ANNUAL REPORT

CALENDAR YEAR 2009
ACTIVITIES UNDER THE AQUATIC SETTLEMENT AGREEMENT

WELLS HYDROELECTRIC PROJECT
FERC LICENSE NO. 2149

Prepared for

Public Utility District No. 1
of Douglas County, Washington
1151 Valley Mall Parkway
East Wenatchee, Washington 98802-4497

Prepared by

Anchor QEA, LLC
1423 Third Avenue, Suite 300
Seattle, Washington 98101

April 2010

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TABLE OF CONTENTS

List of Tables

List of Appendices

1 INTRODUCTION

The Wells Hydroelectric Project (Wells Project) is owned and operated by Public Utility District No. 1 of Douglas County (Douglas PUD). The Aquatic Settlement Agreement (Agreement) for the relicensing of the Wells Project (FERC License No. 2149) was signed by Douglas PUD's commissioners on January 19, 2009, following the receipt of signatures from the Confederated Tribes of the Colville Reservation (CCT; November 10, 2008), Washington State Department of Ecology (Ecology; November 18, 2008), and Washington Department of Fish and Wildlife (WDFW; November 20, 2008). The Yakama Nation (YN) signed the Agreement on February 24, 2009; the U.S. Fish and Wildlife Service (USFWS) signed the Agreement on July 23, 2009; and the Bureau of Land Management (BLM) signed it on November 13, 2009. Preparation of this report was financed by Douglas PUD as a requirement of the Agreement, and it is the first annual report to be developed for activities accomplished under the Agreement, covering the period from January 19, 2009, to December 31, 2009.

The Agreement is intended to resolve all remaining Aquatic Resource issues related to compliance with all federal and state laws applicable to the issuance of a New Operating License for the Wells Project and not already protected by the Original Operating License, the Anadromous Fish Agreement and Habitat Conservation Plan for the Wells Hydroelectric Project (HCP 2002), or other related agreements. The Original Operating License for the Wells Project will expire May 31, 2012. This Agreement is the culmination of three years of collaborative discussions related to relicensing that began in March 2006 with stakeholders.

On December 18, 2009, Douglas PUD filed with FERC the Draft License Application (DLA) for the New Operating License, which included this Agreement. A Final License Application (FLA) is due to FERC on May 31, 2010, and will also include an Offer of Settlement related to this Agreement. Subject to the reservations of authority in Section 13 (Reservations of Authority) of the Agreement, the Agreement establishes Douglas PUD's obligations for the protection, mitigation, and enhancement of Aquatic Resources affected by Wells Project operations under the New Operating License, as well as its obligations to comply with all related federal and state laws applicable to the issuance of the New Operating License for the Wells Project. The Agreement also specifies procedures to be used by the signatory parties

(Parties) to the Agreement to ensure that the New Operating License is implemented consistent with the Agreement and other laws.

The six Aquatic Resource Management Plans contained in Attachments B through G of the Agreement[1], together with the Habitat Conservation Plan (HCP), will function as the Water Quality Attainment Plan (WQAP) in support of the Clean Water Act Section 401 Water Quality Certification for the Wells Project. As of the effective date of the Agreement, pursuant to Section 5 of the Agreement (Term of License and This Agreement), the Parties agreed that the measures set forth in the Aquatic Resource Management Plans are adequate to identify and address Wells Project impacts to Aquatic Resources and are expected to achieve the goals and objectives set forth in each of the six Aquatic Resource Management Plans. However, during the course of the New Operating License, there may be instances where the measures found in individual management plans may need to be adapted. In these instances, "Adaptive Management" will be used to achieve the biological goals and objectives.

2 PROGRESS TOWARD IMPLEMENTING THE AGREEMENT AND THE AQUATIC RESOURCE MANAGEMENT PLANS

Section 11.7 of the Agreement requires preparation of an annual report that compiles all relevant materials associated with Agreement activities during the year. The subsequent sections of this chapter describe activities implemented during 2009 toward implementing the Agreement and Aquatic Resource Management Plans (Attachments B through G of the Agreement).

2.1 2009 Aquatic Settlement Agreement Decisions and Milestones

Decisions made by the Aquatic Settlement Work Group (Aquatic SWG) during 2009 are shown in Table 1 along with milestones related to the Agreement.

[1] Attachment B: White Sturgeon Management Plan; Attachment C: Bull Trout Management Plan; Attachment D: Pacific Lamprey Management Plan; Attachment E: Resident Fish Management Plan; Attachment F: Aquatic Nuisance Species Management Plan; and Attachment G: Water Quality Management Plan

Table 1

2009 Summary of Decisions and Milestones – Aquatic Settlement Work Group

Aquatic Settlement Work Group Decision and Milestones	Meeting Date
The Parties agreed that a neutral third party should be hired to Chair and facilitate meetings of the Aquatic SWG.	February 20
The Yakama Nation became a formal signatory to the Agreement.	February 24
The Parties agreed to a job description for the Aquatic SWG Chair and established a schedule for accepting and reviewing applications.	March 26
The Parties agreed that, based on the lamprey telemetry study results presented to FERC in the Updated Study Report filed on April 15, 2009, Douglas PUD should explore the feasibility of temporary nighttime reductions in fishway entrance velocities to create an environment more conducive to adult lamprey passage during the 2009 migration.	March 26
The Parties agreed that, given tagging effects from invasive procedures, alternative technologies to radio-telemetry should be considered to quantify the effect of the proposed flow reductions on lamprey entrance efficiency.	March 26
The Parties agreed that any change to the fishway at Wells Dam must also be agreed to by the Wells HCP Coordinating Committee, as stated in the Agreement. Currently, the HCP adult fish passage criteria are the default operating criteria for the fishway at Wells Dam.	March 26
The Parties agreed that Douglas PUD should remove the perforated plates from pool 40 within the east and west ladders at Wells Dam to prevent passage obstructions prior to the adult lamprey migration in the fall of 2009.	March 26
The Aquatic SWG unanimously agreed to allow USFWS to continue participation in activities related to the Aquatic Settlement Agreement.	May 13
The Aquatic SWG unanimously agreed that staff of the USFWS and the Bureau of Indian Affairs (BIA) should be allowed to present comments on the Pacific Lamprey Management Plan (PLMP) at the June meeting.	May 13
The Aquatic SWG unanimously selected Dr. Michael Schiewe, of Anchor QEA, LLC, to Chair the Aquatic SWG. The Aquatic SWG requested that Douglas PUD establish a contract with the Chair as soon as possible (preferably before the June meetings). In addition to receiving unanimous approval from all Signatory Parties, Dr. Schiewe also received support from the USFWS (S. Lewis) and BIA (K. Hatch).	May 13
The Aquatic SWG decided to update the Water Quality Management Plan (WQMP), as required by the Aquatic Settlement Agreement, with the latest study results from TDG modeling and Okanogan River turbidity monitoring.	May 13
The Aquatic SWG agreed to meet on the second Wednesdays of the month; future meeting dates would be confirmed at each meeting and in the minutes.	June 10
Douglas PUD agreed to provide the revised WQMP, with the updated Appendix B, to the Aquatic SWG by July 8.	June 10

Aquatic Settlement Work Group Decision and Milestones	Meeting Date
Douglas PUD agreed to provide the final Total Dissolved Gas (TDG) and turbidity reports to the Aquatic SWG by close of business Monday, August 3.	June 10
Douglas PUD agreed to include the final TDG and turbidity results in a revised WQMP. The approved WQMP will then be included in the Draft License Application, in December 2009.	June 10
The Aquatic SWG approved the lamprey passage study plan using DIDSON at the Wells fishway entrances.	June 10
The USFWS became a formal signatory to the Agreement.	July 23
The Aquatic SWG unanimously approved allowing a BIA representative to attend Aquatic SWG meetings as a non-voting observer.	July 8
The Aquatic SWG approved the results of the 2009 Turbidity Monitoring project.	August 12
The Aquatic SWG approved the WQMP with final comments from the Department of Ecology accepted.	August 12
The Aquatic SWG approved changing regularly scheduled monthly meetings to conference calls and holding in-person meetings on a quarterly basis or as requested by Aquatic SWG members.	September 9
The Aquatic SWG unanimously approved the revised PLMP.	September 9
The BLM became a formal signatory to the Agreement.	November 13

2.2 Completed Studies 2009

2.2.1 Total Dissolved Gas Modeling (Phase II and III)

In April 2009, Douglas PUD produced a final report on their examination of Total Dissolved Gas (TDG) production dynamics at the Wells Project[2]. The examination involved a series of assessments aimed at gaining a better understanding of the effect of spill operations on the production, transport and mixing of TDG in the Wells Dam tailrace. The results of the study indicate that specific changes in Wells Project operations can be utilized to meet the numeric water quality standards for TDG up to 7Q10 flows. In July 2009, Douglas PUD produced a final report (Phase III Study[3]) presenting the results of a modeling effort designed to identify

[2] Politano, M., A.A. Amado, and L. Weber. 2009. An investigation into the total dissolved gas dynamics of the Wells Project (Total Dissolved Gas Investigation). Wells Hydroelectric Project, FERC No. 2149. Prepared by IIHR-Hydroscience and Engineering, University of Iowa, Iowa City, Iowa, for Public Utility District No. 1 of Douglas County, East Wenatchee, WA.

[3] Politano, M., A.A. Amado, and D. Hayes. 2009. Total Dissolved Gas modeling and compliance evaluation for the Wells Hydroelectric Project. Prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, WA.

Wells Project operations that minimize TDG downstream of the Wells Dam. The model was used to predict the dynamics of spillway surface jets and the hydrodynamics and TDG distribution within the Wells tailrace as a result of various Wells Project operating configurations. Based on modeling results, identified Optimum Operating Conditions for the Wells Project not only reduce TDG generation in the Wells tailrace but also appear to increase the amount of degassing that takes place in the Rocky Reach Reservoir. Data analysis conducted as part of the Phase III study indicates the Wells Project is reasonably expected to remain in full compliance with State numeric criteria during Wells Project operations.

2.2.2 Lamprey Study Plan

Douglas PUD investigated lamprey passage at Wells Dam during late summer 2009. The study was designed to test passage behavior under different fishway entrance velocities. The Aquatic SWG helped develop, reviewed and approved the study Plan before it was presented to and then approved by the Wells HCP Coordinating Committees. Fish passage at the fishway entrances was monitored using dual-frequency identification sonar (DIDSON) technology. The results are being analyzed and will be presented to the Aquatic SWG along with a draft report at the March 2010 Aquatic SWG meeting.

2.2.3 2009 Turbidity Monitoring Project

In August 2009, the Aquatic SWG approved the results of the 2009 Turbidity Monitoring project. Turbidity data were collected hourly in 2009 at three locations. Monitoring results demonstrated that there were no exceedances of the numeric criteria for turbidity.

2.2.4 2009 Total Dissolved Gas Monitoring

In July 2009, Douglas PUD presented to the Aquatic SWG the final Total Dissolved Gas (TDG) monitoring results from 2009. Douglas PUD will continue monitoring TDG on an annual basis, providing annual reports of data as required by the Ecology-approved Gas Abatement Plans.

2.3 Planned Studies 2010

Douglas PUD is considering a second year of lamprey passage research at Wells Dam in 2010. It is anticipated that testing will be similar to that conducted in 2009; both fishway entrances would be involved simultaneously and the study would span a longer period beginning on a date between August 16 and 20, depending on water conditions and downstream counts. Douglas PUD anticipates having a draft 2010 study plan available for review by mid-year in 2010.

Douglas PUD also anticipated the need to continue total dissolved gas studies at the Wells Project as annually required in past Ecology-approved Gas Abatement Plans. The study is expected to begin in April and continue through August 2010.

3 AGREEMENT ADMINISTRATION

This chapter lists events of note that occurred in 2009 related to the administration of the Agreement, and lists reports published in 2009 that relate to the Aquatic SWG.

3.1 Establishment of the Aquatic Settlement Work Group

A designated technical representative and a separate designated policy representative for each Party make up the Aquatic SWG established under the Agreement. The Aquatic SWG meets collectively to expedite the process for overseeing and guiding the implementation of the Agreement. The policy representatives will meet at least once annually during the term of the New Operating License to review progress and implementation of the Agreement. Minutes from the monthly meetings are compiled in Appendix A of this report. Appendix B lists current members of the Aquatic SWG.

3.2 Selection of Aquatic Settlement Work Group Chair

At the first meeting of the Aquatic SWG in February 2009, the Parties agreed that a Chair would be hired to facilitate Aquatic SWG meetings. At the May 2009 Aquatic SWG meeting, Dr. Michael Schiewe of Anchor QEA was selected as chair of the Aquatic SWG by unanimous decision.

3.3 Selection of Aquatic Settlement Work Group Meeting Dates

At the September 2009 meeting, the Aquatic SWG decided to meet on the second Wednesdays of the month. It was decided that regularly scheduled monthly meetings would be held by conference call, and that in-person meetings would be held on a quarterly basis or as requested by Aquatic SWG members.

3.4 Agreement-Related Reports Published in Calendar Year 2009

The following reports were finalized and approved by the Aquatic SWG in 2009:

- 2009 Total Dissolved Gas Modeling and Compliance Report
- 2009 Turbidity Monitoring Project
- 2009 Revised Water Quality Monitoring Plan (WQMP)
- 2009 Revised Pacific Lamprey Management Plan (PLMP)

3.5 HCP Coordination

On June 23, 2009, the HCP Coordinating Committee was provided a copy of Douglas PUD's plans for lamprey study (2009 Revised PLMP) at Wells Dam, scheduled for late summer 2009. Section 4.1.1 of the Agreement requires Douglas PUD to operate the fishway at Wells Dam in accordance with criteria outlined in the HCP. However, Douglas PUD may modify fishway operations for the benefit of lamprey passage in consultation with the Aquatic SWG and the HCP Coordinating Committee. In July 2009, the 2009 Revised PLMP was reviewed and approved by the Wells HCP Coordinating Committee.

APPENDIX A
AQUATIC SETTLEMENT WORK GROUP MEETING MINUTES AND CONFERENCE CALL MINUTES

Meeting Minutes

Aquatic Settlement Work Group

To: Aquatic SWG Parties **Date**: March 20th, 2009

From: Josh Murauskas, acting Aquatic SWG coordinator

cc: USFWS, NMFS, BIA

re: Draft Minutes of February 20th, 2009 Aquatic SWG meeting

I. Announcements

1. The Aquatic Settlement Agreement for the relicensing of the Wells Project was signed by Douglas PUD's commissioners on January 19th, 2009 following the receipt of signatures from the Confederated Tribes of the Colville Reservation (Nov. 10th, 2008), Washington State Department of Ecology (Nov. 18th, 2008), and Washington State Department of Fish & Wildlife (Nov. 20th, 2008). The Yakama Nation signed the Settlement on February 24, 2009. The U.S. Fish and Wildlife Service indicated that they anticipate signing the Settlement Agreement following the completion of administrative review within the Department of Interior.

II. Summary of Action Items

1. Set date and agenda for next meeting (completed). The next meeting is March 26, 2009.

2. Compile list of Aquatic SWG Chair candidates for distribution at next meeting. All Parties are encouraged to submit viable recommendations (in progress).

3. Each Party is to submit a letter designating their technical and policy representatives (in progress).

III. Summary of Decisions

1. Parties agree that a Chair should be hired to facilitate Aquatic SWG meetings.

2. Parties agree that a 6-month evaluation should be conducted on Chair selection to evaluate performance.

IV. Summary of Discussion

1. Shane Bickford provided the group with a summary of the status of the Relicensing (ILP) for Wells Hydroelectric Project and how that schedule relates to the implementation schedule for the Aquatic Settlement Agreement.

2. Mr. Bickford reviewed the Aquatic Settlement Agreement, including Parties, Recitals, Definitions, Purpose, Terms of the Agreement, Effective Dates and Implementation of Management Plans, Obligation of the Parties, Modification of the Agreement, and Dispute Resolution.

3. The meeting participants discussed the need for a chair and the need to designate, in writing, each parties representatives for future meetings and votes. The committee structure and meeting protocol was discussed. Other sections discussed by the group included the purpose and function of the Aquatic Settlement Work Group, including Committee, Meeting Notices and Agendas, Voting, Studies, Reports, and Meeting Minutes.

4. Josh Murauskas provided the group with an overview of the goals and objectives of each of the six Aquatic Management Plans. The group discussed Pacific lamprey passage and behavior and the upcoming draft report from the second year of radio-telemetry work at Wells Dam. USFWS asked Douglas PUD whether it would be possible to update the PLMP based on results from the 2008 radio-telemetry study. Mr. Muraskas indicated that the PLMP could be updated provided that all of the Parties to the Agreement are in favor of the proposed changes. Mr. Bickford reminded the group that the Settlement included specific provisions, requested by Ecology, to update the water quality management plan to include new information collected during the final DO, pH and turbidity study as well as results from the second report of the TDG model. The group then discussed sturgeon hatchery production issues and the general biology of the species within the mid-Columbia and within the Wells Project. Mr. Murauskas also reviewed a detailed Implementation Timeline and Work Plan to identify immediate needs related to the above mentioned projects.

V. Next Steps

1. Next meeting: ***March 26th, 2009, 10:00 a.m. to 3:00 p.m., East Wenatchee***.

2. Select Aquatic SWG Chair.

3. Review DO, pH, and Turbidity and TDG modeling report updates.

4. Review final adult lamprey passage study.

5. Update the Water Quality Management Plan to reflect results from the final DO, pH and turbidity and final TDG reports.

Meeting Minutes

Aquatic Settlement Work Group

To: Aquatic SWG Parties **Date**: April 13th, 2009

From: Josh Murauskas, acting Aquatic SWG coordinator

cc: J. Gonzales, S. Lewis (FWS), B. Nordlund (NMFS), P. Sleeger (USDI)

re: Draft Minutes of March 26th, 2009 Aquatic SWG meeting

I. Announcements

1. All of the signatory Parties and one presumed signatory Party have designated their Policy and Technical Representatives to the Aquatic SWG.

   The Aquatic SWG Party Representatives are as follows:

Signature Party	Policy Rep.	Technical Rep.	Letter Submitted
Douglas	S. Bickford	J. Murauskas	03/06/09
Yakama	P. Ward	S. Parker	03/09/09 (email)
Ecology	J. Merz	P. Irle	03/09/09
WDFW	T. Eldred	B. Jateff	03/25/09
Colville	J. Peone	B. Towey	04/06/09
Non-Signature Party	**Policy Rep.**	**Technical Rep.**	**Letter Submitted**
USFWS	J. Gonzales	S. Lewis	03/13/09

II. Summary of Action Items

1. Send out job description for Aquatic SWG chair to identified prospects and Parties for further distribution. Acquire resumes and cover letters for distribution to the Aquatic SWG prior to the May meeting (in progress).

2. Provide Ecology (P. Irle) draft DO, pH, and Turbidity Report (completed 3/27) and completed draft Water Quality Management Plan by May 1, 2009. Provide better description of statistical analysis used to compare DO measurements recorded at Malott and Monse (completed 4/06).

3. Douglas PUD (J. Murauskas) to contact Ecology (S. Braley) about potential changes to compliance measures for TDG (12-C High).

4. Provide WDFW (M. Hallock) information regarding lamprey girth and passage success at Wells Dam (request sent to Dr. Dave Robichaud, LGL limited, 3/31, completed).

5. Include additional passage metrics from other projects in the final Adult Lamprey Passage Study report (as requested by B. Rose). Specifically, historical information from mid and lower Columbia River reports, in addition to the research conducted and reported at Bonneville Dam in 2008 (completed 3/27, see final report to be filed 4/15).

6. Begin drafting a study plan to implement and monitor improvements identified in the 2008 Adult Lamprey Passage Study, specifically a reduction in nighttime water velocities at Wells' fishway entrances. Schedule DIDSON expert (P. Johnson, LGL limited) to present technology at May meeting (in progress).

7. Post TDG report on relicensing website http://relicensing.douglaspud.org (in progress).

8. Remove perforated plates from pool 40 within the east and west ladders at Wells Dam prior to the adult lamprey migration in the fall of 2009 (completed).

III. Summary of Decisions

1. Parties agreed that the job description for Aquatic SWG Chair was adequate and should be distributed. The timeline for application submittal shall be moved up so that the resumes from potential applicants can be viewed prior to the next Aquatic SWG meeting.

2. Parties agree that, based on the lamprey telemetry study results, Douglas PUD should explore the feasibility of a nighttime reduction in entrance velocities during the 2009 migration.

3. The Parties agreed that alternative technologies should be considered to quantify the affect of the proposed flow reductions on lamprey entrance efficiency.

4. The Parties agree that any change to the fishway at Wells Dam must also be presented and agreed to by the Parties to the HCP Coordinating Committee. Currently the HCP adult fish passage criteria is the default operating criteria for the fishways at Wells Dam.

5. The Parties agreed that Douglas PUD should remove the perforated plates from pool 40 within the east and west ladders at Wells Dam prior to the adult lamprey migration in the fall of 2009.

IV. Summary of Discussion

1. Shane Bickford initiated the meeting with a discussion of signing status and participation at future Aquatic SWG meetings. Mr. Bickford also presented the names of individuals that have expressed an interested in being the chair for the Aquatic SWG. Parties agreed that the job description for Aquatic SWG chair person was adequate and should be distributed, and the timeline for application submittal shall be moved up so that the resumes from potential applicants can be viewed prior to the next Aquatic SWG meeting. The Parties agree that the selection process should begin at the May meeting (date and time TBD).

   All participants engaged in a discussion regarding the status of signing and implementing the Aquatic Settlement Agreement. USFWS indicated they expect to become signatory Parties within the next month.

   Keith Hatch (BIA) indicated he will be BIA's technical representative, and Bob Dach policy. Mr. Bickford (Douglas PUD) asked BIA whether or not they intended to sign the Aquatic Settlement Agreement. Mr. Hatch indicated that BIA will not likely become a signatory Party but would like to participate in lamprey issues.

   Mr. Bickford indicated that the Settlement Agreement explicitly states that participation by non-signatories will be limited to technical experts only, and only following unanimous consent of all Parties.

   Mr. Hatch indicated the Aquatic Settlement is broad and general, and BIA's interests in it are narrow and specific to lamprey. He further indicated that BIA is looking for something more like the Priest Rapids 401. Mr. Bickford responded that the Wells Aquatic Settlement is more protective of lamprey, and has a faster implementation schedule, than the Priest Rapids 401.

   Steve Lewis (USFWS) indicated USFWS's primary concern with the disagreement within USDI is that BIA has not provided any comments articulating any specific concerns with the Wells Pacific Lamprey Management Plan. Pat Irle (Ecology) stated that BIA has questioned why Ecology has not held Wells to the same standard as the Priest Rapids 401, yet BIA has not provided any specific comments describing their concerns with the Aquatic Settlement for Wells. Ms. Irle indicated that she worked on the 401 water quality certification for the Priest Rapids Project back in the mid-2000s and thought that the fish agencies and tribes had learned a few things since then and that the joint fisheries parties had effectively applied those tools to the Wells Aquatic Settlement Agreement.

2. S. Bickford presented the latest results from the TDG modeling conducted by University of Iowa in order to improve Project operations and manage TDG concentrations in the Wells tailrace. The latest models indicate the spill during 7Q10 flow events can be

effectively managed to meet Ecology's numeric criteria. This is accomplished by concentrating spill flow through one spillway in order to engage the spillway lip and force the flows to the surface rather than going to depth and entraining air (and nitrogen). This approach appears to have reduced tailrace TDG between 4 and 6% over historic spillway operations.

3. Mr. Murauskas presented the updated results from the DO, pH, and Turbidity study. The research indicates there is no apparent Project effect on DO, pH, and Turbidity. Ms. Irle (Ecology) inquired about the strength of the relationship between incoming waters from above the Project boundary (Malott) and measurements within Project boundaries (Monse and HWY 97), specifically for DO on the Okanogan River. Mr. Murauskas indicated that the difference in values is statistically inseparable and that linear regression analyses detailed in the Updated Study Report would provide the statistical analysis of the relationship between water quality monitoring sites.   Douglas PUD offered to provide Ms. Irle with a draft of the DO, pH and Turbidity report so that Ecology's comments could be captured in the study report to be filed with FERC on April 15th.

4. Mr. Murauskas presented information on the Adult Lamprey Passage studies conducted at Wells Dam. Specifically, he presented the original FERC-approved objectives, followed by an overview of fishways at Wells Dam, and presentation of 2007 and 2008 results, including a summary of study modifications to improve research. Mr. Murauskas then provided context for the results, specifically information related to (1) water velocities and lamprey swimming ability; (2) problems related to tagging effects on radio-tagged fish; (3) bioenergetics and how fish at Wells Dam are substantially thinner than fish used in downriver studies (compounding #2 above); (4) run timing and the decreasing temperature regime witnessed at Wells Dam during the studies; and (5) a comparison to similar studies using the same technology during 2008 (Bonneville Dam vs. Wells Dam). The recommendations from the final report were relayed, stating that a reduction in entrance velocities and removal of perforated plates at the trapping site should be considered for improving lamprey passage at Wells Dam. In an effort to remove confounding affects such as surgical tagging, Mr. Murauskas indicated that future studies should consider using alternative monitoring tools that are passive but that also can be easily quantified into treatment and control passage efficiency rates. The group discussed that other modifications, such as adjustments to floor diffusion grating, may be required should reduction in entrance velocities not provide adequate entrance efficiencies. Discussion also arose regarding the need to increase passage count data accuracy (i.e., account for fish that utilize the video bypass system and avoid enumeration). The group also recommended removing the perforated plates from the fish ladders in time for the 2009 lamprey migration.

5. The group actively discussed the results from the 2007 and 2008 Adult Lamprey Passage studies. The group discussed the need to investigate passage modifications in time for

the 2009 migration. Mr. Bickford agreed and reminded the group that the measures within the Settlement Agreement do not kick in until after 2012 and Douglas PUD has received a new operating license. Anything done prior to 2012 is considered early implementation. Douglas PUD cannot implement any actions early, such as passage modification in the ladder, without a clear distinction of who is and who is not a Party to the Settlement Agreement. In particular, Douglas PUD cannot carry out fishway criteria modifications, that will require ESA Section 7 consultation for listed spring Chinook and steelhead (NMFS species of concern), without clear direction from the USFWS, regarding their intentions to be a Party to the Agreement. Mr. Bickford noted that any improvements in lamprey passage conducted in 2009 would be considered early implementation of settlement actions. Douglas PUD is willing to implement these actions to help protect and restore the lamprey resource but not without jurisdictional issues being resolved. The settlement must be done before it can be implement.

6. The Workgroup discussed the need to meet in early May to address the abovementioned action items based on decisions and discussion summarized above.

7. Mr. Bickford provided a line by line comparison of the Lamprey Management Plan included in the Priest Rapids 401 to the Pacific Lamprey Management Plan included into the Wells Aquatic Settlement. The line of discussion was initiated by Mr. Dach (BIA) formally in an email to Mr. Murauskas on March 23rd, 2009 where he stated that "*we intend to base our comments on the 401 certification issued by WDOE for Priest Rapids, with a bit more certainty in Plan requirements, timelines, and standards*." After a line-by-line comparison of goals and timelines, the Workgroup agreed that not only were measurements in the Douglas Pacific Lamprey Management Plan consistent with measures outlined in the Priest Rapids 401 certification, but management efforts proposed by the Douglas PUD Aquatic SWG were more certain, and including a more aggressive timeline (earlier implementation than in the Priest Rapids 401).

8. The group discussed the need to move forward on study planning for 2009. The only impediment to moving forward is the jurisdictional issues raised within the USDI. Molly Hallock (WDFW) stated that she hoped that these issues could be resolved by the next meeting so that a lamprey passage study plan could be prepared and shared with the group in time for the 2009 adult lamprey migration.

V. Next Steps

1. Next meeting: ***May, time TBD, East Wenatchee***.

2. Review Aquatic SWG Chair resumes and discuss chair selection process.

3. Conceptualize 2009 adult lamprey passage improvement study.

Final Meeting Minutes

Aquatic Settlement Work Group

To: Aquatic SWG Parties **Date**: June 30 , 2009

From: Josh Murauskas, acting Aquatic SWG coordinator

cc: J. Gonzales, S. Lewis (USFWS), B. Nordlund (NMFS), M. Schiewe (Chair Elect)

re: Final Minutes of May 13, 2009 Aquatic SWG meeting

I. Announcements

1. A letter from Ken S. Berg, Manager, Washington Fish and Wildlife Office, U.S. Fish and Wildlife Service (USFWS), was submitted to the Aquatic Settlement Work Group (Aquatic SWG) on May 11, 2009 (Appendix A). After a brief introduction and acknowledgement to the signatory Parties to the Aquatic Settlement Agreement (Agreement), the letter officially requests permission for USFWS to continue participation in the activities associated with the Agreement. The letter then states that USFWS anticipates signing the Agreement in the near future in order to implement measures of the Pacific Lamprey Management Plan (PLMP) prior to 2012 (i.e., beginning of the new license term). To reach this goal, USFWS requests to present comments on the PLMP with their Department of Interior (DOI) component agency, Bureau of Indian Affairs (BIA), to the Aquatic SWG for consideration. Following this process, USFWS intends to sign the Agreement, become a signatory Party, and develop the next steps forward in implementing the PLMP for the protection of Pacific lamprey at Wells Dam.

2. Four well-qualified candidates submitted resumes for the Aquatic SWG Chair, including:

    a. Paul Hart, Bridgebuilder Communications

    b. Bao Le, Long View Associates

    c. Chuck Peven, BioAnalysts, Inc.

    d. Mike Schiewe, Anchor QEA, LLC

3. The Updated Study Report (USR) has been filed with the Federal Energy Regulatory Commission (FERC). The most recent updates to studies related to the Water Quality Management Plan (WQMP) are now available for consideration.

II. Summary of Decisions

1. The Aquatic SWG unanimously agreed to allow USFWS to continue participation in activities related to the Aquatic Settlement Agreement. Further, the Aquatic SWG unanimously decided that USFWS, along with their DOI component agency, BIA, should be allowed to present comments on the PLMP at the June meeting, in order to resolve any concerns and move forward with implementation of efforts to protect Pacific lamprey in the Wells Project Area (Item IV-1).

2. The Aquatic SWG unanimously agreed that Dr. Michael Schiewe, of Anchor QEA, LLC, is the most appropriate candidate to Chair the Aquatic SWG. The Aquatic SWG has chosen Dr. Schiewe, and requires Douglas PUD to establish a contract with the Chair as soon as possible (preferably before the June meetings). In addition to receiving unanimous approval from all Signatory Parties, Dr. Schiewe also received support from the USFWS (S. Lewis) and BIA (K. Hatch) (Item IV-2).

3. The Aquatic SWG has decided to update the Water Quality Management Plan, as required by the Aquatic Settlement Agreement, with the latest study results (Item IV-3).

III. Summary of Action Items

1. Party Representatives from the Colville Tribe (not in attendance) will be contacted to seek approval of Chair Nomination (Item IV-1) (Completed; Dr. Schiewe confirmed May 15, 2009).

2. An agreement for professional services will be created and finalized to contract Dr. Michael Schiewe, of Anchor QEA, LLC (Item IV-2) (Completed; contract in place May 26, 2009).

3. The WQMP will be updated to reflect recent water quality studies in the Wells Project and adjust measures in accordance with the study results. A revised draft of the WQMP should be prepared prior to the June meeting (Item IV-3) (Completed; draft submitted to Aquatic SWG on May 27, 2009).

IV. Summary of Discussion

1. Josh Murauskas (Douglas PUD) initiated the meeting with a discussion of the agenda items. He introduced the presenters and their topics for this meeting.

   Steve Lewis (USFWS) asked if the Aquatic SWG planned on selecting an Aquatic SWG Chair today. Shane Bickford (Douglas Public Utility District [Douglas PUD]) was hopeful that the group could come to a consensus and agree upon the Chair at this meeting.

   Mr. Bickford referred to a letter that was contained in the meeting packet regarding a request from Ken Berg (USFWS) to continue participation in the Wells Aquatic SWG. He suggested that Mr. Lewis (via telephone) could give the group some background information. Mr. Lewis said that USFWS is not a signatory party to the Agreement at this time. The intent of the USFWS is to coordinate comments on the PLMP from the BIA and present a workable draft prior to the next meeting. The draft comments would also include the next steps outlined for measures to protect Pacific lamprey. Pat Irle (Washington State Department of Ecology [Ecology]) asked if the USFWS/BIA was going to make a presentation today. Mr. Lewis indicated they would not at this meeting, but plan to do so at the next meeting in June. Bob Dach (BIA) (via telephone) agreed that the presentation would be at the next meeting. Mr. Bickford said that this effort is a positive step forward. Douglas PUD supports the participation of the USFWS and BIA and the Aquatic SWG agreed that they would like to hear their concerns. Mr. Lewis reiterated that the USFWS wants to actively participate even though they have not yet signed the Agreement.

Ms. Irle asked if the USFWS was planning on signing the Agreement but not the BIA. Mr. Dach indicated that he was hoping to get the BIA's issues addressed first and that it was more convenient if the DOI signs as a group rather than individual signatories. Ms. Irle indicated that Ecology was comfortable with this and Tony Eldred (Washington Department of Fish and Wildlife [WDFW]) was in agreement. Mr. Lewis stated that USFWS wants the issues addressed and to get everyone's perspective on the comments provided by BIA.

Mr. Bickford stated that Douglas PUD's goal was to conclude the Agreement by including USFWS and, once concluded, to begin early implementation of lamprey passage improvements. Douglas PUD is eager to get started sooner rather than later, but cannot move forward on implementation while measures are still being developed and revised. Mr. Bickford indicated that if we wanted to make modifications to fishway operations this fall, then Douglas PUD would need to ask for a variance from the National Marine Fisheries Service (NMFS). This would bring about questions related to Endangered Species Act (ESA) listed species and Section 18 Authority.

Mr. Eldred asked what was expected in the way of physical changes to the ladder. Mr. Bickford indicated that physical changes, if the Aquatic SWG identified the need for any, could not be performed this year as the ladders are currently being operated under requirements of the Habitat Conservation Plan (HCP). Mr. Eldred asked if any modifications, other than flow, or any hard changes could be done during maintenance periods. Mr. Bickford and Mr. Lewis indicated that this would be the best time to make any modifications, if needed. Mr. Murauskas reiterated that the PLMP states that adverse impacts may be addressed through operational or physical changes to fishways, as coordinated by the HCP. Mr. Murauskas continued to discuss the fact that there are a whole suite of solutions for varying problems at each unique hydroelectric project on the Columbia River. Mr. Bickford said that modifications to the fishways would be a stepwise process and we would prefer to first evaluate passage during reduced velocity operations. Mr. Murauskas reminded the group that the afternoon presentations will focus on a potential study for 2009 along with related information to develop practical solutions for creating an environment favorable for lamprey passage at the fishway entrances.

Ms. Irle asked Mr. Dach if the BIA had any regulatory issues. Mr. Dach explained how the BIA fits into the scheme, stating that lamprey are treaty protected, therefore BIA must show due diligence in protecting this resource for the tribes. The Columbia River Inter Tribal Fisheries Commission (CRITFC) has voiced concern to the BIA over the PLMP. The position of the BIA as a trustee is to ensure the Feds [federal government] are doing everything possible to protect these fish [lamprey] for the tribes. The Indian tribes will have differences of opinion, but if, for example, there are not enough lamprey 10 years from now, the tribal governments can hold the Feds responsible. Therefore, the job of the BIA is to prevent this from happening. Mr. Bickford indicated that both the Colville and Yakama Tribes have been very supportive and, in fact, have signed the Agreement. That said it seems that some sort of conflict exists between Columbia River Inter-Tribal Fish Commission's (CRITFC's) desires and those of the tribal entities that are within or adjacent to the Wells Project boundaries. Ms. Irle said that the purpose of the Agreement was to create one document (that includes management plans for each aquatic resource) and that it may be that BIA and CRITFC have conflicting views with the tribes that have already signed the Agreement. Mr. Dach indicated that the tribes are not just Bob Heinith, and they just wanted enough comfort in the plan to move forward. Mr. Dach continued and stated that he hopes we can reach consensus on the certainty of specific issues of interest to BIA. Ms. Irle asked if BIA will have CRITFC issues at the June meeting. Mr. Dach said he was not sure if all tribes will have unity. Ms. Irle asked for a quick caucus of the Signatory Parties at this point in the meeting.

Following the caucus, the Aquatic SWG unanimously agreed that it would be good to have BIA present their concerns to the group at a future meeting. The group agreed that it would be best to have BIA represent their issues as a component agency to a future Signatory Party (USFWS). Mr. Dach suggested that Bob Heinith's attendance may provide a better understanding of CRITFC's issues. Mr. Bickford reminded everyone that the USFWS officially requested permission to participate, along with presentation of comments from their component agency, BIA. The group has agreed to their participation toward resolving BIA's PLMP issues. Along the same lines, CRITFC would also have to follow the guidelines set forth in the Agreement and send the Aquatic SWG a letter of request for participation. Mr. Dach said that CRITFC should be informed of this process. Mr. Bickford indicated that Douglas would inform CRITFC that a short letter of intent requesting participation should be sent to the Aquatic SWG. Mr. Dach said he would let them know. Ms. Irle suggested that the policy and technical representatives for BIA be included in the letter. Mr. Dach asked if BIA needed a formal letter. Mr. Bickford indicated that USFWS already submitted a letter on behalf of the BIA to present comments on the PLMP.

Mr. Dach indicated that he has already received comments from Bob Heinith, but it would take time to get consolidated comments developed between the DOI and CRITFC. Mr. Lewis indicated that USFWS wants to carry comments forward.

Mr. Lewis asked if anyone has discussed fishway operational modifications with Bryan Nordlund (NMFS). Mr. Murauskas indicated that the group will discuss lamprey passage this afternoon, but he has indeed discussed these issues with Mr. Nordlund. Mr. Lewis asked when the next Aquatic SWG meeting would be. Mr. Bickford said that it is scheduled for June 10, but this date does not work for Mr. Dach, so another meeting would be scheduled in late June or early July to address BIA's comments. Mr. Murauskas stated that he would send out a straw poll and work out the best date for the BIA meeting. Mr. Murauskas also reiterated that we must move quickly if we are to initiate any early implementation activities this migration, which is currently under way.

2. Mr. Murauskas moved to the next agenda item and presented the four resumes submitted to the Aquatic SWG for the Chair position. Aquatic SWG members participated in a discussion of the candidate's strengths and weaknesses. Following a lengthy discussion, the group then unanimously agreed that Mike Schiewe would be the preferred candidate for chair of the Aquatic SWG. Mr. Murauskas indicated that he had previously received preferences from Bob Rose and that Dr. Schiewe was one of the two candidates that Mr. Rose felt was qualified for the job. The group agreed that the Chair would be helpful at the June meeting. Mr. Verhey thanked Douglas PUD for involving WDFW and other agencies in making the decision for the Chair position. Mr. Bickford stated that he could not envision doing it any other way. Mr. Bickford then indicated that he would contact the Colville tribe to see if they had any concerns with Dr. Schiewe as the Chair.

3. Mr. Murauskas began the discussion of the WQMP. Mr. Murauskas stated that because there is now new information available for Dissolved Oxygen (DO), pH, turbidity, and Total Dissolved Gas (TDG), the WQMP need to be updated, as stated and anticipated by the Agreement. Mr. Murauskas asked if we need a new section, such as 2.4 Project Compliance Summary, or perhaps just a table or a bulleted list may be sufficient. Mr. Bickford agreed that a summary or table would be fine. Ms. Irle thought a summary or table/list would be good. Mr. Eldred suggested a list regarding daily operations and what are the most likely to go wrong and what can be done about it. Mr. Murauskas also suggested a measures section showing continued monitoring efforts. He then stated a summary is a good idea as there is a lot of information in the report and it may be more convenient to show a conclusions section. Mr. Bickford said the WQMP should include a new section in 2.3 showing the new TDG model results. Ms. Irle suggested that may be a new section by itself. The group agreed that adjustments should include:

(1) 2008 DO, pH and turbidity results; (2) Replace 2007 TDG playbook with Iowa 2009 Phase II and Phase III. Ms. Irle suggested new sections to be Turbidity 2008 and 2009; TDG replacement (new section); Phase III; and Project Compliance Summary. Mr. Murauskas agreed and stated that the goals and objectives have been met and suggested changing the language to reflect continued monitoring efforts to make sure the standards are not violated. Ms. Irle pointed to page 26 and suggested that the WQMP needs to be updated regarding compliance. Mr. Murauskas suggested that section 4.0 measures need to be updated as well. Mr. Murauskas stated that Douglas PUD will work with Ecology to update the plan and get back to the Aquatic SWG with proposed edits. He indicated that as a group they need to have a review schedule. Mr. Bickford suggested that Douglas PUD could work with Ecology to come up with a revised WQMP. Mr. Bickford indicated that the Aquatic SWG would need time for review. Ms. Irle suggested there be a placeholder in the draft for TDG results from Iowa's Phase III modeling exercise. Mr. Bickford agreed and suggested a schedule for Phase III results.

Mr. Bickford stated that it would be possible to present the draft for the June meeting, especially sections 2.3, 3.0, and 4.0. Mr. Lewis indicated that everything looked good to him so far. He asked if there would be a section in the plan for discussion of changes in operations. Mr. Murauskas stated that projected studies will be put in place and new operating scenarios for high flow events would be in the plan.

4. Mr. Bickford introduced Rolf Wielick and David Allison, both fishway engineers from Jacobs Engineering, to present information on fishway entrance hydraulics. Peter Johnson, a senior scientist from LGL Limited, was also introduced. Mr. Bickford asked Mr. Wielick to give the Aquatic SWG an update on the Spill, Prevention, Control and Countermeasure (SPCC). Mr. Wielick provided an update on SPCC implementation. Mr. Allison then presented "Fishway Entrance Hydraulics," beginning with a review of various entrance configurations (Keyhole, Vertical, and Uniform Slots). Mr. Allison continued to inform the group on the intended design and reasoning for installation of keyhole entrances at Priest Rapids Dam. The previous entrances there were three-leaf telescoping entrances with an orifice that was adjusted by hoists to match tailwater elevation. Contrary to the misconception that there is a "variable velocity" benefit gained by these entrances, the design actually only offers a variable discharge and eliminates the needs for a hoisting system. Mr. Allison mentioned that the left bank and right bank entrances have not been compared at Priest Rapids dam, and, in fact, there were no lamprey passage studies conducted prior to installation of the keyhole entrances. Mr. Allison then suggested that the benefits gained by these designs are likely related to the full depth "floor," as opposed to a moving orifice. Mr. Allison then provided velocity rating curves for the keyhole entrance at Priest Rapids and the slotted entrance at Wells Dam. The average velocity profiles were actually extremely similar, suggesting that there would be no benefit in changing the entrance geometry of fishway entrances at Wells Dam. The workgroup then had a lengthy discussion of head

differentials used at each hydroelectric project in the Mid-Columbia. Mr. Allison then presented some information to relate head differentials to average and potential velocity. According to general hydraulic principles, velocities in boundary zones will be much lower than overall average velocities. The group then continued discussion on what velocities would be conducive to lamprey passage, keeping in mind the need for adequate attraction flows for salmon. Mr. Allison then provided the following summary: (1) All fishway entrances provide variable velocities due to boundary conditions; (2) original designs for Wells and Priest Rapids dams were based on modeling of 1-foot head differential (roughly 20 percent lower potential velocity head than 1.5-foot condition); and (3) complex hydraulic conditions at entrance should be modeled before physical changes are attempted. The group discussed how Mr. Allison's presentation was helpful in trying to develop lamprey passage measures for Wells Dam.

5. Peter Johnson gave a presentation on Dual Frequency Identification Sonar (DIDSON): Applications & Capabilities for Assessing Lamprey Passage at Wells Dam. Mr. Johnson covered several topics, including: Overview of Technology, Advantages and Limitations, Applications, and Wells Dam Lamprey Passage. The advantages of the DIDSON system are that it is an unobtrusive technology, not limited by turbidity, and provides continuous, equal sampling through all hours. The limitations are range and sample volume, species identification (especially among similarly-shaped fishes), manual data processing, and the fact that deployment and output of the system are not intuitive. Mr. Johnson then reviewed a few applications for fisheries, including adult salmon and lamprey, and showed examples of how DIDSON was used for enumeration, behavioral assessments, habitat utilization, gear efficiency, and monitoring of fish passage (e.g., juvenile out-migration).

   Mr. Hatch asked if DIDSON has been successfully used to identify lamprey. Mr. Johnson replied in the affirmative. Mr. Murauskas mentioned that there are no species of fish in the Columbia River that could be confused with lamprey. Ms. Hallock asked if the U.S. Army Corps of Engineers (COE) considered using the DIDSON system. Mr. Johnson stated that COE was very interested but did not use it because of the cost. John Johnson (USFWS) interjected that the DIDSON system was used at Cowlitz for entrance efficiency. Mr. Murauskas said that the dimensions of the fishway entrances at Wells Dam had excellent potential for DIDSON applications. Mr. Johnson indicated the DIDSON would be good to use at Wells to assess entrance efficiency and approach of lamprey. He then reminded the group that DIDSON would avoid the negative drawbacks of prior assessments, including small sample sizes, handling, and negative surgical effects. Ms. Hallock indicated that lamprey biologists are starting to see considerable surgery effects with radio-telemetry lamprey studies. Mr. Murauskas reiterated that a large benefit of DIDSON was that we could observe fish behavior without collecting and handling the few fish that migrate to Wells Dam.

Mr. Johnson continued with application considerations for Wells Dam: (1) fit sample volume to entrance, and (2) maximize coverage with use of multiple units, track and trolley or rotate and sub-sample. John Johnson asked why we do not mount at the top. Peter Johnson replied that it is too wide at the base and you would have low resolution, and you could not tell if the lamprey passed or not. Ms. Hallock asked about dropback and if he had worked with that. Mr. Johnson said the problem with it is that you do not know if it is the same fish or not. Mr. Murauskas reminded the group that the real question is "does the lower velocity increase the numbers of lamprey that are able to successfully negotiate the fishway entrance?"

Mr. Johnson then discussed data collection and processing. Lamprey DIDSON data would provide aspects such as run timing, trends in hourly passage, entrance efficiency, identification of rejection behavior, rejection zones, and entrance efficiency estimation relative to flows.

John Johnson mentioned there was another sonar system called Blue-View that is similar to DIDSON but not as high quality and lower resolution. Mr. Verhey asked if you could mount the camera on the inside of the fishway. Peter Johnson stated that he has looked at the outside for passage efficiency only. The group then continued discussions related to angle and placement of the camera.

Mr. Hatch stated that DIDSON is a nice tool, but he was curious as to how you would establish the percentage of fish that are able to pass the project. The group then discussed problems related to trapping and tagging, especially evident in upper reaches of the Columbia during latter parts of the migration near the overwintering period. Mr. Hatch then stated that DIDSON is a great tool and interesting, but is still not going to give you a measurement of passage. Mr. Murauskas stated that in fact you would have a measurement of passage, just not one that would be comparable to radio-telemetry results. Mr. Murauskas also reminded the group that the actual question is "does a nighttime reduction in fishway entrance velocity improve the ability of lamprey to negotiate the entrance?" Mr. Patterson stated that if we had an effective tagging program, we would not have to search for alternative technologies. He said that DIDSON, in effect, would be an extremely useful tool to utilize in the interim [until better tag technology is available]. Mr. Hatch indicated that Douglas PUD needs to use caution if they use 24-hour sampling, as data is mind numbing work, difficult to quantify, and expensive. Mr. Murauskas agreed but indicated that given the new study information, there were not many viable study alternatives. Mr. Murauskas then reiterated that Douglas PUD is simply trying to find practical solutions for what has been shown to be the chief issue for lamprey at the Wells Project.

Ms. Irle then returned to tagging issues by asking Mr. Murauskas if he knew the mortality rate of radio-tagged lamprey at Wells Dam. Mr. Murauskas indicated that this figure is hard to know precisely because of the different variables, including tag shedding, overwintering, mortality, etc., but suspected that radio-tags negatively affect as much as 50 percent of fish, or possibly more. Mr. Bickford stated that Douglas PUD could use radio-telemetry if there were several thousand fish to work with, allowing us to select for adequately-sized lamprey, but that is not the case at Wells. Mr. Lewis stated that he hopes that Douglas PUD will look at moving forward with the presented DIDSON monitoring. Mr. Bickford indicated that perhaps Peter Johnson should sit down with Mr. Murauskas and the University of Washington Statistics Department and develop a study plan for the Aquatic SWG to discuss at the next meeting in June.

6. Mr. Murauskas began the discussion on experiment design by reviewing the PLMP. Mr. Murauskas explained that the study plan needs to (1) ensure that we are able to specifically target lamprey during their migratory times; and (2) ensure that we do not interfere with salmon. During the presentation, Mr. Murauskas showed several figures from Wells Dam indicating that salmon are typically active during daylight hours (12 p.m. to 7 p.m.), whereas lamprey are more active during the overnight periods (8 p.m. to 12 a.m.).

   Ms. Hallock asked [in reference to the passage data] how comfortable Douglas PUD is with the counting window. Mr. Murauskas indicated that the upper fishway has 100 percent passage efficiency and that the number of lamprey passing the count station is not a passage issue, but rather an enumeration issue. Mr. Murauskas said that radio-telemetry data has shown that roughly 75 percent of all lamprey bypass the count station, substantially lowering passage estimates at Wells Dam. Mr. Bickford suggested using low light cameras or perhaps DIDSON at the counting windows to develop a better video bypass proportion estimate. Mr. Murauskas reminded the group that Douglas PUD still has to sell the study design (operational modifications) to the HCP committee. Mr. Hatch stated that lamprey are significant to the Colville and Wanapum tribes. He does not know the population but anything we can do is a good thing. Their numbers will fluctuate in size and population with peaks and valleys in their migration. Mr. Hatch asked if we were attempting to exclude the use of radio-telemetry from this point forward. Mr. Murauskas said no, but rather we are simply attempting to use the most appropriate technology available to accurately assess operational changes made to enhance lamprey passage at the Project. The discussion of radio-telemetry continued as Mr. Bickford stated that Bonneville Dam is showing that tagging is having a significant negative effect on passage efficiency and there is now considerable evidence that radio tags are not the best tool for measuring passage efficiency.

   Ms. Hallock asked if the lamprey study would be on the agenda for the June meeting. Mr. Murauskas indicated that the two main items on the agenda for the June meeting were to discuss BIA's concerns with the PLMP and finish edits to the WQMP. Ms. Hallock asked if the study plan for the upcoming migration could be discussed then at the July meeting. Mr. Bickford said that the study plan should be discussed sooner rather than later if we are going to be able to implement the study in time for the 2009 migration. Ms. Hallock stated that it would be a shame to miss this season for the lamprey study. Mr. Lewis indicated that the USFWS wanted to go forward also. Mr. Murauskas asked what it will take to move forward. Mr. Bickford stated that if we have to start over again with extensive and time-consuming edits to the PLMP, then it is hard to imagine how a study could logistically happen in 2009. Douglas PUD is trying to be proactive and find practical solutions to passage issues, implementing them well ahead of the schedule agreed to in the Agreement. However, it will be difficult to implement a study in 2009 without a consensus surrounding the goals and objectives in the PLMP, directly influencing study designs.

V. Next Meetings

1. Next meeting (Aquatic SWG Chair Orientation; updates to WQMP): ***June 10th, 10 a.m.-3:00 p.m., East Wenatchee***.
2. Meeting to host USFWS and BIA for comments on the PLMP: ***June 30th, 10 a.m.-3:00 p.m., East Wenatchee***.

List of Appendices

Appendix A – May 11, 2009, Letter from K. Berg, USFWS, to Aquatic SWG

Final Meeting Minutes

Aquatic Settlement Work Group

To:	Aquatic SWG Parties	**Date**: June 30, 2009	
From:	Mike Schiewe (Anchor QEA)		
cc:	Steve Lewis (USFWS), Jessi Gonzales (USFWS), Bryan Nordlund (NMFS)		
re:	Final Minutes of June 10, 2009 Aquatic SWG meeting		

I. Announcements

1. Effective today, Dr. Mike Schiewe is the Chair of the Aquatic Settlement Work Group (Aquatic SWG). He can be contacted by cell phone at (360) 271-9747. Emails and documents should be sent to both Dr. Schiewe and Ali Wick at mschiewe@anchorqea.com and awick@anchorqea.com for Aquatic SWG distribution (Item IV-1).

II. Summary of Decisions

1. The Aquatic SWG will meet on second Wednesdays of the month. Next meeting dates will be confirmed at each meeting and in the minutes (Item IV-1).

2. Douglas PUD [Douglas] will provide the revised Water Quality Management Plan (WQMP), with the updated Appendix B, to the Aquatic SWG by July 8 (Item IV-3).

3. Douglas will provide the final Total Dissolved Gas (TDG) and turbidity reports to the Aquatic SWG by close of business Monday, August 3 (Item IV-3).

4. Douglas will include the final TDG and turbidity results in the WQMP. The facilitator will include a vote on approval of the WQMP on the agenda for the August 12 meeting (Item IV-3). . The approved WQMP will be included in the Final License Application, in December.

III. Summary of Action Items

1. Dr. Mike Schiewe will call Bob Dach (Bureau of Indian Affairs [BIA]) and confirm that the comments on the Pacific Lamprey Management Plan (PLMP) are expected by the deadline of June 16 (Item IV-2).

2. Josh Murauskas will ask Rolf Weilick (Jacobs Engineering, Portland) to complete the oil spill prevention and control plan (which is Appendix B to the WQMP) by the July 8 Aquatic SWQ meeting (Item IV-3).

3. Josh Murauskas will provide the WQMP to the Aquatic SWG by July 8 (Item IV-3).

4. Josh Murauskas will provide the TDG and turbidity reports to the Aquatic SWG by close of business on Monday, August 3 (Item IV-3).

5. Josh Murauskas will provide the lamprey study plan to Molly Hallock (Washington Department of Fish and Wildlife [WDFW]) and Bao Le (Long View Consulting) for review by June 30 (Item IV-4).

6. Shane Bickford and/or Josh Murauskas will attend the June 23 Wells Habitat Conservation Plan Coordinating Committees (HCP-CC) meeting to discuss the lamprey study plan and to coordinate for later HCP-CC email approval for any needed Wells Dam fishway operating changes (Item IV-4).

7. Josh Murauskas and Jessi Gonzales will each contact the Colville Confederated Tribes (CCT) regarding lamprey (Item IV-4).

8. Steve Lewis will send the most current bull trout "Status of the Species" drafted text to Shane Bickford (discussed as an aside).

IV. Summary of Discussion

1. **Aquatic SWG Chair** – Dr. Michael Schiewe (Anchor QEA) introduced himself as the new chair of the Aquatic SWG. He completed a long career with the National Marine Fisheries Service (NMFS) in 2002, and now works as a technical consultant at Anchor QEA, LLC (Anchor QEA). He has been involved with the Wells, Rocky Reach, and Rock Island HCP Coordinating and Hatchery Committees as committee chair since 2004 and looks forward to serving the Aquatic SWG. Ali Wick (Anchor QEA) introduced herself as a fisheries biologist and environmental scientist at Anchor QEA and will be serving as support to Dr. Schiewe in assisting the group where needed. Dr. Schiewe is available for discussion of issues by cell phone at (360) 271-9747. Emails and documents can be sent to Ms. Wick for group distribution. The attendees introduced themselves as well. It was agreed that for the time being, the Aquatic SWG will meet on the second Wednesday of each month. Next meeting dates will be confirmed at each meeting and in the minutes.

2. **BIA comments on the PLMP** – The group discussed and confirmed that BIA comments on the PLMP are due to the Aquatic SWG by June 16. The Aquatic SWG is scheduled to meet with BIA staff on June 30 to discuss these comments. Dr. Schiewe will call Bob Dach (BIA) to confirm that the comments are needed by the June 16 deadline, and to confirm that meeting this deadline is a key to timely consideration of BIA issues.

3. **WQMP** – Josh Murauskas (Douglas) reviewed the recent edits and updates to the WQMP. He noted that new text and detail has been added on TDG modeling, and that TDG playbooks based on the modeling results have been added. Mr. Murauskas further noted that extensive field and modeling studies were conducted to identify the operating conditions that minimize TDG. Finally, he indicated that a table was added to summarize supporting studies that show compliance with the numeric criteria of the Washington State Water Quality Standards.

   Mr. Murauskas then went on to discuss the updated objectives of the WQMP. Pat Irle (Washington State Department of Ecology [Ecology]) asked whether this WQMP would be finalized after the final Phase III TDG Report. Shane Bickford (Douglas) said that it would, as the Phase III TDG and turbidity reports will be complete in August 2009, and the information from these reports will be folded into the WQMP. The WQMP will be finalized in August 2009 prior to Wells license submittal to the Federal Energy Regulatory Commission (FERC). The WQMP will be provided to the Aquatic SWG for review by July 8. The TDG and turbidity report information will be distributed to the Aquatic SWG by close of business on Monday, August 3. The WQMP will then be on the agenda for approval at the August 12 meeting.

4. **Lamprey Study Plan** – Mr. Murauskas introduced his preliminary plans for the lamprey study plan, including the hypotheses, study plan, and study design. Recent data have indicated that most adult lamprey are entering the adult fishway collection galleries during the hours of 8:00 pm to 12:00 midnight. This is a time period during which few salmon and steelhead enter the collection gallery. The minimal overlap of passage timing creates an opportunity to evaluate reduced gallery entrance velocities as a possible operational change to improve passage of adult lamprey. Mr. Murauskas emphasized that any change to gallery entrance velocities would not require a change in in-ladder flows, would not coincide with peak diurnal passage timing of salmon, could be implemented with a head differential that is at or near original target levels, and represent a minor window of adjustments (4 hours a day, less than 30 days a year). Mr. Murauskas indicated that a key feature of the proposed study was the use of Dual Frequency Identification Sonar (DIDSON) technology to monitor lamprey behavior at the gallery entrances under different velocities. Mr. Murauskas described some factors that will be considered in identifying the locations for DIDSON placement, including information to be collected, data processing, and cost. The project will measure relative success of lamprey passage at low, medium, and high velocities using a randomized block design. Douglas would like to begin the study by August 1. Mr. Murauskas will complete the study plan and will send it to Molly Hallock (WDFW) by June 30. The study plan will be discussed at the July 8 meeting. Mr. Bickford and/or Mr. Murauskas will attend the June 23 HCP-CC meeting to present the study plan concept for discussion and to coordinate for later email approval. Peter Johnson (LGL) will be meeting with Douglas at Wells Dam to discuss the DIDSON placement on June 25.

Dr. Schiewe asked whether the Aquatic SWG members present were on board with the general study plan approach. It was confirmed that all of the signatory parties agreed with the concept. It was noted that the CCT had not yet been briefed on the proposed study. Mr. Murauskas will contact the CCT to provide this information.

V. Next Meetings

1. Meeting to discuss and consider BIA comments on the PLMP: ***June 30, 10 a.m.-3:00 p.m., Douglas PUD in East Wenatchee***.
2. Regularly scheduled upcoming monthly meetings: ***July 8, August 12.***

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Ali Wick	Anchor QEA, LLC
Josh Murauskas	Douglas PUD
Shane Bickford	Douglas PUD
Pat Irle	Washington State Department of Ecology
Patrick Verhey	WDFW
Molly Hallock (afternoon; by conference call)	WDFW
Bob Jateff (afternoon)	WDFW
Jessi Gonzales	USFWS
Steve Lewis	USFWS
Bob Rose (afternoon; by conference call)	Yakama Nation

Final Meeting Minutes

Aquatic Settlement Work Group

To: Aquatic SWG Parties **Date**: August 12, 2009

From: Mike Schiewe (Anchor QEA)

cc: Steve Lewis (USFWS), Jessi Gonzales (USFWS)

re: Final Minutes of June 30, 2009 Aquatic SWG meeting

I. Announcements

1. There were no announcements at this meeting.

II. Summary of Decisions

1. There were no formal Aquatic Settlement Work Group (Aquatic SWG) decision items at this meeting.

III. Summary of Action Items

1. Jessi Gonzales will send an email to convene a conference call with the appropriate U.S. Fish and Wildlife Service (USFWS) and Department of the Interior (DOI) staff to clarify the steps required to clear the way for the USFWS to sign the Wells Settlement Agreement (Item IV-5).

