DEPARTMENT OF
ECOLOGY
State of Washington

Final Environmental Impact Statement

Washington State's Changes to Water Quality Standards for Surface Waters of the State of Washington – WAC 173-201A

December 2019

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Publication and Contact Information

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Final Environmental Impact Statement

Washington State's Changes to Water Quality Standards for Surface Waters of the State of Washington – WAC 173-201A

Water Quality Program

Washington State Department of Ecology

Olympia, Washington

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STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
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December 23, 2019

Dear Interested Party:

The Washington State Department of Ecology (Ecology) is issuing this final Environmental Impact Statement (EIS) on the changes to the Water Quality Standards for Surface Waters of the State of Washington - WAC 173-201A (Water Quality Standards). This EIS was prepared to satisfy the requirements of the State Environmental Policy Act.

The state's water quality standards set limits on pollution in our lakes, rivers, and marine waters in order to protect beneficial uses, such as swimming and fishing. The water quality standards are implemented through discharge permits under the federal Clean Water Act. They are also used to identify polluted waters and set levels for water cleanup.

This rulemaking will adopt:

1. Amendments to numeric criteria for total dissolved gas (TDG) in the Snake and Columbia rivers.
2. Amendments to specific sections of the rule to meet legal obligations in a 2018 Stipulated Order of Dismissal.
3. Clarifications to the descriptions of marine water aquatic life use designations.

This EIS only addresses the risks of adjusting the TDG criteria to allow more spill in the Snake and Columbia rivers that are associated with amendments to the numeric criteria for TDG. The other rule changes were determined not have a probable adverse impact on the environment.

For a comprehensive discussion of the rule language modifications, please visit the agency's website at https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC173-201A-revisions.

For assistance or questions, please contact Susan Braley, rulemaking lead, at swqs@ecy.wa.gov or (360) 407-6414.

Sincerely,

Heather R. Bartlett

Heather R. Bartlett
Water Quality Program Manager

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Fact Sheet

Title:	*Washington State's Changes to Water Quality Standards for Surface Waters of the State of Washington – WAC 173-201A*
Description:	*The rulemaking intends to adopt revisions to Chapter 173-201A WAC on December 30, 2019. The purpose of the final Environmental Impact Statement (EIS) is to evaluate the risks of adjusting the TDG criteria to allow more spill in the Snake and Columbia rivers. The other rule changes will not have a probable adverse impact on the environment.*
Location:	*Statewide and Lower Snake and lower Columbia rivers*
Lead Agency:	*Washington State Department of Ecology*
***Responsible Official**:*	*Heather R. Bartlett, Program Manager* *Water Quality Program* *Department of Ecology* P.O. Box 47600 Olympia, WA 98504-7600

Lead Agency Contact: Susan Braley (swqs@ecy.wa.gov or 360-407-6414)

Scoping Comments Received: May 8, 2019 through May 29, 2019

Date Final EIS was issued: December 23, 2019

Date draft EIS issued: July 31, 2019

Date draft EIS Comments Due: September 26, 2019

Public Hearings:

Ecology held 2 public hearings on these rule changes:

- **September 16, 2019 at 1:30p.m.:** In-person hearing in Vancouver, Washington.
- **September 19, 2019 at 1:30p.m.:** Statewide hearing using online webinar from any computer.

For more information about the hearings, or to review the comments we received during the comment period, visit: https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC173-201A-revisions.

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The Department of Ecology (Ecology) would like to acknowledge and thank the Washington Department of Fish and Wildlife (WDFW) for their contributions to sections that discuss the Flexible Spill Agreement and potential positive impacts of increased spill described in models.

Executive Summary

Ecology is updating Chapter 173-201A Washington Administrative Code (WAC) to amend numeric criteria for total dissolved gas (TDG) in the Snake and Columbia rivers, amend specific sections of the rule to meet legal obligations in a 2018 Stipulated Order of Dismissal, and clarify the descriptions of marine water aquatic life use designations. The purpose of this final Environmental Impact Statement (EIS) is to evaluate the risks of adjusting the TDG criteria to allow dams on the Snake and Columbia rivers to further increase spill for juvenile fish passage. The other rule changes, not including the TDG amendments, have been determined to not have a probable adverse impact on the environment.

This EIS evaluates the impacts of amendments to WAC 173-201A-200(1)(f) TDG criteria to allow more water spill for the purpose of fish passage in the Snake and Columbia rivers. This final rule will allow hydropower facilities (including federal and Public Utility District projects) the opportunity to further increase spill to aid in fish passage during the spring spill season. This allowance would require a submittal of a biological monitoring plan to Ecology for review and approval.

A Flexible Spill Agreement (herein referred to as Spill Agreement) reached for the 2019-2021 spill operations at the eight federal dams on the lower Snake and Columbia rivers was formally announced on December 18, 2018, and signed by the states of Washington and Oregon, the Nez Perce Tribe, the Bonneville Power Administration (BPA), U.S. Army Corps of Engineers, and the Bureau of Reclamation. The Spill Agreement is supported by the states of Idaho and Montana and the Columbia River Inter-Tribal Fish Commission.

The focus and intent of the Spill Agreement is to further improve juvenile salmon and steelhead survival rates as they travel downriver through the federal dams on the lower Snake and Columbia rivers. The Spill Agreement seeks benefits to salmonid survival in concert with managing the Columbia River system for multiple congressionally authorized purposes, including power generation to ensure the Pacific Northwest of an adequate, efficient, economical, and reliable power supply. The Spill Agreement also intends to provide a pause in long-running litigation over the impact of the operations and maintenance of federal dams on Endangered Species Act (ESA)-listed salmon and steelhead, at least until the Columbia River System Operations National Environmental Policy Act process is complete and a new long-term biological opinion (BiOp) for the Federal Columbia River Power System (FCRPS) is released by the National Marine Fisheries Service.

The Spill Agreement is contingent on the implementation of a flexible spill operation that increases spill beyond the levels ordered by a federal court for the 2018 salmon migration season at the times of day when regional energy demand is lower, and reduces spill during times of peak energy demand (generally early morning and late afternoon/evening) and highest energy market values. Recent trends suggest that such flexibility may become more valuable to energy marketers as solar energy continues to be deployed in California and elsewhere in the western United States.

Technical analysis conducted by state and tribal fisheries managers concludes that the spill operations outlined in the Spill Agreement will roughly equal (in 2019) or exceed (in 2020 and 2021) fish survival rates obtained through 2018 court-ordered spill operations, which required spill to existing TDG standards of 115% as measured in dam forebays and 120% as measured in dam tailraces on the lower Snake and Columbia rivers. At the same time, the Spill Agreement operations are designed to maintain or improve power generation revenue relative to 2018 operations.

The Spill Agreement implementation for the 2019 spill season was contingent on Washington, through the process described in this document, raising TDG standards on the lower Snake and Columbia rivers to match Oregon's 120% standard as measured in the dam tailrace for the 2019 salmon migration season. In March 2019, Washington administered a short-term modification of the TDG criteria in the lower eight Snake and Columbia River federal dams that removed the 115% forebay criterion and aligned the 120% tailrace criterion and 125% maximum criterion averaging period with Oregon's TDG requirements. Washington's short-term modification of the TDG criteria met the objectives of the Spill Agreement for 2019. For the 2020 and 2021 migration season, the Spill Agreement is contingent on both Washington and Oregon raising TDG criteria up to 125%.

There have been other requests to increase spill similar to the request in the Spill Agreement on December 18, 2018. For example, the Final Report from the Southern Resident Orca Task Force convened by Governor Jay Inslee includes a recommendation encouraging testing the potential of higher TDG standards and attendant spill to improve salmon survival and abundance, while also considering ways to minimize impacts on the BPA's Fish and Wildlife Program. Task Force Recommendation 8 reads as follows:

- *Recommendation 8: Increase spill to benefit Chinook for Southern Residents by adjusting total dissolved gas allowances at the Snake and Columbia River dams.*
    - *Direct the Department of Ecology to increase the standard for dissolved gas allowances from 115 percent to up to 125 percent, to allow use of the best available science to determine spill levels over these dams to benefit Chinook and other salmonids for Southern Residents.*
    - *Coordinate with the Oregon Department of Environmental Quality to align standards across the two states.*
    - *Maintain rigorous monitoring of impacts to juvenile Chinook and resident fish to ensure any changes in spill levels do not negatively impact salmon or other aquatic species.*
    - *Work with tribes, salmon recovery regions, Ecology and WDFW to minimize revenue losses and impacts to other fish and wildlife program funds.*[1]

The Snake and Columbia rivers have an existing special condition within the TDG surface water quality standard (SWQS) that pertains to fish passage during the spill season:

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

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[1] See Southern Resident Orca Task Force Final Report, November 2018, at p. 48.

Ecology is considering an additional adjustment to the TDG surface water quality standard that could be applied at the lower eight federal dams on the Snake and Columbia rivers and the five public utility district dams on the middle Columbia River (see Figure 1). This criteria would make an addition adjusted criteria available to allow greater increases in spill at each dam. This rulemaking would not require any dams to maximize spill to these allowable TDG levels, but would allow greater flexibility for designing future spring spill regimes.

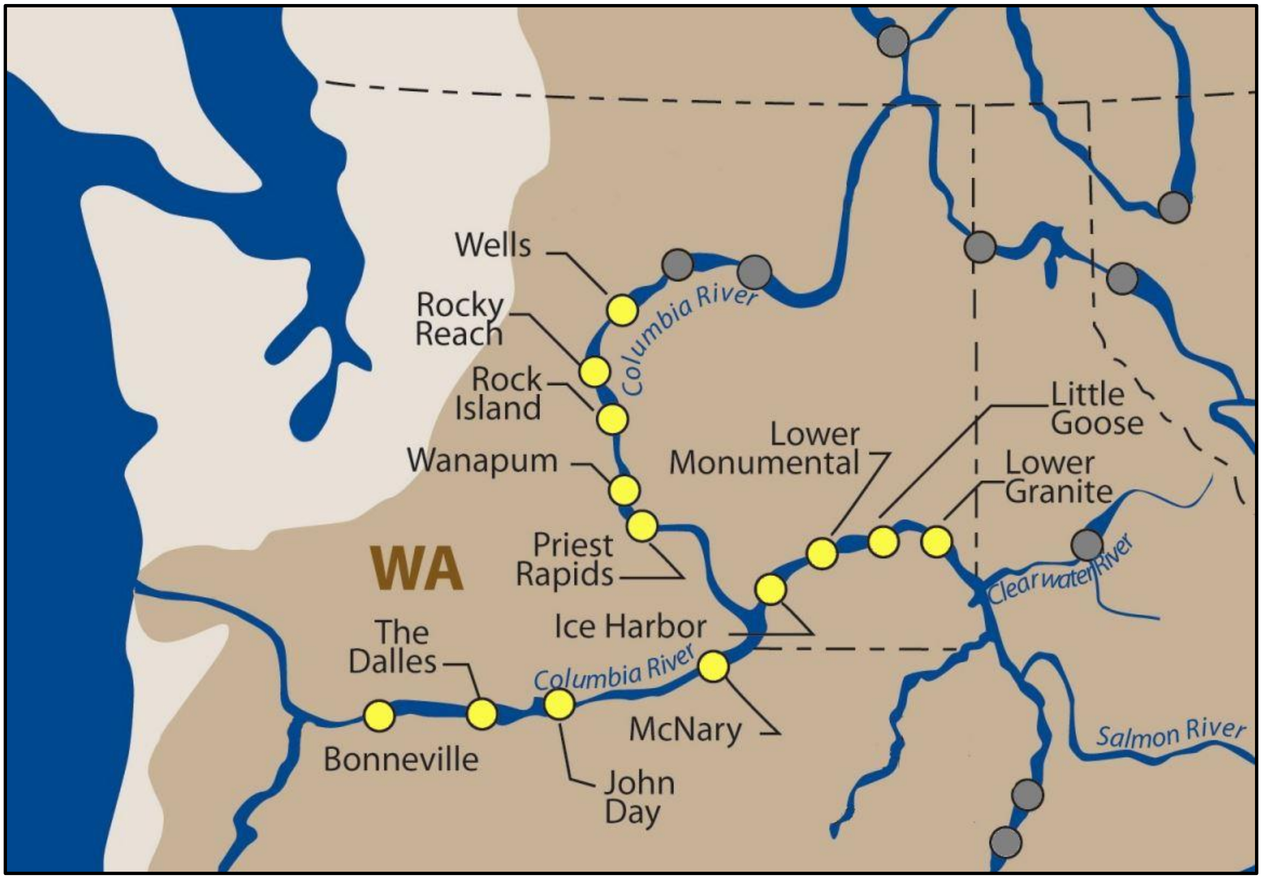

Figure 1. Washington hydropower projects in the Columbia River Basin.

Figure 1 depicts the Snake and Columbia River dams that could apply the adjusted TDG criteria. These include the federal dams; Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles and Bonneville, and the public utility district dams; Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids.

Additional alternatives to the special condition for the TDG standard during the spring spill season in the Snake and Columbia rivers were considered. These alternatives include:

1) No action.

2) **Removal** of the 115% (12-hour average) forebay criterion; while **maintaining** the 120% (12-hour average) tailrace criterion and the 125% (hourly maximum) criterion.

3) **Removal** of the 115% (12-hour average) forebay criterion and 120% (12-hour average) tailrace criterion; while **maintaining** the 125% (hourly maximum) criterion.

4) **Removal** of the 115% (12-hour average) forebay criterion and 120% (12-hour average) tailrace criterion; while **maintaining** the 125% (hourly maximum) criterion. Additionally, this alternative would limit the application of the 125% criterion to be applied approximately 16 hours a day and a return to lower 2014 BiOp spill levels for approximately 8 hours a day. This would be consistent with daily flexible spill operations until June 20, 2021.

Studies have demonstrated that out-migrating juvenile salmonids have higher survival rates in the Snake and Columbia rivers when passed through dams via spillways versus through turbines or smolt bypass systems of hydropower projects (Whitney et al. 1997; Muir et al. 2001). Moreover, some models have predicted that the greater the spill over dams, the greater survival of juvenile salmonids (WA DOE, 2009). However, increased water spillage over dams often leads to increased TDG levels, which can be detrimental to aquatic life. The adjusted TDG criteria seek a balance between impacts of fish passage through hydropower projects and adverse impacts due to supersaturated waters as a result of spill.

The adjustment of the TDG standard is based upon information provided by the Comparative Survival Study juvenile fish passage survival model (CSS model), which predicts improvements in salmon survival and abundance as spill is increased up to those levels that would be permitted by a 125% TDG standard. The CSS model is a joint project of the Fish Passage Center, Columbia River Inter-Tribal Fish Commission, U.S. Fish and Wildlife Service, and the Oregon, Washington, and Idaho departments of fish and wildlife/fish and game. Juvenile survival metrics assessed by the CSS model include water transit time (a surrogate for salmon smolt travel time downriver) and powerhouse encounter rates (with powerhouse defined as dam turbines or bypass systems as opposed to a dam spillway, which avoids the powerhouse). The CSS model considers minimizing powerhouse encounters through measures such as spill or dam removal as critical to reducing “delayed mortality” from hydro system passage and ultimately increasing adult salmon and steelhead returns. The CSS model predicts a two to 2.5-fold increase in Snake River spring Chinook salmon (*Oncorhynchus tshawytscha*) abundance above 2014 FCRPS BiOp spill levels when spill is increased to 125% TDG 24 hours per day/seven days a week in the spring,[2] and smaller projected increase at 120% TDG 24 hours per day.

The relationship between spill and TDG is important in evaluating risk and benefits to aquatic life. The greater amount of spill over dams, the greater the risk of TDG related impacts to aquatic life. The notion of increased spill and increased survival of juvenile salmonids has been proposed and demonstrated in models. However, continuing to increase spill will eventually lead to diminishing benefits, while increased risk of adverse impacts to aquatic life increases with spill due to TDG levels. This EIS considered the risks of increased spill to aquatic life and data gaps in the science regarding TDG impacts and life history traits of aquatic organisms.

Ecology intends to remove the 115% TDG forebay numeric criterion and the 120% tailrace criterion, and to set a 125% tailrace criterion. The 125% tailrace criterion would be calculated as an average of the two highest hourly TDG measures in a calendar day. The 125% tailrace criterion would be applicable at any time during the spring spill season on the Snake and Columbia Rivers. This action coincides with the Spill Agreement that aims to benefit Endangered Species Act listed anadromous fish and hydropower.

Given that dam and salmon managers have not previously provided voluntary (fish passage) spill to 125% TDG, a biological monitoring plan for GBT that includes salmonids and non-salmonids would be required to use the adjusted tailrace criterion of 125%. Hydropower operators on the Snake and Columbia River that do not wish to submit a biological monitoring plan must meet the 115% forebay criterion, 120% tailrace criterion, and 125% maximum TDG level.

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[2] See CSS 2017 Annual Report at xxxi.

Chapter 1: Purpose and Background

In accordance with the Administrative Procedures Act, the Washington State Department of Ecology (Ecology) filed a pre-proposal statement of inquiry, Code Reviser (CR) 101, in May, 2019, to notify the public of its intent to begin rulemaking for the Water Quality Standards for Surface Waters of the State of Washington – Chapter 173-201A WAC.

The CR-101 statement addresses multiple revisions to Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington, which include modifying TDG Criteria to improve fish passage for salmon and steelhead migrating downstream in the Snake and Columbia rivers, meeting legal obligations, aligning shellfish criteria, and clarifying marine use definitions.

The agency decided that it will, in order to provide as much information as possible to aid in decision making, prepare an Environmental Impact Statement (EIS) for parts of this rulemaking process that could have an envrionmental impact.

In July 2019, we filed a CR-102, to notify the public of the proposed rule language modifications to chapter 173-201A WAC. The rule proposal included a draft EIS, which was available for review and comment during the public comment period.

This document is the final EIS. Changes were made to the draft EIS based on public comments that were received as part of ther rulemaking process, however, the comments did not change the draft EIS analyses of the proposed rule language. Responses to comments received on the EIS can be found in the Concise Explanatory Statement that was prepared for this ruleamking, at https://fortress.wa.gov/ecy/publications/summarypages/1910047.html

We intend to adopt the proposed rule changes on December 30, 2019. If adopted, the revised rule becomes effective on January 30, 2019, however the rules cannot be used for Clean Water Act purposes until the Environmental Protection Agency (EPA) approves them.

Amendments to Chapter 173-201A WAC

Ecology considered multiple revisions to Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington (SWQS). The purpose of this final Environmental Impact Statement (EIS) is to evaluate the risks of adjusting the TDG criteria to allow more spill in the Snake and Columbia rivers. The proposed amendment to adjust numeric criteria for TDG is part of a broader rulemaking to update Chapter 173-201A WAC. Besides the TDG proposal, the rulemaking proposed to amend specific sections of the rule to meet legal obligations in a 2018 Stipulated Order of Dismissal and to add clarifying language to the descriptions of marine water aquatic life use designations.

