Sokolowski, Rosana

From: Hampton, Waikele M.
Sent: Monday, January 04, 2010 9:10 AM
To: Sokolowski, Rosana
Subject: FW: Final 2009 Gas Abatement Report

From: Hampton, Waikele M.
Sent: Tuesday, December 29, 2009 2:40 PM
To: 'Irle, Pat (ECY)'
Cc: Merz, Jonathan (ECY); Smith, Michelle
Subject: Final 2009 Gas Abatement Report

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To: Patricia Irle, Washington State Department of Ecology

From: Waikele Hampton, Environmental Permit Coordinator
Public Utility District No. 1 of Chelan County (Chelan PUD)

Re: Rocky Reach (FERC Project No. 2145) and Rock Island (FERC Project No. 943) Gas Abatement Annual Report

Ms. Irle:

In accordance with the 401 Water Quality Certification (401) for the Rocky Reach Hydroelectric Project License, Chelan PUD submits to you the Final 2009 Gas Abatement Report for the Rocky Reach and Rock Island Hydroelectric projects. Though reporting of Rock Island tailrace monitoring is not included in the Rocky Reach 401, it is included in this report, as it seemed prudent that the report include all annual TDG monitoring conducted by Chelan PUD. The final report can be found at the following link: ftp://relicensingftp:relicensingftp987!@ftp.chelanpud.org/Relicensing.

Chelan PUD received comments on two review drafts of the report. Those comments have been addressed throughout the body of the document, as well as in Appendix F, Response to Comments.

If you have any questions, please do not hesitate to contact me.

Thank you,
Waikele Hampton
509-661-4627

GAS ABATEMENT ANNUAL REPORT
ROCKY REACH AND ROCK ISLAND HYDROELECTRIC PROJECTS
2009

Public Utility District Number 1 of Chelan County
Wenatchee, WA

ABSTRACT

The Public Utility District No. 1 of Chelan County (Chelan PUD) monitored total dissolved gas (TDG) at Rocky Reach and Rock Island projects from April 1 through August 31, 2009. The primary objective of this monitoring program was to compare the state water quality TDG numeric criteria to the values observed at the Rocky Reach and Rock Island projects throughout the duration of the 2009 fish passage season (April 1 – August 31). Additionally, Chelan PUD obtained TDG data from Grant County PUD to track TDG levels in the Wanapum Dam forebay. Data analysis showed that water coming into the Rocky Reach forebay from upstream exceeded Washington State water quality criteria on 5 days. TDG exceeded the modified Washington State water quality TDG criteria on 0 days in the Rocky Reach tailrace, Rock Island forebay, and Rock Island tailrace during this monitoring period. Numeric criteria were exceeded on 16 days (using the standard 12-hr rolling average method), and 14 days (using a method that eliminates the double-counting issue) in the Wanapum forebay.

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1. INTRODUCTION

1.1 Project Description

The Columbia River watershed lies east of the Cascade Mountains and west of the Rocky Mountains and encompasses parts of British Columbia, Idaho, Montana, Nevada, Oregon and Washington. Rocky Reach and Rock Island projects are located in mid-Washington State on the mainstem of the Columbia River (Figure 1). The study area involved 59 river miles (RM), from the forebay of Rocky Reach Project (RM 474) downstream to the forebay of Wanapum Project (RM 415). This included the 21 RM between Rocky Reach and Rock Island dams and 38 RM between Rock Island and Wanapum dams.

1.1.1 Rocky Reach

The powerhouse at Rocky Reach Project contains a total of 11 vertical axis-generating units and is situated on the west half of the river parallel to the flow (Figure 2). The spillway at Rocky Reach houses 12 individually opening 170-ton tainter gates arranged on the east half of the river, perpendicular to the river flow. The normal maximum reservoir water surface elevation is 707 ft. with an average tailrace water surface elevation of 618 ft., providing a gross head of 89 ft. The depth of the stilling basin immediately downstream of the project is approximately 40 ft. at average tailwater elevation.

In 2003, Chelan PUD began operation of the Juvenile Bypass System (JBS), which continues to be the primary juvenile fish survival tool at Rocky Reach Project. Testing completed during the first year of operation assisted Chelan PUD in determining the guidance efficiency of the JBS and estimate the level of spill necessary to meet the Rocky Reach Habitat Conservation Plan (RRHCP) survival standards. Due to the success of the JBS, Chelan PUD was able to eliminate fish spill for yearling Chinook and steelhead (generally mid-April to early-June) and was able to reduce spill for summer (generally mid-June to mid/late August) Chinook in 2007 and 2008, and continued this spill regime in 2009. The most efficient use of voluntary fish survival spill at Rocky Reach will be to supplement the effectiveness of the JBS, when needed, to reach survival goals of the RRHCP.

The fish spill program at Rocky Reach was managed to maximize fish passage, meet HCP requirements, minimize voluntary spill, and still stay within the terms of the State TDG fish spill water quality criteria.

Voluntary spill levels were managed in real time as detailed in the TDG Operational Plan (Appendix A) for the Rocky Reach Project. When Project operators observed instantaneous TDG levels that exceeded the criteria as set forth in the Plan, spill was reduced and TDG levels monitored.

1.1.2 Rock Island

Rock Island Project consists of two separate powerhouses connected by a spillway. There are a total of 18 generating units; ten vertical axis Kaplan and Nagler turbines in the first powerhouse on the east shore, and eight horizontal axis bulb turbine generators in the second powerhouse on the west side of the river (Figure 3). The spillway is 1,184 ft. long and houses 31 spillgates divided by a center adult fishway. The east spillway contains a total of 14 gates, arranged perpendicularly to the river flow. The west spillway has 17 gates, situated at a slight angle to the river flow. Spillways are either 33 or 55 feet deep and have two or three spillgates stacked in the gate slot. Lifting one or more of these crest gates regulates spill volume. Each gate is 30 feet wide by 11 or 22 feet high. A total of nine gates have been modified or constructed to provide relatively low volume (1,850 or 2,500 cubic feet per second (cfs)) surface spill for fish bypass. The normal maximum reservoir elevation of Rock Island Project is 613 ft. with a tailrace elevation of 572 ft. and a head of 41 ft. Tailrace bathymetry below Rock Island is complex and ranges in elevation from approximately 580 ft. below bays 21-23 to approximately 520 ft. below Bay 1.

Chelan PUD has developed and installed two flow deflector ramps at Rock Island Dam. One was designed for and installed in a deep spillway bay (Bay 29) in 2000. The second was designed for and installed in a shallow spillway bay (Bay 16) in 2001. The designs for these deflectors were tailored for the use of the notched gate systems at the Rock Island Project. The main objectives for the designs were to reduce the uptake of TDG per total volume of water and to safely pass downstream migrants during the fish spill season. During the 2009 spill season, only the deflector in Bay 16 was utilized, as the deflector in Bay 29 was damaged during the 2005 season and was later removed and has not been replaced.

Additionally, Chelan PUD designed and installed a single bay Over/Under gate between 2004 and 2006. Testing of the gate indicated a reduction in TDG uptake by 8.5 to 13.5% points, as compared to the existing notched gate method, and by an additional 2.5 to 4.5 % points as compared to deflectors. Fish passage survival tests performed indicated that overall survival was between 99% and 100%. Because the original Over/Under gate was successful at reducing TDG and maintaining fish survival, Chelan PUD made the decision to have three in place prior to the initiation of the 2007 spill season and these were utilized in 2008 and again in 2009.

Operating under a spill regime of 20% of the daily average river flow through 2006, the Rock Island HCP (RIHCP) survival standards for spring plan species have been met at Rock Island. Due to the success of the survival studies thus far, Chelan PUD began testing powerhouse optimization in 2007, resulting in spring voluntary (fish) spill being reduced to 10% of the daily average river flow. Chelan PUD continued

the powerhouse optimization test in 2008 and 2009. Summer spill remains at 20% of the daily average river flow.

The fish spill program at Rock Island was managed to maximize fish passage, meet HCP requirements, minimize voluntary spill, and still stay within the terms of the State TDG fish spill water quality criteria.

Voluntary spill levels were managed in real time as detailed in the TDG Operational Plan (Appendix A) for the project. When Project operators observed instantaneous TDG levels that exceeded the criteria as set forth in the Plan, spill was reduced and TDG levels monitored.

1.2 Fixed Monitoring Site (FMS) Locations

At all sampling locations discussed below, TDG measurements were recorded throughout the monitoring season at 15-minute intervals, enabling plant operators to adjust spill volumes to maintain gas levels to reduce the likelihood of exceeding the TDG criteria. These 15-minute intervals were averaged into hourly readings for use in compiling daily and 12-hour averages. All hourly data were forwarded to Chelan PUD headquarters building and then onto the US Army Corps of Engineers Reservoir Control Center and posted at their site on the World Wide Web.

Forebay FMS were located at fixed sites on the upstream face of Rocky Reach and Rock Island projects (Figures 2 and 3, respectively). A dissolved gas probe (Minisonde) developed by Hydrolab, Inc. was lowered down a conduit secured to the upstream face of each project and submerged to a depth of approximately 15 ft.

Tailrace monitoring stations were located downstream of both projects. The Rocky Reach monitoring station was located approximately one third of a mile downstream of the spillway on the juvenile fish bypass outfall (Figure 2), as required by the 401 Water Quality Certification (Ecology, April 4, 2006). This location was chosen because it was the most feasible location near the end of the aerated zone, which is the compliance point for the Mid-Columbia TDG TMDL. There is not a bridge or other structure downriver of Rock Island Project to which a monitoring station can be attached. For this reason, Chelan PUD developed a monitoring station about 1.5 miles downriver from the project on the eastern shoreline (Figure 4). Representativeness of the site is summarized in the Total Maximum Daily Load for Total Dissolved Gas in the Mid-Columbia River and Lake Roosevelt Submittal Report (2004):

> *The representativeness of TDG readings at the tailwater FMS can vary according to spillway and powerhouse operations. Since spill flows tend to hug the east bank, the river is not fully mixed at the tailwater FMS. Operation of the Second Powerhouse will tend to*

push higher TDG flows into the east bank. However, First Powerhouse flows can have the opposite effect, pushing higher TDG flows towards the middle of the channel so that FMS readings reflect forebay TDG levels carried by powerhouse flows.

Either a Hydrolab Minisonde or Datasonde4 was deployed at each tailrace site. The units were submerged approximately 15 ft. below the surface using a 3/8-inch weighted wire cable.

1.3 Regulatory Framework

1.3.1 Washington State Department of Ecology (Ecology) Water Quality Numeric Criteria

The Washington State water quality numeric criterion for TDG is set at 110% of saturation at the water surface barometric pressure, with a special condition for spill for fish passage. This special fish passage criterion states that TDG must not exceed an average of 120% saturation in the tailrace and 115% saturation in the forebay of the next downstream projects. These average TDG saturation levels are based on the average of the 12 highest consecutive hourly measurements in a 24-hour day. The TDG levels shall not exceed an average 125% for more than one hour in a 24-hour day in the tailrace.

The amount of control that Chelan PUD has over TDG supersaturation in the Columbia River is limited to control of spill at the Rocky Reach and Rock Island projects. In high flow years, river flows regularly exceed the hydroelectric capacity of projects located on the mainstem Columbia, forcing large volumes of water to be spilled throughout the basin. Meekin and Allen (1974) noted that supersaturated waters do not completely equilibrate in transit through the downstream reservoirs. In many years, TDG levels arriving at the Rocky Reach forebay exceed the 110% TDG criteria and even the 115% fish passage exemption due to spill at upstream projects. When TDG levels arrive at the Rocky Reach forebay exceeding the 115% forebay criterion, the Chelan PUD projects may not be able to meet the TDG criteria for the tailrace or the forebay of the next project.

1.3.2 Daily TDG Compliance Value Calculation

Chelan PUD calculated TDG levels for compliance with the numeric criteria as per an April 2, 2008 memo from Chris Maynard (former Hydropower Coordinator with Ecology), which reads:

> "Beginning during the 2008 spill season, the operators should use the following method to average and report the 12 consecutive hourly highest (12-C high) TDG reading in a day:
>
> *Method*: Use a rolling average to measure 12 consecutive hours. The highest 12 hour average in 24 hours is reported on the calendar day (ending at midnight) of the final measurement.
>
> - The first averaging period of each calendar day begins with the first hourly measurement at 0100 hrs. This hour is averaged with the previous day's last hourly measurements.

- Each subsequent hourly measure is averaged with the previous 11 hours until there are 24 averages for the day.
- From the 24 hour averages, the highest average is reported for the calendar day.
- Round the 12 hour average to nearest whole number."

Using a rolling average that begins at 0100 hrs results in counting the hours 1400 through 2359 twice – in the average calculations on the day they occur AND on the next reporting day. As a result, a TDG water quality criterion exceedance may be indicated on two separate days based on the same group of hours. Consider a spill event beginning at 1300 hrs on a Tuesday and continuing through 0100 hrs on Wednesday. Suppose TDG values during those hours of spill were 125% and 100% for all remaining hours. Under this situation, 12-C High values would be 125% for both days despite daily averages equaling 112% and 101%, respectively. In other words, Wednesday would be deemed out of compliance despite having only one hour above the standard (since the 0100 hrs moving average includes the 11 previous hours of high spill occurring on Tuesday).

This "double-counting" of some of the hourly TDG values could potentially lead to critical management decisions that alter operational or physical characteristics of a particular hydroelectric project. Because there was no established methodology prior to the 2009 monitoring season to address this "double counting" issue, Chelan PUD followed the below methodology to address such:

1. Calculate a moving average for each hour, including that hour and the previous eleven consecutive hours (which may or may not include the previous calendar day), resulting in a 12-hour moving average, with trailing values, associated with each daily hour.
2. Review the data to determine if there is an exceedance (12-C High > 120%).
3. When it appears an exceedance is a result of the influence of high hourly TDG levels from the previous day, filter the data set to exclude the first twelve 12-hr rolling averages of that day when an exceedance was noted.
4. Tabulate the resulting data set to reflect the maximum value observed on each specific calendar date. In other words, the greatest moving average value (including the previous eleven hours) observed through the last twelve hours of each day should be reported.
5. Count the total number of resulting values that exceed 120%. This should be reported as a number of days and as a proportion of total days observed (e.g., X days above 120% ÷ total number of days measured = XX.X % days of exceedance).

Use of the above methodology allowed for the monitoring of consecutive hours while eliminating "double counting". In the abovementioned example, only one day, not two, would have violated compliance under this method.

Chelan PUD understands and appreciates the need for consistency throughout the basin in regards to compliance monitoring and reporting and will modify or replace the methodology described above at such time as Ecology provides an approved method.

1.4 2009 Gas Abatement Plan (GAP) Requirements

Following is information that summarizes monitoring requirements as per the approved 2009 Gas Abatement Plans for Rocky Reach and Rock Island.

1.4.1 Operational

Operational gas abatement measures proposed at both projects were limited to the operational spill programs (Rocky Reach, See Section 2.3.1.1), continuing powerhouse optimization studies (Rocky Reach and Rock Island), and continuing use of the Over/Under gates (Rock Island).

As stated in the Rocky Reach and Rock Island Gas Abatement Plans, Chelan PUD was to manage spill toward meeting water quality criteria for TDG during all flows below 7Q10 levels, but only to the extent consistent with meeting the passage and survival standards sets forth in the HCPs, as follows:

a. Minimize voluntary spill,
b. During fish passage, manage voluntary spill levels in real time in an effort to continue meeting TDG numeric criteria,
c. Minimize spill, to the extent possible, by scheduling maintenance based on predicted flows.

1.4.2 Structural

No structural gas abatement measures were proposed for either project in 2009, as Chelan PUD continues to conduct RRHCP and RIHCP survival studies. For the studies to be considered valid, the studies need to take place during average flow conditions and normal project operating conditions consistent with the approved study design. This means project operations; including spill levels and configurations, as well as the overall project structure (such as spillway structures), need to remain constant during the survival studies.

1.4.3 Monitoring

As required by issuance of a TDG exemption for the Rocky Reach and Rock Island projects, Chelan PUD was to continue to implement physical and biological monitoring programs during the juvenile fish migration season. Activities include fisheries management activities, participation in water quality forums, collection of TDG data during the migration season, and collection of biological monitoring data.

Details of these monitoring requirements can be found in Appendix B for Rocky Reach, and Appendix C for Rock Island.

2. OPERATIONS

2.1 Description of 2009 Fish-Spill Season Flow Characteristics

Historic (10-yr average, 1999-2008) flows during spring (April 1 – June 9) and summer (June 10 – August 31) at Rocky Reach and Rock Island, as compared to 2009 flows are shown in the table below.

Table 1. 2009 river flows compared to 10-yr average flows (in kcfs).

	10-yr ave flows (1999-2008)	2009 flows	% of 10-yr average
Spring			
Rocky Reach	126.48	118.57	93.75
Rock Island	132.19	124.66	94.13
Summer			
Rocky Reach	124.72	100.21	80.35
Rock Island	129.01	102.97	79.82

2.2 Spill Configurations

2.2.1 Rocky Reach

The spillgate pattern employed at Rocky Reach was originally designed to provide proper conditions in the tailrace to prevent delay of adult salmon and steelhead finding the entrances to the upstream fishway. This spillgate pattern, referred to as the "standard" spill pattern, uses spillgates 2-8 opened at different settings in order to create an inverted "V" of aerated water and water velocities projecting downstream from the spillway. Radio telemetry studies of adult salmon and steelhead have shown that this flow pattern prevents fish from being lead away from the fishway entrances by false attraction to spillway flows and, when properly shaped, prevents cross currents from confusing fish and creating a hydraulic barrier in the vicinity of fishway entrances. This standard spill pattern has also been shown to be successful for juvenile fish passage spill (juvenile survival is very near 100% using this pattern). Gates 9-12 are used only in high flow conditions when gates 2-8 cannot pass enough water.

The spill level that is set for fish passage is subject to real-time modification to meet TDG standards, in accordance with a real-time operational plan. The Project operators are instructed to monitor the tailrace TDG level and reduce spill if TDG levels specified in the TDG Operational Plan (Appendix A) are exceeded. The operators at the Rock Island Hydroelectric Project are also instructed to inform the

operators at Rocky Reach when the Rock Island forebay TDG level exceeds 115%. Since implementation of this plan, TDG exceedances in the Rocky Reach tailrace have been reduced.

The standard spill pattern was not deviated from in 2009 at Rocky Reach.

2.2.2 Rock Island

The standard spill pattern for fish spill at Rock Island first utilizes the three Over/Under gates (31, 32, 30), then with increased spill, followed by the notched gates (1, 26, 16, 18, 24, 29), and finally the full gates (20, 17, 19, 22, 25 and 21).

The spill level that is set for fish passage is subject to real-time modification to meet TDG standards, in accordance with a real-time operational plan. The Project operators are instructed to monitor the tailrace TDG level and reduce spill if TDG levels specified in the TDG Operational Plan (Appendix A) are exceeded. Additionally, the Rock Island operators are also instructed to inform the operators at Rocky Reach when the Rock Island forebay TDG level exceeds 115%. Since implementation of this plan, TDG exceedances in the Rock Island tailrace have been reduced.

The standard spill pattern was not deviated from in 2009 at Rock Island.

2.3 Fish Spill Program

As part of the HCPs for the Rocky Reach and Rock Island Hydroelectric Projects, Chelan PUD is required to meet survival standards for fish migrating through the projects. Juvenile dam passage survival is a key component of project survival. Chelan PUD uses a different combination of tools to facilitate fish passage at the Rocky Reach and Rock Island Projects because of each project's unique features. At Rocky Reach, passage is facilitated by the new $112 million juvenile fish bypass system (JBS), which is the primary method to increase juvenile dam passage survival. The efficiency of the JBS has reduced the amount and duration of spill at certain phases of the migration season, thereby reducing TDG levels. At Rock Island, spill is still the preferred method of moving fish past the project, with most of the spill being passed through the modified "notched" spill gates.

The spill regimes implemented by Chelan PUD at each project are dictated by the timing of each species of fish migration. In the spring (generally mid-April to early- June), yearling Chinook, steelhead and sockeye migrate past the projects, while sub-yearling Chinook migrate during the summer (generally mid-June to mid/late-August).

2.3.1 Fish Spill Quantities and Duration

Spill scenarios can be divided into two categories: fish spill and non-fish spill. Generally speaking, fish spill is considered voluntary and non-fish spill is considered involuntary. Non-fish/involuntary spill scenarios are, but are not limited to:

- Flow in excess of hydraulic capacity
- Plant load rejection spill
- Immediate replacement spill
- Maintenance spill
- Error in communication spill

Definitions of these spills can be found in the 2009 Rocky Reach and Rock Island Gas Abatement Plans.

In 2009, spill events between April 1 and August 31 were predominately voluntary spill events for fish passage; however, there were some non-fish/involuntary spill events at both projects. Of the water spilled at Rocky Reach, 7.5% was involuntary spill (primarily due to spill past units), while 92.5% was voluntary spill. At Rock Island, .31% of water spilled was involuntary spill and 99.69% was voluntary spill for fish.

Tables 2 and 3 below show spill levels for different purposes at Rocky Reach and Rock Island in 2009.

Table 2. Average monthly total flow, spill, and percent of total flow spilled for different purposes at Rocky Reach, April 1 – August 31, 2009.

	Average Flow (Kcfs)	Average Spill (Kcfs)	Misc Flow (Kcfs)	Spill Purpose					
				Fish Spill			Other		
				Spill (Kcfs)	% of flow	% of Total Spill	Spill (Kcfs)	% of flow	% of Total Spill
April	108.17	0.72	0.43	0	0	0	0.72	0.67	100
May	119.32	0	0.07	0	0	0	0	0.00	0
June	144.47	9.7	0.43	8.61	5.9	88.76	1.09	0.75	11.24
July	102.34	8.66	0.43	8.65	8.5	99.88	0.01	0.01	0.12
August	74.2	5.41	0.43	5.39	7.3	99.63	0.02	0.03	0.37

Table 3. Average monthly total flow, spill, and percent of total flow spilled for different purposes at Rock Island, April 1 - August 31, 2009.

	Average Flow (Kcfs)	Average Spill (Kcfs)	Misc Flow (Kcfs)	Spill Purpose					
				Fish Spill			Other		
				Spill (Kcfs)	% of flow	% of Total Spill	Spill (Kcfs)	% of flow	% of Total Spill
April	111.07	6.39	1.5	6.39	5.8	100	0	0	0
May	126.28	13.75	1.5	13.68	10.8	99.49	0.07	0.06	0.51
June	152.38	25.14	1.5	25.07	16.5	99.72	0.07	0.05	0.28
July	103.85	20.9	1.5	20.84	20.1	99.71	0.05	0.05	0.29
August	74.18	8.27	1.5	8.24	11.1	99.64	0.03	0.04	0.36

The following sections describe in detail the voluntary fish spill quantities and durations at Rocky Reach and Rock Island.

2.3.1.1 Rocky Reach

During the spring of 2009, Chelan PUD operated the juvenile fish bypass system exclusively with no voluntary spill for yearling Chinook and steelhead passage. For sockeye, Chelan PUD conducted a survival study testing alternative day/night tagged fish release methods. During this study the powerhouse operated under normal fish bypass operations, with no Project spill. The test was to evaluate the experimental differences between day time and night time releases for tagged juvenile sockeye smolts, and the effects on Project survival for both groups of fish. This test included running the turbine units in best efficiency mode for power production to evaluate the differences in route-specific survival and Project survival with all available river flow passing through turbines.

