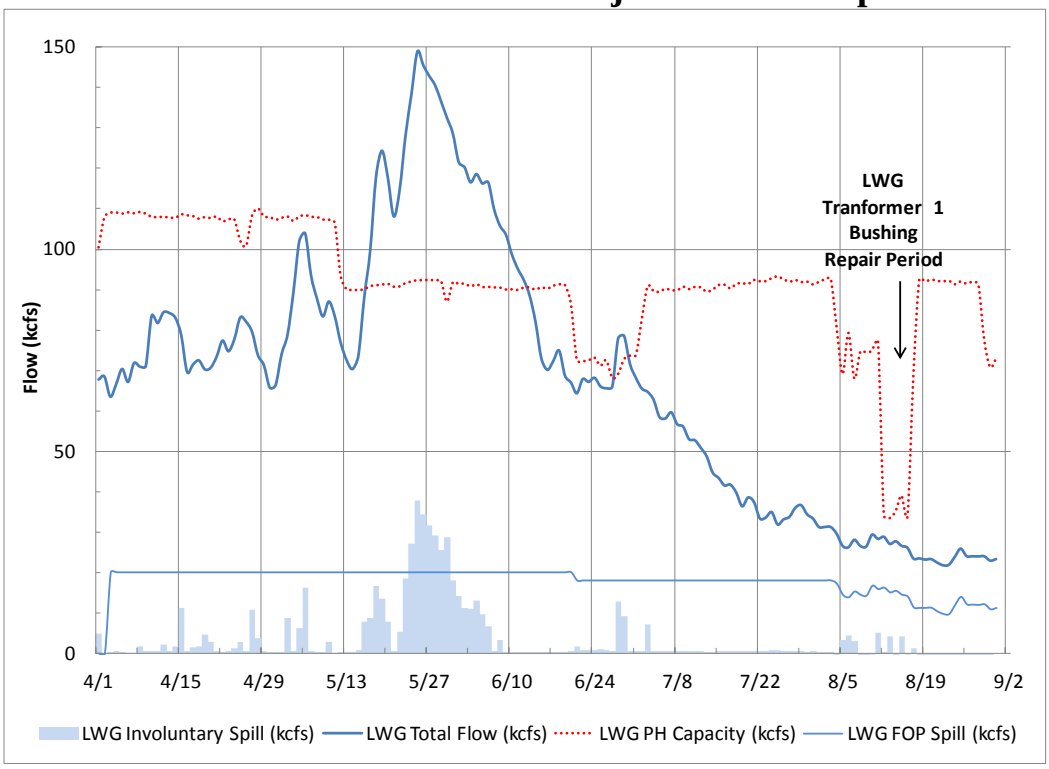
Due to lack of turbine availability, lack of load, and other hydraulic conditions, involuntary spill occurred at the four lower Columbia River, the four lower Snake River dams and Chief Joseph Dam.

Involuntary spill occurred on March 7 at McNary Dam, which was the earliest of all the lower Columbia River dams for a total of 94 days. Both Lower Granite and Little Goose dams started involuntary spill operations on April 1, which was the earliest of all the lower Snake River dams. The other six lower Columbia and lower Snake River dams started involuntary spill from March 28 to May 17. Involuntary spill at Bonneville Dam occurred for 45 days intermittently from March 28 to July 3 (Figure 6). The Dalles Dam had involuntary spill for 24 days intermittently from April 15 to July 3. John Day Dam had involuntary spill for 33 days intermittently from April 15 to June 5.

On the lower Snake River, Ice Harbor Dam had involuntary spill that occurred for 34 days during fish passage season. Lower Granite Dam had involuntary spill for 43 days intermittently from April 1 to August 15 (Figure 9). Thirteen of the 43 days of involuntary

spill at Lower Granite Dam occurred during August as a result of the transformer bushing repairs. Little Goose Dam had involuntary spill for 17 days intermittently from April 1 to August 12. Lower Monumental Dam had involuntary spill for seven days intermittently from May 17 to August 11.

FIGURE 9
2014 Lower Granite Dam Project Flow and Spill



Note: Daily powerhouse capacities provided by BPA Duty Schedulers

4.2 SYSTDG Model

A statistical evaluation of SYSTDG's performance was conducted to assess how well the model estimated percent TDG. The predictive errors that SYSTDG computed in 2014 compared favorably with the predictive errors from previous years. A summary of the predictive error for each FMS can be found in Appendix F, Tables F-1 to F-9.