Ecology reviewed each proposed amendment, and determined that the adjustment of TDG to allow more spill in the Snake and Columbia rivers may have significant environmental impacts and warrants an EIS. The other proposed rule changes were determined by Ecology not to have a probable significant adverse impact on the environment. This determination is based on the following findings and conclusions:

- Ecology is making revisions that were agreed to in a 2018 U.S. District Court Stipulated Order of Dismissal (Order) between Northwest Environmental Advocates (NWEA), the U.S. Environmental Protection Agency (EPA), and Ecology. In the Order, Ecology agreed to take action on certain sections of the SWQS by October 2021, including the following revisions:

i. Remove two sub-sections in the fresh and marine water temperature criteria relating to an incremental temperature allowance from nonpoint source activities when the water is cooler than the assigned numeric criterion (WAC 173-201A-200(1)(c)(ii)(B) and WAC 173-201A-210(1)(c)(ii)(B)

Ecology's rationale for nonsignificant impacts: Removing sub-sections in the fresh and marine water temperature criteria relating to an incremental temperature allowance from nonpoint source activities when the water is cooler than the assigned numeric criterion would not cause an environmental impact. These provisions in the standards were intended to allow a rate of warming from human actions up to, but not exceeding, the numeric criteria when the background condition of the water is cooler than the criteria. The provision provides that "Incremental temperature increases resulting from the combined effect of all nonpoint source activities in the waterbody must not, at any time, exceed 2.8 degrees C." If these provisions are removed, there would be no incremental warming allowance for combined effects of nonpoint source activities. These revisions to the temperature criteria would provide greater protections for fish and marine life, and would not cause an increase in discharges to waters of the state.

ii. Amend footnote 'dd' in WAC 173-201A-240(5) Table 240 to clarify that an adjustment of metals criteria (Water Effects Ratio) pursuant to this footnote requires EPA approval pursuant to 33 U.S.C. § 1313(c).

Ecology's rationale for nonsignificant impacts: Amending footnote 'dd' in Table 240 to clarify that an adjustment of metals criteria (Water Effects Ratio) pursuant to this footnote requires EPA approval pursuant to 33 U.S.C. § 1313(c) would not cause an environmental impact. Ecology agreed to amend the footnote in Table 240 to clarify that adjustments to metals criteria requires EPA approval. EPA previously indicated to Ecology that any efforts to revise metals criteria by developing water effects ratios would need to go through a separate rulemaking, which Ecology agreed to. This amendment would codify the agreed-upon intent of this footnote and would not change how the footnote is currently implemented, nor cause an increase in discharges to waters of the state.

- Ecology proposed revisions to the aquatic life use designation descriptions for marine waters (WAC 173-201A-210(1)(a) and WAC 173-201A-610 Table 610). In a 2003 rulemaking to update Washington's Water Quality Standards, the restructuring of aquatic life use designations descriptions resulted in an unintentional change that applied these use designations to cold water fisheries. This clarification would return the descriptions to their original intent and improve the ability for the public to apply the SWQS appropriately.

  Ecology's rationale for nonsignificant impacts: Revisions to the aquatic life use designation descriptions for marine waters would not cause a negative environmental impact to waters of the state. In a 2003 rulemaking to update Washington's Water Quality Standards, the restructuring of aquatic life use designations descriptions resulted in an unintentional change that applied these use designations to cold water fisheries. This error was recently discovered when the City of Everett petitioned Ecology to revise dissolved oxygen criteria for marine waters. The city pointed out the discrepancies in the marine use designation descriptions, and upon review, Ecology agreed that this was an unintended error and that the agency would correct in a future rulemaking. This clarification would return the descriptions to their original intent and improve the ability for the public to apply the SWQS appropriately.

Purpose of the Environmental Impact Statement

The purpose of this EIS is to identify the potential impacts caused by proposed changes to Chapter 173-201A WAC, the Water Quality Standards for Surface Waters of the State of Washington, and to identify and analyze reasonable alternatives. An EIS provides an impartial discussion of significant environmental impacts. It is used to inform decision makers and the public of reasonable alternatives which would avoid or minimize adverse impacts or enhance environmental quality. This EIS is focused on evaluating the risks of adjusting the TDG criteria to allow more spill in the Snake and Columbia rivers.

It is not the purpose of the EIS to address every possible alternative. The EIS is also not specifically designed to meet the requirement of “least burdensome,” which is evaluated in the Preliminary Regulatory Analyses required as part of the Administrative Procedures Act. The rule proposal materials, which includes the Preliminary Regulatory Analyses and other supporting materials, are available on the water quality standards website.

This EIS is for a nonproject activity. Nonproject actions are governmental actions involving decisions on policies, plans or programs that contain standards controlling use or modification of the environment. This includes the adoption or amendment of comprehensive plans, ordinances, rules and regulations at WAC 197-11-704(b).

The purpose of this EIS is to evaluate the risks of adjusting the TDG criteria to allow more spill in the Snake and Columbia rivers. The amendment to adjust numeric criteria for TDG is part of a broader rulemaking to update Chapter 173-201A WAC. Besides the TDG proposal, the rulemaking amends specific sections of the rule to meet legal obligations in a 2018 Stipulated Order of Dismissal, and to add clarifying language to the descriptions of marine water aquatic life use designations. Ecology reviewed each proposed amendment, and determined that the adjustment of TDG to allow more spill in the Snake and Columbia rivers may have environmental impacts and warrants an EIS. The other proposed rule changes were determined by Ecology not to have a probable significant adverse impact on the environment.

Background

Purpose and need of the rulemaking

Water quality standards are the foundation of water pollution control programs under the Clean Water Act (CWA). The standards are required to protect public health and welfare, and identify designated uses (aquatic life, drinking water, recreation, etc.) and the numeric criteria to protect those uses. Water quality standards are used in writing permits, identifying polluted waters, and setting allocations to clean up already polluted waters.

Federal regulatory requirements

Under the federal CWA, all states are required to develop water quality standards that protect the designated uses of the state’s waters. Federal requirements further define what those standards must contain. The state’s water quality standards set limits on pollution in our lakes, rivers and marine waters in order to protect existing and designated beneficial uses, such as swimming and aquatic life. The CWA requires states to review and revise as necessary their water quality standards every three years.

Clean Water Act 303(c)(2) *303(c)(2)* ***Review; revised standards; publication.***

"The Governor of a State or the State water pollution control agency of such State shall from time to time (but at least once each three year period beginning with the date of enactment of the Federal Water Pollution Control Act Amendments of 1972) hold public hearings for the purpose of reviewing applicable water quality standards and, as appropriate, modifying and adopting standards. Results of such review shall be made available to the Administrator.

Whenever the State revises or adopts a new standard, such revised or new standard shall be submitted to the Administrator. Such revised or new water quality standard shall consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses. Such standards shall be such as to protect the public health or welfare, enhance the quality of water and serve the purposes of this Act. Such standards shall be established taking into consideration their use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and also taking into consideration their use and value for navigation."

State regulatory requirements

Water Pollution Control Act

90.48.010 *Policy enunciated.*

It is declared to be the public policy of the state of Washington to maintain the highest possible standards to insure the purity of all waters of the state consistent with public health and public enjoyment thereof, the propagation and protection of wild life, birds, game, fish and other aquatic life, and the industrial development of the state, and to that end require the use of all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the state of Washington. Consistent with this policy, the state of Washington will exercise its powers, as fully and as effectively as possible, to retain and secure high quality for all waters of the state. The state of Washington in recognition of the federal government's interest in the quality of the navigable waters of the United States, of which certain portions thereof are within the jurisdictional limits of this state, proclaims a public policy of working cooperatively with the federal government in a joint effort to extinguish the sources of water quality degradation, while at the same time preserving and vigorously exercising state powers to insure that present and future standards of water quality within the state shall be determined by the citizenry, through and by the efforts of state government, of the state of Washington.

90.48.035 *Rulemaking authority.*

The department shall have the authority to, and shall promulgate, amend, or rescind such rules and regulations as it shall deem necessary to carry out the provisions of this chapter, including but not limited to rules and regulations relating to standards of quality for waters of the state and for substances discharged therein in order to maintain the highest possible standards of all waters of the state in accordance with the public policy as declared in RCW 90.48.010.

90.48.260 *Federal Clean Water Act – Department designated as state agency, authority – Powers, duties and functions.*
The Department of Ecology is hereby designated as the State Water Pollution Control Agency for all purposes of the federal clean water act as it exists on February 4, 1987, and is hereby authorized to participate fully in the programs of the act.

Water Resources Act of 1971

90.54.020 *General declaration of fundamentals for utilization and management of waters of the state.*
(b) Waters of the state shall be of high quality. Regardless of the quality of the waters of the state, all wastes and other materials and substances proposed for entry into said waters shall be provided with all known, available, and reasonable methods of treatment prior to entry. Notwithstanding that standards of quality established for the waters of the state would not be violated, wastes and other materials and substances shall not be allowed to enter such waters which will reduce the existing quality thereof, except in those situations where it is clear that overriding considerations of the public interest will be served.

Framework for federal review and action

All state-adopted water quality standards are required to be submitted to EPA for review and approval (or disapproval). If EPA does not approve state water quality standards, then they are required to promulgate federal water quality standards for states that do not adopt standards.

The following outlines the steps and timing of the federal action:

1. Ecology submits the adopted rule to EPA.
2. EPA reviews the submittal for acceptability under the CWA.
3. EPA has 60 days to approve or 90 days to disapprove the State’s rule.

As part of EPA’s review EPA consults with the U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service to ensure that state water quality standards do not harm threatened and endangered species.

Chapter 2: SEPA Scoping and Comments

The State Environmental Policy (SEPA) Scoping process to evaluate the risks of making the revisions to Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington that were proposed by Ecology. SEPA scoping is the process of soliciting input on a proposal to define the scope of the EIS. Public notice of SEPA scoping was provided via the SEPA Register, Ecology's Water Quality Info ListServ notice, and on our website.

During the scoping period that ran from May 8-May 29 2019, nine public comment letters were received during the 21-day scoping comment period. Public comments were submitted electronically or via postal mail postmarked by May 29, 2019.

All of the scoping comments were specific to the TDG part of our rule amendments. Ecology has determined that adjusting the numeric criteria for total dissolved gas (TDG) to allow more spill in the Snake and Columbia rivers may have an impact on the environment. The other proposed rule changes were determined not have a probable adverse impact on the environment.

The comments received during the scoping process were considered as the agency identified significant issues, noted elements of the environment that could be affected, developed alternatives, and prepared the draft environmental documents.

All scoping comments are provided, in full, in Appendix A.

Chapter 3: Affected Environment, Potential Impacts, and Mitigation Measures

Affected Environment

The Columbia River and its tributaries are one of the most productive salmon producing river systems in the world. However, over the last 150 years or so, salmon and steelhead runs that once numbered from 10-16 million per year have generally declined to 1-2 million per year[3], a value that includes a combination of natural and hatchery origin fish. Today, thirteen populations of Columbia Basin salmon and steelhead are listed as threatened or endangered under theEndangered Species Act (ESA).[4]

A number of factors have contributed to the decline, including dams, which block or impede access to and from upriver habitat and result in injuries to juvenile salmonid migrants, habitat degradation from development and resource extraction, harvest and hatchery impacts, pollution, and predation due to ecosystem alterations and introduction of non-native species.

The decline of salmon and steelhead in the Columbia Basin has had numerous economic and cultural impacts, including to Native American Tribes and non-tribal commercial and recreational fishers. But even today, commercial and sport-fishing on Columbia Basin fish (primarily based on, but not limited to, salmon and steelhead fishing) is worth $150 million per year.[5]

Meanwhile, hydropower produced by Columbia Basin dams (including many more dams than the eight dams affected by the decision under consideration in this EIS), is worth in excess of $3 billion per year.[6] Spill to benefit salmon and steelhead at the eight federal dams on the lower Snake and Columbia rivers can cost the Bonneville Power Administration (BPA) tens or hundreds of millions of dollars, depending on the water year and market conditions.[7] The changes in spill included in the Flexible Spill Agreement (herein referred to as Spill Agreement) are designed to be revenue neutral or positive for BPA relative to 2018 court-ordered spill operations (see Flexible Spill Agreement section), despite increases in spill during much of the day.

Flexible Spill Agreement

The Spill Agreement for 2019-2021 spill operations at the eight federal dams on the lower Snake and Columbia rivers was formally announced on December 18, 2018, and signed by the states of Washington and Oregon, the Nez Perce Tribe, the Bonneville Power Administration, U.S. Army Corps of Engineers, and the Bureau of Reclamation. The Spill Agreement is supported by the states of Idaho and Montana and the Columbia River Inter-Tribal Fish Commission.

The focus and intent of the Spill Agreement is to further improve juvenile salmon and steelhead survival rates as they travel downriver through the eight federal dams on the lower Snake and Columbia rivers by reducing passage through powerhouses. The Spill Agreement seeks benefits to salmonid survival in

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[3] https://www.nwcouncil.org/reports/columbia-river-history/salmonandsteelhead
[4] https://www.nwcouncil.org/reports/columbia-river-history/endangeredspeciesact
[5] The Value of Natural Capital in the Columbia River Basin: A Comprehensive Analysis, Earth Economics, 2017 at p. 71. https://ucut.org/wp-content/uploads/2017/12/ValueNaturalCapitalColumbiaRiverBasinDec2017.pdf
[6] Id., at p. 54.
[7] See, e.g., 2016 Columbia River Basin Fish and Wildlife Program Costs Report, https://www.nwcouncil.org/sites/default/files/2017-2.pdf

concert with managing the Columbia River system for multiple congressionally authorized purposes, including power generation to ensure the Pacific Northwest of an adequate, efficient, economical, and reliable power supply. The Spill Agreement also intends to provide a pause in long-running litigation over the impact of the operations and maintenance of the federal dams on ESA-listed salmon and steelhead, at least until the Columbia River System Operations National Environmental Policy Act process is complete and a new long-term biological opinion (BiOp) for the Federal Columbia River Power System (FCRPS) is released by the National Marine Fisheries Service.

The Spill Agreement is contingent on the implementation of a flexible spill operation that increases spill beyond the levels ordered by a federal court for the 2018 salmon migration season at the times of day when regional energy demand is lower, and reduces spill during times of peak energy demand (generally early morning and late afternoon/evening) and highest energy market values. Recent trends suggest that such flexibility may become more valuable to energy marketers as solar energy continues to be deployed in California and elsewhere in the western U.S. The “duck curve” energy demand graph below illustrates the times of day with higher and lower energy demand across the western U.S.

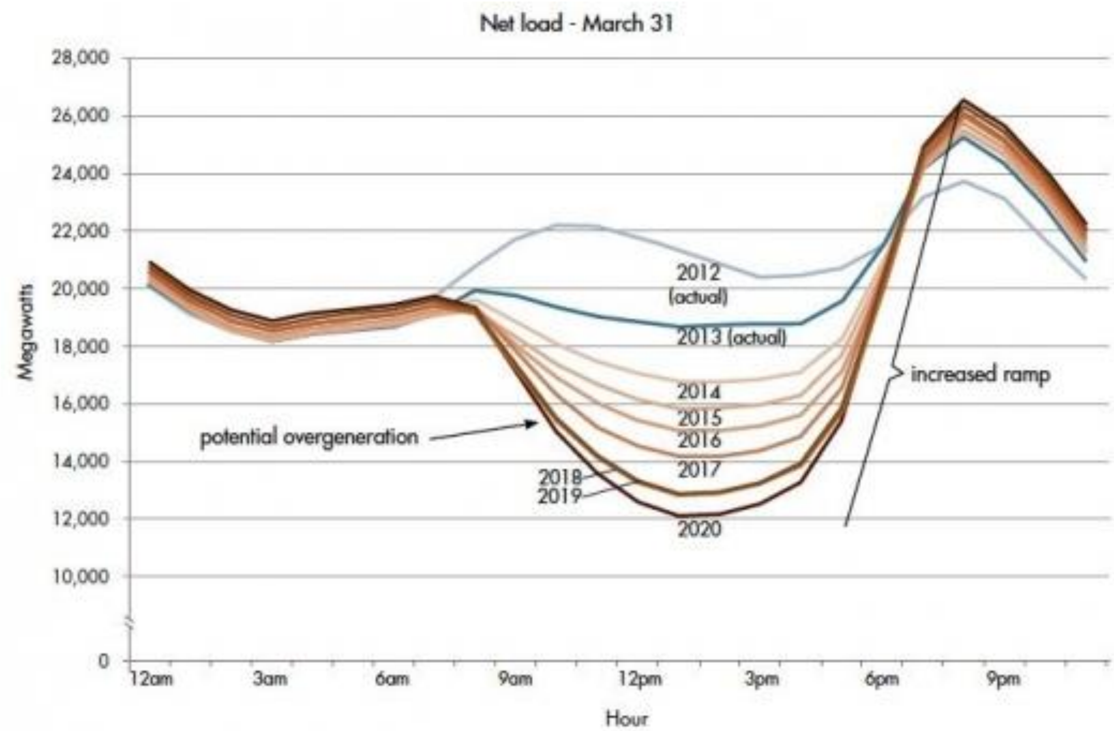

Figure 2. Duck curve energy demand over the course of a day for the western U.S., courtesy of the California Independent System Operator (CAISO).

Figure 2 shows the fluctuations in energy demand (actual and predicted data for 2012 to 2020) throughout the course of the day in the western United States. The energy curves resemble the shape of a duck and therefore has been labeled a duck curve.

Technical analysis conducted by state and tribal fisheries managers concludes that the spill operations outlined in the Spill Agreement will roughly equal (in 2019) or exceed (in 2020 and 2021) fish survival rates obtained through 2018 court-ordered spill operations, which required spill to existing TDG standards of 115% TDG as measured in dam forebays and 120% TDG as measured in dam tailraces on the lower Snake and Columbia rivers[8]. At the same time, the Spill Agreement spill operations are designed to maintain or improve power generation revenue relative to 2018 operations.

The Spill Agreement implementation for 2019 is contingent on Washington, through the process described in this document, raising TDG standards on the lower Snake and Columbia rivers to match Oregon's 120% standard as measured in the dam tailrace for the 2019 salmon migration season. In March 2019, Washington administered a short-term modification that removed the 115% forebay criterion in the lower eight federal Snake and Columbia River dams to meet the objectives of the Spill Agreement. For the 2020 and 2021 migration season, the Spill Agreement is contingent on both Washington and Oregon raising TDG standards to 125%.

Water Quality Standards

Under Section 303(c) of the CWA and federal implementing regulations at 40 CFR § 131.4, states and authorized tribes have the primary responsibility for reviewing, establishing, and revising water quality standards, which consist primarily of the designated uses of a waterbody or waterbody segment, the water quality criteria that protect those designated uses, and an antidegradation policy to protect high quality waters.

EPA has compiled a list of nationally recommended water quality criteria for the protection of aquatic life and human health in surface waters. These criteria are published pursuant to Section 304(a) of the CWA and provide guidance for states and tribes to establish water quality standards and provide the foundation for controlling the release of pollutants and identifying impaired waters. The state water quality standards are federally approved by EPA and describe the level of protection for Waters of the State.