To meet RRHCP survival standards for sub-yearling Chinook, Chelan PUD had a target spill level of 9% of daily average river flow at Rocky Reach for a duration covering 95% of their outmigration during the summer of 2009. The summer spill program for sub-yearling Chinook began on June 10 and initially ended on August 14. Due to an increase in fish counts following termination of fish spill, spill was reinitiated on August 19, ending for the season on August 31. Total spill for the summer spill program amounted to 9.06% of the daily average river flow.

2.3.1.2 Rock Island

Spill through modified gates remains the primary fish passage measure used to meet RIHCP survival standards at Rock Island Project. In 2009, Chelan PUD conducted a third RIHCP Project Survival study for juvenile yearling Chinook, sockeye, and steelhead at a 10% Project spill level. Spring spill of 10%

began on April 17 and was continued through June 9. Total spill for the spring fish spill season amounted to 10.01% of the daily average river flow.

Rock Island fish spill increased to 20% upon onset of the summer outmigration of sub-yearling Chinook. Summer spill commenced on June 10 and continued through August 17. Total spill for the summer fish spill season amounted to 19.96% of the daily average river flow.

Spring and summer spill covered 95% of the juvenile outmigration for steelhead, sockeye, yearling and sub-yearling Chinook.

3. IMPLEMENTATION RESULTS

3.1 Fisheries Management

3.1.1 Fish Passage Efficiencies

A fish passage efficiency study was conducted for sockeye salmon at Rocky Reach in 2009. The study report has not yet been finalized, but preliminary results show a 65.07% fish passage efficiency (fish passing through the Rocky Reach juvenile fish bypass system) during the daytime, and a 32.19% passage efficiency at night. Survival through the Rocky Reach surface collector and bypass system for both day and night was estimated to be 99.68% for all sockeye.

3.1.2 Survival Studies

Both the Rocky Reach and Rock Island HCPs include an overall project survival goal for adult and juvenile fish of 91%. However, biologists agree that at this time adult fish survival cannot be conclusively measured for each species covered by the plan. To compensate for the scientific unknowns, the HCPs set even higher standards for juvenile survival at each project– 95% juvenile dam passage survival and 93% juvenile project survival throughout the Project (i.e.,1,000 feet below the tailrace of the upstream dam to 1,000 feet below the tailrace of the project dam). Juvenile passage survival is the major component of the HCPs, but since the Projects are so distinct, different methods have been and will continue to be used at each dam to meet the survival goals set forth in the HCPs.

3.1.2.1 Rocky Reach

During the spring of 2009 Chelan PUD conducted a survival test to evaluate the experimental differences between day time and night time releases for tagged juvenile sockeye smolts and the effect on Project survival for both groups with no project spill.

Results of the 2009 survival study showed a Project Survival of 95.45% (SE=0.0118) for combined day and night sockeye releases from below Wells Dam. Project Survival for day time releases of sockeye was estimated to be 95.07%, while project survival for night time releases was estimated at 95.92%

3.1.2.2 Rock Island

Chelan PUD planned to conduct a survival study on yearling Chinook, steelhead, and sockeye during the spring of 2009. However, due to acoustic tag battery life issues, the yearling Chinook and steelhead survival studies were discontinued in May. The sockeye test to measure passage survival through the Rock Island Project continued as planned. Results of the test follow.

Rock Island Project Survival for juvenile sockeye in 2009 was estimated to be 94.57% (SE=0.159) with the project spilling 10% of the day average river flow for the spring juvenile outmigration period.

3.2 Biological Monitoring (GBT)

As part of the Fish Passage Center's Smolt Monitoring Program, yearling and sub-yearling Chinook salmon and steelhead were examined for evidence of gas bubble trauma (GBT) at Rock Island Dam between April 23 and July 30, 2009. Each week a random sample of up to 100 fish composed of both yearling Chinook salmon and steelhead were examined in April and May two days per week. In June, when the sub-yearling Chinook salmon collection was greater than the yearling collection, the sample was changed to up to 100 sub-yearling Chinook salmon examined two days per week. Examinations followed Fish Passage Center (FPC) standardized procedure as outlined by FPC (2004).

A total of 2,090 yearling Chinook, sub-yearling Chinook, and steelhead were examined for GBT, with 0.6% showing external signs.

3.3 Water Quality Forums

Chelan PUD participated in (via conference call) the Corps's year-end TDG Monitoring and Quality Assurance/Quality Control (QA/QC) meeting, at which presentations were made from the various agencies conducting TDG (and other water quality) monitoring within the Columbia River Basin. Topics included data completeness, quality, calibration results, new or improved monitoring methods, etc. Agencies presenting at this meeting included the USGS, Corps, other mid-Columbia River PUDs, and private consultants.

Chelan PUD has regularly attended the Transboundary Gas Group Meeting since early in its history and is currently the Co-Chair of the group. This year's agenda included discussions on the history and evolution of the group, Oregon and Washington States' modification of TDG monitoring and tracking requirements, how exceedances are measured in various jurisdictions, Chief Joseph deflector spill test, Spokane River FERC License and efforts to mitigate TDG at Long Lake Dam, TDG study related to the new Wanapum Dam fish bypass system, and an update on the TDG study at Boundary Dam.

3.4 Physical Monitoring (TDG)

3.4.1 Overview

TDG in the forebays and tailraces of Rocky Reach and Rock Island projects, as well as the forebay of Wanapum Project, varied throughout the spring and summer of 2009. Figures 5 and 6 show the average of the 12 highest consecutive hourly readings from each 24-hr period during the fish spill season from each fixed monitoring site. This variation was due in part to changing spill volumes at the projects. At Rocky Reach and Rock Island, 96.09% and 99.71% of spill, respectively, from April 1 to August 31, 2009 was voluntary for fish passage. Tables 2 and 3 outline the percentage and type of voluntary and involuntary spill from April 1 to August 31, 2009 at both Rocky Reach and Rock Island. Monthly average spills at Rocky Reach ranged from 0.00 to 9.88 thousand cubic feet per second (kcfs) and from 6.47 to 25.17 kcfs at Rock Island (Table 3). Minimum and maximum daily average spills at Rocky Reach varied from 0 to 37.13 kcfs and from 0 to 33.46 kcfs at Rock Island Project.

During the 2009 spill season (including voluntary and involuntary spill) monthly average TDG levels decreased an average of 0.2% (range: decrease of 0.5% to an increase of 0.5%) from the Rocky Reach forebay to the Rock Island forebay. Between the forebays of Rock Island and Wanapum projects, TDG gas levels increased an average of 1.0% (range: decrease of 0.9% to an increase of 2.9%). A summary of this data can be found in Table 4 below.

Table 4. Average TDG levels (based on 12- highest consecutive hours) and changes in TDG between the forebays of Rocky Reach, Rock Island, and Wanapum projects, April 1 – August 31, 2009.

	Forebay TDG % Saturation			Change in TDG % Saturation	
	Rocky Reach	Rock Island	Wanapum	Rocky Reach to Rock Island	Rock Island to Wanapum
April	107.0	107.5	106.6	0.5	-0.9
May	110.1	109.6	112.5	-0.5	2.9
June	112.0	111.6	113.3	-0.4	1.6
July	114.0	113.4	115.2	-0.6	1.7
August	109.7	109.9	109.6	0.2	-0.3
Average	**110.6**	**110.4**	**111.4**	**-0.2**	**1.0**

Table 5 below provides a summary of total flow spilled, percent river flow spilled, and change in TDG from forebay to tailrace at Rocky Reach and Rock Dams during the 2009 spill season.

Table 5. Rocky Reach and Rock Island projects: Average of total volume spilled (voluntary and involuntary), percent total river flow spilled, and change in percent TDG from forebay to tailrace, April 1 – August 31, 2009.

	Rocky Reach			Rock Island		
Month	Average Volume Spilled (Kcfs)	Percent Total River Flow Spilled	Change in Percent TDG	Average Volume Spilled (Kcfs)	Percent Total River Flow Spilled	Change in Percent TDG
April	0.72	0.70	-1.8	6.39	5.75	1.3
May	0.00	0.00	-2.2	13.75	10.89	2.7
June	9.70	6.70	0.02	25.14	16.50	3.4
July	8.66	8.46	-1.1	20.90	20.13	3.8
August	5.41	7.29	-0.3	8.27	11.15	2.7
Average	**4.90**	**4.63**	**-1.1**	**14.89**	**12.88**	**2.8**

The extensive nature of the hourly data makes presentation of the complete data set in this report impractical. Hourly data can be obtained upon request from Chelan PUD or can be accessed at the following internet site: http://www.nwd-wc.usace.army.mil/report/tdg.htm.

Regression analysis was used to evaluate the relationship between the change in TDG levels from forebay to tailrace and the total volume spilled at both Rocky Reach and Rock Island projects, as well as from the tailrace of each project to the forebay of the next downstream project. Hourly flow and TDG data were

grouped by spill season (spring: April 1 – June 9, summer: June 10 – August 31, based on fish run-timing). These results were examined to identify any correlation between project operations and spill related TDG fluctuations from the forebay to the tailrace.

Data analysis showed that water coming into the Rocky Reach forebay from upstream exceeded Washington State water quality criteria on 5 days (3.3% of the total number of days observed). TDG exceeded the modified Washington State TDG fish spill water quality criteria on 0 days in the Rocky Reach tailrace, Rock Island forebay, and Rock Island tailrace during this monitoring period. Numeric criteria were exceeded on 16 days (10.6% of the total number of days observed) (using the standard 12-hr rolling average method), and 14 days (using the revised method that eliminates the double-counting issue) in the Wanapum forebay (Grant County PUD). Wanapum Dam Project operations and tailrace compliance were not impacted by the elevated TDG levels in the Project forebay (Hendrick, personal communication).

3.4.2 Data evaluation and analyses (QA/QC)

TDG levels from both the forebay and the tailrace of Rocky Reach and Rock Island projects were obtained every fifteen minutes and the hourly averages of these readings were recorded in the head-quarters computer from April 1 to August 31, 2009. Hourly TDG data from Rocky Reach and Rock Island projects was averaged and the daily averages are presented in Appendix D. A comparison was made to determine what percentage of all possible data (hourly readings at all FMS) was collected throughout the monitoring season. Prior to the start of fish spill-season, software and hardware upgrades were completed at each FMS to help increase the FMS system reliability. Throughout the 2009 monitoring season (April 1 - August 31), 100% of all possible data were collected at the Rocky Reach forebay and tailrace FMS and the Rock Island forebay FMS. At the Rock Island tailrace FMS, 97.4% of all possible data were collected.

Chelan PUD entered into a Professional Services Agreement with Columbia Basin Environmental to perform monthly calibrations and equipment maintenance. Quality Assurance/Quality Control measures were accomplished through training in instrument maintenance, operation, and factory prescribed calibration methods. A detailed log was maintained for all work done on the monitoring equipment, including monthly maintenance, calibration, exchange of instruments, and any other pertinent information. Redundant measurements with a mobile instrument to verify the accuracy of the in-situ instruments were conducted during the monthly calibrations. Calibration reports are included as Appendix E.

3.4.3 Spring 2009

There was no spill during the spring at Rocky Reach Dam in 2009. The spring spill program was conducted from April 17 to June 9 at Rock Island Dam. The following data represents voluntary and involuntary spill events beginning April 1, continuing to June 9 at both projects. ***Data presented in the following are based on the daily average of the 12 highest consecutive hours.***

3.4.3.1 Rocky Reach

From April 1 to June 9, 2009, TDG levels in the Rocky Reach forebay averaged 108.9% and ranged from 103.9% to 112.3%. TDG levels in the tailrace averaged 106.8% and ranged from 102.8% to 110.5%. The average (based on the 12 highest consecutive hours) change in percent TDG from the forebay to the tailrace was a decrease of 2.1%, ranging from a decrease of 3.7% to an increase of 1.9%. A summary of this data can be found in Table 6 below. Because minimal water was spilled (and none for fish purposes) during the spring at Rocky Reach, a regression analysis to determine a relationship between the change in percent TDG between the forebay and tailrace and total volume spilled was not conducted.

3.4.3.2 Rock Island

From April 1 to June 9, 2009, TDG levels in the Rock Island forebay averaged 108.8% and ranged from 104.5% to 112.0%. TDG levels in the tailrace averaged 110.9% and ranged from 103.9% to 114.0%. The average (based on the 12 highest consecutive hours) change in percent TDG from the forebay to the tailrace was an increase of 2.1%, ranging from a decrease of 1.5% to an increase 5.1%. A summary of this data can be found in Table 6 below. Regression analysis showed a moderate relationship between the change in TDG and total volume spilled (r^2=.6976, Figure 9).

3.4.3.3 Wanapum Forebay

From April 1 to June 9, 2009, TDG levels in the Wanapum forebay averaged 110.0% and ranged from 102.7% to 115.2%.

Table 6. Average spring (April 1 – June 9) TDG levels (based on the 12-highest consecutive hours) in forebay and tailrace of Rocky Reach and Rock Island and forebay of Wanapum.

	Rocky Reach		Rocky Reach (spill events only)		Rock Island		Wanapum	
	Average	Range	Average	Range	Average	Range	Average	Range
Forebay TDG	108.9	103.9 - 112.3	107.15	103.9-109.4	108.8	104.5 - 112	110.0	102.7 - 115.2
Tailrace TDG	106.8	102.8 - 110.5	106.3	105-108.9	110.9	103.9 - 114		
Change (FB to TR)	-2.1	-3.7 - 1.9	-0.84	-2.6 - 1.9	2.1	-1.5 - 5.1		

3.4.3.3 Change in TDG from Tailraces to Forebays

As stated above, from April 1 to June 9, 2009, TDG levels in the Rocky Reach tailrace averaged 106.8% (range: 102.8% to 110.5%), and averaged 108.8% (range: 104.5% to 112.0%) in the Rock Island forebay. This amounts to an average increase in TDG of 2% (range: 0.2% to 3.8%) between the Rocky Reach tailrace and the Rock Island forebay. Regression analysis showed a weak relationship between the change in TDG and total volume spilled (r^2=.0166, Figure 10).

As stated above, Rock Island tailrace TDG levels averaged 110.9% (range: 103.9% to 114.0%). Wanapum forebay TDG levels averaged 110.0% (range: 102.7% to 115.2%). The resulting average change in TDG levels between the Rock Island tailrace and Wanapum forebay was a decrease of 0.5% (range: -5.4% to 5.5%). Regression analysis showed a weak relationship between the change in TDG and total volume spilled (r^2=.0165, Figure 11).

Table 7. Change in percent TDG between tailraces and forebays in spring (April 1 – June 9), 2009.

	RRTR	**RIFB**	**Change (TR to FB)**		**RITR**	**WanFB**	**Change (TR to FB)**
average	106.8	108.8	2.0		110.9	110	0.5
min	102.8	104.5	0.2		103.9	102.7	-0.5
max	110.5	112.0	3.8		114.0	115.2	5.5

3.4.4 Summer 2009

The 2009 summer fish spill at Rocky Reach was conducted from June 10 to August 31 and at Rock Island from June 10 to August17. The following data represents voluntary and involuntary spill events beginning June 10, continuing through August 31. ***Data presented in the following is based on the daily average of the 12 highest consecutive hours.***

3.4.4.1 Rocky Reach

From June 10 to August 31, 2009, TDG levels in the forebay of Rocky Reach Project averaged 112.0%, ranging from 106.9% to 116.9%. TDG levels in the tailrace averaged 111.7%, and ranged from 104.6% to 115.5%. The average (based on the 12 highest consecutive hours) change in percent TDG between the forebay and tailrace was a decrease of 0.3%, ranging from a decrease of 3.8% to an increase of 3.5%. A summary of this data can be found in Table 8 below. Regression analysis showed a weak correlation between the change in percent TDG and total volume spilled (r^2= 0.217 Figure 12).

3.4.4.2 Rock Island

From June 10 to August 31, 2009, TDG levels in the forebay of Rock Island Project averaged 111.8% and ranged from 107.3% to 114.9%. The readings in the tailrace averaged 115.2% and ranged from 107.4% to 119.3%. The average (based on the 12 highest consecutive hours) change in TDG from the forebay to the tailrace averaged an increase 3.4% with a range from a decrease of 0.3% to an increase of 6.6%. A summary of this data can be found in Table 8 below. Regression analysis shows a weak correlation between the change in percent TDG from the forebay to the tailrace and total volume spilled (r^2= 0.3731) (Figure 13).

3.4.4.3 Wanapum Forebay

From June 10 to August 31, 2009, TDG levels in the Wanapum forebay averaged 112.6 and ranged from 105.5% to 119.3%.

Table 8. Average summer (June 10 – August 31) TDG levels (based on 12-highest consecutive hours) in forebay and tailrace of Rocky Reach and Rock Island and forebay of Wanapum.

	Rocky Reach		Rock Island		Wanapum	
	Average	Range	Average	Range	Average	Range
Forebay TDG	112	106.9 - 116.9	111.8	107.3 - 114.9	112.6	105.5 - 119.3
Tailrace TDG	111.7	104.6 - 115.5	115.2	107.4 - 119.3		
Change (FB to TR)	-0.3	-3.8 - 3.5	3.4	-0.3 - 6.6		

3.4.4.3 Change in TDG from Tailraces to Forebays

As stated above, from June 10 to August 31, 2009, TDG levels in the Rocky Reach tailrace averaged 111.7% (range: 104.6% to 115.5%), and averaged 111.8% (range: 107.3% to 114.9%) in the Rock Island forebay. This amounts to an average increase in TDG of 0 .1% (range: -3.3% to 2.7%) between the Rocky

Reach tailrace and the Rock Island forebay. Regression analysis showed a moderate negative relationship between the change in TDG and total volume spilled (r^2=.4275, Figure 14).

During this same time, Rock Island tailrace TDG levels averaged 115.2% (range: 107.4% to 119.3%). Wanapum forebay TDG levels averaged 112.6% (range: 105.5% to 119.3%). The resulting average change in TDG levels between the Rock Island tailrace and Wanapum forebay was a decrease of 2.6% (range: -9.2% to 2.7%). Regression analysis showed a weak relationship between the change in TDG and total volume spilled (r^2=.0322, Figure 15).

Table 9. Change in percent TDG between tailraces and forebays in summer (June 10 – August 31), 2009.

	RRTR	RIFB	Change (TR to FB)		RITR	WanFB	Change (TR to FB)
average	111.7	111.8	0.1		115.2	112.6	-2.6
min	104.6	107.3	-3.3		107.4	105.5	-9.2
max	115.5	114.9	2.7		119.3	119.3	2.7

4. DISCUSSIONS OF TOTAL DISSOLVED GAS ABATEMENT MEASURES

4.1 Operational

Due to the success of the juvenile fish bypass system at Rocky Reach and survival studies at both projects, Chelan PUD has been able to reduce spill at both Rocky Reach and Rock Island for at least a portion of the spill season, thereby reducing the generation of total dissolved in the project waters.

4.1.1 Rocky Reach

Chelan PUD continues to operate Rocky Reach under Phase I of the HCP for yearling Chinook, which requires survival studies be conducted during representative flow conditions and specified project operating conditions consistent with the approved study design. No significant changes can be made to operations until the end of Phase I unless an operation is identified and approved by the HCP CC that can increase survival during the Phase I juvenile testing. The actual year in which operational changes can be made is dependent upon reaching Phase III Standards Achieved (93% survival average during 3 years of Phase I juvenile testing). At the completion of Phase I (for yearling Chinook, steelhead, and sockeye), Chelan PUD will implement spill levels that were tested and shown to achieve the necessary 93% juvenile project survival goal. It is at this time Chelan PUD will be able to determine what gas abatement measures are feasible and necessary to meet water quality requirements and HCP survival standards.

A study was conducted in 2003 to determine the bypass efficiency for yearling Chinook, steelhead, and sockeye. Based on the results from that study, and consistent with section 5.4a of the Rocky Reach HCP, spill was eliminated for yearling Chinook and steelhead and set at 24% for sockeye for Phase I testing. While steelhead have met the HCP juvenile project survival standard of 93%, sockeye and yearling Chinook have not. Chelan anticipates completing the third Phase I survival study for yearling Chinook in 2011, and conducting survival testing for juvenile sockeye 2011-2013.Spill may be reduced or eliminated in the future if studies show that it is not needed to reach the juvenile survival standards of the HCP.

In 2009, Chelan PUD operated the juvenile fish bypass (JFB) for yearling Chinook and steelhead with no Project spill. For sockeye, Chelan PUD conducted a survival study (Phase II Additional Tools) to test the effects of alternative day/night tagged fish releases on survival estimates. During this study, the powerhouse operated under normal fish bypass operations, with no Project spill. The goal of this study was to determine if there is a negative bias in survival estimates (study fails to estimate true run-of-river smolt survival due to a faulty methodology) by releasing acoustic-tagged fish during midday only when sight dependent avian and piscivorous predators are most active. Chelan PUD has released its study fish only during the day throughout all previous years' survival studies. Recent research has shown that a large number of juveniles migrate past the dam at night.

4.1.2 Rock Island

After meeting the HCP juvenile survival standards for all spring migrating species under a 20% spring spill regime in 2006, Chelan PUD in spring 2007 implemented a spill reduction study resulting in spring (voluntary) fish spill being reduced to 10% of the daily average river flow. This commenced a second round of HCP Phase I survival studies under the new operational regime.

Because Chelan PUD is operating Rock Island under a second round of Phase I of the HCP for yearling Chinook, steelhead, and sockeye, survival studies must be conducted during representative flow conditions and normal project operating conditions consistent with the approved study design. No significant changes can be made to operations until the end of Phase I 10% spill survival testing. The actual year in which changes can be made is dependent upon the meeting survival standards in Phase I studies. At the completion of Phase I (for yearling Chinook, steelhead, and sockeye), if successful, Chelan PUD would continue a 10% Project spill level during the spring to ensure the Project survival goal is maintained. It is at this time Chelan PUD will be able to rely on this spill reduction as an achieved gas abatement measure to meet water quality requirements and HCP survival standards.

4.2 Structural

At Rock Island Dam, Chelan PUD utilized the Over/Under spill gates during 2009 fish spill operations. Before additional Over/Under gates are constructed, or other structural changes are made, Chelan PUD will operate under the existing structural configuration over the course of the next several years (to include the remainder of Phase I survival testing) to determine the impact on TDG abatement resulting from the three existing Over/Under gates.

No structural modifications were made or utilized at Rocky Reach Dam in 2009.

5. CONCLUSIONS

No exceedances of the TDG criterion were observed in the Rocky Reach tailrace, Rock Island forebay, or Rock Island tailrace in 2009. However, like previous years, there were a number of days (14 if using established methodology, 16 if using revised methodology to eliminate double counting) in 2009 that the Wanapum Project forebay exceeded the State water quality criteria, while the Rock Island tailrace remained within compliance levels of TDG saturation. This is not clearly understood but could be a result of increased TDG pressure associated with increased temperatures and minimal TDG dissipation between the projects.