4.2.1 2014 Improvements Made to SYSTDG:

The following improvements were made to the SYSTDG model in 2014:

1. The links between the coefficients of the weather station and the Little Goose Dam TDG production equations were corrected.

2. SYSTDG was converted to pull current years' data from the CWMS database instead of from two Access databases that were populated from

various internet websites. A suite of 22 queries were established that pull data from CWMS and create text files that SYSTDG downloads into the model. This improvement was initiated in 2013 and completed in 2014.

3. The Washington method of calculating 12 hour averages based on 12 consecutive hours was added to SYSTDG (as recommended in the 2009 Appendix G).

4. The feature of entering spill patterns into SYSTDG was added to Chief Joseph Dam (as recommended in the 2013 Appendix G).

5. RCC Water Quality Unit requested a revised Lower Monumental spill pattern with gate settings for a spill rates as low as 6 kcfs and it was used during the 2014 spill season (as recommended in the 2013 Appendix G).

6. In October 2014, Walla Walla District developed an expanded McNary spill pattern that covers high-flow spillway discharges for the 2015 spill season (as recommended in the 2013 Appendix G).

7. The workbooks and equations used to generate the statistical analysis were added to the SYSTDG model, combining both functions in one workbook.

4.3 TDG Monitoring Studies

TDG monitoring studies are periodically scheduled to investigate significant structural or operational changes of the spillway. These studies are designed to support TDG monitoring and management functions provide updates to TDG gas abatement goals associated with the TDG TMDL, and to update the SYSTDG model. During the 2014 spill season, there were no supplemental TDG monitoring studies conducted at Federal projects on the Columbia or Snake Rivers.

Part 5 Instances of TDG Exceeding WQS

During 2014, most TDG instances occurred when powerhouse capacity was exceeded. As shown above in Figure 6 (Bonneville Dam), total river flows exceed powerhouse capacities on the lower Columbia River for more than three months. As shown in Figure 9 (Lower Granite), total river flows exceed powerhouse capacities on the lower Snake River for just a few weeks. As discussed in Part 1.1.6, the latest state reporting requirements round values of percent TDG readings to the nearest whole number (or three significant digits), which resulted in fewer instances being counted, and less involuntary spill by definition. Part 5 discusses the TDG instances as they applied for 2014.

5.1 TDG Instance Calculation Methods

Calculations and reporting in Part 5 are consistent with the Corps' Operating Guidelines described above in Part 1.1.6.

5.2 TDG Instances

5.2.1 110 percent TDG Instances

In 2014, TDG instances were tracked using the Colville Confederated Tribes WQS and the Washington WQS of 110 percent in the forebay and tailwater of the Chief Joseph Dam located on the middle Columbia River. Table E-6 (Appendix E) shows that there were 2,326 hourly TDG instances in the Chief Joseph Dam tailwater, and 2,376 hourly TDG instances in the Chief Joseph forebay. The maximum TDG values observed for Chief Joseph Dam were 120 percent in the forebay, and 118 percent in the tailwater.

5.2.2 115 percent and 120 percent TDG Instances

Table 6 provides a summary of TDG instances for 2014 spill season for the lower Columbia and lower Snake projects. There were a total of 218 TDG instances in 2014 (Table 6 and Table E-2, Appendix E). Average flows on the Columbia River and Snake River resulted in the majority of gauges (13 of 16) having TDG instances in the April through August period. These observations are consistent with trends observed in previous years with the exception of John Day Tailwater which was experiencing unusual data issues which resulted in erroneous values in August

TABLE 6
2014 Spill Seasons
Number of TDG Instances Exceeding WQS
ODEQ/WDOE Combined Calculation Method

Fixed Monitoring Stations	2014 Qty.	Applicable Standard
Lower Granite Forebay	0	WA
Lower Granite Tailwater	5	WA
Little Goose Forebay	13	WA
Little Goose Tailwater	0	WA
Lower Monumental Forebay	23	WA
Lower Monumental Tailwater	4	WA
Ice Harbor Forebay	41	WA
Ice Harbor Tailwater	3	WA
McNary Forebay	17	WA
McNary Tailwater	14	WA/OR
John Day Forebay	10	WA
John Day Tailwater	19	WA/OR
The Dalles Forebay	11	WA
The Dalles Tailwater	5	WA/OR
Bonneville Forebay	32	WA
Bonneville Tailwater	21	WA/OR
Camas/Washougal	---	---
Total Number of TDG Instances	**218**	

Note: *Does not include days when 7Q10 flows were exceeded (See Table 9); Camas/Washougal not included in 2014 Spill Review.