2. Douglas PUD (Douglas) will provide a draft response memo to the Bureau of Indian Affairs (BIA)/Columbia River Inter-Tribal Fish Commission (CRITFC) comments on the Pacific Lamprey Management Plan (PLMP) for Aquatic SWG review at the July Aquatic SWG meeting (Item IV-5).

IV. Summary of Discussion

1. **BIA comments on the PLMP** – The BIA joined the morning portion of today's meeting. Mike Schiewe introduced this topic, and invited Bob Dach (BIA) to discuss BIA and CRITFC recommendations and comments on the PLMP. Mr. Dach thanked the group for considering these comments. He said that BIA does not intend to make any changes to the Settlement Agreement, and rather are only providing comment on the PLMP. Bill Towey asked for clarification regarding who prepared the comments, and on behalf of whom. Mr. Dach said that the comments are from BIA, in consultation with CRITFC, representing the lower Columbia River treaty tribes. Pat Irle asked Mr. Dach to clarify the list of lower treaty tribes. Mr. Dach and Bob Heinith (CRITFC) said that Mr. Heinith

was attending on behalf of the Umatilla, Nez Perce, and Warm Springs tribes. Jessi Gonzales asked whether the funding needed to implement actions stemming from these comments would be expected from Douglas. Mr. Dach said that he recognized that Douglas may not have funding available or that existing data may not be able to support all of the recommendations. Shane Bickford said that Douglas commissioners will typically support studies that Douglas's team of fisheries biologists feel are necessary, provided that the recommendations are based upon scientifically rigorous results.

Mr. Dach began an overview of BIA comments and recommendations by stating that the PLMP should be consistent with the Priest Rapids 401 Water Quality certification that was issued for the Federal Energy Regulatory Commission (FERC) license. Next, he suggested that text be added stating that Douglas would conduct an additional FERC filing of the PLMP after a 30-day comment/recommendation period following incorporation of BIA comments. Another comment was to develop plans for each of the issues in Section 4; each plan would specify the process that Douglas would go through to reconcile the issues, over the term of the license. Mr. Dach stated that BIA was also recommending a numerical standard for Lamprey Passage Efficiency (LPE) and that the standard should be based on the higher LPEs measured at other Columbia River dams. Dach said that he believes that an 80 percent (plus or minus 2.5 percent) passage standard was reasonable, and he suggested text stating that as long as Douglas was making steady progress (as defined by the Aquatic SWG) toward achieving the standard, then BIA would find that acceptable. He also stated that the Aquatic SWG should have the ability to change the standard during the term of the license, with the understanding that the dispute resolution process would be available in the event there was no agreement.

Pat Irle asked whether Mr. Dach was aware that Douglas was already implementing most of what was proposed in Section 4.2. Mr. Dach said that he was aware of that and added that the purpose of the BIA comments was to add specificity and detail within the vein of the actions that Douglas is already planning to implement. Bob Rose asked Mr. Dach to expand on what he means by "the vein" of work that Douglas was planning to do. Mr. Dach answered that it refers to the schedule and action list that is already incorporated in the PLMP.

Regarding the BIA recommendation to add an objective on water quality in the PLMP, it was suggested by several members of the work group that this issue was already addressed in the Water Quality Management Plan (WQMP). Bob Heinith stated that CRITFC was specifically concerned about methyl mercury and ammonia. Pat Irle asked why CRITFC staff thinks that these may be issues in the Wells project area. Mr. Heinith responded that there have been issues with these substances at Brownlee Reservoir on the Snake River. Mr. Heinith said that he was not, however, aware of any effects that might be attributed to these compounds. This concluded the presentation of BIA/CRITFC comments.

Josh Murauskas then provided an overview of the PLMP that was approved by the settlement signatories and incorporated into the Settlement Agreement. He introduced the individuals and organizations that worked on the PLMP. He then reviewed some of the lamprey passage metrics used for adult Pacific lamprey in the Columbia River basin. These include attraction rate, entrance and fishway efficiency, and fallback rate, which can be used to calculate total fishway passage efficiency. Typical fishway passage efficiency for Mid-Columbia dams ranges from 30 to approximately 50 percent. He then reviewed the work group's general responses to BIA/CRITFC's comments. These ranged from responses to comments on semantics, content, opinions, understanding of Wells Dam, and unique features.

Josh Murauskas spoke specifically to the 80 percent passage target that was suggested by the BIA/CRITFC. He said that regional lamprey experts do not believe that an 80 percent passage target is reasonable at this time, as there is no regional consensus for setting a standard. He also noted that FERC has denied recent requests for other licensees to develop passage standards for lamprey. He also said that it is not possible to measure lamprey passage with the required precision for a passage standard based on current technology and historical passage numbers at Wells Dam. Shane Bickford then commented on BIA and CRITFC suggested use of the term "NNI or no net impact." He acknowledged that the term (NNI) was used for lamprey in the Priest Rapids Settlement Agreement, but noted that it was undefined. Mr. Bickford stated that that the term NNI has only been defined for salmonids, and as far as he knew, only in the Wells, Rocky Reach, and Rock Island HCPs. Bao Le added that the NNI language contemplates a level of attainment that may not be possible for Pacific lamprey given the information available for that species, when compared to the level of information available for salmonids. Pat Irle said that she was not comfortable putting a number on a standard at this time, but would be comfortable with an adaptive management approach. Mr. Bickford said that Douglas would be comfortable adding text to the PLMP stating that when the Columbia Basin Lamprey Technical Work Group (Columbia Basin Fish and Wildlife Authority) develops a standard, and that when that standard is developed and regionally accepted, the Aquatic SWG would consider incorporating it into the Settlement Agreement. Bob Dach said that he was not opposed to this, but would have to check with his agency internally. He said that his comments are based on the fact that BIA would like to add certainty throughout the long license term, which may be up to 50 years.

Bob Heinith explained that the basis for the proposed 80 percent standard was the observation of a 1-year high of 80 percent lamprey passage efficiency at The Dalles Dam. Josh Murauskas responded that he was aware of this information, but reminded the group that an 80 percent passage has never been achieved in the Columbia Basin at any dam with any consistency or statistical precision. Shane Bickford commented that the numerous lamprey passage studies at Bonneville Dam have shown that factors like size of fish and tagging method can significantly affect estimates of passage efficiency, and that a one-time estimate at The Dalles does not necessarily mean that an 80 percent standard is the appropriate standard for Wells Dam. He reminded the meeting attendees that the literature on Pacific lamprey is rather thin at this time. Mr. Heinith stated that preliminary results of lamprey passage at Bonneville Dam this year were showing very high entrance efficiency. Mr. Bickford questioned this statement as the Bonneville Study had only been underway for a week and only a handful of fish had been tagged. Mr. Murauskus indicated that based upon his recent conversations with the Dave Clungston, fish biologist in charge of this study, that there have been no results released due to the preliminary status of tagging and fish movement. Mr. Dach concluded by saying that the BIA is mainly looking for greater specificity for a passage objective.

Shane Bickford said that Douglas would like to begin the 2009 lamprey study in August, but that they will need agreement from the USFWS prior to the start. To the extent that BIA might be holding up USFWS approval, Bob Dach said that he would make himself available to work with Douglas on the outstanding issues in order to meet this timeframe.

Other Aquatic SWG members offered comments. Bob Rose suggested that perhaps the term “interim objective” could be more appropriate than the term “passage standard.” Molly Hallock asked Bob Dach whether all of the plans and actions proposed in the BIA-modified PLMP were relevant to Wells Dam. Mr. Dach said that all of the plans proposed were tied to real data from Wells Dam, such that they were not suggested based on data from other dams.

Mike Schiewe asked whether it was the policy of the DOI to have multiple signatories on a Settlement Agreement. Bob Dach answered that there was no policy, and said that when there is a treaty resource involved, then BIA works directly with the Secretary of the Interior. Dr. Schiewe suggested that the DOI would need to resolve the issue of selecting Aquatic SWG signatory(ies) internally. Jessi Gonzales asked Mr. Dach whether resolving all of BIA comments would mean that the USFWS could sign the Settlement Agreement. Mr. Dach said when a bureau or service within the DOI commits the authority of the Secretary of DOI, those bureaus/services need to agree on the committing of that authority. Ms. Gonzales said that it sounded like the BIA and USFWS could both sign within the structure of the authority of the Secretary, but could sign the Settlement Agreement separately.

Shane Bickford asked Bob Dach about the supplementation and translocation actions suggested in the BIA comments; namely, he asked whether they were intended to be off-site mitigation or enhancement actions. Mr. Dach responded that they would represent mitigation for some impact of the Project.

Josh Murauskas asked for clarification of the difference between dispute resolution and mandatory conditioning. Shane Bickford said that dispute resolution refers to how signatories to the Settlement Agreement resolve conflicts on issues within the Aquatic SWG. Mandatory conditioning is related to a federal agencies ability to conditions a license through the Federal Power Act.

Mr. Murauskas then asked if someone could clarify the relationship between Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Colville Confederated Tribes (CCT), Yakama Nation (YN), CRITFC, and BIA. Bob Dach said that the BIA is a trustee of the resources that are held in trust for the tribes. Pat Gonzales-Rogers spoke to this by saying that the tribes could align themselves with BIA and/or CRITFC, but also have the right to retain sovereignty on any issue or concern. Bill Towey asked BIA what process was used to develop the PLMP comments being discussed today. Mr. Dach said that they were the comments that BIA and CRITFC developed in order to protect the trust resources for all of the tribes, and that the BIA will ensure that all affected tribes are on board and represented in the comments. Mr. Towey stated that the CCT were never contacted and then asked when the consultation with the CCT would occur. Mr. Dach said that today's meeting is a start, and that he will work with Joe Peone at CCT for government-to-government consultation. He said that there has been no government-to-government consultation with any of the tribes at this point. Mr. Gonzales-Rogers said that individual tribes are also free to bring up concerns with BIA at any point.

2. **Lunch –** The group broke for lunch. The representatives from BIA and CRITFC as well as Pat Gonzales-Rogers and Bao Le left the meeting. Carl Merkle also left the call.

3. **Entity Involvement in Aquatic SWG Proceedings** – Pat Irle brought up a question of who will be included in future Aquatic SWG proceedings. Mike Schiewe reminded the group that language in the Settlement outlines the process in which non-signatory parties can attend meetings.

4. **WQMP** – Josh Murauskas updated the group that Douglas initially planned to have a draft WQMP for review for at the July 8 meeting, but learned that the University of Iowa will have a final report for the Phase III Total Dissolved Gas (TDG) efforts and compliance evaluations available within another week. Further, Columbia Basin Environmental will have all of the recent turbidity monitoring data in late July. Mr. Murauskas indicated that he and Pat Irle would like to delay finalizing the WQMP until these results can be included to prevent further adjustments in the near future. The group agreed to postpone the July 8 deadline and limit discussion of the WQMP at the July meeting to presentation of some of the proposed changes and new data.

5. **Path Forward for the PLMP** – The group discussed the path forward for the PLMP. Jessi Gonzales indicated that she will send an email to convene a conference call with the appropriate USFWS and DOI staff (e.g., Preston Sleeger, Eston Meade, Pat Gonzales-

Rogers, Steve Lewis, and herself) to initiate discussions with DOI solicitors regarding Section 18 authority and the importance of timely resolution of any issues so the USFWS can sign the Settlement Agreement . That meeting will also address the required government-to-government communications with the tribes.

Mike Schiewe asked Shane Bickford to explain the proposed path forward to address the BIA comments. Mr. Bickford said that Douglas PUD would like to address issues that the Aquatic SWG and USFWS believes need to be addressed in the PLMP. In terms of a path forward for the CCT, Bill Towey brought up the point that the CCT will not be able to endorse adoption of BIA comments at this time, as CCT and BIA have not conducted the required government-to-government consultation yet.

The Aquatic SWG then identified the key BIA comments that warrant further Aquatic SWG discussion:

- **Comment proposing the incorporation of the NNI concept with a numerical passage standard**: The group discussed that NNI is not defined for lamprey but essentially means anything that is adverse to lamprey passage. The PLMP already addresses adverse Project-related impacts. The group agreed that the concept of "steady progress," as discussed with Bob Dach during the morning session, would be a good approach to addressing this comment; what constitutes steady progress could be developed by the Aquatic SWG.

- **Comment proposing a new objective on water quality impacts to lamprey:** The group agreed that this objective is better addressed in the WQMP and that the PLMP will not be changed. This topic will be discussed at the meeting next week when the WQMP is scheduled to be updated.

- **Comment proposing addressing all upstream habitat, including areas outside the Project Area:** The group discussed that results of previous lamprey studies on spawning and rearing indicating that there is no spawning in the Project Area. The BIA may not have seen this information at the time of their review. The group also agreed that the PLMP would not address spawning issues outside the Project Area.

- **Comment proposing an interim objective of an 80 percent passage standard (± 2.5 percent):** The group agreed that this is better addressed with the concept of "steady progress" and adaptive management until such time that the Columbia Basin Fish and Wildlife Authority's Lamprey Technical Work Group adopts a numeric standard.

- **Comment proposing translocation and supplementation:** The group first discussed that there is little peer-reviewed data on genetic effects of lamprey translocation and supplementation. The group agreed that they could identify "artificial production" as a tool that could be used for juvenile management, but one that is not currently proposed.

- **5- vs. 10-year monitoring timeframe:** The group agreed that they could update the plan to afford additional flexibility in monitoring to state that it would be at least every 10 years or at the discretion of the Aquatic SWG.

- **Habitat Restoration Tributary Fund outside Project Area:** The group agreed that this will not be considered in the plan because FERC typically does not allow proposed work outside the Project Area unless tied to the measurement of impacts that cannot be addressed within the project boundary.

Douglas agreed to take the Aquatic SWG's recommendations from today's meeting and prepare a response memo that will organize these issues for Aquatic SWG review at the July meeting. The group will then decide whether to adjust text or provide a summary of understandings based on the Aquatic SWG input.

V. Next Meetings

1. Meeting to discuss and consider BIA comments on the PLMP: ***July 8, 10 a.m.-3:00 p.m., Douglas PUD in East Wenatchee***.
2. Regularly scheduled upcoming monthly meetings: ***August 12, September 9.***

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Role	Organization
Mike Schiewe	SWG Chair	Anchor QEA, LLC
Ali Wick	Administrative	Anchor QEA, LLC
Bob Dach (morning only)	BIA Technical	BIA
Keith Hatch (morning only)	BIA Technical	BIA
Bill Towey	SWG Technical Rep.	CCT
Carl Merkle (morning only by conference call)	CTUIR Legal	CTUIR
Bob Heinith (morning only)	CRITFC Technical	CRITFC
Josh Murauskas	SWG Technical Rep.	Douglas PUD
Shane Bickford	SWG Policy Rep.	Douglas PUD
Bao Le (morning only)	Consultant	Long View Associates
Pat Irle (by conference call)	SWG Technical Rep.	Ecology
Tony Eldred	SWG Policy Rep.	WDFW
Patrick Verhey	SWG Policy Alternate	WDFW
Molly Hallock	WDFW Technical	WDFW
Bob Jateff	SWG Technical Rep.	WDFW
Jessi Gonzales	USFWS Policy	USFWS
Pat Gonzales-Rogers (morning only)	USFWS Legal	USFWS
Steve Lewis	USFWS Technical	USFWS
Bob Rose	SWG Technical Alternate	YN

Final Meeting Minutes

Aquatic Settlement Work Group

To:	Aquatic SWG Parties	**Date**: August 12, 2009
From:	Mike Schiewe (Anchor QEA)	
cc:	Steve Lewis (USFWS), Jessi Gonzales (USFWS)	
re:	Final Minutes of July 8, 2009 Aquatic SWG meeting	

I. Welcome

1. Mike Schiewe reviewed the agenda.

II. Summary of Decisions

1. There were no formal decision items at this meeting.

III. Summary of Action Items

1. Douglas PUD (Douglas) will modify the lamprey response memo to address the comments from the July 8 meeting and will send it out to the Aquatic Settlement Work Group (Aquatic SWG) by close of business today, July 8 (Item (IV-1).

2. Members of the Aquatic SWG will review and provide written comments on the draft lamprey response memo to Douglas (with copies to all SWG members) by July 15; Douglas will send out a final memo by close of business on July 17, and Aquatic SWG members will email Mike Schiewe and Ali Wick with their opinions on whether a conference call on July 22 is needed to address unresolved concerns (Item IV-1).

3. Josh Murauskas will add text to the lamprey response memo stating that potential water quality impacts to lamprey will be covered in the Water Quality Monitoring Plan (WQMP) (Item IV-5).

4. Josh Murauskas will send the draft WQMP to the group for review on or before July 20 (Item IV-5).

IV. Summary of Discussions

1. **Response Memo to BIA** – Josh Murauskas discussed the draft Aquatic SWG response memo to the Bureau of Indian Affairs (BIA). Mike Schiewe noted that this will not be the

Aquatic SWG's last opportunity to review this memo; today's review is to check the memo for general agreement and content.

Response Memo to BIA – Tony Eldred asked if there was additional information on impacts of sediment toxins to lamprey, especially to juveniles, that should be considered.

The group discussed the draft memo being prepared in response to BIA's comments on the PLMP. Specific to BIA's proposed language regarding No Net Impact (NNI). Bob Rose suggested the following two additional rationales for not using the NNI terminology be added: 1) NNI implies a quantification of effects similar to those obtained in juvenile salmonids survival studies; 2) add Federal Energy Regulatory Commission (FERC) limitations regarding mitigation.

The group agreed that the terminology "safe, timely, and effective" in the Pacific Lamprey Management Plan (PLMP) can be simplified to "effective," as this term implies "safe and timely."

The Aquatic SWG had discussed earlier whether to include text in the PLMP on potential water quality impacts to lamprey. The group agreed that this issue will be addressed in the WQMP, which will be discussed later in today's meeting.

The group discussed the adult passage standard language that is in the draft BIA response memo. The group suggested that the passage standard would be addressed by the concept of "steady progress" and that biologically defensible standards and rigorous measurement techniques adopted by the Lamprey Technical Work Group or other regional technical lamprey forums would be considered for use. The group also agreed that Douglas will clarify the definition and intent of the term "steady progress" to mean long- term progress that takes into account natural variation in passage efficiency.

The group agreed with the conceptual text on entrance efficiency. The group discussed the pros and cons of including the individual "Plans" listed in the BIA's comments. The general consensus was that the memo should be modified to add text to the PLMP that addresses the context and detail suggested by BIA's proposed "Plans" without actually requiring the group to develop each and every one of the individual plans. One reason for this is to minimize the bureaucratic process involved in tracking individual plans compared to addressing these components and tracking them comprehensively as part of the overall implementation of the PLMP.

The group agreed with the general approach to the memo including the remaining sections (items numbered 10 through 15).

For memo item 16, Bob Rose agreed to provide text regarding Translocation and Supplementation (TAS). Bob Rose subsequently provided the proposed TAS language via e-mail to the group prior to lunch. The group agreed to include his proposed TAS language.

The group agreed with the approach for memo items 17 and 18. For memo item 18, which addresses habitat outside of Wells Project boundaries, the group added text to the memo stating that habitat projects outside the boundaries may be used as a mitigation tool if an effect can be linked to the Project and the Aquatic SWG agrees.

The group agreed that the BIA memo's text will be modified to include today's comments and that the revised memo will be sent to the Aquatic SWG by close of business on July 8. The memo will then be finalized as follows: Aquatic SWG comments on this memo are due on July 15 (with copies to all Aquatic SWG members); and the memo will then be revised and sent it back to the Aquatic SWW on July 17; the group will convene by conference all on July 22 from 12:00 pm to 1:00 pm if needed (Note: Aquatic SWG members will email Mike Schiewe and Ali Wick prior to this time if they do not require this call, to resolve any remaining issues). Once finalized, Douglas will send the final BIA response memo to U.S. Fish and Wildlife Service (USFWS) on or before July 24.

2. **SOA on Modifications to the PLMP** – The group reviewed a Statement of Agreement (SOA) regarding modifications to the PLMP based on recent BIA comments. The group decided to review whether an SOA would be necessary. No further action on the SOA was taken at the meeting.

3. **BIA Participation in Aquatic SWG** – Mike Schiewe said that he had received a request from Bob Dach for the BIA to participate in Aquatic SWG meetings as a non-voting member (Dach suggested Keith Hatch). After some discussion, the group agreed that BIA may attend as an observing non-voting member once the Department of Interior (DOI) designates a signatory representation to the Aquatic SWG.

4. **Lamprey Study Plan Status Update** – Josh Murauskas provided an overview of recent changes to the lamprey study plan. The modifications were suggested by the Aquatic SWG and have been reviewed by Molly Hallock (WDFW) and others. Mr. Murauskas said that the DIDSON camera will be oriented horizontally. Pat Irle suggested eventually using DIDSON to look at the elevation at which fish are attempting to pass through the entrance, in order to validate the assumption that the study is sampling a representative portion of the population. Shane Bickford responded that representative sampling is an assumption for this year's study, and that Douglas will consider further investigation of vertical distribution in future year's studies.

5. **WQMP –** The group discussed how and whether to address potential water quality impacts to lamprey, and agreed that Douglas would complete a brief literature review to

evaluate whether lamprey are particularly sensitive to selected environmental contaminants. The group then turned their attention to Dissolved Oxygen (DO), pH, and turbidity; Pat Irle suggested also adding text to the plan saying that these factors are not known problems, but if they do appear problematic in the future, then they would be addressed. Josh Murauskas agreed to add language to the WQMP for the group to review. To close the loop on the earlier discussion on water quality and lamprey (Item IV-2), Mr. Murauskas agreed to add text to the BIA response memo stating that potential water quality impacts to lamprey will be addressed in the WQMP.

Josh Murauskas reviewed the new water quality study results that Douglas recently received, and the proposed changes to the WQMP based on those results. Mr. Murauskas said that the WQMP will now include measures to complete the intensive studies, and then to continue basic Total Dissolved Gas (TDG) monitoring, as well as annual reporting. Douglas will also continue observations of exceedances, and if results indicate a non-compliance event, then Washington State Department of Ecology (Ecology) will be notified for regulatory discretion. For temperature, Douglas will continue monitoring and working toward Total Maximum Daily Load (TMDL) development, as well as reporting all non-compliance events to Ecology. The group agreed that if annual water temperature monitoring results are inconsistent with historical trends and there has been a change in project operations, the temperature model may need to be re-run. For DO, pH, and turbidity, if results indicated non-compliance, the WQMP will state that non-compliance events will be reported to Ecology.

Josh Murauskas and Pat Irle will be meeting tomorrow to review the suggested changes from today's meeting and from these new study results. The group discussed and agreed that for conditions where compliance has been achieved, regular monitoring will be conducted unless new information arises that suggests that a new in-depth study should occur.

The schedule for finalizing the WQMP is set as follows: the draft WQMP will be sent to the Aquatic SWG for review on or before July 20; any Aquatic SWG comments will be sent back to Douglas (and copied to the group) by July 27; Aquatic SWG comments will be addressed and Aquatic SWG entities will send an email of approval to the group prior to July 31. If comments require discussion by conference call, a call will be held at 9:00 am on July 31.

V. Next Meetings

1. Upcoming meetings: ***August 12, September 9, October 14.***

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Role	Organization
Mike Schiewe	SWG Chair	Anchor QEA, LLC
Ali Wick	Administrative	Anchor QEA, LLC
Bill Towey (by conference call)	SWG Policy Rep.	Colville Confederated Tribes
Josh Murauskas	SWG Technical Rep.	Douglas PUD
Shane Bickford	SWG Policy Rep.	Douglas PUD
Bao Le (by conference call)	Consultant	Long View Associates
Pat Irle	SWG Technical Rep.	Washington State Department of Ecology
Tony Eldred	SWG Policy Rep.	WDFW
Molly Hallock (by conference call)	WDFW Technical	WDFW
Steve Lewis	USFWS Technical	USFWS
Bob Rose (by conference call)	SWG Technical Alternate	Yakama Nation

Final Meeting Minutes

Aquatic Settlement Work Group

To:	Aquatic SWG Parties	**Date**:	September 10, 2009
From:	Mike Schiewe (Anchor QEA)		
re:	Final Minutes of August 12, 2009 Aquatic SWG meeting		

I. Welcome

1. Mike Schiewe reviewed the agenda and meeting minutes. The June 30 and July 7 meeting minutes were approved with minor revisions.

II. Summary of Decisions

1. The Aquatic Settlement Work Group (Aquatic SWG) approved the results of the 2009 Turbidity Monitoring project (Item IV-2).

2. The Aquatic SWG approved the Water Quality Monitoring Plan (WQMP) with final comments from Washington State Department of Ecology (Ecology) accepted (Item IV-3).

III. Summary of Action Items

1. Josh Murauskas will provide the final version of the WQMP for the record (Item IV-3).

2. Josh Murauskas will send out an updated red-line version of the Pacific Lamprey Management Plan (PLMP) by Wednesday, August 19, for potential approval at the September Aquatic SWG meeting (Item IV-3).

3. In response to a request from the Aquatic SWG, Josh Murauskas will compile for the next meeting a summary of information on the effects of toxics on lamprey (Item IV-5).

IV. Summary of Discussions

1. **Introduction of USFWS as Signatory Party** – Mike Schiewe noted that the U.S. Fish and Wildlife Service (USFWS) has recently become a signatory party to the Wells Aquatic Settlement. The Bureau of Indian Affairs (BIA) may also sign.

2. **Review of 2009 Turbidity Monitoring in the Okanogan** – Josh Murauskas provided a brief presentation on the recent 2009 turbidity monitoring in the Okanogan River. He noted that supplemental hourly data were collected at three locations in 2008 to

demonstrate compliance with turbidity criteria. The results showed that there were no exceedances of numeric criteria. The Aquatic SWG reviewed and approved these results.

3. **DECISION ITEM: Final Approval of WQMP** – Josh Murauskas reviewed the changes that have been incorporated into the WQMP. The Aquatic SWG approved the WQMP with final comments from Ecology accepted. Mr. Murauskas will provide the final version for Aquatic SWG records.

4. **Initial Review of Update to PLMP** – Josh Murauskas reviewed the edits to the PLMP, which included changes proposed by BIA. The Aquatic SWG added several additional edits at today's meeting, and concluded that these changes have addressed the BIA comments. Mr. Murauskas will send out an updated red-line version of the PLMP by Wednesday, August 19, for potential approval at the September Aquatic SWG meeting.

5. **Pacific Lamprey Study Update** – Josh Murauskas updated the group that the Dual Frequency Identification Sonar (DIDSON) has been installed and a data-recording laptop has been set up for use during the study. The schedule for the study has been reviewed with the dam operators. He noted that two lamprey have passed the dam to date. Mr. Murauskas also indicated that the study was reviewed and approved by the Wells HCP Coordinating Committee. Based on these discussions, the timing of the testing was adjusted to avoid salmon passage periods and to gain information on salmon passage occurring within the lamprey passage test conditions.

   In response to a request from the Aquatic SWG at the last Aquatic SWG meeting, Mr. Murauskas will prepare a summary of published literature regarding the effects of toxics on lamprey. This summary will be discussed at the September Aquatic SWG meeting,

V. Next Meetings

1. Upcoming meetings: ***September 9, October 14, November 11.***

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Role	Organization
Mike Schiewe	SWG Chair	Anchor QEA, LLC
Ali Wick	Administrative	Anchor QEA, LLC
Josh Murauskas	SWG Technical Rep.	Douglas PUD
Shane Bickford	SWG Policy Rep.	Douglas PUD
Pat Irle	SWG Technical Rep.	Washington State Department of Ecology
Tony Eldred	SWG Policy Rep.	Washington Department of Fish and Wildlife
Bob Jateff	SWG Technical Rep.	Washington Department of Fish and Wildlife
Steve Lewis	SWG Technical Rep.	U.S. Fish and Wildlife Service

Final Meeting Minutes

Aquatic Settlement Work Group

To: Aquatic SWG Parties **Date**: October 14, 2009

From: Michael Schiewe (Anchor QEA)

re: Final Minutes of September 9, 2009 Aquatic SWG meeting

I. Welcome

1. Mike Schiewe opened the meeting. The August 12, 2009, meeting minutes were approved.

II. Summary of Decisions

1. The Aquatic Settlement Work Group (Aquatic SWG) approved changing regularly scheduled monthly meetings to conference calls and holding in-person meetings on a quarterly basis or as requested by SWG members (Item IV-1).

2. The Aquatic SWG unanimously approved the revised Pacific Lamprey Management Plan (PLMP) (Item IV-3).

3. The Aquatic SWG unanimously approved allowing a Bureau of Indian Affairs (BIA) representative to attend Aquatic SWG meetings as a non-voting observer (Item IV-4).

III. Summary of Action Items

1. Ali Wick will send an email to the Aquatic SWG identifying upcoming monthly conference call meeting dates and quarterly meeting dates (Item IV-1).

2. Shane Bickford will send out final Aquatic Settlement Agreement management plans and the Aquatic Settlement Agreement as a package to all Settlement Agreement representatives (Item IV-2).

3. Mike Schiewe will notify Bob Dach that the Aquatic SWG approved his request for a BIA representative to attend Aquatic SWG meetings as a non-voting observer (Item IV-4).

IV. Summary of Discussions

1. **Meeting Schedule Change** – The Aquatic SWG discussed and all approved changing monthly meetings to conference calls and in-person meetings to quarterly meetings or as needed. Ali Wick will send out an email confirming these dates.

2. **PLMP** – Josh Murauskas reviewed recent edits to the draft PLMP. These edits included those made in response to BIA and Columbia River Inter-Tribal Fish Commission (CRITFC) comments that were presented to the Aquatic SWG, as well as new text summarizing the findings from the 2009 Pacific lamprey study and the recommendation as contained in the 2009 study by Robichaud et al. The Aquatic SWG discussed the revisions to the PLMP, and noted that no comments had been received from BIA or CRITFC regarding the responses to their comments. The Aquatic SWG unanimously approved the revised PLMP as final.

3. **Draft License Application Status and Consistency with Management Plan** – Josh Murauskas provided an update on the status of the Draft License Application (DLA) and changes to the DLA. During the final review for the DLA, Douglas PUD noticed that there are some minor inconsistencies between and within some of the six aquatic management plans. Douglas PUD is proposing to update the management plans for consistency. All of the changes are editorial and formatting and do not affect the measures within the plans but they are changes to documents that were signed by all of the parties to the Aquatic SWG. Douglas PUD described each of the minor changes to the management plans and there were no objections to the changes. Based upon the revisions agreed upon at the meeting, the PUD will submit the DLA to FERC in December 2009. Shane Bickford also said that the final Aquatic Settlement Agreement and associated management plans will be sent to all of the Settlement parties and representatives.

4. **USFWS/BIA Issues** – Jessi Gonzales briefed the Aquatic SWG on U.S. Department of Interior (DOI) discussions regarding the relationship between the USFWS and BIA after the USFWS signing of the Aquatic Settlement Agreement. Gonzales explained that DOI authority over fishways under Section 18 is delegated by the Secretary of the Interior to USFWS. The BIA has requested clarification on this issue, and the DOI Office of Environmental Policy and Compliance in both the USFWS and BIA will address this issue and will be sending a letter to Douglas PUD to clarify. Meanwhile, USFWS is moving forward on government-to-government consultations with tribal chairs to put on record the extent each tribe intends to participate in this Aquatic SWG process.

   Mike Schiewe said that Bob Dach at BIA has requested that a BIA representative be allowed to attend Aquatic SWG meetings as a non-voting observer. The Aquatic SWG discussed and approved this, with the Yakama Nation abstaining. Mike Schiewe will notify Bob Dach that the Aquatic SWG approved his request.

5. **Pacific Lamprey Study Plan Update** – Josh Murauskas showed underwater footage of the DIDSON camera installation at Wells Dam that is part of the 2009 lamprey passage study. Data are being collected 24 hours per day. The cameras will be operated until September 20 or 22, and data analysis will begin after that.

6. **Summary of Effects of Toxins on Lamprey** – Josh Murauskas prepared and handed out to the workgroup a summary of published literature regarding the effects of toxins on lamprey. Bob Rose recommended that an effort be made to compile and summarize lamprey literature for use in regional lamprey management efforts. Josh Murauskas provided Mr. Rose with an extensive literature review database collected over the past decade.

7. **Mid-Columbia Lamprey Restoration Coordination Efforts** – Bob Rose explained that the Yakama Nation intends to finalize a Pacific lamprey restoration plan and will begin implementing actions in the Yakima subbasin beginning in 2011 and then in the Mid-Columbia region the following year (2012). The Yakama Nation intends to coordinate their lamprey restoration actions with salmon and lamprey recovery planning efforts. Rose said that the Yakama Nation is holding a kick-off meeting on October 9, 2009, in Yakima for the 2010 Yakima subbasin Pacific lamprey restoration planning effort. He said that he would be working with Colville Confederated Tribes (CCT), the PUDs, WDFW, and USFWS to plan a date in October to have the first meeting on coordinating lamprey restoration and management actions in the Mid-Columbia region.

V. Next Meetings

1. Upcoming meetings: ***October 14, November 11, and December 9, all conference calls.***

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Role	Organization
Mike Schiewe	SWG Chair	Anchor QEA, LLC
Carmen Andonaegui	Administrative	Anchor QEA, LLC
Josh Murauskas	SWG Technical Rep.	Douglas PUD
Shane Bickford	SWG Policy Rep.	Douglas PUD
Bob Rose*	SWG Technical Rep.	Yakama Nation
Bill Towey	SWG Technical Rep.	Colville Confederated Tribes
Pat Irle	SWG Technical Rep.	Washington State Department of Ecology
Molly Hallock**	WDFW Technical	Washington Department of Fish and Wildlife
Patrick Verhey *	SWG Policy Alternate	Washington Department of Fish and Wildlife
Tony Eldred	SWG Policy Rep.	Washington Department of Fish and Wildlife
Jessica Gonzalez	SWG Policy Rep.	U.S. Fish and Wildlife Service
Steve Lewis	SWG Technical Rep.	U.S. Fish and Wildlife Service

*Joined the meeting at 1pm. ** Phone participant.

Final Call Minutes

Aquatic Settlement Work Group

To: Aquatic SWG Parties **Date**: November 12, 2009

From: Michael Schiewe (Anchor QEA)

re: Final Minutes of October 14, 2009 Aquatic SWG Conference Call

I. Welcome

1. Mike Schiewe opened the meeting. The revised September 9, 2009, meeting minutes were approved. Bob Rose will send Ali Wick a few minor edits for incorporation.

II. Summary of Decisions

1. There were no decision items at this meeting.

III. Summary of Action Items

1. Josh Murauskas will send out a brief summary of the Pacific Lamprey Study for the group's information (Item IV-1).

2. Mike Schiewe will draft a response to Bob Dach (BIA) to clarify and memorialize the non-voting, observer status of the BIA in the Aquatic Settlement Work Group (SWG) (Item IV-2).

3. Douglas PUD will provide BIA's list of Pacific Lamprey Monitoring Plan (PLMP) questions. Douglas PUD will also provide a draft response by October 23 to the Aquatic SWG for review and comment. Following Aquatic SWG agreement to these responses, the responses will be sent to the BIA (Item IV-3).

IV. Summary of Discussions

1. **Pacific Lamprey Study Update** – Josh Murauskas gave an update on the Pacific Lamprey Study. There are several underwater video clips showing fish behavior at Wells Dam. Divers have retrieved the study equipment, and data are currently being analyzed. Mr. Murauskas said that data will likely be ready to share at the next in-person meeting; he will soon send out a brief summary of the study for the group's information.

2. **BIA Participation** – Mike Schiewe said that he has been asked by Bob Dach of BIA to further clarify the observer status of BIA in the Aquatic SWG. Mr. Dach has replied to Dr. Schiewe that the BIA would like its role to include attending meetings and engaging

in discussion. Mr. Dach also indicated BIA's desire to invite others to Aquatic SWG meetings, but he was reminded that all such non-members were subject to approval by the Aquatic SWG, similar to the same requirement for Aquatic SWG members. Mr. Dach and the Aquatic SWG agreed that the Aquatic SWG would routinely monitor how the BIA's involvement in the Aquatic SWG arrangement is working, and modify the arrangement if necessary to continue achieving the SWG goals of providing a forum for Signatories to oversee and implement the ASWG Settlement Agreement. Dr. Schiewe will draft a response to Mr. Dach to clarify and document the status of BIA in the Aquatic SWG. Following Aquatic SWG agreement to the draft response, the response will be sent to the BIA.

3. **BIA Questions on PLMP** – The BIA has sent a list of questions to Douglas PUD asking for clarification of changes that were made by the Aquatic SWG in the PLMP; these changes were made by the Aquatic SWG in response to earlier BIA comments. The Aquatic SWG agreed today that Douglas PUD will forward the questions to the Aquatic SWG for response. The Aquatic SWG asked Douglas PUD to draft a response to the questions on behalf of the SWG by October 23 for Aquatic SWG for review and comment. Following Aquatic SWG agreement to these responses, the responses will be sent to the BIA.

IV. Next Meetings

1. Upcoming meetings: ***Conference calls on November 12, and December 9. In-person meeting at Douglas PUD on January 13, 2010.***

List of Attachments

Attachment A – List of Attendees

Name	Role	Organization
Mike Schiewe	SWG Chair	Anchor QEA, LLC
Ali Wick	Administrative	Anchor QEA, LLC
Josh Murauskas	SWG Technical Rep.	Douglas PUD
Shane Bickford	SWG Policy Rep.	Douglas PUD
Bob Rose	SWG Technical Rep.	Yakama Nation
Bill Towey	SWG Technical Rep.	Colville Confederated Tribes
Pat Irle	SWG Technical Rep.	Washington State Department of Ecology
Molly Hallock	WDFW Technical	Washington Department of Fish and Wildlife
Tony Eldred	SWG Policy Rep.	Washington Department of Fish and Wildlife

Final Call Minutes

Aquatic Settlement Work Group

To: Aquatic SWG Parties **Date**: December 9, 2009

From: Michael Schiewe (Anchor QEA)

re: Final Minutes of November 12, 2009 Aquatic SWG Conference Call

I. Welcome

1. Mike Schiewe opened the meeting. The revised October 14, 2009, meeting minutes were approved as final.

II. Summary of Decisions

1. There were no decision items at this meeting.

III. Summary of Action Items

1. Josh Murauskas will send the Aquatic Settlement Work Group's (SWG's) revised Bureau of Indian Affairs (BIA) responses out to the Aquatic SWG for final review. The Aquatic SWG will send their concurrence by November 19. Then, Mike Schiewe will send the responses to the BIA on behalf of the Aquatic SWG. These responses will be sent as a PDF by email. (Item IV-1).

IV. Summary of Discussions

1. **Aquatic SWG Responses to Pacific Lamprey Monitoring Plan (PLMP) Questions** – Josh Murauskas summarized the proposed Aquatic SWG's draft responses to the BIA questions regarding the Pacific Lamprey Monitoring Plan (PLMP); the BIA questions had been sent to Douglas PUD by Bob Dach. Prior to today's meeting, Douglas PUD prepared draft responses for consideration and review by the Aquatic SWG. The Aquatic SWG discussed and agreed to the draft responses, with several edits discussed on today's call. These edits will be made to the draft responses and Mr. Murauskas will send these responses to the Aquatic SWG for final review. The Aquatic SWG will send their concurrence to these responses by November 19. Then, Mike Schiewe will send the responses to the BIA on behalf of the Aquatic SWG. These responses will be sent as a PDF by email.

2. **Pacific Lamprey Study Update** – Josh Murauskas said that the Pacific lamprey study is progressing well and he expects that study results will be available by late winter.

3. **Discussion of Changes to Annual TDG Report** – Pat Irle said that she will be meeting soon with Douglas and Chelan PUDs to develop a common format/template for the Annual Total Dissolved Gas (TDG) Reports. This will provide consistency between the TDG reports for these projects.

IV. Next Meetings

1. Upcoming meetings: ***Conference call on December 9; in-person meeting at Douglas PUD on January 13, 2010; conference call on February 10, 2010.***

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Role	Organization
Mike Schiewe	SWG Chair	Anchor QEA, LLC
Ali Wick	Administrative	Anchor QEA, LLC
Keith Hatch	Observer	Bureau of Indian Affairs
Bill Towey	SWG Technical Rep.	Colville Confederated Tribes
Josh Murauskas	SWG Technical Rep.	Douglas PUD
Shane Bickford	SWG Policy Rep.	Douglas PUD
Bob Rose	SWG Technical Rep.	Yakama Nation
Steve Lewis	SWG Technical Rep.	U.S. Fish and Wildlife Service
Pat Irle	SWG Technical Rep.	Washington State Department of Ecology
Tony Eldred	SWG Policy Rep.	Washington Department of Fish and Wildlife

APPENDIX B
LIST OF AQUATIC SETTLEMENT WORK GROUP MEMBERS

Aquatic Settlement Work Group Members

Signatory Parties

Organization	Policy Representative	Work Group Representative
Douglas PUD	Shane Bickford	Josh Murauskas
Yakama Nation	Paul Ward	Steve Parker
U.S. Fish and Wildlife	Jessi Gonzales	Steve Lewis
U.S. Bureau of Land Management	Karen Kelleher	Joe Kelly
Washington State Department of Ecology	John Merz	Pat Irle
Washington Department of Fish and Wildlife	Tony Eldred	Bob Jateff
Colville Confederated Tribes	Joe Peone	Bill Towey

Technical Support

Washington Department of Fish and Wildlife	Molly Hallock	Lamprey
Washington Department of Fish and Wildlife	Brad James	Sturgeon

APPENDIX C
AQUATIC SETTLEMENT WORK GROUP 2009 STUDY REPORTS

List of 2009 study reports identified in Section 3.4 to be included in the final annual report:

- 2009 Total Dissolved Gas Modeling and Compliance Report
- 2009 Turbidity Monitoring on the Okanogan River
- 2009 Revised Water Quality Management Plan (WQMP)
- 2009 Revised Pacific Lamprey Management Plan (PLMP), including review comments from Bob Dach, Bureau of Indian Affairs.

TOTAL DISSOLVED GAS MODELING AND COMPLIANCE EVALUATION FOR THE WELLS HYDROELECTRIC PROJECT

FINAL REPORT

July 2009

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Table of Contents

List of Tables

List of Figures

List of Appendices

ABSTRACT

Total dissolved gas (TDG) production dynamics at the Wells Hydroelectric Project (Wells Project) were examined between 2005 and 2009 to identify operational strategies to manage TDG for compliance with state water quality standards (WQS). This report presents a numerical model able to predict the dynamics of spillway surface jets, the hydrodynamics and TDG distribution within the Wells tailrace. The primary goal of this study was to identify Project operations that minimize TDG downstream of the Wells dam. Attention is focused on the underlying physics that govern the TDG distribution under different scenarios.

An unsteady state three-dimensional (3D) two-phase flow model was calibrated and validated using field data collected in the Wells tailrace in 2006. A gas volume fraction of 3% and bubble diameter of 0.5 mm in the spillbays produced TDG values that bracketed the field observations. Once calibrated, the predictive ability of the model was validated by running three different operational conditions tested in 2006. The numerical results demonstrated that the model provides a reliable predictor of tailrace TDG and therefore can be used as a tool to support evaluation of Project operations.

After validation and calibration, the model was used to analyze the sensitivity of TDG concentration to the operation of the Project. Nine model runs were completed for four river flows in which spill was either spread across the spillbays or concentrated in one or more spillbays to analyze the sensitivity of TDG concentration to the operation of the Project. Concentrated spill operations resulted in the lowest predicted TDG concentration downstream of the dam. According to the model, concentrated spill operations reduce the TDG production and increase the degasification at the free surface.

Based on the results from the sensitivity simulations, several additional operating configurations were tested toward identification of the Optimal Operating Configuration for a 7Q10 flow of 246 kcfs. Spill concentrated in adjacent bays resulted in interaction between spillway jets, bubbles traveling deeper into the tailrace, and slightly higher production of TDG. On the other hand, minimum TDG concentrations were observed when the flow was concentrated in bay 7 and the remaining flow distributed in distant bays. The Optimal Operating Configuration produced an average TDG concentration at transect T3 of 117.7%. Numerical results indicated that dilution by downstream mixing and degasification were enhanced with this optimal operation.

Finally, an additional scenario was modeled to provide the Washington State Department of Ecology (Ecology) with results consistent with settings used at other projects for evaluation of compliance with numeric WQS. This model scenario was called the Standard Compliance Scenario. The simulation was conducted using a concentrated spill in adjacent bays, with a 115% forebay TDG and 90% of maximum powerhouse capacity during a 7Q10 flow. The Standard Compliance Simulation produced an average TDG concentration at transect T3 of 116.7%.

In addition to complying with the TDG standards for the Wells tailrace during the fish passage season, Ecology has also requested an analysis of TDG concentrations during periods of (1) spill outside the fish passage season; (2) TDG changes during non-spill events; and, (3) the

relationship between TDG values in the Wells tailrace and those observed in the forebay of Rocky Reach Dam.

TDG production in the Wells tailrace during non-spill is virtually non-existent, with both median and average delta TDG values at 0.0% and 0.0% (SEM ± 0.0%), respectively. The lack of TDG production during non-spill is further supported by a linear regression showing a significant positive correlation between forebay TDG and tailrace TDG ($y = 0.8873x+11.775$; $P < 0.000$, $R^2 = 0.81$). Median forebay TDG and tailrace TDG values during non-spill events over the past 10 years have both been 104%. Only 7 of the 9,599 (0.07%) hourly values recorded during non-spill events between April and September, 1999-2008 surpassed 110% when forebay TDG was ≤ 110% (DART 2009). These results indicate that Wells Dam is able to meet compliance with the 110% TDG tailrace criteria during non-spill events and outside of the fish passage season.

During the fish passage season, daily average TDG values for the Rocky Reach forebay have averaged 106.6% during the years 1999 to 2008. There is a strong and significant positive linear relationship between the hourly tailrace measurements at Wells Dam and hourly forebay measurements at Rocky Reach Dam within each of the 10 years analyzed ($P < 0.00$) and for all ten years combined ($P < 0.00$). The linear equation for the relationship between Wells tailrace and Rocky Reach forebay TDG, based upon the ten year record, indicates that Wells tailrace TDG values can be as high as 117.5% and still maintain compliance with the 115% standard at the Rocky Reach Dam forebay.

In addition to developing a compliance equation based upon the historical hourly TDG values, an equation was developed specifically for hours when the Optimum Operation Condition was utilized in 2007 and 2008. Based upon this equation, not only does the Optimum Operating Condition reduce TDG generation in the Wells tailrace but it also appears to alter the depth that supersatured waters enters the Rocky Reach reservoir, thereby increasing the amount of degassing that takes place within the Rocky Reach reservoir. When operating under the Optimum Operating Condition in 2007 and 2008 the Wells tailrace TDG values can be as high as 119.1% (average 118.2%) and still maintain compliance with the 115% Rocky Reach forebay standard.

Based on the historic rate of TDG attenuation for the Rocky Reach reservoir, the Wells Project is reasonably expected to remain in full compliance with the numeric criteria set forth to ensure that a 115% TDG standard is met at the forebay of the downstream project (Rocky Reach Dam) provided that the Optimal Operating Conditions is used to spill water and incoming TDG values in the Wells forebay are in compliance with the 115% standard.

1.0 INTRODUCTION

1.1 General Description of the Wells Hydroelectric Project

The Wells Hydroelectric Project (Wells Project) is located at river mile (RM) 515.6 on the Columbia River in the State of Washington (Figure 1.1-1). Wells Dam is located approximately 30 river miles downstream from the Chief Joseph Hydroelectric Project, owned and operated by the United States Army Corps of Engineers (COE), and 42 miles upstream from the Rocky Reach Hydroelectric Project, owned and operated by Public Utility District No. 1 of Chelan County (Chelan PUD). The nearest town is Pateros, Washington, which is located approximately 8 miles upstream from the Wells Dam.

The Wells Project is the chief generating resource for the Public Utility District No. 1 of Douglas County (Douglas PUD). It includes ten generating units with a nameplate rating of 774,300 kW and a peaking capacity of approximately 840,000 kW. The design of the Wells Project is unique in that the generating units, spillways, switchyard, and fish passage facilities were combined into a single structure referred to as the hydrocombine. Fish passage facilities reside on both sides of the hydrocombine, which is 1,130 feet long, 168 feet wide, with a top of dam elevation of 795 feet above mean sea level (msl).

The Wells Reservoir is approximately 30 miles long. The Methow and Okanogan rivers are tributaries of the Columbia River within the Wells Reservoir. The Wells Project boundary extends approximately 1.5 miles up the Methow River and approximately 15.5 miles up the Okanogan River. The surface area of the reservoir is 9,740 acres with a gross storage capacity of 331,200 acre-feet and usable storage of 97,985 acre feet at the normal maximum water surface elevation of 781 feet msl (Figure 1.1-1).

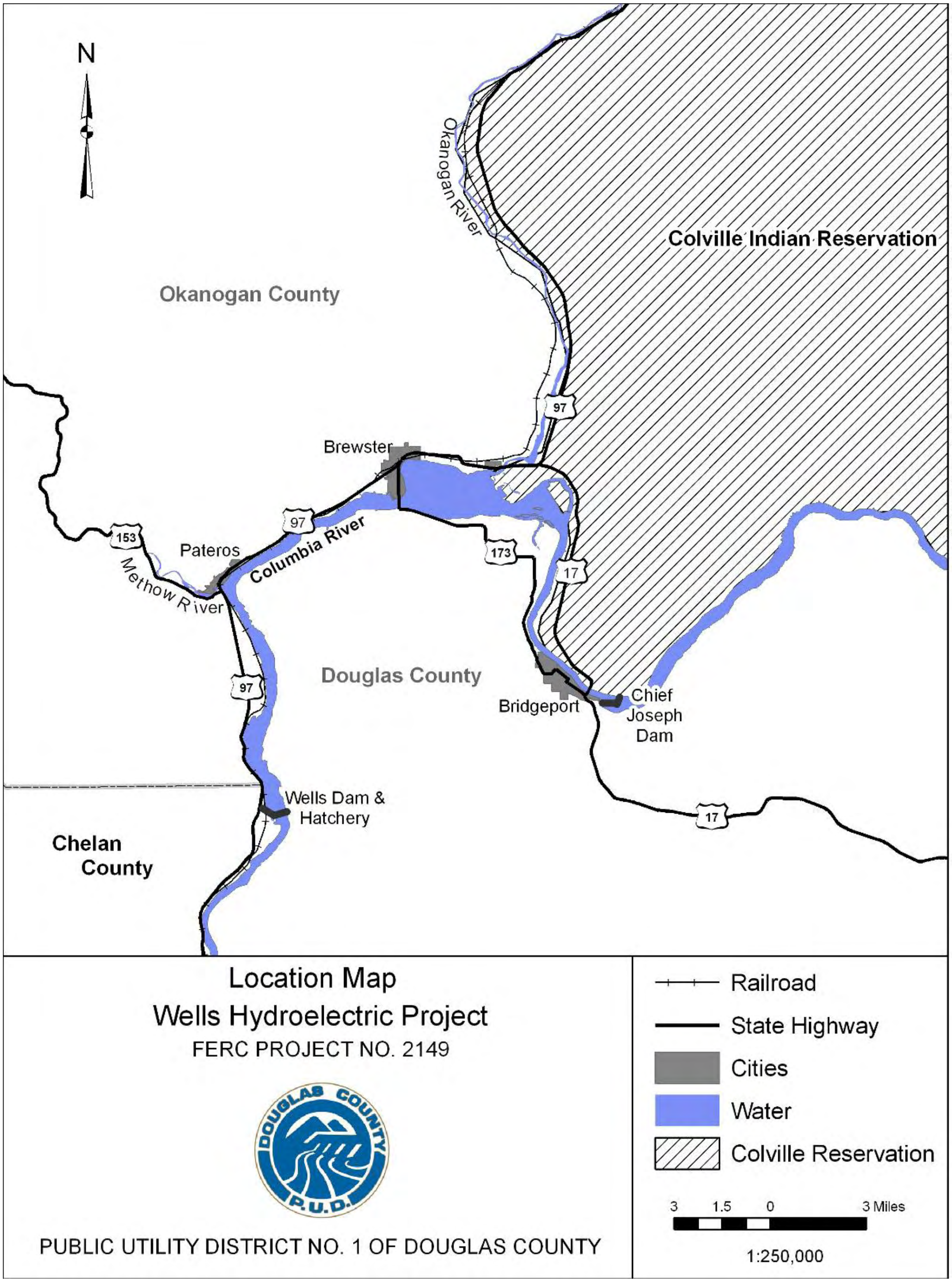

Figure 1.1-1 Location Map of the Wells Hydroelectric Project.

1.2 Overview of Total Dissolved Gas at Wells Dam

The spillway gates at Wells Dam are used to pass water when river flows exceed the maximum turbine hydraulic capacity (forced spill), to assist outmigration of juvenile salmonids (fish bypass spill), and to prevent flooding along the mainstem Columbia River (flood control spill). The Wells Project can pass approximately 22 kcfs through each operating turbine (220 kcfs through 10 turbines) with an additional 10-11 kcfs used to operate the juvenile fish bypass system and 1.0 kcfs to operate the adult fish ladders (ASL Environmental Sciences Inc. 2007). Therefore, spill is forced when inflows are higher than 232 kcfs. Spill may occur at flows less than the hydraulic capacity when the volume of water is greater than the amount required to meet electric system loads. Hourly coordination among hydroelectric projects on the mid-Columbia River was established to minimize unnecessary spill.

Wells Dam is a hydrocombine-designed dam with the spillway situated directly above the powerhouse. Research at Wells Dam in the mid-1980s showed that a modest amount of spill would effectively guide between 92 percent and 96 percent of the downstream migrating juvenile salmonids through the Juvenile Bypass System (JBS) and away from the turbines (Skalski et al., 1996). The operation of the Wells JBS utilizes five spillways that have been modified with constricting barriers to improve the attraction flow while using modest levels of water (Klinge 2005). The JBS will typically use approximately 6-8 percent of the total river flow for fish guidance. The high level of fish protection at Wells Dam has won the approval of the fisheries agencies and tribes and was vital to Douglas PUD meeting the survival standards contained within the Anadromous Fish Agreement and Habitat Conservation Plan (HCP).

State of Washington water quality standards require TDG levels to not exceed 110% at any point of measurement. Due to air entrainment in plunge pools below spillways of hydroelectric dams, TDG levels can sometimes exceed the state standard during spill events at dams. In the State of Washington, there are exceptions allowed to the State's TDG standard. TDG levels are allowed to exceed the standard in order to (1) pass flood flows at the Project of 7Q10 or greater and (2) pass voluntary spill to assist out migrating juvenile salmonids. The 7Q10 flood flow, which is defined as the highest average flow that occurs for seven consecutive days in a once-in-ten-year period, is 246 kcfs at the Wells Project.

2.0 GOALS AND OBJECTIVES

The goal of this study was to optimize spill release configurations at the Wells Project using a validated numerical model to minimize the percent saturation of dissolved gas in the tailrace. Further, descriptive statistics and linear regression techniques are used to demonstrate compliance with TDG criteria outside the fish passage season and at the Rocky Reach forebay monitoring station.

3.0 STUDY AREA

The study area of the numerical model includes approximately 16,500 ft of the Wells tailrace, extending from Wells Dam downstream to transect TW3 (Transect T3) (Figure 3.0-1). Transect TW3 coincides with the Wells TDG compliance monitoring station. The Rocky Reach Dam is located approximately 42 miles downstream of Wells Dam, where the forebay monitor was used to examine degasification through the Wells Dam tailrace and Rocky Reach Dam forebay.

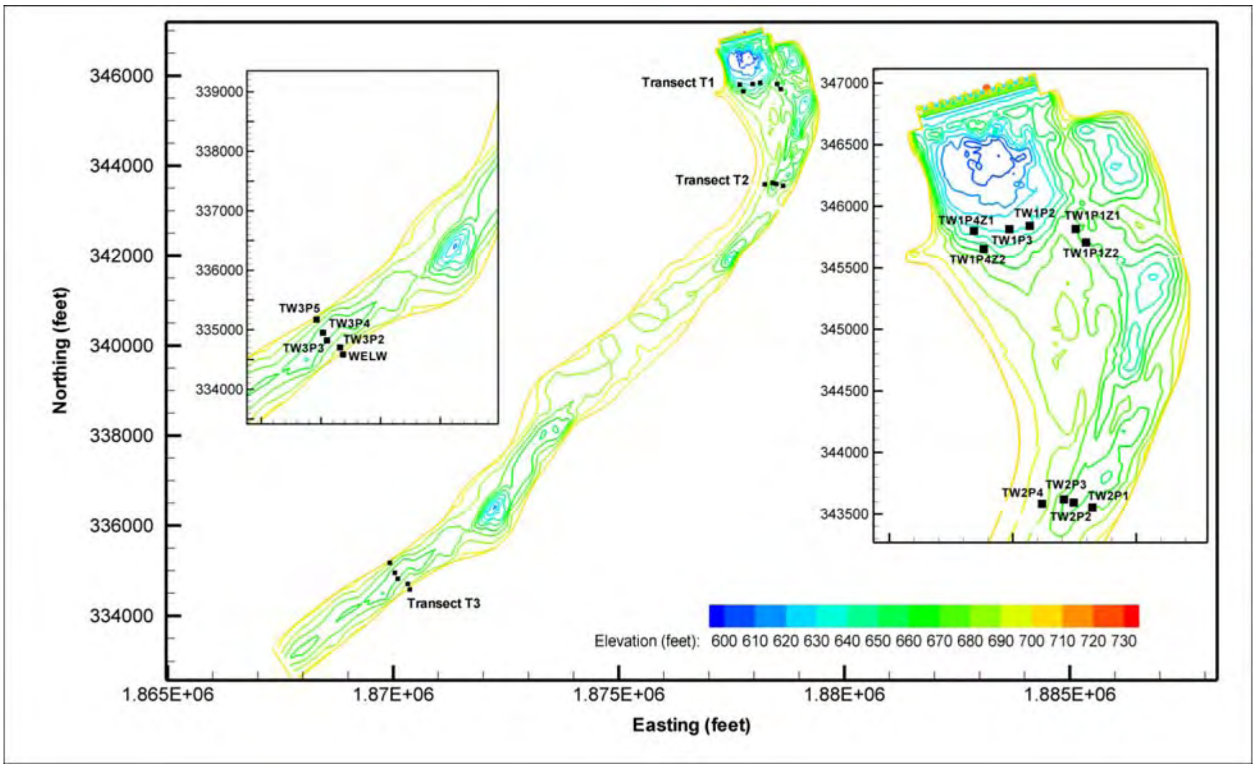

Figure 3.0-1 Study Area for the TDG model.

4.0 BACKGROUND AND EXISTING INFORMATION

4.1 Summary of TDG studies in the Wells Tailrace

Douglas PUD conducted a series of assessments aimed at gaining a better understanding of TDG production dynamics resulting from spill operations at Wells Dam. Each year from 2003 to 2008, Douglas PUD has performed experimental spill operations to document the relationship between water spilled over the dam and the production of TDG.

In 2003 and 2004, Columbia Basin Environmental (CBE) deployed TDG sensors along two transects downstream of Wells Dam. The objectives of this study were to determine the effectiveness of the tailwater sensor and to better understand the relationship between spillway releases and TDG production (CBE 2003, 2004). In a two-week period, the studies showed that the tailwater station provided a reliable record of daily average TDG values in the Wells Dam tailrace.

In spring 2005, Douglas PUD conducted a study to measure TDG pressures resulting from various spill patterns at Wells Dam (CBE 2006). An array of water quality data loggers was installed in the Well tailrace for a period of two weeks between May 23, 2005 and June 6, 2005. The Wells powerhouse and spillway were operated through a controlled range of operational scenarios that varied both total flow and allocation of the spillway discharge. A total of eight configurations were tested including flat spill patterns (near equal distribution of spill across the entire spillway), crowned spill patterns (spill is concentrated towards the center of the spillway), and spill over loaded and unloaded generating units. Results from the study indicated that spill from the west side of the spillway resulted in consistently higher TDG saturations than similar spill from the east side. Flat spill patterns yielded higher TDG saturations than crowned spill for similar total discharges. The results of this study also indicated that TDG levels of powerhouse flows may be influenced by spill.