While TDG levels generally decreased from the forebay of Rocky Reach to the forebay of Rock Island, a consistent increase in the TDG levels between the forebays of Rock Island and Wanapum dams was observed throughout the 2009 monitoring season. As has been observed in previous years, there were instances in 2009 when the Wanapum Dam forebay was out of compliance (>115%) with the State water quality standards, while the Rock Island tailrace remained within the accepted levels of TDG saturation. The mechanism that is causing this is not clearly understood, but could be a result of increased pressure associated with increased temperatures and minimal dissipation between Rock Island and Wanapum dams. As the reservoirs above Rocky Reach, Rock Island, and Wanapum dams are generally well mixed due to the projects' run-of-the-river nature, and generally no stratification occurs in the reservoirs, water temperature changes little with depth. However, water temperature increases slightly moving downstream between projects due to radiant heating. With each degree increase in temperature, there have been observed increases in TDG of nearly 3% (J. Carrol, pers. comm.). This increase occurs due to the laws of partial pressure associated with temperature increases. Because the reach between Rock Island and Wanapum dams is nearly two times the length of the reach between Rocky Reach and Rock Island dams, there is an increased time of exposure to radiant heating, and therefore a likelihood of increased heating.

This may, in part, explain the overall limited dissipation of TDG as the water flowed from the Rock Island tailrace to the Wanapum forebay.

Evaluation of the TDG data shows that TDG levels generally increased from the forebay to the tailrace at both Rocky Reach and Rock Island projects. Generally, there was an increase in TDG levels as the volume of water spilled increased. The increase in TDG levels with respect to the volume of water spilled was more pronounced between the Rock Island forebay and tailrace than between the Rocky Reach forebay and tailrace, as has been observed in previous years.

The extent of compliance with State water quality criteria was due in part to the fish spill programs at Rocky Reach and Rock Island. The fish spill programs at both projects were managed to maximize fish passage, meet HCP requirements, minimize voluntary spill, and still stay within the terms of the State fish spill water quality criteria. Additionally, voluntary spill levels at both projects were managed in real time as detailed in the TDG Operational Plan for each project. When Project operators observed instantaneous TDG levels that exceeded the criteria as set forth in the Plans, spill was reduced and TDG levels monitored, which also played a role in the minimization of TDG production at the projects.

LITERATURE CITED

Pickett, P., H. Rueda, and M. Herold. *Total Maximum Daily Load for Total Dissolved Gas in the Mid-Columbia River and Lake Roosevelt.* Washington State Department of Ecology, Olympia,WA, and U.S. Environmental Protection Agency, Portland, OR. June 2004.

Figure 1. Location of Rocky Reach and Rock Island Hydroelectric Projects on the Columbia River.

Figure 2. Location of forebay and tailrace fixed monitoring stations at Rocky Reach Project.

Figure 3. Location of forebay fixed monitoring station at Rock Island Project.

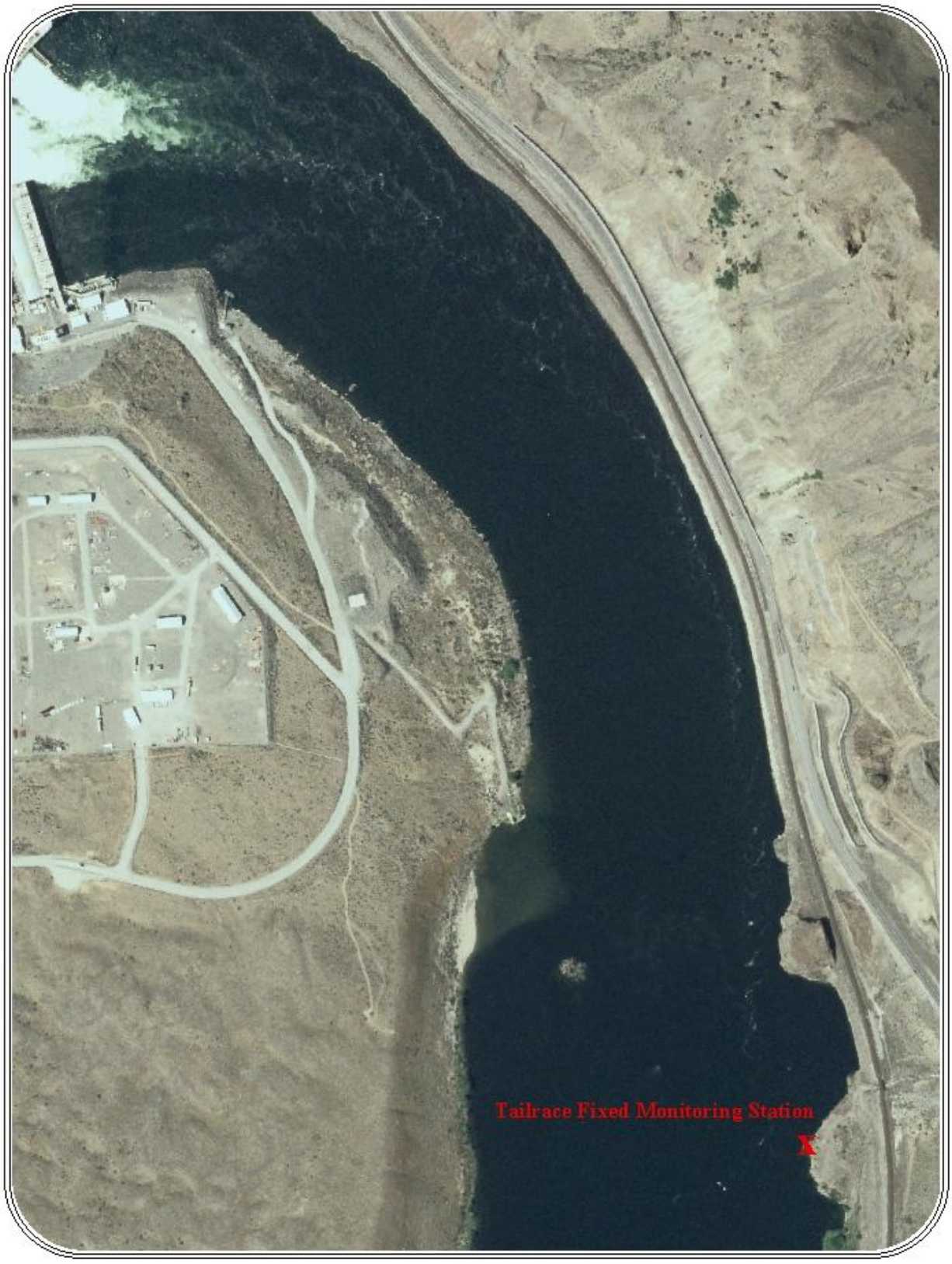

Figure 4. Location of tailrace fixed monitoring station below Rock Island Project.

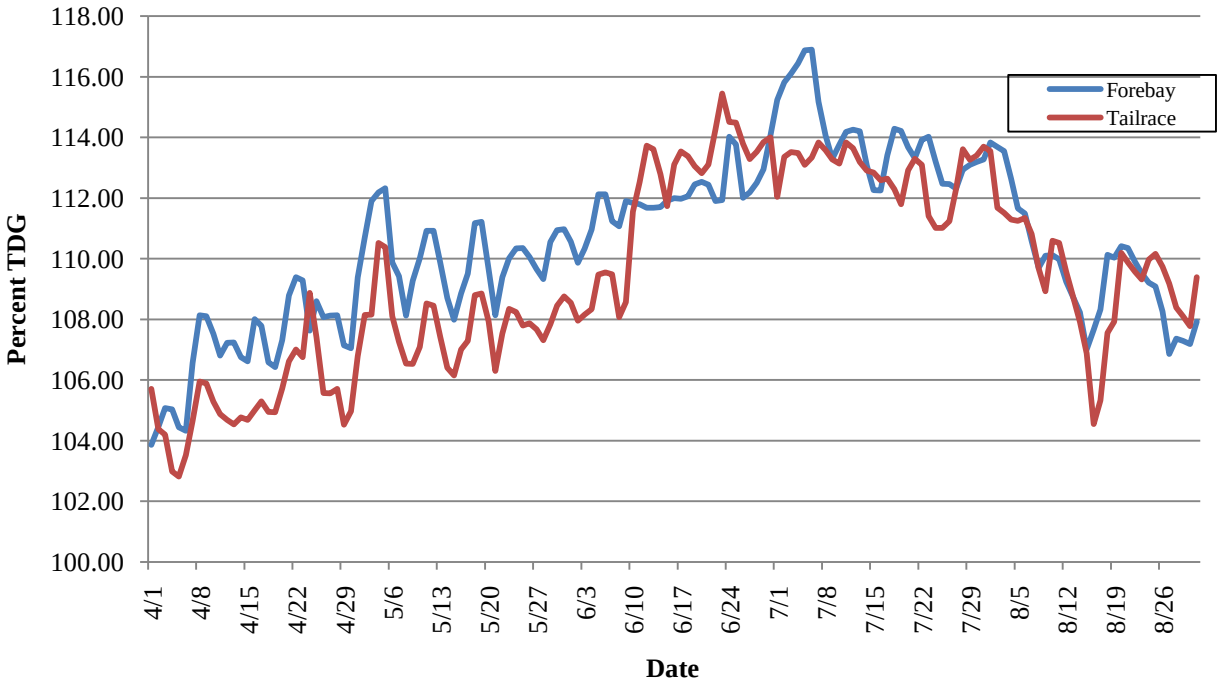

Figure 5. Daily average TDG (based on the 12 highest consecutive hours) in the forebay and tailrace of Rocky Reach Dam during the 2009 fish spill season.

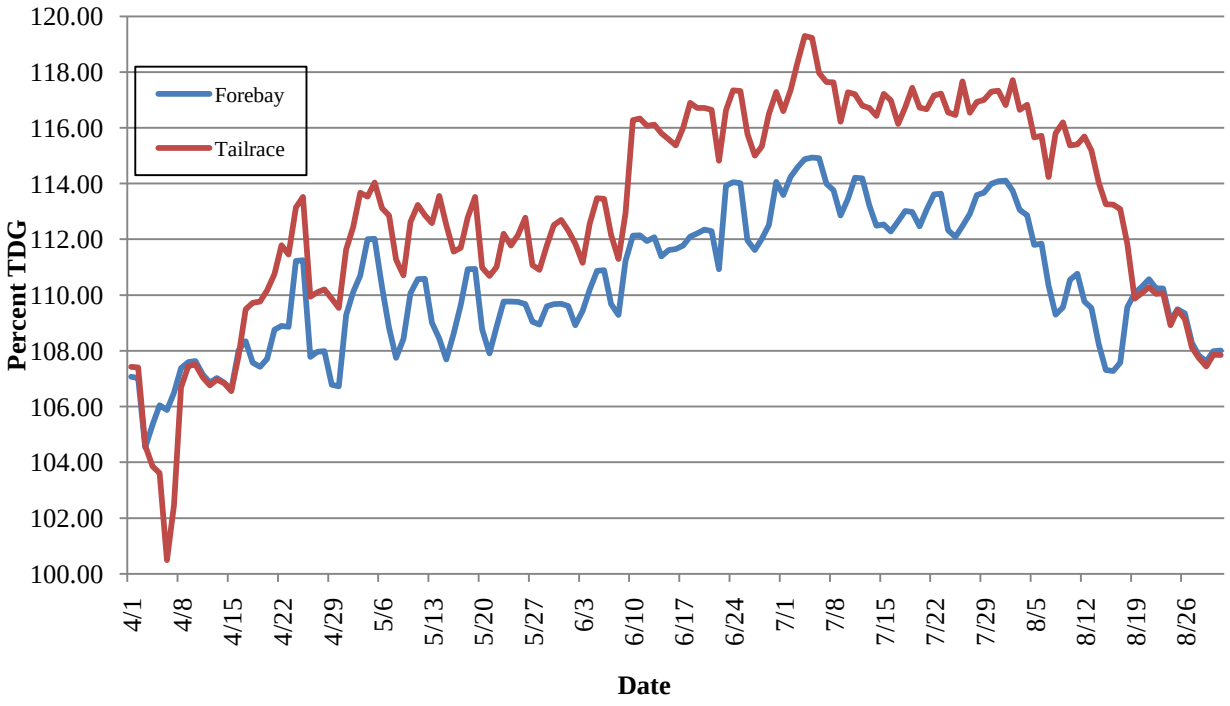

Figure 6. Daily average TDG (based on the 12 highest consecutive hours) in the forebay and tailrace of Rock Island Dam during the 2009 fish spill season.

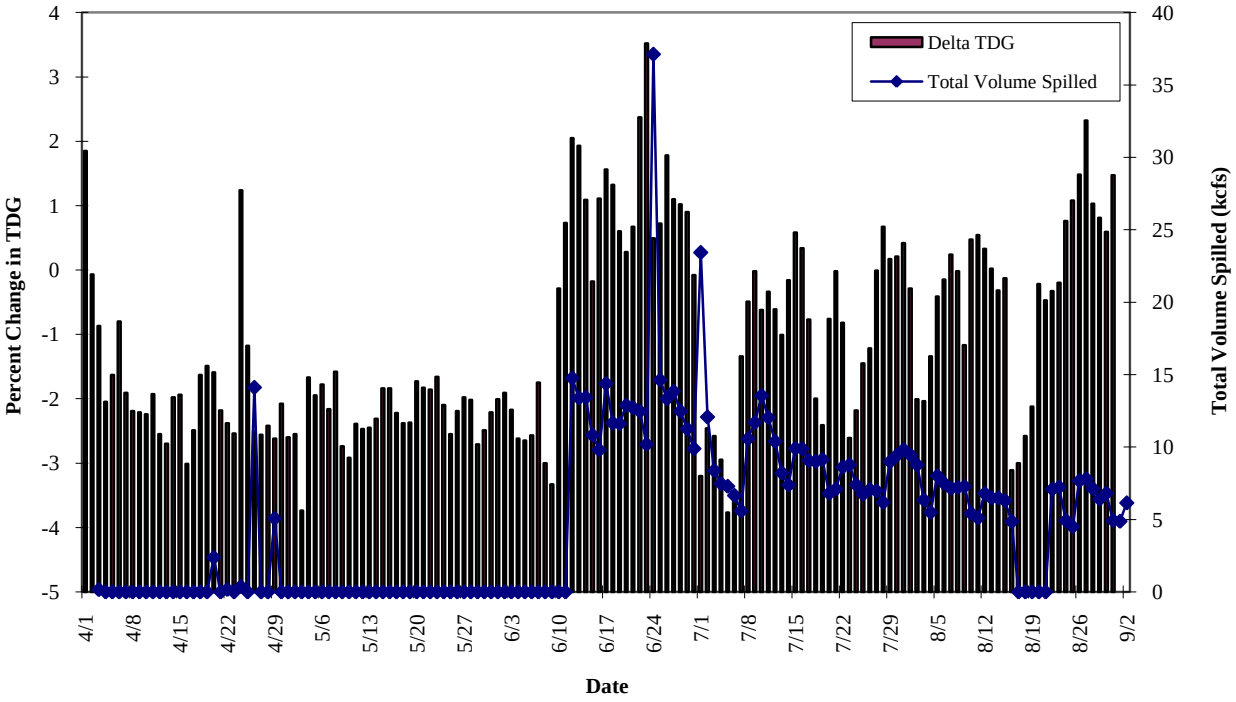

Figure 7. Total volume spilled to percent change in TDG from forebay to tailrace at Rocky Reach Project, April 1 - Aug 31, 2009.

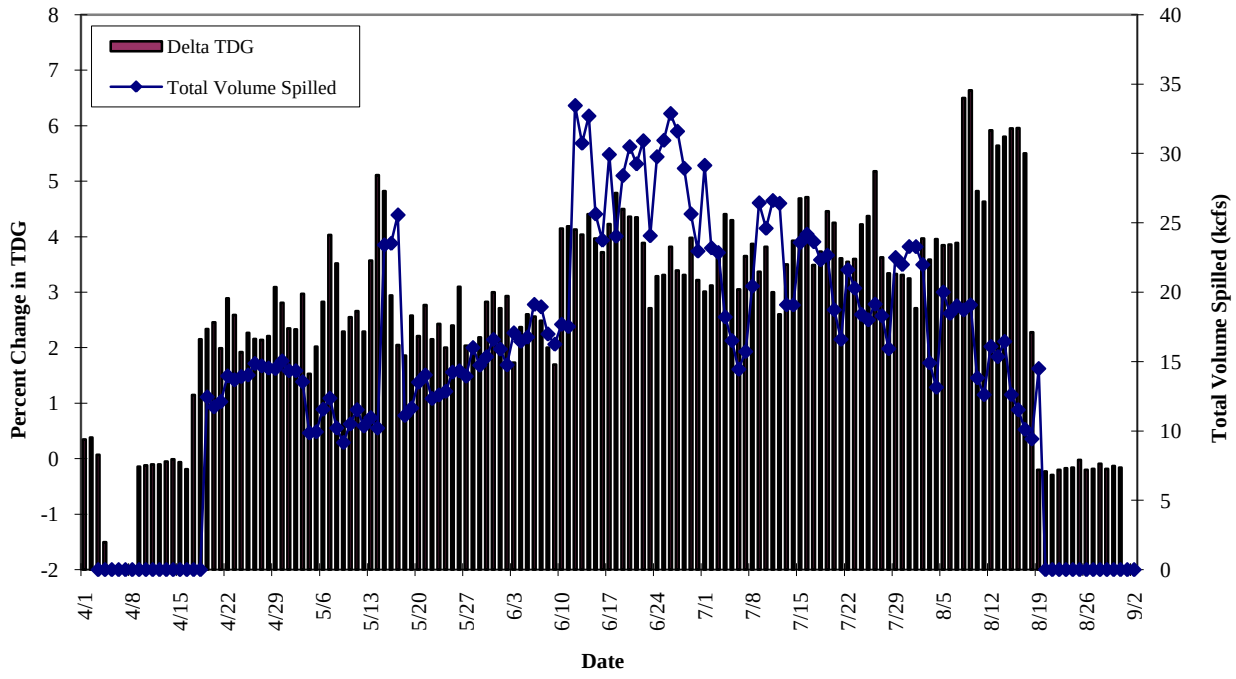

Figure 8. Total volume spilled to percent change in TDG from forebay to tailrace at Rock Island Project, April 1- Aug 31, 2009.

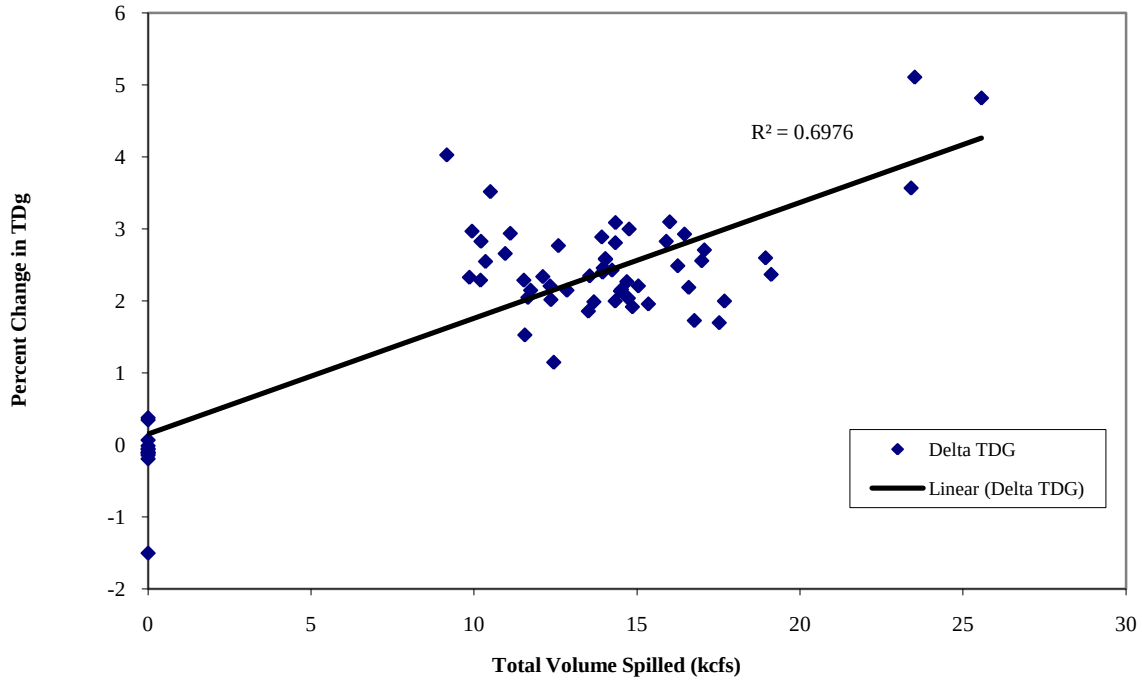

Figure 9. Total volume spilled to percent change in TDG from forebay to tailrace at Rock Island Project, April 1 - June 9 (spring) 2009.

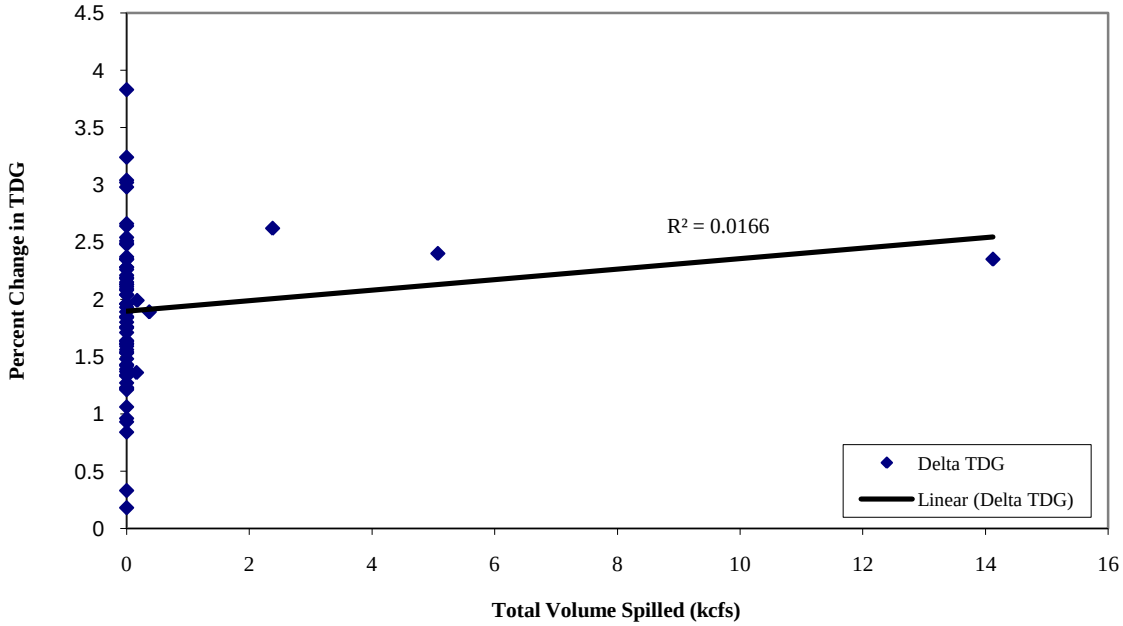

Figure 10. Total volume spilled to percent change in TDG from Rocky Reach tailrace to Rock Island forebay, April 1 - June 9 (spring) 2009.