** Instances are counted if the calculated values exceed either the Oregon or Washington state standards, but the exceedance is only counted as 1 day.

5.2.3 Instances of TDG Exceeding 125 percent WQS

During the 2014 spill season, there were 11 instances (excluding days when 7Q10 flow was exceeded[9]) of hourly TDG exceeding the Washington one-hour standard of 125 percent TDG, Table E-5 (Appendix E). This is due to average flows on the Columbia River and lower Snake River and the shape of the runoff, which were represented by a small peak on the lower Snake River, and a prolonged peak on the lower Columbia River. Additional information is shown in the graphs of the 12-hour percent TDG for the lower Snake and Columbia River dams in the monthly FOP implementation reports (Appendix D).

[9] There were no days at any project where flows exceeded the 7Q10 flow in 2014.

5.2.4 TDG Instances in Oregon (Additional Information)

Oregon requested the following additional information in Table 7 identifying TDG instances that occurred at the dams covered by the Oregon TDG modification.[10] In 2014, there were 44 TDG instances which exceeded the 120 percent TDG standard in the reservoir tailwater. The TDG instances are approximately 6.5 percent of 612 possible spill days (4 gauges x 153 days), from April 1 through August 31.

TABLE 7
2014 Spill Season
Number of TDG Instances Exceeding Oregon WQS

Fixed Monitoring Stations	April 1 - August 31 120% TDG Instances	April 1 - August 31 125% TDG Instances	7Q10 Flow Days	Instances between April 1- April 10
McNary Tailwater	10	0	0	0
John Day Tailwater	19	0	0	0
The Dalles Tailwater	3	0	0	0
Bonneville Tailwater	12	0	0	0
Total Number of Exceedances for Oregon	**44**	**0**	**0**	**0**

5.2.5 7Q10 Flows Days

During 2014, flows on the mid-Columbia, lower Columbia and lower Snake rivers were so low that there were zero days when the 7Q10 flow criteria was exceeded (See Table 3 and 8).

[10] This information does not provide the magnitude or duration of the exceedances, only that the FMS exceeded the state TDG modifications on that day.

TABLE 8
Number of Days
When 7Q10 Flows Were Exceeded In 2014

Fixed Monitoring Stations	Number of 7Q10 Days
Lower Granite Forebay	0
Lower Granite Tailwater	0
Little Goose Forebay	0
Little Goose Tailwater	0
Lower Monumental Forebay	0
Lower Monumental Tailwater	0
Ice Harbor Forebay	0
Ice Harbor Tailwater	0
Chief Joseph Forebay	0
Chief Joseph Tailwater	0
McNary Forebay	0
McNary Tailwater	0
John Day Forebay	0
John Day Tailwater	0
The Dalles Forebay	0
The Dalles Tailwater	0
Bonneville Forebay	0
Bonneville Tailwater	0
Camas/Washougal	0
Total Number of 7Q10 Days	**0**

5.2.6 Comparison of Annual TDG Instances

Table 9 provides daily TDG instances above the WQS's in 2014. Previous years reporting included a multi-year comparison summary. In accordance with the Corps' operating principles (see Part 1.1.6), the 2014 TDG instance tracking was reset, and future years will include multi-year comparison building from 2014.

TABLE 9
2014 Annual Comparison of
TDG Instances Exceeding WQS

Year	Days in Spill Season[1]	Number of Days of Instances	Percent of Days Exceeding TDG Standard (%)	Percent of Days Consistent With TDG Standard (%)	Percent of Normal Runoff at TDA[2]
2014	2448	218	9	91	112
Average	**2448**	**218**	**9**	**91**	**112**

[1] Days in Spill Season based on number of gages x days in spill season.

[2] The Dalles Apr1-Oct1 Observed Runoff (1981-2010) = 79.9 Maf

** Instances are counted if the calculated values exceed either the Oregon or Washington WQS, but the TDG exceedance is only counted as one incident.