The states of Washington and Oregon have both adopted water quality standards that limit TDG to 110% relative to atmospheric pressure. These water quality standards were placed into state rules based on the Federal EPA recommendations.

Total Dissolved Gas Criteria and Aquatic Life Uses

Studies have demonstrated that out-migrating juvenile salmonids have higher survival rates in the Snake and Columbia rivers when passed through dams via spillways versus through turbines or smolt bypass systems of hydropower projects (Whitney et al. 1997; Muir et al. 2001). Moreover, some models have predicted that further increasing spill levels up to a certain point will result in greater survival of juvenile salmonids. However, increased water spillage over dams often leads to increased TDG levels, which can be detrimental to aquatic life.

Since the 1990's both states have accommodated levels of TDG above 110% for fish passage spill operations for ESA-listed juvenile salmonids at the Corps' projects on the lower Snake and Columbia rivers. During spill operations for fish passage, the states of Washington and Oregon have authorized exceptions to the 110% TDG criteria for the four lower Snake River (WA) and four lower Columbia River projects (WA and OR).

The allowance of TDG levels higher than the 110% water quality criterion seeks a balance between impacts of fish passage through hydropower projects and impacts due to supersaturated waters as a result of spill.

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[8] https://www.bpa.gov/efw/FishWildlife/SpillOperationAgreement/doc/ECF-2298_Spill-Notice-and-Agreement.pdf

Current Washington Criteria Adjustment

Chapter 173-201A-200(1)(f) WAC provides the maximum TDG criteria for the protection of aquatic life. Table 200 (1)(f) that states: "Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection." The criteria also address exceptions and adjustments, including a provision allowing for an adjustment of the TDG criteria to aid fish passage over hydroelectric dams when consistent with an approved gas abatement plan. The gas abatement plan must be accompanied by fisheries management and physical and biological monitoring plans.

Chapter 173-201A-200(1)(f)(ii) WAC provides the following adjusted criteria to aid spill for fish passage.

- TDG must not exceed an average of 115% as measured in the forebays of the next downstream dams and must not exceed an average of 120% as measured in the tailraces of each dam (these averages are measured as an average of the 12 highest consecutive hourly readings in any one day, relative to atmospheric pressure); and
- A maximum TDG one hour average of 125% must not be exceeded during spillage for fish passage.

Current requirements for approval to apply the adjusted criteria

- This adjustment may be used when consistent with an approved gas abatement plan.
- The gas abatement plan must be accompanied by fisheries management and physical and biological monitoring plans.

In 2009 Ecology and the Oregon Department of Environmental Quality (ODEQ) issued a joint paper to evaluate the 115% TDG compliance which both states required at that time through their respective adjustment and modification procedures. At that time Ecology determined that there would be a potential for a small benefit to salmon related to fish spill if the 115% forebay criterion was eliminated, but there would also be the potential for a small increase in GBT from elevated TDG levels. Ecology also recognized that there would be additional administrative procedure requirements because the 115% requirement was adopted as a water quality standard. By contrast Oregon periodically renews the modification to the TDG criteria to aid for fish passage, however, the TDG threshold is not stated in the ODEQ water quality standards. The result of the evaluation was different for each state. Ecology maintained the 115% forebay requirement for the four lower Snake River dams and the four lower Columbia River dams. Oregon decided to eliminate the 115% forebay requirement for the four lower Columbia River dams based on a determination that the action would not cause excessive harm to the beneficial uses or aquatic species in the river during the spring spill season. All future TDG modifications approvals have been written without the 115% forebay requirement. Oregon's action did not change the spill operations of the dams because the U.S. Army Corps of Engineers operates voluntary (fish passage) spill operations to meet the more stringent Washington State criteria.

The following describes the current Oregon modified TDG criteria requirements.

Current Oregon Standard Modification

Chapter 340-041-0031 Oregon Administrative Rules (OAR) provides that;

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

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

Requirements for approval of the modified criteria

- Determination that the failure to allow higher spill would result in greater harm to salmon survival through in-river migration than would occur by increased spill.
- Increased spill would provide a reasonable balance of the risk of impairment due to elevated TDG to both resident biological communities and other migrating fish and to migrating adult and juvenile salmonids when compared to other options for in-river migration of salmon.
- Monitoring is sufficient to determine compliance.
- Biological monitoring occurs to document that the migratory salmonid and resident biological communities are being protected.

Compliance of both states' TDG criteria is measured at TDG fixed monitoring stations in the forebay and tailrace of each of the dams which are managed by the U.S. Army Corps of Engineers and U.S. Geological Survey.

Application of the Adjusted TDG Criteria

In accordance with Chapter 173-201A-200(1)(f)(ii) WAC, Ecology periodically issues an approval of the U.S. Army Corps of Engineers' Gas Abatement Plan. This approval acknowledges the operation and structural actions the FCRPS takes to minimize TDG and allows the federal dams that voluntarily spill to aid fish migration to exceed the 110% TDG criterion. Ecology issued a new gas abatement plan approval in January 2019 that allows the use of adjusted criteria for the 2019, 2020, and 2021 spring spill seasons.

A short-term modification of the TDG criteria was completed in March 2019 and issued to the Corps for the 2019, 2020, and 2021 spill seasons. The conditions of the short-term modification modified the current TDG adjusted criteria in the water quality standards by removing the 115% forebay criterion and changing the 120% tailrace criterion and 125% maximum criterion averaging periods. The January 2019 gas abatement plan approval notes that the Corps is allowed to spill to the current TDG criteria as well as to any forthcoming modification to the adjusted criteria. The modification to the TDG criteria in the Snake and Columbia rivers may be achieved through the use of the short-term modification process or through a subsequent rulemaking to change the adjusted TDG criteria thresholds in the water quality standards.

Summary of Objectives

The objectives of the rulemaking is to allow hydropower facilities on the Snake and Columbia river system the option to adjust the TDG criteria to only include a 125% tailrace criterion. The objective of allowing this TDG adjustment is based on:

1) The potential increase in smolt-to-adult returns (SARs) for salmonids by allowing more spill over dams for fish passage,
2) Meeting the Spill Agreement goals to increase fish benefits,
3) Developing consistent TDG criteria in the Snake and Columbia rivers between the States of Washington and Oregon, and

4) Attainment of the Orca Task Force Recommendation aimed at improving the abundance of prey (i.e. Chinook salmon) for Orca by allowing more water spill over dams.

Rule change for Increased Spill

Increased spill has been proposed and demonstrated in models to increase the survival of juvenile salmonids out-migrating to marine waters. However, because of the greater TDG related risk to aquatic life, it is expected that continuing to increase spill beyond a certain threshold would eventually lead to diminished benefits for salmonids. The increased benefits of spill to salmonids should be weighed against the risk of adverse impacts of increased TDG levels that may accompany greater amounts of spill.

Ecology intends to remove the 115% forebay criterion and the 120% tailrace criterion, and to set a 125% tailrace criterion calculated as an average of the two highest hourly TDG measures in a calendar day. This action coincides with the Spill Agreement that aims to benefit salmon and hydropower.

Given that dam and salmon managers have not previously provided fish passage spill to 125% TDG due to the potential for higher TDG levels to increase symptoms of GBT in juvenile salmon, steelhead, and non-listed aquatic species; monitoring for GBT would continue to be required.

The Regional Debate

Since the 1990s, a significant strand of the regional debate over “dams vs. salmon” has included the best level of spill over dams on the Snake and Columbia rivers. Questions have involved how much spill benefits salmon migration past the dams and adult returns, especially when factoring in impacts from elevated TDG levels; uncertainty about the effects of higher levels of spill on aquatic life in the river other than salmonids; and concerns about the value of “foregone” power revenue from spill given impacts to electricity ratepayers and/or other potential fish and wildlife investments. In general, conservation and fishing organizations have supported increasing spill, while utility and ratepayer interests have opposed it. **This EIS is not related to any dam breaching proposals that the Washington State Orca Task Force recommended to Governor Inslee.**

Spill Operations

Existing Spill Conditions

The Snake and Columbia rivers hydrology is heavily modified by the presence of hydropower projects that provide energy for the State. The hydropower projects within the Snake and Columbia river system have been designed for upstream anadromous fish passage. However, operations of the hydropower projects is a tightly regulated process. Reservoirs in the forebay of dams are regulated to endure fluctuations in water levels that account for other hydropower operations, climatic shifts, and hydrological changes.

During the spring season, large amounts of runoff from melting snowpack leads to vast inputs of water into the Snake and Columbia river tributaries and leads to high flows within the Snake and Columbia river system, better known as the spring freshet. When hydropower operations cannot pass all of the incoming water through turbines and cannot store water, water is spilled involuntarily over dams through spill gates. The spring spill season typically begins on April 3rd in the lower Snake River and April 10th in the lower Columbia River, and ends on June 15th in the Columbia River and June 20th in the Snake River. Voluntary spill is used to pass out-migrating salmonids downstream though spillways to estuarine and marine waters. Involuntary spill also occurs during the spring freshet depending on snowpack to manage the incoming water at hydropower projects.

In 2008 National Oceanic and Atmospheric Administration (NOAA) issued a 10-year BiOp for the FCRPS that recommended a reasonable and prudent alternative (RPA) sufficient to avoid impacts for 13 species of salmon and steelhead affected by FCRPS operation. The 2008 FCRPS BiOp describes 10-year operations and configuration plans for FCRPS facilities as well as main stem effects for other hydro projects on Columbia River tributaries. The FCRPS actions include additional habitat, hatchery management, predation management, and harvest actions to mitigate for adverse effects of the hydro system. The adaptive management implementation plan for the 2008 BiOp, released in 2009, includes accelerated and enhanced action to protect species, enhanced research and monitoring to improve certainty of information, specific biological triggers for contingencies linked to declining abundances of listed fish, contingency actions to improve fish survival, and regional collaboration and independent scientific review to provide ongoing scientific input and actions to support and inform adaptive management decisions.

In 2010 a supplemental FCRPS BiOp was released that summarized and assessed relevant new information and resulted in six new actions to identify and protect against uncertainties associated with climate change, toxics, invasive species, and hatchery fish.

In 2014, a supplemental FCRPS BiOp was released that examined the updated science and data in regards to the biological status of the listed species. The 2014 BiOp concluded that the RPAs are sufficient so as to not jeopardize the continued existence of 13 listed species or modify critical habitat and that additional mitigation actions are not necessary to satisfy the requirements of ESA.

The FCRPS BiOps from 2001 to 2014 have been invalidated in courts. In 2018, a U.S. District Court order mandated hydropower projects to spill water to the 120% tailrace or the 115% forebay gas caps, depending on which was more limiting. The 2018 mandate sought to increase spill for the benefit of fish passage for endangered salmon and steelhead. The Flexible Spill Agreement signed in late 2018 has resulted in a pause in litigation and will conclude in 2021.

NOAA recently issued a 2019 FCRPS BiOp that incorporated operations described in the Flexible Spill Agreement. The 2019 FCRPS BiOp considered the effects of the proposed operations and maintenance on ESA-listed salmon and steelhead. NOAA fisheries concluded that the effects of the actions related to the Flexible Spill Agreement are not likely to jeopardize ESA listed species or adversely impact their habitat.

Additional Spill for Fish Passage

Threatened Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) returns increased from very low population levels in the 1990s during the 2000s and early 2010s, but more recently have declined. According to the Comparative Survival Study's 2017 annual report, SARs, a key indicator for the abundance and growth trend in these salmonid stocks, remain below the 2-6% SARs (with a 4% average) necessary for recovery according to the NW Power and Conservation Council's 2014 Fish and Wildlife Plan.[9]

Current SARs for Snake River spring/summer Chinook salmon have been 1.1 since 2000.[10] The CSS has modeled expected changes to SARs from spilling to BiOp standards, 115% forebay/120% tailrace, 120%

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[9] NW Power and Conservation Council 2014 Fish and Wildlife Program at p. 157. See https://www.nwcouncil.org/sites/default/files/2014-12_1.pdf

[10] CSS 2017 Annual Report – p. 102. http://www.fpc.org/documents/CSS/2017%20CSS%20Annual%20Report%20ver1-1.pdf

tailrace-only, and 125%. All spill regimes modeled by the CSS are 24 hours, seven days per week. When spill is increased to 125% TDG 24 hours per day/seven days a week in the spring, the CSS predicts a two to 2.5-fold increase in Snake River spring chinook salmon abundance above the levels resulting from 2014 FCRPS BiOp spill levels,[11] and smaller projected increase when spilling to existing gas standards or 120% TDG 24 hours per day. Steelhead SARs are also predicted to increase significantly, but less dramatically than Chinook salmon.

2019 spill operations under the Spill Agreement are predicted to provide a small improvement in survival and SARs compared to the 2018 court-ordered spill operations to spill to existing gas caps.[12] This is based on a projection that 2019 Spill Agreement operations will result in a reduction in smolts' "powerhouse encounter rate," or the number of dam powerhouses (defined as turbines or bypass systems) a smolt encounters while migrating down river. Spillway passage allows smolts to avoid powerhouses.

2018 operations result in an average of 1.76 dam powerhouses encountered by each smolt, while 2019 Spill Agreement operations will result in an estimated 1.73 powerhouse encounters. That compares to 2.98 powerhouse encounters under 2014 FCRPS BiOp operations, and 1.4 to 1.5 powerhouse encounters expected under the operations anticipated in 2020-2021 under the Spill Agreement.

Total Dissolved Gas in Aquatic Systems

Total Dissolved Gas and Hydropower

Total dissolved gas is the summation of the partial pressures of individual gases in solution. The gas content in water bodies is a function of the partitioning of gases between the atmosphere and hydrosphere. The atmosphere is composed primarily of nitrogen (78%) and oxygen (21%). These two elements, with minor contributions of carbon dioxide, comprise the components of TDG measured in water. When gases in the atmosphere and water are in equilibrium, TDG pressure is 100%. Natural processes can deplete gas content in water, for example, oxygen consumption from respiring aquatic organisms (<100% TDG), while other natural processes such as waterfalls can supersaturate gases in water (>100% TDG).

The entrainment of gases in water from the plunging of highly aerated spill water can trap air in water, forming bubbles, facilitating the dissolution of gases into water. The solubility of gases is a function of temperature, atmospheric pressure, and hydrostatic pressure. The solubility of gases increases with water depth due to greater hydrostatic pressure, thus the deeper the plunge of water, the greater dissolution of gases. The portion of gases not dissolved beneath the water will rise to the surface. This degasification process occurs as a result of the lower density of gases compared to water. Degasification occurs in the aeration zone, where gases are removed from the water column. The expanse of the aeration zone can vary depending on bathymetry of the river, climate, water plunge depth, and dam structure. In the area below the aeration zone, gases can remain in the water column due to hydrostatic pressure, resulting in persistently high TDG concentrations.

Hydropower dams can alter the dynamics of gas exchange between the atmosphere and hydrosphere. Dams impede the passage of water, often creating reservoirs. Within these reservoirs, water is diverted through turbines through hydrostatic pressure. When the incoming flow exceeds the capacity of the

[11] See CSS 2017 Annual Report at xxxi.

[12] Juvenile Chinook salmon PITPH Index estimates based on Comparative Survival Study methods (McCann et al. 2015; McCann et al. 2016; McCann et al. 2017) and https://nptfisheries.shinyapps.io/pitph2/ web application tool.

turbine to pass water, the reservoir can exceed its capacity and the hydropower dam must spill water through gates built into the dam. Spill can result from storm events or operational spill. Operational spills occur when the ability to pass water through the turbine is limited or lack of market when power demand is low. When dams spill, water is released near the top of the reservoir, falling large vertical distances. These dam spill events are similar to supersaturation that occurs at the base of waterfalls. In most natural waterfall settings the impact of TDG is limited in distance downstream of the waterfall as the river naturally degasses in shallower waters downstream. While the nature of spills at dams can vary depending on their structure, gas entrainment can contribute significantly to TDG in the water system. These supersaturated waters can travel long distances downstream in the deeper reservoir of the next downstream dam. This duration and large area of high TDG conditions in reservoirs has the potential to cause health impairments to aquatic life.

Aquatic Life Hydrostatic Depth Compensation

Total dissolved gas is measured in percent saturation. Percent saturation measures the amount of air that water will hold in equilibrium with the atmosphere at the total pressure present at the water's surface. At the water's surface, atmospheric pressure is the only variable influencing pressure in the water. At increasing depths, both hydrostatic and atmospheric pressure contribute to the equilibrium state of gases in water. The result is increased capacity of water to dissolve gases at greater depths. Thus, aquatic life at depths experience different TDG levels than aquatic life near surface waters. The compensation rate is about 10% of saturation per meter of depth (Weitkamp et al. 2008). For example, a fish swimming at a depth of 2 meters when surface water TDG levels are 120% would experience a saturation level of 100%, while a fish at the surface would experience 120% TDG. Vertical movement of aquatic life within the water column is therefore an important consideration when evaluating risks related to TDG. The figure below by Weitkamp et al. (2008) depicts the concept of hydrostatic depth compensation.

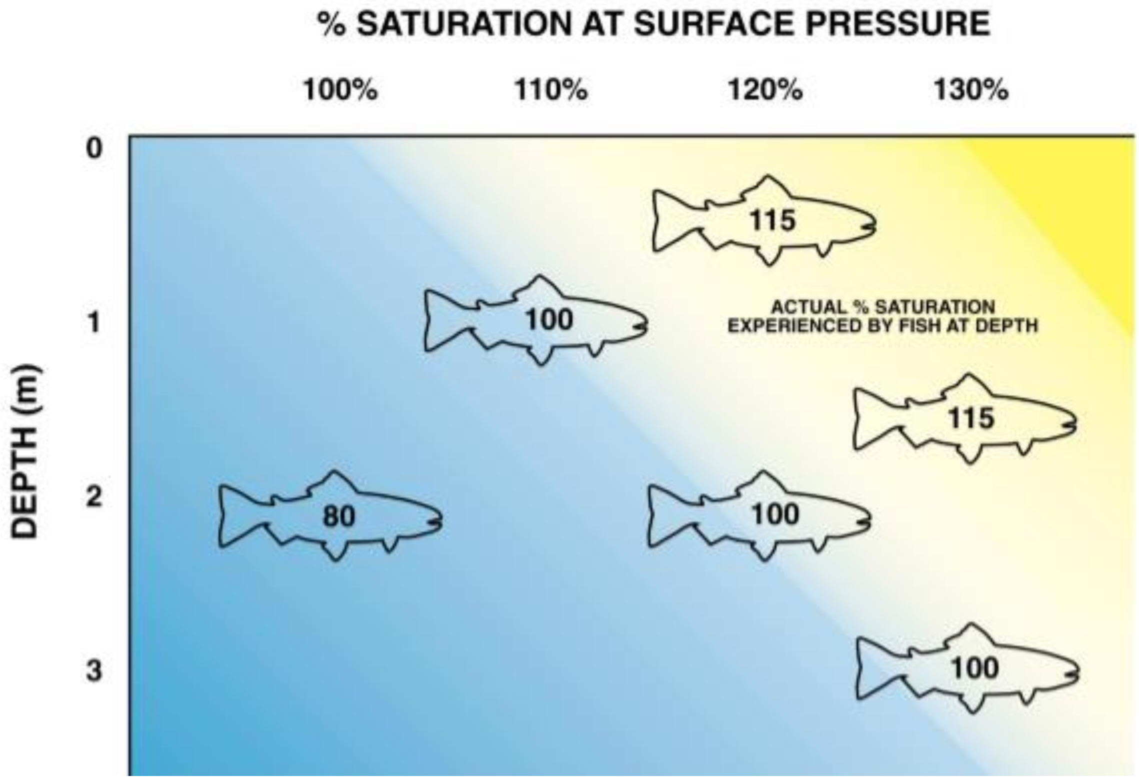

Figure 3. Relationship of measured and actual total dissolved gas levels.