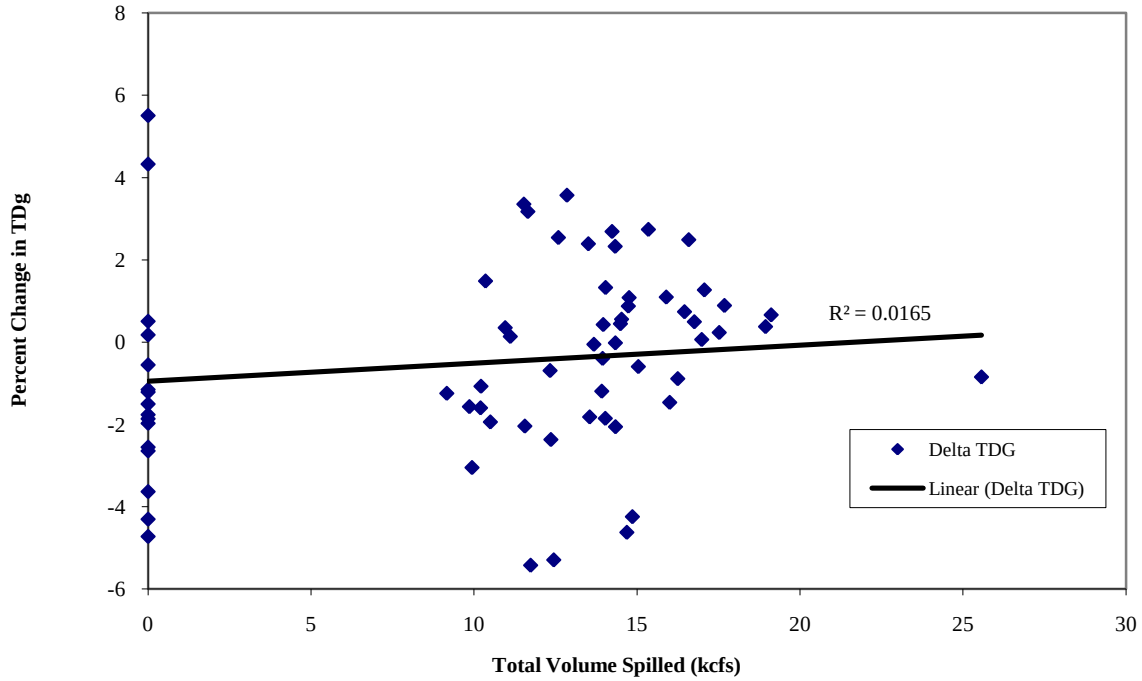

Figure 11. Total volume spilled to percent change in TDG from Rock Island tailrace to Wanapum forebay, April 1 - June 9 (spring) 2009.

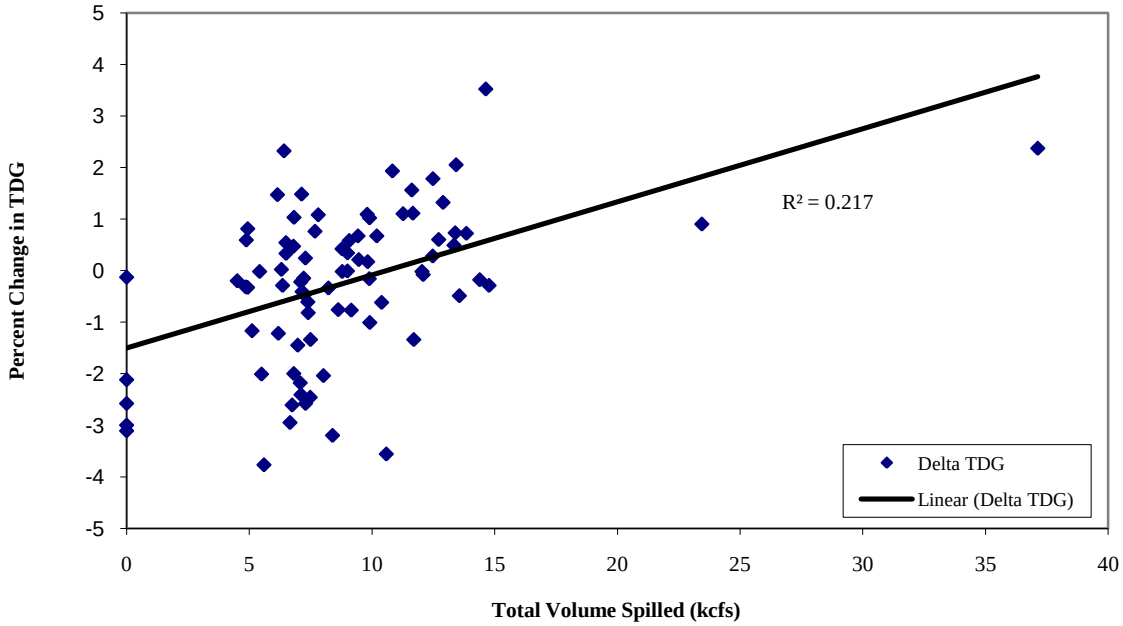

Figure 12. Total volume spilled to percent change in TDG from forebay to tailrace at Rocky Reach Project, June 10-August 31 (summer) 2009.

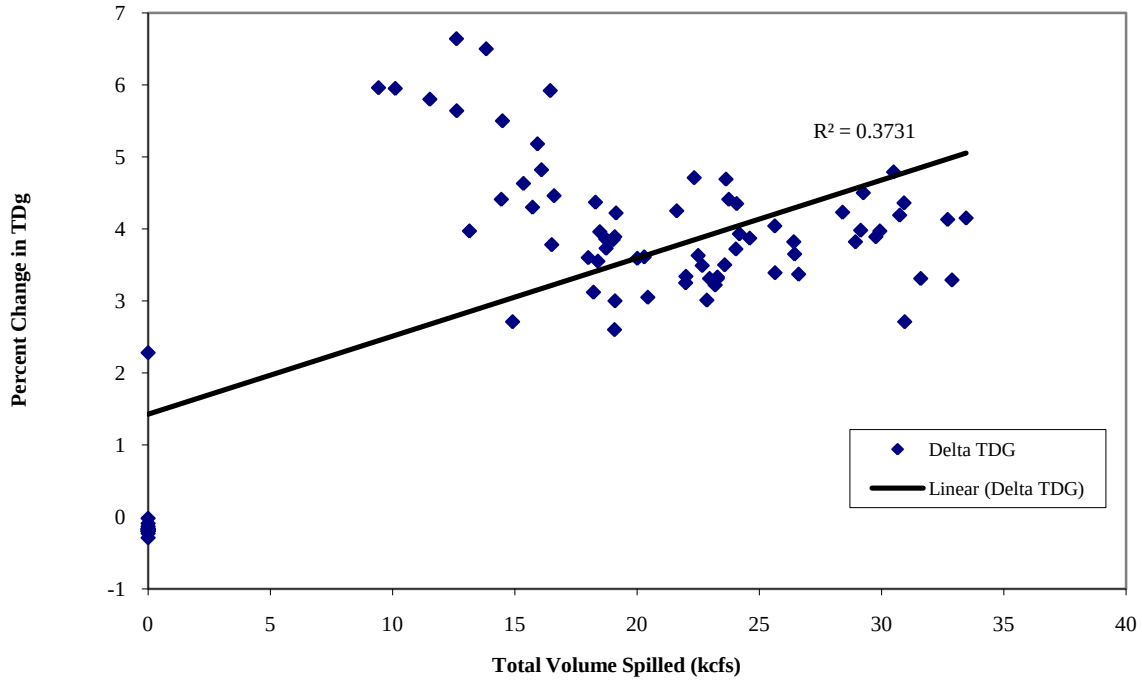

Figure 13. Total volume spilled to percent change in TDG from forebay to tailrace at Rock Island project, June 10 - August 31 (summer) 2009.

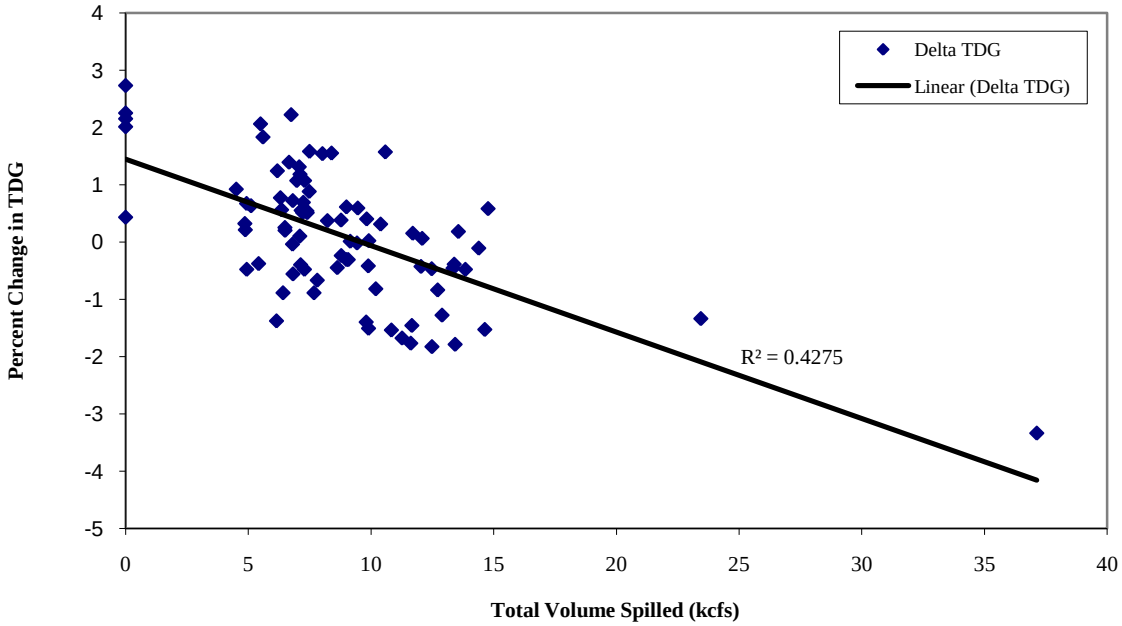

Figure 14. Total volume spilled to percent change in TDG from Rocky Reach tailrace to Rock Island forebay, June 10-August 31 (summer) 2009.

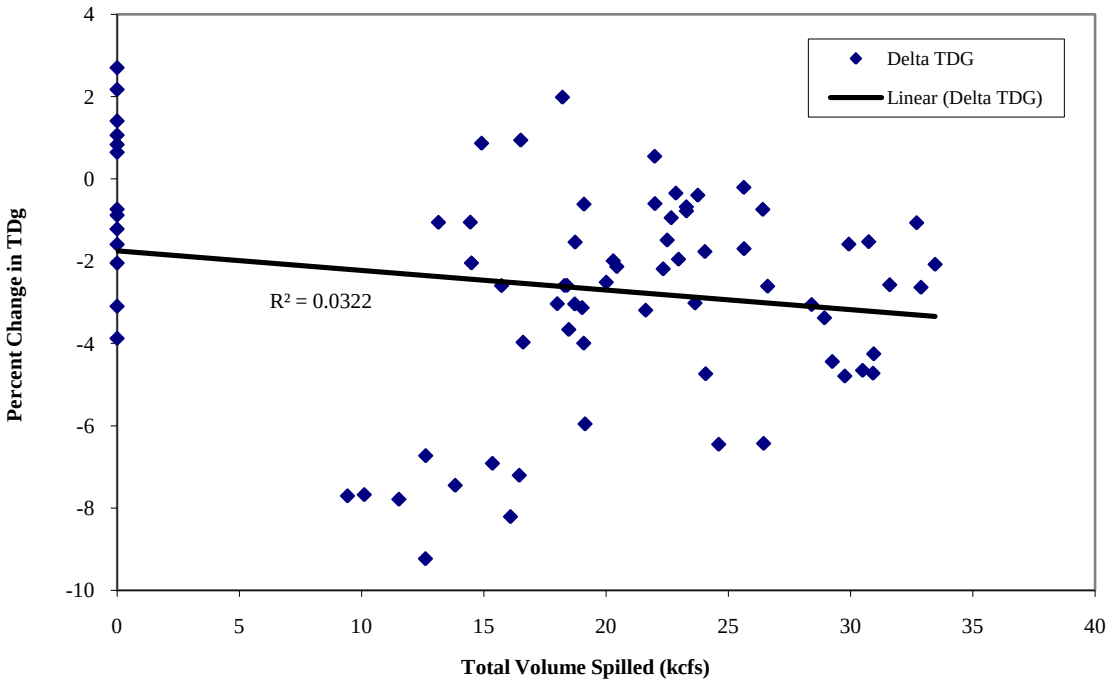

Figure 15. Total volume spilled to percent change in TDG from Rock Island tailrace toWanapum forebay, June 10 - August 31 (summer) 2009.

APPENDIX A

TDG Operational Plans
Rocky Reach and Rock Island

2009 Rocky Reach Operational Plan

for Total Dissolved Gas During Fish Spill Season

April 1 – August 31

(All spill between these dates is subject to the actions contained in this plan.)

Protocol

1. If tailrace TDG average is greater than ***120% for the 6-hour average***
   - reduce spill by 3 kcfs
   - monitor for 1 hour
   - if the 6-hr average TDG >120%, reduce spill by another 2 kcfs
   - monitor for 1 hour
   - continue reducing spill by 2 kcfs until 6-hr average TDG is less than 120% for one full hour
   - **if after reducing spill to control TDG levels, TDG drops below 118% for one full hour, increase spill by 2 kcfs and monitor ****

2. If tailrace TDG is greater than ***125% for 1 hr***
   - follow protocol outlined above, but instead, use **one-hour TDG levels of 125%** as the metric
   - continue until TDG is less than 125% for 1 hr and until the 6-hr average TDG <120%

If you receive a call from RI advising that the RI forebay is out of compliance (greater than 115%) and the RR forebay is 115% or less, reduce spill by 3 kcfs. Two hours after reducing spill, call RI to determine what the RI forebay gas levels are. If still above 115%, reduce spill another 2 kcfs. If after reducing spill for this reason, the Rock Island forebay drops to less than 113%, Rock Island will call again and advise. At this point, increase back to the hourly spill volume target by increasing spill in the reverse order it was decreased. For example, if to bring the RI forebay back into compliance, it was necessary to reduce spill by a total of 5 kcfs, begin by increasing spill by 2 kcfs, wait two hours, and call RI to determine what the forebay TDG levels are. If TDG is still below 115%, increase spill by 3 kcfs (back to the target volume in this case). This will allow for a ramping effect, rather than an open/shut effect which could bump the Rock Island forebay TDG levels back out of compliance (>115%).

**** Note**: It will not be necessary to monitor for one full hour after re-opening if it appears that TDG is approaching the upper threshold, rather, the procedure will repeat upon reaching the threshold. It is anticipated that in time, the operators will "get a feel" for how much change in TDG will occur as a result of opening or closing gates and it will be possible to hold the TDG around 118% or 119% or so. Once the operators have this down, instead of closing a gate entirely, it may only be necessary to close partially, and visa versa for the opening process.

2009 Rock Island Operational Plan

for Total Dissolved Gas During Fish Spill Season

April 1 – August 31

(All spill between these dates is subject to the actions contained in this plan.)

Protocol

1. If tailrace TDG average is greater than ***120% for the 6-hour average***
   - monitor for 2 hours, re-check 6-hour average
   - if TDG >120% for 6-hr average, shift spill from gate 20 to 27
   - monitor for 2 hours, re-check 6-hour average
   - if TDG >120% for 6-hr average, open gate 20 and close 2 notched gates (closure order is listed below)
   - monitor for 2 hrs; re-check 6-hour average
   - if TDG >120% for 6-hr average, close two more notched gates
   - **if after closing gates to control TDG levels, the TDG 1-hr average drops below 118%, reopen notched gates in the reverse order of closure**

2. If tailrace TDG is greater than ***125% for 1 hr***
   - follow protocol outlined above, but instead, use **one-hour TDG levels of 125%** as the metric
   - continue until TDG is less than 125% for 1 hr and until the 6-hr average TDG <120%

3. If forebay TDG exceeds 115% for greater than one hour, call Rocky Reach and advise that the RI forebay is out of compliance. Rocky Reach will then reduce spill, but only if the RR forebay TDG is 115% or less. Once RI forebay TDG levels reduce to 113% call RR again so that they may return to previous spill operations.

4. Order of notched gate closure: **29, 24, 18, 16**
   If we have to close any more gates than this, we have a big problem that we will need to be addressed by means other than continuing to reduce spill.

**** Note**: It will not be necessary to monitor for one full hour after re-opening if it appears that TDG is approaching the upper threshold, rather, the procedure will repeat upon reaching the threshold. It is anticipated that in time, the operators will "get a feel" for how much change in TDG will occur as a result of opening or closing gates and it will be possible to hold the TDG around 118% or 119% or so. Once the operators have this down, instead of closing a gate entirely, it may only be necessary to close partially, and visa versa for the opening process.

APPENDIX B

2009
Total Dissolved Gas Abatement Plan
Rocky Reach Hydroelectric Project

TOTAL DISSOLVED GAS ABATEMENT PLAN
ROCKY REACH HYDROELECTRIC PROJECT

February 2009

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1. INTRODUCTION

This Gas Abatement Plan (GAP) is being submitted to Washington State Department of Ecology as a condition of the 2006 Special Fish Passage Exemption (WAC 173-201A-200(1)(f)). Chelan County Public Utility District (Chelan PUD) respectfully submits this plan with the goal of receiving a waiver commencing with the 2009 fish spill season.

1.1 Total Dissolved Gas

Research has shown that releasing water through spillways is a safe and effective means of passing downstream migrating salmonids past some hydroelectric projects. However, monitoring has shown that in doing so there may be adverse effects to water quality, specifically supersaturation of river water with atmospheric gases. The spilled water carries atmospheric gases to the depths of the river where increased hydrostatic pressure supersaturates the water with those gases.

Many variables contribute to the saturation levels of TDG, including, but not limited to, existing forebay gas concentrations, spill flow rates, tailwater depths, air entrainment, spill plunge depths, entrainment flows, and temperature of the water.

1.1.1 Total Dissolved Gas and Impacts to Aquatic Life

A potential consequence of total dissolved gas (TDG) supersaturation to fish and other aquatic species is a condition known as gas bubble trauma (GBT) (Jensen et al., 1986). GBT is a physically induced condition caused by pressure dis-equilibrium between liquid and gas phases (Jensen et al., 1986), which can result in tissue lesions (i.e., blood emboli and emphysema of fish), causing physiological dysfunction (Bouck, 1980). Although it has been shown that TDG levels of 110% can result in GBT when fish are held in shallow water, there is little evidence that TDG levels of 110% are detrimental to juvenile salmonids migrating through the mainstem of the Columbia River (Meekin and Turner 1974, Bouck et al., 1976; Weitkamp and Katz, 1980 and Bernard, 1993). The severity of GBT is related to the degree of TDG saturation relative to the depth where fish reside and the exposure time at a given concentration.

1.1.2 Washington State Numeric Water Quality Criteria

The Washington State water quality numeric criterion states TDG measurements shall not exceed 110 percent at any point of measurement in any state water body. However, WAC 173-201A-200(1)(f)(ii) provides a special fish passage criteria for TDG to aid fish passage over hydroelectric dams when consistent with a WDOE approved gas abatement plan:

> *"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:*
>
> > *1. TDG must not exceed an average of one hundred fifteen percent as measured in the forebays of the next downstream dams and must not exceed an average of one*

hundred twenty 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

2. A maximum TDG one hour average of one hundred twenty-five percent must not be exceeded during spillage for fish passage."

1.2 Habitat Conservation Plan

More than fifteen years ago, Chelan PUD began to assess how it should respond to a changing regulatory environment that was increasingly affecting operation of Rocky Reach and Rock Island Hydroelectric Projects on the Columbia River. Chelan PUD has since developed two Habitat Conservation Plans (HCP) for anadromous fish in cooperation with federal and state regulatory agencies and Tribes. The HCPs were developed to conserve and protect all anadromous fish species over the long term, and to support ongoing compliance with the ESA while allowing continued operation of the Project. All measures proposed in the HCPs are intended to minimize and mitigate impacts to the Plan species, to the "maximum extent practicable" as required by the Endangered Species Act. Measures that promote fish passage survivability include spills and modified spills that generate TDG during the outmigration of juvenile fish. The plans commit Chelan PUD to a 50-year program to ensure our hydro projects have "no-net-impact" on mid-Columbia salmon and steelhead runs.

The HCPs began by implementing the "Phase I Plan to Achieve the Performance Standards". Assessment (survival) studies have been conducted over the last three years to determine the survival rates of plan species. For the studies to be considered valid, the studies needed to take place during average flow conditions and normal project operating conditions consistent with the approved study design. This means project operations; including spill levels and configurations, as well as the overall project structure (such as spillway structures), need to remain constant during the survival studies. If Chelan PUD finds feasible gas abatement methods during these studies, implementation of those methods will be considered following Phase I.

2. GOALS AND OBJECTIVES

The purpose of this TDG Abatement Plan is to outline the long-term plan for enhancing water quality at Rocky Reach Dam. This plan will identify Chelan PUD's steps to meet the state of Washington's Department of Ecology (DOE) TDG requirements at Rocky Reach.

The initial goal of this schedule is to identify measures that will aid Chelan PUD in improving water quality. However, Chelan PUD's long-term goal is to choose reasonable and feasible measures that do not conflict with other natural resource protection goals (i.e. anadromous fish passage) and have a measurable biological benefit.

Flexibility will be necessary in the following schedule due to unknown factors, including levels of success in the Project's permanent fish bypass system, success of Habitat Conservation Plan survival studies, and river conditions.

This Gas Abatement Plan summarizes the Rocky Reach Project, associated facilities and water management, discusses Rocky Reach Project spill scenarios and defines the measures associated with Chelan PUD's monitoring program during spill operations in support of juvenile fish passage, and provides a summary of past TDG activities and a future schedule of Rocky Reach Project TDG compliance activities.

3. ROCKY REACH PROJECT

3.1 Project Description

Rocky Reach Dam is owned and operated by Chelan County Public Utility District No. 1. The project is located on the Columbia River at river mile 474, about 7 miles upstream of the city of Wenatchee. Construction of the dam and powerhouse began in 1956 and the project was completed and put into production in 1961. The impounding structures are a mass of reinforced concrete consisting of a forebay wall section about 460 feet long, a combined intake and powerhouse section 1,088 feet long, a non-overflow center dam spillway that is 740 feet long consisting of 12 bays, each controlled by a 50 foot wide, 58 foot high radial gate. A 2,000-foot sub-surface cutoff consisting of a grout curtain and a compacted impervious barrier limits seepage through a terrace forming the east bank.

The forebay wall consists of mass concrete gravity blocks of various heights, with a maximum height of 118 feet. The service bay connects the forebay wall to the powerhouse. The powerhouse consists of 11 units, each 86 feet wide and approximately 200 feet long. The 11 turbines provide the total nameplate generating capacity of 1,213 MW and a total hydraulic capacity of 217.5 thousand cubic feet per second (kcfs).

A permanent bypass system was installed at the Project from September 2002 to March 2003, and has been in operation since then. The system consists of a surface collection system and a bypass conduit to provide downstream passage to juvenile salmon and steelhead.

3.2 Runoff and Coordination

The climate of the Columbia Basin in eastern Oregon, Washington and British Columbia is best described as desert. The major portion of the precipitation experienced within the basin falls in the form of snow during the period of November through March of each year. Runoff usually occurs from mid-April through July, with the historical peak occurring during the month of June. Storage dams in the U.S. and Canada capture spring and summer high flows to hold for release in the winter months.

In general, the hydropower system and reservoir operations in the Columbia River are coordinated through a set of complex agreements and policies to optimize the benefits and minimize the adverse effects of project operations, including the Mid-Columbia Hourly Coordination Agreement (Hourly Coordination).