In 2006, Douglas PUD continued TDG assessments at the Wells Project by examining alternative spill configurations and project operations to minimize the production of TDG. The purpose of the 2006 study was to evaluate how the Project could be operated to successfully pass the 7Q10 river flow while remaining in compliance with Washington State TDG standards. Thirteen sensors were placed along transects in the tailrace located at 1,000, 2,500 and 15,000 feet below Wells Dam. There were also three sensors placed across the forebay. The sensors were programmed to collect data in 15 minute intervals for both TDG and water temperature. Each test required the operations of the dam to maintain stable flows through the powerhouse and spillway for at least a three hour period. While there were 30 scheduled spill events, there were an additional 50 events in which the powerhouse and spillway conditions were held constant for a minimum three hour period. These additional events provided an opportunity to collect TDG data on a variety of Project operations that met study criteria. These are included in the results of the 2006 TDG Abatement Study (EES et al. 2007). Spill amounts ranged from 5.2 to 52.0% of project flow and flows ranged from 2.2 to 124.7 kcfs for spill and 16.4 to 254.0 kcfs for total discharge. There were six tests that were performed at flows that exceeded the Wells Dam 7Q10 flows of 246 kcfs. Results of the study indicated that two operational scenarios, spread spill and concentrated spill (spill from 1 or 2 gates), produced the lowest levels of TDG.

The 2006 study also indicated that the current location of the tailwater TDG compliance monitoring station is appropriate in providing representative TDG production information both longitudinally and laterally downstream of Wells Dam.

4.2 Numerical studies of TDG in Tailraces

Early studies to predict TDG below spillways were based on experimental programs and physical models (Hibbs and Gulliver 1997; Orlins and Gulliver 2000). The primary shortcoming of this approach is that the laboratory models cannot quantitatively predict the change in TDG due to model scaling issues. The approach relies on performance curves that relate flow conditions with past field experiences. This has led to inconsistent results at hydroelectric projects, some being quite successful while others less successful.

Computational fluid dynamics (CFD) modeling offers a powerful tool for TDG and hydrodynamics prediction. In the application to tailrace flows, an understanding of the underlying physics and the capability to model three-dimensional physical phenomena is of paramount importance in performing reliable numerical studies.

The TDG concentration depends on complex processes such as mass transfer between bubbles and water, degasification at the free surface, and TDG mixing. Tailrace flows in the region near the spillway cannot be assumed to have a flat air/water interface which results in the required computation of the free surface shape. As an additional complexity, spillway surface jets may cause a significant change in the flow pattern since they attract water toward the jet region, a phenomenon referred to as water entrainment. Water entrainment leads to mixing and modification of the TDG field. The presence of bubbles has a strong effect on water entrainment. Bubbles reduce the density (and pressure) and effective viscosity in the spillway region and affect the liquid turbulence.

A TDG predictive model must account for the two-phase flow in the stilling basin and the mass transfer between bubbles and water. An unsteady 3D two-phase flow model to predict TDG concentrations in hydropower tailraces was developed by Politano et al. (2007a, 2007b). Variable bubble size and gas volume fraction were calculated by the model to analyze dissolution and the consequent source of TDG. The model assumes anisotropic turbulence and takes into account the effect of bubbles on the flow field and attenuation of normal fluctuations at the free surface. Bubble size and gas volume fraction at the spillway gates were inputs to the model.

5.0 METHODOLOGY

5.1 Model Overview

The models used in this study are based upon the general purpose CFD code FLUENT, which solves the discrete Reynolds Averaged Navier Stokes (RANS) equations using a cell centered finite volume scheme. Two models were used to predict the hydrodynamics and TDG distribution within the tailrace of the Wells Project: a volume of fluid (VOF) model and a rigid-lid non-flat lid model.

The VOF model predicted the flow regime and free-surface for the first 1,000 feet downstream of the dam. The free-surface shape was then used to generate a grid conformed to this geometry and fixed throughout the computation (rigid, non-flat lid approach). After the statistically-steady state was reached, the VOF solution that minimizes the difference between measured and predicted tailwater elevation was selected. Water surface elevations and local slopes derived from simulations using the Hydrologic Engineering Centers River Analysis System (HEC-RAS) were used at the downstream region of the model. The HEC-RAS computations were performed using geometric input files provided by Douglas PUD with a roughness coefficient of 0.035.

The rigid-lid model allowed proper assessment of water entrainment and TDG concentration. The model assumed one variable bubble size, which could change due to local bubble/water mass transfer and pressure. The air entrainment (gas volume fraction and bubble size) was assumed to be a known inlet boundary condition. It must be noted that the choice of bubble size and volume fraction at the spillway bays has an important effect on the level of entrainment and TDG distribution. In this study a reasonable single-size bubble diameter and volume fraction were used at the spillway gates to bracket the experimental TDG data during the model calibration and the same values are used for all computations.

Specific two phase flow models and boundary conditions were implemented into FLUENT through User Defined Functions (UDFs). Two-phase User Defined Scalars (UDSs) transport equations were used to calculate the distribution of TDG and bubble number density.

The model included the main features of the Wells Dam, including the draft tube outlets of the generating units, spillway, top spill in bays 2 and 10 and fish passage facilities (Figure 5.1-1). Bathymetric data supplied by Douglas PUD were used to generate the river bed downstream of the dam. Detail of Figure 5.1-1 shows a cross section through a spillway unit illustrating the Wells Hydrocombine.

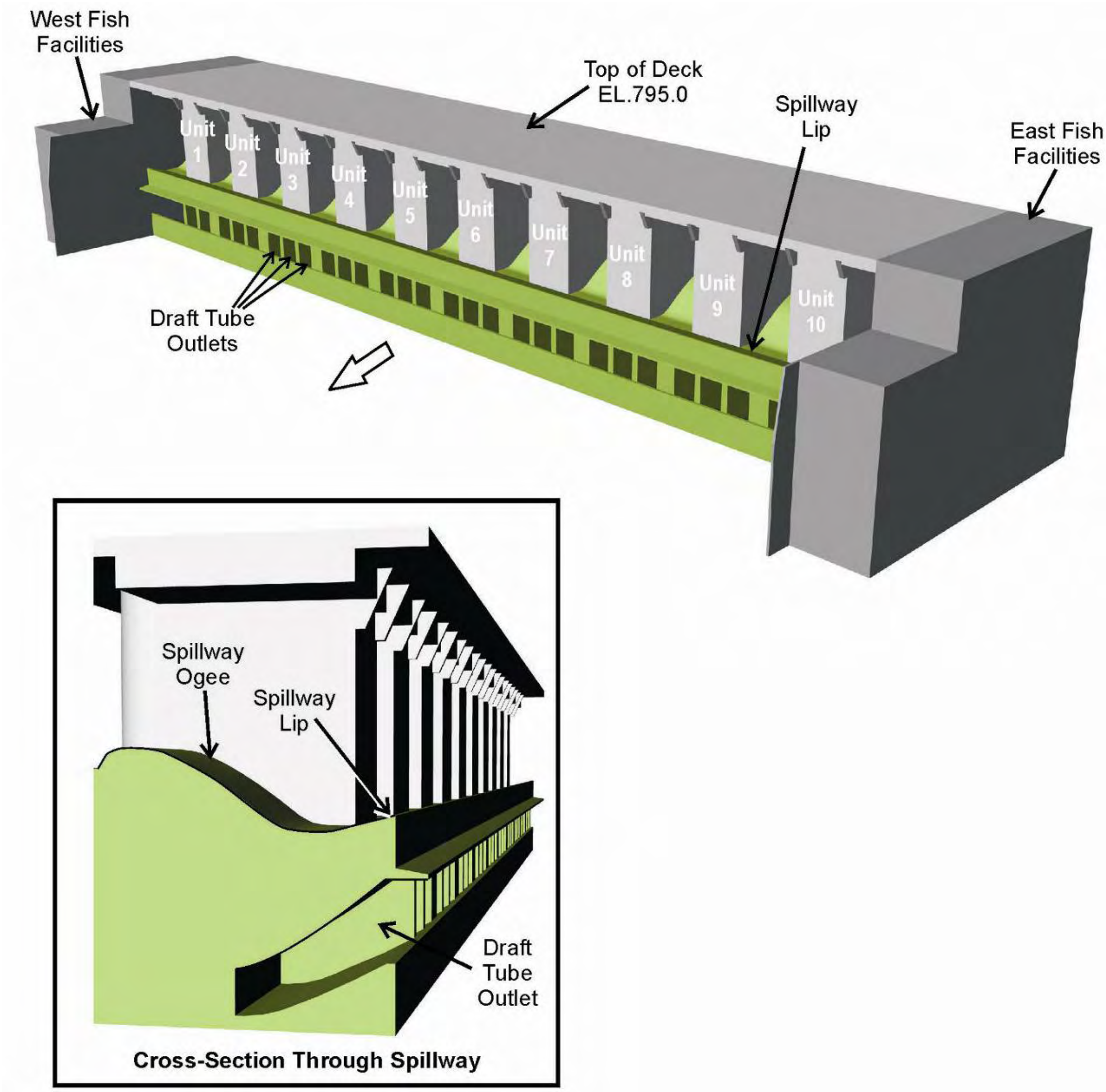

Figure 5.1-1 Structures included in the TDG model.

5.2 VOF Model

5.2.1 Mathematical Model

In the VOF model, the interface between fluids is calculated with a water volume fraction (α_w) transport equation:

$$\frac{\partial \alpha_w}{\partial t} + \vec{v} \cdot \nabla \alpha_w = 0 \qquad (1)$$

Mass conservation requires that $\sum \alpha_i = 1$. The jump conditions across the interface are embedded in the model by defining the fluid properties as: $\varphi = \sum \alpha_i \varphi_i$, where φ is either the density or the viscosity. In the VOF approach, each control volume contains just one phase (or the interface). Points in water have $\alpha_w = 1$, points in air have $\alpha_w = 0$, and points near the interface have $0 < \alpha_w < 1$. The free surface was generally defined in the VOF using an α_w of 0.5.

5.2.2 Grid Generation

The domain was divided into a number of blocks and a structured mesh was generated in each block with common interfaces between the blocks. Each individual block consists of hexahedral cells. To resolve the critical regions of interest, the grids were refined near the solid boundaries, near the turbine intakes and spillway where large accelerations are expected, and near the free surface. The grids containing between 6×10^5 to 8×10^5 nodes were generated using Gridgen V15. Grid quality is an important issue for free surface flow simulations. As fine grids are needed near the interface to minimize numerical diffusion, each simulation required the construction of a particular grid. The grids were constructed nearly orthogonal in the vicinity of the free surface to improve convergence. Figure 5.2-1 shows an overall 3D view of the grid used for the June 5, 2006 simulation. An extra volume at the top of the grid was included to accommodate the air volume for the VOF method.

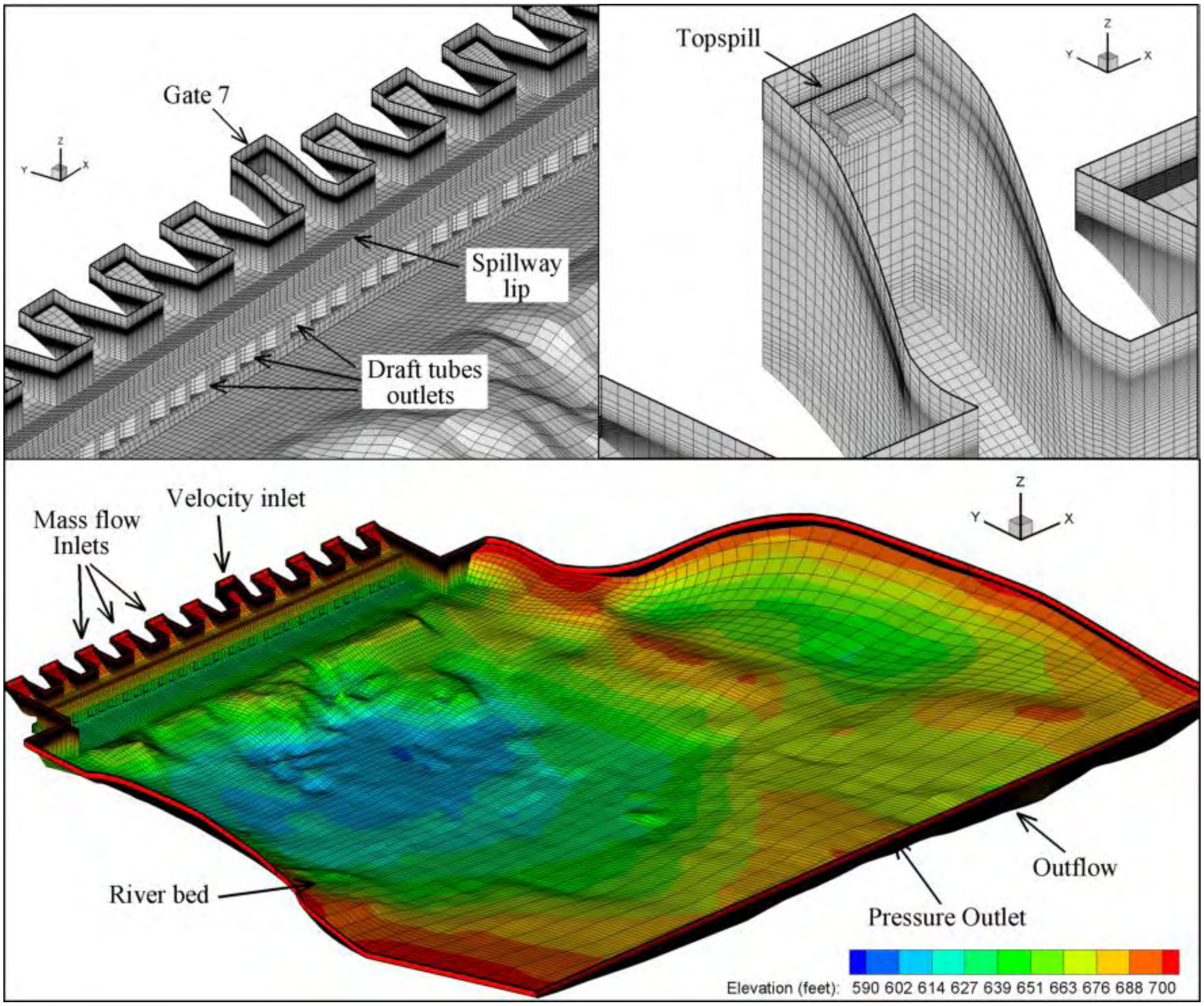

Figure 5.2-1 3D view of a typical grid used for the VOF simulations.

5.2.3 Boundary Conditions

5.2.3.1 Inlet

A given mass flow rate of water assuming uniform velocity distribution was used at each of the turbine units and spillway bays.

5.2.3.2 Walls and River Bed

A no-slip (zero velocity) surface condition was imposed on all walls and tailrace bed.

5.2.3.3 Exit

The free water surface elevation (WSE) was imposed by specifying the water volume fraction distribution. The WSE measured at the tailwater elevation gage was used at the exit (outflow condition in Figure 5.2-1). A hydrostatic pressure was imposed at the outflow using a UDF. At the top of the outflow a pressure outlet boundary condition was used to avoid air pressurization.

5.2.3.4 Top Surface

A pressure outlet boundary condition with atmospheric pressure was applied at the top to allow free air flow and avoid unrealistic pressure.

5.3 Rigid-lid Model

The rigid-lid model is an algebraic slip mixture model (ASMM) that accounts for buoyancy, pressure, drag and turbulent dispersion forces to calculate the gas volume fraction and velocity of the bubbles. The model considers the change of the effective buoyancy and viscosity caused by the presence of the bubbles on the liquid and the forces on the liquid phase due to the non-zero relative bubble-liquid slip velocity.

5.3.1 Mathematical Model

5.3.1.1 Mass and Momentum Conservation for the Mixture

The two phase model provides mass and momentum equations for the liquid and gas phases (Drew & Passman 1998). Summing the mass and momentum equations for each phase results in continuity and momentum equations for the mixture gas-liquid phase:

$$\frac{\partial \rho_m}{\partial t} + \nabla \cdot \left[\rho_m \vec{u}_m \right] = 0 \tag{2}$$

$$\frac{\partial}{\partial t}\left(\rho_m \vec{u}_m \right) + \nabla \cdot \left(\rho_m \vec{u}_m \vec{u}_m \right) = -\nabla P + \nabla \cdot \left[\boldsymbol{\sigma}_m^{\mathrm{Re}} + \boldsymbol{\tau}_m \right] + \rho_m \vec{g} - \nabla \cdot \left(\sum_{k=g,l} \alpha_k \rho_k \vec{u}_k \vec{u}_{dr,k} \right) \tag{3}$$

where P is the total pressure, $\vec{g}$ is the gravity acceleration, and $\boldsymbol{\sigma}_m^{\mathrm{Re}}$ and $\boldsymbol{\tau}_m = \rho_m \nu_m \left(\nabla \vec{u}_m + \nabla \vec{u}_m^T \right)$ are the turbulent and molecular shear stresses, respectively. ρ_m , μ_m and $\vec{u}_m$ are the mixture density, viscosity and mass-averaged velocity defined as $\rho_m = \sum_{k=g,l} \alpha_k \rho_k$, $\mu_m = \sum_{k=g,l} \alpha_k \mu_g$ and $\vec{u}_m = \frac{1}{\rho_m} \sum_{k=g,l} \alpha_k \rho_k \vec{u}_k$, with α_g the gas volume fraction. The subscripts *g, l* and *m* denote gas, liquid and mixture, respectively. $\vec{u}_{dr,k}$ is the drift velocity defined as the velocity of the phase k relative to the mixture velocity.

The gas density is calculated using the ideal gas law $\rho_g = M\,P/(RT)$ with P the pressure, M the molecular weight of air, R the universal gas constant, and T the absolute temperature.

5.3.1.2 Mass Conservation for the Gas Phase

The continuity equation for the gas phase is (Drew & Passman 1998):

$$\frac{\partial}{\partial t}\left(\alpha_g\,\rho_g\right) + \nabla\cdot\left(\alpha_g\,\rho_g\,U_{g,i}\right) = -S \tag{4}$$

where $\vec{u}_g$ is the bubble velocity and S is a negative gas mass source; in this application the TDG source due to the air transfer from the bubbles to the liquid.

5.3.1.3 Momentum Conservation for the Gas Phase

The ASMM assumes that the inertia and viscous shear stresses are negligible compared to pressure, body forces and interfacial forces in the momentum equation of the gas phase (Antal et al. 1991; Lopez de Bertodano et al. 1994; Manninen et al. 1997):

$$0 = -\alpha_g\,\nabla P + \alpha_g\,\rho_g\,\vec{g} + \vec{M}_g \tag{5}$$

where $\vec{M}_g$ represents the interfacial momentum transfer between the phases.

5.3.1.4 Bubble Number Density Transport Equation

Most of the two fluid models in commercial codes (Fluent, CFX, CFDLib, among others) assume a mean constant bubble size with a given relative velocity (Chen et al. 2005). In tailrace flows the use of a mean constant bubble size for the evaluation of the bubble-liquid mass transfer and interfacial forces is not valid. As a consequence of the complex processes of generation, breakup, and coalescence, the bubbles resulting from air entrainment have different sizes. These processes occur at the plunging jet region immediately after the spillway, where the gas volume fraction and turbulence can be large. The model used in this study is intended for the region downstream of the plunging jet, where bubble size changes mainly due to mass transfer and pressure variations, and therefore bubble breakup and coalescence processes can be neglected. This assumption is considered a reasonable hypothesis for low gas volume fractions (Politano et al. 2007b).

Let $f\,dm\,d\vec{r}$ represent the number of bubbles with original (at the insertion point, before any physical process modifies the bubble mass) mass m, located within $d\vec{r}$ of $\vec{r}$ at time t. The Boltzmann transport equation for f is:

$$\frac{\partial f}{\partial t} + \nabla\cdot\left[\vec{u}_g\;f\right] + \frac{\partial}{\partial m}\left[\frac{\partial m}{\partial t}\,f\right] = 0 \tag{6}$$

Note that this is a Lagrangian representation, and thus *f* has a different interpretation than the usual Eulerian approach (Guido-Lavalle et al. 1994; Politano et al. 2000). Integration of Eq. (6) for bubbles of all masses results in a transport equation for the bubble number density N :

$$\frac{\partial N}{\partial t} + \nabla \cdot \left[\vec{u}_g \, N \right] = 0 \tag{7}$$

The bubble radius is calculated from $R = \left[3\alpha / (4\pi N) \right]^{1/3}$.

5.3.1.5 Two-phase TDG Transport Equation

TDG is calculated with a two-phase transport equation (Politano et al. 2007b):

$$\frac{\partial \alpha_l \, C}{\partial t} + \nabla \cdot \left(\vec{u}_l \, \alpha_l \, C \right) = \nabla \cdot \left(\left(\nu_m + \frac{\nu_t}{Sc_C} \right) \alpha_l \, \nabla C \right) + S \tag{8}$$

where C is the TDG concentration, and ν_m and ν_t are the molecular and turbulent kinematic viscosity, respectively. In this study, a standard Schmidt number of $Sc_C = 0.83$ is used.

5.3.1.6 Turbulence Closure

In this study a Reynolds Stress Model (RSM) was used. The ASMM assumes that the phases share the same turbulence field. The turbulence in the mixture phase is computed using the transport equations for a single phase but with properties and velocity of the mixture. The transport equations for the Reynolds stresses $\boldsymbol{\sigma}^{\mathrm{Re}}_{i,j} = \rho_m \overline{u'_{m,i} \, u'_{m,j}}$ are:

$$\frac{\partial \boldsymbol{\sigma}^{\mathrm{Re}}}{\partial t} + \left(\nabla \cdot \vec{u}_m \right) \boldsymbol{\sigma}^{\mathrm{Re}} + \vec{u}_m \left(\nabla \cdot \boldsymbol{\sigma}^{\mathrm{Re}} \right) = \nabla \cdot \left[\rho_m \frac{\nu_m^t}{\sigma_R} \nabla \boldsymbol{\sigma}^{\mathrm{Re}} \right] - \mathbf{P} + \boldsymbol{\varphi} + \boldsymbol{\varepsilon} + \mathbf{S}_{\boldsymbol{\sigma}} \tag{9}$$

where the stress production tensor is given by $\mathbf{P} = \boldsymbol{\sigma}^{\mathrm{Re}} \cdot \nabla \vec{u}_m^T + \left(\boldsymbol{\sigma}^{\mathrm{Re}} \cdot \nabla \vec{u}_m^T \right)^T$, $\boldsymbol{\varepsilon} = 2/3 \mathbf{I} \, \rho_m \, \varepsilon$ and $\sigma_R = 0.85$. The pressure-strain tensor $\boldsymbol{\varphi}$ is calculated using the models proposed by Gibson and Lander (1978), Fu et al. (1987) and Launder (1989). In this study, $\mathbf{S}_{\boldsymbol{\sigma}}$ represents the effect of the bubbles on the Reynolds stresses. The transport equation for the turbulent dissipation rate reads:

$$\frac{\partial}{\partial t} \left(\rho_m \, \varepsilon \right) + \nabla \cdot \left(\rho_m \, \vec{u}_m \, \varepsilon \right) = \nabla \cdot \left[\rho_m \left(\nu_m + \frac{\nu_m^t}{\sigma_\varepsilon} \right) \nabla \varepsilon \right] - C_{\varepsilon 1} \, \rho_m \, \frac{1}{2} \mathrm{Tr} \left(\mathbf{P} \right) \frac{\varepsilon}{k} - C_{\varepsilon 2} \, \rho_m \, \frac{\varepsilon^2}{k} + S_\varepsilon \tag{10}$$

with $C_{\varepsilon 1} = 1.44$, $C_{\varepsilon 2} = 1.92$, and $\sigma_{\varepsilon} = 1$. The turbulent kinetic energy is defined as $k = \frac{1}{2\rho_m} \mathrm{Tr}(\boldsymbol{\sigma})$. The source term S_{ε} accounts for the effect of the bubbles on the turbulent dissipation rate. The turbulent kinematic viscosity is computed as in the $k-\varepsilon$ models using $\nu_t = C_{\mu} k^2 / \varepsilon$, with $C_{\mu} = 0.09$.

5.3.1.7 Constitutive Equations

In order to close the model, interfacial transfer terms emerging from the relative motion between the bubbles and the continuous liquid need to be modeled.

Interfacial momentum

Since in this particular application there are no significant velocity gradients or flow accelerations (in the bubble scale), most interfacial forces such as lift and virtual mass are negligible compared with drag and turbulent dispersion forces:

$$\vec{M}_g = \vec{M}_g^D + \vec{M}_g^{TD} \tag{11}$$

where $\vec{M}_g^D$ and $\vec{M}_g^{TD}$ are the drag and turbulent dispersion terms. The drag force can be modeled as (Ishii and Zuber 1979):

$$\vec{M}_g^D = -\frac{3}{8} \rho_m \alpha_g \frac{C^D}{R} \vec{u}_r |\vec{u}_r| \tag{12}$$

where $\vec{u}_r$ is the relative velocity of the gas phase respect to the liquid phase. Most of the numerical studies use drag correlations based on rising bubbles through a stagnant liquid proposed by Ishii & Zuber (1979) (see Lane et al. 2005):

$$C^D = \begin{cases} \dfrac{24}{\mathrm{Re}_b} & if\ R < 0.0002 \\ \dfrac{24\left(1 + 0.15\,\mathrm{Re}_b^{0.867}\right)}{\mathrm{Re}_b} & if\ 0.0002 < R < 0.0011 \end{cases} \tag{13}$$

where $\mathrm{Re}_b = 2\rho_l |\vec{u}_r| R / \mu_l$ is the bubble Reynolds number. The turbulent dispersion term is modeled as (Carrica et al. 1999):

$$\vec{M}_g^{TD} = -\frac{3}{8} \frac{\nu^t}{Sc_b} \rho_m \frac{C^D}{R} |\vec{u}_r| \nabla \alpha_g \tag{14}$$

where $Sc_b = \nu^t / \nu^b$ is the bubble Schmidt number. Following Carrica et al. (1999), $Sc_b = 1$ is used.

Bubble dissolution and absorption

The rate of mass transfer is computed considering that the air is soluble in water and obeys Henry's law and that the air molar composition is that of equilibrium at atmospheric pressure, which implies that the air is considered a single gas with molar averaged properties. The mass flux from gas to liquid can be expressed by (Deckwer 1992; Politano et al. 2007b):

$$S = 4\pi N R^2 k_l \left(\frac{P + \sigma/R}{He} - C \right) \tag{15}$$

where σ is the interfacial tension and He is the Henry constant. The second term on the RHS of Eq. (15) accounts for the effect of the interfacial tension on the equilibrium concentration. The effect of temperature on the Henry constant is modeled using the Van 't Hoff equation:

$$He(T) = He(T_o) \exp\left[-C_T \left(\frac{1}{T} - \frac{1}{T_o} \right) \right] \tag{16}$$

where T is the absolute temperature and T_o refers to the standard temperature (298 K). A constant for air $C_T = 1388\,K$ is used in this model.

Takemura and Yabe (1998) proposed a correlation for the mass transfer coefficient of spherical rising bubbles, where the turbulence is generated by the rising bubbles:

$$k_l^{rb} = \frac{D\,Pe_b^{0.5}}{\sqrt{\pi} R} \left(1 - \frac{2}{3\left(1 + 0.09\,\mathrm{Re}_b^{2/3}\right)^{0.75}} \right) \tag{17}$$

where D is the molecular diffusivity and the bubble Peclet number is $Pe_b = 2\left|\overrightarrow{u_r}\right| R / D$.

External turbulence could be important in flows downstream of spillways, mainly in regions of high shear near the walls and where the plunging jet impacts and enhances the mass transfer. In this application, the mass transfer coefficient can be calculated using the expression proposed by Lamont and Scott (1970):

$$k_l^t = 0.4\,Sc^{-1/2} (\nu\,\varepsilon)^{1/4} \tag{18}$$

where $Sc = D/\nu$. In this study, the same order of magnitude is obtained from Eqs. (17) and (18), thus the maximum mass transfer coefficient between bubbles rising in stagnant liquid (k_l^{rb}) and bubbles in turbulent flow (k_l^t) is used: $k_l = \max\left(k_l^{rb}, k_l^t\right)$.

5.3.2 Grid Generation

The Wells tailrace structures and the bathymetry are meshed with structured and unstructured multi-block grids containing only hexahedral elements, using Gambit and Gridgen V15. Typical grid sizes are in the range of $7\ 10^5$ to $1\ 10^6$ nodes. Figure 5.3-1 shows typical grids used for the rigid-lid model. Details (a) and (b) show free surface shapes for spread and concentrated flows, respectively. Detail (c) shows the unstructured grid, extended from approximately 1,500 feet to 3,500 feet downstream of the Wells Dam, used to reduce grid size and improve aspect ratio.

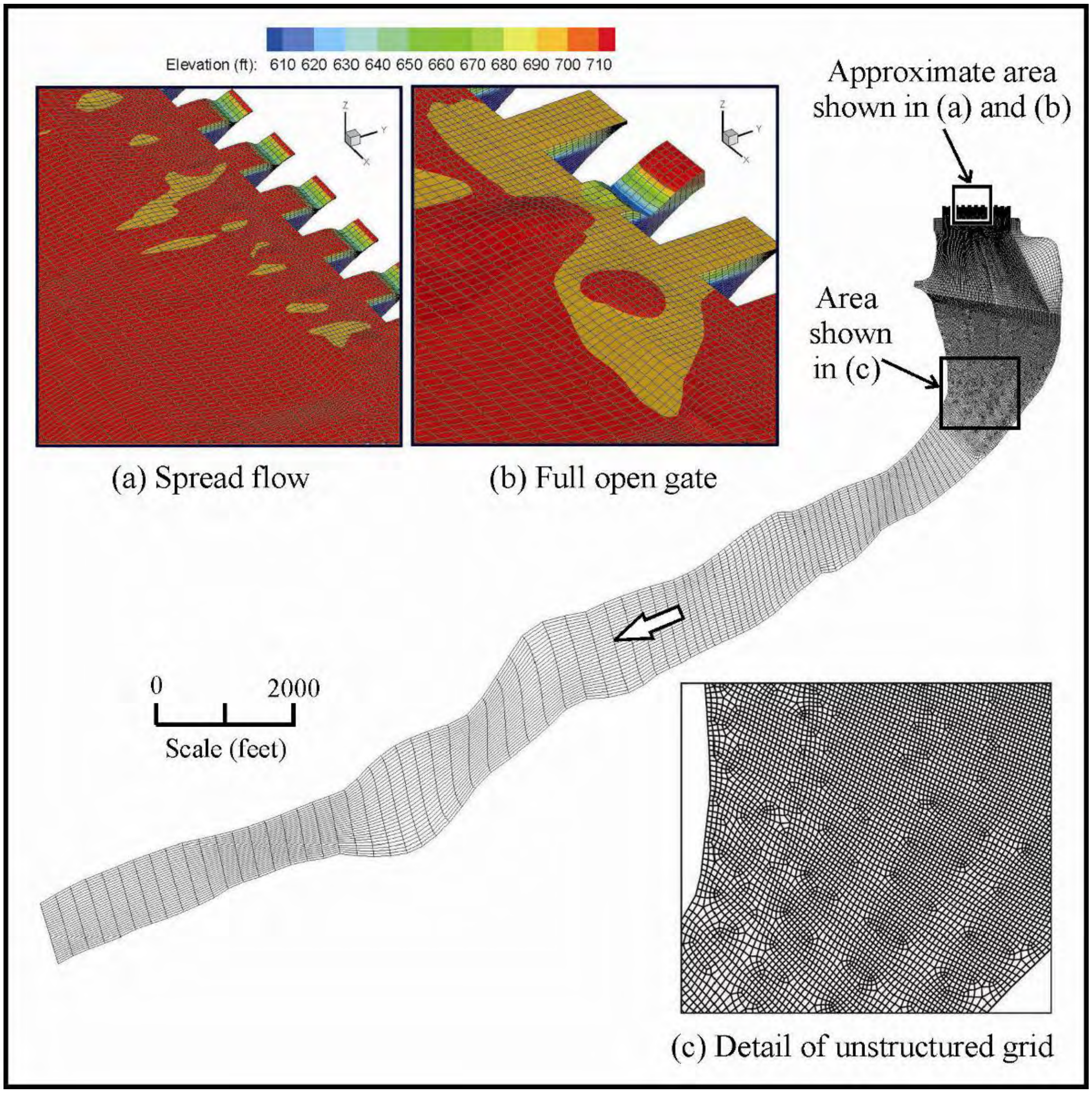

Figure 5.3-1 3D view of a typical grid used for the rigid-lid simulations.

5.3.3 Boundary Conditions

5.3.3.1 Free Surface

Kinematic and dynamic boundary conditions enforcing zero normal velocity fluctuations at the free surface are programmed through UDFs. Details of the implementation of the boundary conditions used for the Reynolds stress and velocity components are found in Turan et al. (2007).

In order to allow the gas phase to flow across the interface, the normal component of the gas velocity at the free surface is calculated using a mass balance for the gas phase in each control volume contiguous to the interface. The resulting equation is implemented using UDFs.

For the TDG concentration, a Neumann boundary condition is used. A mass transfer coefficient at the free surface of $k_l = 0.0001$ m/s as measured by DeMoyer et al. (2003) for tanks and bubble columns is used.

5.3.3.2 Walls and River Bed

The sides and the river bed are considered impermeable walls with zero TDG flux. For the gas phase, no penetration across walls is imposed.

5.3.3.3 Exit

The river exit is defined as an outflow. A zero gradient condition was programmed for the TDG concentration and bubble number density.

5.3.3.4 Spillbays and Powerhouse Units

Uniform velocities with constant gas volume fraction of $\alpha = 0.03$ and bubble diameter 5 mm are used for the 11 bays in the spillway region. The gate opening for a give spill flow rate was selected based on the forebay elevation and spillway gate rating provided by Douglas PUD.

It is assumed that air is not entrained with the turbine inflow. The TDG concentration measured in the forebay is used at the spillway bays and powerhouse units.

5.4 Modeling Assumptions and Model Inputs

5.4.1 Model Assumptions

The model used in this study assumes that:

- Gas and liquid phases are interpenetrating continua. Since the volume of a phase cannot be occupied by the other phases, the concept of volume fraction is used.
- A local equilibrium over short spatial length scale is assumed. Therefore, the gas-liquid relative velocity can be calculated with algebraic equations.
- The liquid phase is considered incompressible.
- The turbulence can be described by the RSM turbulence model.

- The free surface shape, computed from VOF simulations, is not affected by the presence of bubbles. The presence of bubbles is accounted in the two-phase rigid-lid model.
- The air is considered a unique gas with molar averaged properties.
- Bubble size changes mainly due to mass transfer and pressure and breakup and coalescence are negligible.

5.4.2 Model Inputs

The bubble size and gas volume fraction at the inlet (spillway bay gates) are model parameters selected based upon the calibration of the model.

Environmental factors such as forebay TDG, forebay elevation, and water temperature are based upon historical data most likely to occur during flows equal to or greater than the 7Q10 flow of 246 kcfs.. The conditions were based on hourly observations recorded between April and September throughout the ten-year period 1999-2008 (daily average flows ≥ 200 kcfs did not occur outside of the April to September time frame; DART Hourly Water Quality Composite Report www.cbr.washington.edu/dart/hgas_com.html).

5.4.2.1 Environmental Conditions

The environmental data described above (43,200 hourly records) were subsequently filtered to include values in which outflow was equal to or greater than 200 kcfs to represent high flow conditions at Wells Dam (2,941 hourly records). Temporal distribution of hourly values (by week of the year) range from early April to early September, with the middle quartiles (25% to 75%) occurring between weeks 23 and 26 (4-June and 25-June). Median values of the distribution occur at week 24. Hourly flow measurements averaged 221 kcfs (±18 kcfs SD) during these 'high flow' events, though 50% (median) of flows were ≤ 215 kcfs and only 12% of values exceeded 246 kcfs. Water temperatures during these occurrences range from 4.1-19.7°C, with a median temperature of 13.0°C (Figure 5.4-1). Forebay TDG during these occurrences (≥ 200 kcfs) range from 99.9-120.1% with a median TDG of 112.5 % (Figure 5.4-2). Average daily forebay elevations were also collected from DART throughout the same period (1999-2008; www.cbr.washington.edu/dart/river.html). When average daily flows were ≥ 200 kcfs, forebay elevation ranges from 775-781 feet, with a median elevation of 779.6 feet (Figure 5.4-3; note that the five outliers ~ 775 feet occurred consecutively between June 4th and June 8th, 2002). Since the distributions of the three values needed for model input (water temperature, forebay TDG, and forebay elevation) have a slightly negative or 'left' skew (that is, mean values are slightly less than median values), the median values, rounded to the nearest whole number or percent, were used to best represent environmental conditions under high-flow events.

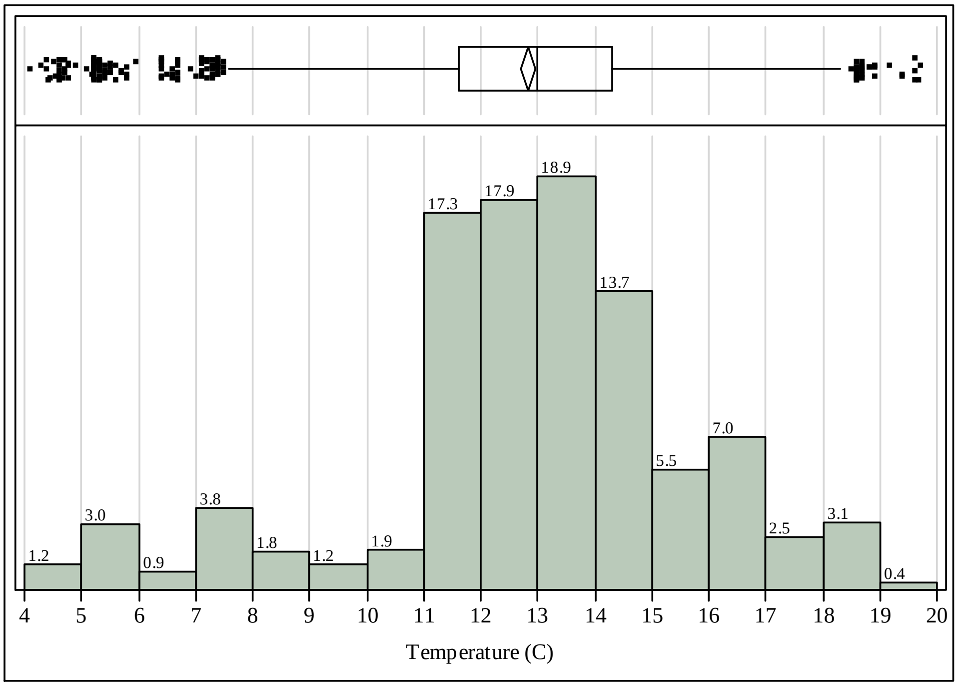

Figure 5.4-1 **Distribution of water temperatures (°C) during flows equal to or greater than 200 kcfs between April and September, 1999-2008. Percent occurrence of values is shown above histogram bars.**

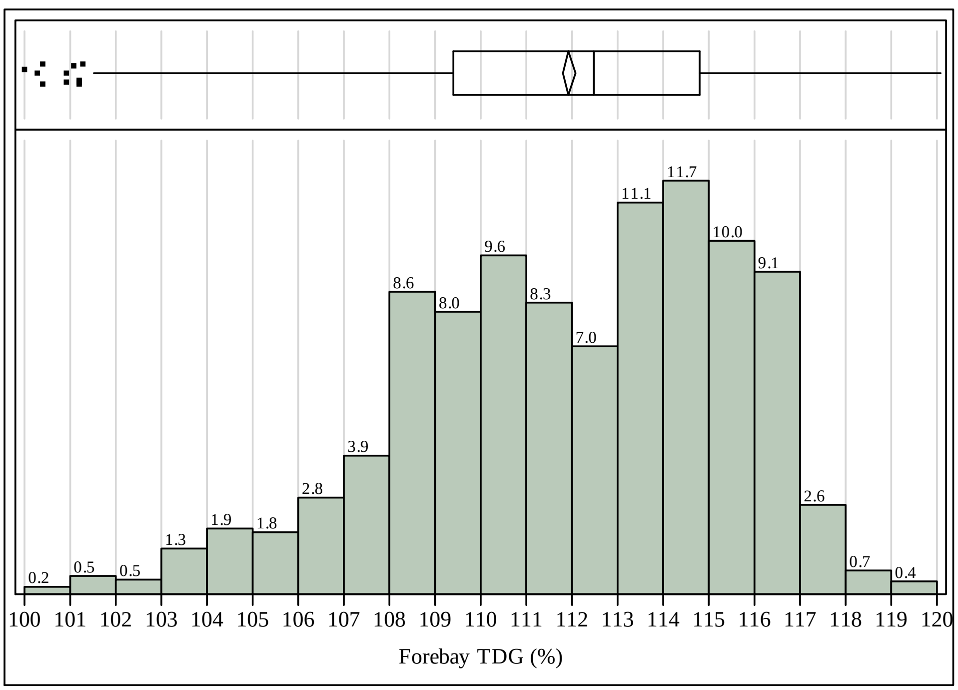

Figure 5.4-2 **Distribution of forebay TDG (%) during flows equal to or greater than 200 kcfs between April and September, 1999-2008. Percent occurrence of values is shown above histogram bars.**

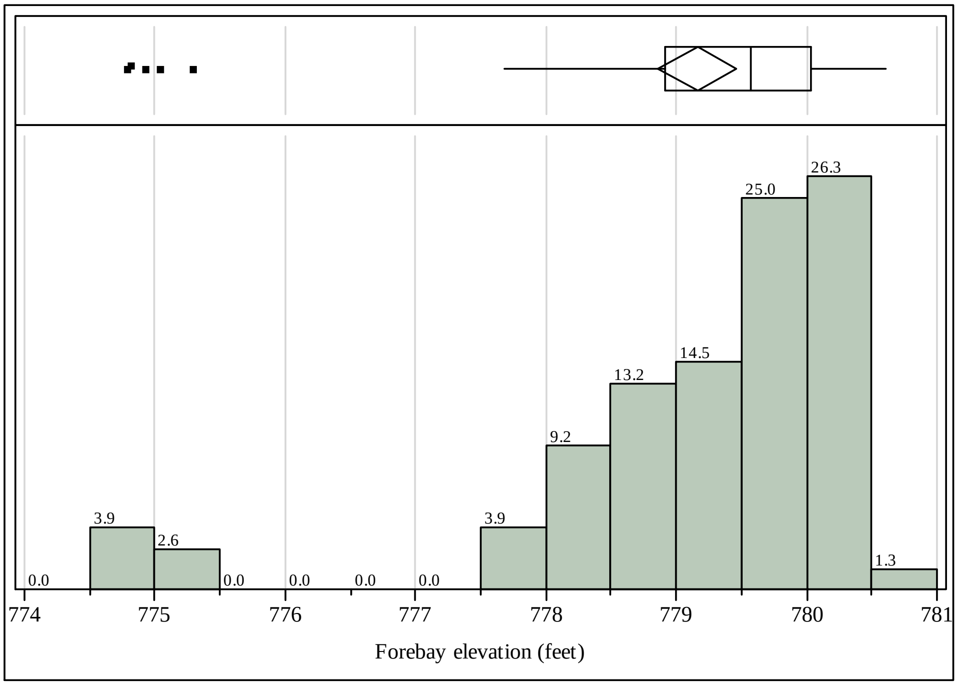

Figure 5.4-3 Distribution of forebay elevations (feet) during daily average flows equal to or greater than 200 kcfs, 1999-2008. Percent occurrence of values is shown above histogram bars.

6.0 NUMERICAL METHOD

The computations were performed using 4 processors of a Linux cluster with 2 GB of memory per processor and in three dual socket dual core Xeon Mac Pro systems.

6.1 VOF Model

The discrete RANS equations and Eq. (1) were solved sequentially (the segregated option in Fluent) and coupled to a realizable $k-\varepsilon$ model with wall functions for turbulence closure. The pressure at the faces is obtained using the body force weighted scheme. The continuity equation was enforced using a Semi-Implicit Method for Pressure-Linked (SIMPLE) algorithm. A modified High Resolution Interface Capturing (HRIC) scheme was used to solve the gas volume fraction.

Unsteady solutions were obtained using variable time-step between 0.001 to 0.01 seconds. Typically, two to three nonlinear iterations were needed within each time step to converge all variables to a L_2 norm of the error $<10^{-3}$. The flow rate at the exit and the elevation at the tailwater elevation gauge location were selected as convergence parameters.

6.2 Rigid-lid Model

The ASMM model equations were solved sequentially. The VOF and rigid-lid simulations were performed using the same discretization schemes for the continuity and pressure equations. A first order upwind scheme was used for the gas volume fraction and Reynolds stress components.

Unsteady solutions were obtained using a fixed time-step of 10 seconds. In order to improve convergence, the model was first run assuming single-phase flow and then bubbles were injected into the domain. The rigid-lid model was computed in typically 7 hours (2 days of computation time) to obtain a steady condition for the flow field and TDG concentration.

7.0 VALIDATION AND CALIBRATION OF THE MODEL

7.1 Simulation Conditions

The ability of the model to predict the TDG distribution and hydrodynamics was evaluated using field data collected for a period of six weeks between May 14, 2006 and June 28, 2006, during the TDG production dynamics study (EES et al. 2007). Velocities were measured on three transects in the near field region of the Wells tailrace on June 4, 2006 and June 5, 2006. Figure 3.0-1 shows the 15 stations where TDG sensors were deployed during the field study.

7.1.1 Calibration

The model was calibrated with data collected on June 4 and June 5, 2006, referred to as treatments 46 and 47 in the report by EES et al. (2007). The spillway flow was spread across all spillbays on June 4 and concentrated in a single spillbay on June 5. Total river flows during these treatments were 172.4 kcfs and 222.3 kcfs, respectively. Tables in Appendix A summarize plant operations, TDG saturation in the forebay, and tailwater and forebay elevations on these days. Powerhouse and spillway units are numbered from west to east.

7.1.2 Validation

The predictive ability of the numerical model was validated using three different spillway conditions tested in 2006. The three spillway conditions are: treatment 1-Full Gate (FG); treatment 11-FG; and treatment 63-Concentrated (C). The FG designates the use of a single spill bay whereas C designates a crowned spill pattern. Total river flows during these treatments were 120.4 kcfs, 157.2 kcfs and 205.5 kcfs, respectively. Plant operation and tailwater elevations associated with each of the treatments are tabulated on Tables in Appendix A.

7.2 VOF Model Results

The objectives for the calibration and verification VOF simulations were to establish a steady state solution that yield a flow field, including spillway jet regimes, consistent with that was observed in the field.

7.2.1 Calibration

The calibration cases were run in a domain of approximately 3,000 ft downstream of the dam. Zero velocities and turbulence were used as initial conditions in the entire domain.

The convergence parameters for the calibration cases were:

$$46S - June\ 4, 2006 \rightarrow \left(flowrate : 172.4\ kcfs, WSE : 717.3\ ft \right)$$
$$47FG - June\ 5, 2006 \rightarrow \left(flowrate : 222.3\ kcfs, WSE : 720.2\ ft \right)$$

Horizontal lines in Figure 7.2-1 show the target flow rate (blue line) and WSE at the tailwater elevation gage (green line). The evolution of the simulations for the calibration cases is illustrated in Figure 7.2-1; blue lines represent the flow rate at the exit and the green lines the free surface elevation. It was found that statistically steady solutions were obtained at approximately 30 minutes, which required about 60 days of computation time.

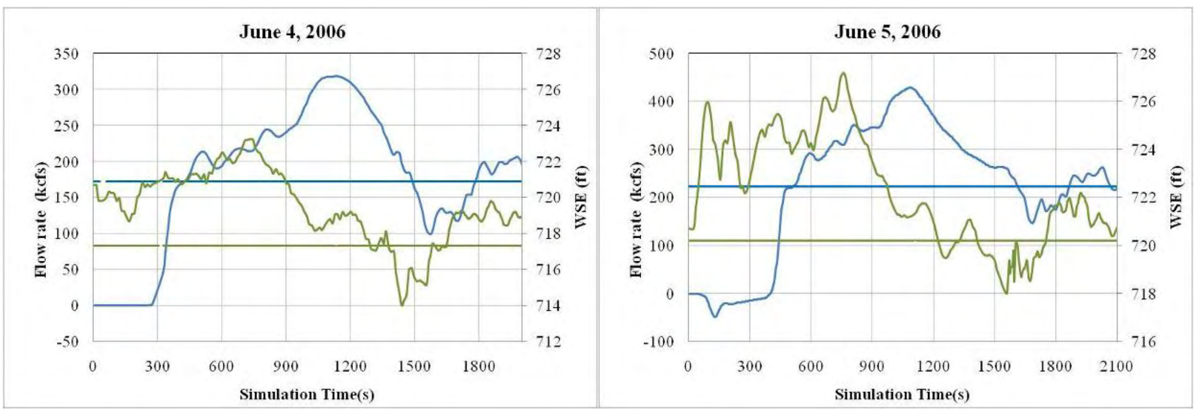

Figure 7.2-1 Evolution of the flow rate at the exit (blue line) and free surface elevation (green line) for June 4, 2006 and June 5, 2006. Horizontal lines represent target values.

Figure 7.2-2 shows an isosurface of gas volume fraction $\alpha_w = 0.5$ representing the free-surface location used to create the top of the rigid-lid grid for the June 4, 2006 simulation. In Figure 7.2-3 a horizontal slice at 27 ft from the free-surface (top) and a vertical section at the center of spillway bay 7 (bottom) show the predicted flow field with the VOF method. Red and blue contours represent water and air, respectively. For clarity, predicted velocity vectors were interpolated in structured uniform grids. Almost uniform flow is observed close to the spillway during the spread flow operation. Surface jets are predicted in all the spillway bays due to elevated tailwater levels. In addition, water flow from the powerhouse units prevented the spillway jet from plunging to depth within the stilling basin.

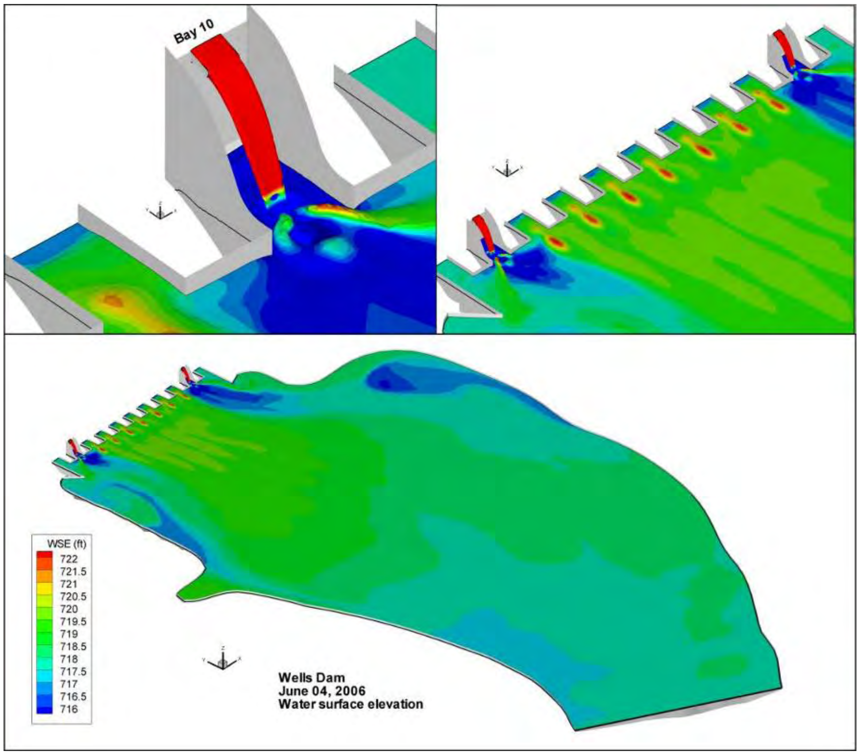

Figure 7.2-2 Predicted free surface shape for June 4, 2006.

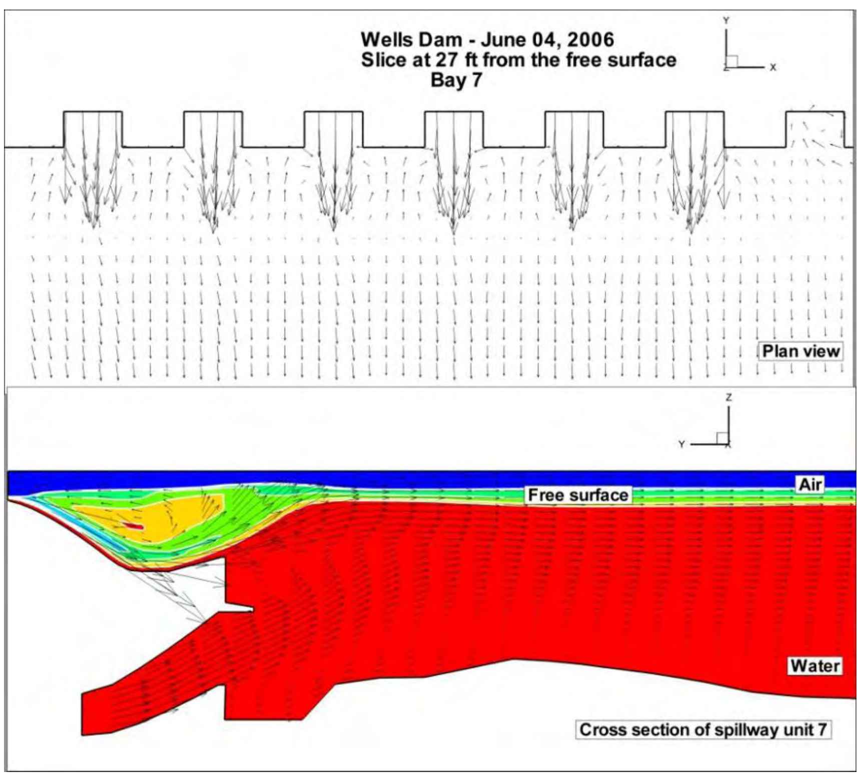

Figure 7.2-3 Predicted flow field for June 4, 2006.

The free surface used to create the rigid-lid grid for June 5, 2006 is shown in Figure 7.2-4. The top of Figure 7.2-5 shows the water attraction toward the surface jet on bay 7 (water entrainment) caused by the full open gate operation. The water entrainment causes the formation of two large eddies near the east and west bank of the Wells tailrace. As observed on June 4, 2006, the strong surface jet originated in bay 7 remains close to the free surface (see bottom picture in Figure 7.2-5) due to the favorable tailwater elevation and plant operation on this day.

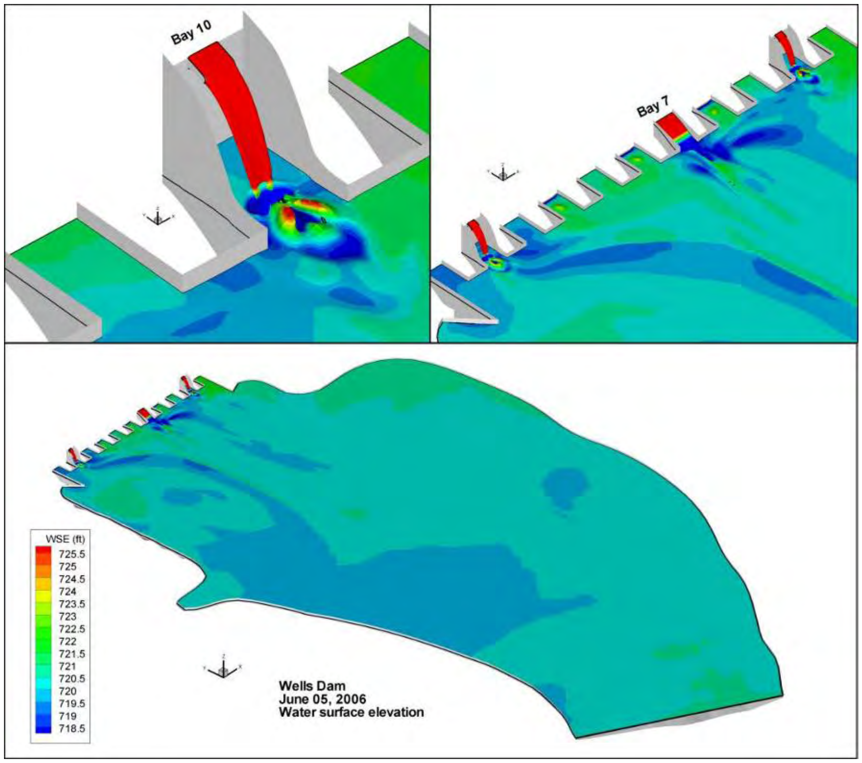

Figure 7.2-4 Predicted free surface shape for June 5, 2006.

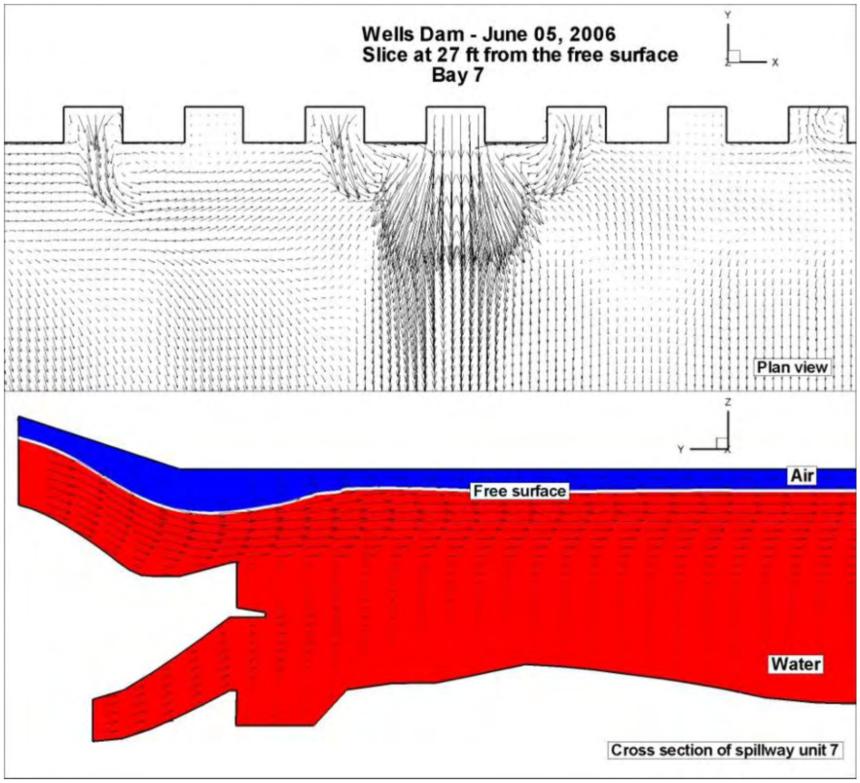

Figure 7.2-5 Predicted flow field for June 5, 2006.

7.2.2 Validation

The domain used to simulate the validation cases was reduced to 1,700 ft downstream of the dam with the purpose of speeding up the VOF computations. During the calibration it was observed that the effect of the top spill on the free surface shape is limited to a small region near spillway bays 2 and 10. Therefore the validation cases assumed that spillway bays 2 and 10 were closed and the free surface shape obtained during the calibration process was used near the top spills.

The numerical solution (pressure, velocity, free surface location and turbulent quantities) obtained on June 5, 2006 was used as an initial condition for the validation cases.