Figure 3 shows the relationship of measured and actual total dissolved gas levels experienced by fish at various depths in the river (from Weitkamp et al. 2003a).

Total Dissolved Gas Studies: Laboratory versus Field

Salmonids are often the focal point for impacts of TDG levels in the Snake and Columbia rivers, however, resident fish and aquatic invertebrates should be considered when determining adverse impacts of TDG. When evaluating effects of TDG levels on aquatic organisms, hydrostatic depth compensation should be evaluated. A major criticism of several laboratory studies is the water depth in which studies are conducted. Shallow laboratory studies don't account for depth compensation that is often afforded in deep aquatic systems. Given that some laboratory studies do not allow for hydrostatic depth compensation, effects may be exacerbated compared with field conditions. However, laboratory studies are useful for determining effect levels for different species under controlled conditions. Effect levels determined in laboratory studies can be applied to field conditions to determine if ambient water conditions may be detrimental to particular aquatic species. Field studies represent more realistic exposure scenarios but results are often associated with high data variability, confounding stressors, and uncertainties in study design. Furthermore, little is known about aquatic organism's actual TDG exposures while navigating through aquatic systems. Both laboratory and field studies will be used in this review but limitations of both study types should be noted.

Potential Impacts

Potential Positive Impacts of Increased Spill

Scientific support for increased spill has come primarily from the Comparative Survival Study, a joint project of the Fish Passage Center, Columbia River Inter-Tribal Fish Commission, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and the U.S. Fish and Wildlife Service. The CSS model predicts steady improvements in juvenile survival and adult returns as spring spill (April 4 through June 20) increases up to at least 125% TDG. Several studies support the information and conclusions of the CSS model (Schaller and Petrosky, 2007; Petrosky and Schaller, 2010; Haesecker et al. 2012; Schaller et al. 2013).

NOAA Fisheries' COMPASS model is less optimistic about the benefits of additional spring spill compared with the CSS model. This may largely be attributed to the assumption of latent or delayed mortality due to powerhouse (i.e., non-spillway) passage routes in the COMPASS model and different conclusions about the relative benefit of fish transportation as an alternative to spill.[13]

The Northwest Power and Conservation Council's Independent Scientific Advisory Board (ISAB) has weighed in on the spill debate at numerous points, critiquing and posing questions of both the CSS and COMPASS models.

The ISAB has not directly compared CSS and COMPASS, but in 2018 reviewed the NOAA Fisheries document A Power Analysis of Two Alternative Experimental Designs to Evaluate a Test of Increased Spill at Snake and Columbia River dams, Using SARs of Anadromous Salmonids (January 2018 draft). As the ISAB noted, the NOAA analysis "considers two general experimental designs: (1) a before/after design for which there is no variation of spill levels during prospective years and (2) a block design that includes variations between two spill levels during prospective years."[14]

The Spill Agreement described in this document is a version of experimental design (1) above, while NOAA Fisheries was exploring design (2) at the time of the ISAB review. The ISAB review found advantages and disadvantages to NOAA's "block spill design," noting that the "key advantage to the block design is that high year-to-year variation is controlled for by conducting both spill regimes in the same year." At the same time, the ISAB noted that "the advantages [of the block spill design] are somewhat tempered because of several sampling and estimation issues," and that "while a theoretical implementation (i.e., NOAA's block spill paper) may show high statistical power, and implementation may have less power"[15] ISAB also noted that there was a "[n]eed to acknowledge the consequences of the [block design] experiment on migrant survival compared to full spill for entire seasons at 115/120% or 125% spill," noting that "[i]f survival is lower at lower spill rates, the survival that results from the experiment will be lower for ten years than it would have been with the higher spill throughout the entire spill season each year."[16]

In summary, ISAB seems to find value in both the CSS and COMPASS models, and has generally acknowledged that proponents of each model and of different spill tests have merit. The lack of a

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[13] See, e.g., Issue Summaries of the 2008 FCRPS Biological Opinion, NOAA Fisheries, at pp. 5-7. https://www.westcoast.fisheries.noaa.gov/publications/hydropower/fcrps/2008fcrps_issuesummaries.pdf

[14] Review of NOAA Fisheries document: *A Power Analysis of Two Alternative Experimental Designs to Evaluate a Test of Increased Spill at Snake and Columbia River Dams, Using Smolt-to-Adult Returns of Anadromous Salmonids (January 2018 draft)*, at p. 1. See https://www.nwcouncil.org/sites/default/files/isab-2018-2-noaa_spillstatisticalpoweranalysis19march.pdf

[15] Id., at p. 1.

[16] Id., at p. 8.

definitive opinion from the ISAB created an opportunity to increase spring spill to benefit salmon while also providing options for increased power generation when power demand and corresponding power revenue is the highest.

Model Predictions for Salmonid and Steelhead Survival

CSS Model

The CSS model predicts improvements in salmon survival and abundance as spring spill is increased up to those levels that would be permitted by a 125% TDG standard. Juvenile survival metrics assessed by the CSS include water transit time (a surrogate for salmon smolt travel time downriver) and powerhouse encounter rates (with powerhouse defined as dam turbines or bypass systems as opposed to a dam spillway, which avoids the powerhouse). An analysis of instantaneous mortality of juvenile fish migrating downstream, found that mortality tends to be lower when there is lower powerhouse passage (McCann et al. 2018). The CSS model considers minimizing powerhouse encounters through measures such as spill or dam removal as critical to reducing "delayed mortality" from hydro system passage and ultimately increasing adult salmon and steelhead returns.

The CSS model predicts a two to 2.5-fold increase in Snake River spring Chinook salmon abundance above 2014 FCRPS BiOp spill levels when spill is increased to 125% TDG 24 hours per day/seven days a week in the spring[17] and a smaller projected increase at 120% TDG 24 hours per day. Potential indirect effects of increasing spill, although not quantified, include reduced predation of out-migrating juvenile salmonid in reservoirs from faster migration travel time and reduced holding times and water temperature.[18]

In order to provide revenue neutrality or better for hydropower production and associated revenue, the Spill Agreement calls for spilling to 120% TDG in the spring of 2019 for sixteen hours a day, and spilling to lower "performance" spill levels eight hours per day.[19] The CSS model predicts that this operation would slightly benefit salmon relative to 2018 injunction operations (spill to existing gas caps 24 hours a day/seven days a week), while BPA predicts that it would provide similar power revenue. The 2019 operations would be an incremental step toward a flexible spill operation that would be expanded in 2020 to include flexible spill (i.e. approximately 16 hours of higher spill and 8 hours of "performance" spill, depending on the hydropower project) to 125% TDG.[20] Flexible spill operations to 125% TDG are predicted by CSS model to benefit juvenile fish survival and adult returns relative to both 2018 court-ordered operations and proposed 2019 flex spill operations to 120%, but not as much as would be predicted for full-time spill to 125% TDG during the spring spill season.

COMPASS Model

The COMPASS model is less optimistic than the CSS model regarding benefits of increased spill and has not been reviewed by the Independent Scientific Advisory Board (ISAB). COMPASS model results for flexible spill operations are outlined in the 2019 FCRPS BiOp. Generally, the COMPASS model predicts that increased spill levels resulting from flexible spill operations up to 120% TDG will reduce average

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[17] See CSS 2017 Annual Report at xxxi.

[18] Effects of in-river environment on Juvenile Travel Time based on Comparative Survival Study (CSS) methods (McCann et al. 2015; McCann et al. 2016; McCann et al. 2017)

[19] See Agreement, Table 1.1, at p. 17.

[20] The Agreement calls for further refinement of proposed 2020 operations. See Agreement at pp. 5-6 and Tables 1.3.a and 1.3.b, at p. 19.

travel times for juvenile salmon and steelhead, increase average survival, and increase the number of spill passage events. The degree of benefit for each one of these estimates varies significantly based on the species and location.

Analysis of the gas cap flexible spill operation up to 125 percent indicated there is little difference between this operation and the estimates for the gas cap flexible spill operation up to 120 percent, assuming direct survival improvements only, or 10, 25, and 50 percent improvements in productivity that could result from increased spill (2019 FCRPS BiOp).

Potential for Negative Impacts of Total Dissolved Gas

Salmonids

Early Development

Salmonid spawning in the main-stem Snake and Columbia rivers is limited to particular areas due to the lack of suitable habitat and thus, many adults spawn in tributaries of the two rivers and may not be impacted. Dauble and Geist (2000) reported the majority of spawning is concentrated in the Hanford Reach and Hells Canyon reach of the Snake and Columbia rivers. Since the development of hydropower, the fall Chinook salmon habitat has been reduced to 13% and 20% of the historical habitat in the main-stem Snake and Columbia rivers, respectively (Dauble et al. 2003). Chinook salmon are known to spawn in the Hanford reach of the Columbia River, below the Bonneville Dam (Van der Naald et al. 2001), above the mouth of the Snake River and in the Snake and Clearwater rivers above the Lower Granite reservoir.

Tracking early development of salmonids in the natural environment presents several difficulties including the long incubation period (>30 days), monitoring logistics, fluctuating ambient water conditions, and detecting and following egg development. Field studies examining early developmental stages of salmonids are limited in the Snake and Columbia rivers. In one of the first comprehensive studies examining TDG, Meekin and Allen (1974), found that eyed Chinook salmon eggs successfully hatched at 122% TDG, while steelhead eggs experienced mortality at 122%, suggesting sensitivity differences in developing embryos between salmonid species. Jensen (1980) found little effect to embryos, alevins, and fry up to 110% TDG. TDG levels of 110-111% in shallow waters led to low incidences of TDG related effects to salmon fry that included burst swim bladders (2.6%) and 1.4% opercular deformities (1.4%).

A few studies have examined TDG effects on early life stages of chum salmon (*Oncorhynchus keta*) in the Columbia River below Bonneville Dam (Geist et al. 2013; Arntzen et al. 2009). Murray et al. (2011) demonstrated that timing of emergence of chum salmon below Bonneville Dam can occur as early as February 10 and can extend to April 9. Thus, early life developmental stages of Chum salmon are likely to be present below Bonneville Dam during fish-spill season.

The most recent study by Geist et al. (2013) examined survival of chum salmon alevins between hatch and emergence (early, middle, and late stages) in shallow laboratory waters at six TDG levels between 100% and 130%. Each life stage was exposed for 49 days (d; early stage), 28 d (middle stage), and 15 d (late stage) through emergence. The estimated median lethal concentration (LC50) was 128.7% for early and middle life stages. The maximum mortality at the 130% TDG treatment for the late life stage was 35%. Early life stage fish were the least sensitive life stage and able to tolerate 120-130% TDG for several days before mortality was observed. Middle and late life stages experienced mortality during the first day of exposure between 120-130% TDG. After 48 hours (h) of exposure to 115% TDG or higher, 20-40%

of emerging fish had bubbles in the nares and 50-70% of fish had gas bubbles in their yolk sacs. No gas bubbles in yolk sacs were observed at 100% or 105% TDG. Overall, chum salmon fry exposed to TDG between 100 and 115% survived equally as well to emergence, averaging 92% survival. All developmental stages survival decreased significantly when gas concentrations were at 117% TDG or above. Under field conditions at the TDG levels examined by Giest et al. (2013), early life stage chum salmon will likely be at depths that allow for depth compensation and thus protect developing embryos. Geist et al. (2013) supported existing management guidelines that limit depth-compensated TDG levels to 105% for chum salmon spawning.

In another study by Arntzen et al. (2009), chum salmon spawning sites below Bonneville Dam in the Ives Island and Multnomah Falls areas were monitored to determine environmentally relevant TDG exposure levels. Chum salmon sac fry at Ives Island were exposed to depth-compensated TDG greater than 103% up to 200 h and greater than 105% for up to 100 h primarily during the spring spill. At the Multnomah Falls site, chum salmon sac fry were not exposed to depth-compensated TDG greater than 103%. In the laboratory component of this study, TDG levels up to 113% did not influence survival, growth, or development of chum salmon sac fry (Hand et al. 2009). The first observed effects of TDG to chum salmon fry survival were observed at 121% TDG.

The impacts of TDG to chum salmon sac fry has also been evaluated in-river downstream of Bonneville Dam. Carter et al. (2009) reported that Chum alevins sampled in a wild redds at Ives Island had signs of GBT when depth-compensated TDG exceeded 105%, which also represents the management guidelines to ensure protection of chum salmon. Subsequently, Carter et al. (2009) built an artificial redd north of Ives Island and placed egg tubes to monitoring impacts of developing chum salmon to ambient TDG levels during the Spring season. The symptoms of GBT, notably bubbles in the eyes, were more prevalent in fish during sampling periods that coincided with depth-compensated TDG at 105% or greater.

Juveniles

Field Studies

Juvenile salmonids outmigration in the Snake and Columbia rivers coincides with high river flows from snowpack melt in the spring. Juveniles passing downstream to the Columbia River estuary and marine waters can incur mortality depending on the route of passage through hydropower dams. Juvenile passage may occur through dam turbines, mechanical bypass facilities, surface passage routes, or spillway passage. Studies have shown spillway passage (Whitney et al. 1997; Muir et al. 2001) and surface passage routes (NMFS — 2010 Supplemental FCRPS Biological Opinion; 2019 CRS Biological Opinion; Ploskey et al. 2012) are associated with the lowest mortality. Increasing spill over dams has been proposed as a method for increasing survival of out-migrating juvenile salmonids. However, increasing spill can be accompanied by high TDG levels which may have adverse impacts on salmonids.

The relationship between TDG levels and the incidence of GBT in juvenile salmonids has been recorded in several field studies. Ebel (1969) placed juvenile coho (*Oncorhynchus kisutch)* and Chinook salmon in cages at various depths in the forebay of Priest Rapids Dam for 200-280 h and concluded that at 130-140% TDG, fish must remain below 2.5 m to survive. During the study, coho salmon held between 0.5 - 1.5 m experienced 100% mortality and coho in pens at depths of 2-3 m had 70% mortality. In a later study by Ebel (1971), mortality ranged from 45-68% in 4.5 m deep cages containing spring and fall Chinook salmon at 127-134% dissolved nitrogen (N_2) in the forebay of Ice Harbor Dam.

When summer Chinook salmon eggs were exposed to 100 and 122% TDG in shallow waters, both exposure groups had high survival (Meekin and Allen 1974). The surviving fry were exposed to 122% TDG and displayed behavioral changes such as swimming in circles on their backs and sides, and loss of swimming ability. The first fingerling mortality occurred on the 126th d from test initiation (including egg incubation) and mortalities increased abruptly after the 140th d. At 160 d (test termination), 66 of 87 (76%) juveniles did not survive. In a separate experiment, Meekin and Allen (1974) reported significant mortalities at treatment levels between 120 to 135% TDG, with smaller juveniles surviving longer than the larger fish. Observations showed that fry exposed to 122% TDG were not feeding, while feeding was occurring at 112% TDG. In the 67-d experiment, growth of fingerling Chinook salmon decreased with increasing TDG exposure (48.9 mm at 98%, 45.3 mm 107%, 44.0 mm 112%, and 39.5 mm in 122% TDG).

In a long-term biological monitoring study (1996-1999) at 5 different hydropower projects on the Snake and Columbia rivers, fewer than 2% of juvenile salmonids examined displayed external signs of GBT, with most of those with GBT signs having less than 5% fin occlusion (Backman et al. 2002). Of the salmonids examined, steelhead was the most sensitive species to GBT incidences (2.3%), followed by sockeye (1.4%; *Oncorhynchus nerka*), and then Chinook (0.8%) and coho (0.7%). GBT symptoms exceeded 15% GBT when TDG levels approached 130% but at less than 125% TDG, GBT prevalence was well below 15% (15% GBT represents the action criteria established in the 2000 NOAA Biological Opinion). The prevalence and severity of GBT observed was noticeably higher at TDG levels in the range of 125-130% versus 120-125% but the overall incidence rates were relatively low (Backman et al. 2002).

In another field study at sites downstream of Bonneville, Ice Harbor, and Priest Rapids Dams, juvenile salmonid passage was monitored during the spring freshet of 1993 and 1994 (Dawley 1996). In 1993 below Bonneville Dam, 17 species of fish were collected and examined for external signs of GBT. Among the fish examined in 1993, juvenile salmonids were the most sensitive to TDG. Coho salmon had the highest incidence of GBT at 3%, followed by steelhead (2%), and Chinook salmon (0.1%). Most signs of GBT were only observed when the average daily TDG levels exceeded 120%. In 1994 below Ice Harbor Dam, GBT ranged from 12 to 50% for salmonids held in surface cages and from 0 to 37.5% for salmon held in net pens with depths of 0-4 meters. Salmon held in control cages at 1.5 to 2.5 meter depths, had a 10% GBT prevalence when TDG levels averaged 125%.

Biological monitoring at Rocky Reach and Rock Island for juvenile salmonids occurred extensively for a number of years (Mesa et al. 1997; Grassell and Hampton 2001; Grassell et al. 2000a, 2000b; Hampton 2002, 2003; Murdoch and McDonald 1997; Maitland et al. 2003). TDG levels from 110 to 120% was common and resulted in GBT symptoms in 1-5% of juvenile Chinook salmon and steelhead. In 1997, TDG levels exceeded 120% for approximately two months and led to a GBT incidence of 20-80% in juvenile salmon collected at the two dams, suggesting increased risk during chronic exposures.

Sampling of out-migrating juvenile salmon on Priest rapids has occurred over several years. Hagen et al. (1998) reported GBT signs in 21.5% of sockeye salmon, 9.4% of Chinook salmon, and 8.7% of steelhead at TDG levels of 120-135%. During the summer, when TDG levels dropped to 110-125%, Hagen et al. (1998) reported GBT in only 2.3% of Chinook salmon. In a long-term monitoring program from 1996 to 2002, Duvall et al. (2002) found juvenile salmon had an incidence of GBT from 1.7 to 8.3% during spring spill when TDG averaged 113 to 130%. When TDG levels averaged between 113-120% in 1998, GBT incidence ranged from 1.7-5.8%.