The Rocky Reach Project is a participant in the Mid-Columbia Hourly Coordination Agreement (Hourly Coordination). Hourly Coordination operates the seven dams from Grand Coulee through the Priest Rapids Dam to meet system load requests while minimizing the reductions in

head that could result if the projects independently used active storage in their reservoirs to meet individual loads. Efficient load following is accomplished by matching load requests to the movement of water released from Grand Coulee as it passes sequentially through the downstream projects, while maintaining the forebays of these projects as near full as possible. Limitations to operations flexibility at any of the projects with active storage result in greater fluctuations in discharge and forebay elevation at the remaining coordinated projects.

4. HISTORY OF OPERATIONS AND COMPLIANCE

The passage and protection of migrating juvenile fish is provided at many dams with high levels of spill. At most projects, this route is preferred for safe passage and research indicates that survival of migrating juvenile salmonids is greatly enhanced via spill passage routes (NMFS 2000). However, at Rocky Reach Dam the juvenile fish bypass system is the preferred method of juvenile fish passage, and spill is utilized as a supplemental method for fish bypass. At Rocky Reach Dam, TDG monitoring during fish passage spill has occurred since 1996.

4.1 Spill Scenarios

The six main scenarios that could result in spill at Rocky Reach Dam are, but are not limited to:

- fish bypass spill
- flow in excess of hydraulic capacity
- powerplant load rejection spill
- immediate replacement spill
- maintenance spill
- error in communication with Corps reservoir

It is recognized that achieving regulatory TDG levels may not be possible during spill associated with large flood (7Q10) events. However, at Rocky Reach Dam it may be possible to achieve current regulatory TDG levels during releases for fish bypass and up to the 7Q10 flows (252 kcfs) by selective operation of spillway bays.

4.1.1 Fish Spill

Spill is an ineffective method of bypassing fish away from the turbines at Rocky Reach Dam (Raemhild, et al. 1984, Steig et al. 1997) and, consequently, is not considered as the solution for the long-term fish bypass program. As an alternative to spill, Chelan PUD is focusing its efforts on increasing the fish passage efficiency and survival through the fish bypass system. Spill is utilized as a supplemental method for fish bypass for downstream migrating juvenile salmonids. Fish spill at Rocky Reach falls into two categories, Spring Spill and Summer Spill. For more information regarding spill during the spring and summer spill seasons, please refer to Section 4.1 above.

4.1.2 Flow in Excess of Hydraulic Capacity

The minimal storage and limited hydraulic capacity of the project occasionally force Chelan PUD to spill water past the project. This spill is required to maintain headwater elevations within the limits set by the project's Federal Energy Regulatory Commission license, to prevent overtopping of the project, and to maintain optimum operational conditions. With this type of release, flows up to, and in excess of the 7Q10 flood flows (252 kcfs) can be accommodated.

To reduce negative impacts of flow in excess of hydraulic capacity Chelan PUD has completed and implemented a TDG Operational Plan. Chelan PUD anticipates that this will be an operational function, which will require no structural modifications.

4.1.3 Plant Load Rejection Spill

This type of spill occurs when the plant is forced off line by an electrical fault, which trips breakers, or any activity forcing the units off line. This is an emergency situation and generally requires emergency spill. When the units cannot process flow, the flow must be passed by other means to avoid overtopping the dam.

Chelan PUD has completed and will implement a TDG Operational Plan to address this emergency situation. This will be an operational function, which will require no structural modifications.

4.1.4 Immediate Replacement Spill

Immediate replacement spill is used to manage TDG levels throughout the Columbia River basin. The Technical Management Team (including National Marine Fisheries Services (NMFS), US Army Corps of Engineers, and Bonneville Power Administration) implements and manages this spill. Immediate replacement spill occurs when TDG levels are significantly higher in one river reach than they are in another reach. To balance the TDG levels throughout the basin, spill is reduced and generation increased in the reach with high TDG levels and the energy is transferred to reaches with lower TDG levels where spill is increased. The result is higher generation in the reaches with high TDG levels, increased spill in reaches with lower TDG levels, and equal distribution of TDG levels throughout the basin.

To control TDG levels that may result from immediate replacement spill, Chelan PUD has completed and will implement the TDG Plan. We expect that this will be an operational function, which will require no structural modifications.

4.1.5 Maintenance Spill

Maintenance spill is utilized for any maintenance activity that requires spill to assess the routine operation of individual spillways and turbine units. These activities include forebay debris flushing, checking gate operation, gate maintenance, and all other maintenance that would require spill. The Federal Energy Regulatory Commission requires that all spillway gates be operated once per year. This operation requires a minimal amount of spill for a short duration annually and is generally accomplished in conjunction with fish passage spill operations.

To control TDG levels that may result from immediate replacement spill, Chelan PUD has completed and will implement the TDG Operation Plan. We expect that this will be an operational function, which will require no structural modifications.

4.1.6 Error in Communication Spill

Error in communication with the U.S. Army Corps Reservoir Control Center, including computer malfunctions or human error in transmitting proper data, can contribute to spill. Hourly coordination

between hydroelectric projects on the river minimizes this type of spill, but it does occur occasionally.

To control TDG levels that may result from immediate replacement spill, Chelan PUD has completed and will implement the TDG Operation Plan. We expect that this will be an operational function, which will require no structural modifications.

4.2 Compliance Activities in 2004-2008

4.2.1 TMDL Activities

The Summary Implementation Strategy (SIS) for the Mid-Columbia TDG TMDL outlined short-term implementation actions that each project had previously initiated, or was to initiate by 2006. As per the SIS, Chelan PUD was to begin a TDG literature review, or rather an engineering assessment of potential gas abatement techniques, by 2006. This review was completed in 2003, and a copy of the report submitted to the Department of Ecology in 2004.

4.2.2 Literature Review

In addition to the engineering review completed in 2003, Chelan PUD, in partnership with the other Mid-C PUDs, funded a consultant to compile a document reviewing TDG literature from 1980-2007. This document has been completed and was presented to the Adaptive Management Team in 2008.

4.2.3 Spill Reductions

The permanent fish bypass system continues to serve as the primary fish survival tool at Rocky Reach Dam. The most efficient use of voluntary fish survival spill at Rocky Reach will be to supplement the effectiveness of the fish bypass system, when needed, to reach survival goals of the HCP.

Due to the success of the fish bypass system, Chelan PUD has been able to reduce spill at Rocky Reach. In the past, voluntary spill for fish passage has been as much as 24% of the current day's forecasted flow during the spring and 9% during the summer. In 2007 and 2008, Chelan PUD operated the juvenile fish bypass exclusively (no spill) for yearling Chinook and steelhead. For sockeye, Chelan PUD conducted a powerhouse operations test with no spill to evaluate differences in route-specific survival and Project survival with all available river flow passing through turbines. During the summer outmigration of subyearling Chinook, Chelan PUD spilled 9% of the day's forcasted average river flow for a duration covering 95% of their outmigration.

4.2.4 Potential Operational Changes

Potential operational changes that have been identified to date that are available at the project to meet state water quality standards and the required HCP spill to meet fish survival standards are:

1) changes to spill configurations
2) powerhouse operations
3) revise the operations protocol to be used when conditions of non-compliance may occur

5. PROPOSED OPERATIONS AND ACTIVITIES

5.1 Operational Spill Plan

Fish spill operations in 2009 at Rocky Reach will be implemented by Chelan PUD according to certain juvenile survival standards that have been achieved by Chelan PUD and some that have yet to be achieved.

During the juvenile fish migration season, Chelan PUD will prioritize the dispatch of generating units to achieve peak plant operating efficiency as follows 1,2,3,5,4,6,7,8,9,10,11.

Rocky Reach 2009 Spring Spill

In 2009, Chelan PUD will operate the juvenile fish bypass (JFB) for yearling Chinook and steelhead with no Project spill. For sockeye, Chelan PUD tentatively plans to conduct a survival study testing alternative day/night tagged fish release methods. During this study the powerhouse will operate under normal fish bypass operations, with no Project spill (this plan is awaiting final approval from the HCP Coordinating Committee). The goal of this study is to determine if there is a negative bias in survival studies by releasing fish during midday only, as has been done by Chelan PUD throughout previous years' survival studies.

Rocky Reach 2009 Summer Spill

Summer spill at Rocky Reach for subyearling Chinook will be 9% of day average river flow. Spill will likely begin in the first week of June, after completion of the juvenile sockeye no-spill study. Spill for subyearling Chinook may commence only after study requirements (test fish released, test blocks completed, and detections verified) for sockeye have been completed. Summer spill will continue through the 95 percent passage for the subyearling migrants. The guidelines for starting summer spill at Rocky Reach are as follows:

1. Summer spill will likely start in the first week of June, but only upon verification that the spring sockeye study is complete and arrival of subyearlings at Rocky Reach is verified.

2. Summer spill season will likely end no later than August 15, or when subyearling index counts are 0.3% or less of the cumulative run for three out of any five consecutive days (same protocol as used in 2006-08) and Program RealTime shows the 95% passage percentile has been reached.

Spill not provided for juvenile passage will be shaped to avoid delay of upstream migrants according to agreements made within the HCP Coordinating Committee and will be shaped to follow the diel distribution of the fish present.

5.2 TDG Monitoring Program

As required by issuance of a TDG exemption for the Rocky Reach Project, Chelan PUD will continue to implement a physical and biological monitoring program at Rocky Reach Dam during the juvenile fish migration season. Activities include fisheries management activities, participation in water quality forums, collection of TDG data during the migration season, and collection of biological monitoring data.

5.2.1 Fisheries Management Activities

Juvenile

The Juvenile Fish Bypass (RRJFB) will run continuously from April 1 to August 31. Operations outside these dates can occur if it is deemed necessary to encompass 95% of the fish run based on discussion with the HCP Coordinating Committee.

Adult

The adult fish passage facilities at Rocky Reach Dam consist of a fishway with the right (RPE) and left (LPE) powerhouse entrances, powerhouse collection and transportation channels, a spillway tunnel channel, a main spillway entrance (MSE), and a fish ladder. The LPE is located at mid-dam between the powerhouse and spillway. The RPE is located on the south end of the powerhouse. The fishway includes a counting station on the right bank. The system includes a pumped attraction water supply and a gravity auxiliary water supply.

For operation and maintenance purposes, the primary fish passage season is considered to be April through November. Adult facilities will be open from March 1st to December 31st each year.

5.2.2 Water Quality Forums

Chelan PUD regularly participates in the Regional Water Quality Team and Transboundary Gas Group.

5.2.3 Physical Monitoring

Chelan PUD will maintain two fixed monitoring stations at the dam to monitor TDG levels annually from April through August, one in the forebay and one in the tailrace at the approved monitoring sites.

TDG measurements will be recorded throughout the monitoring season at 15-minute intervals, enabling plant operators to adjust spill volumes to maintain gas levels to prevent exceedances of the TDG criteria. These 15-minute intervals will be averaged into hourly readings for use in compiling daily and 12-hour averages. All hourly data will be forwarded to Chelan PUD headquarters building and then onto the US Army Corps of Engineers Reservoir Control Center and posted at their site on the World Wide Web.

Chelan PUD will enter into a Professional Services Agreement with Columbia Basin Environmental (CBE) to perform monthly calibrations and equipment maintenance during the 2008 monitoring season. It is anticipated at this time that Chelan PUD will continue to contract with CBE into the future. QA/QC measures will be accomplished through training in instrument maintenance, operation, and factory prescribed calibration methods. A detailed log will be maintained for all work done on the monitoring equipment, including monthly maintenance, calibration, exchange of instruments, and any other pertinent information. Redundant measurements with a mobile instrument to verify the accuracy of the in-situ instruments will be conducted during the monthly calibrations.

5.2.4 Biological Monitoring

Chelan PUD no longer conducts annual biological monitoring at Rocky Reach.

5.3 Compliance Activities for 2009-2012

5.3.1 HCP Survival Study Operations

Because the project is operating under Phase I of the HCP, which requires survival studies be conducted during representative flow conditions and normal project operating conditions consistent with the approved study design, no significant changes can be made to operations until the end of Phase I. The actual year in which changes can be made is dependent upon the success of Phase I. At the completion of Phase I, if successful, Chelan PUD may know what levels of spill are necessary to ensure the survival goal is met. It is at this time Chelan PUD will be able to determine what gas abatement measures are feasible and necessary to meet water quality requirements and HCP survival standards.

5.3.2 Spring Spill No Spill Test

No spill will be provided for yearling Chinook and steelhead in 2008. In 2003, a study was conducted to determine the bypass efficiency for steelhead, Chinook yearlings, and sockeye. Based on the results from that study, and consistent with section 5.4a of the Rocky Reach HCP, spill was eliminated for Chinook yearlings and steelhead and set at 24% for sockeye for Phase I testing. While steelhead have met the HCP juvenile project survival standard of 93%, sockeye and Chinook have not, and spill may be used in the future for these species if empirical information suggests it is needed to reach the juvenile survival standards of the HCP. In 2008, Chelan PUD will not spill for the juvenile sockeye out migration because of a powerhouse study that modifies powerhouse operations to improve fish passage through the fish bypass system and increased survival through the powerhouse.

Spill programs for 2010-2012 are unknown at this time, as the programs are dependent upon the continued success of the juvenile fish bypass and fish survival.

5.4 Additional Requirements

Chelan PUD will operate the Project in accordance with the following:

1. 7Q10. The 7Q10 for Rocky Reach is 252 kcfs. The Project will not be expected to comply with state water quality standards for TDG for incoming flows exceeding this value.

2. Fish Spill. For the purposes of compliance, the "fish spill" season is taken to occur from April 1 – August 31; and "non-fish spill" season occurs from September 1 to March 31, unless otherwise specified in writing by Ecology.

3. Compliance During Non-Fish Spill. During non-fish spill, Chelan PUD will make every effort to remain in compliance with the 110% standard.

4. Compliance During Fish Spill. During fish spill, Chelan PUD will make every effort not to exceed an average of 120% as measured in the tailrace of the dam. The Project also must not exceed an average of 115% as measured in the forebay of the next downstream dam. These averages are based on the twelve (12) highest consecutive hourly readings in any 24-hour period. In addition, there is a maximum one-hour average of 125%, relative to atmospheric pressure, during spillage for fish passage. Nothing in these special conditions allows an impact to existing and characteristic uses.

5. TDG Monitoring. Chelan PUD will maintain two fixed monitoring stations at the dam to monitor TDG levels annually from April through August, one in the forebay and one in the tailrace at the approved monitoring sites. This information is available on a real time basis to all interested parties at the US Army Corps of Engineers website (http://www.nwd-wc.usace.army.mil/report/tdg.htm).

6. Reporting Spill for Fish and TDG Exceedances. Chelan PUD will notify Ecology within 24 business hours of spill for fish and when TDG standards are exceeded. Reporting shall be electronically (via e-mail) to the hydropower project manager in Ecology's Central Region Office.

7. General TDG Abatement Measures. Chelan PUD will manage spill toward meeting water quality criteria for TDG during all flows below 7Q10 levels, but only to the extent consistent with meeting the passage and survival standards sets forth in the HCP and Fish Management Plans, as follows:

a. Minimize voluntary spill,
b. During fish passage, manage voluntary spill levels in real time in an effort to continue meeting TDG numeric criteria,
c. Minimize spill, to the extent possible, by scheduling maintenance based on predicted flows.

8. Annual TDG Monitoring Report. Chelan PUD shall submit an annual monitoring report. A draft monitoring report of the year's monitoring report shall be submitted to Ecology by October 31 of the monitoring year. Chelan PUD will submit the final report, incorporating Ecology's suggested corrections, by December 31 of the same year. The contents of the report shall include, at a minimum:

a. Flow and TDG levels, on a daily basis, with purpose of spill (e.g. fish spill, turbine down time),
b. Summary of exceedances and what was done to correct the exceedances,
c. Results of the fish passage efficiency (FPE) studies and survival per the HCP

9. Revised Gas Abatement Plan (GAP). Chelan PUD will revise the GAP annually, to reflect any changes, and new or improved information and technologies. Chelan PUD will submit a draft to Ecology for review and approval by February 28 of the year of implementation. The GAP shall be in the format of Chelan PUD's 2009 GAP, unless modifications are requested by Ecology.

10. Ecology Contact. Chelan PUD will direct its correspondence to:

Pat Irle, Hydropower Projects Manager
Department of Ecology, Central Region Office
Water Quality Program
15 W. Yakima Ave., Suite 200
Yakima, WA 98902-3452

6. REVISIONS TO THE TAILRACE MONITORING PLAN

Based on the recommendation of a study conducted by Waterways Experiment Station in 2002, Chelan PUD installed a probe on the outfall of the juvenile fish bypass in 2007 to determine if the site would be acceptable as a new permanent tailrace monitoring location that would better represent the impacts of spill on TDG levels than the Odabashin Bridge location. Because there was some concern that the fish bypass outfall location may experience eddies and other water conditions that may result in poor representation of the impacts of spill on TDG, Chelan PUD maintained the Odabashin Bridge site and collected data for nearly two seasons at the outfall location to ensure the data would be representative before permanently relocating the site.

Data collected from the site was compared to predicted levels computed using an equation developed by Michael L. Schneider and Steven C. Wilhelms of the U.S. Army Engineer Research and Development Center in a 2005 report on Operational and Structural Total Dissolved Gas Management at Rocky Reach. Development of the model included actual data from numerous locations in the forebay and tailrace (including near the fish bypass outfall) of Rocky Reach collected during a field study conducted in 2002. The model uses TDG data from the existing tailrace monitoring location and spill volume to predict TDG levels at the fish bypass outfall location. Details of this prediction tool and how it was developed are included in the Schneider and Wilhelms report. The data comparison supported the theory that the fish bypass outfall location would provide a representative sample of spill impacts on TDG. Therefore, late in the 2008 monitoring season Chelan PUD permanently relocated Rocky Reach tailrace monitoring site to the juvenile fish bypass outfall.

LITERATURE CITED

Bernard, L. 1993. Impacts of dissolved gas supersaturation on the Columbia and Snake River anadromous fish. Fish Passage Center. Portland, OR.

Bouck, G. R. 1980. Etiology of gas bubble disease. *Transactions of the American Fisheries Society* 109:703-707.

Bouck, G.R., A.V. Nebeker, and D.G. Stevens. 1976. Mortality, saltwater adaptation, and reproduction of fish exposed to gas supersaturated water. Ecol. Res. Ser. EPA-600/1-76-050: 1-54. US Environmental Protection Agency, Western Fish Toxicology Station, Corvalis, OR.

Jensen, J.O.T., J. Schnute, and D. F. Alderice. 1986. Assessing juvenile salmonid response to gas supersaturation using a general multivariate dose – response model. *Canadian Journal of Fisheries and Aquatic Sciences.* Vol. 43: 1694-1708.

Meekin, Thomas K. and Ben K. Turner. 1974. Tolerance of salmonid eggs, juveniles and squawfish to supersaturated nitrogen. WDFW Tech. Rep. 12.

National Marine Fisheries Service (NMFS). 2000. Endangered Species Act – Section 7 Consultation: Biological Opinion. Consultation on Remand for Operation of the Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia Basin. F/NWR/2004/00727. November 30, 2005. Pages 5-6, 5-7, 5-53, 10-9, and Appendix E: Risk Analysis.

Schneider, M.L. and S.C. Wilhelms. 2005. Rocky Reach Dam: Operational and Structural Total Dissolved Gas Management. Prepared by COE, Engineer Research and Development Center, for Chelan PUD. July 2005. http://www.chelanpud.org/rr_relicense/study/reports/7773_1.pdf

Weitkamp, D. E., and M. Katz. 1980. A review of dissolved gas supersaturation literature, *Transactions of the American Fisheries Society. 109: 659-702.*

APPENDIX C

2009
Total Dissolved Gas Abatement Plan
Rock Island Hydroelectric Project

TOTAL DISSOLVED GAS ABATEMENT PLAN
ROCK ISLAND HYDROELECTRIC PROJECT

February 2009

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1. INTRODUCTION

This Gas Abatement Plan (GAP) is being submitted to Washington State Department of Ecology as a condition of the 2006 Special Fish Passage Exemption (WAC 173-201A-200(1)(f)). Chelan County Public Utility District (Chelan PUD) respectfully submits this plan with the goal of receiving a waiver commencing with the 2009 fish spill season.

1.1 Total Dissolved Gas

Research has shown that releasing water through spillways is a safe and effective means of passing downstream migrating salmonids past some hydroelectric projects. However, monitoring has shown that in doing so there may be adverse effects to water quality, specifically supersaturation of river water with atmospheric gases. The spilled water carries atmospheric gases to the depths of the river where increased hydrostatic pressure supersaturates the water with those gases.

Many variables contribute to the saturation levels of TDG, including, but not limited to, existing forebay gas concentrations, spill flow rates, tailwater depths, air entrainment, spill plunge depths, entrainment flows, and temperature of the water.

1.1.1 Total Dissolved Gas and Impacts to Aquatic Life

A potential consequence of total dissolved gas (TDG) supersaturation to fish and other aquatic species is a condition known as gas bubble trauma (GBT) (Jensen et al., 1986). GBT is a physically induced condition caused by pressure dis-equilibrium between liquid and gas phases (Jensen et al., 1986), which can result in tissue lesions (i.e., blood emboli and emphysema of fish), causing physiological dysfunction (Bouck, 1980). Although it has been shown that TDG levels of 110% can result in GBT when fish are held in shallow water, there is little evidence that TDG levels of 110% are detrimental to juvenile salmonids migrating through the mainstem of the Columbia River (Meekin and Turner 1974, Bouck et al., 1976; Weitkamp and Katz, 1980 and Bernard, 1993). The severity of GBT is related to the degree of TDG saturation relative to the depth where fish reside and the exposure time at a given concentration.

1.1.2 Washington State Numeric Water Quality Criteria

The Washington State water quality numeric criterion states TDG measurements shall not exceed 110 percent at any point of measurement in any state water body. However, WAC 173-201A-200(1)(f)(ii) provides a special fish passage criteria for TDG to aid fish passage over hydroelectric dams when consistent with a WDOE approved gas abatement plan:

> *"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:*
>
> > *1. TDG must not exceed an average of one hundred fifteen percent as measured in the forebays of the next downstream dams and must not exceed an average of one*

hundred twenty 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

2. A maximum TDG one hour average of one hundred twenty-five percent must not be exceeded during spillage for fish passage."

1.2 Habitat Conservation Plan

More than fifteen years ago, Chelan PUD began to assess how it should respond to a changing regulatory environment that was increasingly affecting operation of Rocky Reach and Rock Island Hydroelectric Projects on the Columbia River. Chelan PUD has since developed two Habitat Conservation Plans (HCP) for anadromous fish in cooperation with federal and state regulatory agencies and Tribes. The HCPs were developed to conserve and protect all anadromous fish species over the long term, and to support ongoing compliance with the ESA while allowing continued operation of the Project. All measures proposed in the HCPs are intended to minimize and mitigate impacts to the Plan species, to the "maximum extent practicable" as required by the Endangered Species Act. Measures that promote fish passage survivability include spills and modified spills that generate TDG during the outmigration of juvenile fish. The plans commit Chelan PUD to a 50-year program to ensure our hydro projects have "no-net-impact" on mid-Columbia salmon and steelhead runs.