The convergence parameters for the calibration cases were:

$$1FG - May\ 14, 2006 \rightarrow \left(flowrate : 120.4\ kcfs, WSE : 711.5\ ft \right)$$
$$11FG - May\ 17, 2006 \rightarrow \left(flowrate : 157.2\ kcfs, WSE : 715.4\ ft \right)$$
$$63C - June\ 17, 2006 \rightarrow \left(flowrate : 205.5\ kcfs, WSE : 718.6\ ft \right)$$

Figure 7.2-6 shows the evolution of the flow rate and WSE at the tailwater elevation gauge for the validation cases. Blue and green lines represent the flow rate and WSE, respectively. The above mentioned simplifications allowed the calibration cases to reach the statistically steady solutions in typically 20 minutes using 30 days of computation time.

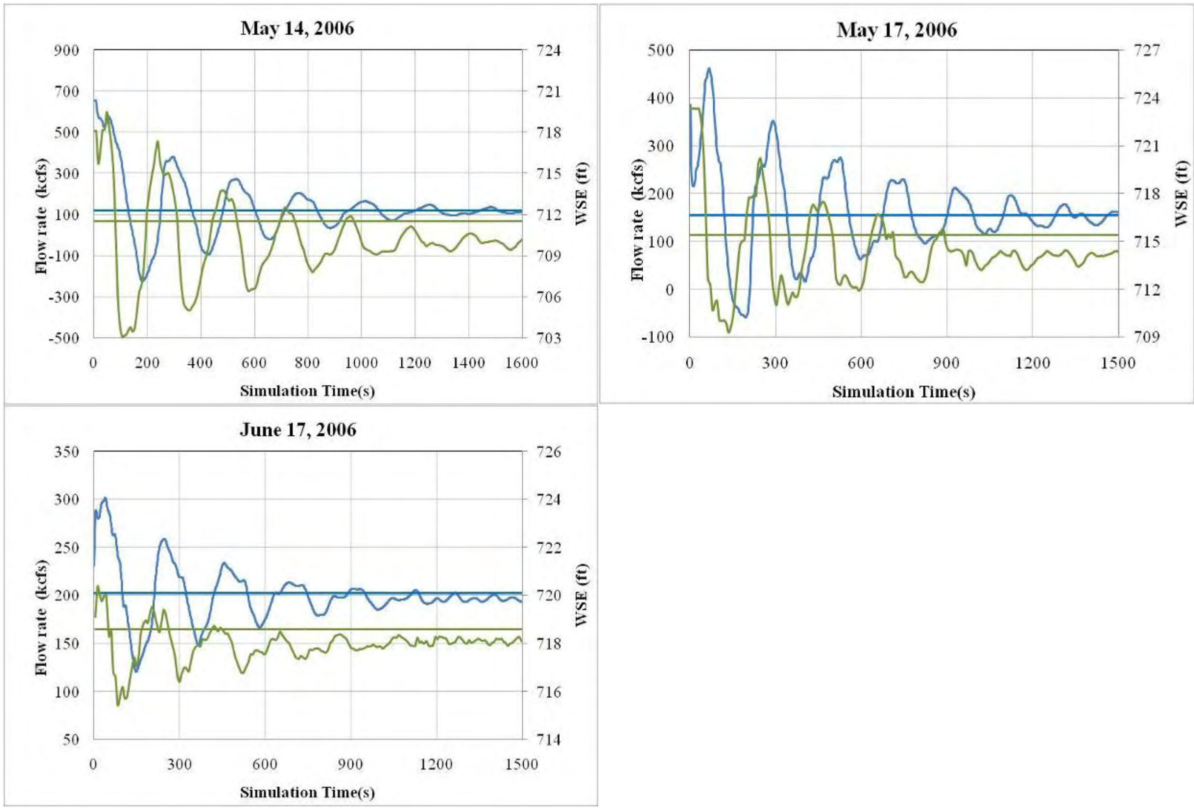

Figure 7.2-6 **Evolution of the flow rate at the exit (blue line) and free surface elevation (green line) for May 14, 2006, May 17, 2006, and June 17, 2006. Horizontal lines represent target values.**

7.3 Rigid-lid Model Results

7.3.1 Hydrodynamics

Figures 7.3-1 and 7.3-2 show depth-averaged velocity data collected in the field on June 4, 2006 and June 5, 2006 and those predicted by the rigid-lid model. Good agreement between observed and predicted velocity vectors was found, especially at the downstream transect where flow conditions were more stable and the Acoustic Doppler Current Profiler (ADCP) velocity data are less affected by turbulence and non-steady conditions.

As observed in the field, the model captured the counterclockwise eddy near the east bank and the almost uniform profile at the most downstream transect.

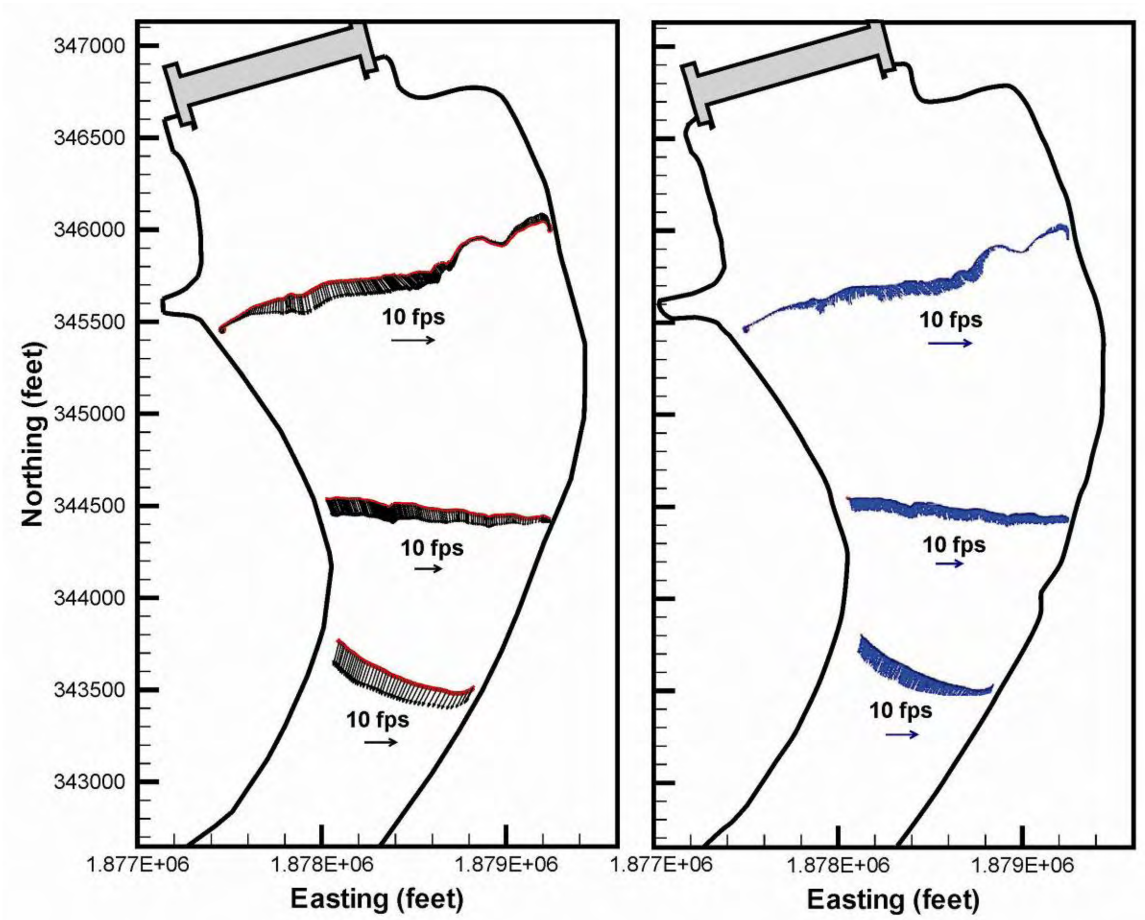

Figure 7.3-1 Flow field on June 4, 2006. Black vectors: rigid-lid model predictions and blue vectors: velocity field data.

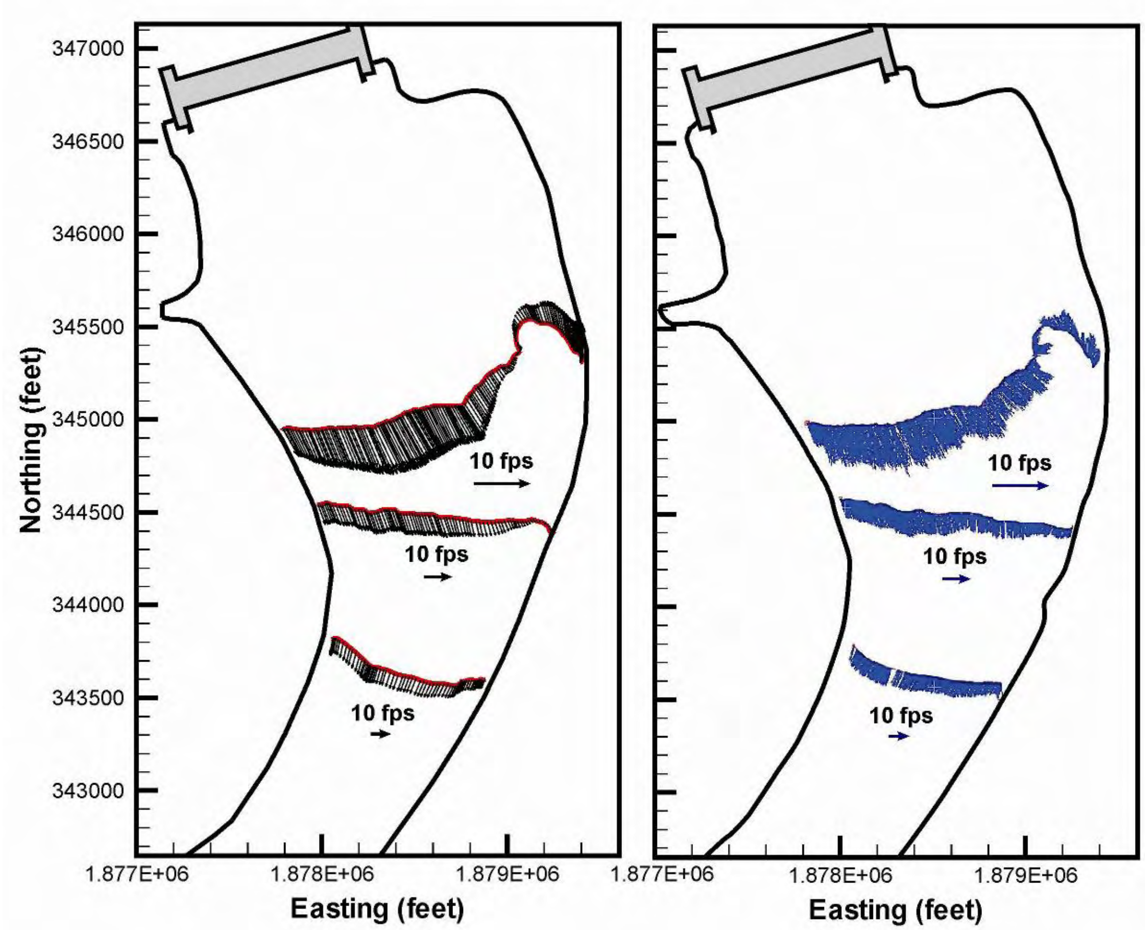

Figure 7.3-2 **Flow field on June 5, 2006. Black vectors: rigid-lid model predictions and blue vectors: velocity field data**

7.3.2 TDG Model

The percent saturation of TDG measured in the field at each station and the mean TDG in each of the three transects together with the values generated by the CFD model for the calibration and validation cases are shown in Appendix B. Figures 7.3-3 to 7.3-7 show measured and predicted values at each probe location. A bubble diameter of 0.5 mm and gas volume fraction of 3% in the spillbays produced TDG values that bracketed field observations.

The model captures the reduction of TDG with distance downstream and the lateral gradient observed in the field. As measured, the highest predicted TDG value at Transect TW1 occurred in the center of the channel and the lateral gradients in transects TW2 and TW3 were negligible.

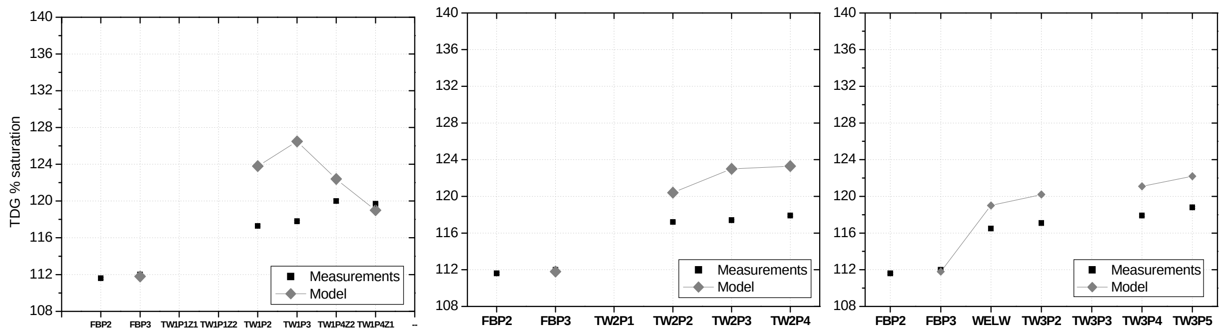

Figure 7.3-3 **Comparison between measured and predicted TDG on June 4, 2006. Gray diamonds represent TDG model predictions and black squares represent field observations.**

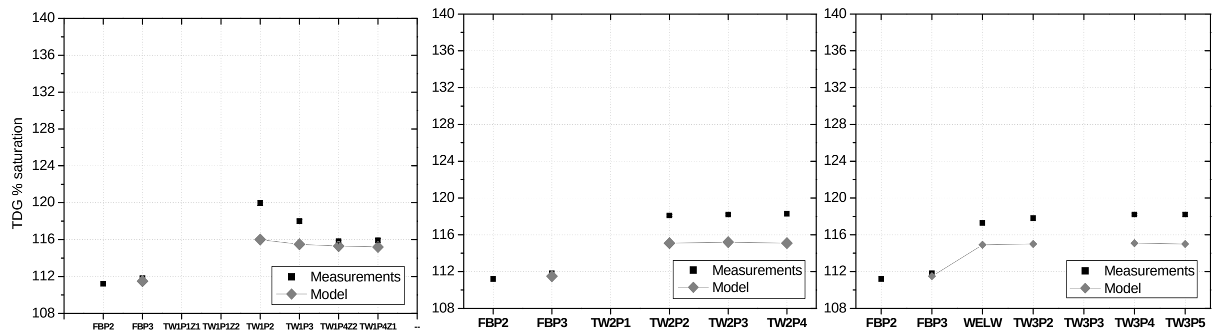

Figure 7.3-4 **Comparison between measured and predicted TDG on June 5, 2006. Gray diamonds represent TDG model predictions and black squares represent field observations.**

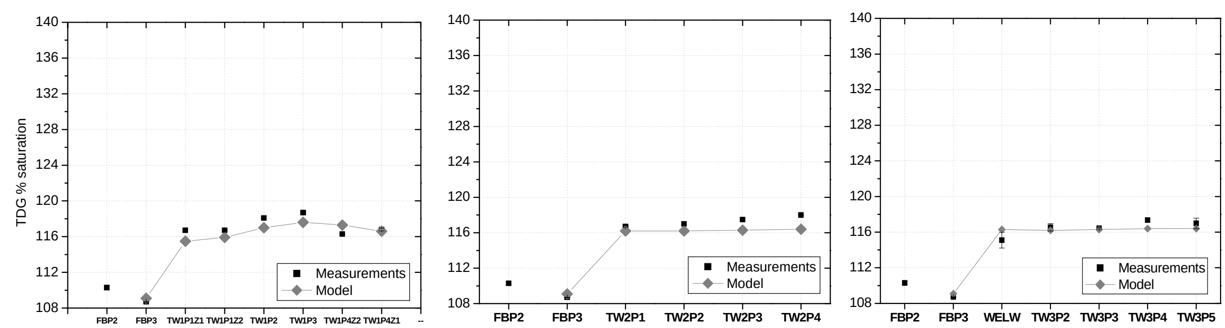

Figure 7.3-5 **Comparison between measured and predicted TDG on May 14, 2006. Gray diamonds represent TDG model predictions and black squares represent field observations.**

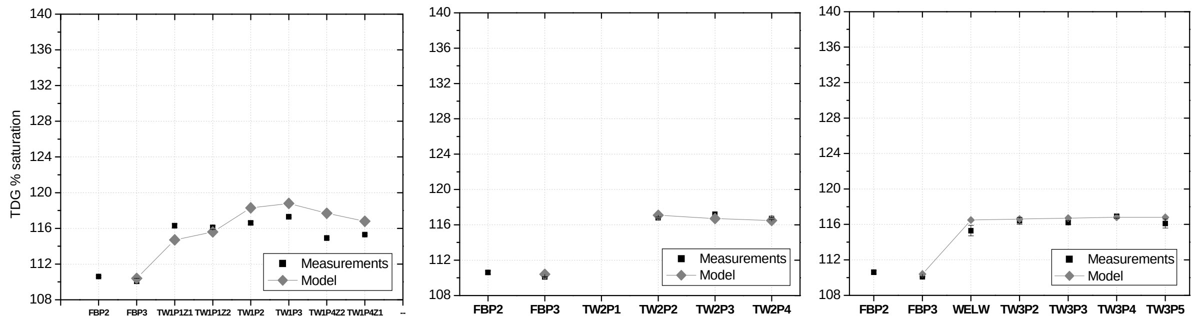

Figure 7.3-6 **Comparison between measured and predicted TDG on May 17, 2006. Gray diamonds represent TDG model predictions and black squares represent field observations.**

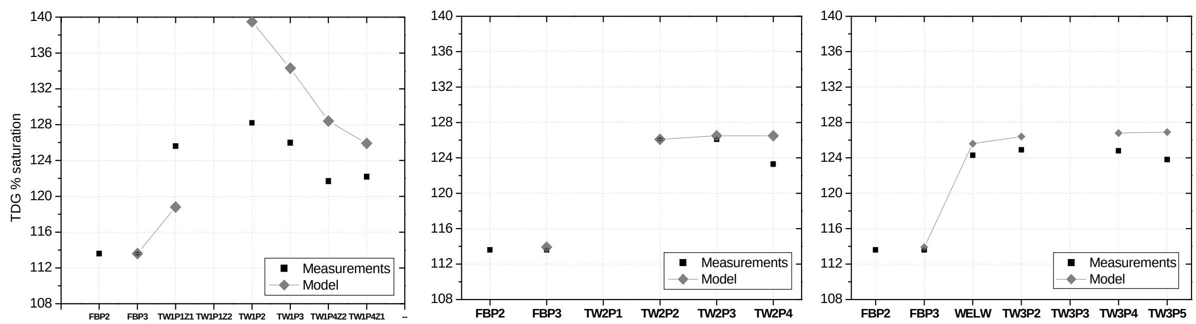

Figure 7.3-7 **Comparison between measured and predicted TDG on June 17, 2006. Gray diamonds represent TDG model predictions and black squares represent field observations.**

Figures 7.3-8 and 7.3-9 show isosurfaces of TDG, gas volume fraction and bubble diameter for June 4, 2006 and June 5, 2006 where the spill operation was adjusted to test both a spillway discharge pattern that was spread across the spill bays (Figure 7.3-8) and a concentrated spill pattern (Figure 7.3-9). As shown by the gas volume fraction isosurfaces, the model predicts uniformly distributed bubbles on the spillway region during spread spill operations. On the other hand, bubbles concentrate near the center of the spillway for full open gate operation. The maximum TDG occurs at the center region due to the exposure of water to the aerated flow as it travels within the stilling basin (see TDG isosurfaces). The rate of mass exchange depends on the gas volume fraction, the bubble size and the difference in concentration between the bubble boundary and the water. The gas dissolution region occurs mainly within 500 to 1,000 ft downstream of the spillway; afterwards the bubbles moved up to regions of lower pressure and the dissolution rate decreased. The bubbles shrink near the bed due to the air mass transfer and high pressure. The smaller the bubble size the stronger its tendency to dissolve. Substantial desorption of TDG takes place near the free surface downstream of the spillway. Once the air bubbles are vented back into the atmosphere the rate of mass exchange decreases significantly. The TDG concentration reaches a developed condition approximately 1,300 ft from the spillway. According to the simulation results, the draft tube deck extensions and spillway lip tend to act as deflectors for the spill, and powerhouse operation prevented spilled flow from plunging deep, reducing the exposure of bubbles to high pressure.

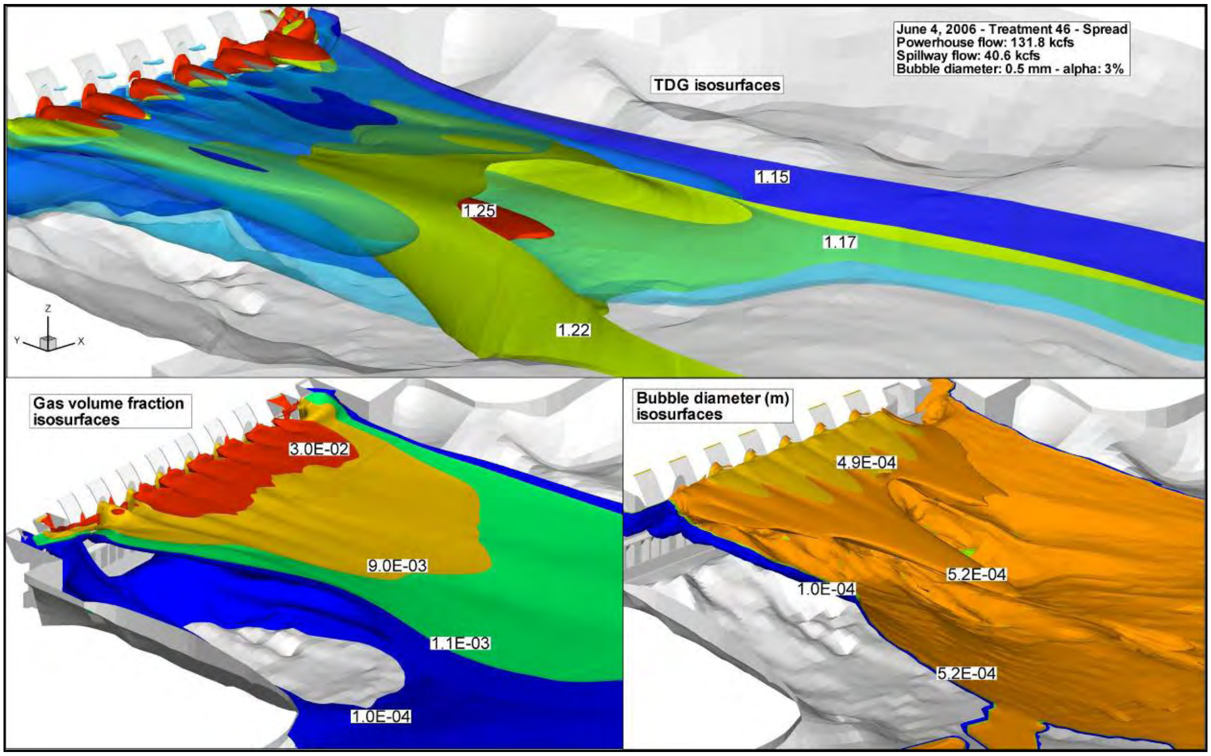

Figure 7.3-8 **TDG, gas volume fraction and bubble diameter isosurfaces for June 4, 2006.**

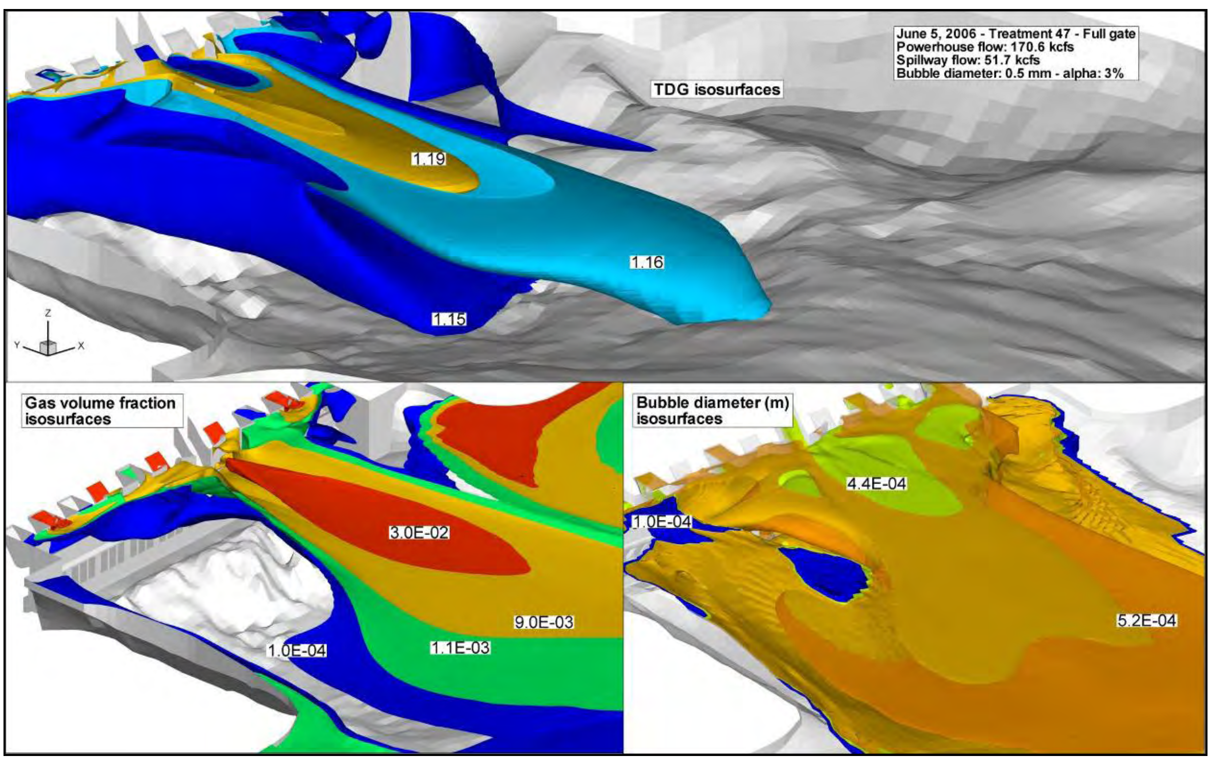

Figure 7.3-9 **TDG, gas volume fraction and bubble diameter isosurfaces for June 5, 2006.**

Table 7.3-1 summarizes simulation conditions and averaged predicted TDG at transects T1, T2 and T3. The last column in the table shows the difference between averaged TDG at transect T3 and forebay TDG, $\Delta TDG = TDG_{T3} - TDG_{forebay}$ indicating the approximate net production of TDG in the tailrace.

Table 7.3-1 Averaged predicted TDG in Transects 1, 2 and 3 for the calibration and validation cases

Case	Date	Spill (kcfs)	Total Q (kcfs)	% Spilled	Unit Spill (kcfs/ft)	Tailwater Elevation (feet)	Spillway Submergence (feet)	% TDG Forebay	% TDG Transect 1	% TDG Transect 2	% TDG Transect 3	Difference % TDG Forebay to Transect 3
46 S	4-Jun	40.6	172.4	23.5	0.11	717.3	26.3	111.8	122.9	122.2	120.7	8.9
47 FG	5-Jun	51.7	223.3	23.2	0.77	720.2	29.2	111.5	115.5	115.1	115.0	3.5
1 FG	14-May	44.6	120.4	37.0	0.62	711.5	20.5	109.1	116.7	116.3	116.3	7.2
11FG	17-May	42.6	157.2	27.1	0.60	715.4	24.4	110.4	117.0	116.9	116.7	6.3
63C	17-Jun	87.4	205.5	42.5	0.55	718.6	27.6	113.9	130.5	126.4	126.4	12.5

8.0 SENSITIVITY SIMULATIONS

8.1 Simulation Conditions

Nine model runs (MR) with two spillway configurations (spread and concentrated spill) and four total river flows were simulated to analyze the sensitivity of TDG production as a function of total flow, spill releases, and tailwater elevation. These simulations were run assuming forebay TDG was 115% and water temperature was 12^{o}C. Tables in Appendix A summarize plant operations, TDG saturation in the forebay, and tailwater elevation used for these simulations.

8.2 VOF Model Results

The free surface shape for the sensitivity simulations was extracted from VOF computations in a domain extending about 1,700 ft downstream of the dam. The convergence parameters for these simulations were:

$$MR1 \text{ and } MR5 \rightarrow (\mathit{flowrate}: 208.5\ \mathit{kcfs}, WSE: 718.8\ \mathit{ft})$$

$$MR2,\ MR6 \text{ and } MR8 \rightarrow (\mathit{flowrate}: 246.0\ \mathit{kcfs}, WSE: 721.4\ \mathit{ft})$$

$$MR3 \text{ and } MR7 \rightarrow (\mathit{flowrate}: 128.0\ \mathit{kcfs}, WSE: 713.4\ \mathit{ft})$$

$$MR4 \text{ and } MR9 \rightarrow (\mathit{flowrate}: 165.5\ \mathit{kcfs}, WSE: 715.9\ \mathit{ft})$$

The initial conditions from the MR simulations were obtained from interpolation of the numerical solutions for the calibration/validation cases. The MR cases reached the statistically steady solutions in typically 20 to 30 minutes (30 to 45 days of computation time).

8.3 Rigid-lid Model Results

Tables in Appendix C show the percent saturation of TDG predicted by the model at each station and the mean TDG in each of the three transects for the MR simulations. Figures 8.3-1 to 8.3-3 show predicted TDG values at each probe location. Table 8.3-1 summarizes simulation conditions, averaged predicted TDG at transects T1, T2, T3 and ΔTDG .

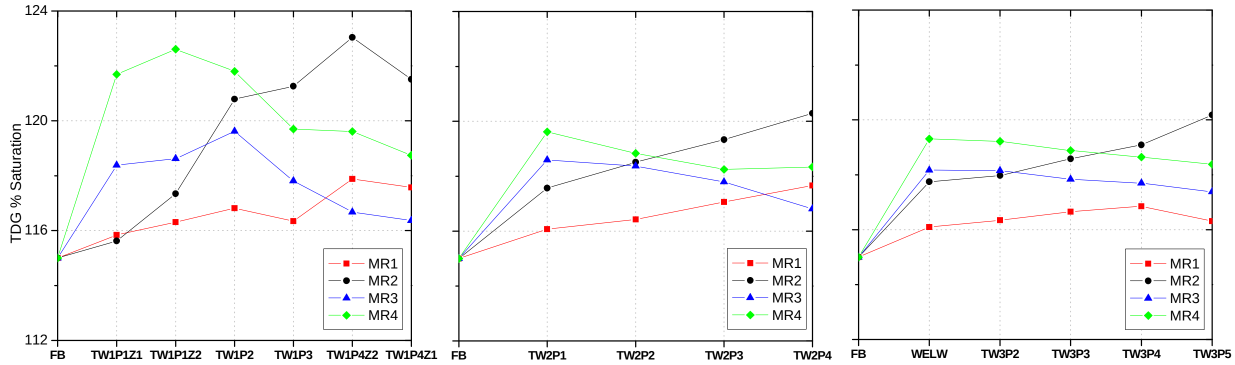

Figure 8.3-1 Predicted TDG concentration for spread operation.

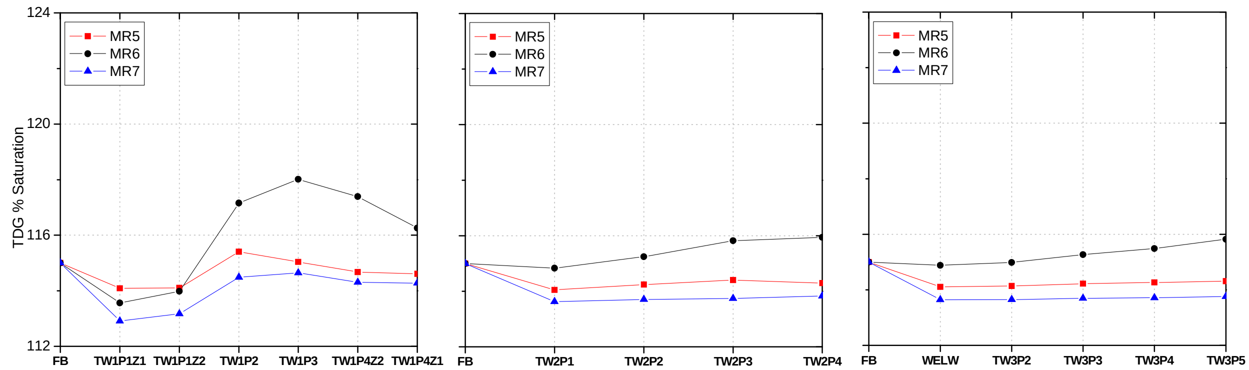

Figure 8.3-2 Predicted TDG concentration for full open gate operation.

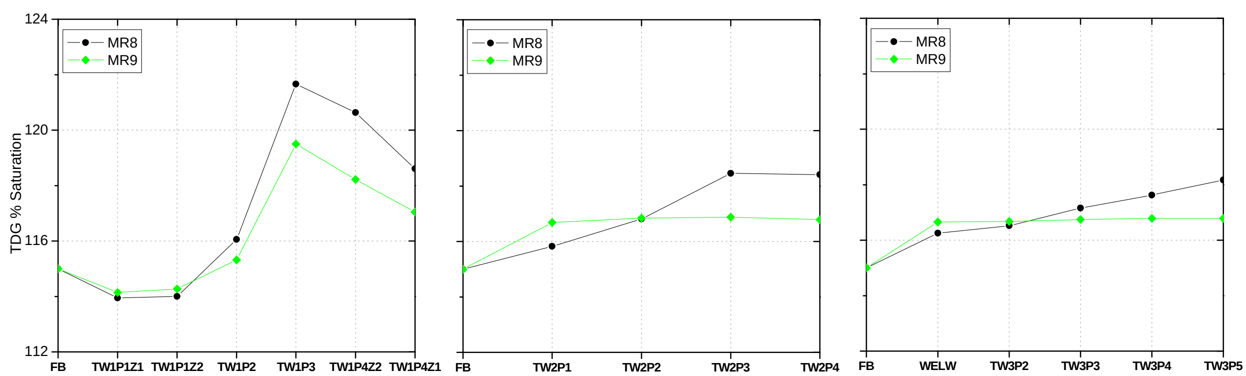

Figure 8.3-3 Predicted TDG concentration for two full open gates operation.

Table 8.3-1 Averaged predicted TDG in Transects 1, 2 and 3 for the sensitivity simulations.

Case	Type	Spill (kcfs)	Total Q (kcfs)	% Spilled	Unit Spill (kcfs/ft)	Tailwater Elevation (feet)	Spillway Submergence (feet)	% TDG Forebay	% TDG Transect 1	% TDG Transect 2	% TDG Transect 3	Difference % TDG Forebay to Transect 3
1	S	23.0	208.5	11.0	0.07	718.8	27.8	115.0	117.3	118.1	117.9	2.9
2	S	60.5	246.0	24.6	0.19	721.4	30.4	115.0	123.7	124.1	123.7	8.7
3	S	23.0	119.0	19.3	0.07	713.4	22.4	115.0	121.3	120.7	120.7	5.7
4	S	60.5	156.5	38.7	0.19	715.9	24.9	115.0	126.3	124.5	124.7	9.7
5	1-FG	23.0	208.5	11.0	0.50	718.8	27.8	115.0	116.0	116.8	116.7	1.7
6	1-FG	60.5	246.0	24.6	1.32	721.4	30.4	115.0	121.1	121.4	121.3	6.3
7	1-FG	23.0	119.0	19.3	0.50	713.4	22.4	115.0	117.5	117.1	117.3	2.3
8	2-FG	60.5	246.0	24.6	0.66	721.4	30.4	115.0	121.2	123.0	122.6	7.6
9	2-FG	60.5	156.5	38.7	0.66	715.9	24.9	115.0	122.2	122.9	122.9	7.9

In order to understand the effect of plant operations on TDG production and mixing, the simulations were grouped as follow:

1. Simulations with the same spill and powerhouse flows:
   $\left\{ [\text{MR1 and MR5}],\ [\text{MR2, MR6 and MR8}],\ [\text{MR3 and MR7}],\ \text{and}\ [\text{MR4 and MR9}] \right\}$

2. Simulations with the same spill operation (concentrated or spread spill) and same powerhouse flows:
   $\left\{ \mathit{Spread}: [\text{MR1(S=23 kcfs) and MR2}(\text{S=60.5 kcfs})]\ \text{and}\ [\text{MR3(S=23 kcfs) and MR4(S=60.5 kcfs)}] \right\}$
   $\left\{ \mathit{FG}: [\text{MR5}(\text{S=23 kcfs})\ \text{and MR6}(\text{S=60.5 kcfs})] \right\}$

3. Simulations with the same spill operation (concentrated or spread spill) and same spill flows:
   $\left\{ \mathit{Spread}: [\text{MR1}(\text{P=185.5 kcfs})\ \text{and MR3}(\text{S=96 kcfs})]\ \text{and}\ [\text{MR2}(\text{S=185.5 kcfs})\ \text{and MR4}(\text{S=96 kcfs})] \right\}$
   $\left\{ \mathit{FG}: [\text{MR5}(\text{S=185.5 kcfs})\ \text{and MR7}(\text{S=96 kcfs})] \right\}$

where S and P denote spillway and powerhouse flows, respectively.

Simulations with the same spill and powerhouse flows

Substantial differences in downstream TDG levels were observed with spread or full open gate operations. Numerical results indicate that, for the same spill and powerhouse flows, full open gate operation resulted in the lowest TDG concentration. On the other hand, the highest TDG concentrations were observed with spread flow operation. Simulations MR6 and MR8 show that distributing the same spill flow into two gates produced more TDG than concentrating the flow through a single bay.

To understand the underlying physics that cause larger TDG concentrations with spread operation, the volume of air available for dissolution and TDG sources for simulations MR1 (spread) and MR5 (FG) were analyzed at two transects downstream of the dam.

Figure 8.3-4 shows the cumulative volume of air in bubbles per unit length and cumulative TDG source per unit length as a function of the distance from the free surface at 50 m downstream of the dam. Solid lines show the cumulative volume of air in bubbles per unit length for simulations MR1 and MR5. Almost no air was present below 10 m. Note that the amount of air available for dissolution for concentrated spill operation (MR5) is always smaller than that for spread flows (MR1). The distribution of gas volume fraction and TDG at a vertical slice at 50 m from the dam for both types of operation is shown in 8.3-5. Note that the gas volume fraction, and consequently the TDG, is significantly larger for spread operation. As shown in Figure 8.3-6, for the simulated flow rates, the spread operation produces a submerged jet while the full open gate operation produces a surface jump. The residence time of bubbles entrained in a submerged jet is longer than those entrained in a surface jump. Bubbles reach the free surface more quickly in a surface jump because, on average, they travel closer to the free surface and because the water depth on the spillway face is smaller. In addition, large vertical liquid velocities downstream of the spillway lip help bubbles leave the tailrace more quickly for the concentrated spill operation.

The dotted lines in Figure 8.3-4 show the cumulative TDG source for simulations MR1 and MR5. Since the amount of air in bubbles available to produce TDG is larger for the spread operation, both the degasification (negative source of TDG) and production of TDG (positive source of TDG) are increased for this case. The net TDG production for spread and concentrated spill operations are approximately 0.15 kg air/(s m) and 0.06 kg air/(s m), respectively.

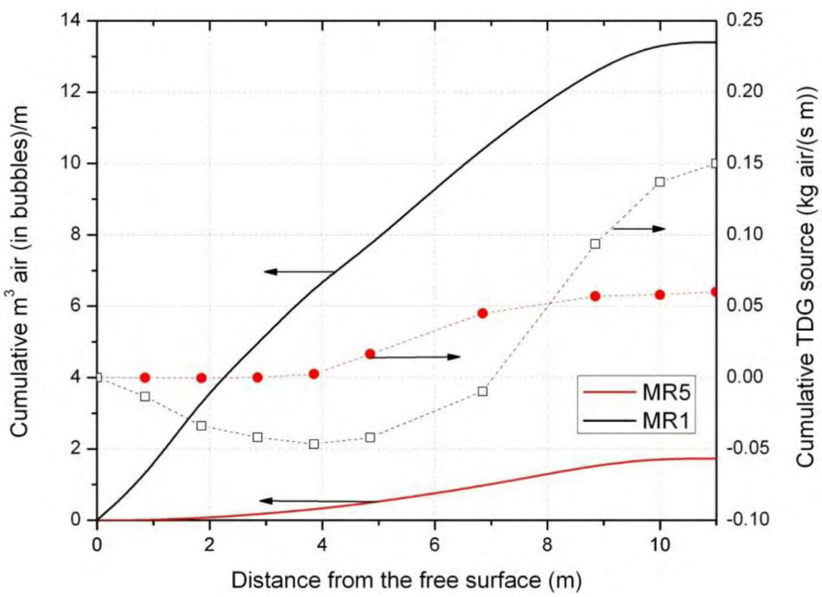

Figure 8.3-4 Cumulative volume of air in bubbles per unit length (left) and cumulative TDG source per unit length (right) as a function of the distance from the free surface at a plane at 50 m from the dam.

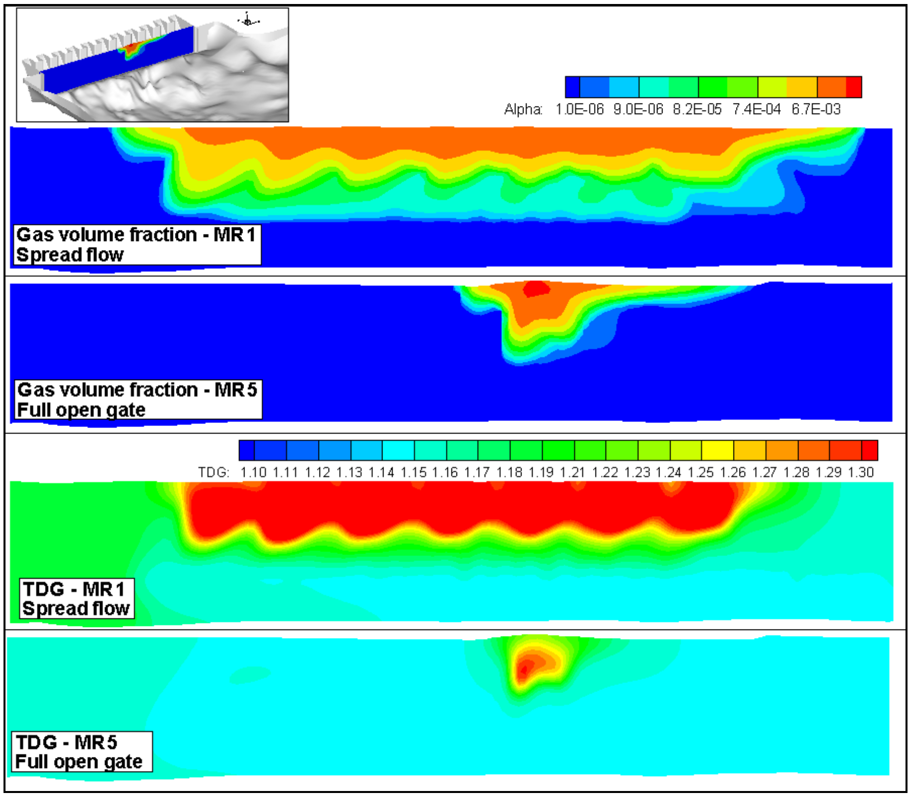

Figure 8.3-5 Contours of gas volume fraction and TDG at 50 m from the dam for simulations MR1 and MR5.

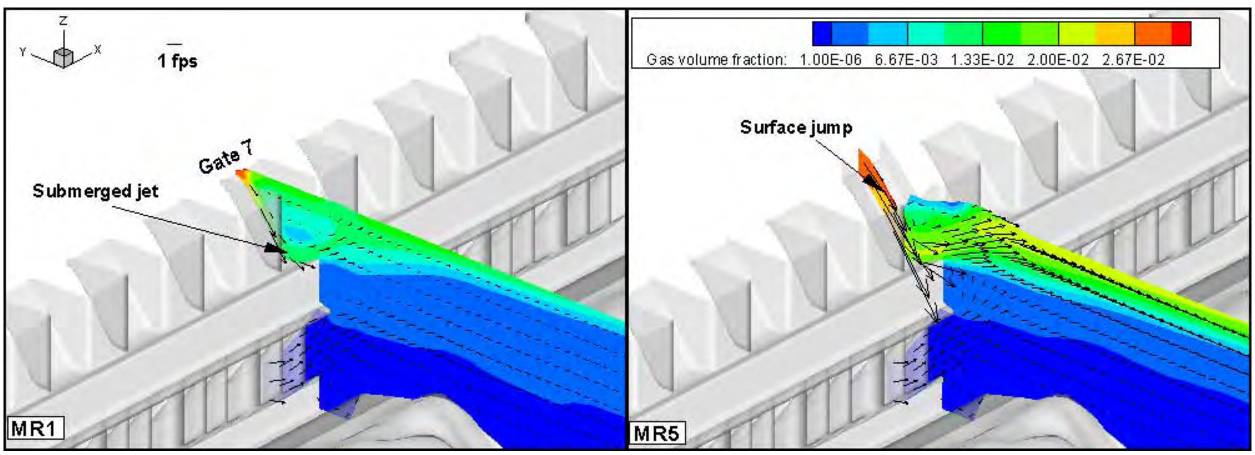

Figure 8.3-6 Contours of gas volume fraction and velocity vectors at a slice through gate 7 for MR1 (top) and MR5 (bottom).

Figure 8.3-7 shows the cumulative curves at Transect 1 location, 370 m downstream of the dam. Contrary to observations at 50 m from the dam, more bubbles are present at transect T1 for concentrated spill operation than for spread flows. The distributions of gas volume fraction and resulting TDG for MR1 and MR5 are shown in Figure 8.3-8. Higher liquid velocities with concentrated spill operation transport bubbles further in the tailrace. In addition, higher turbulent dispersion, created by a stronger jet in a full open gate operation, entrains bubbles deeper into the tailrace increasing bubble residence times. Note that 100% of the bubbles at Transect T1 are 2m or less from the free surface for the spread operation. On the other hand, due to turbulent dispersion, about 65% of the bubbles are 2 m from the free surface for full open gate operation. The TDG source is negative (degasification) for both type of operations. However, more degasification is observed with concentrated spill due to more availability of gas and an elevated mass transfer coefficient at the free surface for higher turbulent flows. As shown in Figure 8.3-8, TDG is higher for the spread operation as a result of more TDG production and less degasification at the free surface.

The flow pattern and TDG distribution in the tailrace for cases MR1 and MR5 are shown with streamlines colored by TDG concentration in Figures 8.3-9 and 8.3-10, respectively.

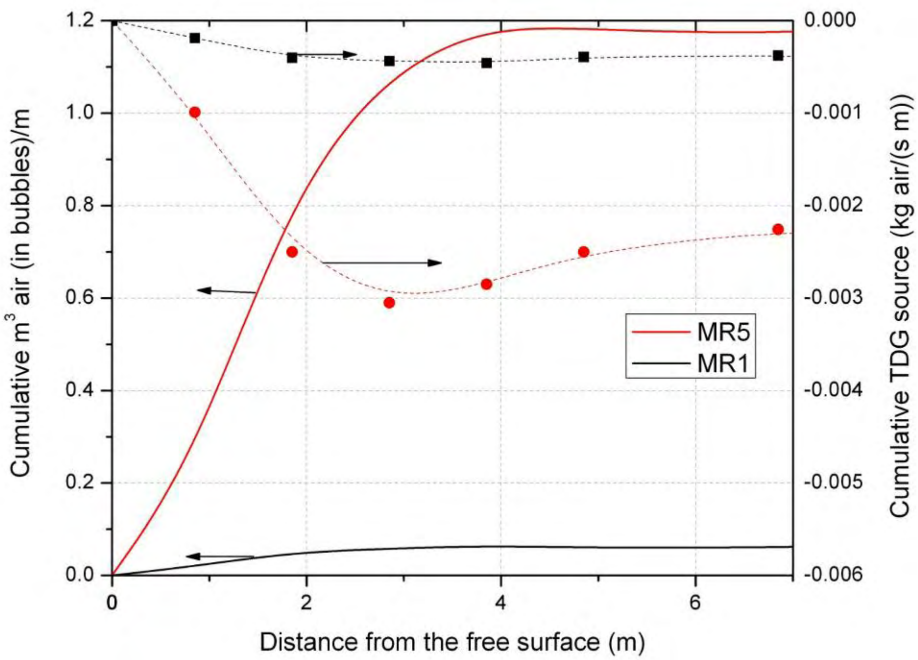

Figure 8.3-7 Cumulative volume of air in bubbles per unit length (left) and cumulative TDG source per unit length (right) as a function of the distance from the free surface at a plane at 370 m from the dam.

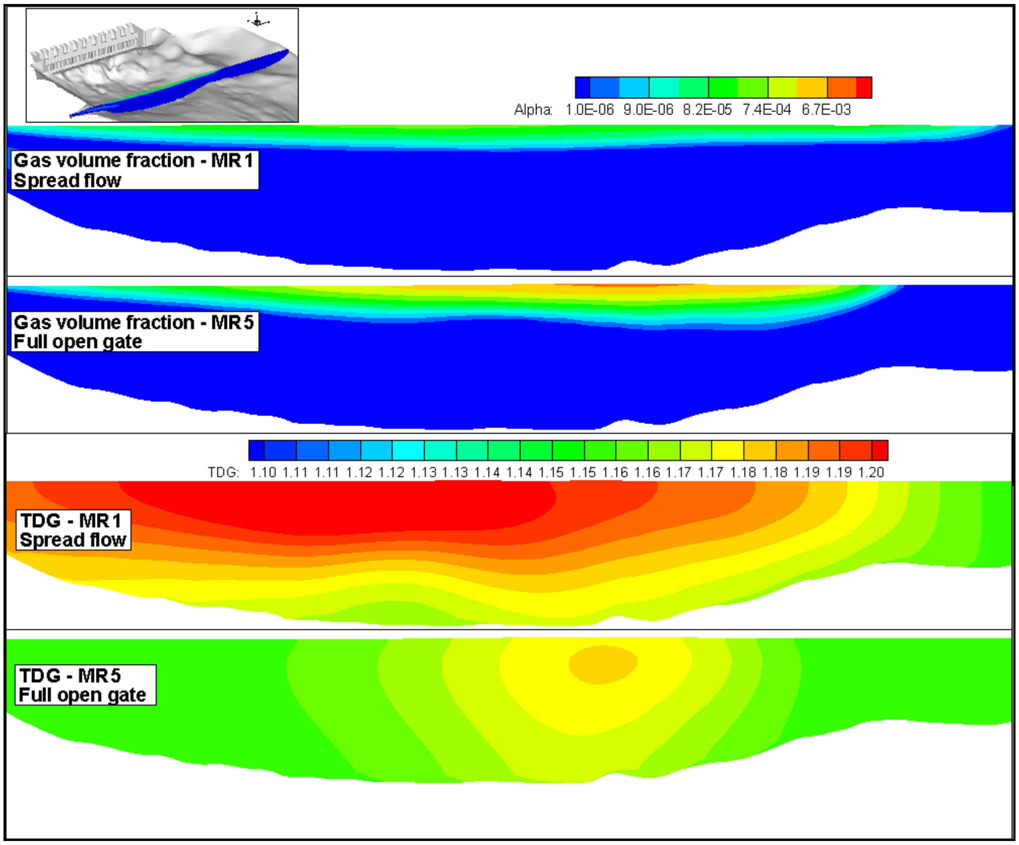

Figure 8.3-8 Contours of gas volume fraction and TDG at 370 m from the Dam for simulations MR1 and MR5.

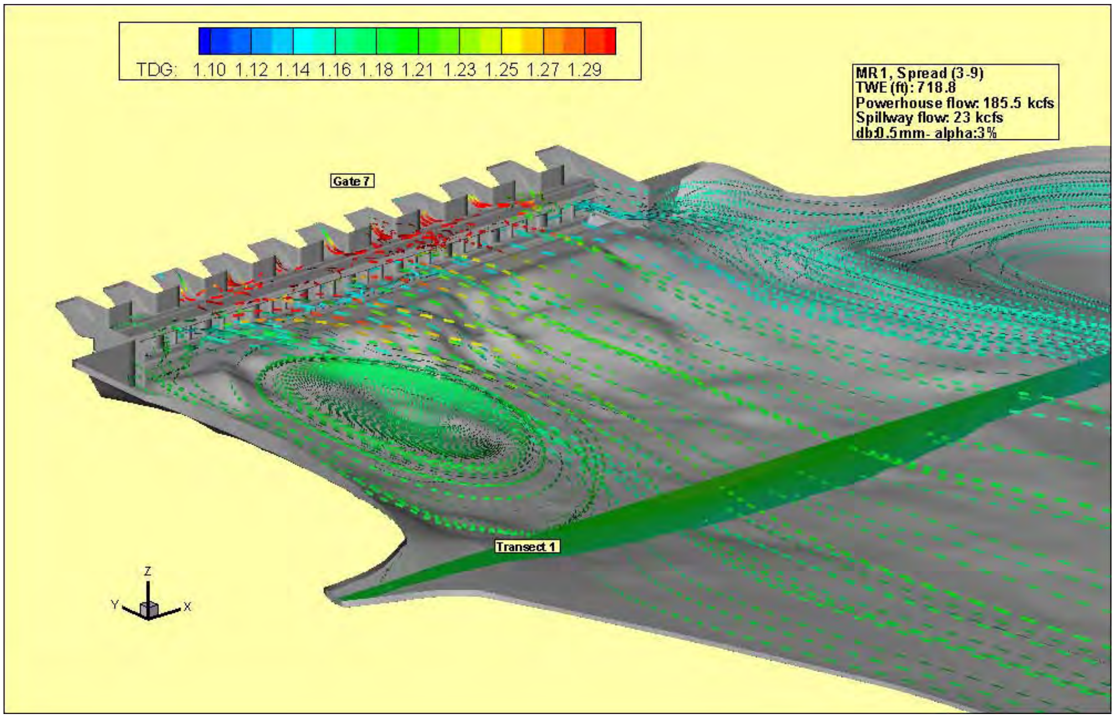

Figure 8.3-9 **Streamlines colored by TDG concentration for MR1.**

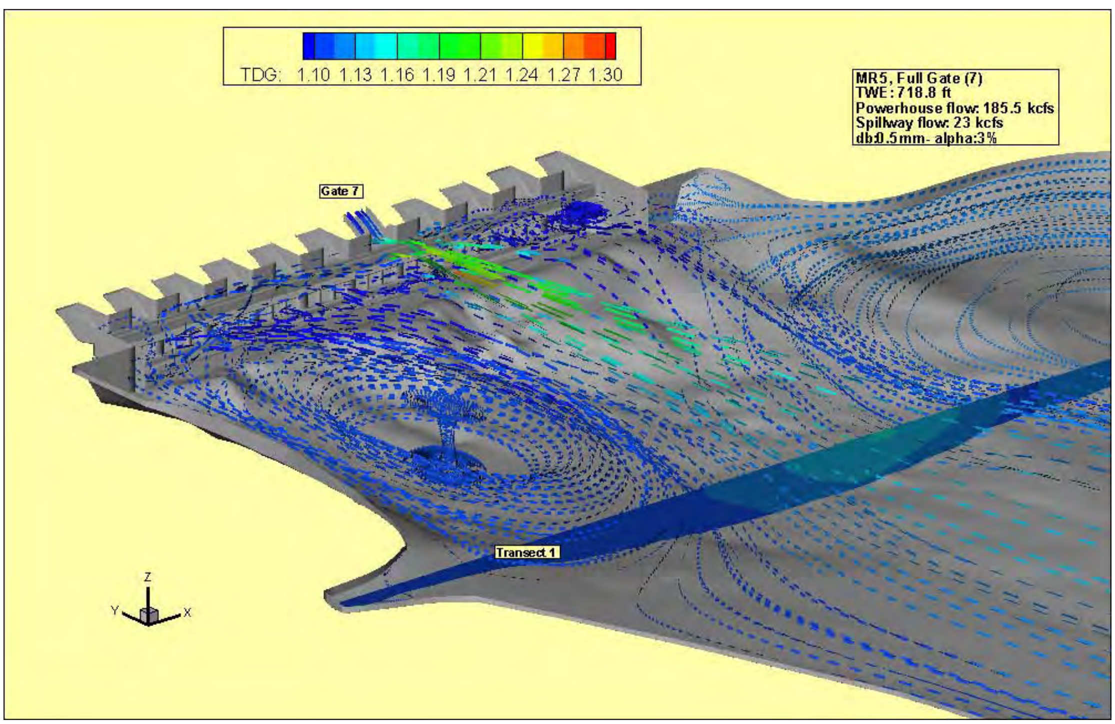

Figure 8.3-10 **Streamlines colored by TDG concentration for MR5.**

Simulations with the same spill operation and same powerhouse flows

Downstream TDG levels depend on the percentage of spilled water. For constant powerhouse flows, the greater the amount of spill, the greater the amount of bubbles entrained and the turbulence generated in the tailrace, and therefore, the greater the TDG production. Thus, the simulations for spread flows MR1 and MR3 with 23 kcfs spill flow produces less TDG than the equivalent MR2 and MR4 simulations with 60.5 kcfs (see Figure 8.3-1). Streamlines colored by TDG show the flow pattern and TDG distribution for MR1 (Figure 8.3-1) and MR2 (Figure 8.3-11). For these cases, the maximum TDG levels occurred at the west bank of the Wells tailrace.

Figures 8.3-12 and 8.3-13 show the submergence depth of the flip lip as a function of spill per unit width for full open gate and spread operations, respectively. The submergence depth is defined as the tailwater elevation minus the elevation of the top of the flip lip (691 ft) and the spill per unit width is:

$$\text{Spill per unit width} = \frac{1}{S_T W} \sum_i S_i^2 \qquad (19)$$

where W is the width of the spillbay, S_T is the total spill, and S_i is the spill of a generic bay i. Orange triangles represent field data black stars: predicted data at the model calibration/validation, black squares: sensitivity simulations. Labels indicate ΔTDG values. Data were grouped based on the percentage spill between 0 to 19%, 20 to 39%, 40 to 59%, and 60 to 100%. These plots confirm that the TDG production is strongly dependent on the percentage of spilled water.

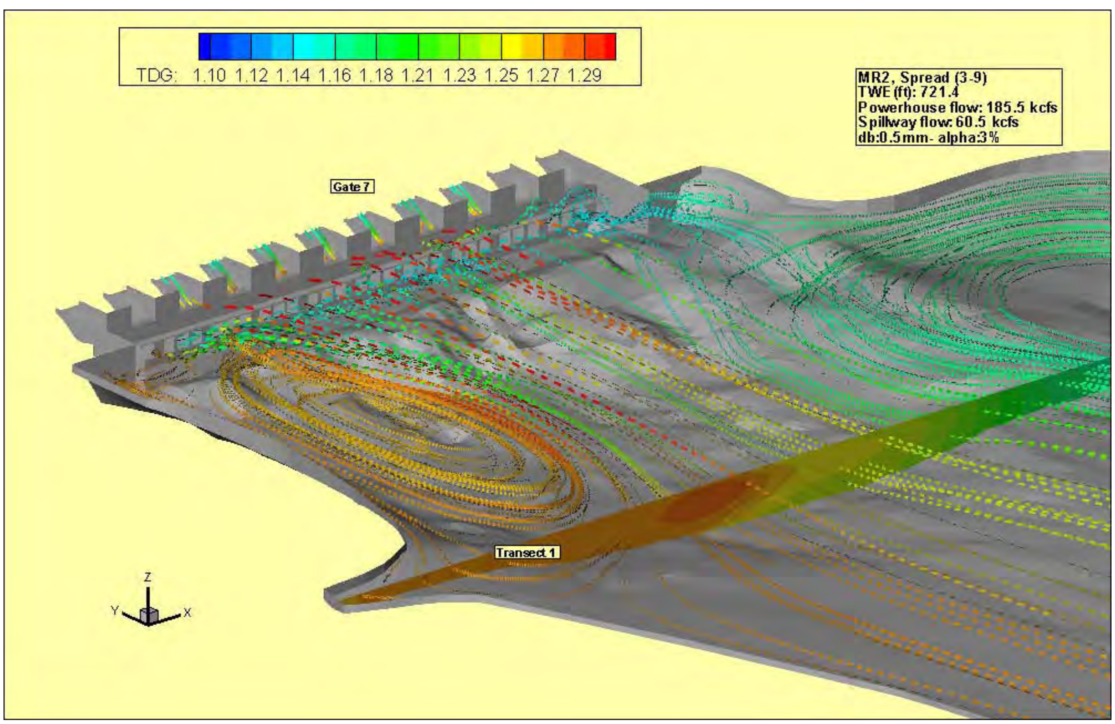

Figure 8.3-11 Streamlines colored by TDG concentration for MR2.