During high spill levels in 1997, Ryan and Dawley (1998) monitored juvenile salmonids at Ice Harbor Dam, and downstream from Ice Harbor and Bonneville Dams. From April 20 to June 23 at Ice Harbor Dam, TDG levels remained near 130% for 2 months and then dropped to roughly 120% for the rest of the period. From April 24 to June 10, GBT prevalence was 13.7% of 738 juvenile salmonids collected 15 km downstream from Ice Harbor Dam. During this same period, prevalence of GBT at Ice Harbor Dam in the juvenile bypass system was 5.2%. Steelhead comprised the majority of the juvenile salmon collected. Steelhead downstream of Ice Harbor Dam had an average 49% higher prevalence of GBT than steelhead examined at Ice Harbor Dam. From March 14 to August 22, 0.6% of juvenile salmonids had signs of GBT downstream of Bonneville Dam when average TDG levels did not exceed 117%.

In 4-d net-pen studies downstream from Ice Harbor Dam, juvenile hatchery Chinook salmon were placed in cages at the surface, 0-4 m, or 2-3 m deep (Ryan and Dawley 1998). Signs of GBT were prevalent in 80% of juvenile Chinook salmon in surface cages, 52% in 0-4 m cages, and 6% in 2-3 m cages when weekly average TDG measured between 122% and 130%. In surface cages (excluding data from July 28-Aug 1) at TDG levels between 126-130%, 94% mortality was observed in Chinook salmon, 71% mortality at 122% TDG, and 3% mortality between 117-118% TDG. In the 0-4 m cages (excluding data from July 28-Aug 1), mortality was 30% at TDG exposure levels of 126-130%, 32% mortality at 122% TDG, and 2% at 117-118% TDG. In the deep (2-3 m) cages (excluding data from July 28-Aug 1), mortality was 20% at 126-130% TDG, 25% at 122% TDG, and 4% at 117-118% TDG. The authors noted disparities between GBT incidences in net pens versus river conditions, with lower incidences of GBT of fish collected in-river.

Toner and Dawley (1995) reported that juvenile salmonids were the most sensitive species to GBT among 17 species of fish. The highest incidence on a single day at Bonneville Dam for smolts was 8% for wild steelhead, 11% for hatchery steelhead, 2.7% for coho, 0.7% for sockeye, and 0.2% for Chinook salmon at TDG levels between 120-125%. Toner et al. (1995) examined juvenile salmonids downstream from Ice Harbor when TDG was >130% for 7-11 h each day and observed GBT incidence in 5-10% of fish captured.

In 1996, Hans and Maule (1997) monitored juvenile salmonids when TDG levels exceeded 120% for a period of eight straight weeks. GBT incidence in fish averaged 2-4% for spring Chinook salmon and 6-7% for steelhead. At John Day Dam, GBT prevalence in spring Chinook salmon was 5.5%. Steelhead reached a maximum of 9.9% GBT incidence at Bonneville Dam. Mesa et al. (1997) concluded within the same report that GBT was not a threat to migrating juvenile salmon when TDG levels were less than 120%.

The Fish Passage Center monitored GBT in juvenile salmonids from 2008 to 2017 and reported greater than 15% GBT in three instances out of 1,004 GBT samples[21]. In all three instances, TDG levels were in excess of 125%. In a historical analysis of data collected by the Fish Passage Center from 1995-2018, the 15% GBT criterion has been exceeded in only 37 instances of 2,870 samples and 28 instances occurred when TDG was greater than 125%[22].

Laboratory Studies

In field monitoring studies, it is difficult to control extraneous variables, track the progression and severity of GBT, and measure survival. Laboratory studies enable the isolation of variables that can be effective at determining effect thresholds in a controlled environment. However, laboratory bioassays conducted in shallow water may overestimate effects if aquatic test species are not able depth compensate and move to less harmful TDG conditions.

Ebel (1973) placed juvenile Chinook salmon in 2.4 m deep tanks for 60 d and recorded insignificant mortality at 118% TDG but 100% mortality in fish held in 0.25 m of water. Dawley et al. (1976) placed juvenile Chinook salmon in 2.5 m deep water and reported mortalities of 67% and 97% at TDG levels of 124% and 127%, respectively. When the same study was conducted in 0.25 m depth tanks, the same mortalities (67% and 97%) occurred at 115% and 120% TDG. At 110% TDG at water depths of 0.25 m, 15% mortality occurred, while only 5% mortality occurred in 2.4 m water depths at 120% TDG. These

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[21] http://www.fpc.org/documents/memos/25-18.pdf

[22] Appendix J: http://pweb.crohms.org/tmt/wqnew/tdg_and_temp/2018/

studies suggest that hydrostatic depth compensation is important factor in determining risk in supersaturated waters.

During a 50-55 d chronic exposure at 120 to 130% TDG, juvenile salmon and steelhead experienced 11% and 6% mortalities, respectively, in 2.5 m tanks compared to 80% mortality for both species in 1 m deep tanks (Blahm 1974 and Blahm et al. 1976). Mortality was most prevalent near the end of the experimental period when TDG levels ranged between 123% and 127%. Juvenile cutthroat demonstrated less ability to depth compensate, with 42% mortality at 1 m depth and 27% mortality at 2.5 m. To understand the sensitivity of different aquatic organisms to TDG, further research may be necessary to determine the ability for aquatic species to depth compensate.

In a laboratory study by Mesa et al. (2000), juvenile Chinook salmon and steelhead were exposed to treatments of 110% up to 22 d, 120% up to 140 h, or 130% TDG for 11 h in shallow water depths of 28 cm. The study design did not allow for depth compensation typically accompanying field monitoring studies. At the 110% TDG treatment, the prevalence of GBT in Chinook salmon increased over the exposure period of 22 d, with fin occlusion prevalence reaching up to 60% and no observed mortalities. Juvenile Chinook salmon exposed to 120% TDG resulted in 20% mortality within 40 to 120 h, depending on the trial. Moreover, over 50% mortality was observed in 2 of the 3 trials at 120% TDG. At the 120% TDG exposure level, 100% of fish had GBT signs in their lateral line. At the 130% TDG treatment level, 20% mortality was observed within 3 to 6 h, depending on the trial. At 130% TDG, the prevalence of lateral line bubbles reached 100% within hours. For steelhead exposed to 120% TDG, 20% mortality occurred within 20 to 35 h, with about 60% prevalence of bubbles in gills at the end of the experiment. Over 90% mortality was observed within 60 h in 2 of 4 trials at 120% TDG. At 130% TDG, steelhead mortalities reached 20% after 5 to 7 h. Mortality greater than 50% was observed in all 5 trials at 130% TDG.

Another laboratory study examined the influence of TDG on predator avoidance of juvenile Chinook salmon exposed to 112% TDG for 13 d, 120% TDG for 8 h, or 130% TDG for 3.5 h (Mesa and Warren, 1997). Fish exposed to 130% TDG was the only exposure group that demonstrated a significant increase in susceptibility to predation.

Rainbow trout (*Oncorhynchus mykiss*) exposed to 114%, 118%, 125% at shallow depths (0.25 m) did not show differences in swim bladder over inflation or rupture compared to control fish (Antcliffe et al. 2002). In the 114% treatment group, all fish survived for 6 d and at 110% TDG for 9 d. At 116% TDG, mortality was 9% after 96 h and 42% after 9 d. At the 122% TDG treatment, mortality was 89% after 96 h. At the 140% TDG treatment, mortality was 100% within 24 h. At the 122% and 140% TDG treatment, the mean time to 50% mortality was 55 h and 5.1 h, respectively. When cage depths ranged from 0-1 m at 122% TDG, 96 h mortality was 22% and at cage depths between 0-2.5 m, no mortality observed.

A field laboratory study was conducted using ambient water pumped from the Columbia River and fed into two tanks of different depth containing juvenile Chinook and coho salmon (Blahm et al. 1975). The maximum depth of the shallow water tank was 1 m and the deep test tank had a water depth of 2.5 m. During the 72-d test period in the shallow tank, mortalities of Chinook and coho salmon reached 98.2 and 80.1%, respectively. In the deep tank, mortalities of Chinook and coho salmon were 8.7 and 4.2% respectively. External signs of GBT were first observed in deep tanks when N2 levels reached 120% and above. When N2 levels reached 120-125% and were maintained, the prevalence of GBT symptoms in deep tanks for Chinook salmon ranged between 40-65% in June and 20-55% for coho salmon.

Adults

Field Studies

As mentioned in Backman and Evans (2002), relatively few studies have focused on impacts of TDG to adult salmonids. In one of the first studies on adults by Westgard (1964), Chinook salmon were placed in live boxes at N_2 levels of 104-107% and 116-130%. TDG exposure levels of 116-130% for 10 d resulted in blindness for 34% of fish and 88% of blinded fish died before spawning, whereas only 6% of non-blind fish died before spawning. Effects were not observed in fish exposed to 104-107% N_2.

In 1967, Ebel (1969) monitored 2,300 adult Chinook salmon, 1,600 steelhead, and 1,000 sockeye salmon for GBT symptoms at Bonneville and McNary Dams when TDG levels fluctuated between 104-131%. GBT symptoms were only observed in 1% of sockeye and 0% of Chinook salmon and steelhead.

Meekin and Allen (1974) found that at TDG levels between 125 to 135% occurred from spilling at Grand Coulee Dam and did not equilibrate while passing through Chief Joseph reservoir. Boat searches and aerial surveys found mortalities of unspawned summer Chinook and sockeye salmon during spill season and that these mortalities were not observed after spilling stopped.

In a sampling study in 1995, GBT signs were monitored in an estimated 3-4% of adult salmonids passing Bonneville Dam and reported no visible signs when TDG levels were 114-120% (Fryer 1995). Backman and Evans (2002) examined adult Chinook salmon, sockeye salmon, and steelhead GBT symptoms at Bonneville Dam from 1995 to 1999. Overall less than 2% of salmonids exhibited external symptoms of GBT. Steelhead was the most sensitive to TDG with a GBT incidence of 2.3%, followed by sockeye salmon (1.4%), Chinook salmon (0.8%), and coho salmon (0.7%). Differences in the prevalence and severity of GBT were evident between TDG levels of 120-125% (less than 0.5% of samples) and 125-130% TDG (up to 5% of samples).

In a field spawning study, Gale et al. (2004) exposed mature female Chinook salmon to TDG levels of 114 to 126% in shallow waters (0.5 m) to determine impacts on reproduction. Test exposures were stopped at the first mortality (ranged from 10 to 68 h). No changes to spawning or pre-spawn mortality was observed between controls and TDG treated fish. Fertilization rates and survival of eyed stage salmon were not affected by TDG exposures.

Non-salmonids

The following studies include TDG related impacts to native and non-native fish. Non-native fish species can be detrimental to the fitness of native fish species. Studies examining impacts of TDG to non-native fish species are included in this analysis for comparative purposes due to the lack of available data on non-salmonids and to avoid highlighting only specific data from studies. A list of native and non-native fish species in the Columbia and Snake rivers can be found in Appendix C. The species list is based on *Fishes of the Columbia Basin* by Dennis D. Dauble (2009, Keokee Books, Sandpoint, ID).

Field Studies

While much of the focus of TDG effects in the Snake and Columbia rivers are on salmonids, impacts to resident aquatic species should be considered when evaluating the risk of elevated levels of TDG.

In the Snake and Columbia rivers, smallmouth bass typically spawn during the spring in inshore and slough areas at times corresponding to the annual freshet at depths ranging from 0.7 to 5.6 m (Scott and Crossman 1973; Montgomery et al. 1980). Montgomery and Becker (1980) examined GBT in 179 smallmouth bass (*Micropterus dolomieu*) and 85 northern pikeminnow (*Ptychocheilus oregonensis*) between Lower Monumental Dam on the Snake River and John Day Dam on the Columbia River in May 1975 and May through August 1976. GBT was observed in 72% of smallmouth bass and 84% of northern pikeminnow caught by anglers. GBT was observed when TDG exceeded 115%. In May 1975, TDG levels reached approximately 122% in Ice Harbor and McNary Dams in 1975, whereas Lower Monumental Dam reached approximately 140%. From May to June 1976, average TDG levels were estimated at 125% in Ice Harbor and Lower Monumental Dams, whereas McNary Dam rarely reached 120%. Between July and August 1976, TDG levels were below 120% at all three dams. The authors noted that although resident fish have depth compensating mechanisms, smallmouth bass and northern pikeminnow health condition was reflective of GBT symptoms in a high proportion of fish. The study fails to describe the TDG levels when GBT was observed in fish sampled, making it difficult to determine relationships between TDG and GBT.

In a field monitoring study in 1993 and 1994, resident fish were examined for GBT symptoms. In 1993, less than 1% incidence of GBT was observed in 10 resident species below Bonneville Dam (Dawley 1996). Data indicated that GBT signs were observed when TDG levels exceeded 120%. In 1994, no GBT symptoms were observed in 4,955 non-salmonids sampled below Bonneville Dam. Downstream from Ice Harbor Dam, when TDG levels exceeded 130% TDG, prevalence of GBT was 11.5% in resident fish. Resident fish with the highest prevalence of GBT were smallmouth bass (4.3%), yellow perch (4.0%; *Perca flavescens*), largemouth bass (3.3%; *Micropterus salmoides*), pumpkinseed (3.2%; *Lepomis gibbosus*), and largescale suckers (2.8%; *Catostomus macrocheilus*).

During the spring freshet of 1994-1997, resident fish were collected from reaches of the Snake and Columbia rivers (below Ice Harbor Dam, Priest Rapids reservoir, and below Bonneville Dam) and examined for symptoms of GBT (Ryan et al. 2000). Generally, when TDG was below 120%, GBT signs were not present or observed in less than 1% of fish. When TDG ranged between 120-125%, GBT incidences ranged from 0.9% to 9.2%. When GBT reached 130% or greater, GBT signs were typically around 18%, with daily prevalence reaching 40.8%. In 1996, 1,227 Catostomidae larvae were collected below Bonneville Dam and 14.3% had signs of GBT.

In a study by Schrank et al. (1997) from April to August of 1995, resident fish were collected downstream from Bonneville Dam, in the reservoir and downstream from Priest Rapids Dam, and downstream from Ice Harbor Dam. Downstream from Bonneville, only sculpin (2.6%) had a GBT prevalence greater than 1%. During monitoring TDG reached a maximum of 118%, and GBT incidences in resident fish reached a maximum of 0.7%. At the Priest Rapids Dam reservoir, GBT incidences were most frequent in the sand roller (5.6%; *Percopsis transmontana*), sculpin (4.8%; *Cottus sp.*), and smallmouth bass (1.6%). Daily mean TDG levels reached a maximum of 122% and the highest recorded GBT incidence was 5.4% in resident fish at 121% TDG. Downstream from Ice Harbor Dam, GBT incidence was highest in smallmouth bass (16.5%), crappie (13.6%; *Pomoxis sp.*), brown bullhead (11.8%; *Ameiurus nebulosus*), bluegill (9.2%; *Lepomis macrochirus*), and redside shiner (8.3%; *Richardsonius balteatus*). Daily mean TDG levels between 115-119%, 120-124%, and 125-129% resulted in a GBT prevalence of 2.7-40.8%, 14.3-15.2%, and 10.7-26.6%. The relationship between TDG levels and GBT was inconsistent, making it difficult to discern differences in effects among TDG levels.

Schrank et al. (1998) monitored resident fish species from March to August in 1996 for GBT throughout the lower Snake and Columbia rivers. Downstream from Bonneville Dam, GBT symptoms in resident fish were less than 4%. Downstream of Bonneville Dam, daily mean TDG levels between 115-119%, 120-124%, and 125-129% saturation led to GBT incidences of 0-8.2%, 0-15.8%, and 0-13.8%, respectively. At Priest Rapids reservoir, GBT signs were observed the most frequently in suckers (26.6%; *Catostomus sp.*), bluegill (16.7%), sculpins (15.6%), chiselmouth (6.9%; *Acrocheilus alutaceus*), stickleback (5.9%; *Gasterosteus sp.*), and pumpkinseed (5.1%). Downstream from Priest Rapids Dam, GBT incidences were reported in suckers (13.2%), smallmouth bass (7.7%), chiselmouth (4.5%), and northern pikeminnow (2.1%). Downstream from Priest Rapids Dam and in the reservoir, daily mean TDG levels between 115-

119%, 120-124%, 125-129%, and 130-135% resulted in a GBT prevalence of 0-13.7%, 0-23.1%, 0-5.2%, and 6.3-16.7%, respectively. Downstream from Ice Harbor Dam, GBT signs were observed most frequently in suckers (21.6%), sculpin (13.2%), northern pikeminnow (12.3%), yellow perch (12.3%), smallmouth bass (12.0%), and carp (10.9%; *Cyprinus sp.*). Daily mean TDG levels between 115-119%, 120-124%, 125-129%, and 130-135% resulted in a GBT prevalence of 0-35.5%, 3.6-35.3%, 24.3-37.8%, and 18.1-33.3%, respectively. Again, relationships between TDG levels and GBT were difficult to establish, potentially due to highly variability in field studies and fish life history characteristics.

In 1997, Ryan and Dawley (1998) monitored GBT occurrences in resident fish at Ice Harbor Dam reservoir and downstream of Bonneville and Ice Harbor Dams. Prevalence of GBT in Ice Harbor reservoir was highest in bluegill (15.5%), largemouth bass (15.5%), pumpkinseed (14.0%), smallmouth bass (12.3%), sculpin (11.8%), and bullhead (10.8%; *Ameiurus sp.*). When daily mean TDG levels were between 120-125%, GBT prevalence ranged from 0-66.7% in resident fish. Downstream from Ice Harbor Dam, GBT occurrence was highest in bluegill (11.1%), sculpin (8.1%), and pumpkinseed (7.7%), When TDG levels were between 115-119%, 120-124%, and 125-130%, GBT prevalence was 0-20.0%, 0-10.0%, 4.2-30%, respectively. Downstream from Bonneville Dam, the highest occurrence of GBT in resident species was sucker (10.3%), peamouth (7.6%; *Mylocheilus caurinus*), sculpin (5.4%), and northern pikeminnow (5.2%). When TDG levels were between 115-119%, 120-124%, and 125-130%, GBT prevalence was 0-0.9%, 0-18.7%, 11.5-30.1%, respectively.

Laboratory Studies

Meekin and Allen (1974) used hook and line to capture northern pikeminnow from the Columbia River and placed the fish in a 100% TDG control trough or 120% TDG trough in shallow waters (16.5 cm). Northern pikeminnow exposed to 120% became lethargic immediately and had little activity. After 3 d at 120% TDG, bubble formation was observed on fins of all fish. Juvenile Chinook salmon and steelhead (prey) were placed into each trough. Northern pikeminnow at 120% TDG showed no interest in feeding, while all prey were consumed within 48 h in the control trough. After 8 d, the 120% TDG treatment was reduced to 100% and northern pikeminnow immediately became active and started feeding. Saturation levels was increased to 120% TDG again, and fish became lethargic again. After 17 d, no mortalities occurred but northern pikeminnow were in poor condition. In another feeding study, northern pikeminnow food consumption decreased in proportion to increases in TDG levels when held in shallow tanks (0.25 m; Bentley and Dawley 1981). Northern pikeminnows consumed 14.2 g/d at 100% TDG, 6.2 g/d at 117% TDG, and 2.3 g/d at 126% TDG. Both Meekin and Allen (1974) and Bentley and Dawley (1981) studies were conducted in shallow waters, precluding the ability of fish to depth compensate and circumvent TDG related impacts.