The HCPs began by implementing the "Phase I Plan to Achieve the Performance Standards". Assessment (survival) studies have been conducted over the last three years to determine the survival rates of plan species. For the studies to be considered valid, the studies needed to take place during average flow conditions and normal project operating conditions consistent with the approved study design. This means project operations; including spill levels and configurations, as well as the overall project structure (such as spillway structures), need to remain constant during the survival studies. If Chelan PUD finds feasible gas abatement methods during these studies, implementation of those methods will be considered following Phase I.

2. GOAL AND OBJECTIVES

The purpose of this TDG Abatement Plan is to outline the long-term plan for enhancing water quality at the Public Utility District No. 1 of Chelan County's (District) Rock Island Hydroelectric Project. This plan will identify Chelan PUD's steps to meet the Washington Department of Ecology's (DOE) TDG requirements at the project.

The initial goal of this schedule is to identify measures that will aid Chelan PUD in improving water quality. However, Chelan PUD's long-term goal is to choose reasonable and feasible measures that do not conflict with other natural resource protection goals (i.e. anadromous fish passage) and have a measurable biological benefit.

Flexibility will be necessary in this schedule due to unknown factors, including levels of success of Habitat Conservation Plan survival studies and river conditions.

This Gas Abatement Plan summarizes the Rock Island Project, associated facilities and water management, discusses Rock Island Project spill scenarios and defines the measures associated with Chelan PUD's monitoring program during spill operations in support of juvenile fish passage, and provides a summary of past TDG activities and a future schedule of Rock Island Project TDG compliance activities.

3. ROCK ISLAND PROJECT

3.1 Project Description

Rock Island Dam is owned and operated by Chelan County Public Utility District No. 1. The structure is 3,800 ft. in length and is constructed from reinforced concrete. The dam is located at Columbia River mile 453.4, about 12 miles downstream from the city of Wenatchee. The project contains a reservoir extending 21 miles up river to the tailrace of Rocky Reach Dam and covers 3,300 acres. The Rock Island Project has no significant water storage capabilities. The pond contains about 7,500 acre-feet of usable storage with a four-foot drawdown and a minimum operating pool at elevation 609 ft. (USGS) above sea level. The dam deck is at 616.02 ft. (USGS). Average headwater elevation for the project is 614.1 ft. (USGS), and the average tailwater elevation is 572 ft. (USGS). The project discharges into a reservoir ponded by Wanapum Dam located 37.6 miles downstream.

The project consists of two powerhouses. Powerhouse 1 is located on the east bank of the project at a 45-degree angle from the bank. The powerhouse consists of 10 vertical shaft turbines with a rated output of 212 MW. Powerhouse 2 is located on the west bank and is 470 ft. wide, housing eight horizontal shaft turbines with a rated power output of 410 MW. The combined hydraulic capacity of both powerhouses is 220 kcfs.

The project configuration includes a spillway of 32 bays with a total length of 1,184 ft. Gates are separated by a middle fish ladder (located at bay 15) that divides the spillway into east and west sections. The west (Chelan County side) spillway consists of seven deep bays and ten shallow bays, and the east (Douglas County side) spillway consists of six deep bays and eight shallow bays. Each spillway has two or three crest gates, which are stacked one on top of the other. The crest gates are 30 ft. wide and either 11 or 22 ft. high. The larger crest gates are positioned closest to the water surface, and when fully raised, spill approximately 10 kcfs.

The deep bays have a sill elevation of 559-ft. (USGS), which is about 13 ft. below the average tailwater elevation of 572 ft. (USGS). The shallow bays have a sill elevation of 581.5 ft. (USGS), which is about 9.5 ft. above the average tailwater elevation.

The focus of juvenile fish bypass at Rock Island Dam has been directed towards optimizing the efficiency of fish passage via spill. To achieve this, nine of the thirty-two spill bays have had their spill gates modified to provide surface spill. Surface spill was accomplished by putting notches in the upper sections of the spill gates. Six of the nine gates have notches that are 8 feet wide by 17 feet deep and can spill up to 2,500 cfs. The remaining gates have notches that are smaller and pass less volume (approximately 1,850 cfs). The total amount of water that can be passed through the notched gates is approximately 21,000 cfs. Three of the modified gates have

had further modification and now have a "over-under" design which enables surface flow attraction and delivers water in the tailrace towards the surface, thus reducing the uptake of atmospheric gases.

3.2 Runoff and Coordination

The climate of the Columbia Basin in eastern Oregon, Washington and British Columbia is best described as desert. The major portion of the precipitation experienced within the basin falls in the form of snow during the period of November through March of each year. Runoff usually occurs from mid-April through July, with the historical peak occurring during the month of June. Storage dams in the U.S. and Canada capture spring and summer high flows to hold for release in the winter months.

In general, the hydropower system and reservoir operations in the Columbia River are coordinated through a set of complex agreements and policies to optimize the benefits and minimize the adverse effects of project operations, including the Mid-Columbia Hourly Coordination Agreement (Hourly Coordination).

Hourly Coordination operates the seven dams from Grand Coulee through the Priest Rapids Dam to meet system load requests while minimizing the reductions in head that could result if the projects independently used active storage in their reservoirs to meet individual loads. Efficient load following is accomplished by matching load requests to the movement of water released from Grand Coulee as it passes sequentially through the downstream projects, while maintaining the forebays of these projects as near full as possible. Limitations to operations flexibility at any of the projects with active storage result in greater fluctuations in discharge and forebay elevation at the remaining coordinated projects. The Rock Island Project has very little active storage capability and therefore is rarely used in Hourly Coordination to shape system loads.

4. HISTORY OF OPERATIONS AND COMPLIANCE

The passage and protection of migrating juvenile fish is provided at many dams with high levels of spill. At most projects, this route is preferred for safe passage and research indicates that survival of migrating juvenile salmonids is greatly enhanced via spill passage routes (NMFS 2000). At Rock Island Dam, TDG monitoring during fish passage spill has occurred since 1996.

4.1 Spill Scenarios

The six main scenarios that could result in spill at Rock Island Dam are, but are not limited to:

- fish bypass spill
- flow in excess of hydraulic capacity
- powerplant load rejection spill
- immediate replacement spill
- maintenance spill
- error in communication with Corps reservoir

It is recognized that achieving regulatory TDG levels may not be possible during spill associated with large flood (7Q10) events. However, at Rock Island Dam it may be possible to achieve current regulatory TDG levels during releases for fish bypass and up to the 7Q10 flows (264 kcfs) by selective operation of spillway bays. The Rock Island Project is unique due to the diversity of variations in how flow is released, which may assist in the development of spill scenarios that could result in a reduction of gas in the tailrace.

4.1.1 Fish Bypass Spill

In accordance with the Rock Island HCP, spill is currently the primary method for fish bypass at Rock Island Dam. This document provides for spring spill and summer spill. The spring spill covers the out-migration period of spring chinook and steelhead smolts, and typically begins in mid-April and ends in June of each year. The summer spill covers the out-migration of summer chinook and typically begins in late June to early July and ends no later than August 31 of each year. For more detail regarding fish spill, please see Section 4.1 above.

4.1.2 Flow in Excess of Hydraulic Capacity

The limited hydraulic capacity and minimal storage capacity of the project occasionally force Chelan PUD to spill water past the project. This spill is required to maintain headwater elevations within the limits set by the Federal Energy Regulatory Commission license, to prevent overtopping of the project, and to maintain optimum operational conditions. With this type of spill release the 7Q10 flood flows (264 kcfs) are also accommodated.

4.1.3 Plant Load Rejection Spill

This type of spill occurs when a plant is forced off line by an electrical fault, which trips breakers, or any other activity forcing the units off line. When the units cannot process flow, the flow must be passed by other means to avoid overtopping the dam, which usually requires emergency spill through the use of auto hoists.

Chelan PUD will immediately implement the Operational Spill Management Plan to address this emergency situation. It is expected that this will be addressed operationally, which requires no structural modifications.

4.1.4 Immediate Replacement Spill

Immediate replacement spill is used to manage TDG levels throughout the Columbia River basin. This spill is implemented and managed by the Technical Management Team (including National Marine Fisheries Service (NMFS), US Army Corps of Engineers (USACE), and Bonneville Power Administration (BPA)). Immediate replacement spill occurs when TDG levels are significantly higher in one river reach than they are in another. To balance the TDG levels throughout the basin, spill is reduced and generation increased in the reach with high TDG levels and the energy is transferred to reaches with lower TDG levels where spill is increased. The result is higher generation in the reaches with high TDG levels, increased spill in reaches with lower TDG levels, and equal distribution of TDG levels throughout the basin.

To control TDG levels that may result from immediate replacement spill, Chelan PUD has completed and implemented a TDG Operational Plan. It is expected that this will be addressed operationally, requiring no structural modifications.

4.1.5 Maintenance Spill

Maintenance spill is utilized for any maintenance activity that requires spill to assess the routine operation of individual spillways and turbine units. These activities include forebay debris flushing, checking gate operation, gate maintenance, and all other maintenance that would require spill. The Federal Energy Regulatory Commission requires that all spillway gates be operated once per year. This operation requires a minimal amount of spill for a short duration annually, and is generally accomplished in conjunction with fish passage spill operations.

Chelan PUD has completed and will implement an TDG Operational Plan to address potentially elevated TDG levels that may result from this form of spill. It is expected that this will be addressed operationally, requiring no structural modifications.

4.1.6 Error in Communication Spill

This type of spill is caused by error in communication with The U.S. Army Corps Reservoir Control Center, including computer malfunctions or human error in transmitting data. Hourly coordination between hydroelectric projects on the river minimizes this type of spill, which does occur occasionally.

To address potentially elevated TDG levels that may result from this form of spill, Chelan PUD has completed and will implement a TDG Operational Plan and will maintain hourly coordination. This will be addressed operationally, requiring no structural modifications.

4.2 Compliance Activities in 2004-2008

4.2.1 TMDL Activities

The Summary Implementation Strategy (SIS) for the Mid-Columbia TDG TMDL outlined short-term implementation actions that each project had previously initiated, or was to initiate by 2006. The actions identified for Rock Island included the completion of a literature review and investigations into additional submerged spill bays (over/under gates), both of which Chelan PUD has either begun or completed. In addition, Chelan PUD, in partnership with the other Mid-C PUDs, funded a consultant to compile a document reviewing TDG literature from 1980-2007. This document has been completed and was presented to the Adaptive Management Team in 2008.

4.2.2 Over/Under Gate Installation

In 2004 Chelan PUD determined that an Over/Under prototype gate structure was a potential gas reducing structure and approved the modeling, design, installation, and testing of one prototype. Chelan PUD modeled, designed, installed, and tested a single bay Over/Under prototype gate between 2004 and 2006. The test results indicated that the prototype was capable of reducing TDG uptake by 8.5 to 13.5 % points, as compared to the existing notched gate method, and by an additional 2.5 to 4.5 % points as compared to deflector prototypes. The fish passage survival tests performed indicates that overall survival was 100% and 99.1% through the gate system in the aerated and non-aerated configurations, respectively. As a result of the success of the Over/Under gates during prototype testing, Chelan PUD made the decision to have three in place prior to the initiation of the 2007 spill season.

This spill configuration employs a spillway with both an upstream gate and a downstream gate. The upstream overflow spill gate is opened at the surface for the purpose of attracting fish. The downstream gate is lifted from the bottom, resulting in submerged spill, which the 1999 WES study showed eliminated gas entrainment since no air could mix with spillway flows. The desired outcome of this configuration is to achieve a high level of fish passage and survival through the overflow gate while maintaining a submerged spill condition under the downstream gate.

4.2.3 Reductions in Spill

Operating under a spill regime of 20% of the daily average river flow, the survival standards for spring plan species have been met at Rock Island. Due to the success of the survival studies thus far, Chelan PUD began testing powerhouse optimization in 2007, resulting in spring voluntary spill being reduced to 10% of the daily average river flow. Chelan PUD will continue to test this spill scenario in the 2009 spill season. Summer spill remains at 20% of the daily average river flow.

4.2.4. Potential Operational Changes

Potential operational changes that have been identified to date that are available at the project to meet state water quality standards and the required HCP spill to meet fish survival standards are:

1) changes to spill configurations (moving some spill from deep spill bays to shallow bays, flattening out spill to more level volumes over the entire day instead of peaks and valleys, sending a portion of spill through submerged gates instead of full gates)
2) powerhouse operations
3) revise the operations protocol to be used when conditions of non-compliance may occur

5. PROPOSED OPERATIONS AND ACTIVITIES

5.1 Operational Spill Plan

Fish spill operations in 2009 at Rock Island will be implemented by Chelan PUD according to certain juvenile survival standards that have been achieved by Chelan PUD and some that have yet to be achieved.

Rock Island 2009 Spring Spill

In 2009, under Section 5.3.3 of the Rock Island HCP, Chelan PUD will re-evaluate Project Survival for yearling Chinook (as a representative spring species) under a 10% spill level. The 10% spill level will begin no later than April 17, and end on approximately June 1, following completion of the 10% spring spill study. The Rock Island bypass trap will be operated seven days per week by WDFW personnel to provide daily juvenile index counts. The trap will operate from April 1 through August 31. Index counts will provide the basis for comparison to determine the start and end of seasonal spill periods. Guidelines to start and end the spring spill program at Rock Island are proposed as follows:

1. The Rock Island spring spill program will begin when the Rock Island daily passage index (expanded counts) exceeds 400 fish for more than 3 days (this corresponds to the historic 5% passage date), or no later than April 17, as outlined in Section 5.4.1. (a) of the HCP. Wenatchee River smolt trap counts (at Monitor) will be used to help validate a decision to start spring spill prior to April 17.

2. The Rock Island spring spill will likely end in the first week of June, unless the 2009 yearling Chinook, steelhead, and sockeye survival studies have not yet been completed.

Rock Island 2009 Summer Spill

Rock Island will spill 20% of the daily average river flow over 95% of the summer out migration. Daily sub-yearling Chinook samples at the bypass trap will provide the basis for decisions to the start and stop spill periods at Rock Island Dam. The proposed guidelines to start and stop the summer spill at Rock Island are outlined as follows:

1. Rock Island summer spill will likely begin in the first week of June, after completion of the spring survival study. The summer spill level will be 20% and continue for a duration covering 95 percent of the subyearling outmigration.

2. Spill will likely end no later than August 15th, or when subyearling counts from the Rock Island trap are 0.3% or less of the cumulative run total for any three out of five consecutive days (same protocol used in 2005-08).

All spill for fish passage will come from notched gates in bays 1, 16, 18, 30, 31, 32, 24, 26, and 29. If the spill through the aforementioned bays is insufficient to meet daily estimated flow (DEF), or hydraulic capacity is exceeded, full gates in bays 20, 19, 25, 17, 22, and 21 (in that order) are to be pulled. If it is necessary to spill a larger volume of water then the above gates provide; gates are pulled in the order necessary to maintain plant safety.

Spill not provided for juvenile passage will be shaped to avoid delay of upstream migrants according to agreements made within the HCP Coordinating Committee and will be shaped to follow the diel distribution of the fish present.

5.2 TDG Monitoring Program

As required by issuance of a TDG exemption for the Rock Island Project, Chelan PUD will continue to implement a physical and biological monitoring program at Rock Island Dam during the juvenile fish migration season. Activities include fisheries management activities, participation in water quality forums, collection of TDG data during the migration season, and collection of biological monitoring data.

5.2.1 Fisheries Management Activities

Chelan PUD shall continue to operate the Rock Island adult fishways and manage spill in accordance with HCP operations criteria to protect aquatic life designated uses.

Juvenile

At Rock Island, downstream migrant passage facilities are incorporated in the second powerhouse and right bank fishway. The downstream migrant facilities consist of two separate bypass systems that fish enter volitionally. Both systems combine to utilize a common 36-inch discharge pipeline. The intake gatewell system (GWS) consists of a series of ports at the second powerhouse intake gate slots and a fingerling bypass channel that extends along the upstream face of the powerhouse structure. The traveling water screen bypass (TWSB) consists of a series of ports and vertical riser pipes. The traveling water screens are located adjacent to the right bank fishway exit. Incorporated in the bypass pipeline is a fish trapping facility for the collection and examination of downstream migrants.

The Rock Island bypass trap will be operated seven days per week April 1 – August 31 by WDFW personnel to provide daily juvenile index counts. Index counts will provide the basis for comparison to determine the start and end of seasonal spill periods.

Adult

Rock Island Dam is equipped with three fishways, one at each powerhouse and one that divides the spillway in half. All three fishways consist of entrances with attraction water systems, a pool and ladder section, flow regulation weirs, and a fish counting station. The left bank fishway (powerhouse 1) has two vertical slot entrances located at the shoreline and a gravity attraction water system. The center fishway (spillway) has a gravity attraction water system, a main vertical slot entrance that discharges perpendicular to the spillway, and a small vertical slot entrance that discharges parallel with spillway flow just downstream of the spillway stilling basin. The right fishway (powerhouse 2) has four vertical slot entrances; one at the north end of the powerhouse, two at the shoreline corner (south end of the powerhouse) and a tailrace entrance that is located downstream of the powerhouse. The attraction water in the right fishway is provided by a combination of gravity and three motor-operated attraction water pumps. Lights have been installed from the counting window to the fishway exit to improve fish passage through this section of the upper fishway.

For the purpose of operation and maintenance, primary fish passage is considered to occur from March through November of each year. Adult facilities will be open from March 1 to December 1 each year.

5.2.2 Water Quality Forums

Chelan PUD regularly participates in the Regional Water Quality Team and Transboundary Gas Group.

5.2.3 Physical Monitoring

Chelan PUD will maintain two fixed monitoring stations at the dam to monitor TDG levels annually from April through August, one in the forebay and one in the tailrace at the approved monitoring sites.

TDG measurements will be recorded throughout the monitoring season at 15-minute intervals, enabling plant operators to adjust spill volumes to maintain gas levels to prevent exceedances of the TDG criteria. These 15-minute intervals will be averaged into hourly readings for use in

compiling daily and 12-hour averages. All hourly data will be forwarded to District headquarters building and then onto the US Army Corps of Engineers Reservoir Control Center and posted at their site on the World Wide Web.

Chelan PUD will enter into a Professional Services Agreement with Columbia Basin Environmental (CBE) to perform monthly calibrations and equipment maintenance during the 2008 monitoring season. It is anticipated at this time that Chelan PUD will continue to contract with CBE into the future. QA/QC measures will be accomplished through training in instrument maintenance, operation, and factory prescribed calibration methods. A detailed log will be maintained for all work done on the monitoring equipment, including monthly maintenance, calibration, exchange of instruments, and any other pertinent information. Redundant measurements with a mobile instrument to verify the accuracy of the in-situ instruments will be conducted during the monthly calibrations.

5.2.4 Biological Monitoring

The WDFW, in conjunction with the FPC, conducts gas bubble trauma (GBT) monitoring at the Rock Island Bypass Trap. Random samples of 100 spring chinook, steelhead and subyearling chinook are examined two days per week during the sampling season (April 1st to August 31st). Examinations for GBT symptoms follow a standardized FPC protocol. The results of each examination are transmitted to the FPC. A year-end report is prepared by the WDFW summarizing the results of the sampling season.

5.3 Compliance Activities for 2009-2010

5.3.1 Powerhouse Optimization Studies

Chelan PUD will continue powerhouse optimization studies, thereby reducing voluntary spill volumes. Because the project is operating under Phase I of the HCP, which requires survival studies be conducted during representative flow conditions and normal project operating conditions consistent with the approved study design, no significant changes have been can be made to operations until the end of the Phase 1. The actual year in which changes can be made is dependent upon the success of Phase I. At the completion of Phase I Chelan PUD will know what levels of spill are necessary to ensure the survival goal is met. It is at this time Chelan PUD may be able to determine what gas abatement measures are feasible and necessary to meet water quality requirements and HCP survival standards.

5.3.2 Over/Under Spill Gate Operation

Chelan PUD intends to utilize the Over/Under spill gates through at least 2012. Before additional Over/Under gates are constructed, or other structural changes are made, Chelan PUD will operate under the existing structural configuration over the course of the next several years to determine the impact on TDG abatement resulting from the three existing Over/Under gates.

5.4 Additional Requirements

Chelan PUD will operate the Project in accordance with the following:

1. 7Q10. The 7Q10 for Rock Island is 264 kcfs. The Project will not be expected to comply with state water quality standards for TDG for incoming flows exceeding this value.

2. Fish Spill. For the purposes of compliance, the "fish spill" season is taken to occur from April 1 – August 31; and "non-fish spill" season occurs from September 1 to March 31, unless otherwise specified in writing by Ecology.

3. Compliance During Non-Fish Spill. During non-fish spill, Chelan PUD will make every effort to remain in compliance with the 110% standard.

4. Compliance During Fish Spill. During fish spill, Chelan PUD will make every effort not to exceed an average of 120% as measured in the tailrace of the dam. The Project also must not exceed an average of 115% as measured in the forebay of the next downstream dam. These averages are based on the twelve (12) highest consecutive hourly readings in any 24-hour period. In addition, there is a maximum one-hour average of 125%, relative to atmospheric pressure, during spillage for fish passage. Nothing in these special conditions allows an impact to existing and characteristic uses.

5. TDG Monitoring. Chelan PUD will maintain two fixed monitoring stations at the dam to monitor TDG levels annually from April through August, one in the forebay and one in the tailrace at the approved monitoring sites. This information is available on a real time basis to all interested parties at the US Army Corps of Engineers website (http://www.nwd-wc.usace.army.mil/report/tdg.htm).

6. Reporting Spill for Fish and TDG Exceedances. Chelan PUD will notify Ecology within 24 business hours of spill for fish and when TDG standards are exceeded. Reporting shall be electronically (via e-mail) to the hydropower project manager in Ecology's Central Region Office.

7. General TDG Abatement Measures. Chelan PUD will manage spill toward meeting water quality criteria for TDG during all flows below 7Q10 levels, but only to the extent consistent with meeting the passage and survival standards sets forth in the HCP and Fish Management Plans, as follows:

a. Minimize voluntary spill,
b. During fish passage, manage voluntary spill levels in real time in an effort to continue meeting TDG numeric criteria,
c. Minimize spill, to the extent possible, by scheduling maintenance based on predicted flows.

8. Annual TDG Monitoring Report. Chelan PUD shall submit an annual monitoring report. A draft monitoring report of the year's monitoring report shall be submitted to Ecology by October 31 of the monitoring year. Chelan PUD will submit the final report, incorporating Ecology's suggested corrections, by December 31 of the same year. The contents of the report shall include, at a minimum:

a. Flow and TDG levels, on a daily basis, with purpose of spill (e.g. fish spill, turbine down time),
b. Summary of exceedances and what was done to correct the exceedances,
c. Results of the fish passage efficiency (FPE) studies and survival per the HCP

9. Revised Gas Abatement Plan (GAP). Chelan PUD will revise the GAP annually, to reflect any changes, and new or improved information and technologies. Chelan PUD will submit a draft to Ecology for review and approval by February 28 of the year of implementation. The GAP shall be in the format of Chelan PUD's 2009 GAP, unless modifications are requested by Ecology.

10. Ecology Contact. Chelan PUD will direct its correspondence to:

Pat Irle, Hydropower Projects Manager
Department of Ecology, Central Region Office
Water Quality Program
15 W. Yakima Ave., Suite 200
Yakima, WA 98902-3452

6. REVISIONS TO THE TAILRACE MONITORING PLAN

There are no revisions to the Rock Island tailrace monitoring plan anticipated at this time.