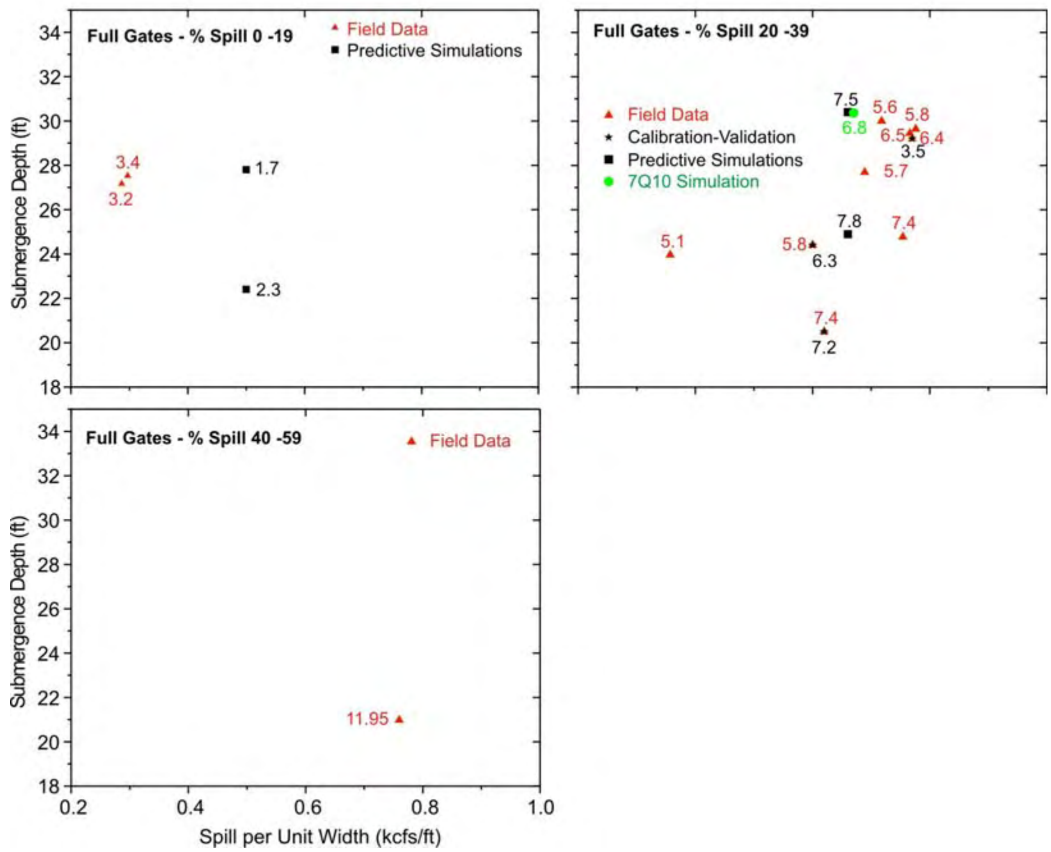

Figure 8.3-12 Submergence depth as a function of spill per unit width for full open gate operation. Red triangles: field data, black stars: predicted data at the model calibration/validation, black squares: sensitivity simulations, and green circle 7Q10 simulation. Labels indicate ΔTDG values.

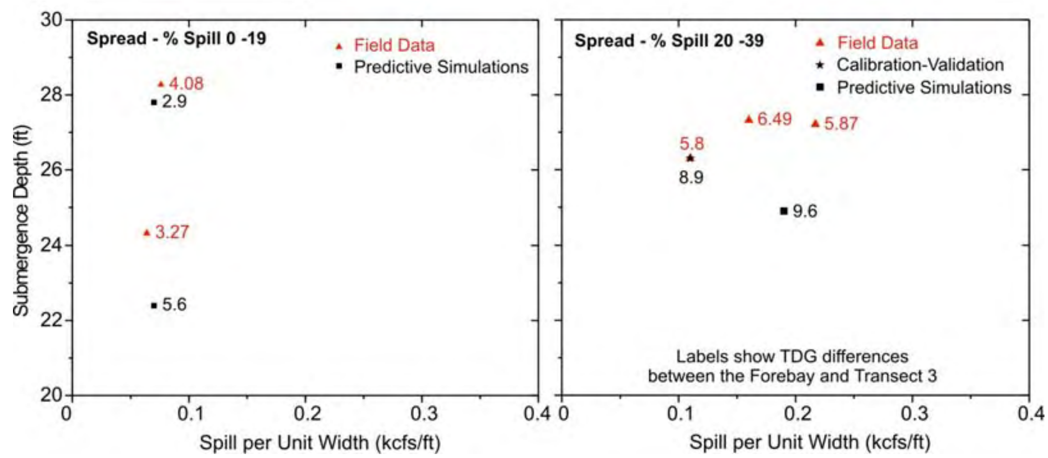

Figure 8.3-13 Submergence depth as a function of spill per unit width for spread operation. Red triangles: field data, black stars: predicted data at the model calibration/validation, and black squares: sensitivity simulations. Labels indicate ΔTDG values.

Simulations with the same spill operation and spilled flows

Mixing and dilution from increased powerhouse flows resulted in reduced TDG levels downstream for both spread and concentrated spill operations. The most notable effect of the powerhouse flow reduction was the increment of TDG values at the east bank for spread flow operation. The TDG distribution predicted in simulation MR4 with 96 kcfs powerhouse flow compared with the predicted values for MR2 with 185.5 kcfs powerhouse flow are shown in Figures 8.3-14 and 8.3-11, respectively.

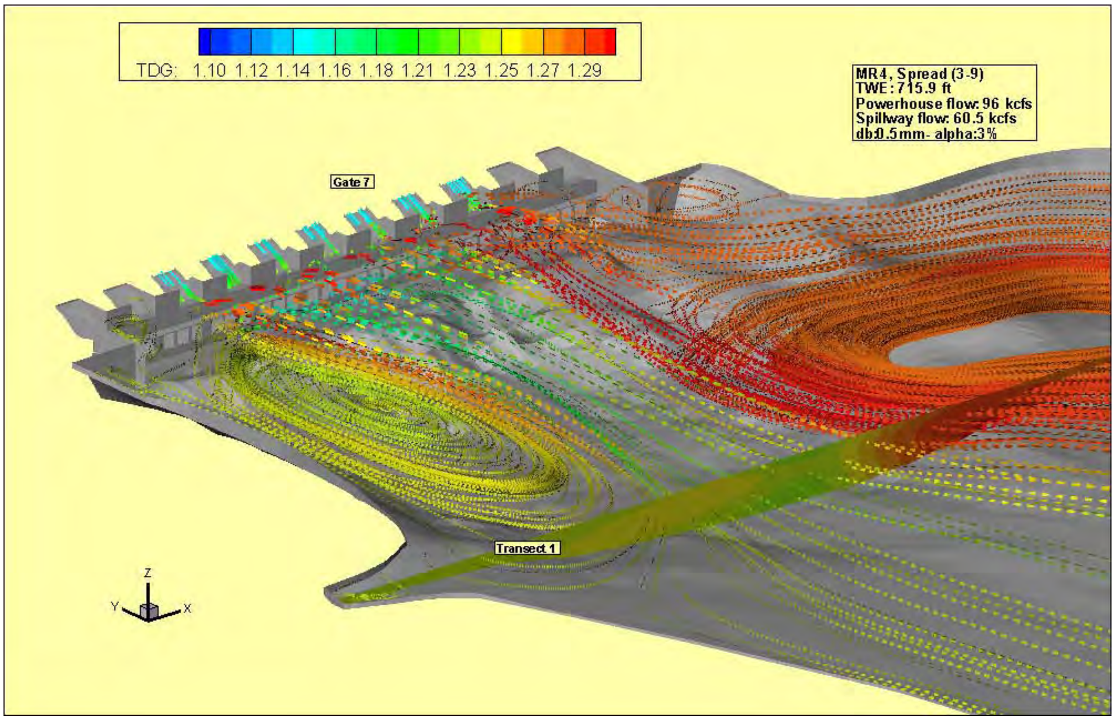

Figure 8.3-14 Streamlines colored by TDG concentration for MR4.

9.0 7Q10 FLOW SIMULATIONS

Numerical results of the sensitivity simulations confirmed what seemed to be demonstrated by field data, that is, saturation of gases in the tailrace could be minimized by concentrating the spill through one or more gates rather than spread across the spillway. This lead to further model runs in which various concentrated spill patterns were tested with the objective of reducing TDG production for a 7Q10 flow in the Wells Tailrace.

9.1 Simulation Conditions

The inputs for three 7Q10 simulations are tabulated in Appendix A. A forebay TDG of 113% and water temperature equal of 13^{o}C were used in the simulations based upon median values for these parameters extracted from the historical data (Section 5.4.2.1). Operational conditions included 9 of 10 turbine units[1] (each unit running at 20 kcfs[2]), 10 kcfs running through the Juvenile Bypass System[3], and 1 kcfs flowing down the fish ladders, and 55 kcfs through the spillways (combined spillway and bypass flow of 66 kcfs).

9.2 VOF Model Results

The convergence parameters for the 7Q10 simulations were:

$$\text{7Q10 S} \rightarrow \left(\mathit{flowrate} : 246\ \mathit{kcfs}, \mathit{WSE} : 721.4\ \mathit{ft} \right)$$

The numerical solution of MR6 was used as an initial condition for the 7Q10-A simulation. This case reached the statistically steady solution in approximately 15 minutes (21 days of computation time). Solution obtained for 7Q10-A was used as an initial condition for simulations 7Q10-B and 7Q10-C.

9.3 Rigid-lid Model Results

Tables in Appendix B show the percent saturation of TDG predicted by the model at each station for the 7Q10 simulations. Figure 9.3-1 illustrates TDG values predicted by the model at each probe location and Table 9.3-1 shows the average TDG at transects T1, T2 and T3. Numerical results indicate that, spilling most of the water in adjacent bays results in the highest TDG downstream. On the other hand, the lowest TDG values were observed with a full open gate through spillbay 7 and most of the remaining flow in bay 3. Operation 7Q10-B appeared to be the Optimal Operating Condition for the Wells Project as this condition consistently produced the lowest TDG profile in the Wells tailrace (117.7%) (Table 9.3-1).

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[1] Ecology has requested that the TDG model be operated utilized only 9 of the 10 available turbine units at Wells Dam. This request was intended to simulate a condition where one turbine unit is off-line for maintenance.

[2] Note that the maximum flow for each of the 10 turbines at Wells Dam is 22.0 kcfs for a total powerhouse capacity of 220 kcfs. The TDG model used a more conservative 20 kcfs per turbine which represents a more normal operation condition when flows at Wells Dam are approaching the hydraulic capacity of the powerhouse (>200 kcfs).

[3] Note that the Juvenile Bypass System uses up to 11 kcfs of water when operating through all five bottom gates. The TDG model assumed that only 10 kcfs of water was used to operate the Juvenile Bypass System. This can be achieved by running the system in a top spill configuration on gates 2 and 10 and in bottom spill configuration for gates 4, 6 and 8.

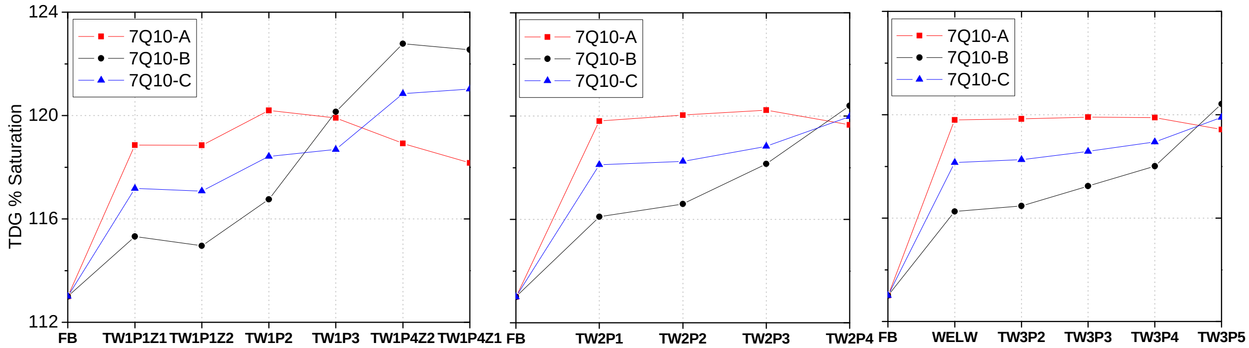

Figure 9.3-1 Predicted TDG concentration for 7Q10 simulations.

Table 9.3-1 Averaged predicted TDG in Transects 1, 2 and 3 for three initial 7Q10 simulations.

Case	Type	Spill (kcfs)	Total Q (kcfs)	% Spilled	Unit Spill (kcfs/ft)	Tailwater Elevation (feet)	Spillway Submergence (feet)	% TDG Forebay	% TDG Transect 1	% TDG Transect 2	% TDG Transect 3	Difference % TDG Forebay to Transect 3
7Q10-A	1-FG	64.6	245.6	26.3	0.67	721.4	30.4	113.0	119.2	119.9	119.8	6.8
7Q10-B	1-FG	65.0	246.0	26.4	0.67	721.4	30.4	113.0	118.8	117.8	117.7	4.7
7Q10-C	1-FG	65.0	246.0	26.4	0.67	721.4	30.4	113.0	118.9	118.8	118.8	5.8

Figures 9.3-2 and 9.3-3 show gas volume fraction and TDG distribution at a plane located 50 m downstream of the dam for the 7Q10 simulations. According to the model, the production of TDG is similar for the simulated cases. Operations 7Q10-A and 7Q10-CC both contained a higher concentration of spill flow in adjacent bays and both produced resultant bubbles traveling deeper in the tailrace with a slightly higher TDG concentration in the center of the spillway.

Figures 9.3-4 shows the TDG distribution at 370 m from the dam. Note that the lateral distribution of TDG is significantly different for the simulated cases, suggesting different level of TDG mixing. Figures 9.3-5 to 9.3-6 show streamlines colored by TDG concentration. The highest lateral TDG gradient is observed when the spillway is operated with gate 7 full opened and most of the remaining flow placed in bay 3 (7Q10-B). In this case, both the degasification at the free surface and the downstream dilution are improved. Note that most of the water of the east bank is basically undisturbed water, with gas saturations nearly to forebay TDG.

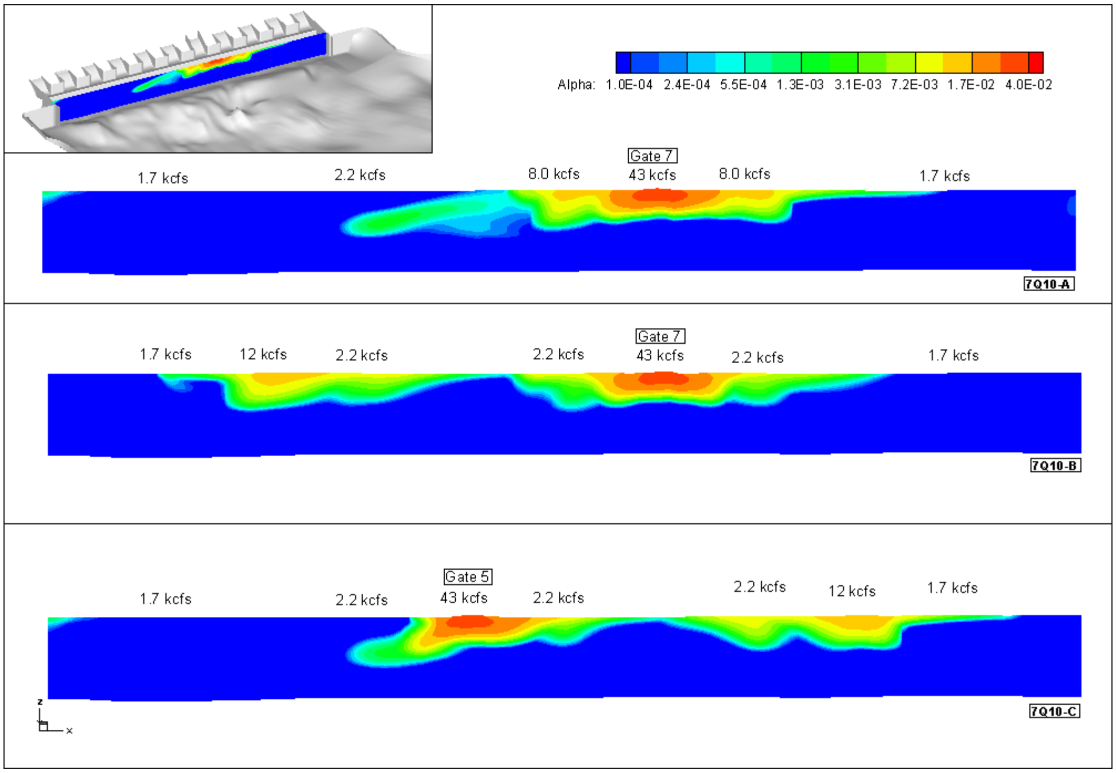

Figure 9.3-2 **Contours of gas volume fraction at 50 m from the Dam for 7Q10 simulations.**

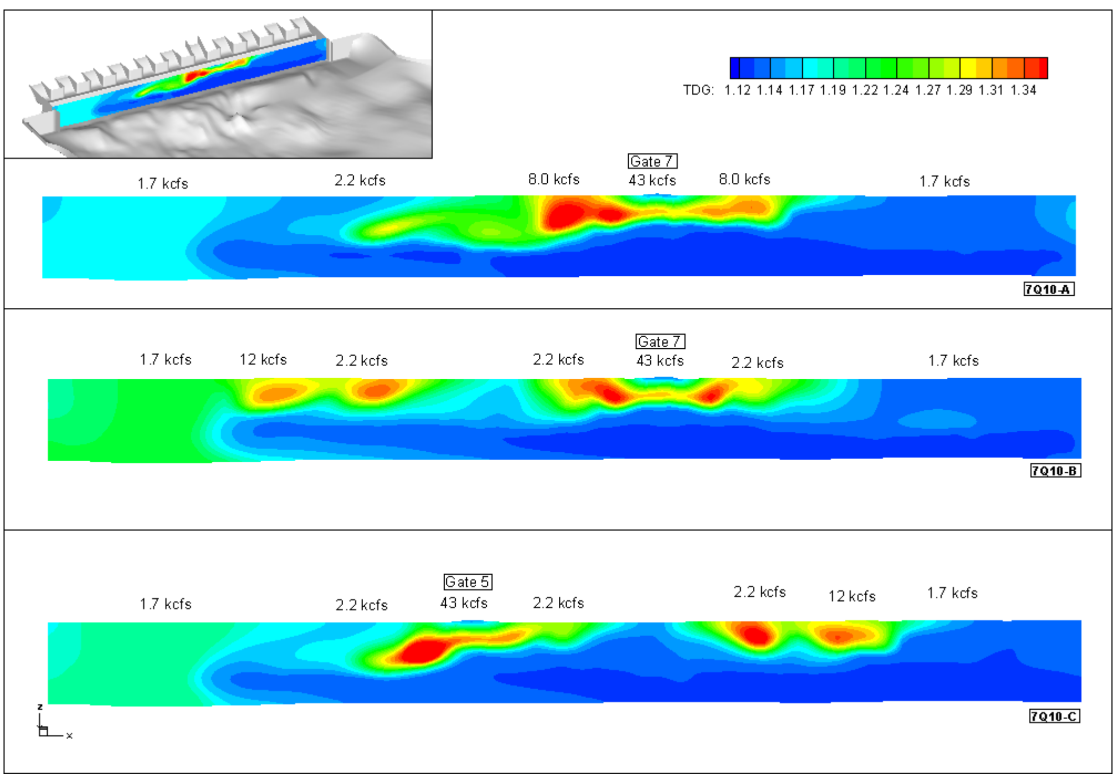

Figure 9.3-3 **Contours of TDG at 50 m from the Dam for the 7Q10 simulations.**

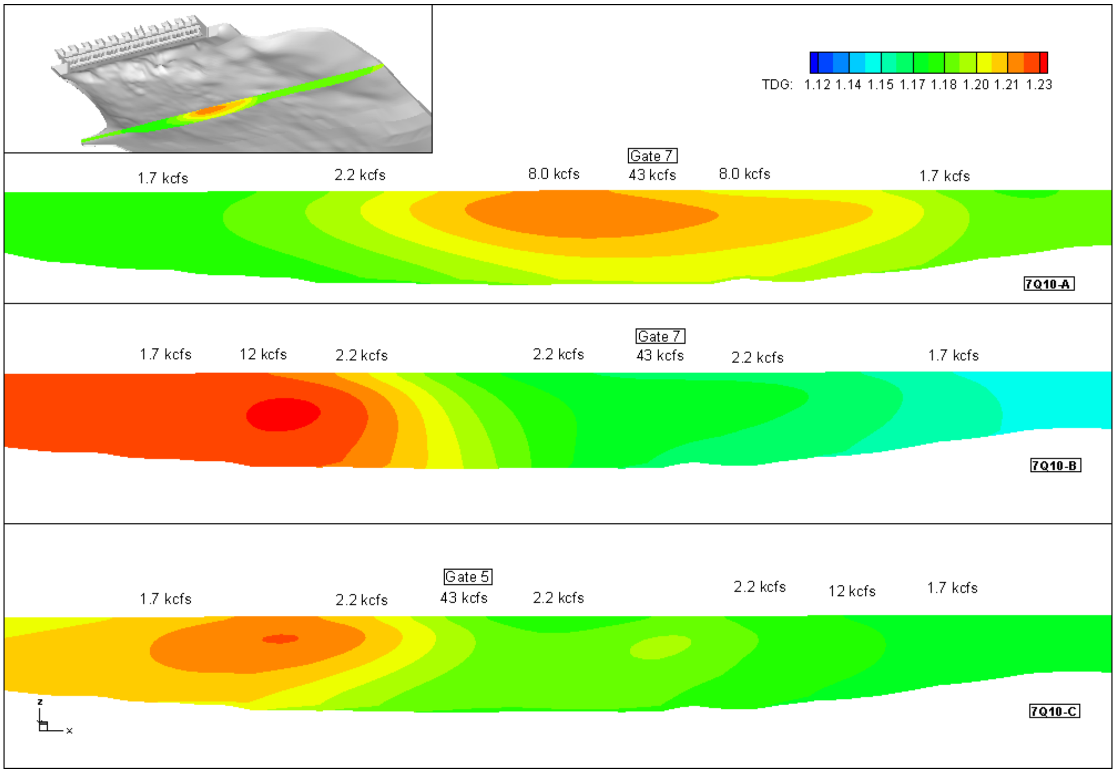

Figure 9.3-4 **Contours of TDG at 370 m from the Dam for the 7Q10 simulations.**

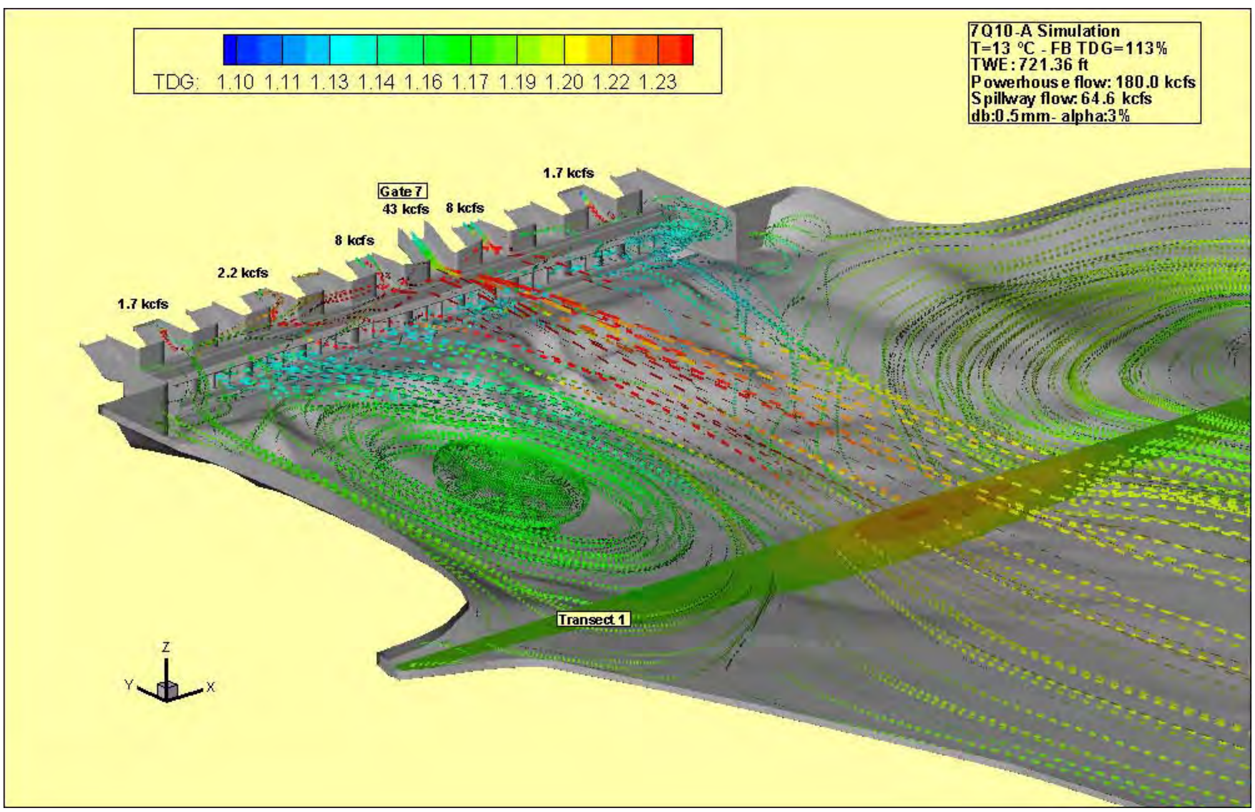

Figure 9.3-5 **Streamlines colored by TDG concentration for the 7Q10-A simulation.**

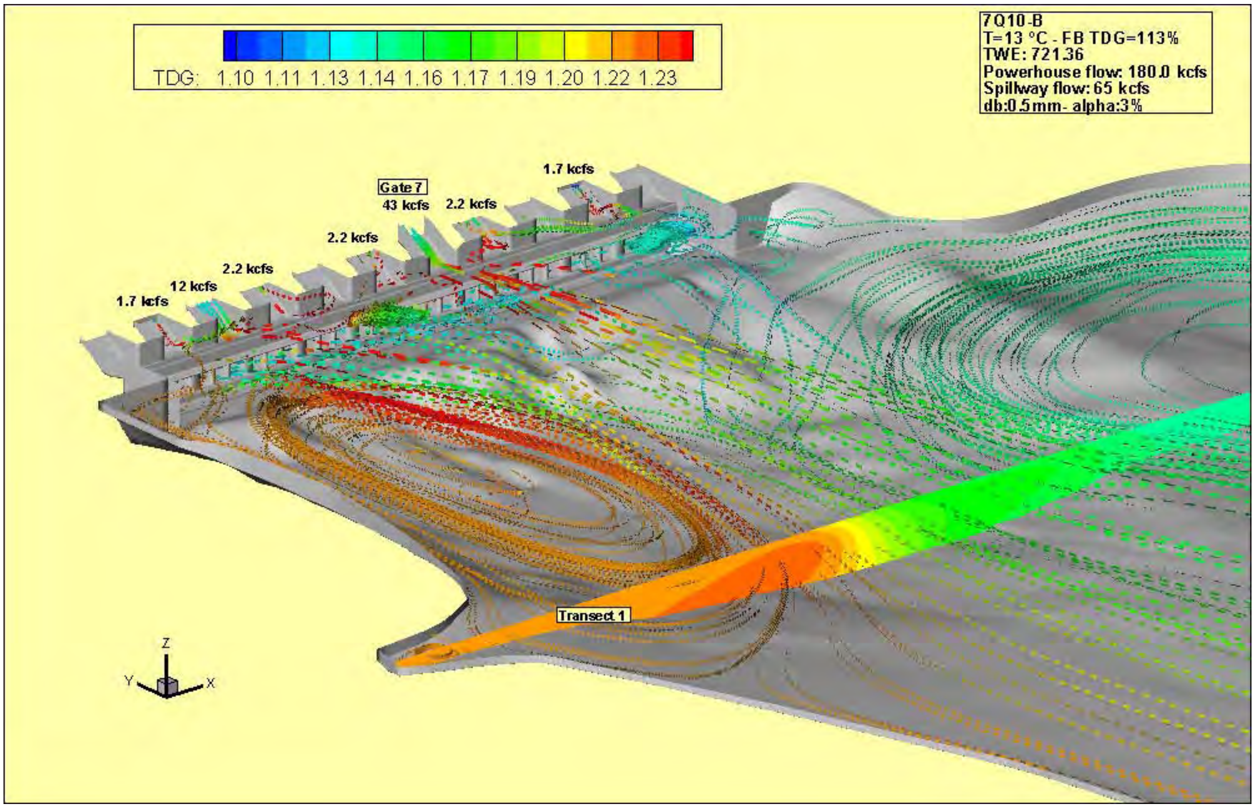

Figure 9.3-6 **Streamlines colored by TDG concentration for the 7Q10-B simulation.**

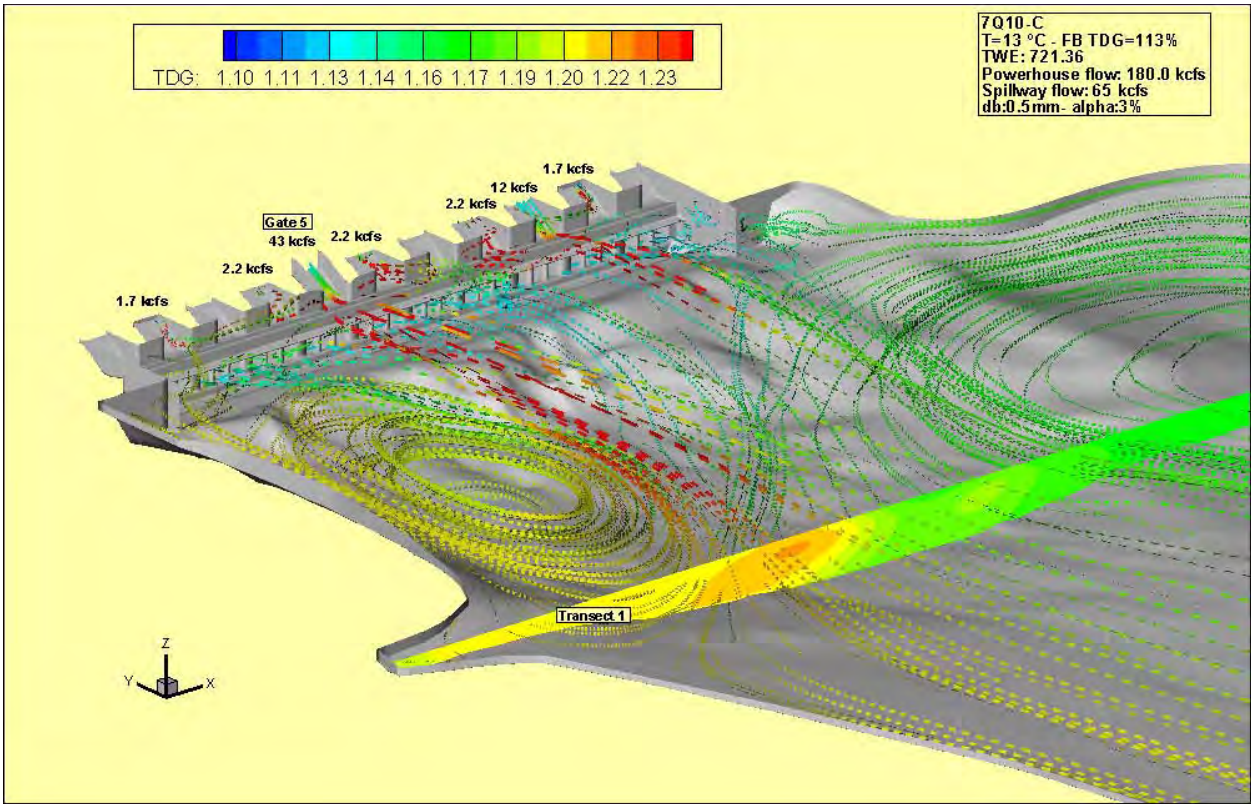

Figure 9.3-7 **Streamlines colored by TDG concentration for the 7Q10-C simulation.**

10.0 STANDARD COMPLIANCE EVALUATIONS

10.1 Simulation Conditions

In addition to identifying the Optimal Operating Conditions representative of high flow conditions at the Wells Project, Ecology also requested that a Standard Compliance Scenario also be modeled consistent with settings used at other projects for evaluation of compliance with numeric WQS. The spill configuration was similar to simulation 7Q10-A presented in section 9 however, the simulation was conducted with a 115% forebay TDG and 90% of maximum powerhouse capacity (22 kcfs per turbine, with nine of ten units in operation). Temperature was 15.5 ^{o}C, consistent with median values observed at 115% forebay TDG. Table 10.1-1 summarizes project operations used for the compliance simulation (CS).

Table 10.1-1 Conditions used for the Standard Compliance Numerical Simulation

Treatment CS									
Tailwater Elevation: 721.4 ft – Forebay Elevation: 780.5 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Powerhouse Total: 198.0 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	1.7	0.0	2.2	0.0	2.2	37.0	2.2	0.0	1.7
Spillway Total: 47.0 kcfs									
Total River Flow: 245.0 kcfs									
Forebay TDG: 115.0%									

10.2 VOF Model Results

The convergence parameters for the Standard Compliance Simulation were:

$$\text{Compliance Simulation} \rightarrow \left(flowrate : 245.0\ kcfs, WSE : 721.4\ ft \right)$$

Figure 10.2-1 shows the spillway jet characteristics predicted with the VOF method for the Standard Compliance Simulation. Similar to observations on June 5, 2006, the surface jet originating from bay 7 attracts water toward the center of the dam. The cross section of spillway 7 in Figure 10.2-1 shows that the surface jet remains close to the free surface minimizing air entrainment. Minor contributions to TDG production are expected from bays 6 and 8 (see cross section of spillway unit 6 in Figure 9.2-1) because of their relatively small volume of spilled water.

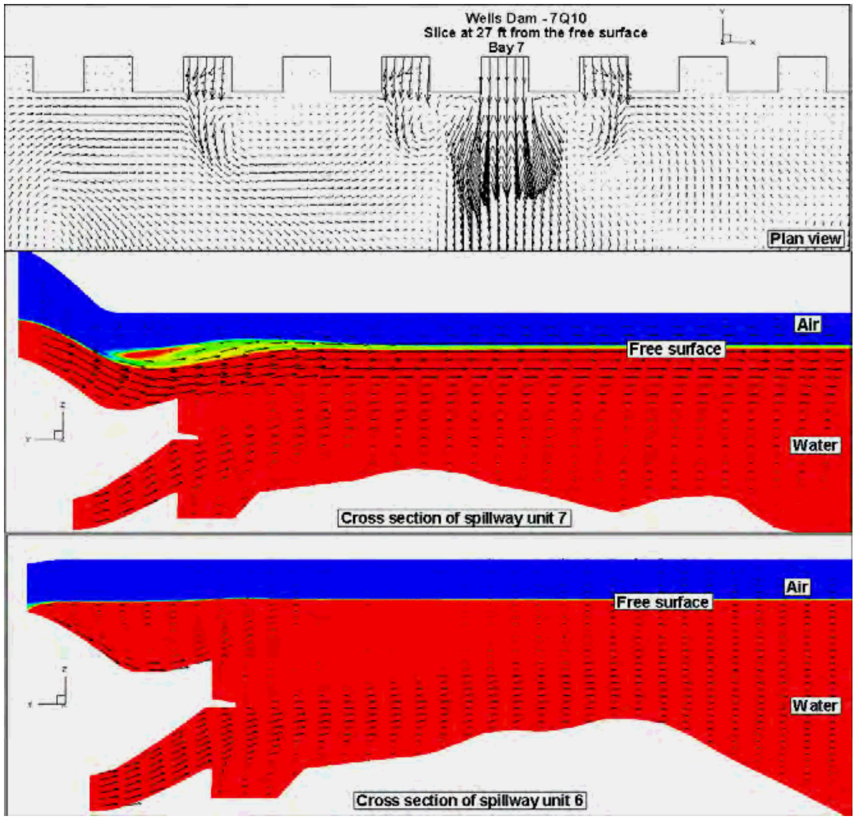

Figure 10.2-1 Predicted flow field for the Standard Compliance Simulation.

10.3 Rigid-lid Model Results

Tables in Appendix B show the percent saturation of TDG predicted by the model at each station for the Standard Compliance Simulation. Figure 10.3-1 shows TDG values predicted by the model at each probe location for this simulation. The TDG distribution at the Wells tailrace together with predicted TDG values at each station are shown in Figure 10.3-2. The main process affecting TDG production and mixing occurs upstream of transect T2, after which TDG production reaches a developed condition with minor changes associated with small mass transfer at the free surface. Table 10.3-1 shows the average TDG at transects T1, T2 and T3. According to the model, the average gas saturation at the three transects is approximately 117%.

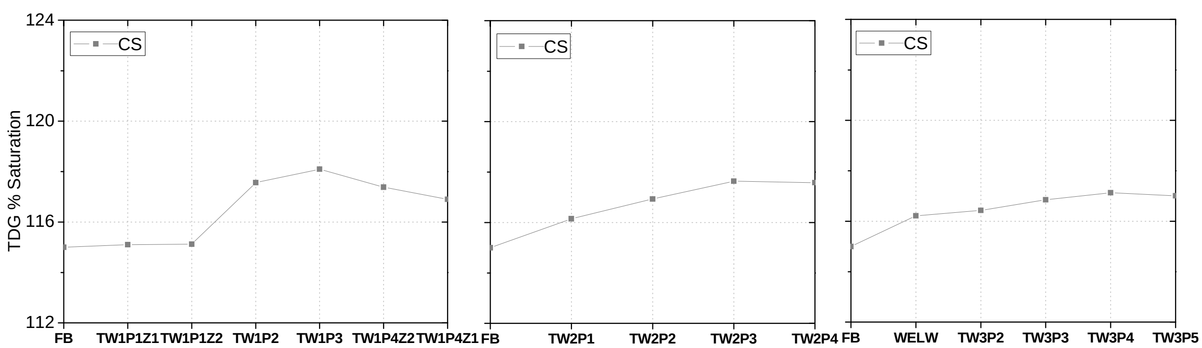

Figure 10.3-1 Predicted TDG concentration for the Standard Compliance Simulation.

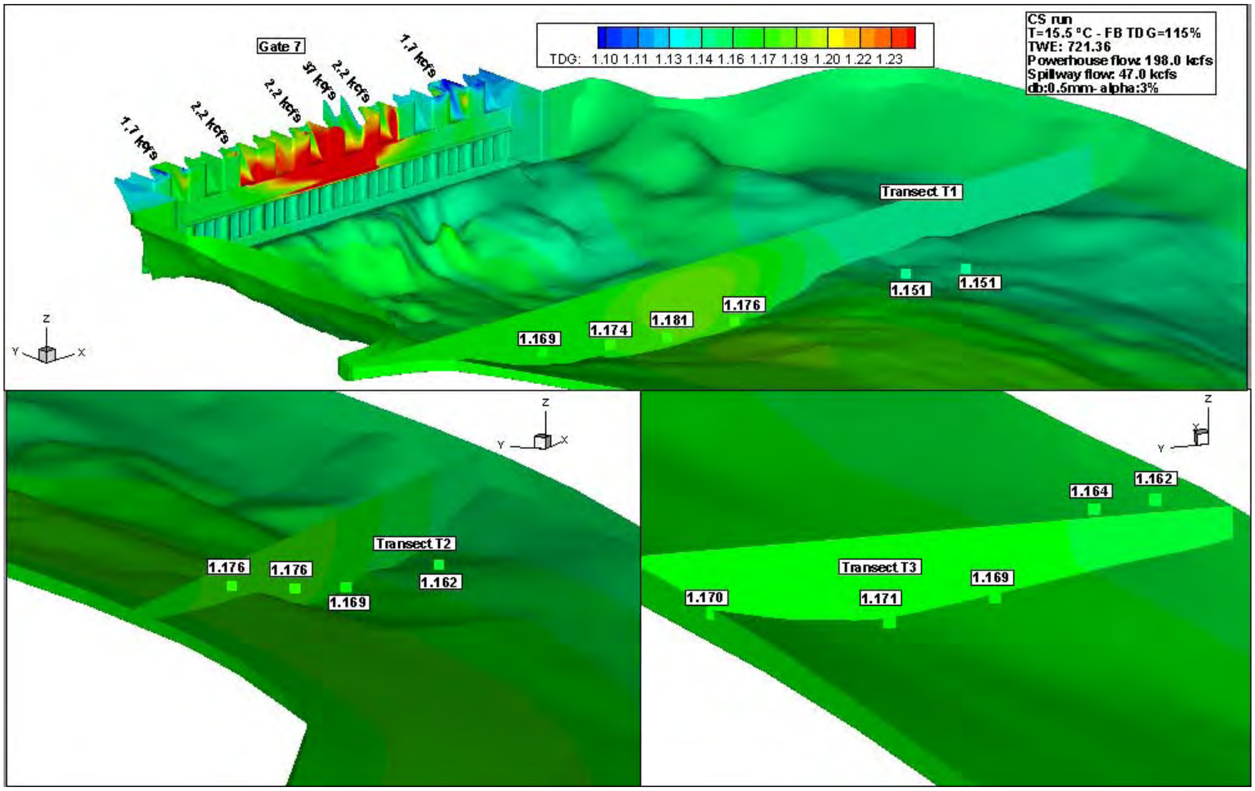

Figure 10.3-2 TDG distribution for the compliance simulation.

Table 9.3-1 Averaged predicted TDG in Transects 1, 2 and 3 for the compliance simulation.

Case	Type	Spill (kcfs)	Total Q (kcfs)	% Spilled	Unit Spill (kcfs/ft)	Tailwater Elevation (feet)	Spillway Submergence (feet)	% TDG Forebay	% TDG Transect 1	% TDG Transect 2	% TDG Transect 3	Difference % TDG Forebay to Transect 3
CS	1-FG	47	246	19.1	0.64	721.4	30.4	115.0	116.7	117.1	116.7	1.7

Figure 10.3-3 show isosurfaces of TDG, gas volume fraction and bubble diameter for the Standard Compliance Simulation. The highest TDG isosurfaces are observed directly below spillbay 7 corresponding with the zone of higher gas volume fraction (aerated zone). In this area, the entrained bubbles generate high levels of TDG. However, the supersaturated water quickly degasses by mass exchange with bubbles near the free surface and mass transfer at the turbulent free surface near the spillway. Moreover, as shown the streamlines of Figure 10.3-4, strong lateral currents caused by the surface jet on bay 7 directed water toward the center of the dam contributing further to fully mixed flow and TDG dilution.

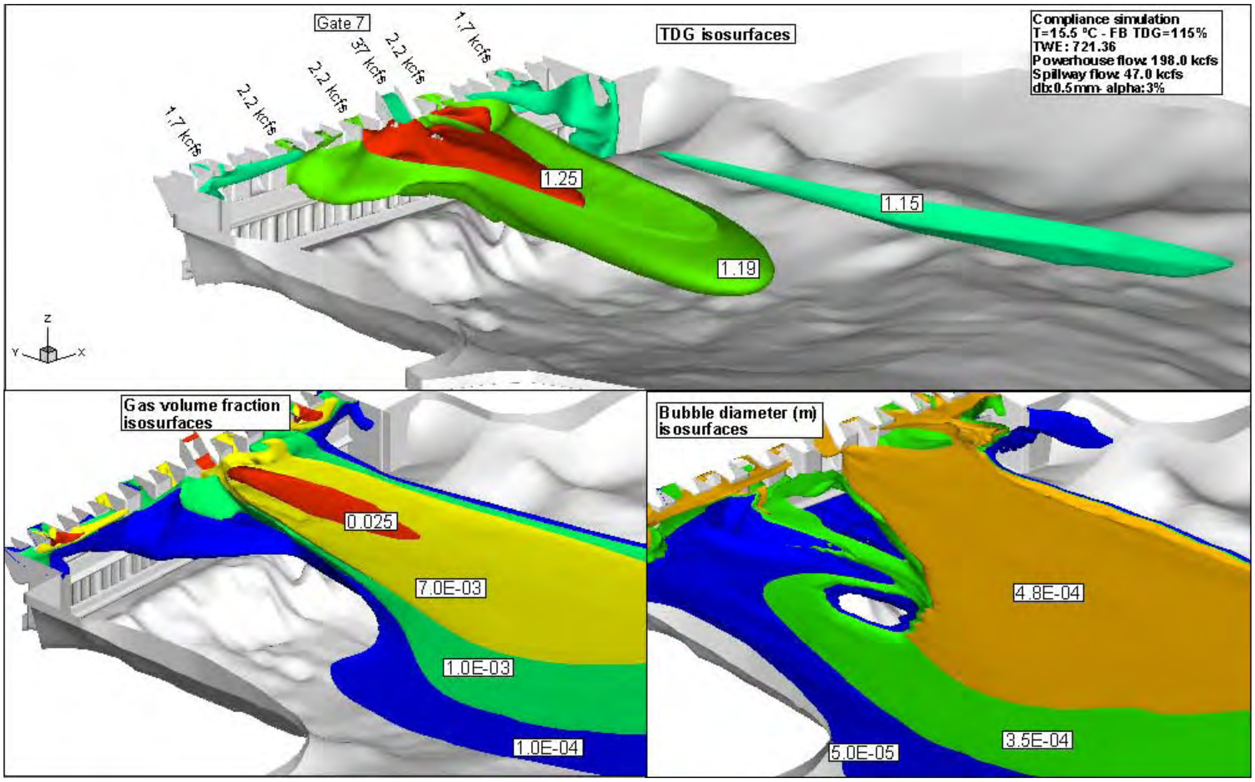

Figure 10.3-3 Streamlines colored by TDG concentration for the Standard Compliance Simulation.

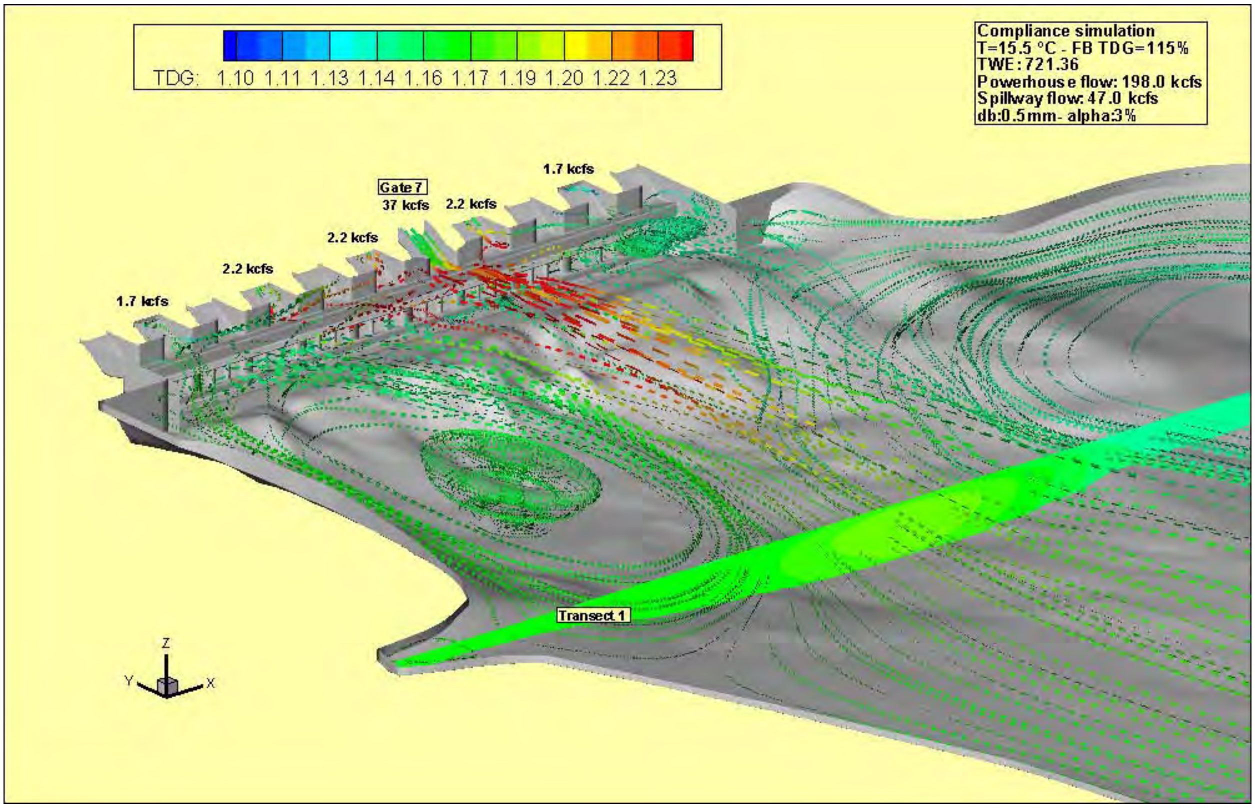

Figure 10.3-4 Streamlines colored by TDG concentration for the Standard Compliance Simulation.

10.4 TDG Dynamics During Non-Spill

Spill at Wells Dam typically occurs only during the fish passage season (April 1 to August 31), coinciding with high river flows observed during this period (Figure 10.4-1). TDG production during non-spill is virtually non-existent, with both median and average delta TDG values at 0.0% and 0.0% (SEM ± 0.0%), respectively. Delta TDG generally ranges ± 1%, often at negative values (Figure 10.4-2). The lack of TDG production during non-spill is further supported by a linear regression showing a significant positive correlation between forebay TDG and tailrace TDG ($y = 0.8873x+11.775$; $P < 0.000$, $R^2 = 0.81$). Median forebay TDG and tailrace TDG values during non-spill events over the past 10 years have both been 104% (average values for both measurements also 104%, SEM ± 0.0%; DART 2009). Only 7 of the 9,599 (0.07%) hourly values recorded during non-spill events between April and September, 1999-2008 surpassed 110% when forebay TDG was ≤ 110% (DART 2009). This negligible number of events is not biologically meaningful when encapsulated in any sort of daily average, including the 12-C High metric currently used by Ecology for compliance measures. These results indicate that Wells Dam is able to meet compliance with the 110% TDG tailrace criteria during non-spill events and outside of the fish passage season.

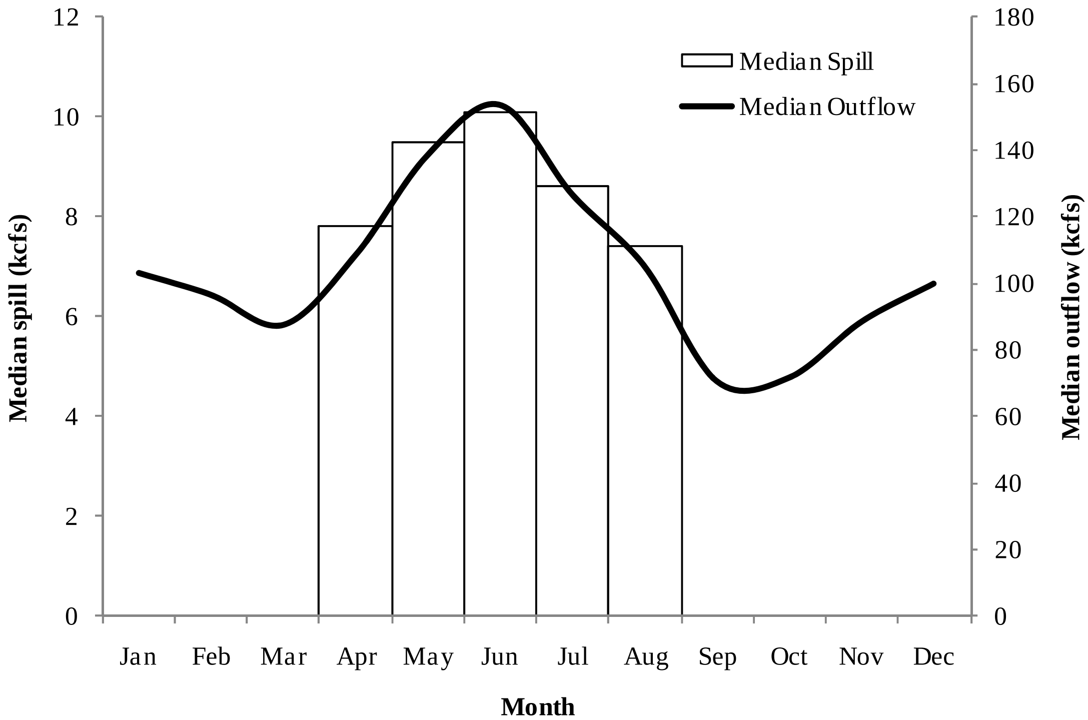

Figure 10.4-1 Median spill and outflow at Wells Dam by month, 1999-2008 (DART 2009).

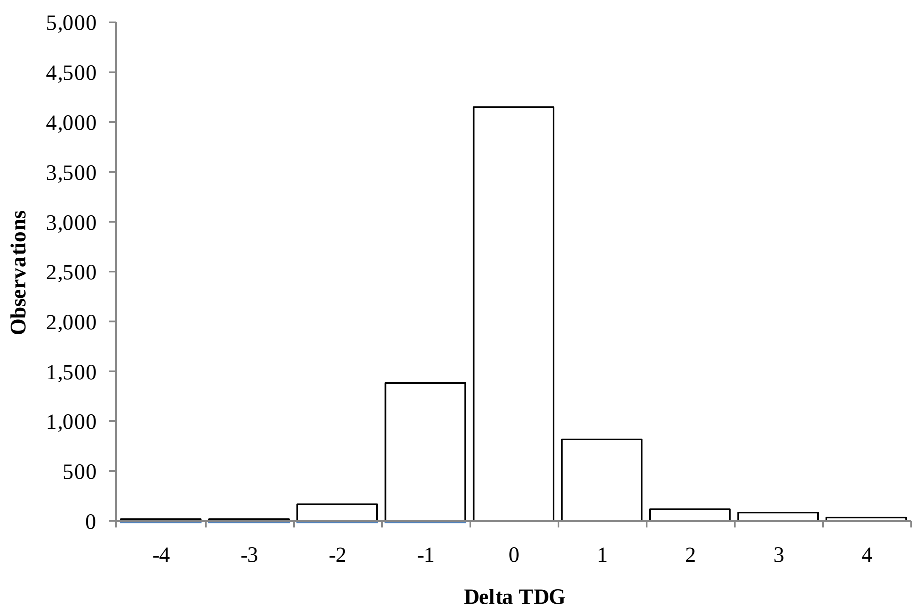

Figure 10.4-2 Delta TDG (tailrace TDG – forebay TDG) during non-spill at Wells Dam, 1999-2008 (n = 9,598 hourly values; DART 2009).

10.5 TDG Dynamics in the Rocky Reach Dam Forebay

Hourly TDG values in the Rocky Reach Dam forebay averaged 109.2% (± 0.0% SEM; median = 109.2%) during the fish passage season between 1999 and 2008, whereas daily TDG values averaged 106.6% (± 0.1% SEM; median = 107.5%; DART 2009). There is a strong and significant positive linear relationship between the tailrace measurements at Wells Dam and forebay measurements at Rocky Reach Dam amongst each of these years ($P < 0.00$) and combined ($P < 0.00$). The linear equations (Table 10.5-1) for these relationships indicate that:

- Wells tailrace TDG values up to 117.5% are required in order to reach 115% at the Rocky Reach Dam forebay monitoring station based on the historic 1999-2008 database.
- Years of spill testing (2004-2006) allowed for a lower than average maximum Wells Dam tailrace TDG (116.2%). At these relatively low levels of spill, the TDG standard at Rocky Reach forebay was not violated.
- Maximum tailrace TDG at Wells Dam to reach compliance at the Rocky Reach Dam forebay subsequent to implementing the Spill Playbook (2007) has ranged from 117.3% to 119.1% (average 118.2%).

Based on the historic operation at Wells Dam and the historic rate of TDG attenuation for the Rocky Reach reservoir, the Wells Project is reasonably expected to remain in full compliance with the numeric criteria set forth to ensure that a 115% TDG standard is met at the forebay of the downstream project (Rocky Reach Dam) under the Optimal Operating Conditions if incoming water to the forebay of Wells Dam is in compliance (115%). An annual TDG report is provided to Ecology each year to report observed values and any non-compliance events.

Table 10.5-1 Linear equations for hourly TDG values collected at the Wells Dam tailrace (WELW) and Rocky Reach Dam forebay (RRH). Spill testing occurred from 2004-2006, TDG Spill Playbooks were implemented in 2007.

Year	Equation	Maximum Tailrace TDG for 115% at RRH
’99-‘08	DisGasP, RRH = 27.120291 + 0.7478797*DisGasP, WELW	117.5
2004	DisGasP, RRH = 12.180962 + 0.8921431*DisGasP, WELW	115.2
2005	DisGasP, RRH = 22.815513 + 0.7906628*DisGasP, WELW	116.6
2006	DisGasP, RRH = 15.817845 + 0.8496649*DisGasP, WELW	116.7
2007	DisGasP, RRH = 36.643504 + 0.6579736*DisGasP, WELW	119.1
2008	DisGasP, RRH = 24.728595 + 0.7696586*DisGasP, WELW	117.3

11.0 LOCATION OF THE COMPLIANCE MONITORING STATION

The TDG distribution at transect T3 was analyzed to evaluate the location of the tailrace TDG compliance monitoring station WELW. The standard deviation, defined as:

$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(C - C_{ave}\right)^2}$, and the error of the TDG predicted at the compliance monitoring station calculated from $\text{Error}(\%) = \frac{\left(C_{WELW} - C_{ave}\right)}{C_{ave}} * 100$ are tabulated in Table 9.4-1.

Table 11.4-1 Averaged predicted TDG in Transect T3 and TDG at WELW.

Simulation	TDG Average	σ_{TDG}	WELW	Average-WELW Relative Difference (%)
MR1	1.179	0.00537	1.172	-0.580
MR2	1.237	0.01819	1.219	-1.459
MR3	1.207	0.00757	1.214	0.632
MR4	1.247	0.00493	1.251	0.365
MR5	1.167	0.00225	1.167	0.050
MR6	1.213	0.00103	1.212	-0.057
MR7	1.173	0.00490	1.178	0.435
MR8	1.226	0.00928	1.214	-0.920
MR9	1.229	0.00306	1.231	0.166
7Q10-A	1.198	0.00196	1.198	0.024
7Q10-B	1.177	0.01680	1.163	-1.189
7Q10-C	1.188	0.00706	1.181	-0.589
CS	1.167	0.00394	1.162	-0.428

In most of the cases the TDG gradient at transect T3 is small, indicating that the TDG gauge station is located in a region where substantial mixing has occurred.

12.0 CONCLUSIONS

A numerical study was performed with the objective of developing a spillway operation that would minimize TDG production in the Wells Tailrace. A two-phase flow model capable of predicting the dynamics of spillway surface jets, the hydrodynamics and TDG distribution within the Wells tailrace is presented. Variable bubble size and gas volume fraction were used to analyze dissolution and the consequent source of TDG. The model uses an anisotropic RSM turbulence model and attenuation of fluctuations at the free surface.