In a shallow (26 cm) water laboratory study, resident fish below Grand Coulee Dam were collected and examined for GBT at TDG levels of 115, 125, and 130% (Beeman et al. 2003). At 125% TDG, the most sensitive species was northern pikeminnow, followed by largescale sucker, longnose sucker (*Catostomus catostomus*), redside shiner, and walleye (*Sander vitreus*) and at 130% the order of sensitivity was largescale sucker, northern pikeminnow, longnose sucker, redside shiner, and walleye. Generally, the time to 50% mortality was approximately 2-fold less at 130% as compared to 125% TDG, suggesting duration of exposure is important in evaluating TDG related risks.

When bluegills were acclimated to surface pressures, acute GBT signs were present at 135% TDG and chronic GBT effects at 120% TDG (Abernethy and Amidan 2001). At 135% TDG, bluegill began to die within 10-12 hr. Bluegill exposed to 100, 120, and 135% TDG at pressures simulating 3 m depths had no external signs of GBT. Bluegill were reported as more resistant to TDG effects than fall Chinook salmon or rainbow trout (least resistant).

White sturgeon (*Acipenser transmontanus*) are known to spawn from April to July, during the fish spring spill season when TDG levels are known to increase significantly. Laboratory studies have observed newly hatched white sturgeon larvae swim up in the water column for the first 5 d after hatching and others have captured larvae in plankton nets (Brannon et al. 1985; Parsley et al. 1993). Counihan et al. (1998) exposed white sturgeon larvae to TDG levels of 118% and 131% in laboratory bioassays in shallow water (25 cm). No mortality was observed at 118% TDG for 10 d but 50% mortality occurred at 131% TDG after 13 d (most mortalities were observed by day 4 at 131%). GBT was first observed at stage 34 at 118% TDG and stage 33 at 131% TDG. When GBT signs were first observed, 50% of 20 larvae sampled had GBT at 118% TDG compared with 85% of larvae at 131% TDG. When stage 33 and 34 larvae were exposed to 118% and 131% TDG for the first time, GBT signs developed within 15 min. The authors conclude that little is known about white sturgeon larvae and that the laboratory study results may represent a worst-case scenario, given that the shallow water test conditions preclude depth compensation.

In the only known studies of TDG effects in amphibians, Colt (1984) examined GBT symptoms in bullfrog (*Rana catesbeiana*) tadpoles. Tadpoles placed in shallow water (0.25 m) exhibited gas inflation of the gastrointestinal tract when exposed to TDG supersaturated waters by floating on their sides or upside down. However, these symptoms could be reversed by reducing TDG levels. A 4-d exposure to approximately 122% TDG had no effect on survival but at day 10, increased mortality and the presence of redleg disease was noted. When adult bullfrogs were exposed to TDG of 116.8% for 4-d no mortality was recorded but subcutaneous gas bubbles were observed in webbing and body. Exposures of 132.9% TDG resulted in 40% mortality within one day, while no signs of GBT were recorded in adult bullfrogs exposed to TDG levels of 108.8% for 27 d.

Colotelo et al. (2012) examined juvenile brook (*Lampetra planeri*) and Pacific lamprey (*Entosphenus tridentatus*) to GBT in a laboratory study. Lamprey acclimated to depths of 4.6 m and subject to rapid decompression to a very low pressure. No mortality or GBT signs were observed for lamprey. Colotelo et al. (2012) notes that the lack of a swim bladder may account for the reduced sensitivity to TDG.

Aquatic Invertebrates

Field Studies

In 1994, 23 taxa and a total 4,133 invertebrates were collected near Bonneville (downstream), Priest Rapids (upstream) and Ice Harbor (downstream) dams and evaluated for signs of GBT (Dawley 1996). GBT signs in invertebrate species were rare. Of the invertebrates sampled, only cladocerans (1.5%) had signs of GBT below Ice Harbor Dam. TDG levels exceeded 130% on occasion during the sampling period.

Schrank et al. (1997) examined 804 invertebrates below Bonneville Dam and reported minimal effects to only cladocerans (0.5%) when TDG levels averaged 114%. Below Ice Harbor Dam, only 0.4% of the 499 invertebrates collected showed signs of GBT when TDG levels were recorded between 105-131%. In another study, three species of invertebrates were collected below Bonneville Dam including Asian clams (*Corbicula sp.*), crayfish (*Procambarus sp.*), and dragonfly larvae (*Gomphus sp.*) and no signs of GBT were observed when TDG levels were mostly between 115-125% (Toner and Dawley 1995). Of the 23 taxa collected by Toner and Dawley (1995) in 1994 below Bonneville and Ice Harbor Dam, GBT was only reported in 4% of cladocerans.

White et al. (1991) conducted bioassays with macroinvertebrates at depths less than 1 meter on the Bighorn River in Montana and found that most were affected at TDG levels of 127% or greater. The most susceptible invertebrate was *Baetis tiicaudatus* at 115% TDG, while *Ephemerella inermis* and *Tricorthyodes minutus* showed effects near 118% TDG.

Laboratory Studies
GBT in *Daphnia sp.*, crayfish, and stoneflies (*Pteronarcys sp.*) have previously been reported by Nebeker (1976). *Daphnia magna* were affected by supersaturated waters above 110%. The mean LC50 for *Daphnia magna* was 122.5% when fed and held in static water. When *Daphnia* were not fed in flowing water the 96 h LC50 was 114%. The 7-d LC50 was 120% and the 10-d LC50 was 117.5%. In crayfish, effects of supersaturated water were observed at 130% or above. The mean crayfish 96-h LC50 was 147%; the 7-d and 10-d LC50s were 145% and 133%, respectively. The 10-d median effective concentration (EC50) for stoneflies was 135% for *Acroneuria californica*, and greater than 125% for *Acroneuria pacifica*, and *Pteronarcys californica*.

In a laboratory study by Nebeker et al. (1981), the effects of TDG supersaturation were examined on the adult emergence of the mayfly (*Timpanoga Hecuba*), caddisfly (*Dicosmoecus gilvipes*), mosquito (*Culex peus*), and midge (*Cricotopus sp*.). The 96-h median lethal concentration (LC50) for the mayfly was 129% TDG and the median lethal time-to-death (LT50) was 2.7 d. The caddisfly LT50 was 45 d at 135% TDG. The adult midges and mosquitoes emerged at TDG levels greater than 140%, whereas adult mayflies and caddisflies did not emerge or survive at TDG levels of 134% and higher.

Malouff et al. (1972) reported GBT symptoms in bivalves (*Crassostrea virginica, Crassostrea gigas, and Mercenaria mercenaria*) exposed to supersaturated water created by water temperature. A separate experiment indicated that temperature changes do not create GBT symptoms observed. Symptoms included gas-filled conchiolin blisters on valves and gas bubbles in gill filaments in clams and in mantle tissue of oysters.

P. californica, *Isogenus serratus*, *Cloeon ingens*, *Hydropsyche sp.*, Lepidostomatidae, and Tendipedidae were examined for GBT signs after exposure to varying TDG levels at different depths (Fickeisen and Montgomery 1975). The authors found *P. californica* had external bubbles at the 140% TDG level after 1 d and after 5 d at 108% TDG but no mortalities were reported. Hydropsyche, *I. serratus*, *C. ingens* reported high mortality but few signs GBT. Lepidostomatidae reported two mortalities at 140% TDG but no signs of GBT, while Tendipedidae had no signs of GBT up to 140% TDG.

Evaluating Risks of Total Dissolved Gas

Depth Distribution of Migrating Fish

The migration depth of salmonids is important in determining if hydrostatic depth compensation is adequate to relieve salmonids from TDG levels known to cause adverse effects in the Snake and Columbia rivers. This section describes the available depth migration and distribution data of salmonids. Consideration is given to the behavior of outmigrating juveniles, adult migration, and the use of fish ladders.

Adult Salmon

Johnson et al. (2005) found that adult spring and summer Chinook salmon spend the majority of their time deeper than 2 m, with occasional movement shallower than 2 m. The percentage of time adult Chinook salmon spent below 2 m ranged from 66% at Ice Harbor Dam to 85.1% at Bonneville Dam. Fish were deeper than 1 m 90.7% of the time at Little Goose Dam to 97% at Bonneville Dam. The time adult Chinook salmon spent at depths less than 2 m typically ranged from seconds to minutes. However, the maximum duration spent less than 1 m and less than 2 m by an individual fish was 1.3 and 19.5 h, respectively. The authors concluded that there was minimal potential for GBT on adult spring and summer Chinook salmon under average river conditions, despite the fact that fish tissues were likely supersaturated with dissolved gases. Similarly, Gray and Haynes (1977) reported adult spring Chinook salmon spent approximately 89% of their time at depths greater than 2 m in the Snake River downstream of Little Goose Dam when saturation levels were below 130%.

In another study, Johnson et al. (2007) concluded that adult salmon swam at depths sufficient for hydrostatic depth compensation 95.9% of the time in the Bonneville Dam tailrace and 88.1% of the time in the Ice Harbor Dam tailrace. At higher TDG levels of 125-130%, adult Chinook salmon were exposed to supersaturated conditions 70.7% of the time after accounting for depth compensation. When accounting for depth compensation, 46.5% of the time fish experienced 101-110% TDG, 43.1% of the time exposures were 111-115% TDG, and 10.4% of the time experienced TDG was 116 to 120%.

Juvenile Salmon

Juvenile steelhead were tagged and tracked from Ice Harbor to McNary Dam to determine migration depth (Beeman et al. 1999; Beeman et al. 2000). Median depths of 3 juvenile fish ranged from 1.1 to 4.3 m at locations with TDG ranging from 119.8 to 125.8%. In another study at the McNary Dam forebay median depths of yearling Chinook and steelhead were observed at 2.4 and 2.7 m, respectively (Beeman et al. 2000). Beeman et al. (1999) reported the median TDG experienced by fish ranged between 82.4% and 107.4% after accounting for hydrostatic depth compensation. Mean TDG exposures for juvenile Chinook salmon and steelhead were 89.0% and 94.6% (Beeman et al. 1999). Backman et al. (2002) found juvenile Chinook salmon and steelhead spent more than 60% of their time deep enough to compensate for TDG levels as great as 124%.

Ebel and Raymond (1976) concluded that when juvenile or adult salmonids are confined to one meter, mortality may occur at 115% TDG after 25 d of exposure and when salmonids are allowed the option of hydrostatic depth compensation, mortality may occur when TDG levels exceed 120% for more than 20 d. As previously mentioned, the duration of exposure in relation to TDG levels and depth compensation are necessary components when evaluating risk.

In another study, mean migration depths of yearling Chinook salmon in the Columbia River varied by year and ranged from 2.1-2.8 m from 1997-1999. Mean migration depth in the Snake River was 1.5 m (Beeman and Maule 2006). Hydrostatic depth compensation ranged from 12.7% to 16.9% in the Snake River where TDG was highest and 27.0 to 34.6% in the lower Columbia River where TDG was the lowest. Mean migration depths for juvenile steelhead ranged from 2.0 to 2.3 m. Hydrostatic depth compensation ranged from 16.9% to 21.3% for the Snake River and from 19.2% to 24.4% in the lower Columbia River.

Fish Ladders

When fish migrate through fish ladders they are restricted to a maximum depth of approximately 2 m. Observations have indicated that fish frequently move towards the surface in fish ways but also pass through deep passage orifices between each progressive pool. However, fish ladders often quickly degas and have reduced TDG levels in comparison to the main-stem river (Bouck 1996). The time spent in fish ways can vary drastically depending on the individual fish, fish ladder design, and salmonid species. Spring Chinook salmon tracked at Bonneville Dam took 4 to 57 h (average 22 h) to pass through fish ladders, while those same fish took 3 to 23 h (average 7 h) to pass Dalles Dam (Monan and Liscom 1975).

Timing of Migrating Salmonids

The timing of salmonid migration is an important factor in determining what salmonid species are present and TDG exposure conditions. Adult salmonid species whose migrating timing overlaps with the spring-spill season (typically April 3rd -June 20th in the Snake River and April 10th-June 15th in the Columbia River) include spring Chinook salmon and sockeye salmon. The adult spring Chinook salmon run begins and ends during the spill season and thus reaches maximum abundance when TDG levels become elevated in the Snake and Columbia rivers (Figures 4 and 5). The timing of the vast majority of juvenile salmonids outmigrating corresponds with spring spill season, including subyearling and yearling Chinook salmon, steelhead, sockeye salmon, coho salmon, and chum salmon (chum rarely pass Bonneville Dam; see Figures 5 and 6).

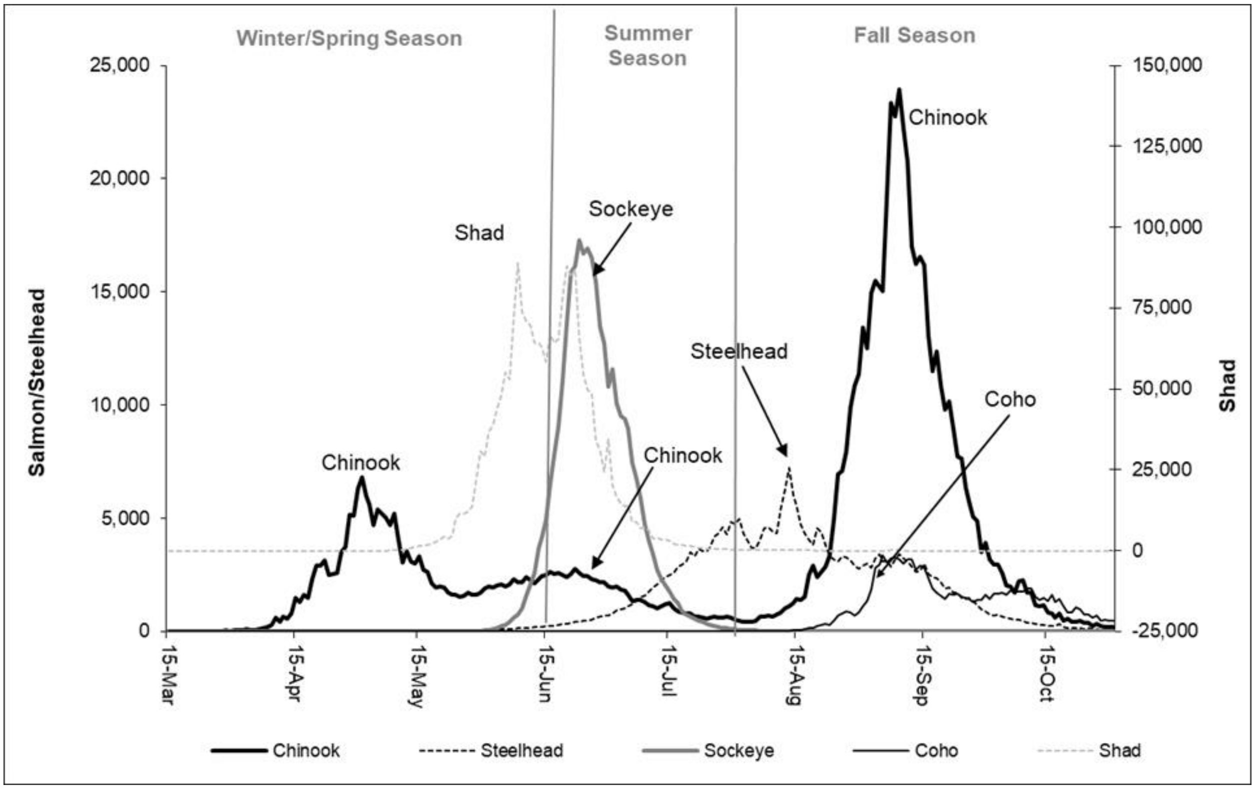

Figure 4. Average daily counts at Bonneville Dam, 2008–2017.

Figure 4 shows the average daily counts of salmon, steelhead, and American Shad at Bonneville Dam, 2008–2017 (https://wdfw.wa.gov/publications/01973/wdfw01973.pdf).

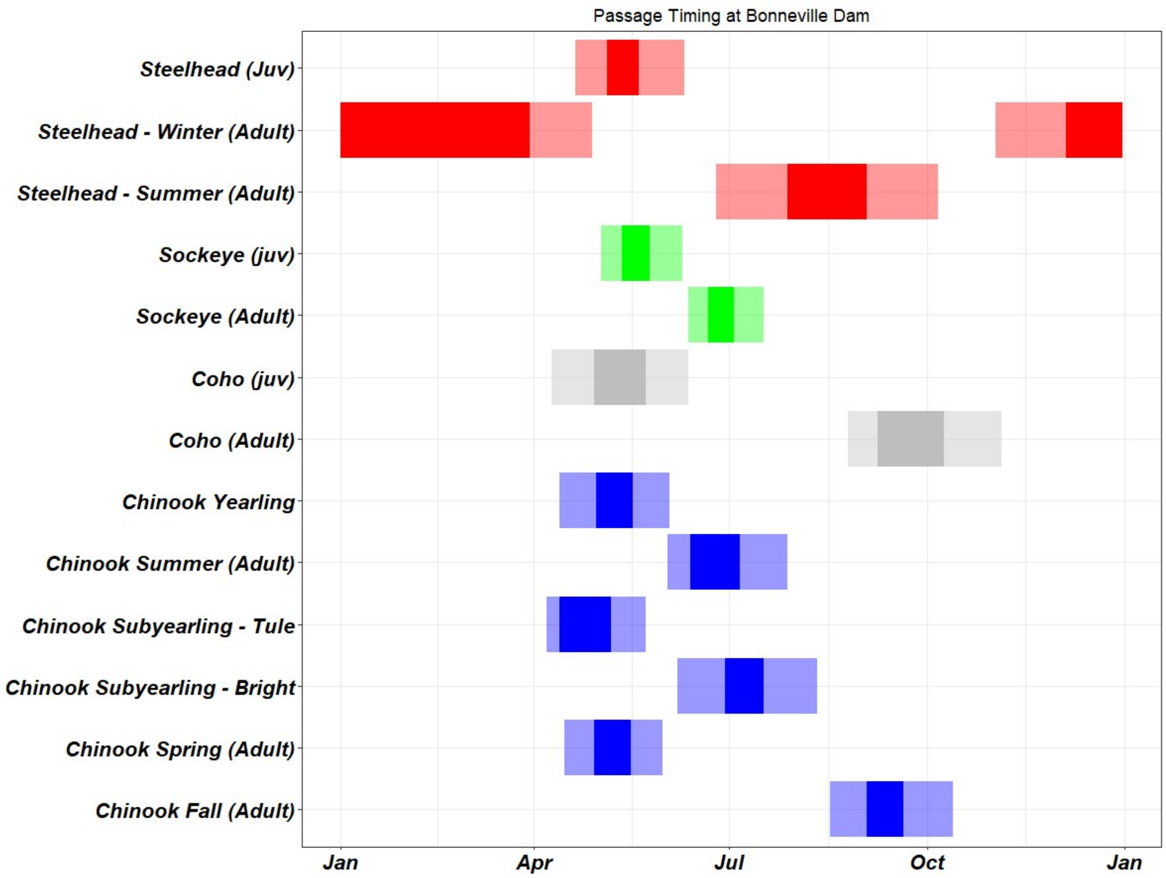

Figure 5. Passage timing by species (and life stage) at Bonneville Dam.