LITERATURE CITED

Bernard, L. 1993. Impacts of dissolved gas supersaturation on the Columbia and Snake River anadromous fish. Fish Passage Center. Portland, OR.

Bouck, G. R. 1980. Etiology of gas bubble disease. *Transactions of the American Fisheries Society* 109:703-707.

Bouck, G.R., A.V. Nebeker, and D.G. Stevens. 1976. Mortality, saltwater adaptation, and reproduction of fish exposed to gas supersaturated water. Ecol. Res. Ser. EPA-600/1-76-050: 1-54. US Environmental Protection Agency, Western Fish Toxicology Station, Corvalis, OR.

Jensen, J.O.T., J. Schnute, and D. F. Alderice. 1986. Assessing juvenile salmonid response to gas supersaturation using a general multivariate dose – response model. *Canadian Journal of Fisheries and Aquatic Sciences.* Vol. 43: 1694-1708.

Meekin, Thomas K. and Ben K. Turner. 1974. Tolerance of salmonid eggs, juveniles and squawfish to supersaturated nitrogen. WDFW Tech. Rep. 12.

National Marine Fisheries Service (NMFS). 2000. Endangered Species Act – Section 7 Consultation: Biological Opinion. Consultation on Remand for Operation of the Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia Basin. F/NWR/2004/00727. November 30, 2005. Pages 5-6, 5-7, 5-53, 10-9, and Appendix E: Risk Analysis.

Schneider, M.L. and S.C. Wilhelms. 2005. Rocky Reach Dam: Operational and Structural Total Dissolved Gas Management. Prepared by COE, Engineer Research and Development Center, for Chelan PUD. July 2005. http://www.chelanpud.org/rr_relicense/study/reports/7773_1.pdf

Weitkamp, D. E., and M. Katz. 1980. A review of dissolved gas supersaturation literature, *Transactions of the American Fisheries Society. 109: 659-702.*

APPENDIX D

Hourly Dissolved Gas Levels at
Rocky Reach, Rock Island, and Wanapum projects
April - August 2009

April 2009. Numbers in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill)			
																				Rocky Reach		Rock Island	
2009	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-Apr	104	103	104	106	105	105	107	107	112	107	107	112	103	0.16	0.00	84.18	89.82	0.70	0.00	n/a	n/a	n/a	n/a
2-Apr	104	104	105	104	104	105	107	104	105	107	105	105	103	0.00	0.00	46.80	47.22	0.00	0.00	n/a	n/a	n/a	n/a
3-Apr	105	105	105	104	103	104	105	104	105	105	104	104	103	0.00	0.00	43.89	44.50	0.00	0.00	n/a	n/a	n/a	n/a
4-Apr	105	105	105	103	103	103	105	105	106	104	103	105	103	0.00	0.00	54.95	55.92	0.00	0.00	n/a	n/a	n/a	n/a
5-Apr	104	104	104	103	103	103	106	106	107				104	0.00	0.00	36.76	37.64	0.00	0.00	n/a	n/a	n/a	n/a
6-Apr	104	104	105	104	103	104	106	105	106				106	0.00	0.00	62.61	62.29	0.00	0.00	n/a	n/a	n/a	n/a
7-Apr	107	106	107	105	104	105	106	106	107				107	0.00	0.00	68.82	70.08	0.00	0.00	n/a	n/a	n/a	n/a
8-Apr	108	108	108	106	106	106	107	107	108				107	0.00	0.00	80.20	79.90	0.00	0.00	n/a	n/a	n/a	n/a
9-Apr	108	107	108	106	105	106	108	107	108	107	107	108	106	0.00	0.00	85.78	86.23	0.00	0.00	n/a	n/a	n/a	n/a
10-Apr	108	107	107	105	105	105	108	107	108	108	107	107	106	0.00	0.00	105.33	108.39	0.00	0.00	n/a	n/a	n/a	n/a
11-Apr	107	107	107	105	104	105	107	106	107	107	106	107	107	0.00	0.00	95.35	94.75	0.00	0.00	n/a	n/a	n/a	n/a
12-Apr	107	107	107	105	104	105	107	106	107	107	106	107	105	0.00	0.00	118.34	123.67	0.00	0.00	n/a	n/a	n/a	n/a
13-Apr	107	107	107	105	104	105	107	107	107	107	107	107	105	0.00	0.00	89.92	92.19	0.00	0.00	n/a	n/a	n/a	n/a
14-Apr	107	107	107	105	105	105	107	106	107	107	106	107	104	0.00	0.00	132.53	127.00	0.00	0.00	n/a	n/a	n/a	n/a
15-Apr	107	106	107	105	104	105	107	106	107	107	106	107	104	0.00	0.00	120.17	123.59	0.00	0.00	n/a	n/a	n/a	n/a
16-Apr	108	107	108	105	104	106	108	107	109	108	107	109	104	0.00	0.00	132.09	129.41	0.00	0.00	n/a	n/a	n/a	n/a
17-Apr	108	107	107	105	105	105	108	107	108	109	109	111	104	0.00	12.45	126.30	131.27	0.00	10.04	n/a	n/a	100	0
18-Apr	107	106	107	105	105	106	108	107	108	110	109	111	104	2.38	11.74	136.85	139.35	1.63	8.49	0	100	100	0
19-Apr	106	106	107	105	104	105	107	106	107	110	109	110		0.00	12.11	106.57	113.94	0.00	11.18	n/a	n/a	100	0
20-Apr	107	107	107	106	105	106	108	107	108	110	109	113	111	0.17	13.96	124.13	125.27	0.11	15.08	0	100	100	0
21-Apr	109	108	109	107	106	107	109	108	109	111	110	111	111	0.00	13.68	129.69	136.14	0.00	10.43	n/a	n/a	100	0
22-Apr	109	109	110	107	107	107	109	109	109	112	111	114	111	0.37	13.92	120.12	127.98	0.46	12.05	0	100	100	0
23-Apr	109	108	109	107	106	107	109	108	109	111	110	112	110	0.00	14.03	133.50	138.18	0.00	10.43	n/a	n/a	100	0
24-Apr	108	107	108	109	107	111	111	109	115	113	111	116	109	14.12	14.86	151.80	159.09	6.81	9.56	0	100	100	0
25-Apr	109	108	108	107	106	106	111	107	108	114	110	111	109	0.00	14.69	127.10	134.12	0.00	11.03	n/a	n/a	100	0
26-Apr	108	107	108	106	105	106	108	107	108	110	110	110	111	0.00	14.53	138.40	143.47	0.00	10.19	n/a	n/a	100	0
27-Apr	108	108	108	106	105	106	108	107	108	110	110	111	111	5.07	14.49	144.69	146.57	3.09	9.97	0	100	100	0
28-Apr	108	107	108	106	105	106	108	107	109	110	110	111	110	0.00	15.04	144.29	151.23	0.00	10.25	n/a	n/a	100	0
29-Apr	107	106	107	105	104	105	107	106	107	110	109	111	108	0.00	14.34	138.53	142.92	0.00	10.00	n/a	n/a	100	0
30-Apr	107	107	108	105	105	105	107	106	107	110	109	110	110	0.00	14.34	132.35	138.55	0.00	10.40	n/a	n/a	100	0

May 2009. Numbers in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill)			
																				Rocky Reach		Rock Island	
2009	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-May	109	109	110	107	106	107	109	108	110	112	110	112	110	0.00	13.55	116.86	119.15	0.00	11.64	0	0	100	0
2-May	111	111	111	108	108	109	110	110	111	112	112	113	111	0.00	9.86	100.90	110.53	0.00	9.58	0	0	100	0
3-May	112	111	112	108	108	109	111	110	111	114	113	115	111	0.00	9.94	54.50	58.33	0.00	18.87	0	0	100	0
4-May	112	112	112	111	110	111	112	111	112	114	113	114	111	0.00	11.56	123.39	123.26	0.00	12.47	0	0	100	0
5-May	112	111	112	110	109	110	112	111	112	114	113	116	112	0.00	12.36	92.86	98.64	0.00	14.88	0	0	100	0
6-May	110	109	110	108	107	108	110	109	110	113	112	116	112	0.00	10.21	73.56	77.31	0.00	15.59	0	0	100	0
7-May	109	108	109	107	106	107	109	108	109	113	108	111	112	0.00	9.16	82.39	85.47	0.00	14.92	0	0	100	0
8-May	108	107	108	107	106	107	108	107	108	111	110	115	109	0.00	10.50	119.91	124.05	0.00	11.56	0	0	100	0
9-May	109	108	110	107	106	107	108	108	109	111	110	111	114	0.00	11.53	119.31	127.36	0.00	9.15	0	0	100	0
10-May	110	110	110	107	107	108	110	109	110	113	112	113	114	0.00	10.35	97.04	104.33	0.00	10.44	0	0	100	0
11-May	111	111	111	109	108	109	111	110	111	113	112	115	114	0.00	10.96	117.81	119.98	0.00	10.10	0	0	100	0
12-May	111	110	111	108	108	108	111	109	110	113	112	114	111	0.00	10.20	122.00	130.37	0.00	8.83	0	0	100	0
13-May	110	108	109	107	106	107	109	108	109	113	112	114	109	0.00	23.41	125.44	131.33	0.00	19.62	0	0	100	0
14-May	109	108	109	106	106	107	108	108	108	114	113	115	110	0.00	23.52	119.27	124.63	0.00	19.93	0	0	100	0
15-May	108	107	108	106	106	107	108	107	108	113	112	113	112	0.00	25.57	133.53	136.57	0.00	20.89	0	0	100	0
16-May	109	108	109	107	106	108	109	108	109	112	111	114	112	0.00	11.11	108.99	113.14	0.00	12.39	0	0	100	0
17-May	110	109	110	107	107	108	110	109	110	112	111	113	115	0.00	11.65	111.73	117.54	0.00	11.08	0	0	100	0
18-May	111	111	111	109	108	109	111	110	111	113	112	114	115	0.00	13.51	117.81	125.62	0.00	12.10	0	0	100	0
19-May	111	110	111	109	108	108	111	109	110	114	112	114	115	0.00	14.04	118.91	131.36	0.00	11.41	0	0	100	0
20-May	110	108	109	108	106	107	109	108	108	111	110	113	110	0.00	12.33	108.98	120.13	0.00	12.45	0	0	100	0
21-May	108	108	108	106	106	106	108	107	108	111	110	111	113	0.00	12.59	117.59	127.61	0.00	10.02	0	0	100	0
22-May	109	109	110	108	107	108	109	108	109	111	111	113	115	0.00	12.85	123.56	131.18	0.00	11.02	0	0	100	0
23-May	110	110	110	108	108	109	110	109	110	112	112	115	115	0.00	14.23	133.54	141.60	0.00	11.80	0	0	100	0
24-May	110	110	111	108	108	108	110	109	110	112	112	113	114	0.00	14.33	133.33	143.78	0.00	10.44	0	0	100	0
25-May	110	110	110	108	107	108	110	109	110	112	112	113	112	0.00	13.94	125.35	133.35	0.00	11.38	0	0	100	0
26-May	110	110	110	108	107	108	110	109	109	113	112	113	111	0.00	16.00	140.10	149.19	0.00	11.62	0	0	100	0
27-May	110	109	109	108	107	108	109	109	109	111	111	112	112	0.00	14.73	152.94	162.05	0.00	9.25	0	0	100	0
28-May	109	109	110	107	107	107	109	108	109	111	110	111	114	0.00	15.35	155.83	165.61	0.00	9.27	0	0	100	0
29-May	111	110	111	108	107	108	110	109	110	112	112	113	114	0.00	16.59	156.82	166.92	0.00	10.09	0	0	100	0
30-May	111	110	111	108	108	109	110	109	110	113	112	114	114	0.00	15.90	141.19	155.61	0.00	10.29	0	0	100	0
31-May	111	110	111	109	108	109	110	109	110	113	112	116	114	0.00	14.76	136.41	150.91	0.00	11.19	0	0	89	11

June 2009. Numbers in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill)			
																				Rocky Reach		Rock Island	
2009	12-hr a	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-Jun	111	110	110	109	107	108	110	109	109	112	112	113	114	0.00	17.07	139.93	153.80	0.00	11.47	n/a	n/a	100	0
2-Jun	110	109	110	108	107	108	109	108	109	112	111	114	113	0.00	16.46	142.85	157.28	0.00	11.63	n/a	n/a	100	0
3-Jun	110	110	111	108	108	108	109	109	110	111	111	112	112	0.00	16.76	169.24	181.61	0.00	9.22	n/a	n/a	100	0
4-Jun	111	110	111	108	108	109	110	109	111	113	112	113	113	0.00	19.12	173.83	185.18	0.00	10.35	n/a	n/a	100	0
5-Jun	112	111	112	109	109	110	111	110	111	113	113	114	114	0.00	18.94	165.28	179.31	0.00	10.56	n/a	n/a	100	0
6-Jun	112	112	112	110	109	110	111	109	110	113	112	113	114	0.00	16.99	143.10	156.78	0.00	10.89	n/a	n/a	100	0
7-Jun	111	110	110	109	108	109	110	109	109	112	111	113	111	0.00	16.25	143.23	158.37	0.00	10.30	n/a	n/a	100	0
8-Jun	111	110	112	108	108	108	109	109	110	111	111	112	112	0.00	17.68	167.82	175.41	0.00	10.18	n/a	n/a	96.6	3.4
9-Jun	112	112	112	109	108	109	111	110	112	113	112	113	113	0.00	17.52	160.89	171.19	0.00	10.19	n/a	n/a	100	0
10-Jun	112	111	112	112	110	112	112	111	113	116	115	117	114	14.77	33.46	157.28	169.55	9.34	19.66	100	0	100	0
11-Jun	112	111	112	113	112	113	112	111	112	116	115	116	115	13.39	30.74	146.72	156.59	9.09	19.60	100	0	100	0
12-Jun	112	111	112	114	112	115	112	111	113	116	115	117	115	13.43	32.70	145.87	155.84	9.30	20.95	100	0	97.2	2.8
13-Jun	112	111	112	114	112	114	112	111	112	116	115	116	**116**	10.83	25.63	132.84	144.78	8.25	17.89	99.9	0.1	100	0
14-Jun	112	111	112	113	111	112	111	111	111	116	115	117	115	9.80	23.75	102.81	115.59	9.93	21.28	100	0	100	0
15-Jun	112	112	112	112	111	112	112	111	112	116	115	116	114	14.39	29.93	95.20	103.10	15.00	29.87	97.8	2.2	99.1	0.9
16-Jun	112	112	112	113	112	115	112	111	112	115	114	116	114	11.66	24.04	104.01	110.46	14.88	28.60	84.9	15.1	100	0
17-Jun	112	111	112	114	113	114	112	111	112	116	115	117	113	11.62	28.40	131.32	135.82	12.03	27.13	100	0	100	0
18-Jun	112	112	112	113	112	114	112	111	113	117	116	118	112	12.89	30.49	148.31	156.22	8.73	19.67	99.9	0.1	100	0
19-Jun	112	112	113	113	112	114	112	112	113	117	116	117	112	12.71	29.25	147.79	155.62	8.58	18.90	100	0	98	2
20-Jun	113	112	113	113	112	114	112	112	113	117	116	117	112	12.47	30.92	137.94	146.07	9.04	21.48	100	0	100	0
21-Jun	112	112	112	113	112	114	112	111	111	117	114	115	112	10.19	24.07	141.97	146.95	7.40	16.93	99.9	0.1	100	0
22-Jun	112	111	112	114	112	117	111	110	114	115	115	116	110	37.13	29.76	164.01	161.86	19.57	18.62	40	60	100	0
23-Jun	112	111	112	115	113	116	114	113	115	117	116	117	112	14.63	30.94	156.14	161.45	9.31	19.26	87.5	12.5	100	0
24-Jun	114	114	114	115	114	115	114	113	114	117	116	118	115	13.34	32.88	152.19	154.82	8.90	21.59	100	0	100	0
25-Jun	114	112	113	114	113	115	114	112	113	117	116	117	115	13.84	31.60	146.89	147.95	9.94	22.57	100	0	100	0
26-Jun	112	111	111	114	112	113	112	111	112	116	115	116	112	12.48	28.93	145.06	147.08	9.52	21.41	100	0	100	0
27-Jun	112	111	113	113	112	114	112	111	112	115	114	116	113	11.26	25.64	140.66	144.92	8.73	18.98	100	0	100	0
28-Jun	113	112	113	114	113	114	112	112	113	115	115	116	113	9.90	22.96	143.94	148.94	6.69	15.59	100	0	100	0
29-Jun	113	112	113	114	113	116	113	112	113	116	116	117	114	23.44	29.14	158.00	161.51	13.21	17.30	68.7	31.3	100	0
30-Jun	114	113	114	114	112	115	114	113	116	117	117	119	114	12.08	23.19	107.87	118.81	10.85	20.78	84.5	15.5	100	0

July 2009. Numbers in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

A value in parentheses represents the TDG value when using the the modified (to eliminate double counting) method to determine the 12-C High.

	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Reason for Spill (in % of total spill) Rocky Reach		Rock Island	
2009	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-Jul	115	115	116	112	111	113	114	113	114	117	116	118	**116**	8.39	22.85	73.81	78.56	12.90	32.40	100	0	93.3	6.7
2-Jul	**116**	115	116	113	112	114	114	114	115	117	117	118	**119**	7.48	18.21	93.70	97.53	8.60	20.59	100	0	100	0
3-Jul	**116**	116	117	114	112	115	115	114	115	118	118	120	**119**	7.29	16.51	74.76	78.62	13.64	27.36	100	0	100	0
4-Jul	**116**	116	117	113	112	114	115	114	116	119	118	121	**118**	6.66	14.45	75.74	78.93	11.28	23.47	100	0	100	0
5-Jul	**117**	117	118	113	112	113	115	114	115	119	118	122	**117**	5.60	15.72	73.39	75.19	9.07	23.45	100	0	100	0
6-Jul	**117**	115	117	113	112	113	115	114	115	118	117	120	**116 (114)**	10.58	20.44	108.49	109.84	10.79	23.78	100	0	100	0
7-Jul	115	114	115	114	113	114	114	114	115	118	117	118	111	11.70	26.44	140.43	144.00	8.51	18.86	100	0	100	0
8-Jul	114	113	113	114	112	115	114	112	113	118	116	118	111	13.56	24.60	116.53	121.54	12.71	23.94	100	0	100	0
9-Jul	113	113	114	113	112	114	113	112	113	116	116	117	114	12.04	26.61	133.53	134.08	9.72	21.25	100	0	100	0
10-Jul	114	113	114	113	112	113	113	113	114	117	117	118	**117**	10.39	26.41	132.17	134.58	7.91	19.80	100	0	100	0
11-Jul	114	114	114	114	112	114	114	113	115	117	116	118	**117**	8.22	19.09	120.83	126.43	8.04	17.82	100	0	100	0
12-Jul	114	114	114	114	112	113	114	113	114	117	117	118	**117**	7.38	19.08	105.00	106.33	7.39	18.27	99.8	0.2	100	0
13-Jul	114	113	114	113	112	114	113	112	112	117	115	116	115	9.91	23.58	120.73	126.04	8.64	19.90	99.9	0.1	100	0
14-Jul	113	112	113	113	112	114	112	112	113	116	116	117	112	9.89	24.18	115.05	119.87	9.12	21.17	100	0	100	0
15-Jul	112	112	112	113	111	113	113	112	113	117	116	119	114	9.07	23.64	106.34	108.83	11.85	28.61	100	0	99.1	0.9
16-Jul	112	112	113	113	111	113	112	111	113	117	116	119	115	9.00	22.33	103.95	103.81	10.77	27.57	100	0	100	0
17-Jul	113	113	114	113	111	113	113	112	113	116	116	118	115	9.15	22.66	101.17	104.66	10.29	26.14	95.8	4.2	100	0
18-Jul	114	114	115	112	111	113	113	113	113	117	116	118	115	6.81	18.73	80.80	83.27	9.78	26.34	99.8	0.2	100	0
19-Jul	114	113	114	112	110	112	113	112	113	117	117	119	113	7.11	16.60	78.47	80.02	10.32	23.11	100	0	100	0
20-Jul	114	112	113	113	111	114	112	112	113	117	116	119	114	8.62	21.62	103.51	100.58	11.37	29.82	100	0	100	0
21-Jul	113	113	113	113	112	114	113	112	114	117	116	117	115	8.79	20.29	100.47	102.32	11.86	24.81	100	0	100	0
22-Jul	114	113	115	113	111	112	114	113	114	117	117	117	115	7.40	18.40	85.68	86.97	10.59	25.12	100	0	100	0
23-Jul	114	113	114	111	110	112	114	112	113	117	117	118	114	6.74	18.00	81.05	82.48	10.80	29.93	100	0	100	0
24-Jul	113	112	113	111	110	113	112	112	112	117	116	117	111	7.07	19.14	86.73	89.27	9.33	25.13	99.8	0.2	100	0
25-Jul	112	112	113	111	110	112	112	112	112	116	116	118	114	6.97	18.30	81.26	83.03	9.72	24.69	100	0	100	0
26-Jul	112	112	113	111	110	112	112	112	113	118	116	120		6.18	15.93	90.94	91.85	8.47	21.23	100	0	100	0
27-Jul	112	112	112	112	111	113	113	112	114	117	116	118	115	9.00	22.50	112.93	114.72	8.32	21.16	100	0	100	0
28-Jul	113	112	113	114	112	114	114	113	114	117	117	118	**116**	9.43	22.00	113.73	116.50	9.51	22.02	100	0	100	0
29-Jul	113	113	114	113	112	114	114	113	114	117	116	117	**116**	9.82	23.28	112.03	114.31	9.64	22.99	100	0	100	0
30-Jul	113	113	114	113	112	114	114	113	115	117	117	119	**117**	9.46	23.28	110.69	111.23	9.67	24.35	100	0	100	0
31-Jul	113	113	113	114	112	115	114	113	115	117	117	118	**118**	8.78	21.98	107.98	109.16	10.68	26.42	100	0	100	0

August 2009. Numbers in bold exceed the water quality criteria.

All TDG values are rounded to the nearest whole number, as specified in the April 2, 2008 memo from Chris Maynard.

A value in parentheses represents the TDG value when using the the modified (to eliminate double counting) method to determine the 12-C High.