The model was calibrated and validated using field data collected on May 14, May 17, June 4 June 5 and June 17, 2006 during the TDG Production Dynamics Study (EES et al. 2007). The spillway flow was spread across spillbays on June 4, concentrated through a single spillbay on May 17, June 4 and June 5, and crowned on June 17. Velocity distribution measured in the tailrace on June 4 and June 5 was captured by the model. The bubble size and gas volume fraction at the inlet were the parameters of the model. A bubble diameter of 0.5 mm and gas volume fraction of 3% in the spillbays produced TDG values that bracketed field observations. In this study, the gas volume fraction and bubble size were selected to be above and below the averaged TDG measured on June 4 and 5, 2006.

The model captured the lateral TDG distribution and the reduction of TDG longitudinally as observed in the field. The model brackets the results of the field measurements for the validation cases with a deviation of about +/- 3% of the average TDG values for Transect 3. Numerical results obtained during calibration and validation demonstrated that the model used in the study captured the main features of the two-phase flow in the Wells tailrace and the trends of TDG values across all three transects.

Different spill releases and TDG production as a function of flow and tailwater elevation were analyzed to determine spillway operations that would minimize gas saturation in the tailrace. Nine runs with two spillway configurations (spread and FG) and four total river flows were simulated in an effort to identify how sensitive the model is to various spillway operating conditions. From this analysis it was concluded that:

- Full open gate operations result in the lowest TDG values downstream, followed by two open gates operation. The spread operation with moderate flow through each gate produced the highest TDG values as a result of more entrained air in the tailrace and smaller degasification at the free surface.

- TDG production is directly related to percentage of water spilled. In general, higher downstream TDG is observed as the spill percentage increases. Likewise, TDG production increases as the amount of spill increases. In addition, TDG levels downstream are reduced by dilution as powerhouse flow increases.

Based upon general gas dynamics defined by the results from the nine sensitivity runs, three additional simulations were performed to optimize spillway operations and further reduce TDG concentration downstream of the Wells Project during a 7Q10 (246 kcfs) event. Though the TDG production was similar for the simulated operations, the predicted lateral TDG distribution was significantly different. The Optimal Operating Condition that produced the lowest downstream TDG was a full open gate in bay 7 with most of the remaining flow in bay 3. This operation maximizes the lateral TDG gradient close to the dam promoting the degasification and downstream mixing. According to the model, spilling in a full open gate in bay 7 performs better than a mirror operation with full open gate in bay 5.

Finally, an additional scenario was modeled to provide Ecology with results consistent with settings used at other projects for evaluation of compliance with numeric WQS. The Standard Compliance Scenario was conducted using a concentrated spill in adjacent bays, with a 115% forebay TDG and 90% of maximum powerhouse capacity during a 7Q10 flow. The Standard Compliance Simulation produced an average TDG concentration at transect T3 of 116.7% well within the 120% TDG standard. This operation also maintained compliance with the TDG standard for the Rocky Reach forebay under the conditions described by the Standardized Compliance Simulation.

In addition to complying with the TDG standards for the Wells tailrace during the fish passage season, the Wells Project has also demonstrated an ability to meet the 119% TDG standard outside the fish passage season and, that ability to comply with the Rocky Reach forebay standard (115%). These three analyses, along with the considerable improvements identified in the TDG modeling, demonstrate the ability of the Wells Project to meet all numeric criteria for TDG under both the Optimal Operating Condition and the Standard Compliance Scenario.

13.0 ACKNOWLEDGMENTS

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Appendix A

Conditions Used for the Calibration, Validation, Sensitivity and 7Q10 Simulations

Treatment 46 S - June 4, 2006									
Tailwater Elevation: 717.3 ft – Forebay Elevation: 779.6 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	14.7	14.7	14.4	14.7	14.7	14.8	14.8	14.4	14.7
Powerhouse Total: 131.8 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	1.6	5.4	5.2	5.4	5.2	5.4	5.2	5.4	1.6
Spillway Total: 40.6 kcfs									
Total River Flow: 172.4 kcfs									
Forebay TDG: 111.8%									

Treatment 47 FG - June 5, 2006									
Tailwater Elevation: 720.2 ft – Forebay Elevation: 778.6 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	18.9	18.0	18.5	18.3	19.0	20.2	19.6	19.9	18.2
Powerhouse Total: 170.6 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	1.3	0.0	2.2	0.0	2.2	42.5	2.2	0.0	1.3
Spillway Total: 51.7 kcfs									
Total River Flow: 222.3 kcfs									
Forebay TDG: 111.5%									

Treatment 1 FG - May 14, 2006									
Tailwater Elevation: 711.5 ft – Forebay Elevation: 778.7 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	15.0	15.0	14.8	0.0	0.0	0.0	0.0	14.8	15.2
Powerhouse Total: 74.8 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	1.3	0.0	2.2	0.0	2.2	35.4	2.2	0.0	1.3
Spillway Total: 44.6 kcfs									
Total River Flow: 120.4 kcfs									
Forebay TDG: 109.1%									

Treatment 11 FG - May 17, 2006									
Tailwater Elevation: 715.4 ft – Forebay Elevation: 777.3 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	18.9	19.1	18.7	19.2	0.0	0.0	0.0	18.7	19.2
Powerhouse Total: 113.7 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.9	0.0	2.2	0.0	2.2	34.1	2.2	0.0	0.9
Spillway Total: 42.6 kcfs									
Total River Flow: 157.2 kcfs									
Forebay TDG: 110.4%									

Treatment 63 C - June 17, 2006									
Tailwater Elevation: 718.6 ft – Forebay Elevation: 780.1 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	13.0	13.0	12.9	13.0	13.0	13.1	13.1	12.8	13.1
Powerhouse Total: 117.1 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	1.7	0.0	2.2	0.0	2.2	29.8	19.9	29.8	1.7
Spillway Total: 87.4 kcfs									
Total River Flow: 205.5 kcfs									
Forebay TDG: 113.9%									

Simulation MR1									
Tailwater Elevation: 718.8 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Powerhouse Total: 185.5 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	0.0
Spillway Total: 23.0 kcfs									
Total River Flow: 208.5 kcfs									
Forebay TDG: 115.0%									

Simulation MR2									
Tailwater Elevation: 721.4 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Powerhouse Total: 185.5 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	8.6	8.6	8.6	8.6	8.6	8.6	8.6	0.0
Spillway Total: 60.5 kcfs									
Total River Flow: 246.0 kcfs									
Forebay TDG: 115.0%									

Simulation MR3									
Tailwater Elevation: 713.4 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	0.0	19.2	19.2	19.2	19.2	19.2	0.0	0.0	0.0
Powerhouse Total: 96.0 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	0.0
Spillway Total: 23.0 kcfs									
Total River Flow: 119.0 kcfs									
Forebay TDG: 115.0%									

Simulation MR4									
Tailwater Elevation: 715.9 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	0.0	19.2	19.2	19.2	19.2	19.2	0.0	0.0	0.0
Powerhouse Total: 96.0 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	8.6	8.6	8.6	8.6	8.6	8.6	8.6	0.0
Spillway Total: 60.5 kcfs									
Total River Flow: 156.5 kcfs									
Forebay TDG: 115.0%									

Simulation MR5									
Tailwater Elevation: 718.8 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Powerhouse Total: 185.5 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	0.0	0.0	0.0	0.0	23.0	0.0	0.0	0.0
Spillway Total: 23.0 kcfs									
Total River Flow: 208.5 kcfs									
Forebay TDG: 115.0%									

Simulation MR6									
Tailwater Elevation: 721.4 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Powerhouse Total: 185.5 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	0.0	0.0	0.0	0.0	60.5	0.0	0.0	0.0
Spillway Total: 60.5 kcfs									
Total River Flow: 246.0 kcfs									
Forebay TDG: 115.0%									

Simulation MR7									
Tailwater Elevation: 713.4 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	0.0	19.2	19.2	19.2	19.2	19.2	0.0	0.0	0.0
Powerhouse Total: 96.0 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	0.0	0.0	0.0	0.0	23.0	0.0	0.0	0.0
Spillway Total: 23.0 kcfs									
Total River Flow: 119.0 kcfs									
Forebay TDG: 115.0%									

Simulation MR8									
Tailwater Elevation: 721.4 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Powerhouse Total: 185.5 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	0.0	0.0	30.3	0.0	30.3	0.0	0.0	0.0
Spillway Total: 60.5 kcfs									
Total River Flow: 246.0 kcfs									
Forebay TDG: 115.0%									

Simulation MR9									
Tailwater Elevation: 715.9 ft – Forebay Elevation: 781.0 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	0.0	19.2	19.2	19.2	19.2	19.2	0.0	0.0	0.0
Powerhouse Total: 96.0 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	0.0	0.0	0.0	30.3	0.0	30.3	0.0	0.0	0.0
Spillway Total: 60.5 kcfs									
Total River Flow: 156.5 kcfs									
Forebay TDG: 115%									

Treatment 7Q10-A									
Tailwater Elevation: 721.4 ft – Forebay Elevation: 780.5 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Powerhouse Total: 180.0 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	1.7	0.0	2.2	0.0	8.0	43.0	8.0	0.0	1.7
Spillway Total: 64.6 kcfs									
Total River Flow: 244.6 kcfs									
Forebay TDG: 113.0%									

Treatment 7Q10-B									
Tailwater Elevation: 721.4 ft – Forebay Elevation: 780.5 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Powerhouse Total: 180.0 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	1.7	12.0	2.2	0.0	2.2	43.0	2.2	0.0	1.7
Spillway Total: 65.0 kcfs									
Total River Flow: 245.0 kcfs									
Forebay TDG: 113.0%									

Treatment 7Q10-C									
Tailwater Elevation: 721.4 ft – Forebay Elevation: 780.5 ft									
Powerhouse Unit Discharge (kcfs)									
U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
0.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Powerhouse Total: 180.0 kcfs									
Spillway Unit Discharge (kcfs)									
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0	1.7	0.0	2.2	43.0	2.2	0.0	2.2	12.0	1.7
Spillway Total: 65.0 kcfs									
Total River Flow: 245.0 kcfs									
Forebay TDG: 113.0%									

Appendix B

Measured and Predicted TDG Concentrations at Probe Locations

Comparison between measured and predicted TDG on June 4, 2006

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	TDG measured	diff %	Average predicted	Average measured	Average error %
TW1P2	1878138.7	345839.8	648.7	1.238	1.173	5.58			
TW1P3	1877972.7	345812.5	648.4	1.265	1.178	7.41			
TW1P4Z1	1877766.1	345652.5	692.0	1.224	1.200	1.97			
TW1P4Z2	1877685.6	345800.1	657.0	1.190	1.197	-0.61	1.229	1.187	3.56
TW2P2	1878494.5	343593.5	675.9	1.204	1.172	2.72			
TW2P3	1878414.7	343618.3	679.9	1.230	1.174	4.78			
TW2P4	1878237.5	343582.5	698.6	1.233	1.179	4.55	1.222	1.175	4.02
WELW	1870372.9	334581.1	692.0	1.190	1.165	2.18			
TW3P2	1870323.5	334702.2	698.7	1.202	1.171	2.69			
TW3P4	1870037.3	334949.0	673.4	1.211	1.179	2.74			
TW3P5	1869929.7	335169.1	697.9	1.222	1.188	2.87	1.207	1.176	2.62

Comparison between measured and predicted TDG on June 5, 2006

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	TDG measured	diff %	Average predicted	Average measured	Average error %
TW1P2	1878138.7	345839.8	648.7	1.160	1.200	-3.38			
TW1P3	1877972.7	345812.5	648.4	1.155	1.180	-2.05			
TW1P4Z1	1877766.1	345652.5	692.0	1.153	1.158	-0.46			
TW1P4Z2	1877685.6	345800.1	657.0	1.152	1.159	-0.68	1.155	1.174	-1.66
TW2P2	1878494.5	343593.5	675.9	1.151	1.181	-2.53			
TW2P3	1878414.7	343618.3	679.9	1.152	1.182	-2.57			
TW2P4	1878237.5	343582.5	698.6	1.151	1.183	-2.73	1.151	1.182	-2.61
WELW	1870372.9	334581.1	692.0	1.149	1.173	-2.04			
TW3P2	1870323.5	334702.2	698.7	1.150	1.178	-2.35			
TW3P4	1870037.3	334949.0	673.4	1.151	1.182	-2.68			
TW3P5	1869929.7	335169.1	697.9	1.150	1.182	-2.67	1.150	1.179	-2.44

Comparison between measured and predicted TDG on May 14, 2006

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	TDG measured	diff %	Average predicted	Average measured	Average error %
TW1P1Z1	1878593.6	345704.7	692.0	1.155	1.167	-1.00			
TW1P1Z2	1878511.2	345814.2	669.1	1.159	1.167	-0.67			
TW1P2	1878138.7	345839.8	648.7	1.170	1.181	-0.96			
TW1P3	1877972.7	345812.5	648.4	1.176	1.187	-0.91			
TW1P4Z1	1877766.1	345652.5	692.0	1.173	1.163	0.88			
TW1P4Z2	1877685.6	345800.1	657.0	1.166	1.168	-0.21	1.167	1.172	-0.48
TW2P1	1878645.0	343552.6	675.6	1.162	1.167	-0.43			
TW2P2	1878494.5	343593.5	675.9	1.162	1.170	-0.71			
TW2P3	1878414.7	343618.3	679.9	1.163	1.175	-1.05			
TW2P4	1878237.5	343582.5	698.6	1.164	1.180	-1.38	1.163	1.173	-0.89
WELW	1870372.9	334581.1	692.0	1.163	1.151	1.01			
TW3P2	1870323.5	334702.2	698.7	1.162	1.165	-0.28			
TW3P3	1870104.4	334818.9	679.0	1.163	1.164	-0.12			
TW3P4	1870037.3	334949.0	673.4	1.164	1.173	-0.80			
TW3P5	1869929.7	335169.1	697.9	1.164	1.170	-0.48	1.163	1.165	-0.14

Comparison between measured and predicted TDG on May 17, 2006

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	TDG measured	diff %	Average predicted	Average measured	Average error %
TW1-1S	1878593.6	345704.7	692.0	1.147	1.163	-1.38			
TW 1-1	1878511.2	345814.2	669.1	1.156	1.161	-0.44			
TW 1-2	1878138.7	345839.8	648.7	1.183	1.166	1.45			
TW 1-3	1877972.7	345812.5	648.4	1.188	1.173	1.21			
TW1-4S	1877766.1	345652.5	692.0	1.177	1.149	2.47			
TW 1-4	1877685.6	345800.1	657.0	1.168	1.153	1.30	1.170	1.161	0.77
TW 2-2	1878494.5	343593.5	675.9	1.168	1.168	0.01			
TW 2-3	1878414.7	343618.3	679.9	1.171	1.172	-0.11			
TW 2-4	1878237.5	343582.5	698.6	1.167	1.167	0.04	1.169	1.169	-0.02
WELW	1870372.9	334581.1	692.0	1.165	1.153	1.05			
TW 3-2	1870323.5	334702.2	698.7	1.166	1.164	0.15			
TW 3-3	1870104.4	334818.9	679.0	1.167	1.162	0.47			
TW 3-4	1870037.3	334949.0	673.4	1.168	1.169	-0.11			
TW 3-5	1869929.7	335169.1	697.9	1.168	1.161	0.59	1.167	1.162	0.43

Comparison between measured and predicted TDG on June 17, 2006

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	TDG measured	diff %	Average predicted	Average measured	Average error %
TW1P1Z1	1878593.6	345704.7	692.0	1.188	1.256	-5.39			
TW1P2	1878138.7	345839.8	648.7	1.398	1.282	12.97			
TW1P3	1877972.7	345812.5	648.4	1.343	1.260	6.57			
TW1P4Z1	1877766.1	345652.5	692.0	1.284	1.217	5.54			
TW1P4Z2	1877685.6	345800.1	657.0	1.259	1.222	3.03	1.305	1.247	4.58
TW2P2	1878494.5	343593.5	675.9	1.261	1.261	-0.02			
TW2P3	1878414.7	343618.3	679.9	1.265	1.261	0.34			
TW2P4	1878237.5	343582.5	698.6	1.265	1.233	2.58	1.264	1.252	0.95
WELW	1870372.9	334581.1	692.0	1.256	1.243	1.06			
TW3P2	1870323.5	334702.2	698.7	1.264	1.249	1.16			
TW3P4	1870037.3	334949.0	673.4	1.268	1.248	1.58			
TW3P5	1869929.7	335169.1	697.9	1.269	1.238	2.53	1.264	1.245	1.58

MR1

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.169	
TW1P1Z2	1878511.2	345814.2	669.1	1.162	
TW1P2	1878138.7	345839.8	648.7	1.174	
TW1P3	1877972.7	345812.5	648.4	1.168	
TW1P4Z1	1877766.1	345652.5	692.0	1.182	
TW1P4Z2	1877685.6	345800.1	657.0	1.182	1.173
TW2P1	1878645.0	343552.6	675.6	1.170	
TW2P2	1878494.5	343593.5	675.9	1.176	
TW2P3	1878414.7	343618.3	679.9	1.187	
TW2P4	1878237.5	343582.5	698.6	1.190	1.181
WELW	1870372.9	334581.1	692.0	1.172	
TW3P2	1870323.5	334702.2	698.7	1.175	
TW3P3	1870104.4	334818.9	679.0	1.180	
TW3P4	1870037.3	334949.0	673.4	1.183	
TW3P5	1869929.7	335169.1	697.9	1.185	1.179

MR2

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.203	
TW1P1Z2	1878511.2	345814.2	669.1	1.180	
TW1P2	1878138.7	345839.8	648.7	1.240	
TW1P3	1877972.7	345812.5	648.4	1.246	
TW1P4Z1	1877766.1	345652.5	692.0	1.273	
TW1P4Z2	1877685.6	345800.1	657.0	1.278	1.237
TW2P1	1878645.0	343552.6	675.6	1.217	
TW2P2	1878494.5	343593.5	675.9	1.232	
TW2P3	1878414.7	343618.3	679.9	1.247	
TW2P4	1878237.5	343582.5	698.6	1.266	1.241
WELW	1870372.9	334581.1	692.0	1.219	
TW3P2	1870323.5	334702.2	698.7	1.223	
TW3P3	1870104.4	334818.9	679.0	1.234	
TW3P4	1870037.3	334949.0	673.4	1.244	
TW3P5	1869929.7	335169.1	697.9	1.264	1.237

MR3

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.246	
TW1P1Z2	1878511.2	345814.2	669.1	1.247	
TW1P2	1878138.7	345839.8	648.7	1.232	
TW1P3	1877972.7	345812.5	648.4	1.193	
TW1P4Z1	1877766.1	345652.5	692.0	1.181	
TW1P4Z2	1877685.6	345800.1	657.0	1.182	1.213
TW2P1	1878645.0	343552.6	675.6	1.227	
TW2P2	1878494.5	343593.5	675.9	1.216	
TW2P3	1878414.7	343618.3	679.9	1.201	
TW2P4	1878237.5	343582.5	698.6	1.185	1.207
WELW	1870372.9	334581.1	692.0	1.214	
TW3P2	1870323.5	334702.2	698.7	1.214	
TW3P3	1870104.4	334818.9	679.0	1.206	
TW3P4	1870037.3	334949.0	673.4	1.203	
TW3P5	1869929.7	335169.1	697.9	1.197	1.207

MR4

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.297	
TW1P1Z2	1878511.2	345814.2	669.1	1.295	
TW1P2	1878138.7	345839.8	648.7	1.262	
TW1P3	1877972.7	345812.5	648.4	1.230	
TW1P4Z1	1877766.1	345652.5	692.0	1.248	
TW1P4Z2	1877685.6	345800.1	657.0	1.248	1.263
TW2P1	1878645.0	343552.6	675.6	1.258	
TW2P2	1878494.5	343593.5	675.9	1.244	
TW2P3	1878414.7	343618.3	679.9	1.237	
TW2P4	1878237.5	343582.5	698.6	1.243	1.245
WELW	1870372.9	334581.1	692.0	1.251	
TW3P2	1870323.5	334702.2	698.7	1.251	
TW3P3	1870104.4	334818.9	679.0	1.247	
TW3P4	1870037.3	334949.0	673.4	1.244	
TW3P5	1869929.7	335169.1	697.9	1.239	1.247

MR5

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.158	
TW1P1Z2	1878511.2	345814.2	669.1	1.157	
TW1P2	1878138.7	345839.8	648.7	1.171	
TW1P3	1877972.7	345812.5	648.4	1.163	
TW1P4Z1	1877766.1	345652.5	692.0	1.155	
TW1P4Z2	1877685.6	345800.1	657.0	1.157	1.160
TW2P1	1878645.0	343552.6	675.6	1.168	
TW2P2	1878494.5	343593.5	675.9	1.172	
TW2P3	1878414.7	343618.3	679.9	1.170	
TW2P4	1878237.5	343582.5	698.6	1.163	1.168
WELW	1870372.9	334581.1	692.0	1.1672	
TW3P2	1870323.5	334702.2	698.7	1.16764	
TW3P3	1870104.4	334818.9	679.0	1.1681	
TW3P4	1870037.3	334949.0	673.4	1.16751	
TW3P5	1869929.7	335169.1	697.9	1.16264	1.167

MR6

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.208	
TW1P1Z2	1878511.2	345814.2	669.1	1.205	
TW1P2	1878138.7	345839.8	648.7	1.221	
TW1P3	1877972.7	345812.5	648.4	1.217	
TW1P4Z1	1877766.1	345652.5	692.0	1.205	
TW1P4Z2	1877685.6	345800.1	657.0	1.211	1.211
TW2P1	1878645.0	343552.6	675.6	1.213	
TW2P2	1878494.5	343593.5	675.9	1.215	
TW2P3	1878414.7	343618.3	679.9	1.216	
TW2P4	1878237.5	343582.5	698.6	1.213	1.214
WELW	1870372.9	334581.1	692.0	1.212	
TW3P2	1870323.5	334702.2	698.7	1.213	
TW3P3	1870104.4	334818.9	679.0	1.214	
TW3P4	1870037.3	334949.0	673.4	1.214	
TW3P5	1869929.7	335169.1	697.9	1.212	1.213

MR7

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.193	
TW1P1Z2	1878511.2	345814.2	669.1	1.192	
TW1P2	1878138.7	345839.8	648.7	1.191	
TW1P3	1877972.7	345812.5	648.4	1.165	
TW1P4Z1	1877766.1	345652.5	692.0	1.155	
TW1P4Z2	1877685.6	345800.1	657.0	1.156	1.175
TW2P1	1878645.0	343552.6	675.6	1.181	
TW2P2	1878494.5	343593.5	675.9	1.176	
TW2P3	1878414.7	343618.3	679.9	1.168	
TW2P4	1878237.5	343582.5	698.6	1.159	1.171
WELW	1870372.9	334581.1	692.0	1.178	
TW3P2	1870323.5	334702.2	698.7	1.178	
TW3P3	1870104.4	334818.9	679.0	1.173	
TW3P4	1870037.3	334949.0	673.4	1.171	
TW3P5	1869929.7	335169.1	697.9	1.167	1.173

MR8

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.180	
TW1P1Z2	1878511.2	345814.2	669.1	1.178	
TW1P2	1878138.7	345839.8	648.7	1.194	
TW1P3	1877972.7	345812.5	648.4	1.248	
TW1P4Z1	1877766.1	345652.5	692.0	1.227	
TW1P4Z2	1877685.6	345800.1	657.0	1.243	1.212
TW2P1	1878645.0	343552.6	675.6	1.210	
TW2P2	1878494.5	343593.5	675.9	1.223	
TW2P3	1878414.7	343618.3	679.9	1.244	
TW2P4	1878237.5	343582.5	698.6	1.241	1.230
WELW	1870372.9	334581.1	692.0	1.214	
TW3P2	1870323.5	334702.2	698.7	1.218	
TW3P3	1870104.4	334818.9	679.0	1.227	
TW3P4	1870037.3	334949.0	673.4	1.233	
TW3P5	1869929.7	335169.1	697.9	1.236	1.226

MR9

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.213	
TW1P1Z2	1878511.2	345814.2	669.1	1.212	
TW1P2	1878138.7	345839.8	648.7	1.218	
TW1P3	1877972.7	345812.5	648.4	1.244	
TW1P4Z1	1877766.1	345652.5	692.0	1.217	
TW1P4Z2	1877685.6	345800.1	657.0	1.228	1.222
TW2P1	1878645.0	343552.6	675.6	1.232	
TW2P2	1878494.5	343593.5	675.9	1.233	
TW2P3	1878414.7	343618.3	679.9	1.230	
TW2P4	1878237.5	343582.5	698.6	1.223	1.229
WELW	1870372.9	334581.1	692.0	1.231	
TW3P2	1870323.5	334702.2	698.7	1.231	
TW3P3	1870104.4	334818.9	679.0	1.230	
TW3P4	1870037.3	334949.0	673.4	1.229	
TW3P5	1869929.7	335169.1	697.9	1.224	1.229

7Q10-A Simulation

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.189	
TW1P1Z2	1878511.2	345814.2	669.1	1.188	
TW1P2	1878138.7	345839.8	648.7	1.202	
TW1P3	1877972.7	345812.5	648.4	1.199	
TW1P4Z1	1877766.1	345652.5	692.0	1.182	
TW1P4Z2	1877685.6	345800.1	657.0	1.189	1.192
TW2P1	1878645.0	343552.6	675.6	1.198	
TW2P2	1878494.5	343593.5	675.9	1.200	
TW2P3	1878414.7	343618.3	679.9	1.202	
TW2P4	1878237.5	343582.5	698.6	1.197	1.199
WELW	1870372.9	334581.1	692.0	1.198	
TW3P2	1870323.5	334702.2	698.7	1.198	
TW3P3	1870104.4	334818.9	679.0	1.199	
TW3P4	1870037.3	334949.0	673.4	1.199	
TW3P5	1869929.7	335169.1	697.9	1.194	1.198

7Q10-B Simulation

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.150	
TW1P1Z2	1878511.2	345814.2	669.1	1.153	
TW1P2	1878138.7	345839.8	648.7	1.168	
TW1P3	1877972.7	345812.5	648.4	1.202	
TW1P4Z1	1877766.1	345652.5	692.0	1.228	
TW1P4Z2	1877685.6	345800.1	657.0	1.225	1.188
TW2P1	1878645.0	343552.6	675.6	1.161	
TW2P2	1878494.5	343593.5	675.9	1.166	
TW2P3	1878414.7	343618.3	679.9	1.181	
TW2P4	1878237.5	343582.5	698.6	1.204	1.178
WELW	1870372.9	334581.1	692.0	1.163	
TW3P2	1870323.5	334702.2	698.7	1.165	
TW3P3	1870104.4	334818.9	679.0	1.172	
TW3P4	1870037.3	334949.0	673.4	1.180	
TW3P5	1869929.7	335169.1	697.9	1.204	1.177

7Q10-C Simulation

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.171	
TW1P1Z2	1878511.2	345814.2	669.1	1.172	
TW1P2	1878138.7	345839.8	648.7	1.184	
TW1P3	1877972.7	345812.5	648.4	1.187	
TW1P4Z1	1877766.1	345652.5	692.0	1.208	
TW1P4Z2	1877685.6	345800.1	657.0	1.210	1.189
TW2P1	1878645.0	343552.6	675.6	1.181	
TW2P2	1878494.5	343593.5	675.9	1.182	
TW2P3	1878414.7	343618.3	679.9	1.188	
TW2P4	1878237.5	343582.5	698.6	1.200	1.188
WELW	1870372.9	334581.1	692.0	1.181	
TW3P2	1870323.5	334702.2	698.7	1.183	
TW3P3	1870104.4	334818.9	679.0	1.186	
TW3P4	1870037.3	334949.0	673.4	1.189	
TW3P5	1869929.7	335169.1	697.9	1.199	1.188

Compliance Simulation

Transect	Easting (feet)	Northing (feet)	Z (feet)	TDG predicted	Average predicted
TW1P1Z1	1878593.6	345704.7	692.0	1.151	
TW1P1Z2	1878511.2	345814.2	669.1	1.151	
TW1P2	1878138.7	345839.8	648.7	1.176	
TW1P3	1877972.7	345812.5	648.4	1.181	
TW1P4Z1	1877766.1	345652.5	692.0	1.174	
TW1P4Z2	1877685.6	345800.1	657.0	1.169	1.167
TW2P1	1878645.0	343552.6	675.6	1.162	
TW2P2	1878494.5	343593.5	675.9	1.169	
TW2P3	1878414.7	343618.3	679.9	1.176	
TW2P4	1878237.5	343582.5	698.6	1.176	1.171
WELW	1870372.9	334581.1	692.0	1.162	
TW3P2	1870323.5	334702.2	698.7	1.164	
TW3P3	1870104.4	334818.9	679.0	1.169	
TW3P4	1870037.3	334949.0	673.4	1.171	
TW3P5	1869929.7	335169.1	697.9	1.170	1.167

Memorandum

Aquatic Settlement Work Group

Date: August 3rd, 2009

To: Aquatic Settlement Work Group and USFWS

From: Douglas PUD and Columbia Basin Environmental

cc:

re: 2009 Turbidity Monitoring on the Okanogan River

Columbia Basin Environmental was contracted to monitor turbidity in the Okanogan River and the Wells Forebay during the spring of 2009. These data were collected to supplement results from the turbidity monitoring conducted in 2008, in which data gaps occurred on occasion due to log jams, battery failure, and location of instrumentation. Specifically, Douglas was requested to implement an additional season of data collection to demonstrate that turbidity did not increase in the Okanogan River as a result of Project effects. The Washington State water quality standard (WQS) is that turbidity shall not exceed 5 NTU over background when the background is 50 NTU or less; or a 10% increase in turbidity when the background turbidity is more than 50 NTU.

Hourly data were collected with a Hydrolab equipped with Hach's Self-Cleaning Turbidity Sensor[1] at Malott (RM 17.0, above Project boundary), Monse (RM 5.0), and the Highway 97 Bridge (RM 1.3; Figure 1). Instrument housing at Monse created a condition in which sediments were collecting in the Hydrolab and negating results for portions of the 2009 monitoring season (Figure 2; data not available between May 28th and June 10th, and between June 12th and 25th). Instrumentation was cleaned, calibrated, and re-deployed on June 25th. A 2100P IS Portable Turbidimeter[2] was subsequently used to conduct weekly grab samples beginning June 25th as an additional measure to compare turbidity between Malott and Monse.

Daily turbidity at Wells Dam Forebay was negligible, ranging from 0.00 to 2.42 NTUs (median 0.00 NTUs, average 0.29 NTUs, standard error ± 0.09 NTUs), and therefore not included in the attached graphs. There were no instances where turbidity at the Wells Dam Forebay exceeded measurements at Malott, Monse, or the Highway 97 Bridge (43, 17, and 42 comparable days between May 27th and July 8th, respectively). Compliance with the WQS numeric criteria for turbidity was demonstrated during all periods in the Wells Forebay.

[1] Accuracy: ± 1% up to 100 NTU, ± 3% from 100-400 NTU, ± 5% from 400-3000 NTU

[2] Accuracy: ± 2% of reading plus stray light from 0 to 1000 NTU (stray light: <0.02 NTU)

Turbidity in the Okanogan River decreased significantly from above the Project Boundary at Malott to Monse, and as waters reached the confluence with the Columbia River (Highway 97; Figure 3). There were no instances where turbidity at the Highway 97 Bridge exceeded measurements at Malott (background) out of 42 comparable days (May 28th – July 8th, 2009). Compliance with the WQS numeric criteria was demonstrated during all periods at the Highway 97 Bridge.

Turbidity was also examined between Monse and the background (Malott) since Columbia River water is known to influence the lowermost portions of the Okanagan River. Measurements collected at Monse (RM 5.0) supported the abovementioned trend of decreasing turbidity throughout the Okanogan and Columbia rivers. Average turbidity at Monse was typically lower than values collected at Malott. Despite the loss of data during periods of instrument blockage, 17 comparable days were collected at Monse. On only one of these days (June 11th) did turbidity at Monse exceed those observed at Malott, but only by 3.2 NTUs – well within the numeric criteria for turbidity (33.1 and 29.9 NTUs, respectively). Grab samples supported these findings that turbidity decreased between Malott and Monse (Table 1, Figure 4). On only one of the weekly grab samples (collected July 14th) did the turbidity at Monse exceed those observed at Malott, but only by 0.7 NTUs, also within the numeric criteria for turbidity (2.6 and 1.9 NTUs, respectively). Data collected in 2008 showed similar patterns between Malott and Monse, with turbidity generally lower at Monse and less deviation around the mean (Table 2, Figure 5).

Collectively, results from both the Hydrolab and grab samples indicate that the Wells Project is in compliance for turbidity at all locations, including Monse, Highway 97, and the Wells Dam Forebay. There were no instances where turbidity at Monse or Highway 97 exceeded turbidity at Malott by more than 5 NTU, and values were generally lesser at downstream locations. These results are consistent with limnological processes.

Figure 1. Location of CBE monitoring stations on the Okanogan River, 2009.

Figure 2. Hyrdolab and sediment blockage after retrieval from Monse on the Okanogan River, 2009.

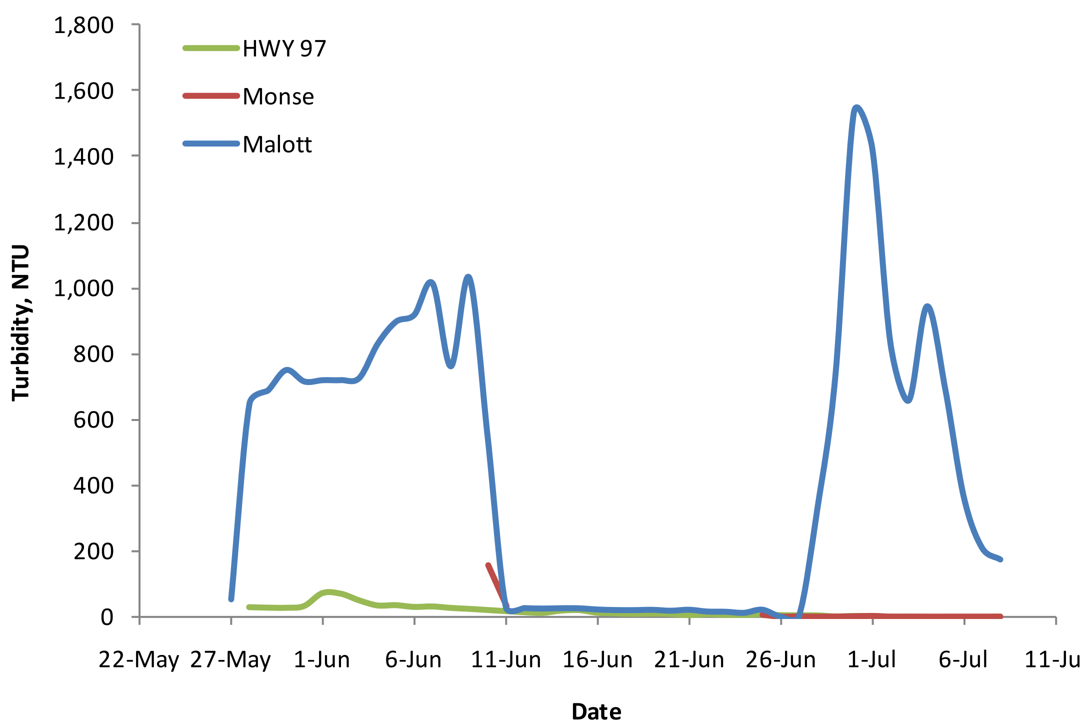

Figure 3. Turbidity (NTUs) collected by Hydrolabs in the Okanogan River at Malott, Monse, and Highway 97, 2009.

Table 1. Grab samples collected from the Okanogan River at Malott and Monse, 2009.

Site	Date	Sample	NTU	Site	Date	Sample	NTU
Malott	06/25/09	19:15	7.0	Monse	06/25/09	19:55	5.2
Malott	06/25/09	19:15	7.1	Monse	06/25/09	19:55	5.5
Malott	06/25/09	19:15	8.2	Monse	06/25/09	19:55	6.0
Malott	07/01/09	15:25	4.2	Monse	07/01/09	15:10	3.7
Malott	07/01/09	15:25	4.8	Monse	07/01/09	15:10	3.9
Malott	07/01/09	15:25	5.2	Monse	07/01/09	15:10	3.5
Malott	07/08/09	9:30	3.3	Monse	07/08/09	11:20	3.4
Malott	07/08/09	9:30	3.9	Monse	07/08/09	11:20	2.5
-	-	-	-	Monse	07/08/09	11:20	2.7
Malott	07/14/09	15:05	2.1	Monse	07/14/09	15:20	2.5
Malott	07/14/09	15:05	1.9	Monse	07/14/09	15:20	2.7
Malott	07/14/09	15:05	1.6	-	-	-	-

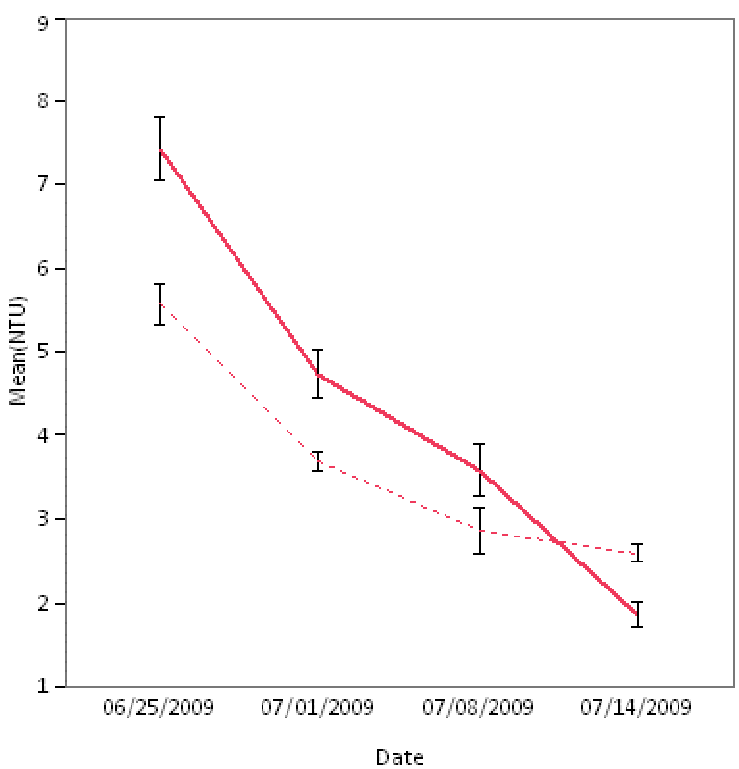

Figure 4. Mean turbidity values (NTUs, ± standard error) collected by a 2100P IS Portable Turbidimeter from the Okanogan River at Malott and Monse (dashed line), 2009.

Table 2. Quantiles and Moments of Hydrolab turbidity data collected at Malott and Monse on the Okanogan River, 2008.

Location	Malott	Monse
Quantiles		
Maximum	546.0	53.7
75% Quartile	15.7	8.5
Median	**5.6**	**4.9**
25% Quartile	2.8	1.2
Minimum	0.3	0.1
Moments		
Mean	**26.4**	**8.4**
Std Dev	81.8	11.6
Std Err Mean	7.8	1.2
upper 95% Mean	41.8	10.7
lower 95% Mean	11.0	6.0
N	111	97

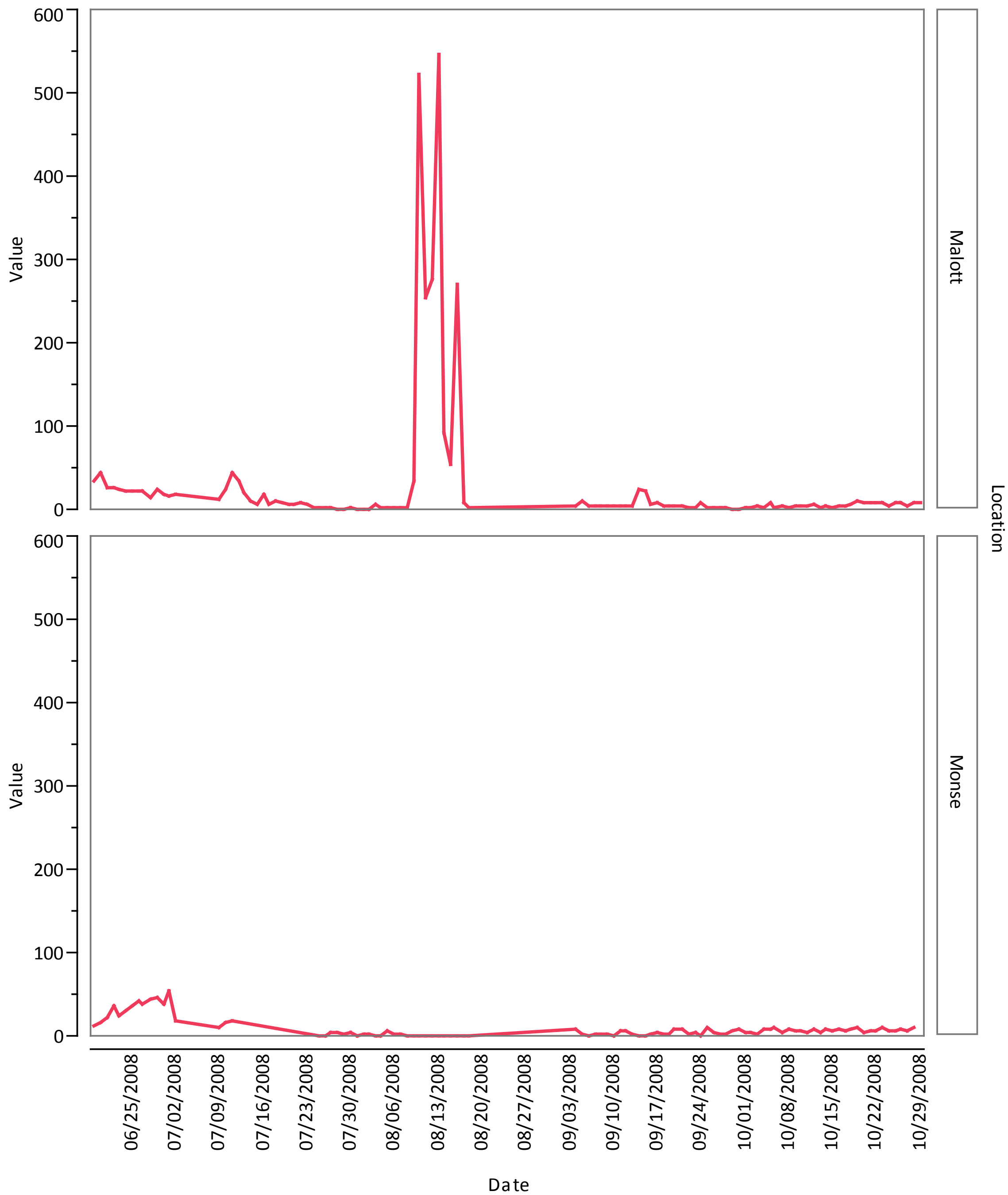

Figure 5. Overlapping Hydrolab turbidity data (NTUs) collected at Malott and Monse on the Okanogan River in 2008.

WATER QUALITY MANAGEMENT PLAN

WELLS HYDROELECTRIC PROJECT

FERC PROJECT NO. 2149

August 2009

Prepared by:
Public Utility District No. 1 of Douglas County
East Wenatchee, Washington

EXECUTIVE SUMMARY

The Water Quality Management Plan (WQMP) is one of six Aquatic Resource Management Plans (Plans) contained within the Aquatic Settlement Agreement (Agreement). To ensure active stakeholder participation and support, the Public Utility District No. 1 of Douglas County (Douglas) developed all of the resource management plans in close coordination with agency and tribal natural resource managers (Aquatic Settlement Work Group or Aquatic SWG). The goal of the WQMP is to protect the quality of the surface waters affected by the Wells Hydroelectric Project (Project) with regard to the numeric criteria. Studies conducted during the relicensing process have found water quality within the Wells Project to be within compliance. Douglas, in collaboration with the Aquatic SWG, has agreed to implement measures in support of the WQMP. Reasonable and feasible measures will be implemented in order to maintain compliance with the numeric criteria of the Washington State Water Quality Standards (WQS), Chapter 173-201A WAC. The measures presented within the WQMP (Section 4.0) are designed to meet the following objectives:

Objective 1: Maintain compliance with state WQS for TDG. If non-compliance is observed, the Aquatic SWG will identify reasonable and feasible measures, which will be implemented by Douglas;

Objective 2: Maintain compliance with state WQS for water temperature. If information becomes available that suggests non-compliance is occurring or likely to occur, the Aquatic SWG will identify reasonable and feasible measures, which will be implemented by Douglas;

Objective 3: Maintain compliance with state WQS for other numeric criteria. If information becomes available that suggests non-compliance is occurring or likely to occur, the Aquatic SWG will identify reasonable and feasible measures, which will be implemented by Douglas;

Objective 4: Operate the Project in a manner that will avoid, or where not feasible to avoid, minimize, spill of hazardous materials and implement effective countermeasures in the event of a hazardous materials spill; and

Objective 5: Participate in regional forums tasked with improving water quality conditions and protecting designated uses in the Columbia River basin.

The WQMP is intended to be compatible with other water quality management plans in the Columbia River mainstem, including Total Maximum Daily Loads (TMDL). Furthermore, the WQMP is intended to be supportive of the Habitat Conservation Plan (HCP), Bull Trout Management Plan, Pacific Lamprey Management Plan, Resident Fish Management Plan, White Sturgeon Management Plan, and Aquatic Nuisance Species Management Plan through the protection of designated uses (WAC 173-201A-600) in Project waters. The WQMP is intended to be not inconsistent with other management strategies of federal, state and tribal natural resource management agencies.

1.0 INTRODUCTION

The Water Quality Management Plan (WQMP) is one of six Aquatic Resource Management Plans (Plans) contained within the Aquatic Settlement Agreement (Agreement). Collectively, these six Plans are critical to direct implementation of Protection, Mitigation, and Enhancement measures (PMEs) during the term of the new license. The Plans, together with the Wells Anadromous Fish Agreement and Habitat Conservation Plan (HCP), will function as the Water Quality Attainment Plan (WQAP) for aquatic life in support of the Clean Water Act (CWA) Section 401 Water Quality Certification (401 Certification) for the Wells Hydroelectric Project (Project).

During the development of this plan, the Aquatic Settlement Work Group (Aquatic SWG) focused on management priorities for resources potentially impacted by Project operations. Entities that participated in the Aquatic SWG include the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), Washington Department of Ecology (Ecology), Washington State Department of Fish and Wildlife (WDFW), the Confederated Tribes of the Colville Reservation (Colville), the Confederated Tribes and Bands of the Yakama Nation (Yakama), and Douglas.

The Washington State Water Quality Standards (WQS) found at WAC 173-201A include designated uses (recreation, agriculture, domestic and industrial use, and habitat for aquatic life) and supporting numeric criteria. The WQMP is intended to address only the numeric criteria of the WQS. Aquatic life uses of the Project identified by the WQS shall be addressed by the five other Aquatic Resource Management Plans within the Agreement and by the measures implemented in the HCP.

This management plan summarizes the relevant resource issues and background (Section 2), identifies goals and objectives of the plan (Section 3), and describes the relevant measures (Section 4) to maintain compliance with the numeric criteria of state WQS during the term of the new license.

2.0 BACKGROUND

Section 401 of the Clean Water Act (33 USC Chapter 26 § 1341 *et seq.*) requires that applicants for a hydroelectric project license from the Federal Energy Regulatory Commission (FERC) provide FERC with a 401 Certification that provides reasonable assurance that the Project will comply with applicable WQS and any other appropriate requirements of state law. In Washington State, Ecology is responsible for issuing 401 Certifications.

2.1 Water Quality Standards

Congress passed the CWA in 1972, and designated the U.S. Environmental Protection Agency (EPA) as the administering federal agency. This federal law requires that a state's water quality standards protect the surface waters of the U.S. for beneficial or designated uses, such as recreation, agriculture, domestic and industrial use, and habitat for aquatic life. Any state WQS, or amendments to these standards, do not become effective under the CWA until they have been approved by EPA.

Ecology is responsible for the protection and restoration of Washington State's waters. Ecology establishes WQS that set limits on pollution in lakes, rivers, and marine waters in order to protect water quality and specified designated uses of such water bodies. These standards are found in WAC 173-201A.

2.1.1 Water Quality Standards for the Project

The Project includes the mainstem Columbia River above Wells Dam, one mile of the mainstem Columbia River below Wells Dam, the Methow River (up to river mile [RM] 1.5) and the Okanogan River (up to RM 15.5).

Under the 2006 WQS, the Project includes designated uses for spawning/rearing (aquatic life), primary contact recreation, and all types of water supply and miscellaneous uses. Numeric criteria to support the protection of these designated uses consist of various physical, chemical, and biological parameters including total dissolved gas (TDG), temperature, dissolved oxygen (DO), pH, turbidity, and toxins.

Unless stated otherwise in the subsections below, WQS criteria discussed in subsections 2.1.1.1 to 2.1.1.6 apply to all waters within the Project.

2.1.1.1 Total Dissolved Gas

TDG is measured as a percent saturation. Based upon criteria developed by Ecology, TDG measurements shall not exceed 110% at any point of measurement in any state water body. The WQS state that an operator of a dam is not held to the TDG standards when the river flow exceeds the seven-day, 10-year-frequency (7Q10) flood. The 7Q10 flow is the highest value of a running seven consecutive day average using the daily average flows that may be seen in a 10-year period. The 7Q10 total river flow for the Project was computed by Ecology (Pickett et al 2004) using the hydrologic record from 1974 through 1998 and a statistical analysis to develop the number from 1930 through 1998. The U.S. Geological Survey Bulletin 17B, "Guidelines for Determining Flood Flow Frequency" was followed. The resulting 7Q10 flow at Wells Dam is 246,000 cubic feet per second (cfs).

In addition to allowances for TDG standard exceedances during natural flood flows in excess of 7Q10, the TDG criteria may be adjusted to accommodate spill to facilitate fish passage over hydroelectric dams when consistent with an Ecology-approved Gas Abatement Plan (GAP). Ecology has approved on a per application basis, an interim exemption to the TDG standard (110%) to allow spill for juvenile fish passage on the Columbia and Snake rivers (WAC 173-201A-200(1)(f)(ii)). Dams in the Columbia and Snake rivers may be granted such an exemption. The GAP must be accompanied by fisheries management, physical, and biological monitoring plans (173-201A-200(1)(f)(ii)).

Columbia and Snake River TDG Exemption

On the Columbia and Snake rivers, three conditions apply to the TDG exemption. First, in the tailrace of a dam, TDG shall not exceed 125% as measured in any one-hour period during spillage for fish passage. Second, TDG shall not exceed 120% in the tailrace of a dam, as an average of the 12 highest consecutive hourly readings in any one day (24-hour period), relative to atmospheric pressure. Third, TDG shall not exceed 115% in the forebay of the next dam downstream, also based on an average of the 12 highest consecutive hourly readings in any one day (24-hour period), relative to atmospheric pressure.

The increased levels of spill resulting in elevated TDG levels are intended to allow increased fish passage without causing more harm to fish populations than caused by turbine passage. The TDG exemption provided by Ecology is based on a risk analysis study conducted by the NMFS (NMFS 2000).

2.1.1.2 Temperature

Temperature is measured by the 7-day average of the daily maximum temperatures (7-DADMax). The 7-DADMax for any individual day is calculated by averaging that day’s daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date (WAC 173-201A-020).

Under the WQS, the 7-DADMax temperature within the Columbia, Methow, and Okanogan river portions of the Project shall not exceed 17.5°C (63.5°F) (WAC 173-201A-602 and 173-201A-200(1)(c)). Additionally, the WQS contains additional supplemental temperature requirements for the Project portion of the Methow River (see Methow River Supplemental Requirements section below). When a water body's temperature is warmer than 17.5°C (or within 0.3°C (0.54°F) of the criteria) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C (0.54°F).

When the background condition of the water is cooler than 17.5°C, the allowable rate of warming up to, but not exceeding, the numeric criteria from human actions is restricted as follows:

(A) Incremental temperature increases resulting from individual point source activities must not, at any time, exceed 28/(T+7) as measured at the edge of a mixing zone boundary (where "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge).

(B) Incremental temperature increases resulting from the combined effect of all non-point source activities in the water body must not, at any time, exceed 2.8°C (5.04°F).

Temperatures are not to exceed the criteria at a probability frequency of more than once every ten years on average. Temperature measurements should be taken to represent the dominant aquatic habitat of the monitoring site. This typically means samples should:

(A) Be taken from well mixed portions of rivers and streams.

(B) Not be taken from shallow stagnant backwater areas, within isolated thermal refuges, at the surface, or at the water's edge.

The following guidelines on preventing acute lethality and barriers to migration of salmonids are also used in determinations of compliance with the narrative requirements for use protection established in WAC 173-201A (e.g., WAC 173-201A-310(1), 173-201A-400(4), and 173-201A-410 (1)(c)). The following site-level considerations do not, however, override the temperature criteria established for waters in WAC 173-201A-200(1)(c) or WAC 173-201A-602:

(A) Moderately acclimated (16-20°C, or 60.8-68.0°F) adult and juvenile salmonids will generally be protected from acute lethality by discrete human actions maintaining the 7-DADMax temperature at or below 22°C (71.6°F) and the 1-day maximum (1-DMax) temperature at or below 23°C (73.4°F).

(B) Lethality to developing fish embryos can be expected to occur at a 1-DMax temperature greater than 17.5°C (63.5°F).

(C) To protect aquatic organisms, discharge plume temperatures must be maintained such that fish could not be entrained (based on plume time of travel) for more than two seconds at temperatures above 33°C (91.4°F) to avoid creating areas that will cause near instantaneous lethality.

(D) Barriers to adult salmonid migration are assumed to exist any time the 1-DMax temperature is greater than 22°C (71.6°F) and the adjacent downstream water temperatures are 3°C (5.4°F) or cooler.

Methow River Supplemental Requirements

Ecology has identified water bodies, or portions thereof, which require special protection for spawning and incubation in accordance with Ecology publication 06-10-038. This publication indicates where and when the following criteria are to be applied to protect the reproduction of native char, salmon, and trout. Water temperatures are not to exceed 13°C from October 1 to June 15 in the lower Methow River including the portion within the Project boundary (up to RM 1.5).

2.1.1.3 Dissolved Oxygen

DO criteria are measured in milligrams per liter (mg/L). Under the WQS, DO measurements shall not be under the 1-day minimum of 8.0 mg/L. 1-day minimum is defined as the lowest DO reached on any given day. When a waterbody's DO is lower than the 8.0 mg/L criteria (or within 0.2 mg/L of the criteria) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the DO of that water body to decrease more than 0.2 mg/L. Concentrations of DO are not to fall below 8.0 mg/L at a probability frequency of more than once every ten years on average.

DO measurements should be taken to represent the dominant aquatic habitat of the monitoring site. This typically means samples should:

(A) Be taken from well mixed portions of rivers and streams.

(B) Not be taken from shallow stagnant backwater areas, within isolated thermal refuges, at the surface, or at the water's edge.

2.1.1.4 pH

pH is defined as the negative logarithm of the hydrogen ion concentration. Under the WQS, pH measurements shall be in the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.5 units.

2.1.1.5 Turbidity

Turbidity is measured in nephelometric turbidity units (NTUs). Turbidity shall not exceed 5 NTU over background when the background is 50 NTU or less; or a 10% increase in turbidity when the background turbidity is more than 50 NTU.

2.1.1.6 Toxins

Toxic substances shall not be introduced above natural background levels in waters of the state which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by Ecology.

Ecology shall employ or require chemical testing, acute and chronic toxicity testing, and biological assessments, as appropriate, to evaluate compliance with WAC 173-201-240 and to ensure that aquatic communities and the existing and characteristic beneficial uses of waters are being fully protected.

Within the Project Area, specifically within the Project portion of the Okanogan River, two toxic substances are of concern: Dichloro-Diphenyl-Trichloroethane (DDT) and Polychlorinated Biphenyls (PCBs). DDT is a synthetic organochlorine insecticide that was frequently used in agriculture prior to being banned in 1972. PCBs are an organic compound that were used as coolants and insulating fluids for transformers, and capacitors. PCBs are classified as persistent organic pollutants and production was banned in the 1970s due to its high level of toxicity.

Toxic substances criteria identified in the WQS for these two substances are as follow:

(A) In freshwater, DDT (and metabolites) shall not exceed 1.1 μg/L as an instantaneous concentration at any time. Exceedance of the criteria is defined as an acute condition. DDT (and metabolites) shall not exceed 0.001 μg/L as a 24-hour average. Exceedance of the criteria is defined as a chronic condition.

(B) In freshwater, PCBs shall not exceed 2.0 µg/L as a 24-hour average. Exceedance of the criteria is defined as an acute condition. PCBs shall not exceed 0.01 µg/L as a 24-hour average. Exceedance of the criteria is defined as a chronic condition.

2.1.2 305(b) Report, 303(d) List and Total Maximum Daily Loads

Every two years, the EPA, as specified in section 305(b) of the CWA, requires Ecology to compile an assessment of the state's water bodies. Data collected from the water quality assessment are used to develop a 305(b) report. The report evaluates and assigns each water body into five categories based upon the Ecology's evaluation of the water quality parameters collected from within each water body.

Category 1 states that a water body is in compliance with the State WQS for the parameter of interest.
Category 2 states a water body of concern.
Category 3 signifies that insufficient data are available to make an assessment.
Categories 4a-4c indicates an impaired water body that does not require a Total Maximum Daily Load (TMDL) for one of three reasons:

- Category 4a indicates a water body with a finalized TMDL.
- Category 4b indicates a water body with a Pollution Control Program.
- Category 4c indicates a water body impaired by a non-pollutant (e.g., low water flow, stream channelization, and dams).

Category 5 represents all water bodies within the state that are considered impaired and require a Water Quality Implementation Plan (WQIP) (formerly TMDL). The 303(d) list consists of only water bodies with Category 5 listings.

Information presented below in subsections 2.1.2.1 to 2.1.2.6 are based upon the Draft 2008 Water Quality Assessment and candidate 303(d) list that has been finalized by Ecology and submitted to the EPA for approval.

2.1.2.1 Total Dissolved Gas

The reach of the Columbia River within the Project is on the state's 1998 303(d) list for TDG impairment (Category 5 listing). In 2004, Ecology developed a TDG TMDL (which was approved by EPA) for the mid-Columbia River and as such, this reach of the Columbia River, which includes the Project, is no longer on the 303(d) list for TDG (Category 4a).

Neither the reach of the Methow River within the Project (RM 1.5) nor the reach of the Okanogan River within the Project (RM 15.5) are listed on the 2008 303(d) list for TDG.

2.1.2.2 Temperature

The reach of the Columbia River within the Project is on the state's 2004 303(d) list for temperature impairment. The EPA has developed a draft temperature TMDL for the mainstem Columbia River, including that portion of the Columbia River contained within the Project. It is anticipated that the EPA will issue the final temperature TMDL for the Columbia River at some future date. The TMDL will address the water temperature effects of dams and other human actions, including model analyses and load allocations for mainstem hydroelectric projects including Wells Dam.

The reach of the Methow River within the Project (RM 1.5) is not on the 2008 303(d) list for temperature.

The reach of the Okanogan River within the Project (RM 15.5) is not on the 2008 303(d) list for temperature. However, reaches of the Okanogan River upstream of the Wells Project boundary are listed on the 2008 303(d) list for temperature.

2.1.2.3 DO

No part of the Project area is on the 2008 303(d) list for DO.

2.1.2.4 pH

No part of the Project area is on the 2008 303(d) list for pH.

2.1.2.5 Turbidity

No part of the Project area is on the 2008 303(d) list for turbidity.

2.1.2.6 Toxins

Neither the reach of the Columbia River within the Project nor the reach of the Methow River within the Project (RM 1.5) is on the 2008 303(d) list for toxins.