Figure 5 shows the passage timing by species (and life stage) at Bonneville Dam. Shaded regions represent 95% passage (i.e. area between 2.5 and 97.5 percentiles), with darker sections representing the middle 50% of passage (i.e. area between 25 and 75 percentiles). Chinook salmon are represented in blue, coho salmon in gray, sockeye salmon in green, and steelhead in red. Adult timing is indicated by (adult) in y-axis.

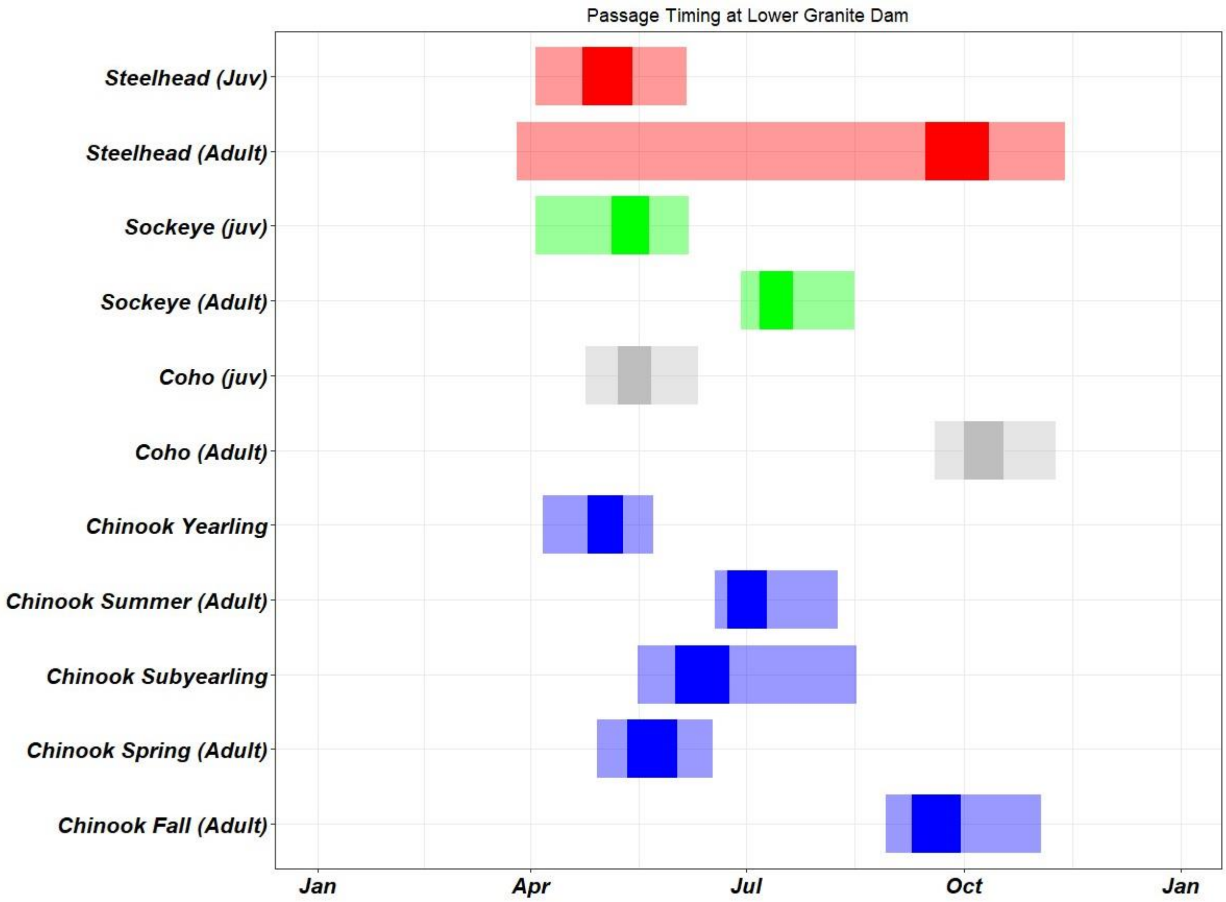

Figure 6. Passage timing by species (and life stage) at Lower Granite Dam.

Figure 6 shows the passage timing by species (and life stage) at Lower Granite Dam. Shaded regions represent 95% passage (i.e. area between 2.5 and 97.5 percentiles), with darker sections representing the middle 50% of passage (i.e. area between 25 and 75 percentiles). Chinook salmon are represented in blue, coho salmon in gray, sockeye salmon in green, and steelhead in red. Adult timing is indicated by (adult) in y-axis.

Fish Movement in Response to Elevated TDG Levels

Several studies have examined behavioral responses of fish exposed to elevated TDG levels and made determinations on whether fish can detect high TDG levels and purposely depth compensate to avoid GBT. There is uncertainty on whether fish have internal mechanisms to detect the need to depth compensate in the presence of high TDG conditions. Shrimpton et al. (1990) described the mechanism of regulating buoyancy in gas supersaturated water. Buoyancy was determined by changes in the volume of the swim bladder which is regulated by pressure. Smaller fish can be subject to positive buoyancy due to the high swim bladder pressure required to force gas out of the pneumatic duct. The smaller the fish, the greater the buoyancy. In smaller fish, swim bladder over-inflation must be compensated by depth compensation to attain neutral buoyancy and decompress the swim bladder. Stroud et al. (1975) observed abnormal buoyancy in juvenile Chinook salmon prior to death. If water depth is not adequate for hydrostatic depth compensation, then mortalities may occur (Ebel and Raymond 1976). Shrimpton et al. (1990) suggested that depth compensation behavior is limited to small rainbow trout, as fish weighing less than 10 g increased depth with increases in TDG. Increasing TDG did not have a constant effect on fish above 40 g; some were higher in the column, some lower, and some did not change their mean depth. Larger fish can vent swim bladders and maintain neutral buoyancy at lower pressures than smaller fish. Positive buoyancy in fish requires large expenditures of energy to swim both vertically and horizontally and overcome the upward force of additional drag by the inflated swim bladder (Alexander 1966). Positive buoyancy requires fish to continuously swim to maintain position in the water column if unable to depth compensate. Further research on energy expenditures to maintain preferred water column depths and the consequences are needed.

Beeman (2006) found that with each increase in 10% TDG, the average migration depth of Chinook salmon decreased by 0.2 m and juvenile steelhead increased by 0.3 m. Stevens et al. (1980) also found differences between salmonid species tendency to avoid supersaturated waters. Juvenile Chinook salmon, coho salmon, sockeye salmon, and rainbow trout avoided TDG levels of 125% and 145%, while steelhead did not avoid any TDG levels.

Beeman et al. (2003) reported no correlation between TDG and depths of tagged fish and concluded that fish do not have the ability to detect or avoid supersaturated waters. In support Lund and Heggberget (1985) found no different in depth distribution between rainbow trout held in a 1.6 m deep tank at 115-125% TDG and control fish held in 100% TDG water. At 114% and 125% TDG, laboratory studies involving rainbow trout did not exhibit behavior different from control fish, however, in 2.5 m deep cages trout were observed schooling at depths > 1 m (Antcliffe et al. 2002). Kokanee held in 9 m deep live cages at TDG levels >120% appeared to vertically migrate through the water column based on diurnal changes in lighting rather than a response to TDG conditions (Weitkamp et al. 2003b).

VanderKooi et al. (2003) reported that resident fish of the Snake and Columbia rivers (redside shiner, northern pikeminnow, largescale sucker, longnose sucker, and walleye) had decreased activity and had a tendency to settle or swim near the bottom of shallow tanks (26 cm) as they developed GBT. Behavioral changes in carp and black bullhead were only noted when TDG levels were at exceedingly high values of 146% in 30 cm deep water (Gray et al. 1982; Gray et al. 1983a). When the Atlantic croaker was exposed 145% TDG, movement initially occurred towards the surface of a 2.5 m deep tank but later, movement oscillated up and down to eventually deeper depths (Chamberlain et al. 1980).

Effects of Repeated Exposures to High TDG Levels

Total dissolved gas levels in the Snake and Columbia rivers fluctuate throughout the spill season. Aquatic life may be subject to highly variability TDG levels on a daily or weekly basis resulting in periods of supersaturation and periods below supersaturation when accounting for depth compensation.

Furthermore, a significant portion of both adult and juvenile migrating salmonids and steelhead in the Snake and Columbia rivers have to navigate several hydropower projects where they may be subjected to repeated exposures of high TDG levels followed by periods of reprieve. Few studies have examined the impacts of repeated TDG exposures with relief periods in between TDG exposures but such studies may be applicable to the Snake and Columbia rivers.

Anticliffe et al. (2002) acclimated rainbow trout at 122% or 124% TDG to tanks with depths of 0-2.5 m and cycled fish to the surface (max depth of 0.25 m) and recorded lethal times to 10% mortality (LT10) and time to initiation of mortality. Rainbow trout acclimated to 122% for 3 h in deep tanks had LT10s that were on average 6 h less than fish acclimated to 122% for 6 h. This data suggests that longer acclimation periods reduce the onset of TDG related effects. When fish were acclimated to 124% TDG for 6 h, the mean LT10 was about 11 h less than fish acclimated at 122% for 6 h. When examining the first recorded mortality, the first transfer of fish from deep to the surface took substantially longer to achieve the first mortality than subsequent cycles of fish from depth to the surface. However, the re-initiation of mortality with each depth cycle took longer after the second cycle (cycle 1: 18.2 h, cycle 2: 11.4 h, cycle 3: 13.9 h, cycle 4: 16.0 h).

White et al. (1991) found that juvenile brown trout repeatedly exposed to 118% TDG, with 30 d recovery intervals between exposures, developed more severe GBT with each successive exposure. The formation of gas bubbles from previous exposures appeared to lead to faster onset of GBT symptoms during subsequent exposures and tissue damage from earlier exposures may have weakened fish, resulting in increased vulnerability to TDG.

McGrath et al. (2006) discusses the uncertainties associated with repeated and chronic exposures to supersaturated water conditions. The body of literature can be conflicting, where in some studies previous exposure to TDG followed by depth compensation prolonged mortality (Knittel et al. 1980; Fidler 1988; Antcliffe et al. 2002), while other studies suggest an increased susceptibility to GBT (Ebel et al. 1971; White et al. 1991). Knittel et al. (1980) noted that longer holding times at depth increased survival times when juvenile steelhead were moved to high TDG conditions at the surface.

Recovery from Gas Bubble Trauma

Gas bubble formation under high TDG conditions can result in sublethal and lethal effects to aquatic life. Mortality may be from factors other than gas bubble disease itself, such as disease, increased vulnerability to predation, or reduced swimming performance. Rapid dissipation of gas bubbles when aquatic species are removed from supersaturated waters has been reported, suggesting GBT symptoms can be reversed.

Hans et al. (1999) reported rapid disappearance of bubbles in gill filaments (2 h) and lateral line (5 h) after transfer into water at TDG levels of 104%. External bubble formation was largely absent after 48 h, however, some bubbles remained as long as 4 d. Fish activity changed from lethargic to near-normal after 30 min after changing from high to lower TDG conditions. The authors concluded that fish can recover quickly from potentially lethal TDG levels if moved into water in equilibrium with atmospheric gases.

When juvenile steelhead were subject to high TDG levels for durations that were nearly lethal and then moved to deeper depths (3 m), complete recovery occurred in 2 h (Knittel et al. 1980). Elston et al. (1997) reported the disappearance of lateral line bubbles after 30 min, with 50% of bubble coverage absent after 5 min. In gills and fins, gas bubbles were negligible after 5 min and 120 min, respectively. Schiewe (1974) reported normal swimming performances after 2 h in recovery water following 120% TDG treatments.

Northern pikeminnow exposed to TDG levels of 120% N_2 immediately became lethargic and GBT signs appeared on day 3 of exposure at shallow water depths (Meekin and Allen 1974). After 8 d, northern pikeminnow were placed at 100% saturation and immediately became active and resumed feeding.

Some studies implicated mortalities in fish that recovered from exposures to elevated TDG exposures to have acquired fungal infections indirectly resulting from GBT (Weitkamp 1976). Weitkamp (1976) recorded fungal infections in the caudal fin of all dead fish and reported degraded fins in live-cage experiments at Bonneville Dam in peamouth, threespine stickleback (*Gasterosteus aculeatus*), and a largescale sucker. Mortality was 10% for juvenile Chinook salmon that were held at 118-126% TDG for 10 or 20 d and then transferred to 3-4 m depths for 20 d (Weitkamp 1976). Of the 10% of fish that died, most had developed fungal infections of the caudal fin which was attributed to lesions in the region that may have been associated with GBT. Jensen (1974) also suggested GBT lesions may have been associated with fungal infections in largemouth bass. Toner and Dawley (1995) acknowledged that caudal fins may be susceptible to secondary fungal infections of GBT damaged tissues and Lutz (1995) linked fin rot and infection to chronic GBT.

Chronic exposure to high TDG levels has been linked to increased susceptibility to infections that may subsequently lead to mortality. Huchzermeyer (2003) suggested that impact on GBT on vulnerability to fungal infections is underestimated. When rainbow trout were exposed to TDG levels at less than 120% in combination with Renibacterium salmoninarum infection (bacterial kidney disease), time to mortality was shortened (Weiland et al. 1999). Weiland et al. (1999) noted that bacterial kidney disease has potential to turn sublethal GBT exposure into a lethal exposure.

Efficacy of Biological Monitoring Programs

Hydropower projects have biological monitoring programs intended to sample adult and juvenile salmonids for the purpose of monitoring GBT impacts from spill on the Snake and Columbia rivers. Criticisms on the methods used in the biological monitoring programs have created uncertainty on whether monitoring methods are adequately capturing GBT symptoms. Furthermore, some studies suggest that symptoms of GBT such as bubble formation may be poorly correlated with TDG levels and that monitoring for GBT may not fully represent the impacts of TDG on aquatic life.

Montgomery Watson (1995) reported that pressurization of juvenile Chinook salmon at pressures experienced by smolt monitoring programs at hydropower projects, can significantly reduce GBT prevalence. Furthermore, Elston et al. (1997) found gas bubble reabsorption during pressurization to occur in a matter of minutes and reported significantly less GBT symptoms. The authors state that current monitoring programs may underestimate the prevalence and severity of GBT to smolts due to pressurization in the smolt bypass system. However, hydropower projects often collect fish samples at the separator as a way to avoid pressurization to reduce uncertainty with gas bubble reabsorption.

Conversely, several studies conducted by Backman and others (Backman et al. 2000; Backman and Evans 2002; Backman et al. 2002) have suggested that smolt monitoring programs overestimate GBT compared with in situ river sampling. Elson et al. (1997b) suggested that smolts need to be monitored immediately for GBT symptoms due to potentially misclassifying lipid structures as gas bubbles. Depths of holding tanks and holding times should be considered when evaluating smolts for GBT symptoms.

The relationship between biological effects of supersaturated waters on aquatic life and the presence of GBT has been questioned. Mesa et al. (2000) described four limitations for using GBT to assess effects of gas supersaturation that included differences in susceptibility of individuals within a species, limited knowledge of the relationship between GBT and TDG exposure concentrations as fish migrate through water systems, persistence of GBT symptoms, and inconsistent relationships between GBT and mortality. Monk et al. (1997) noted that dam passage had complex effects on the incidence of GBT and that GBT severity increased in some individuals and decreased in others. Weiland et al. (1999) suggested that measuring GBT alone may underestimate the effects of high TDG due to the presence of multiple stressors, some of which may have synergistic effects.

A concern with the biological monitoring program is the lack of external GBT symptoms when mortalities have been observed in high TDG conditions. Meekin and Allen (1974) reported that juvenile salmonids did not always show external GBT symptoms when acute toxicity was observed. In a live cage experiment with juvenile rainbow and cutthroat trout, Weitkamp et al. (2003b) observed fish that survived more than 2 d exhibited severe signs of GBT but many fish that died from acute toxicity showed minor or no signs of GBT. Additional research on physiological changes to aquatic live in supersaturated waters may be necessary to determine the full spectrum of TDG related effects and to improve biological monitoring of TDG exposures.

Uncertainty Analysis

There are several uncertainties associated with the science examining the impacts of TDG in aquatic life. Margins of safety or safety factors are often applied when there is uncertainty regarding one or more aspects of the science when developing threshold values for the protection of aquatic life. Setting threshold values or criteria at levels that afford no or little margin of safety has potential to result in less than full protection.

While several studies have collected and examined resident fish (i.e. non-salmonids) for GBT or studied various fish indigenous to the Snake and Columbia rivers in laboratories, several data gaps exist on their life history traits. Knowledge on spawning, early life stage development and movement, coping mechanisms for high TDG conditions, foraging needs, and water column preferences for several resident fish are unknown. To examine potential risks of TDG thoroughly, more information is needed in regards to this information to determine TDG exposure frequency and magnitude, which can then be translated into potential effects. While salmonids are often the focus of research studies in the Snake and Columbia rivers, more information is needed on developing embryos for natural spawning fish that do not return to a hatchery. Wild salmonids continue to decline and thus, further research may be necessary to determine if current TDG levels are having an adverse impact on salmonid and steelhead populations in the Snake and Columbia rivers as it relates to energetic reserves, behavior, and spawning success. Little data exists concerning the impacts of TDG or changes in hydrology of the Snake and Columbia rivers on the anadromous lamprey.

Studies have demonstrated that depth compensation is a mechanism that protects aquatic life from TDG related effects. However, there is controversy whether fish can detect supersaturated waters and purposely depth compensate or if they haphazardly move through the water column to a preferred foraging or migration depth. Moreover, some studies suggest that depth compensation is more efficient for some fish than others. Significant differences in mortality for different fish at the same water depths and TDG levels, suggest that coping mechanisms for high TDG conditions may differ depending on the species.

Finally, a few studies have suggested that GBT may not be an appropriate metric to measure TDG-related effects during very high acute TDG exposure events. Some researchers found poor relationships between GBT observations and elevated TDG conditions that result in mortality (Meekin and Allen 1974; Weitkamp et al. 2003b). This brings into question the efficacy of biological monitoring programs at hydropower projects in particular scenarios, and whether observations of GBT accurately represents the health of aquatic life at all times.

Mitigation Measures

Timing and Duration of the Applicable Rule

The adjustment of the TDG criteria coincides with the spring freshet when large amounts of runoff enter the Snake and Columbia rivers. During this same time period, the majority of juvenile salmon outmigrate to marine waters and adult spring Chinook and sockeye salmon migrate upstream. Studies have demonstrated that outmigrating juvenile salmonids have higher survival rates in the Snake and Columbia rivers when passed through dams via spillways versus through turbines or smolt bypass systems of hydropower projects (Whitney et al. 1997; Muir et al. 2001). Thus, increasing spill during the spring freshet is expected to improve juvenile salmon fish passage downstream.