5.2.7 Types of Daily TDG Instances

Beginning in 2003, Oregon and the Technical Management Team (TMT) requested the Corps track the causes of TDG instances where percent TDG exceeded WQS. Table E-1 (Appendix E) provides a listing of the three causes or TDG instance types. The Corps tracked the daily TDG instance types for the forebay and tailwater of each of the Corps' FCRPS dams during the 2014 spill season. Each type of TDG instance represents conditions that cause daily average percent TDG to exceed WQS. The 2014 tracking results are summarized in Table 10. Daily details by dam can be found in Appendix E. The daily TDG instance type designation given for each occurrence is based on the Corps' determination of causation.

During the 2014 spill season, there were a total of 218 instances[11] out of 2,448 gauge-days in which the TDG levels were above the TDG criteria. Certain types of TDG instances, such as Types 1 and 2a, associated with high flows and malfunctioning gauges respectively, may occur every year and are a normal part of reservoir operations. Efforts continue to reduce daily instances when possible.

TABLE 10
2014 Spill Seasons
Types and Numbers of TDG Instances

2014	TYPE	DEFINITION
140	**1**	TDG levels exceed the TDG standard due to exceeding powerhouse capacity at run-of-river projects resulting in spill above the BiOp fish spill levels.
0	**1a**	Planned and unplanned outages of hydro power equipment including generation unit, intertie line, or powerhouse outages.
5	**2**	TDG exceedances due to the operation or mechanical failure of non-generating equipment.
22	**2a**	Malfunctioning FMS gauge, resulting in fewer TDG or temperature measurements when setting TDG spill caps.
51	**3**	TDG exceedances due to uncertainties when using best professional judgment, SYSTDG model and forecasts.
218	**Totals**	

[11] This information does not provide the magnitude or duration of the exceedances, only that the FMS exceeded the state TDG modifications or criteria adjustments on that day.

Part 6 Gas Bubble Trauma Monitoring

6.1 Biological Monitoring Highlights

The Fish Passage Center compiles a report of GBT monitoring results collected in 2014 (included as Appendix J). The following is a summary of biological monitoring results.

The monitoring of juvenile salmonids in 2014 for GBT was conducted at mid-Columbia, lower Columbia, and lower Snake River sites. Fish were collected and examined for signs of GBT at Bonneville and McNary dams on the lower Columbia River, and at Rock Island Dam on the mid-Columbia River. The Snake River monitoring sites were Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam.

Sampling occurred two days per week at the Columbia River sites and one day a week at each of the Snake River sites during the time period that fish passage spill was implemented. The goal of the sampling program was to sample 100 salmonids of the most prevalent species (limited to Chinook and steelhead) during each day of sampling at each site, with the proportion of each species sampled dependent upon their prevalence at the time of sampling. Yearling Chinook and steelhead were sampled through the spring at all the sampling sites. Once subyearling Chinook predominated at sampling sites, the program shifted from sampling yearling Chinook and steelhead to sampling subyearling Chinook, which continued through the end of August.

Examinations of fish were conducted using variable magnification (6x to 40x) dissecting scopes. The eyes and unpaired fins of specimens were examined for the presence of bubbles. The bubbles present in the fins were quantified using a ranking system based on the percent area of the fins covered with bubbles as shown in Table J-1 (Appendix J).

The action criteria for GBT is established as 15 percent of fish showing any signs of GBT, or 5 percent of fish sampled showing signs of fin GBT greater than or equal to rank 3. Neither of these two action criteria was met in 2014.[12]

In 2014, a total of 14,259 juvenile salmonids were examined for GBT between April and August as shown in Table J-2 (Appendix J). Fin signs were found in 36 or 0.25% percent of the total fish sampled at all sites as shown in Table J-3 (Appendix J). The fish that were examined and determined to have signs of GBT exhibited the fin signs, 34 were rank 1 where less than 5 percent of a fin area was covered with bubbles, and two were rank 2 where 6 percent to 25 percent a fin area was covered with bubbles. No signs of rank 3 or 4 were seen in 2014. Table J-4 (Appendix J) compares the 2014 estimates of the overall percentage of fish with signs of GBT to past years' estimates. The overall annual incidence of GBT in 2014 was in the lower range among the past 18 years.

[12] From 2009-2012, reports received from the FPC inadvertently specified "rank 1" rather than "rank 3" as the metric to be used to determine the action criteria for GBT. The FPC discovered this error in 2013; therefore, this report reflects the correction and that "rank 3" was used to determine the action criteria for GBT. Also see memo, FPC 151-13, dated December 20, 2013.