The reach of the Okanogan River within the Project (RM 15.5) is not listed on the 2008 303(d) list for toxins. In 1998, Ecology put the portion of the Okanogan River within Project boundary on the 303(d) list for 4, 4'-DDE, 4,4'-DDD, PCB-1254, and PCB 1260 concentrations above standards in edible carp tissue (Ecology 1998). In 2004, Ecology completed the Lower Okanogan River DDT and PCB TMDL (which was approved by EPA).

2.2 Project Water Quality Monitoring Results

2.2.1 Total Dissolved Gas

TDG supersaturation is a condition that occurs in water when atmospheric gasses are forced into solution at pressures that exceed the pressure of the overlying atmosphere. Water containing more than 100% TDG is in a supersaturated condition. Water may become supersaturated through natural or dam-related processes that increase the amount of air dissolved in water. Supersaturated water in the Columbia River may result from the spilling of water at Columbia River dams. The occurrence of TDG supersaturation in the Columbia River system is well documented and has been linked to mortalities and migration delays of salmon and steelhead (Beiningen and Ebel 1970; Ebel et al. 1975).

At Wells Dam, Douglas has monitored TDG for compliance with state and federal water quality regulations since 1998 and more recently in support of its GAP and TDG exemption issued by Ecology for juvenile fish passage (Le 2008). Douglas is required to monitor TDG in the Wells Dam forebay and tailrace area (on the Columbia River, near RM 515.6). Douglas uses Rocky Reach forebay TDG data collected by Chelan County PUD for downstream forebay monitoring compliance data.

A TDG study conducted in 2006 indicated that the current location of the TDG compliance monitoring stations are appropriate in providing representative TDG production information both longitudinally and laterally downstream of Wells Dam (EES Consulting et al. 2007). Detailed information regarding the study is provided in Section 2.3.1.2.

Since 2003, Douglas has operated the Project during the juvenile fish passage season (April – August) in accordance with an Ecology-approved GAP and associated TDG exemption. TDG monitoring at Wells Dam is facilitated through the deployment of Hydrolab Minisonde probes in the center of the Wells forebay and approximately 3 miles downstream of Wells Dam. TDG data are logged every fifteen minutes, averaged (4 in an hour) and transmitted on the hour. Probes are serviced and checked monthly for accuracy and calibrated if necessary. Average, minimum, and maximum TDG measurements in the Wells Dam forebay and tailrace since monitoring began are provided in Table 2.2-1. Also included in Table 2.2-1 are Rocky Reach forebay TDG data acquired from Chelan County PUD's TDG monitoring program.

Levels of TDG at Wells Dam and the Rocky Reach Dam forebay that result in exceedances of the numeric criteria are most likely to occur during April through August as a result of high flows caused by either rapid snow melt or federal flow augmentation intended to aid downstream juvenile salmonid passage. Douglas monitors for TDG at Wells Dam between April 1 and September 15 annually to coincide with this observation (Figure 2.2.1 and 2.2.2). Chelan County PUD monitors for TDG at Rocky Reach Dam between April 1 and August 31 (Figure 2.2.3). High TDG values at both Wells Dam and Rocky Reach Dam resulting in exceedances are often associated with various factors including high spring flows, unit outages, and upstream Federal Columbia River Power System operations, including federal flow augmentation, resulting in water entering the Project with relatively high TDG levels. During these time periods, river conditions in the mid-Columbia River system are conducive to exceedances of the TDG criteria.

In past years, Wells forebay monitoring data show that on average TDG values at this location range from 107-110% with maximum values sometimes exceeding the 115% standard specified by the TDG exemption. Rocky Reach forebay monitoring data indicate that on average TDG values at this location range from 108-110% with maximum values sometimes exceeding the 115% standard. In general, Wells Dam adds relatively small amounts of TDG through the use of spill intended to aid in the passage of juvenile salmonids (0-2%). However, similar to other hydroelectric facilities on the Columbia River system, probabilities for exceedances are more likely during late spring periods of high river flow and low electrical demand. Table 2.2-1 contains historic average, minimum and maximum TDG measurements associated with the Wells Project. Note that the high TDG values recorded during 2006 were a direct result of the 2006 TDG Study that required Douglas to intentionally spill water in various spillway configurations. This study was intended to define the gas generation dynamics of the Wells Project under various operating parameters.

Table 2.2-1 Average, minimum, and maximum TDG measurements at Wells Dam from Hydrolab MiniSonde stations placed in the Wells Forebay, Wells Tailrace and Rocky Reach Forebay. Values are in percent dissolved gas and are 12-hour high (non-consecutive) averages.

Location	TDG	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Wells Forebay	Avg.	108.3	110.1	108.5	107.1	110.8	108.1	108.2	107.4	109.9	108.3
	Min	104.4	104.0	101.8	100.1	102.6	101.3	102.0	110.8	102.5	100.9
	Max	113.7	113.9	113.2	111.7	118.5	114.5	113.5	100.9	116.1	113.2
Wells Tailrace	Avg.	111.1	112.4	110.1	108.1	113.9	109.8	109.6	109.1	114.0	110.9
	Min	105.5	105.6	102.2	100.4	103.9	101.9	101.6	102.8	103.2	103.5
	Max	122.4	125.7	125.4	112.0	136.9	126.0	113.7	116.8	131.3	122.0
Rocky Reach Forebay	Ave	109.4	N/A	108.5	108.5	112.9	110.1	109.1	109.6	114.4	110.4
	Min	101.8	N/A	101.9	104.7	103.9	103.8	104.7	103.3	102.7	104.5
	Max	118.7	N/A	112.6	113.0	133.8	120.8	114.3	120.4	130.0	118.0

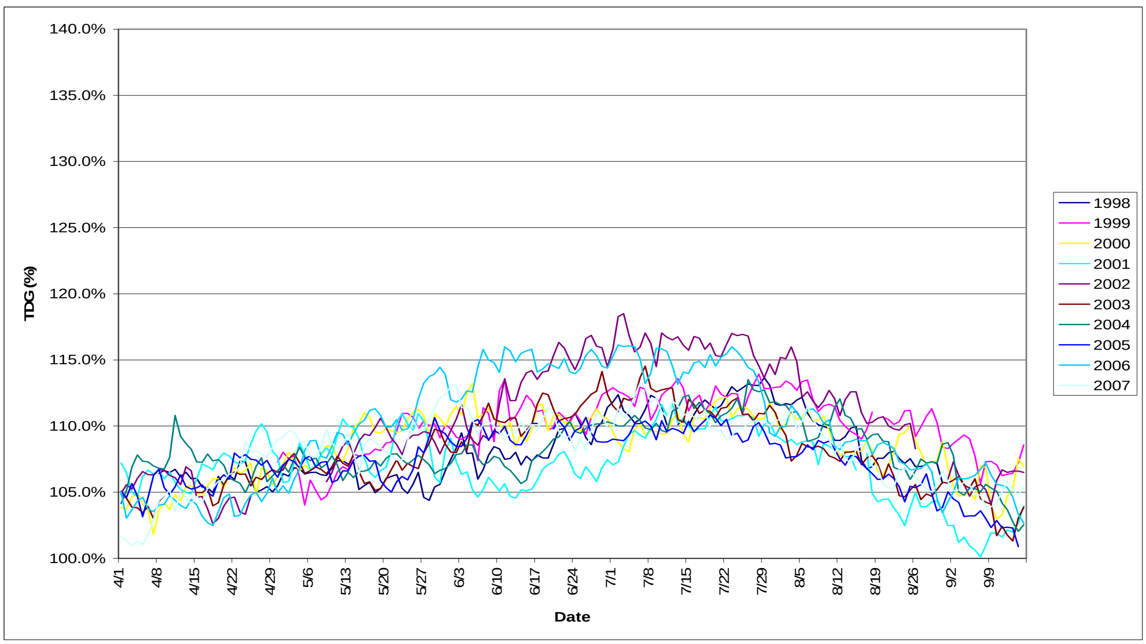

Figure 2.2-1 Wells Dam forebay average 12-hour high TDG measurements. The average 12-hour high is defined as the average of the 12 highest hourly readings within a 24-hour period. Monitoring season is typically April 1 to September 15. Data for years 1998-2007.

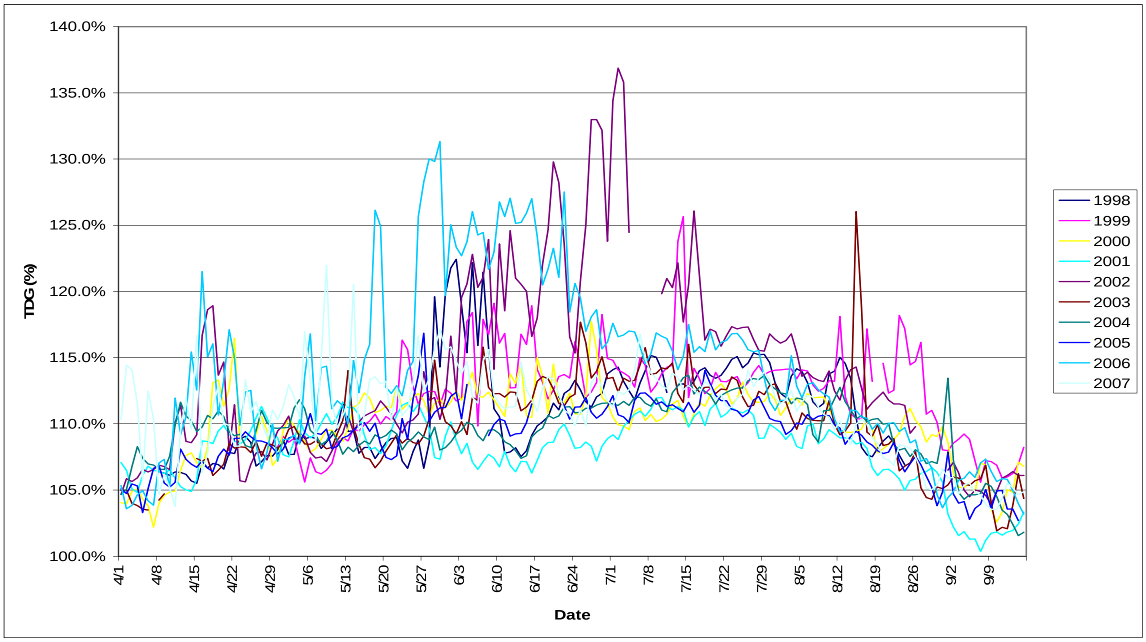

Figure 2.2-2 **Wells Dam tailrace average 12-hour high TDG measurements. The average 12-hour high is defined as the average of the 12 highest hourly readings within a 24 hour period. Monitoring season is typically April 1 to September 15. Data for years 1998-2007 (Breaks in data are the result of equipment malfunction).**

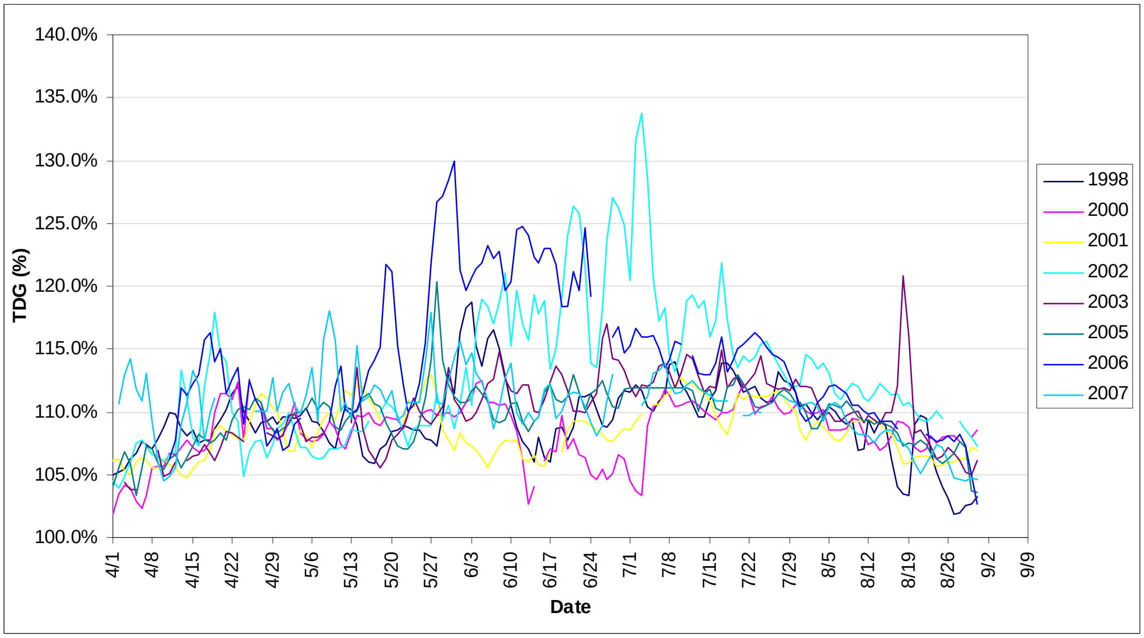

Figure 2.2-3 **Rocky Reach forebay average 12-hour high TDG measurements. The average 12-hour high is defined as the average of the 12 highest hourly readings within a 24 hour period. Monitoring season is typically April 1 to August 31. Data for years 1998-2007 (Breaks in data are the result of equipment malfunction).**

2.2.2 Temperature

Beginning in 2001, an extensive water temperature monitoring effort was initiated by Douglas in order to better understand the temperature dynamics throughout the Wells Reservoir. Temperature data was collected by Douglas at four locations in the Columbia River (RM 544.5, RM 535.3, RM 530.0, and RM 515.6) and at one site each on the Okanogan (RM 10.5) and Methow (RM 1.4) rivers. Data collected by Douglas were collected hourly using Onset tidbit temperature loggers. Monitoring start and end dates varied from year to year but generally began in the early spring and ended in late fall. Quality assurance and control measures were implemented prior to deploying and upon retrieving temperature loggers to ensure that data collected were accurate. Due to sensor loss or sensor malfunction in some years, the availability of data at some of these monitoring locations is sporadic.

In general, 7-DAD Max temperature data indicate that the portion of the Columbia River upstream of and within the Project generally warms to above 17.5°C (WQS numeric criteria) in mid-July and drops below the numeric criteria by early October (Figure 2.2-4). Water temperatures in the Methow River upstream of the Project warm to above 17.5°C in mid-July and drop below the numeric criteria by September (Figure 2.2-5), while trends in the Okanogan River (upstream of the Project) indicate warming above 17.5°C from early June with cooling by late September (Figure 2.2-6). Maximum water temperatures typically occur in late summer (August) with temperatures below Chief Joseph Dam, the Methow River (RM 1.4), and the Okanogan River (RM 10.5) reaching 20.0°C, 22.5°C, and 27.0°C, respectively. It is important to note that these data are representative of water temperatures as they flow into the Project. In 2006, Douglas expanded the Project temperature monitoring season to cover the entire year and implemented a more frequent downloading schedule. Douglas also added additional monitoring stations at the mouths of the Okanogan (RM 0.5) and Methow (RM 0.1) rivers. These have been used to model temperature and allocate the effects of Project operations on water temperatures at Wells Dam and within the Wells Reservoir as they relate to compliance with the WQS numeric criteria for temperature.

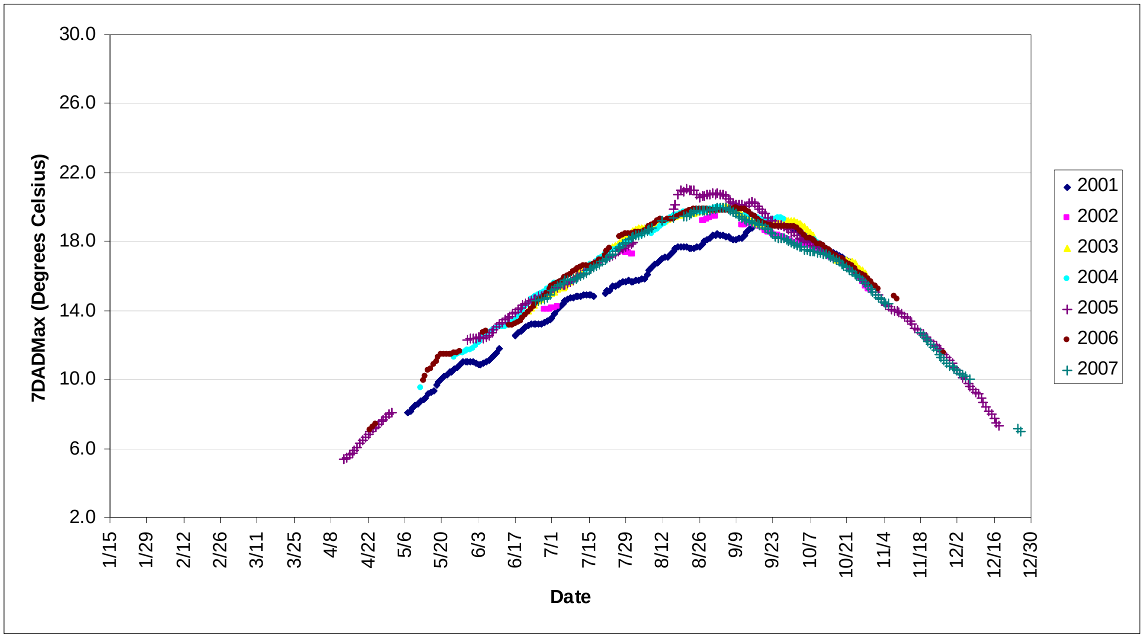

Figure 2.2-4 **7-DAD Max water temperature collected in the tailrace of Chief Joseph Dam (RM 544) using Onset temperature loggers for years 2001-2007.**

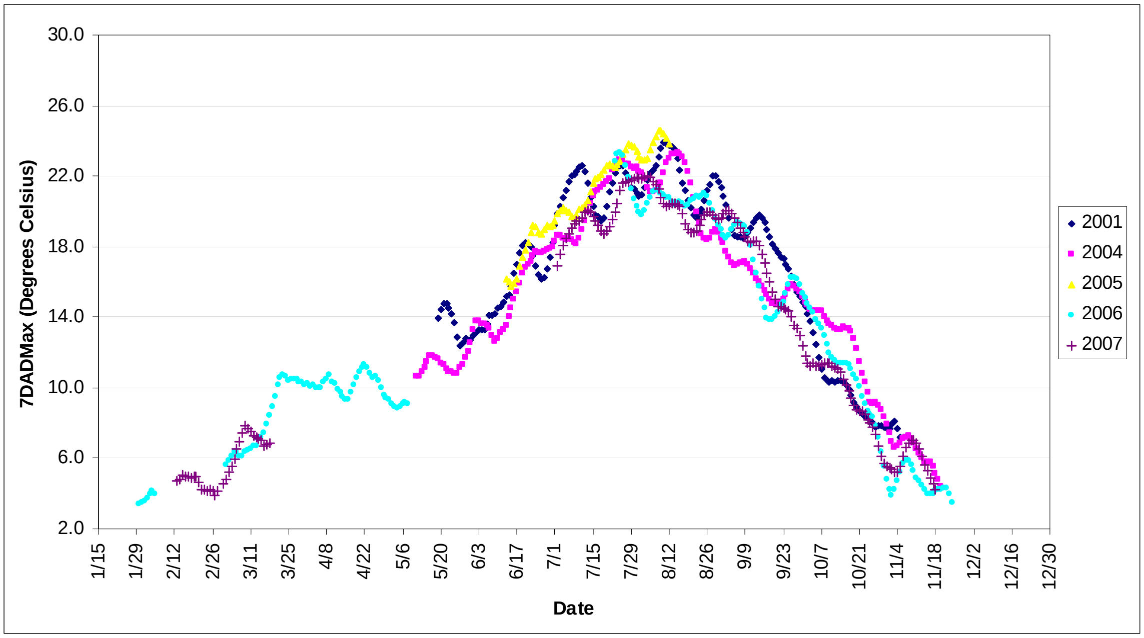

Figure 2.2-5 7-DADMax water temperature collected in the Methow River upstream from the influence of Wells Dam (RM 1.4) using Onset temperature loggers for years 2001-2007. Data were unavailable in 2002 and 2003.

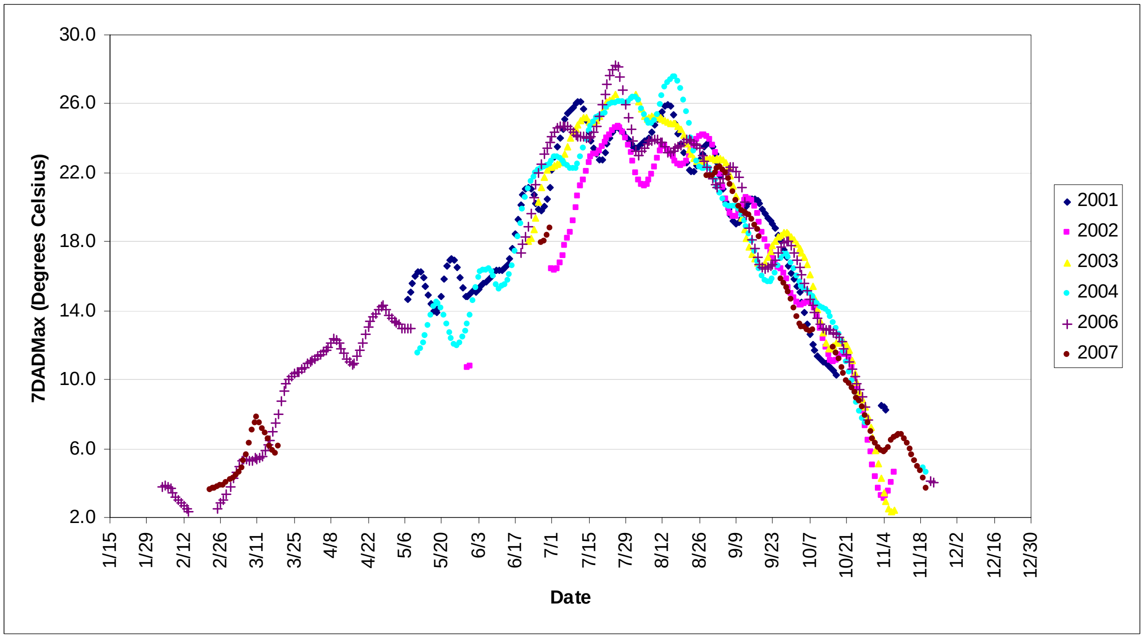

Figure 2.2-6 7-DADMax water temperature collected in the Okanogan River (RM 10.5) using Onset temperature loggers for years 2001-2007.

2.2.2.1 Wells Dam Fish Ladder Temperature Monitoring

Wells Dam has two fish ladders, one at each end of the dam. The two fish ladders are conventional staircase type fish ladders with 73 pools. The water source for the upper pools is the Wells Dam forebay. The flow through the upper 17 pools varies from 44 cfs at full reservoir to approximately 31 cfs at maximum reservoir drawdown. The lower 56 pools discharge a constant 48 cfs of water. To maintain the flow at 48 cfs in the lower ladder pools, supplementary water (auxiliary water supply) is introduced into Pool No. 56 through a pipeline from the reservoir. Pools are numbered in order from the bottom (near the collection gallery and entrance) to the top (exit to the Wells Dam forebay). The ladders are enclosed.

According to the HCP Biological Opinion (BO) issued by NMFS, all entities that use the fish trapping facilities at Wells Dam are required to discontinue trapping operations when fish ladder water temperatures exceed 68.0º F (20.6°C). In 2001 and 2003, Douglas added supplemental temperature recording equipment at Pool 39 near the broodstock collection facilities in the east fishway at Wells Dam to ensure compliance with requirements in the NMFS BO. In 2001, hourly data indicated that water temperatures at this location in the east fish ladder did not exceed 68.0ºF (20.6°C) at any time during the monitoring period (Figure 2.2-7), which ran from late July to early December. In 2003, data were recorded every two hours and exceedances of greater than 68.0ºF (20.6°C) were observed on three hourly occasions (Figure 2.2-8).

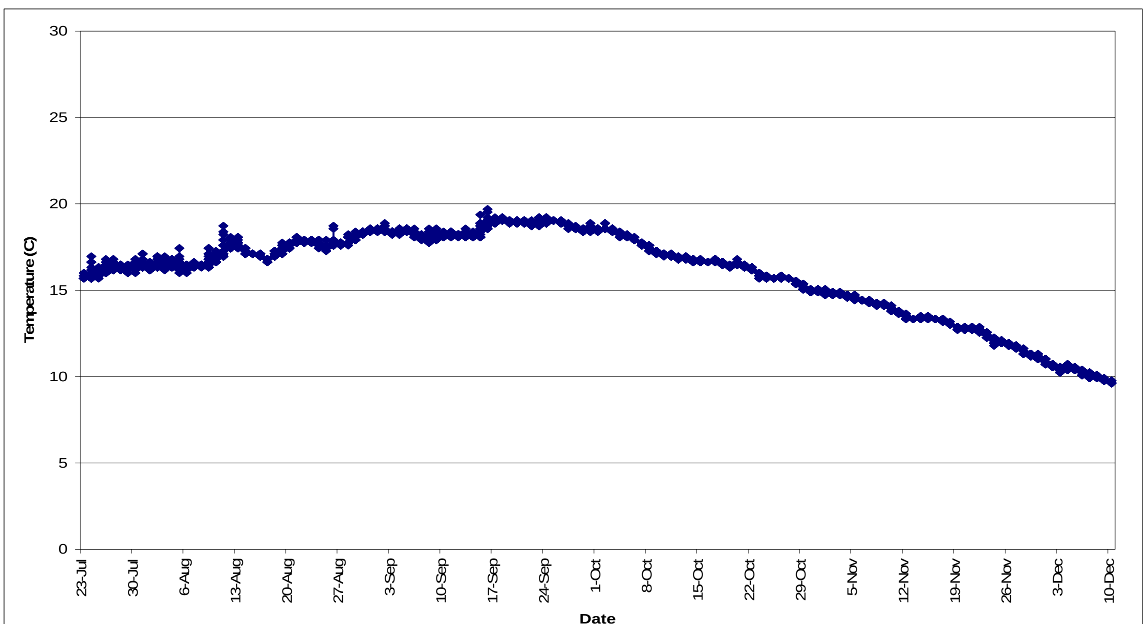

Figure 2.2-7 Hourly water temperatures collected at the Wells Dam east fish ladder trap during 2001.

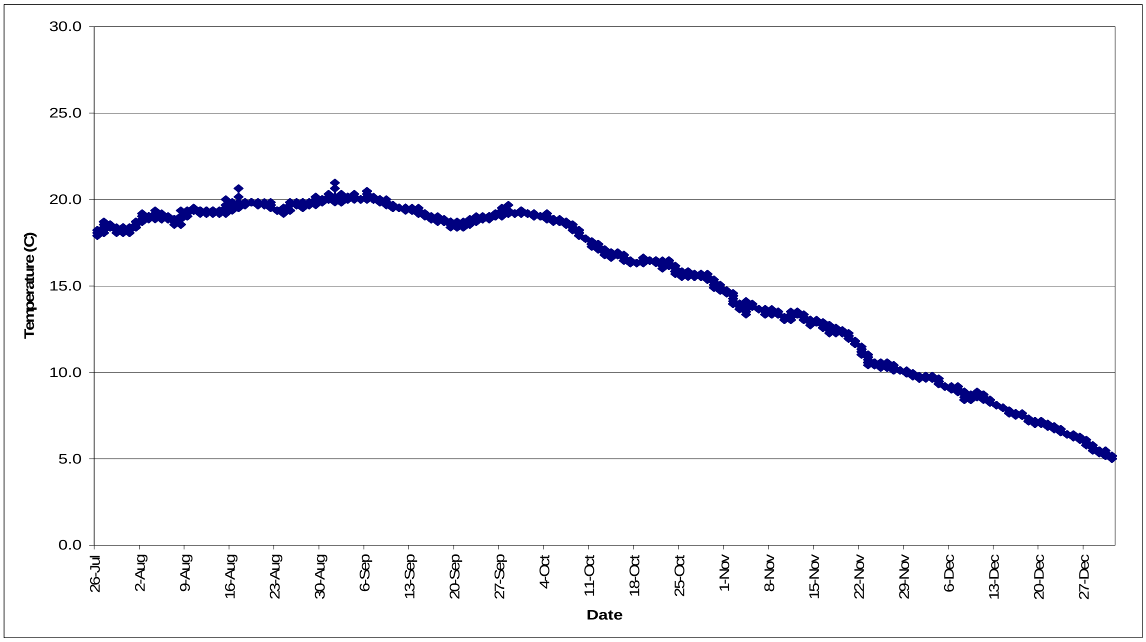

Figure 2.2-8 Water temperatures collected every two hours at the Wells Dam east fish ladder trap during 2003.

2.2.3 DO, pH, and Turbidity

2.2.3.1 DO and pH

In 2005, Douglas added sensors to its existing forebay TDG monitoring equipment (Hydrolab Minisonde) in order to collect preliminary information on pH and DO within the Project to monitor these parameters during the late summer when probabilities of exceedance are highest. In 2006, Douglas expanded the monitoring period to include the entire late summer period. In 2007, Douglas further expanded the monitoring period to begin in July and end in early December (Figure 2.2-9 and 2.2-10). The monitoring data indicate that values for these parameters are generally in compliance with the WQS numeric criteria at this site. pH values are consistently within the range of 6.5 to 8.5 as specified by the numeric criteria. During August and September periods of this study, there were periodic excursions of DO below the numeric criteria of 8.0 mg/L. Probable causes are likely due to the physiological processes of aquatic plants; however, these exceedances do not appear to be the dominant trend.

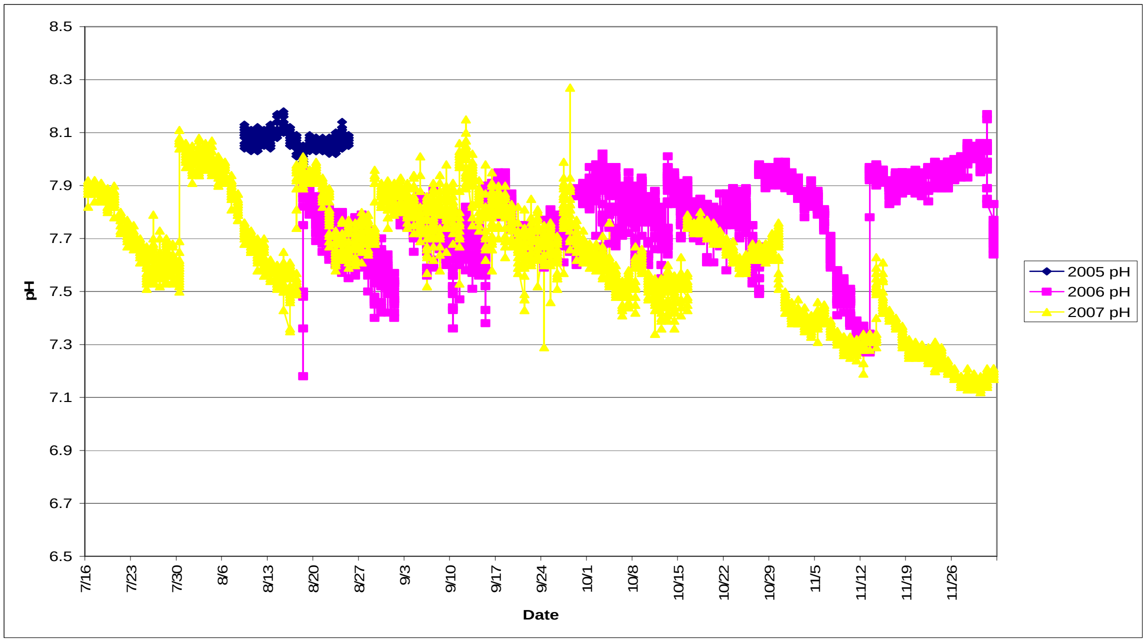

Figure 2.2-9 **pH measurements collected at the Wells Forebay TDG monitoring station (Hydrolab MiniSonde), 2005-2007.**

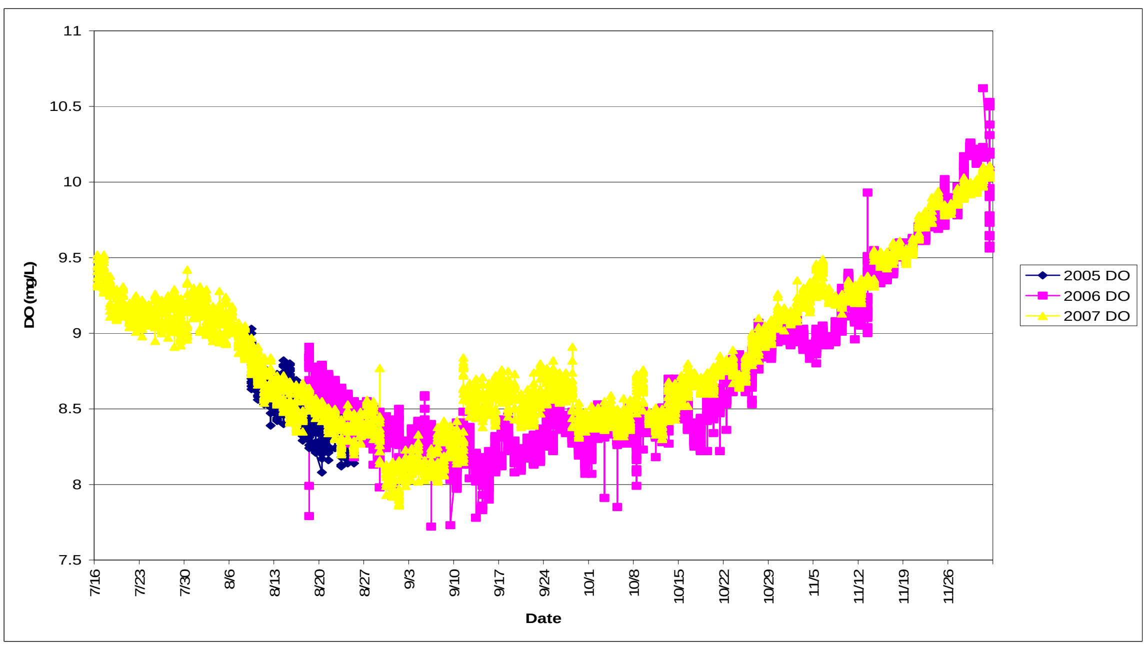

Figure 2.2-10 **DO measurements collected at the Wells Forebay TDG monitoring station (Hydrolab MiniSonde), 2005-2007.**

2.2.3.2 Turbidity

At Wells Dam, Secchi disk readings are taken daily during the adult fish passage assessment period of May 1 to November 15 to examine turbidity. A standard Secchi disk is lowered into the forebay on the west side of Wells Dam near the exit to the west fishway. Measurements are recorded in meters of visibility and records have been made since the early 1970s; however, continuous, reliable information adhering to a standard protocol has been collected since 1998. General trends of Secchi disk data suggest relatively lower periods of visibility (0.6 meters to 1.2 meters) during the spring and early summer. These relatively low periods of visibility are highly correlated with high flows during the spring runoff period. As the high flow period subsides, Secchi disk values increase to between 3.4 and 4.6 meters for the remainder of the monitoring period. In 2008, Douglas installed a fixed turbidity sensor near the east fishway exit in the Wells forebay and collected turbidity data in the Wells Dam forebay.

2.3 Project Water Quality Studies

2.3.1 Total Dissolved Gas

Each year from 2003-2008, Douglas implemented spill testing activities to examine the relationship between water spilled over the dam and the production of TDG. These results were subsequently used by IIHR-Hydroscience and Engineering of University of Iowa to develop and calibrate an unsteady state three-dimensional (3D), two-phase flow computational fluid dynamics (CFD) tool to predict the hydrodynamics of gas saturation and TDG distribution within the Wells tailrace. These tools were then used to reliably predict TDG production at Wells Dam and establish how preferred operating conditions and spillway configurations can be used as methods to manage TDG within WQS numeric criteria (Politano et al. 2009b).

2.3.1.1 Project TDG Assessments 2003-2005

In 2003 and 2004, Douglas hired Columbia Basin Environmental (CBE) to determine the effectiveness of the tailwater sensor relative to the tailwater cross section profile for TDG and better define the relationship between spillway releases and TDG production (CBE 2003, 2004). CBE deployed TDG sensors along two transects. Based on the results of these studies, the tailwater station provided an accurate record of daily average TDG values in the Wells Dam tailrace. The studies also showed that at times, gas levels from some turbine flows were being affected by spill.

In spring 2005, Douglas contracted with CBE to implement a TDG study at Wells Dam designed to measure TDG pressures resulting from various spill patterns at the dam (CBE 2006). An array of water quality data loggers was installed in the Wells Dam tailwater for a period of two weeks between May 23, 2005 and June 6, 2005. The Wells Dam powerhouse and spillway were operated through a predetermined range of operational scenarios that varied both total flow and shape of the spillway discharge. A total of eight configurations were tested including flat spill patterns (near equal distribution of spill across the entire spillway), crowned spill patterns (spill is concentrated towards the center of the spillway) and spill over loaded and unloaded units (Table 2.3-1).

Table 2.3-1 Test matrix for 2005 Wells Dam TDG Production Dynamics Study.

Test	Description
1A	Spill over load, east spill/east generation
1B	Spill over unloaded units, east spill/west generation
1C	Spill over unloaded units, west spill/east generation
1D	Spill over load, west spill/west generation
2A	Crowned spill, modest flow
2B	Dentated spill, modest flow
2C	Crowned spill, high flow
2D	Flat spill, high flow

Results from the study indicated that spill from the west side of the spillway resulted in consistently higher TDG saturations than similar spill from the east side. All Dentated spill patterns and flat spill patterns at high river flow yielded higher TDG saturations than crowned spill for similar total discharges. The results of this study also indicated that TDG levels of powerhouse flows may have been influenced by spill.

2.3.1.2 EES Consulting 2006 Project TDG Production Dynamics Study

In 2006, Douglas continued TDG assessments at the Project by examining the best spillway configurations and project operations to minimize the production of TDG. Douglas hired a team of hydraulic and TDG experts from the Pacific Northwest to help design a monitoring program for a study that would examine various operational scenarios and their respective TDG production dynamics.

Thirteen sensors were placed along three transects at 1,000, 2,500, and 15,000 feet below Wells Dam. There were also three sensors placed across the forebay, one being the fixed monitoring station midway across the face of the dam and two more a distance of 300 feet from the dam. The sensors were programmed to collect data in 15-minute intervals for both TDG and water temperature. Each test required the operations of the dam to maintain static flows through the powerhouse and spillway for at least a three-hour period. While there were 30 scheduled spill events, there were an additional 50 events where the power house and spillway conditions were held constant for a minimum three-hour period. These “incidental” events provided an opportunity to collect additional TDG data on a variety of Project operations that met study criteria and are included in the results of the 2006 TDG Abatement Study. Spill amounts ranged from 5.2 to 52% of project flow; the volume of spill ranged from 2.2 to 124.7 kcfs and the total discharge ranged from16.4 to 254.0 kcfs. There were six tests that were done at flows that exceeded the Wells Dam 7Q10 flows of 246 kcfs.

Results of the study indicated that two operational scenarios, spread spill and concentrated spill, produced the lowest levels of TDG. The EES Consulting team recommended continued testing of operational measures to ameliorate TDG production at Wells Dam (EES Consulting et al. 2007). The 2006 study confirmed that the current locations of the forebay and tailwater TDG compliance monitoring station are appropriate in providing representative TDG production information both longitudinally and laterally downstream of Wells Dam.

2.3.1.3 IIHR-Hydroscience and Engineering TDG Modeling

A study was initiated with the University of Iowa IIHR-Hydroscience and Engineering in 2007 to develop a numerical model capable of predicting the hydrodynamics and TDG concentrations in the tailrace of the Wells Project. The purpose of the model was to assist in the understanding of the underlying dynamics of TDG production allowing an accurate evaluation of the effectiveness of various spill configurations and plant operations in reducing TDG at Wells Dam. The modeling efforts were divided into three phases. Phase I was a developmental stage for calibration and validation. The results from Phase I were successful and the model was proven to provide a reliable predictor of tailrace TDG and therefore a useful tool to identify Project operations that can minimize TDG concentrations downstream of Wells Dam (Politano et al. 2008). Phase II was a series of model runs using varying spill configurations based on typical 7Q10 events observed over the past decade. The final model run, referred to as Scenario-9, showed that preferred operating conditions and spillway configurations are able to reduce tailrace TDG to levels within Washington State WQS (< 120%) during a 7Q10 flow (Politano et al. 2009a).

Phase III included a final series of model runs aimed at gaining further reductions in tailrace TDG by reconfiguring the spillway operations used to achieve the tailrace standard in Phase II (Scenario-9). In addition to gaining additional reductions in TDG, IIHR-Hydroscience and Engineering ran a "Standard Compliance Comparison" scenario. The Standard Compliance Comparison scenario included a forebay TDG of 115%, along with 9 of 10 units operating at full capacity (i.e., 90% of total powerhouse capacity), to provide results comparable to downstream hydroelectric project TDG evaluations. The Phase III report also demonstrated compliance with two other requirements of the state WQS: (1) the ability to meet 115% in the forebay of Rocky Reach Dam during fish spill; and (2) the ability to maintain 110% in the tailrace during non-fish spill periods (Politano et al. 2009b).

2.3.1.4 Project TDG Playbooks

Since 2007, spill playbooks have been developed annually for operators at Wells Dam. The original spill playbook in 2007 focused on a range of operations to evaluate TDG production along with potential operational constraints. The subsequent playbooks evolved to the current 2009 format that simply focuses on strategies that have been identified to effectively manage TDG production in the tailrace of Wells Dam. The resulting spill strategies are based on three basic principles:

- Spill operations concentrated through a single spillbay (as opposed to spread through several spillbays) reduce TDG production and increase degasification at the tailwater surface.
- Discharge from spillbays (denoted S hereafter) located near the middle of the dam (e.g., S7) prevent water with high TDG from attaching to the shoreline.
- Forced spill exceeding Juvenile Bypass System (JBS) flows of 2.2 kcfs must be increased to ≥ 15 kcfs to ensure that the submerged spillway lip below the ogee is engaged. The resulting force creates flows that are surface oriented, ultimately promoting degasification at the tailwater surface.

The above principles are used as a guideline for Project operators to spill at a range of outflows to ensure the future compliance with the Washington State WQS for TDG.

2.3.2 EES Consulting 2006 Project Limnology

In 2005, Douglas implemented a study to collect baseline limnological information for waters within the Project (EES Consulting 2006). The objectives of this study were to further document existing water quality conditions within the Project and to collect information to fill water quality data gaps identified by Douglas to support the water quality certification process administered by Ecology. A total of nine sampling sites, consisting of 5 mainstem sites, 2 tributaries and 2 littoral habitats, were selected to represent the spatial variability within the Project (Table 2.3-2). The year-long study began in May 2005 and investigated various water quality parameters at each of the nine sampling sites. Sampling included physical, chemical and biological water quality characteristics. A total of 22 water quality characteristics were sampled. All procedures used for the purpose of collecting, preserving and analyzing samples followed established EPA 40 CFR 136 protocol.

Table 2.3-2 Water quality sampling sites for the 2005-2006 Project Limnological Investigation.

Site	Description
1	Downstream of Chief Joseph Dam (at Hwy 17 bridge)
2	Columbia River just downstream of the Brewster Bridge
3	Bridgeport Bar littoral site
4	Columbia River downstream of Pateros where the thalweg approaches maximum depth in the lower Wells Reservoir
5	Okanogan River upstream of confluence with Columbia River
6	Methow River upstream of confluence with Columbia River
7	Lower Wells Reservoir/Starr Boat Launch littoral site
8	Wells Forebay
9	Wells Tailrace

Results from the limnological investigation showed that the Project is characterized by low to moderately low levels for nutrients, slightly basic pH (range 7.5–8.5), well-oxygenated water and low turbidity with moderately low algae growth. Average Secchi depth for the Wells Reservoir varied minimally during May through August with only a slight increase as the season progressed (study average per site range 4.1 meters to 4.5 meters). Secchi depth (transparency) increased to a seasonal peak in September of 6.25 meters before slightly decreasing in October to a mean depth of 5.3 meters. Transparency increased downstream at the Brewster Bridge and Wells Forebay relative to the head of the reservoir at the Chief Joseph Dam tailrace for all months.

Turbidity in the Columbia River showed little seasonal variation with an annual average of 0.98 NTU and a variation of 0.38 NTU in September, 2005 (Wells Forebay site) to 3.81 NTU in February, 2006 (Brewster Bridge site). Longitudinal variation in turbidity was also minimal; sampling did not occur within the mixing zone plume of the Okanogan River. Turbidity in the Okanogan River was consistently higher than the Columbia River. Turbidity in the Methow

River was higher than in the Columbia River in May (due to sediment load) and in August due to phytoplankton growth. The only turbidity reading over 5.0 NTU was in the Methow River during May where turbidity was 5.6 NTU.

Under the EES Consulting limnology study, water temperature in the Wells Reservoir is primarily governed by the temperature of inflowing water at Chief Joseph Dam with little warming occurring as water traverses the Wells Reservoir’s length. Similar to the Wells hourly temperature monitoring data (Section 2.2.2), results of the study indicate that the Project waters remained unstratified throughout the entire study period and was vertically homogeneous for DO. Figure 2.3-1 shows a vertical water profile of the Project. Low respiration rates at depth, a lack of vertical stratification and short water retention times resulted in homogeneous DO levels at all depths within the Project.

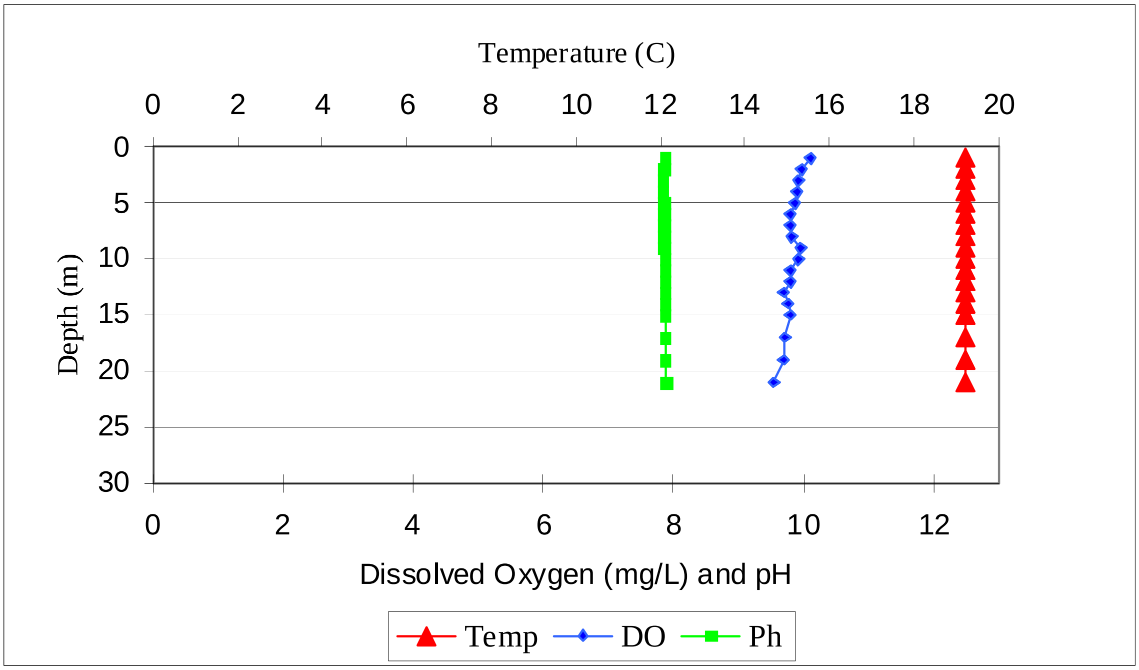

Figure 2.3-1 **Vertical water quality profile of the Project forebay from sampling date August 17, 2005.**

DO levels at one meter depth increased from upriver to downriver; the average difference (May through October) was 1.07 mg/L. The difference was more pronounced during May through August. The difference in September and October was 0.3 mg/L, which is at the limit of instrument reliability. Upstream to downstream differences in surface DO were negligible for the February 2006 sampling event. Littoral DO was similar or slightly higher than pelagic DO for surface waters. DO saturation levels were equal to or greater than 100% for all sites and all depths in all months except October when DO percent saturation for surface waters ranged from 110% to 91% saturation. The lower saturation levels in October may be due to reduced primary productivity while water temperatures were still relatively warm. All DO readings were above 8.0 mg/L and in compliance with the WQS numeric criteria.

Nitrogen and phosphorus are the two primary macronutrients needed for plant growth. Silica is important for diatomaceous phytoplankton. Ammonia (Nitrogen) levels were near or below detection levels for pelagic and littoral Columbia River Project waters as well as the Okanogan River for May through August and in February. Ammonia levels were only slightly higher in September and October. Ammonia peaked in the Methow River in August. Nitrates/Nitrites (Nitrogen) for Columbia River Project waters were higher in May before leveling off during the summer and fall. Nitrates/Nitrites were significantly higher at all sites for the February sample than any other month. Nitrates within littoral waters were lower than pelagic waters except in February when levels were similar. Nitrates/Nitrites in both the Okanogan and Methow rivers showed an increasing trend during the growing season. Total nitrogen levels for Columbia River pelagic and littoral waters were similar and relatively constant with the exception of significantly higher levels at most sites during February.

Orthophosphorus peaked for all stations in July. Orthophosphorus levels for pelagic and littoral waters were similar in all months except July when littoral orthophosphorus concentrations were significantly higher than observed for pelagic areas. Orthophosphorus levels in the Methow and Okanogan rivers were higher than in the Columbia River. Orthophosphorus was partially depleted in the Okanogan River but not in the Methow River at the time of the August sampling. Total phosphorus was slightly higher in littoral waters than in pelagic areas. Wave disturbance to bottom sediments may be a factor for this difference. Total phosphorus levels in pelagic surface waters ranged from below detection limits to 30.8 ug/L. Total phosphorus was higher for the Okanogan River than elsewhere, which is likely due to the higher sediment load. Total phosphorus for all stations peaked in July before gradually declining throughout the rest of the growing season.

The range in Nitrogen to Phosphorus (N:P) ratios for the Project waters was 2.5 to 30.8. The average Total Nitrogen to Total Phosphorus (TN:TP) ratio in the Project waters was 13.7 for the photic zone and averaged 14.8 for samples from all depths. These values are within the suggested literature ranges for phosphorus limitation. The N:P ratios peaked in July with pelagic and littoral waters showing similar trends. A decreasing N:P ratio through the major part of the algae growing season is typical of moderate to low nutrient waters as algae assimilate available nutrients. The N:P ratios were higher in the tributary rivers relative to the Columbia River. The N:P ratios are an indicator but not an absolute confirmation of factors limiting productivity.

Moderate to low chlorophyll *a* concentrations (range 0.5 *u*g/L to 5.8 *u*g/L) occurred throughout the sample period with peaks in July and October for the Project waters. Concentrations were lowest in August and also had the least variability among sites for the August sampling event. Pelagic and littoral waters were similar for chlorophyll *a* concentrations in most months except October when littoral waters reported twice as high *c*hlorophyll *a* levels.

Phytoplankton were dominated by diatoms for all months at all sites sampled with Chryptophyta (small unicellular flagellates) being second dominant based on biovolume. Diatoms and Chryptophyta are both considered a good food source for the rest of the aquatic food web. Diatoms comprised 75% to 84% of the total phytoplankton biomass for the Project sites. Chlorophytes (green algae) were sub-dominant in the tailrace but only a minor component elsewhere. Total phytoplankton biomass was relatively low for all Project sample sites; total biomass was generally less than 200,000 um^3/ml. Biomass peaked in July and August for pelagic areas of the Project waters and minor peaks occurred in October for littoral sites. The timing of peaks varied among all stations. Cyanophyta (blue-green algae) were only recorded in the Project sites for the July sample at Brewster Bridge where they comprised 16% of the total biomass; however, the biomass of Cyanophytes were comprised of relatively few but very large multicellular units. Cyanophytes also were recorded in the Wells Tailrace (4.7% biomass) in July. Diatoms dominated phytoplankton in the Methow River where peak biomass occurred in August (1,455,158 um^3/ml). This peak is much higher than biomass observed anywhere else in the Project. Biomass levels in the Okanogan River were only slightly higher than in the Columbia River for most months with minor peaks occurring in May and October. Cyanophytes were a small proportion of the August biomass sample for the Okanogan River.

Diatoms also dominated periphyton. Seasonal lows occurred in July for all sites except Bridgeport shallows where the trend was decreasing periphyton biovolume as the season progressed.

Zooplankton density for pelagic waters was greatest in July (6,080/m^3) and lowest (1,289/m^3) in August. Copepods dominated the zooplankton population. Zooplankton densities in the tributary river mouths peaked in May. Although rotifers were present in all months, their density dropped to very low levels after May. Cladocera were the third most prevalent group with a minor peak occurring in July for this group.

Trophic Status Index (TSI) developed by Carlson (1977, 1996) and modified for nitrogen by Kratzer and Brezonik (1981) is an indication of the productivity of a lake based on Secchi depth, TP, TN and chlorophyll *a* concentrations for summer months (June through September). Project waters are classified as oligo-mesotrophic based on a mean TSI score of 36.5 with 40 to 50 being the range for mesotrophic classification (EES 2006).

2.3.3 Okanogan River Sediment Loading Analysis

In 2006, Douglas, at Ecology's request, conducted an analysis to assess sediment accumulation within the Project portion of the Okanogan River (lower 15.5 miles). The request was based upon concerns that Project operations might be contributing to the accumulation of DDT and PCB-laden sediment that could impact aquatic life designated use. Douglas contracted with Erlandsen and Associates to collect bathymetric information at nine transects (RM 0.8, 1.3, 2.7, 4.9, 8.2, 10.5, 14.4, 16.6, and 19.0) within and above the Project portion of the Okanogan River. Bathymetric data of these same nine transects were collected previously by the Bechtel Corporation in 1997. A comparison of the bathymetric data for all nine transects between 1997 and 2006 indicated that sediment is not accumulating in the Project portion of the Okanogan River. It was concluded that with regard to sediment loading, the Okanogan River is exhibiting natural riverine processes and is not affected by Project operations. Douglas presented the results of the information to Ecology and the issue has been resolved.

2.3.4 Temperature, Dissolved Oxygen, pH, and Turbidity

2.3.4.1 Water Temperature Modeling

To assess compliance with the State temperature standards, two 2D laterally-averaged temperature models (using CE-QUAL-W2) were developed that represent existing (or "with Project") conditions and "without Project" conditions of the Wells Project including the Columbia River from the Chief Joseph Dam tailrace to Wells Dam, the lowest 15.5 miles of the Okanogan River, and the lowest 1.5 miles of the Methow River. The results were processed to develop daily values of the seven-day average of the daily maximum temperatures (7-DADMax), and then compared for the two conditions (West Consultants, Inc. 2008).

The model analyses demonstrated that "with Project" temperatures in the Columbia, Okanogan and Methow rivers do not increase more than 0.3^{o}C compared to ambient ("without Project") conditions anywhere in the reservoir, and that the Project complies with state water quality standards for temperature. The analyses also show that backwater from the Wells Project can reduce the very high summer temperatures observed in the lower Okanogan and Methow rivers. The intrusion of Columbia River water into the lowest 1-2 miles of the Okanogan River and lowest 1.5 miles of the Methow River can significantly decrease the temperature of warm summer inflows from upstream, and can also moderate the cold winter temperatures by 1-3^{o}C, reducing the extent and length of freezing.

2.3.4.2 Dissolved Oxygen, pH, and Turbidity

A study to collect additional DO, pH, and turbidity data from within the Wells Project was proposed by the Aquatic Resource Workgroup in 2007. The goal of this study was to obtain required DO, pH, and turbidity information for the Wells Dam forebay and lower Okanogan River, both above and within the Wells Project boundary. The information gathered from these monitoring efforts demonstrated that the Project, as proposed to be operated under the new license, will meet the numeric criteria for WQS (Parametrix, Inc. 2009).

DO measurements demonstrated that the Okanogan River and the forebay of Wells Dam were in compliance with WQS. Project effects on DO concentrations in the Okanogan River were not evident as incoming water quality closely resembled that of the inundated portions of the Okanogan River. Changes in background minimum DO levels at Malott (above Project boundary) have a strong and significant linear relationship ($P < 0.0001$) with minimum values recorded within Project boundaries at both Monse and the Highway 97 Bridge. These results indicate that there is no statistically significant difference between minimum DO measurements collected above the Project and within the Project. DO concentrations in the forebay of Wells Dam remained well above the minimum numeric water quality criterion, excluding an instrument-related malfunction observed in early October (Parametrix, Inc. 2009).

Only on one occasion did pH within the Project exceed background measurements, but only by 0.06 units, well within the water quality allowance for human caused conditions. These results indicate that pH measurements within the Project boundary are well within the numeric criteria for WQS (Parametrix, Inc. 2009).

It is not clear what effect, if any, the Wells Project may have had on turbidity. Elevated turbidity values appeared to coincide with snowmelt and precipitation causing increased river flow. Turbidity levels in the Okanogan River above the Project (at Malott) were inconsistent with readings collected at both Monse (5 of 122 comparable days, or 4%) and Highway 97 (8 of 165 comparable days, or 5%), suggesting that such events are not widespread or persistent within the Wells Project (Parametrix, Inc. 2009). In 2009, Douglas contracted Columbia Basin Environmental to continue monitoring turbidity for an additional year. Results from the 2009 field season indicate that turbidity decreases from the background monitoring location (Malott, RM 17.0), to both Monse (RM 5.0) and the Highway 97 Bridge (RM 1.3). No exceedances were observed and the data showed that the Wells Project is in compliance with the Washington State water quality standards for turbidity (DCPUD and CBE 2009).

2.3.5 Summary of Compliance with WQS

Based on the Initial and Updated Study Reports the Aquatic SWG was able to determine that waters within the Wells Project currently meet state numeric criteria of WQS as defined in Chapter 173-201A WAC. The following table presents supporting studies, by standard:

Standard	Studies	Result(s)	Continued Monitoring
TDG	Politano et al. 2008, 2009a, 2009b.	Compliance met under preferred operating conditions and standard compliance scenario.	Yes
Temperature	West Consultants, Inc. 2008	Compliance met, zero exceedances. Potential future TMDL.	Yes
DO	Parametrix, Inc. 2009	Compliance met, zero exceedances	No
pH	Parametrix, Inc. 2009	Compliance met, zero exceedances	No
Turbidity	Parametrix, Inc. 2009; DCPUD and CBE 2009.	Compliance met, zero exceedances	No

3.0 GOAL AND OBJECTIVES

The goal of the WQMP is to protect the quality of the surface waters affected by the Project with regard to the numeric criteria. Studies conducted during the relicensing process have found water quality within the Wells Project to be within compliance. Douglas, in collaboration with the Aquatic SWG, has agreed to implement measures in support of the WQMP. Reasonable and feasible measures will be implemented in order to maintain compliance with the numeric criteria of the Washington State WQS, Chapter 173-201A WAC. The measures presented within the WQMP (Section 4.0) are designed to meet the following objectives:

Objective 1: Maintain compliance with state WQS for TDG. If non-compliance is observed, the Aquatic SWG will identify reasonable and feasible measures, which will be implemented by Douglas;
Objective 2: Maintain compliance with state WQS for water temperature. If information becomes available that suggests non-compliance is occurring or likely to occur, the Aquatic SWG will identify reasonable and feasible measures, which will be implemented by Douglas;

Objective 3: Maintain compliance with state WQS for other numeric criteria. If information becomes available that suggests non-compliance is occurring or likely to occur, the Aquatic SWG will identify reasonable and feasible measures, which will be implemented by Douglas;

Objective 4: Operate the Project in a manner that will avoid, or where not feasible to avoid, minimize, spill of hazardous materials and implement effective countermeasures in the event of a hazardous materials spill; and

Objective 5: Participate in regional forums tasked with improving water quality conditions and protecting designated uses in the Columbia River basin.