																			Reason for Spill (in % of total spill)			
	Rocky Reach Forebay			Rocky Reach Tailrace			Rock Island Forebay			Rock Island Tailrace			Wan FB	Average Daily Spill		Total Flow		% Flow Spilled		Rocky Reach		Rock Island	
2009	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	24-hr	High	12-hr	RR	RI	RR	RI	RR	RI	Fish	Other	Fish	Other
1-Aug	114	113	115	114	111	112	114	113	114	117	116	118	**118**	6.35	14.91	81.76	86.11	9.44	20.78	100	0	93.9	6.1
2-Aug	114	113	115	112	110	112	114	113	113	118	117	120	**117 (114)**	5.50	13.14	58.86	58.91	11.46	27.68	100	0	100	0
3-Aug	114	113	114	112	111	112	113	113	113	117	116	119	114	8.02	20.01	82.98	84.61	12.02	29.18	96.3	3.7	100	0
4-Aug	113	111	112	111	110	112	113	111	112	117	116	119	113	7.49	18.47	88.71	89.02	10.95	27.21	100	0	100	0
5-Aug	112	111	112	111	110	112	112	111	112	116	115	117	113	7.15	19.02	96.55	95.63	8.97	24.50	100	0	100	0
6-Aug	111	111	111	111	110	112	112	111	112	116	115	118	113	7.21	18.72	96.22	99.06	10.36	25.21	95.7	4.3	100	0
7-Aug	111	110	110	111	109	111	110	109	110	114	114	116	110	7.29	19.08	80.70	81.42	10.06	27.74	100	0	100	0
8-Aug	110	109	110	110	108	110	109	109	110	116	114	117	108	5.42	13.83	57.15	57.74	12.15	30.49	100	0	100	0
9-Aug	110	110	111	109	108	109	110	109	110	116	114	118	107	5.11	12.61	55.69	53.82	11.58	29.47	100	0	100	0
10-Aug	110	110	110	111	109	112	111	110	111	115	114	119	107	6.80	16.09	78.63	83.47	11.60	26.63	100	0	100	0
11-Aug	110	109	110	111	109	110	111	110	111	115	114	120	108	6.49	15.35	87.69	88.18	8.75	21.22	99.8	0.2	100	0
12-Aug	109	109	109	110	109	109	110	110	110	116	115	121	108	6.50	16.45	67.67	69.16	11.55	29.06	100	0	100	0
13-Aug	109	108	109	109	108	109	110	109	109	115	114	120	108	6.31	12.62	60.55	63.73	12.90	24.41	100	0	100	0
14-Aug	108	107	108	108	107	108	108	107	108	114	113	116	106	4.86	11.52	57.10	59.66	11.20	24.69	100	0	100	0
15-Aug	107	107	108	107	105	106	107	107	108	113	112	117	106	0.00	10.11	48.96	49.00	0.00	25.64	100	0	100	0
16-Aug	108	107	108	105	104	105	107	107	108	113	112	116	106	0.00	9.42	47.43	47.52	0.00	24.43	n/a	n/a	100	0
17-Aug	108	108	109	105	105	106	108	107	108	113	112	118	111	0.00	14.49	82.54	83.26	0.00	20.52	n/a	n/a	100	0
18-Aug	110	109	111	108	106	108	110	109	110	112	109	112	111	0.00	0.00	86.27	88.18	0.00	0.00	n/a	n/a	100	0
19-Aug	110	109	111	108	107	108	110	110	110	110	110	110	111	0.00	0.00	93.06	91.14	0.00	0.00	n/a	n/a	n/a	n/a
20-Aug	110	110	111	110	109	111	110	110	111	110	110	111	113	7.10	0.00	82.94	84.83	11.38	0.00	n/a	n/a	n/a	n/a
21-Aug	110	110	111	110	109	111	111	110	111	110	110	110	112	7.24	0.00	80.63	78.26	11.67	0.00	100	100	n/a	n/a
22-Aug	110	109	110	110	109	111	110	110	111	110	110	110	107	4.93	0.00	61.83	63.11	11.89	0.00	100	100	n/a	n/a
23-Aug	110	109	110	109	109	110	110	109	110	110	109	110	106	4.51	0.00	51.13	49.71	12.98	0.00	100	100	n/a	n/a
24-Aug	109	109	109	110	109	111	109	108	110	109	108	110	108	7.68	0.00	88.41	86.35	11.09	0.00	99.9	0.1	n/a	n/a
25-Aug	109	109	109	110	110	111	109	109	110	109	109	110	108	7.81	0.00	82.42	83.49	12.20	0.00	100	0	n/a	n/a
26-Aug	108	107	107	110	109	111	109	108	109	109	108	109	107	7.13	0.00	81.35	85.87	12.62	0.00	99.7	0.3	n/a	n/a
27-Aug	107	106	107	109	108	109	108	107	108	108	107	108	109	6.41	0.00	76.28	73.60	12.17	0.00	100	0	n/a	n/a
28-Aug	107	107	108	108	108	109	108	107	108	108	107	108	109	6.82	0.00	66.44	66.22	12.38	0.00	100	0	n/a	n/a
29-Aug	107	107	108	108	107	108	108	107	108	107	107	108	108	4.93	0.00	59.72	58.68	9.81	0.00	100	0	n/a	n/a
30-Aug	107	106	108	108	107	108	108	108	109	108	107	108	107	4.88	0.00	59.45	58.64	9.78	0.00	100	0	n/a	n/a
31-Aug	108	107	108	109	108	111	108	108	108	108	108	108	108	6.15	0.00	69.47	69.72	11.07	0.00	100	0	n/a	n/a

APPENDIX E

Monthly Calibration Logs

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 29-Apr-09
Arrival Time: 12:50
Departure Time: 14:00

Site: RIGW
Probe ID: 37607

Calibration Type: Field

Date: 29-Apr-09 **Time:** 13:15

BP Station:
754.1 mmHg

	Std	Initial	Final
Temperature	7.48	7.4	N / C
TDG 100%	754.1	755	N / C
TDG 113%	854.1	855	N / C
TDG 126%	954.1	955	N / C
TDG 139%	1054.1	1055	N / C
TDG membrane ID	CPUD-09-04		
Integrity Check	Pass		

Comments:

Report created June 07, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 29-Apr-09
Arrival Time: 14:20
Departure Time: 14:55

Site: RIS
Probe ID: 38641

Calibration Type: Field

Date: 29-Apr-09 **Time:** 14:30

BP Station: 753.0 mmHg	**Std**	**Initial**	**Final**
Temperature	7.10	6.9	N / C
TDG 100%	753	754	753
TDG 113%	853	854	853
TDG 126%	953	954	953
TDG 139%	1053	1055	1053
TDG membrane ID	CPUD-09-03		
Integrity Check	Pass		

Comments:

Report created June 07, 2009

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 29-Apr-09
Arrival Time: 15:35
Departure Time: 16:05

Site: RRDW
Probe ID: 38865

Calibration Type: Field

Date: 29-Apr-09 **Time:** 15:45

BP Station: 751.9 mmHg	**Std**	**Initial**	**Final**
Temperature	7.10	6.9	N / C
TDG 100%	751.9	752	N / C
TDG 113%	851.9	852	N / C
TDG 126%	951.9	952	N / C
TDG 139%	1051.9	1052	N / C
TDG membrane ID	CPUD-09-02		
Integrity Check	Pass		

Comments:

Report created June 07, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 29-Apr-09
Arrival Time: 16:15
Departure Time: 16:40

Site: RRH
Probe ID: 37606

Calibration Type: Field

Date: 29-Apr-09 **Time:** 16:20

BP Station: 750.1 mmHg	**Std**	**Initial**	**Final**
Temperature	6.42	6.3	N / C
TDG 100%	750.1	749	N / C
TDG 113%	850.1	849	N / C
TDG 126%	950.1	949	N / C
TDG 139%	1050.1	1049	N / C
TDG membrane ID	CPUD-09-01		
Integrity Check	Pass		

Comments:

Report created June 07, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 29-May-09
Arrival Time: 9:45
Departure Time: 10:40

Site: RIGW
Probe ID: 37607

Calibration Type: Field

Date: 29-May-09 **Time:** 10:05

BP Station: 746.8 mmHg	**Std**	**Initial**	**Final**
Temperature	12.82	12.8	N / C
TDG 100%	746.8	749	747
TDG 113%	846.8	849	847
TDG 126%	946.8	949	947
TDG 139%	1046.8	1049	1047
TDG membrane ID	CPUD-09-05		
Integrity Check	Pass		

Comments:

Report created June 07, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 29-May-09
Arrival Time: 11:05
Departure Time: 11:35

Site: RIS
Probe ID: 38641

Calibration Type: Field

Date: 29-May-09 **Time:** 11:15

BP Station:
745.5 mmHg

	Std	Initial	Final
Temperature	12.51	12.3	N / C
TDG 100%	745.5	746	N / C
TDG 113%	845.5	845	N / C
TDG 126%	945.5	946	N / C
TDG 139%	1045.5	1046	N / C
TDG membrane ID	CPUD-09-06		
Integrity Check	Pass		

Comments:

Report created June 07, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 29-May-09
Arrival Time: 12:05
Departure Time: 12:40

Site: RRDW
Probe ID: 38865

Calibration Type: Field

Date: 29-May-09 **Time:** 12:25

BP Station:
745.2 mmHg

	Std	Initial	Final
Temperature	12.39	12.2	N / C
TDG 100%	745.2	745	N / C
TDG 113%	845.2	845	N / C
TDG 126%	945.2	945	N / C
TDG 139%	1045.2	1045	N / C
TDG membrane ID	CPUD-09-07		
Integrity Check	Pass		

Comments:

Report created June 07, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 29-May-09
Arrival Time: 12:50
Departure Time: 13:15

Site: RRH
Probe ID: 37606

Calibration Type: Field

Date: 29-May-09 **Time:** 12:55

BP Station: 743.0 mmHg	**Std**	**Initial**	**Final**
Temperature	12.97	12.8	N / C
TDG 100%	743	741	743
TDG 113%	843	840	842
TDG 126%	943	940	943
TDG 139%	1043	1040	1043
TDG membrane ID	CPUD-09-08		
Integrity Check	Pass		

Comments:

Report created June 07, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 24-Jun-09
Arrival Time: 11:40
Departure Time: 12:35

Site: RIGW
Probe ID: 37607

Calibration Type: Field

Date: 24-Jun-09 **Time:** 12:00

BP Station:
742.0 mmHg

	Std	Initial	Final
Temperature	15.72	15.7	N / C
TDG 100%	742	742	N / C
TDG 113%	842	842	N / C
TDG 126%	942	942	N / C
TDG 139%	1042	1042	N / C
TDG membrane ID	CPUD-09-04		
Integrity Check	Pass		

Comments:

Report created July 27, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 24-Jun-09
Arrival Time: 13:00
Departure Time: 13:30

Site: RIS
Probe ID: 38641

Calibration Type: Field

Date: 24-Jun-09 **Time:**

BP Station: 740.5 mmHg	**Std**	**Initial**	**Final**
Temperature			N / C
TDG 100%	740.5		N / C
TDG 113%	840.5		N / C
TDG 126%	940.5		N / C
TDG 139%	1040.5		N / C
TDG membrane ID			
Integrity Check			

Comments: Unable to retrieve probe for calibration due to debris jam inside deployment pipe.

Report created July 27, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 24-Jun-09
Arrival Time: 14:30
Departure Time: 15:05

Site: RRDW
Probe ID: 38865

Calibration Type: Field

Date: 24-Jun-09 **Time:** 14:50

BP Station:
740.2 mmHg

	Std	Initial	Final
Temperature	16.00	15.9	N / C
TDG 100%	740.2	737	740
TDG 113%	840.2	837	840
TDG 126%	940.2	937	940
TDG 139%	1040.2	1037	1040
TDG membrane ID	CPUD-09-02		
Integrity Check	Pass		

Comments:

Report created July 27, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 24-Jun-09
Arrival Time: 15:10
Departure Time: 15:35

Site: RRH
Probe ID: 37606

Calibration Type: Field

Date: 24-Jun-09 **Time:** 15:20

BP Station:
738.7 mmHg

	Std	Initial	Final
Temperature	15.87	15.8	N / C
TDG 100%	738.7	738	N / C
TDG 113%	838.7	837	N / C
TDG 126%	938.7	938	N / C
TDG 139%	1038.7	1038	N / C
TDG membrane ID	CPUD-09-01		
Integrity Check	Pass		

Comments:

Report created July 27, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 22-Jul-09
Arrival Time: 11:15
Departure Time: 12:00

Site: RIGW
Probe ID: 37607

Calibration Type: Field

Date: 22-Jul-09 **Time:** 11:30

BP Station:
745.2 mmHg

	Std	Initial	Final
Temperature	19.80	19.7	N / C
TDG 100%	745.2	744	N / C
TDG 113%	845.2	844	N / C
TDG 126%	945.2	944	N / C
TDG 139%	1045.2	1044	N / C
TDG membrane ID	CPUD-09-05		
Integrity Check	Pass		

Comments:

Report created July 27, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 22-Jul-09
Arrival Time: 10:20
Departure Time: 10:50

Site: RIS
Probe ID: 38641

Calibration Type: Field

Date: 22-Jul-09 **Time:** 10:30

BP Station:
744.3 mmHg

	Std	Initial	Final
Temperature	18.72	18.7	N / C
TDG 100%	744.3	743	744
TDG 113%	844.3	842	843
TDG 126%	944.3	942	943
TDG 139%	1044.3	1042	1044
TDG membrane ID	CPUD-09-03		
Integrity Check	Pass		

Comments:

Report created July 27, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 22-Jul-09
Arrival Time: 8:20
Departure Time: 8:55

Site: RRDW
Probe ID: 38865

Calibration Type: Field

Date: 22-Jul-09 **Time:** 8:35

BP Station:
742.7 mmHg

	Std	Initial	Final
Temperature	18.54	18.4	N / C
TDG 100%	742.7	745	743
TDG 113%	842.7	844	843
TDG 126%	942.7	944	943
TDG 139%	1042.7	1044	1043
TDG membrane ID	CPUD-09-08		
Integrity Check	Pass		

Comments:

Report created July 27, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 22-Jul-09
Arrival Time: 9:00
Departure Time: 9:35

Site: RRH
Probe ID: 37606

Calibration Type: Field

Date: 22-Jul-09 **Time:** 9:20

BP Station:
741.4 mmHg

	Std	Initial	Final
Temperature	18.80	18.7	N / C
TDG 100%	741.4	743	741
TDG 113%	841.4	842	840
TDG 126%	941.4	942	940
TDG 139%	1041.4	1043	1041
TDG membrane ID	CPUD-09-07		
Integrity Check	Pass		

Comments:

Report created July 27, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 21-Aug-09
Arrival Time: 14:20
Departure Time: 14:45

Site: RRH
Probe ID: 37606

Calibration Type: Field

Date: 21-Aug-09 **Time:** 14:30

BP Station:
742.9 mmHg

	Std	Initial	Final
Temperature	20.89	20.9	N / C
TDG 100%	742.9	741	743
TDG 113%	842.9	841	842
TDG 126%	942.9	941	943
TDG 139%	1042.9	1041	1043
TDG membrane ID	CPUD-09-01		
Integrity Check	Pass		

Comments:

Report created August 31, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 21-Aug-09
Arrival Time: 13:50
Departure Time: 14:15

Site: RRDW
Probe ID: 38865

Calibration Type: Field

Date: 21-Aug-09 **Time:** 14:00

BP Station: 744.8 mmHg	**Std**	**Initial**	**Final**
Temperature	19.80	19.7	N / C
TDG 100%	744.8	742	745
TDG 113%	844.8	842	845
TDG 126%	944.8	942	945
TDG 139%	1044.8	1042	1045
TDG membrane ID	CPUD-09-02		
Integrity Check	Pass		

Comments:

Report created August 31, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 21-Aug-09
Arrival Time: 12:25
Departure Time: 13:05

Site: RIS
Probe ID: 38641

Calibration Type: Field

Date: 21-Aug-09 **Time:** 12:45

BP Station: 745.3 mmHg	**Std**	**Initial**	**Final**
Temperature	20.66	20.6	N / C
TDG 100%	745.3	744	745
TDG 113%	845.3	843	845
TDG 126%	945.3	943	945
TDG 139%	1045.3	1043	1045
TDG membrane ID	CPUD-09-06		
Integrity Check	Pass		

Comments:

Report created August 31, 2009

Columbia Basin Environmental

Calibration Report

Client: Public Utility District No. 1 of Chelan County

Date: 21-Aug-09
Arrival Time: 10:55
Departure Time: 11:55

Site: RIGW
Probe ID: 37607

Calibration Type: Field

Date: 21-Aug-09 **Time:** 11:30

BP Station:
745.9 mmHg

	Std	Initial	Final
Temperature	19.29	19.3	N / C
TDG 100%	745.9	744	746
TDG 113%	845.9	844	845
TDG 126%	945.9	944	945
TDG 139%	1045.9	1045	1046
TDG membrane ID	CPUD-09-04		
Integrity Check	Pass		

Comments:

Report created August 31, 2009

APPENDIX F

Response to Comments

Section, Paragraph	Comment	Chelan PUD Response
Abstract	How did it differ from the fish passage operation?	Language revised in response to comment.
Abstract	A casual reader would assume the PUD was responsible for this.	Language revised in response to comment.
Abstract	What did you determine, using data collected this year?	This is addressed in Section 3.4.1.
1.1	It would be helpful if the actual distance between dams were included as well.	Language revised in response to comment.
1.1	Why use metric here and English units elsewhere throughout the document?	Language revised in response to comment.
1.1.1 1st paragraph	Grammatical observation: Would be nice to be consistent in how numbers are presented. I'm used to one through tem being written out, then switching to 11, 12, etc.	Language revised in response to comment.
1.1.1 2nd Paragraph	Is this more important than the fish ladder? How did you make that determination?	The juvenile bypass system and fish ladder serve two distinctly different purposes. The juvenile bypass is for juvenile fish passage, while the fish ladder is for adult passage.
1.1.1 2nd Paragraph	HCP is used throughout this document. I am assuming that the HCP covers both Rocky Reach and Rock Island dams.	There is an HCP for each project. Where necessary, RR/RI have been added to HCP (RRHCP, RIHCP) to improve clarity.
1.1.1 2nd Paragraph	[which occurs in which months?]	Language revised in response to comment.
1.1.2 2nd Paragraph	Were any deflectors installed before this?	Language revised in response to comment.
1.1.2 2nd Paragraph	Is there any intention to replace this deflector? How effective was it at removing TDG compared to the Bay 16 deflector? (Question from 2nd draft).	Not at this time. Studies showed that the deflector in Bay 16 reduced TDG by 2.7% and that the deflector in Bay 29 reduced TDG by 4.2-4.8%.
1.1.2 3rd Paragraph	Recommended addition of "improving" in regards to fish survival.	Did not include "improving", as that is not necessarily a valid statement. Instead, added "maintaining".
1.2 3rd Paragraph	Have these locations been determined to be representative?	Language revised in response to comment.
1.2 3rd Paragraph	It appears that moving this monitoring station (or adding another) may be something we may want to consider to improve accuracy reported values. (Comment from 2nd draft)	There is no other feasible location for probe deployment.
1.3.1 2nd paragraph	At higher flows (exceeding those experienced in 2009)? (Question from 2nd draft)	At any flows, not just those exceeding that were experienced in 2009.
1.3.2 3rd Paragraph – bullets	Was this done for this report?	Yes, in Section 3.4.1. However, in the form of % days in exceedance rather than % days in compliance. Language has been revised to reflect such.
1.3.2 3rd Paragraph – bullets	This does not appear to have been in this report. Maybe you should delete this? (Comment from 2nd draft)	This is included in the report. See Section 3.4.1.

General	It would be appropriate to describe GAP requirements early in this document.	Language added in response to comment.
	Thanks! Also, should mention (briefly) monitoring requirements (for fisheries, GBT, TDG) and WQ forums. (Comment from 2nd draft)	Language added in response to comment.
2.1.1	It would be helpful if this information were provided in a table.	Table has been added in response to comment. See Table 1.
2.2.1	Suggested addition of "located on the river banks"	This was not included, as the entrances are not on the river banks.
2.3 2nd paragraph	Months?	Language has been revised in response to comment.
2.3.1	Please discuss involuntary spills in this section.	Language has been added in response to comment.
2.3.1 2nd paragraph	Primarily due to? (Question from 2nd draft)	Language added in response to comment.
2.3.1 Table 2	????? – regarding misc flow (Question from 2nd draft)	This is the way the logs record this minute amount of flow.
2.3.1.1 1st paragraph	Explain briefly – efficiency to generate power?	Language revised in response to comment.
2.3.1.1 1st paragraph	Suggested addition of "which did not involve spill. The test was" (comment from 2nd draft)	Language revised in response to comment.
3.1.2 1st paragraph	For Rocky Reach and RI combined? Or for each separately?	Each separately. Language revised in response to comment.
3.1.2 1st paragraph	Suggested rewording regarding survival standards.	This has been reworded to read the same as the HCPs.
3.2 1st paragraph	Please explain why only monitored at Rock Island.	GBT monitoring is part of the Fish Passage Center's Smolt Monitoring Program. Rock Island is part of that program, but Rocky Reach is not.
3.4.1 2nd paragraph	Compared to what?	Language revised in response to comment.
3.4.1 6th paragraph	Again, the reader unfamiliar with state standards would assume Chelan PUD was at fault. (Comment from 2nd draft).	Language revised in response to comment.
3.4.1 5th paragraph	Did elevated levels affect compliance?	Language revised in response to comment.
3.4.2 2nd paragraph	And to train Chelan PUD staff? (And two other questions related to the same thing). (Question from 2nd draft)	Training of staff is not part of the contract. The contractor maintains the logs associated with the maintenance and calibration work.
3.4.3	Can we have a table for the results presented below (for spring and summer, RR and RI?)	Tables 6 and 8 have been added in response to comment.
3.4.3	It would be good to discuss and analyze the change in TDG from the tailrace of one project to the forebay of the next (i.e., from RR to RI, and from RI to Wan)	Language and tables have been added in response to comment. Please see Tables 7 and 9.
3.4.3.1	Does the TDG monitor levels to this degree of accuracy?	Rounded numbers to the nearest tenth in response to comment.

Table 6	Does this include all those days when there was no spill? What happens if you just show the days when there was spill? (Question from 2nd draft).	Added "Spill Events Only" averages and ranges for Rocky Reach.
4.1	What happens if you include this years' data with previous years' data? (Question from 2nd draft).	This paragraph states that TDG production has been reduced at both projects due to the success of the Rocky Reach Juvenile Fish Bypass System and survival studies at both projects and was not intended to go into detail regarding previous years' data.
4.1	Suggested addition…."Note, however, that flows were less than average and that during higher flow years (up to the 7Q10), it may not be possible to meet water quality standards." (Comment from 2nd draft).	Suggestion not added, as this paragraph does not address compliance with water quality standards, but rather states that TDG production has been reduced at both projects due to the success of Rocky Reach Juvenile Fish Bypass System and survival studies at both projects.
4.1.1 1st paragraph	What is the status at this time?	Chelan PUD completed Phase I testing for steelhead at Rocky Reach in 2006 with a three-year (2004-2006) mean survival of 95.78%. Juvenile steelhead are now in HCP Phase III (Juvenile Survival Standards Achieved).
4.1.1 3rd paragraph	What is the predicted duration (years) of these studies at this time?	Language added to address comment.
4.1.1 4th paragraph	Relevance to TDG	Paragraph deleted.
4.1.2 2nd paragraph	When is Phase I currently estimated to be completed?	Chelan PUD anticipates completion of Phase I survival study testing at Rock Island by 2011.
5. 1st paragraph	This would be good to also include in the introduction section.	Language added to introduction in response to comment.
5. 2nd paragraph	Suggested rewording.	Conclusion section is being revised and the suggested rewording may not be necessary.
5. 3rd paragraph	How does this sentence related to the discussion in the previous paragraph? It appears to contradict the statement in previous paragraph.	Sentence deleted.
5. 4th paragraph	This is one of the most important sentences in this report. I suggest that it be made the subject of this section; along with a discussion of meeting (or not meeting) TDG criteria in the Wanapum forebay.	Language has been added to the introduction in response to comment.
5. 5th paragraph	Suggested rewording.	Conclusion section is being revised and this suggested rewording may not be necessary.
5. 5th paragraph	Or compliance?	Conclusion section is being revised and this paragraph may be eliminated.