The WQMP is intended to be compatible with other water quality management plans in the Columbia River mainstem, including TMDLs. Furthermore, the WQMP is intended to be supportive of the HCP, Bull Trout Management Plan, Pacific Lamprey Management Plan, Resident Fish Management Plan, White Sturgeon Management Plan, and Aquatic Nuisance Species Management Plan through the protection of designated uses (WAC 173-201A-600) in Project waters. The WQMP is intended to be not inconsistent with other management strategies of federal, state and tribal natural resource management agencies.

The schedule for implementation of specific measures within the WQMP is based on the best information available at the time the Plan was developed. As new information becomes available, the measures proposed in the WQMP may be adjusted through consultation with the Aquatic SWG.

4.0 WATER QUALITY MEASURES

In order to fulfill the goals and objectives described in Section 3.0, Douglas, in consultation with the Aquatic SWG, has agreed to implement the following measures.

4.1 TDG Compliance (Objective 1)

4.1.1 Monitoring

Douglas shall continue to maintain fixed monitoring stations in the forebay and tailrace area of Wells Dam to monitor TDG and barometric pressure. TDG will be monitored hourly during the fish spill season each year. Data from the Wells forebay and tailrace stations will be transmitted on a daily basis to the applicable web-accessible database used by Ecology and regional fish management agencies. Douglas shall maintain this monitoring program consistent with activities described in the then-current Wells Gas Abatement Plan (Section 4.1.3).

Douglas shall provide an annual report of all spill (and predicted TDG levels in the tailrace) occurring outside the fish passage season (currently October 1 to March 15).

4.1.2 Spill Operations

Within one year of issuance of the new license, Douglas shall coordinate the annual HCP Project Fish Bypass/Spill Operations Plan with the Aquatic SWG and the GAP, using best available information to minimize the production of TDG during periods of spill. All operations identified within the plan shall require the approval of the Wells HCP Coordinating Committee and the Aquatic SWG in order to ensure that spill operations are aimed at protecting designated uses and complying with the WQS numeric criteria for TDG in the Columbia River at the Project. In consultation with the Wells HCP Coordinating Committee and Aquatic SWG, the spill operations plan will be reviewed and updated, as necessary.

4.1.3 Project Gas Abatement Plan and TDG Exemption

Pending Ecology's approval of each subsequent GAP (which provides for the TDG exemption), Douglas shall continue to implement the activities identified within the previously-approved plan. Douglas shall submit the GAP to Ecology by February 28th of each year, or on a less frequent basis, as documented by Ecology in writing. Douglas shall submit the GAPs through the term of the new license or until no longer required by Ecology.

The GAP will include the Spill Operations Plan (Section 4.1.2) and will be accompanied by a fisheries management plan and physical and biological monitoring plans. The GAP shall include information on any new or improved technologies to aid in the reduction in TDG.

It is anticipated that: (1) the TDG monitoring activities described in Section 4.1.1 will be adequate for the physical monitoring plan requirement; and (2) the Wells HCP and Aquatic Resource Management Plans in the Aquatic Settlement Agreement with respect to fish passage will be adequate for fish management plans, for the purposes of the GAP. Additional biological monitoring studies for purposes of Gas Bubble Trauma Monitoring may be required.

Douglas shall provide an annual TDG report as required by the Ecology-approved GAP.

4.1.4 Measures to Address Non-Compliance

Douglas shall report all occurrences of non-compliance with TDG numeric criteria immediately to Ecology for regulatory discretion and to the Aquatic SWG for consideration.

If the Project is found to be consistently out of compliance with TDG at any time during the new license term, Douglas shall, in coordination with the Aquatic SWG, take the following steps:

(A) Evaluate any new reasonable and feasible technologies that have been developed; and

(B) After the evaluation, if no new reasonable and feasible improvements have been identified, propose an alternative to achieve compliance with the standards, such as site-specific criteria, a use attainability analysis, or a water quality offset.

4.2 Water Temperature Compliance (Objective 2)

4.2.1 Monitoring

Douglas shall continue to monitor temperature at the Wells Dam forebay and tailrace in conjunction with its TDG monitoring program (currently April 1-September 15). Temperature data from the TDG monitoring program will be recorded hourly and reported daily to regional databases. Water temperatures shall also be monitored at all boundary conditions of the Project (Methow River RM 1.5, Okanogan River RM 10.5, and Columbia River RM 544.5) and in the Well Dam forebay and tailrace as required by the Aquatic SWG.

Douglas shall continue to collect hourly fish ladder temperatures 24 hours a day during the fish passage season (May 1 to November 15) at Pool No. 39 on the east ladder. Water temperatures shall also be monitored hourly in the auxiliary water supply system and near the east shore of the Wells Dam forebay (bottom, middle, and surface depths) during this same time period.

4.2.2 Temperature TMDL Development and Implementation

Douglas shall participate in EPA Region 10's water temperature TMDL development for the U.S. portion of the Columbia River, in coordination with the Parties of the Aquatic SWG. Temperature data from the monitoring program at Wells Dam (Section 4.2.1) and software and results of the CE-QUAL-W2 model will be made available to EPA and other entities to assist in the development of the Columbia River temperature TMDL.

Where the measures identified in the TMDL are more protective than other measures in this plan, provisions of the temperature TMDL and implementation plans relevant to the Project and its operations, including specified time frames for implementing improvement measures, shall be implemented at the Project.

If a TMDL is not timely approved by EPA, Ecology may establish an allocation. In this case, Ecology will work with the Aquatic SWG and other interested parties to identify reasonable and feasible measures.

This plan does not exclude the option of the Aquatic SWG to consider modifying the water quality standard through a use attainability analysis or other process.

4.2.3 Measures to Address Non-Compliance

Douglas shall report information indicative of non-compliance with water temperature immediately to Ecology for regulatory discretion and to the Aquatic SWG for consideration. Such information may include changes in Project operations likely to increase water temperature or observations inconsistent with related environmental parameters.

If the Project is found to be consistently out of compliance with water temperature at any time during the new license term, Douglas shall, in coordination with the Aquatic SWG, take the following steps:

(A) Evaluate alternative Project operations or any new reasonable and feasible technologies that have been developed; and

(B) After the evaluation, if no new reasonable and feasible improvements have been identified, propose an alternative to achieve compliance with the standards, such as site-specific criteria, a use attainability analysis, or a water quality offset.

4.3 Compliance with Other Numeric Criteria (Objective 3)

Douglas shall report information indicative of non-compliance with other numeric criteria immediately to Ecology for regulatory discretion and to the Aquatic SWG for consideration. This includes existing or developed criteria for toxic substances in water or sediments within Project Boundaries. The Aquatic SWG shall evaluate the information, and, if needed, require Douglas to develop a plan to identify and address Project-related impacts, if any.

After the evaluation, if no reasonable and feasible improvements have been identified, Douglas may propose an alternative to achieve compliance with the standards, such as site-specific criteria, a use attainability analysis, or a water quality offset.

4.4 Spill Prevention and Control (Objective 4)

4.4.1 Spill Prevention and Control Requirements

Douglas shall operate the Project in a manner that will minimize spill of hazardous materials and implement effective countermeasures in the event of a hazardous materials spill. The Project Spill Prevention Control and Countermeasures Plan (SPCC) will be updated pursuant to FERC requirements and recommendations as provided by Ecology. Douglas shall comply with the updated version(s) of the SPCC.

4.4.2 Participation in the Columbia and Snake River Spill Response Initiative

Douglas shall continue participation in the Columbia and Snake River Spill Response Initiative (CSR-SRI). The CSR-SRI is a collaborative effort made up of local, state, and federal oil spill response community as well as members of industry and was developed to address the immediate need for oil spill preparedness and response in the area along the Columbia and Snake rivers. In addition to participation in the CSR-SRI, Douglas shall continue to operate the Project in accordance with its SPCC (Jacobs 2007).

4.4.3 Inspections

For the term or the new license, Douglas shall, upon reasonable notice, allow Ecology staff or representatives access to inspect the Project, including inside the dam, for the purpose of assessing Spill Prevention and Control measures and compliance with Section 4.4.1. Following inspection, Douglas shall address oil and hazardous material prevention and control issues identified by Ecology.

4.5 Regional Forums (Objective 5)

4.5.1 Participation in Regional Water Quality Forums

Douglas shall continue its participation in both the Water Quality Team and Adaptive Management Team meetings to address regional water quality issues, including sharing the results from monitoring, measuring, and evaluating water quality in the Wells Project. However, Douglas will not advocate for any water quality measures in regional forums without consulting with the Aquatic SWG.

4.5.2 Project Operations

Douglas may, following notice and opportunity for hearing, coordinate the operation of the project, electrically and hydraulically, with other mid-Columbia hydroelectric operations to the extent practicable. Coordinated operations are intended to reduce spill, increase generating efficiencies and thereby reduce the potential for exceedances of the TDG numeric criteria. These coordinated operations should be beneficial to TDG compliance and Aquatic Resources.

4.6 Reporting

Douglas shall provide a draft annual report to the Aquatic SWG summarizing the previous year's water quality activities and activities proposed for the coming year, in accordance with the WQMP and as determined by the Aquatic SWG. The report will include any decisions, statements of agreement, evaluations, or changes made pursuant to this WQMP. If significant activity was not conducted in a given year, Douglas may prepare a memorandum providing an explanation of the circumstances in lieu of the annual report. A summary of monitoring results, any analyses and compliance with the WQS numeric criteria will be included in an appendix to the annual report.

4.6.1 Study Plans

Douglas shall prepare study plan(s) that include quality assurance project plan(s) (QAPP) for each parameter to be monitored. The QAPPs shall follow the Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies (July 2004 Ecology Publication Number 04-03-030) or its successor. The QAPPs shall contain, at a minimum, a list of parameter(s) to be monitored, a map of sampling locations, and descriptions of the purpose of the monitoring, sampling frequency, sampling procedures and equipment, analytical methods, quality control procedures, data handling and data assessment procedures and reporting protocols.

Douglas shall review and update the QAPPs annually based on a yearly review of data and data quality. Ecology may also require future revisions to the QAPP based on monitoring results, regulatory changes, changes in Project operations, and/or the requirements of TMDLs.

The initial QAPPs and any changes shall be submitted to the Aquatic SWG for review and are subject to approval by Ecology. Implementation of the monitoring program shall begin upon Ecology's written approval of the QAPP, unless otherwise provided by Ecology.

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PACIFIC LAMPREY MANAGEMENT PLAN

WELLS HYDROELECTRIC PROJECT

FERC PROJECT NO. 2149

September 2009

Prepared by:
Public Utility District No. 1 of Douglas County
East Wenatchee, Washington

EXECUTIVE SUMMARY

The Pacific Lamprey Management Plan (PLMP) is one of six Aquatic Resource Management Plans contained within the Aquatic Settlement Agreement (Agreement). Collectively, these six Aquatic Resource Management Plans are critical to direct implementation of Protection, Mitigation, and Enhancement measures (PMEs) during the term of the new license and, together with the Wells Anadromous Fish Agreement and Habitat Conservation Plan (HCP) will function as the Water Quality Attainment Plan (WQAP) in support of the Clean Water Act Section 401 Water Quality Certification for the Wells Hydroelectric Project (Project).

To ensure active stakeholder participation and support, the Public Utility District No. 1 of Douglas County (Douglas) developed all of the resource management plans in close coordination with agency and tribal natural resource managers (Aquatic Settlement Work Group or Aquatic SWG). During the development of this plan, the Aquatic SWG focused on developing management priorities for resources potentially impacted by Project operations. Members of the Aquatic SWG include the U.S. Fish and Wildlife Service (USFWS), Washington Department of Ecology (Ecology), Washington State Department of Fish and Wildlife (WDFW), the Confederated Tribes of the Colville Reservation (Colville), the Confederated Tribes and Bands of the Yakama Indian Nation (Yakama), and Douglas.

The National Marine Fisheries Service (NMFS) was invited to participate in the development of Aquatic Resource Management Plans, but declined because its interests are currently satisfied by the measures within the HCP.

The goal of the PLMP is to implement measures to monitor and address impacts, if any, on Pacific lamprey (*Lampetra tridentata*) resulting from the Project during the term of the new license. Douglas, in collaboration with the Aquatic SWG, has agreed to implement several Pacific lamprey PMEs in support of the PLMP. The PMEs presented within the PLMP are designed to meet the following objectives:

Objective 1: Identify and address any adverse Project-related impacts on passage of adult Pacific lamprey;

Objective 2: Identify and address any Project-related impacts on downstream passage and survival and rearing of juvenile Pacific lamprey;

Objective 3: Participate in the development of regional Pacific lamprey conservation activities.

The PLMP is intended to be compatible with other Pacific lamprey management plans in the Columbia River mainstem. Furthermore, the PLMP is intended to be supportive of the HCP, the critical research needs identified by the Columbia River Basin Technical Working Group, the Resident Fish Management Plan, Bull Trout Management Plan, and White Sturgeon Management Plan by continuing to monitor and address ongoing impacts, if any, on Pacific lamprey resulting from Project operations. The PLMP is intended to be not inconsistent with other management strategies of federal, state and tribal natural resource management agencies and supportive of designated uses for aquatic life under Washington state water quality standards found at WAC 173-201A.

1.0 INTRODUCTION

The Pacific Lamprey Management Plan (PLMP) is one of six Aquatic Resource Management Plans contained within the Aquatic Settlement Agreement (Agreement). Collectively, these six Aquatic Resource Management Plans are critical to direct implementation of Protection, Mitigation, and Enhancement measures (PMEs) during the term of the new license and, together with the Wells Anadromous Fish Agreement and Habitat Conservation Plan (HCP), will function as the Water Quality Attainment Plan (WQAP) in support of the Clean Water Act Section 401 Water Quality Certification for the Wells Hydroelectric Project (Project).

To ensure active stakeholder participation and support, the Public Utility District No. 1 of Douglas County (Douglas) developed all of the resource management plans in close coordination with agency and tribal natural resource managers (Aquatic Settlement Work Group or Aquatic SWG). During the development of this plan, the Aquatic SWG focused on developing management priorities for resources potentially impacted by Project operations. Entities invited to participate in the Aquatic SWG include the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), Washington Department of Ecology (Ecology), Washington State Department of Fish and Wildlife (WDFW), the Confederated Tribes of the Colville Reservation (Colville), the Confederated Tribes and Bands of the Yakama Indian Nation (Yakama), and Douglas.

The PLMP will direct implementation of measures to protect against and mitigate for potential Project impacts on Pacific lamprey (*Lampetra tridentata*). To ensure active stakeholder involvement and support, Douglas developed this plan, along with the other aquatic management plans, in close coordination with the members of the Aquatic SWG.

The Aquatic SWG agrees on the need to develop a plan for the long-term management of Pacific lamprey in the Project. This management plan summarizes the relevant resource issues and background (Section 2), identifies the goal and objectives of the plan (Section 3), and describes the relevant PMEs (Section 4) for Pacific lamprey during the term of the new license.

2.0 BACKGROUND

2.1 Pacific Lamprey Biology

Pacific lamprey are present in most tributaries of the Columbia River and in the mainstem Columbia River during their migration stages. They have cultural, utilitarian and ecological significance in the basin, because Native Americans have historically harvested them for subsistence, ceremonial and medicinal purposes (Close et al. 2002). As an anadromous species, they also play an important role in the food web by contributing marine-derived nutrients to the basin and may act as a predatory buffer for juvenile salmon and steelhead. Little specific information is available on the life history or status of lamprey in the mid-Columbia River watersheds. They are known to occur in the Methow, Wenatchee and Entiat rivers (NMFS 2002) and recently have been captured during juvenile salmon and steelhead trapping operations in the Okanogan River.

In general, adults are parasitic on fish in the Pacific Ocean while ammocoetes (larvae) are filter feeders that inhabit the fine silt deposits in backwaters and quiet eddies of streams (Wydoski and Whitney 2003). Adults generally spawn in low-gradient stream reaches in the tail areas of pools and in riffles, over gravel substrates (Jackson et al. 1997). Adults die after spawning. After hatching, the ammocoetes burrow into soft substrate for an extended larval period filtering particulate matter from the water column (Meeuwig et al. 2002). The ammocoetes undergo a metamorphosis into macrophthalmia (outmigrating juvenile lamprey) between 3 and 7 years after hatching, and then migrate from their parent streams to the ocean (Close et al. 2002). Adults typically spend 1-4 years in the ocean before returning to freshwater tributaries to spawn.

Pacific lamprey populations of the Columbia River have generally declined in abundance over the last 40 years according to counts at dams on the lower Columbia and Snake rivers (Close et al. 2002). Starke and Dalen (1995) reported that adult lamprey counts at Bonneville Dam regularly exceeded 100,000 fish in the 1960s and more recently have ranged between 20,000 and 120,000 for the period 2000-2004 (DART - www.cqs.washington.edu/dart/adult.html).

In the mid-Columbia River Basin, adult lamprey count data at hydroelectric projects varies by site but is generally available for all projects since 1998 (with the exception of Wanapum Dam where data is only available for 2007). As is expected, the general trend for mid-Columbia River counts is relatively consistent with observations at Bonneville Dam from year to year (i.e., relatively high count years at Bonneville result in relatively high count years in the mid-Columbia River). It is important to note that the daily and seasonal time periods as well as the counting protocols may differ at each project. These differences may affect data reliability and need to be considered when examining and comparing these data. Table 2.1-1 provides a summary of adult lamprey passage data for mid-Columbia River hydroelectric facilities.

Table 2.1-1. Minimum, maximum, and average counts for adult Pacific lamprey at mid-Columbia River hydroelectric projects from 1998 to 2007.

	Priest Rapids	Wanapum*	Rock Island	Rocky Reach	Wells
Min	1,130	4,771	559	303	21
Max	6,593	4,771	5,074	2,583	1,417
Average	3,016	4,771	2,157	952	326

* Wanapum Dam counts are only available for 2007.

Close et al. (1995, 2002) identified several factors that may account for the decline in lamprey counts in the Columbia River Basin. This includes reduction in suitable spawning and rearing habitat from flow regulation and channelization and pollution, reductions of prey in the ocean, and juvenile and adult passage problems at dams. Mesa et al. (2003) found that adult Pacific lamprey had a mean critical swimming speed of approximately 85 cm/s which suggests that they may have difficulty negotiating fishways with high current velocities that were designed for salmon and steelhead passage.

The study of adult Pacific lamprey migration patterns past dams and through reservoirs in the lower Columbia River has provided the first data sets on lamprey passage timing, travel times, and passage success at hydroelectric projects (Vella et al. 2001; Ocker et al. 2001; Moser et al. 2002a; Moser et al. 2002b). These studies have shown that approximately 90% of the radio-tagged lamprey released downstream of Bonneville Dam migrated back to the tailrace below Bonneville Dam; however, less than 50% of the lamprey which encountered a fishway entrance actually passed through the ladder exit at the dam (Nass et al. 2005).

Similar collection and passage efficiency results were observed at Rocky Reach, Wanapum, and Priest Rapids dams during tagging studies conducted at those projects (Nass et al. 2003; Stevenson et al. 2005).

Of the 125 radio-tagged lampreys released approximately 7 kilometers downstream of Rocky Reach Dam, 93.6% were detected at the project, and of those fish, 94.0% entered the fishway. Of the fish that entered the Rocky Reach fishway, 55.5% exited the ladder (Stevenson et al. 2005).

During studies at Wanapum and Priest Rapids dams, a total of 51 and 74 lamprey were radio-tagged and released downstream of Priest Rapid Dam in 2001 and 2002, respectively. Over the two years of study, the proportion of fish that approached the fishway that exited the ladders was 30% and 70% at Priest Rapids and 100% and 51% at Wanapum Dam in 2001 and 2002, respectively (Nass et al. 2003).

Two recent reviews of Pacific lamprey (Hillman and Miller 2000; Golder Associates Ltd. 2003) in the mid-Columbia River have indicated that little specific information is available regarding their population status (Stevenson et al. 2005).

2.2 Status of Pacific Lamprey

In January 2003, the USFWS received a petition from 11 environmental groups seeking the listing of four lamprey species (Pacific lamprey, river lamprey, western brook lamprey, and Kern brook lamprey). The petition cited population declines and said lampreys are threatened by artificial barriers to upstream and downstream migration, de-watering and habitat degradation among other threats. In response to the petition, the USFWS conducted an initial review to determine whether an emergency listing was warranted and decided in March 2003 that such a situation did not exist.

In an agreement stemming from a lawsuit filed by the petitioners in response to the initial finding, the USFWS committed to the issuance of a 90-day finding on the petition by December 20, 2004. Again, the USFWS announced that the petition seeking a listing of the four lamprey species did not contain enough information to warrant further review and the agency was not going to place the lamprey species on the Endangered Species list. For Pacific lamprey, the petitioners provided information showing a drop in range and numbers, but did not provide information describing how the regional portion of the species' petitioned range, or any smaller portion, is appropriate for listing under the Endangered Species Act (ESA). The agency did however decide it will continue to work with others on efforts to gather information related to the conservation of lamprey and their habitats.

2.3 Monitoring and Studies of Outmigrating Juvenile Lamprey (Macrophthalmia)

Little information in the mid-Columbia River basin exists with regard to the outmigration timing and abundance of juvenile Pacific lamprey. Upstream of the Project, recent juvenile salmonid trapping operations by WDFW and the Colville Tribe have provided preliminary information on the presence of juvenile lamprey outmigrants in both the Methow and Okanogan rivers. This information represents incidental captures of juvenile lamprey, and may not be reflective of actual abundance or population trends. In the Okanogan River, information is available for 2006 and 2007 where 220 and 24 juvenile lamprey were observed, respectively, during spring trapping operations. In the Methow River watershed, information is available for two sites; the Twisp and Methow rivers. At the Twisp River site, no juvenile lamprey have been observed since data has been collected (2005). At the Methow River site, for the years 2004-2007, 89, 84, 831, and 37 juvenile lamprey were observed, respectively, in trapping operations that typically last from April to November with peaks generally occurring in the spring. Data collection from these activities is likely to continue and provide information on juvenile Pacific lamprey as they begin their outmigration through the Columbia River hydrosystem towards the Pacific Ocean.

Although there is a growing body of information on adult Pacific lamprey and their interactions at hydroelectric projects, relatively little information exists describing the effects of hydroelectric plant operations on outmigrating juvenile lamprey (macrophthalmia). Recent juvenile lamprey studies at hydroelectric projects have addressed testing for lamprey macrophthalmia survival through juvenile bypass facilities (Bleich and Moursund 2006), impingement at intake diversion screens (Moursund et al. 2000 and 2003), validation of existing screening criteria (Ostrand 2005), and responses of juvenile Pacific lamprey to simulated turbine passage environments (Moursund et al. 2001; INL 2006). Results of other studies targeting predaceous birds and fish suggest that juvenile lamprey may compose a significant proportion of the diets of these predators (Poe et al. 1991; Merrell 1959).

A review of the recent body of work addressing juvenile lamprey at hydroelectric facilities concludes that there is a current lack of methods and tools to effectively quantify the level of survival for juvenile lamprey migrating through hydroelectric facilities. Furthermore, no studies exist that assign a level of survival attributed to a project's operations. This is due to the lack of miniaturized active tag technologies to overcome two study limitations. Macrophthalmia (juvenile outmigrating lamprey) are relatively small in size and unique in body shape and they tend to migrate low in the water column resulting in the rapid attenuation of active tag signal strength. In an effort to develop a tagging protocol, the Bonneville Power Administration (BPA) funded Oregon State University (OSU) to identify and develop tag technologies for lamprey macrophthalmia. Recent reports on this developmental effort have concluded that the smallest currently available radio-tag was still too large for implantation in the body cavity of a juvenile lamprey (Schreck et al. 2000). Additionally, external application was not effective as animals removed tags within the first week and fish performance was affected. This report also concluded that internal implantation of Passive Integrated Transponder (PIT) tags was the most viable option for tagging juvenile lamprey although this method included severe limitations such as the limited range of detection systems and the ability to tag only the largest outmigrating juvenile lamprey (Schreck et al. 2000).

2.4 Project Adult Pacific Lamprey Counts and Passage Timing

Returning adult Pacific lamprey have been counted at Wells Dam since 1998. Between the years of 1998 and 2007, the number of lamprey passing Wells Dam annually has averaged 326 fish and ranged from 21 fish in 2006 to 1,417 fish in 2003 (Table 2.3-1). In addition to the overriding condition that Pacific lamprey numbers are declining in the Columbia River system, the relatively small number of adult lamprey observed at Wells Dam may be attributed to fact that the Project is the last of nine passable dams on the mainstem Columbia River and the fact that the Project is over 500 miles upstream from the Pacific Ocean and the bioenergetic expenditure for a relatively poor swimming species such as Pacific lamprey is likely great.

Adult lamprey pass Wells Dam from early July until late November with peak passage times between mid-August and late October (Figures 2.4-1 and 2.4-2). In all years since counting was initiated, Pacific lamprey counts at the east fish ladder were greater than at the west fish ladder except for 2007. It is important to note that historically, counting protocols were designed to assess adult salmonids and did not necessarily conform to lamprey migration behavior (Moser and Close 2003). Traditional counting times for salmon did not coincide with lamprey passage activity which occurs primarily at night; the erratic swimming behavior of adult lamprey also makes them inherently difficult to count (Moser and Close 2003). Beamish (1980) also noted that lamprey overwinter in freshwater for one year prior to spawning. Consequently, lamprey counted in one year may actually have entered the system in the previous year (Moser and Close 2003) which confounds annual returns back into the Columbia River Basin. In addition to salmonid-specific counting protocols, adult fishway facilities have been constructed specifically for passage of salmonids. Recent research has identified areas such as picketed lead structures downstream of fish count windows that adult lamprey may access to bypass count stations and avoid being enumerated (LGL 2008). It is unknown to what degree lamprey behavior and methodological and structural concerns are reflected in Columbia River lamprey passage data. However, it is important to consider such caveats when examining historic lamprey count data at Columbia River dams including Wells Dam.

Table 2.4-1 Adult Pacific lamprey counts at Wells Dam for east and west fish ladders, 1998-2007.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
East	174	47	96	153	226	724	263	151	13	17
West	169	26	59	106	117	694	140	64	8	18
Total	343	73	155	259	343	1418	403	215	21	35

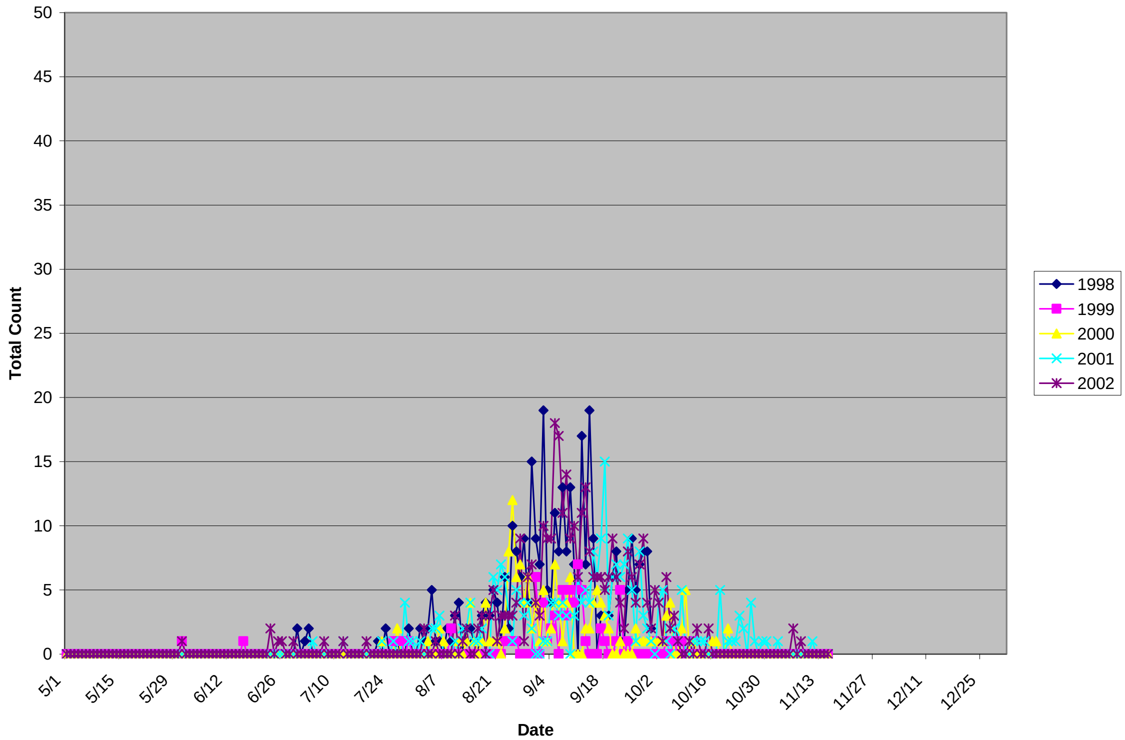

Figure 2.4-1 **Daily counts of adult Pacific lamprey at Wells Dam during the fish counting season, 1998-2002.**

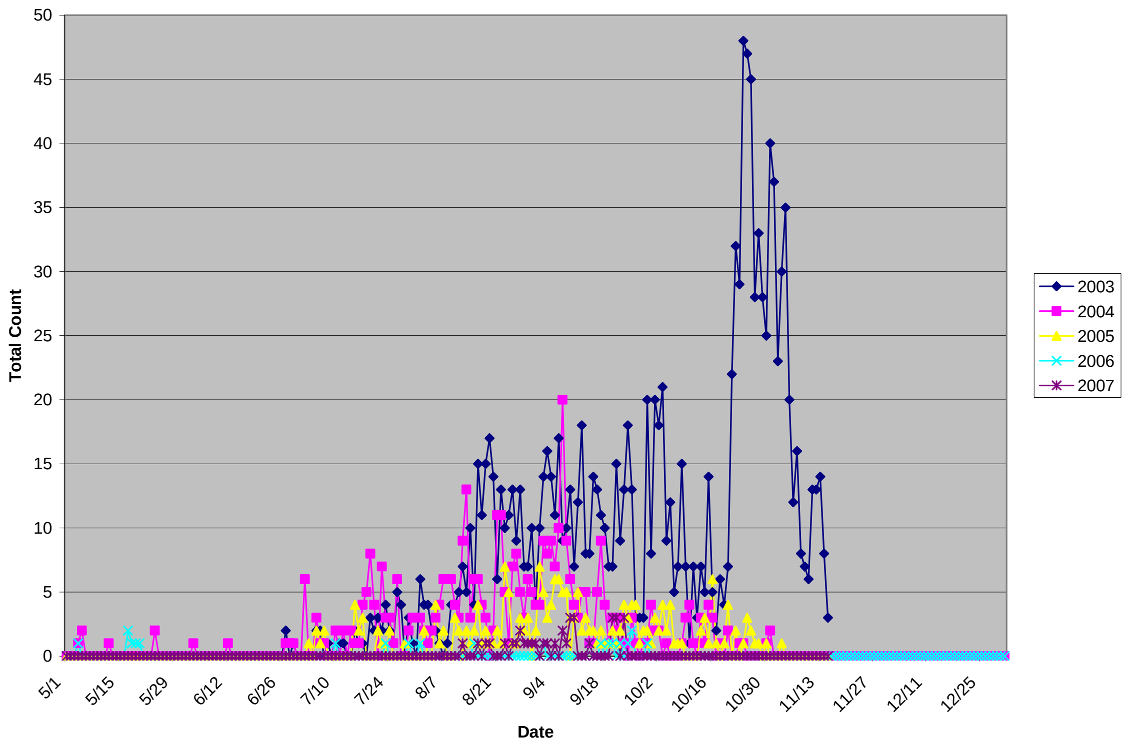

Figure 2.4-2 **Daily counts of adult Pacific lamprey at Wells Dam during the fish counting season, 2003-2007.**

2.5 Project Pacific Lamprey Studies

Until recently, relatively little information was available on Pacific lamprey in the mid-Columbia River Basin. However, with increased interest in the species coupled with a petition for listing under the ESA (Section 2.2), Douglas has initiated studies to address Pacific lamprey passage and migratory behavior in the Project consistent with currently available technology.

2.5.1 2001-2003 Project Pacific Lamprey Study

In 2004, Douglas contracted with LGL Limited to conduct a lamprey radio-telemetry study at Wells Dam in coordination with Chelan PUD, which was conducting a similar study at Rocky Reach Dam. A total of 150 lamprey were radio-tagged and released at or below Rocky Reach Dam. The radio-tags used in this study had an expected operational life of 45 days (Nass et al. 2005). It is important to note that as a result of the lamprey release site being located over 50 miles downstream of Wells Dam, the value of the study results for the Project was limited by the relatively small numbers of tagged fish detected upstream at Wells (n=18) and the fact that many of the radio-tags detected at Wells Dam were within days of exceeding their expected battery life.

The 2004 study at Wells Dam was implemented through a combination of fixed-station monitoring at the dam and fixed-stations at tributary mouths. Collectively, these monitoring sites were used to determine migration and passage characteristics of lamprey entering the Project Area. Of the 150 adult lamprey released at or below Rocky Reach in 2004, 18 (12% of 150) were detected in the Wells Dam tailrace, and ten (56% of 18) of these were observed at an entrance to the fishways at Wells Dam. A total of 3 radio-tagged lamprey passed Wells Dam prior to expiration of the tags, resulting in a Fishway Efficiency estimate of 30% (3 of 10) for the study period. A single lamprey was detected upstream of Wells Dam at the mouth of the Methow River (Nass et al. 2005).

For lamprey that passed the dam, the majority (92%) of Project Passage time was spent in the tailrace. Median time required to pass through the fishway was 0.3 d and accounted for 8% of the Project Passage time (Nass et al. 2005).

Although the 2004 study at Wells Dam provided preliminary passage and behavioral information for migrating adult lamprey, the limited observations due to the small sample size (n=18) were insufficient in addressing the objectives of the 2004 study.

2.5.2 2007-2008 Project Pacific Lamprey Study

In 2007, Douglas contracted with LGL Limited to conduct a second lamprey radio-telemetry study at Wells Dam. The study was scheduled to occur from early August through November and utilized tags that had 87 days of battery life. A total of 21 adult lamprey were tagged and released for the purpose of this study. However, due to very low adult lamprey returns to Wells Dam in 2007 (n=35) and low trapping efficiency, only 6 adult Pacific lamprey were captured at Wells Dam during trapping activities (August 14 to October 3). Therefore, 15 additional adult lamprey were collected at Rocky Reach Dam, transported to Wells Dam, tagged and released. The project was continued in 2008 to obtain additional information.

A comprehensive report was produced in February of 2009 containing the results from the two-year radio-telemetry behavior studies (Robichaud et al. 2009). Results indicated that the "greatest impediment to successful passage of adult lamprey at Wells Dam appears to be the conditions at the fishway entrance, probably related to water velocities that limit swimming and attachment capabilities." An equally significant impediment to successful passage of adult lamprey at Wells Dam in 2008 was the installation of perforated plates on the floor of the weir orifices in an effort to increase trapping efficiency. Robichaud et al. further recommended the following:

- Implement a reduction in fishway head differential to reduce entrance velocities to levels within the swimming capabilities of Pacific lamprey (0.8 to 2.1 m/s). These proposed flow reductions should be restricted to hours of peak lamprey activity (i.e., nighttime) and within their primary migratory period at Wells Dam (August-September).
- Remove perforated plates from orifice floors at the current trapping locations and discontinue trapping efforts at Wells Dam.
- Consider using monitoring tools that are less intrusive, do not require the collection of fish from the ladders at Wells Dam, and minimize the surgical implantation of tags in fish that are nearing their physiological limits.

2.5.3 2009 Pacific Lamprey Ladder Modification Study

In response to Robichaud et al. (2009), Douglas PUD, in consultation with the Aquatic SWG, prepared a plan to implement and evaluate measures to enhance passage of adult Pacific lamprey at Wells Dam (Murauskas and Johnson, 2009). These measures, originally scheduled for year two after license issuance (2013), were designed to determine whether temporary velocity reductions at the fishway entrances would enhance the attraction and relative entrance success of adult lamprey at Wells Dam. Three alternative entrance flow velocities (i.e., existing high, moderate, and low) will be assessed using Dual-frequency Identification Sonar (DIDSON) in a randomized block design during the fall of 2009. The goal is to identify optimal hydraulic conditions conducive to entry of adult lampreys into the fishways at Wells Dam.

3.0 GOALS AND OBJECTIVES

The goal of the PLMP is to implement measures to monitor and address impacts, if any, on Pacific lamprey resulting from the Project during the term of the new license. Douglas, in collaboration with the Aquatic SWG, has agreed to implement several Pacific lamprey PMEs in support of the PLMP. The PMEs presented within the PLMP are designed to meet the following objectives:

Objective 1: Identify and address any adverse Project-related impacts on passage of adult Pacific lamprey;

Objective 2: Identify and address any Project-related impacts on downstream passage and survival, and rearing of juvenile Pacific lamprey;

Objective 3: Participate in the development of regional Pacific lamprey conservation activities.

The PLMP is intended to be compatible with other Pacific lamprey management plans in the Columbia River mainstem. Furthermore, the PLMP is intended to be supportive of the HCP, the critical research needs identified by the Columbia River Basin Technical Working Group, the Resident Fish Management Plan, Bull Trout Management Plan, and White Sturgeon Management Plan by continuing to monitor and address ongoing impacts, if any, on Pacific lamprey resulting from Project operations. The PLMP is intended to be not inconsistent with other management strategies of federal, state and tribal natural resource management agencies and supportive of designated uses for aquatic life under Washington state water quality standards found at WAC 173-201A.

The schedule for implementation of specific measures within the PLMP is based on the best information available at the time the Plan was developed. As new information becomes available, implementation of each activity may be adjusted through consultation with the Aquatic SWG.

4.0 PROTECTION, MITIGATION AND ENHANCEMENT MEASURES

Douglas, in consultation with the Aquatic SWG, will implement PMEs for Pacific lamprey in the Project consistent with the goals and objectives identified in Section 3.0. The measures proposed in this section are intended to serve as PMEs for Pacific lamprey throughout the new license term.

4.1 Adult Pacific Lamprey Passage (Objective 1)

4.1.1 Upstream Fishway Operations Criteria

Douglas shall operate the upstream fishways at Wells Dam in accordance with criteria outlined in the HCP. Based upon information collected from activities conducted in Sections 4.1.3 - 4.1.7, Douglas, in consultation with the Aquatic SWG and the HCP Coordinating Committee, may evaluate various operational and structural modifications to the upstream fishways (e.g., reduction in fishway flows at night) for the benefit of Pacific lamprey passing upstream through Wells Dam during the new license term. If requested, the Aquatic SWG shall develop an Operations Study Plan (OS Plan) that specifically identifies all operational modifications to be evaluated, the proposed monitoring strategy, implementation timeline and criteria for success. The plan shall include a component to evaluate the effects of lamprey modifications on salmon. Upon completion of the evaluation, the Aquatic SWG, in consultation with the HCP Coordinating Committee, will determine whether the proposed modifications should be made permanent, removed, or modified.

4.1.2 Salvage Activities During Ladder Maintenance Dewatering

Douglas shall continue to implement the Adult Fish Passage Plan and associated Adult Ladder Dewatering Plan as required by the HCP. These plans include practices and procedures utilized during fishway dewatering operations to minimize fish presence in the fish ladders and then once dewatered directs Douglas staff to remove stranded fish and safely place them back into the

Columbia River. All fish species, including Pacific lamprey that are encountered during dewatering operations are salvaged consistent with the protocol identified in the HCP. Any adult lamprey that are captured during salvage activities will be released upstream of Wells Dam, unless otherwise determined by the Aquatic SWG. Douglas will coordinate salvage activities with the Aquatic SWG and allow for member participation. Douglas will provide a summary of salvage activities in the annual report.

4.1.3 Upstream Fishway Counts and Alternative Passage Routes

Douglas shall continue to conduct annual adult fish passage monitoring in the Wells Dam fishways using the most current technology available, to count and provide information on upstream migrating adult Pacific lamprey 24-hours per day during the adult fishway monitoring season (May 1- November 15). Based upon information collected from activities conducted in Sections 4.1.6 - 4.1.7, Douglas, in consultation with the Aquatic SWG, may choose to address the use of alternative upstream passage routes around Wells Dam fishway counting stations by adult Pacific lamprey. Potential measures to improve counting accuracy, following consultation and approval of the Aquatic SWG, may include, but may not be limited to, the development of a correction factor based upon data collected during passage evaluations (Sections 4.1.6 and 4.1.7) or utilization of an alternative passage route as a counting facility for adult Pacific lamprey.

4.1.4 Upstream Passage Improvement Literature Review

If additional passage improvement measures are deemed necessary by the Aquatic SWG, then within six months after this determination, Douglas, in consultation with the Aquatic SWG, shall complete a literature review on the effectiveness of upstream passage measures (i.e., lamprey passage systems, plating over diffuser grating, modifications to orifices, rounding sharp edges, fishway operational changes, etc.) implemented at other Columbia and Snake river hydroelectric facilities. The literature review will be conducted in support of activities identified in Section 4.1.5 to help in the selection of reasonable measures that may be implemented to improve adult lamprey passage at Wells Dam.

4.1.5 Fishway Modifications to Improve Upstream Passage

If additional passage improvement measures are deemed necessary by the Aquatic SWG, based upon the results of studies conducted at Wells Dam, then within one year or as soon as practicable following consultation with the Aquatic SWG, Douglas shall identify, design and implement any reasonable upstream passage modifications (structural and/or operational). Passage measures will be designed to improve passage performance by providing safe, effective, and volitional passage for Pacific lamprey through the Wells Dam fishways without negatively impacting the passage performance of adult anadromous salmonids. The following components shall be included in these passage measures:

- Fishway Inspection: Within one year of license issuance or as soon as practicable following consultation with the Aquatic SWG, Douglas shall conduct a fishway inspection with the Aquatic SWG and regional lamprey passage experts to identify and prioritize measures to improve adult lamprey passage and enumeration at Wells

Dam. Additional ladder inspections will be conducted at the request of the Aquatic SWG, consistent with winter ladder dewatering operations.

- Entrance Efficiency: Within one year of license issuance or as soon as practicable following consultation with the Aquatic SWG, Douglas shall develop a Lamprey Entrance Efficiency Plan (LEE Plan) for evaluating operational and physical ladder entrance modifications intended to create an environment at the fishway entrances that are conducive to adult lamprey passage without significantly impacting the passage of adult salmonids. These improvements shall be evaluated until compliance, as described below, is attained.
- Diffuser Gratings: Within five years of license issuance or as soon as practicable following consultation with the Aquatic SWG, Douglas shall identify and address, if needed, diffuser gratings within fishways at Wells Dam that adversely affect passage of adult Pacific lamprey.
- Transition Zones: Within five years of license issuance or as soon as practicable following consultation with the Aquatic SWG, Douglas shall identify and address, if needed, transition zones within fishways at Wells Dam that adversely affect passage of adult Pacific lamprey.
- Ladder Traps and Exit Pools: Within five years of license issuance or as soon as practicable following consultation with the Aquatic SWG, Douglas shall identify and address, if needed, lamprey ladder traps and exit pools within fishways at Wells Dam that adversely affect passage of adult Pacific lamprey.

Douglas shall exhibit steady progress, as agreed to by the Aquatic SWG, towards improving adult lamprey passage until performance at Wells Dam is determined to be similar to other mid-Columbia River hydroelectric dams, or until scientifically rigorous standards and evaluation techniques are established by the Lamprey Technical Workgroup, or its successor, and adopted regionally. The Aquatic SWG will then evaluate, and if applicable and appropriate, adopt these standards for use at Wells Dam. If compliance is achieved, Douglas shall only be required to implement activities pursuant to Section 4.1.7 (Periodic Monitoring) for adult Pacific lamprey passage.

4.1.6 Adult Pacific Lamprey Upstream Passage Evaluation

Should upstream passage measures be implemented under Section 4.1.5, then within one year following the implementation of such measures, Douglas, in consultation with the Aquatic SWG, shall conduct a one-year study to monitor the effectiveness of such measures on upstream passage performance of adult Pacific lamprey through Wells Dam. If monitoring results indicate that passage rates at Wells Dam are not similar to passage rates at other mid-Columbia River dams or within standards as described in Section 4.1.5, Douglas, in consultation with the Aquatic SWG, shall develop and implement additional measures to improve upstream Pacific lamprey passage. Measures described in Sections 4.1.5 and 4.1.6 may be repeated, as necessary, until adult passage through Wells Dam is similar to passage rates at other mid-Columbia River hydroelectric dams or within standards as described in Section 4.1.5.

4.1.7 Periodic Monitoring

Once adult Pacific lamprey upstream passage rates at Wells Dam are similar to rates at other mid-Columbia River dams or within standards as described in Section 4.1.5, Douglas, in consultation with the Aquatic SWG, shall periodically monitor adult Pacific lamprey passage performance through Wells Dam fishways to verify the effectiveness of passage improvement measures. Specifically, every ten years after compliance has been achieved, or as determined by the Aquatic SWG, Douglas shall implement a one-year study to verify the effectiveness of the adult fish ladders with respect to adult lamprey passage. If results of the monitoring program confirm the effectiveness of adult lamprey passage measures and the results indicate that passage rates are still in compliance, then no additional measures are needed. If the results indicate that adult upstream passage rates are out of compliance, then the upstream passage study will be replicated to confirm the results. If the results after two years of study both indicate that passage rates have not been maintained, Douglas, in consultation with the Aquatic SWG, shall develop and implement measures to improve upstream Pacific lamprey passage, if any (see Section 4.1.5).

4.2 Juvenile Pacific Lamprey Downstream Passage and Survival and Rearing (Objective 2)

4.2.1 Downstream Bypass Operations Criteria

Douglas is required to operate the downstream bypass system at Wells Dam in accordance with criteria outlined in the HCP.

4.2.2 Salvage Activities During Ladder Maintenance Dewatering

Douglas shall continue to conduct salvage activities as required by the HCP's Adult Fish Passage Plan during fishway dewatering operations. All fish species, including Pacific lamprey that are encountered during dewatering operations shall be salvaged consistent with the protocol identified in the HCP. Any juvenile Pacific lamprey that are captured during salvage activities will be released downstream of Wells Dam. Douglas will coordinate salvage activities with the Aquatic SWG and allow for member participation. Douglas will provide a summary of salvage activities in the annual report.

4.2.3 Juvenile Pacific Lamprey Passage and Survival Literature Review

Beginning in year five and every five years thereafter during the new license, Douglas, in consultation with the Aquatic SWG, shall conduct a literature review to summarize available technical information related to juvenile lamprey passage and survival through Columbia and Snake river hydroelectric facilities. This information will be used to assess the feasibility of conducting activities identified in Section 4.2.4.

4.2.4 Juvenile Pacific Lamprey Downstream Passage and Survival Evaluation

Based upon the current state of the science regarding tag technology and methodologies for Pacific lamprey macrophthalmia (Section 2.3), coupled with the challenges of obtaining macrophthalmia in sufficient numbers within the Project to meet sample size requirements for a statistically rigorous study, a juvenile downstream passage and survival evaluation is not feasible at this time.

During the term of the new license, if tag technology and methodologies are developed and field tested and a sufficient source of macrophthalmia in or upstream of the Project are identified to ensure that a field study will yield statistically rigorous and unbiased results, Douglas, in consultation with the Aquatic SWG, shall implement a one-year juvenile Pacific lamprey downstream passage and survival study.

If statistically valid study results indicate that Project operations have a significant negative impact on the Pacific lamprey population above the Wells Dam, Douglas, in consultation with the Aquatic SWG, shall identify and implement scientifically rigorous and regionally accepted measures (e.g., translocation, artificial production or habitat enhancement), if any, or additional studies to address such impacts. If operational changes are needed to improve passage survival of juvenile lamprey migrants, then those changes need to be coordinate with the HCP Coordinating Committee.

4.2.5 Juvenile Pacific Lamprey Habitat Evaluation

Within three years of the effective date of the new license, Douglas shall implement a one-year study to examine presence and relative abundance of juvenile Pacific lamprey in habitat areas within the Project that may be affected by Project operations. As part of this measure, Douglas shall identify areas of potential juvenile Pacific lamprey habitat for future evaluation. Sampling of these areas will assess presence/absence and relative abundance. Any sampling methodologies used in support of this activity will require coordination with the HCP Coordinating Committee and regulatory approval of the federal and state agencies.

4.3 Participate in Regional Pacific Lamprey Conservation Activities (Objective 3)

4.3.1 Regional Lamprey Working Groups

Douglas shall participate in Pacific lamprey work groups in order to support regional conservation efforts (e.g., the Pacific Lamprey Technical Work Group and the USFWS Lamprey Conservation Initiative). Activities may include but are not limited to information exchanges with other entities, meeting attendance, and coordination of Douglas' Pacific lamprey activities with other entities conducting lamprey research in the mid-Columbia River. Activities may also include conducting PLMP research within the Project, and sharing that information with other entities.

4.4 Reporting

Douglas will provide an annual report to the Aquatic SWG summarizing the previous year's activities and proposed activities for the following year undertaken in accordance with the PLMP. The report will document all Pacific lamprey activities conducted within the Project and describe activities proposed for the following year. Furthermore, any decisions, statements of agreement, evaluations, or changes made pursuant to this PLMP will be included in the annual report. If significant activity was not conducted in a given year, Douglas will prepare a memorandum providing an explanation of the circumstances in lieu of the annual report.

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Robert Dach/ALBUQUERQUE/BIA/DOI

10/09/2009 11:51 AM

To Josh Murauskas
cc ShaneB@dcpud.org
Subject PLMP Redline Draft for SWG review

Hi Josh,

I've been going through your last edits to the lamprey management plan over the last couple of days, and I have a few questions (in no particular order) that will help me to better understand the proposal:

1. We added some language in paragraph 2 of section 2.5.1, the last bullet in 2.5.2 and added a Summary of Effects section as 2.5.3. Was there something factually incorrect about those insertions?

The Aquatic SWG unanimously agreed that adjustments to background information (as opposed to measures) were not needed. However, the Aquatic SWG agreed to replace the preliminary data in 2.5.2 with the 2009 conclusive results (consistent with a "summary of effects" section) as recommended by Robichaud et al. (2009).

2. The phrase "if any" implies that the information does not currently reflect any impacts on lamprey from the Wells Project - is that the intent of the statement?

The phrase "if any" is standard language used throughout the settlement agreement. It has been used to denote that there is little or no information available, and that without adequate information a determination of effect cannot be made or assigned to the project. Keep in mind that if any impacts are documented through the studies, then measures will be implemented to address the identified impacts.

3. Do you differentiate between the terms "monitor" and "evaluate"?

In general "monitoring" is the collection of data and "evaluating" is the analysis of data collected. For example, (a) we monitored radio tagged lamprey to gain information about the behavior of fish within the ladders and other project facilities; (b) we evaluated data from radio tagged lamprey to reach conclusions as to lamprey passage efficiency at the Project.

4. Do you think the concept of "timely" passage is captured in the phrase "safe, effective, and volitional"?

The SWG unanimously agreed timely is implied within the phrase "safe, effective, and volitional."

5. What is meant by the phrase "not inconsistent with"?

*It means that the plans will not run counter to other regionally developed plans. However, please keep in mind the context of the statement. In the same paragraph, the PLMP also states that, "The PLMP is intended to be **compatible** with other Pacific lamprey management plans in the Columbia River mainstem." It also states that the PLMP is, "…intended to be **supportive** of the HCP, the critical research needs identified by the Columbia River Basin Technical Working Group,..". Finally, it states that the*

*PLMP will be, "**supportive** of designated uses for aquatic life under Washington State water quality standards…".*

6. How would you define a "reasonable" measure?

First, the SWG would like to note that this has not been defined in the signed Aquatic SA, so all we can do is present our general thoughts about the subject. We think that reasonable means the decision will be based on the scientific information available, and what the group sees as sensible, not extreme or excessive.

7. At what point is performance at other Mid-Columbia River hydroelectric dams considered sufficient to set the standard to be met by DCPUD? is there a certain number of years that another project must have demonstrated a certain performance metric, is there a level of expected statistical precision/rigor that must be achieved at the other projects, is it an average of the other projects or does the best project set the standard? What do you think the current performance level is at other mid-Columbia River Projects?

Performance at Wells and other Mid-Columbia River hydroelectric dams will be assessed by the Aquatic SWG consistent with the language the parties unanimously developed for Section 4.1.5. "Douglas shall exhibit steady progress, as agreed to by the Aquatic SWG, towards improving adult lamprey passage until performance at Wells Dam is determined to be similar to other mid-Columbia River hydroelectric dams, or until scientifically rigorous standards and evaluation techniques are established by the Lamprey Technical Workgroup, or its successor, and adopted regionally. The Aquatic SWG will then evaluate, and if applicable and appropriate, adopt these standards for use at Wells Dam. If compliance is achieved, Douglas shall only be required to implement activities pursuant to Section 4.1.7 (Periodic Monitoring) for adult Pacific lamprey passage."

Priest Rapids Dam (RM 397) was reported to have 79% entrance efficiency, 75% ladder efficiency, and 14% fallback rate, for a total of 51% approach to forebay ratio (Nass et al. 2005). Wanapum Dam (RM 416) was reported to have 65% entrance efficiency, 84% ladder efficiency, and 4% fallback rate, for a total of 52% approach to forebay ratio (Nass et al. 2005). Adult lamprey passage at Rock Island Dam (RM 453) has not yet been determined. Rocky Reach Dam (RM 474) was reported to have 94% entrance efficiency, 56% ladder efficiency, and 22% fallback rate, for a total of 41% approach to forebay ratio (Stevenson et al. 2005).

8. Does the language in section 4.1.3 ("Douglas shall continue to conduct annual fish passage monitoring in the Wells Dam fishway...") mean you will continue to do annual radio-telemetry evaluations of lamprey passage at the project until performance is "similar to other mid-Columbia River " dams?

Section 4.1.3 is titled "Upstream Fishway Counts and Alternative Passage Routes." The abovementioned sentence, in whole, states "Douglas shall continue to conduct annual adult fish passage monitoring in the Wells Dam fishways using the most current technology available, to count and provide information on upstream migrating adult Pacific lamprey 24-hours per day during the adult fishway monitoring season (May 1- Nov 15)." This language is referring to fish enumeration efforts and not passage performance (see Section 4.1.5).

9. Does the phrase "Douglas, in consultation with the Aquatic SWG, may choose" mean that Douglas

will implement measures requested by the ASWG or does it mean that Douglas would consider implementing measures requested by the ASWG?

The Aquatic SWG will consult on, coordinate, and oversee all aspects of implementation of the Aquatic Resource Management Plans. Section 4.1.3 is the only instance in which "choosing" is used in the PLMP to describe an option for providing an alternative passage around fish enumeration stations within Wells Dam fishways. An alternative passage route has already been established around the counting station following consultations with the SWG (as compared to improving counting accuracy, which is captured in Section 4.1.3).

10. Why is a one-year study sufficient to demonstrate that passage performance is met, but a two-year study is required to determine if it is not (see sections 4.1.6 and 4.1.7)?

The PLMP does not state that a two-year study is needed to identify that the passage standard has not been met. Instead, Section 4.1.6 clearly states, "…,Douglas, in consultation with the Aquatic SWG, shall conduct a ***one-year*** *study to monitor the effectiveness of such measures on upstream passage performance of adult Pacific lamprey through Wells Dam. If monitoring results indicate that passage rates at Wells Dam are not similar to passage rates at other mid-Columbia river dams or within standards as described in Section 4.1.5, Douglas, in consultation with the Aquatic SWG,* ***shall develop and implement additional measures*** *to improve upstream Pacific lamprey passage.*

Section 4.1. addresses the conduct of periodic monitoring following prior attainment of the passage standard (under 4.1.6). Because the project has already successfully achieved the passage standard, as demonstrated through a one-year study (per 4.1.6), then only one additional year of study is needed, periodically, to periodically verify that the standard continues to be achieved. Conversely, if the second year of study (first year of periodic monitoring) documents that passage has dropped below the standard, then there exists a conflict in study results (one year of study demonstrating attainment of standards under 4.1.6 and one year demonstrating that the project does not meet the standard under 4.1.7). Because there is a conflict in the data collected, one additional year (second year of study under 4.1.7) is needed to either confirm or refute the results of the first year of periodic monitoring.

11. Can you describe DCPUD's intended efforts to help develop new tagging technologies for macrophthalmai, and to increase numbers of available test fish upstream of the project?

The PLMP, consistent with the scope of FERC relicensing, does not contain research and development for biotelemetry. However, page 1 of the PLMP states, "The PLMP is intended to be supportive … the critical research needs identified by the Columbia River Basin Technical Working Group, …". Also see Section 4.3.1 for regional coordination efforts.

We may be talking past one-another, so written answers to these questions will help me to better interpret the intent of the language in the Plan and maybe develop some alternative language that can address both of our issues, or at least develop a strategy for coordinating our issues with the PLMP.

Although I was hoping to provide you and Shane with some more concise feedback on the proposed changes, I don't think we're quite ready for that as yet. I will use your responses to the above questions to inform our next steps, which we will provide following a meeting between BIA and all of the affected Tribes. I am cognizant of the relicensing timeline and will endeavor to ensure that we are timely within that schedule.

Let me know if I need to clarify anything - thanks for your help!

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Robert Dach/ALBUQUERQUE/BIA/DOI

10/13/2009 11:11 AM

To Josh Murauskas
cc ShaneB@dcpud.org
Subject PLMP Redline Draft for SWG review

Hi Josh,

One more clarification - In section 4.1.5, you've added 5 bullets which reflect to a certain extent what we had provided as a section 4.1. Specificity has been removed in your version and a few of the dates have been modified. You also have the bullets under a section that initially states "If additional passage improvement measures are deemed necessary by the Aquatic SWG, based upon the results of studies conducted at Wells Dam, then within one year... The following components shall be included in these passage measures:"

For clarification please be aware that all of the recent changes made within the Pacific Lamprey Management Plan, to address comments provided by BIA, CRITFC and USFWS, were developed, edited, reviewed and finalized by the members of the Aquatic SWG. When you refer to these changes as being made by me (e.g., "you've added," "your version," "you also," etc.), please keep in mind that these changes were developed and approved by a committee of technical experts on aquatic resources.

My questions are as follows:

1. The way 4.1.5 is currently drafted, there appears to be a requirement for the ASWG to first determine that additional passage improvement measures are necessary based upon studies conducted at Wells, before any of the bullets would be implemented - can you clarify which studies this statement refers to and when those studies will be conducted?

Adult passage studies were conducted at Wells Dam in coordination with Chelan PUD in 2004, and more recently in 2007 and 2008 (as documented in Robichaud et al. 2009, FERC Updated Study Report filed April 15th, 2009). Consistent with the recommendations of this report, the SWG has unanimously agreed that improvements to enhance adult passage efficiency should be implemented at the earliest possible time.

Rather than waiting for FERC to issue a new license, Douglas PUD, in close coordination with the Aquatic SWG, voluntarily developed, received Aquatic SWG approval for, and implemented a study to look at operational modifications at the fishway entrances to improve lamprey passage efficiency. Digital imaging sonar techniques were proposed by regional experts, and approved by the Aquatic SWG, as the best tool for evaluating operational fishway entrance modifications in 2009.

2. The opening paragraph seems to contradict the bullets, as far as scheduling, in that each bullet has its own implementation schedule identified (i.e., within one year, or five years, of license issuance as the case may be). Are additional studies needed prior to implementing these bullets as described in the 1st general paragraph, or are they implemented on the schedules identified in each bullet?

No additional studies are required to implement bulleted items within 4.1.5. Each item will be implemented on the schedule defined within each bullet.

3. Why was the clarifying language included in our last redline removed?

Technical recommendations proposed by the BIA were considered and acted upon by unanimous consent of the Aquatic SWG signatory parties. The particular location and wording was adjusted to be consistent with other management plans within the SA, and to reflect the judgment of the technical experts represented on the Aquatic SWG.

4. Also, is it DCPUD or the ASWG that determines whether these actions are needed? It seems if the ASWG determined that they were needed then DCPUD would implement?

You are correct: The Aquatic SWG, under the settlement agreement, determines which measures are needed to satisfy the requirements of each of the six aquatic resource management plans. Douglas PUD then implements the required measures.

Thanks for your help clarifying!

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