The adjusted TDG criteria applies seasonally during the time when the majority of juvenile salmon outmigrate to marine waters (see Figures 5-6) for the purpose of improving fish passage and increasing the survival of salmon. This rule will apply during the spring spill season which typically occurs from April through June every year (April 3rd – June 20th in the lower Snake River and April 10th – June 15th in lower Columbia River).

Biological Monitoring

The Smolt Monitoring Program has been collecting data on juvenile fish condition and GBT in the Columbia River Basin since 1995. Since the enactment of the GBT monitoring program in 1995, the action criteria for reduction of spill was defined as greater than 15% of fish showing any signs of GBT, or greater than 5% of fish sampled showing severe signs of GBT (NOAA Biological Opinion 2000). Severe signs of GBT are defined as ≥26% of a fin area occluded with bubbles. This action level incorporates a margin of safety based on studies finding significant mortality does not occur in test fish until approximately 60% of a population is showing signs of GBT (Maule et al. 1997a, 1997b). Spill may be curtailed, if possible, when one or both of these action criteria are met.

In addition to the Smolt Monitoring Program, an Ecology approved biological monitoring plan will be required to utilize the adjusted tailrace criterion of 125%. The intent of the biological monitoring plan is to ensure that sensitive fish species are not adversely effected by elevated TDG levels in the Snake and Columbia rivers. Biological monitoring is for non-salmonids is aimed at fish bypass systems or shallow waters downstream from projects. Fish bypass systems and shallow water areas should represent worse case impacts for fish species due to limitations in hydrostatic depth compensation.

The biological monitoring plan requires evaluation of GBT in non-salmonids and salmonids, with weekly minimum sample sizes of 50. The biological monitoring plan allows the use of the adjusted TDG criterion of 125% if biological thresholds are met for GBT. The action criteria established in the 2000 NOAA Biological Opinion are equivalent to the biological thresholds required to be met for using the adjusted TDG criterion of 125%. More details can be found in the TDG Biological Monitoring Plan guidance within the Implementation Plan.

Aquatic Life Depth Compensation

This rulemaking would effectively allow more spill over dams which can increase TDG levels. Aquatic organisms that are mobile or have life history traits with tendencies for deeper habitats in aquatic systems may have the potential to depth compensate to avoid TDG related effects. The ability to depth compensation enables fish to experience reduced TDG levels at deeper depths when compared with

TDG levels in surface waters. Therefore, the ability to move vertically in the water column in response to TDG levels may protect an individual from TDG related effects.

Chapter 4. Evaluation of Reasonable Alternatives

Reasonable Alternatives

The adjustment of TDG criteria is intended to be applied only during the spring spill season. The following reasonable alternatives were considered:

Alternative 1: No action. Do not adjust TDG criteria through a rulemaking process. The adjusted TDG criteria for the lower eight dams in the Snake and Columbia rivers would remain at 115% in the forebay and 120% in the tailrace for the spring spill season. A maximum one hour average of 125% TDG should not be exceeded.

Alternative 2: Adjust the TDG criteria in the Snake and Columbia Rivers through a rulemaking to maintain the 120% and 125% tailrace criteria and remove the 115% forebay criterion. The 120% TDG tailrace criterion would be calculated as an average of the 12 highest hourly measurements in a calendar day. The 125% TDG tailrace criterion would be measured as an average of the two highest hourly TDG measures in a calendar day. This alternative would only apply during the spring spill season.

Alternative 3: Adjust the TDG criteria in the Snake and Columbia Rivers through a rulemaking allow spill up to 125% TDG level in the tailrace calculated as an average of the two highest hourly TDG measures in a calendar day.

Alternative 4: Adjust the TDG criteria in the Snake and Columbia Rivers through a rulemaking to spill up to 125% TDG level in the tailrace calculated as an average of the two highest hourly TDG measures in a calendar day. This alternative would follow flexible spill operations, which at most dams call for a period of higher spill for much of the day (~16 hours) and lower levels of spill (increased powerhouse flows) during shorter periods of the day (~8 hours) during the spring spill season.

Alternative 1: No Action Alternative

Description: Selecting this alternative, TDG criteria on the Snake and Columbia rivers during the spill season would be 115% forebay criterion and 120% tailrace criterion measured over the 12 highest consecutive hourly readings in any one day. A maximum one hour average of 125% TDG must not be exceeded.

The no action alternative assumes that no change is made to the existing TDG criteria for the Snake and Columbia rivers and aquatic life would be as equally protected as in previous years. However, in 2018 a court order mandated hydropower projects to spill water to the 120% tailrace or the 115% forebay gas caps in 2018, depending on which was more limiting. The order to spill to gas caps effectively increased the duration of exposure to TDG at 120% for the lower Columbia River and lower Snake River dams. In previous years, the amount of water spilled over dams in the spring season was controlled by FCRPS BiOp requirements pertaining to spill volume, market demand for power generation, and high flow water input into the system. During high power generation, less spill occurs and lower TDG levels result. The no action alternative does not change the allowable TDG levels in the Snake and Columbia rivers but the duration of exposure, an integral part of determining risk, may change depending on hydropower operations and court orders to spill to gas caps.

Alternative 2: Removal of 115% Forebay Criterion and Maintain the 120% Tailrace Criterion

Description: Selecting this alternative, TDG criteria on the Snake and Columbia rivers during the spring spill season would include a 120% tailrace criterion as measured over the 12 highest hourly readings in a calendar day and a one hour maximum of 125%.

Potential Positive Impacts

The 2019 spill operations under the Spill Agreement are predicted by the CSS model to provide a small improvement in survival and SARs compared to the 2018 court-ordered spill operations to spill to existing gas caps and a larger improvement in survival compared to 2014 BiOp operations.[23] This is based on a projection that 2019 Spill Agreement operations will result in a reduction in smolts' "powerhouse encounter rate," or the number of dam powerhouses (defined as turbines or bypass systems) a smolt encounters while migrating down river. Spillway passage allows smolts to avoid powerhouses.

2018 operations result in an average of 1.76 dam powerhouses encountered by each smolt, while 2019 Spill Agreement operations will result in an estimated 1.73 powerhouse encounters. That compares to 2.98 powerhouse encounters under 2014 FCRPS BiOp operations, and 1.4 to 1.5 powerhouse encounters expected under the operations expected in 2020 under the Spill Agreement.

Potential Negative Impacts

The primary differences between alternatives 1 and 2 is the removal of the forebay standard of 115%. The forebay requirement of 115% primarily serves as a safety factor to ensure dams will not reach or exceed 120% TDG during the fish spill season. If TDG enters the forebay at 115%, then the hydropower project is provided a 5% TDG addition as part of hydropower dam spill operations as measured in the tailrace downstream of the project (i.e. 120% TDG tailrace requirement). Furthermore, the forebay requirement requires hydropower projects to consider impacts of their operations on downstream projects.

Removal of 115% forebay requirements could allow for additional spill at each upstream dam. The 120% TDG criterion in the tailrace and one hour average of 125% would remain as the maximum TDG level. The TDG levels are anticipated to increase by the removal of the need to meet the 115% TDG forebay target. The increased duration of exposure at TDG levels of 120% may result in an increased risk of GBT to aquatic life, when water depths or organism's life history traits preclude depth compensation.

The body of literature suggests that when adequate water depths are available (generally 1-2 m or greater) at TDG levels of 115-120%, then depth compensation may be sufficient to protect aquatic life from GBT. When aquatic life are present in waters of 1 m or less at TDG levels of 120%, the likelihood of adverse effects increases, especially for chronic exposures.

The removal of the forebay criterion of 115% may slightly increase the risk of TDG related impacts to aquatic life by increasing the duration of exposure at 120% TDG level. Spilling to 120% TDG over long periods is a concern for chronic effects of TDG on aquatic life, given that data suggests that GBT is more prevalent at lower TDG levels when an exposure is prolonged. Literature suggests that fluctuating TDG

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[23] Juvenile Chinook salmon PITPH Index estimates based on Comparative Survival Study (CSS) methods (McCann et al. 2015; McCann et al. 2016; McCann et al. 2017) and https://nptfisheries.shinyapps.io/pitph2/ web application tool.

levels over multi-day periods may provide some relief from TDG symptoms and that chronic TDG levels maintained at the water quality criterion may present greater risk.

Alternative 3: Removal of the 115% Forebay Criterion and Change to a 125% Trailrace Criterion

Description: Selecting this alternative, TDG criteria on the Snake and Columbia rivers during the spring spill season would include a tailrace criterion of 125% calculated as an average of the two highest hourly TDG measures in a calendar day.

During the public comment period on this rulemaking it was pointed out that hydropower operators would not be able to attain 125% TDG spill levels with a maximum TDG criterion of 125% in the tailrace. The precision of spill operations need to account for fluctuations in TDG levels while optimizing spill levels. A TDG criterion of 125% TDG does not allow for TDG levels to reach 125% and result in the fish passage benefits outlined in the CSS model. Given that information, we have added a 126% TDG maximum calculated as a two consecutive hour average into the rule, to provide flexibility to hydropower project operators to spill to 125% TDG, We also changed the 125% tailrace averaging period to an average of the 12 highest hourly TDG measures. The TDG maximum level of 126% was suggested by the Fish Passage Center and should provide the ability to spill to 125% TDG. The scientific literature examining TDG effects does not indicate a different in risk between 125% and 126% TDG and therefore, the potential environmental impacts described herein continue to apply.

Potential Positive Impacts

Current SARs for Snake River spring/summer Chinook salmon have been 1.1 since 2000.[24] The CSS has modeled expected changes to SARs from spilling to BiOp standards, 115% forebay/120% tailrace, 120% tailrace-only, and 125%. All spill regimes modeled by the CSS are 24 hours, seven days per week. When spill is increased to 125% TDG 24 hours per day/seven days a week in the spring, the CSS predicts a two to 2.5-fold increase in Snake River spring Chinook salmon abundance above the levels resulting from 2014 FCRPS BiOp spill levels,[25] and smaller projected benefits when spilling to existing gas standards or 120% TDG 24 hours per day. Steelhead SARs are also predicted to increase significantly, but less dramatically than Chinook salmon.

Potential Negative Impacts

The removal of the 115% forebay and the 120% tailrace criteria and an allowance of a 125% TDG tailrace criterion effectively increasing the maximum TDG level by 5% in the tailrace and 10% in the forebay. This increase in TDG has the potential to cause additional incidences of GBT and TDG related effects in aquatic life. Data suggests that aquatic life at water depths of 2 m or greater may provide adequate protection when TDG levels are at 125%. However, the ability of fish to sense high TDG levels is unknown and thus, there is uncertainty as to whether aquatic life would be fully protected at the 125% TDG level with adequate depth compensation.

Spilling to higher TDG levels than the current standards over long periods would be a concern for chronic effects of TDG on aquatic life, given that data suggests that GBT is more prevalent at lower TDG levels over longer durations. Literature suggests that fluctuating TDG levels over multi-day periods may provide some relief from TDG symptoms.

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[24] CSS 2017 Annual Report at p. 102.

[25] See CSS 2017 Annual Report at xxxi.

Salmonid Risk

Salmonid spawning in the main-stem Snake and Columbia rivers primarily occurs below Bonneville Dam, in the Hanford Reach of the Columbia River (above the confluence with the Snake and above the lower Columbia River dams), and in the free-flowing Snake River above Lower Granite Reservoir, the uppermost reservoir on the lower Snake River. Field studies examining early developmental stages of salmonids are limited in the Snake and Columbia rivers. Chum salmon spawn below Bonneville Dam prior to the spill season but egg incubation and rearing occur throughout the spill season. Giest et al. (2013) stated that the location and depth of Chum salmon redds within the tailwater spawning area can be variable and protection from TDG effects is dependent on depth. Carter et al. (2009) reported Chum alevins sampled in wild redds in the Columbia River had GBT symptoms when depth-compensated TDG exceeded 105%. However, to provide protection managers have set water depths to limit impacts on Chum early life stages. If TDG reached 115% at the surface, then to meet the 105% TDG management goal, 1 m of water is required for adequate depth compensation. Arntzen et al. (2007, 2008, 2009) monitored downstream for Bonneville Dam and found that depth compensated TDG levels can exceed the 105% TDG management guideline when water levels were low but usually for short periods of time.

Juvenile salmonid outmigration in the Snake and Columbia rivers coincides with high river flows from snowpack melt in the spring season. Field monitoring studies are highly variable due to fluctuating TDG conditions that can change TDG exposures on an hourly basis. These highly fluctuating conditions make it difficult to determine TDG exposures to aquatic life and therefore broad generalizations must be made on potential effects. Furthermore, long-term field monitoring studies often summarize data over long study periods that have the potential to mask impacts that occurred within a short time period. Field monitoring studies of outmigration juvenile salmonids highlight the importance of depth compensation at low to moderately high TDG levels (Backman et al. 2002; Duvall et al. 2002; Mesa et al. 1997). However, high incidences of GBT in field monitoring studies have been reported. Hagen et al. (1998) reported GBT signs in 21.5% of sockeye salmon, 9.4% of Chinook salmon, and 8.7% of steelhead at TDG levels ranging from 120-135%. During the summer, when TDG levels dropped to 110-125%, GBT was noted in 2.3% of Chinook salmon. Backman et al. (2002) found GBT symptoms exceeded 15% when TDG levels approached 130% and at <125% TDG, GBT prevalence was below 15%. Maule et al. (1997b) concluded that GBT was not a threat to migrating juvenile salmonids when TDG levels were less than 120%. In a historical analysis of data collected by the Fish Passage Center from 1995-2018, there were 2,870 sampling events that met sample size criterion. Of the 2,870 GBT sampling events, only 37 instances exceeded the 15% GBT criterion for juvenile salmonids over all TDG levels and 28 of the 37 instances occurred when TDG was greater than 125% [26].

Field studies that utilized live cages at various depths in ambient waters generally reported a higher incidence of GBT and mortalities than in situ monitoring studies. Live cage studies offer the advantage of controlling depth and assessing GBT incidence with the assumption that depth compensation can be achieved. In a live cage study, Ebel (1969) concluded that at 130-140% TDG, fish must remain below 2.5 m to survive. High mortalities have been recorded in live cages when juvenile Chinook salmon were exposed to 127-134% TDG at depths (up to 4.5 m) expected to be adequate for depth compensation (Ebel 1971). Dawley (1996) observed GBT incidences from 12 to 50% for salmonids held in surface cages and from 0 to 37.5% for salmon held in net pens with depths of 0-4 meters below Ice Harbor Dam. Salmon held in control cages at 1.5 to 2.5 meter depths, had a 10% GBT prevalence when TDG levels averaged 125%. In 1 m deep tanks, mortalities for Chinook and coho salmon were over 80%, while mortalities in the 2.5 m deep tank was less than 9% for both species. While it is recognized that depth

[26] Appendix J: http://pweb.crohms.org/tmt/wqnew/tdg_and_temp/2018/

compensation can be protective of salmonids, the ability to detect supersaturated waters remains unclear.

Resident Aquatic Species Risk

Salmonids and steelhead often receive more emphasis than other aquatic species when evaluating effects of TDG related to spill. Salmonids and steelhead navigate upstream and downstream past hydropower projects to complete their life cycle and thus, have additional impediments to reproduction and survival compared with resident fish species. Moreover, Pacific salmon are an iconic species and a revered natural resource of the Northwest states and tribes.

However, the CWA requires that state water quality standards protect all aquatic life species, thus resident fish species must be considered as they are also an important part of the aquatic ecosystem.

In a study where anglers used hook and line to sample resident fish, GBT was observed in 72% of smallmouth bass and 84% of northern pikeminnow. GBT was observed when TDG levels exceeded 115%. The authors noted that even though these resident species have the ability to depth compensate, GBT signs were apparent in a large proportion of fish. This study highlights the lack of knowledge on the interactions between resident fish species life histories, tendencies within the water column, and TDG exposures.

GBT signs have been observed in resident fish when TDG levels reach 120% (Dawley 1996). When TDG levels exceeded 130% TDG, GBT reached a maximum incidence of 11.5% in resident fish. Ryan et al. (2000) reported very few signs of GBT in resident fish when TDG was below 120%. When TDG reached 130% or greater, GBT signs were much more prevalent (about 18%). Studies by Schrank et al. (1997) and Schrank et al. (1998) demonstrated the high variability in GBT symptoms among resident fish at varying TDG levels. In one instance, TDG levels averaging 120% led to daily prevalence of 40.8% GBT in resident fish, while most days GBT levels were relatively low at similar TDG levels. Generally, GBT prevalence increased with TDG but the daily incidences of GBT varied greatly. The high variability observed within field studies exemplifies the difficulties of analyzing field data and compiling data from multiple species with distinct life history traits in a fluctuating environment.

Another factor to be considered when aquatic organisms are exposed to supersaturated conditions is feeding behavior and activity. Meekin and Allen (1974) reported a disinterest in feeding and lethargy of northern pikeminnow exposed to 120% TDG in shallow tanks that preclude depth compensation but a return to normal activity when returned to waters at 100% TDG. Food consumption in the northern pikeminnow was also substantially decreased when comparing exposures of 100% TDG to 126% TDG in a shallow water laboratory study (Bentley and Dawley 1981).

Studies examining non-fish resident species is very limited. Amphibian studies by Colt (1984) suggested that amphibians may be vulnerable to GBT. Tadpoles and other amphibians bound to the aquatic environment may be susceptible to GBT, given they remain near surface waters. However, more information is needed on the prevalence of amphibians in the Snake and Columbia rivers and their sensitivity to TDG.

In aquatic invertebrate studies, cladocerans have emerged as one of the more sensitive invertebrates. Laboratory studies have suggested impacts to invertebrates at less than 125% TDG. However, in the laboratory studies, organisms were subject to instantaneous changes in TDG levels from saturation levels to supersaturated levels , which is not likely to be experienced in the environment and laboratory studies often preclude the ability of organisms to depth compensate. In field studies in the Snake and Columbia rivers, incidences of GBT were relatively low in invertebrates across a range of TDG conditions (Dawley 1996). Studies have reported successful emergences for several species at high TDG levels

(Nebeker et al. 1981) and low incidences of GBT collected in the Columbia River (Schrank et al. 1997). Nebeker et al. (1981) concluded that all insects were more tolerant to TDG than fish.

Alternative 4: Removal of the 115% Forebay Criterion and Change to a 125% Tailrace Criterion while Implementing Flexible Spill Operations with a Sunset Date of June 20, 2021

Description: Selecting this alternative, TDG criteria on the Snake and Columbia rivers during the spring spill season would include a tailrace criterion of 125% calculated as an average of the two highest hourly TDG measures in a calendar day. This alternative would limit the application of the 125% tailrace criterion to approximately 16 hours a day and would require a return to lower 2014 BiOp spill levels for approximately 8 hours a day. This would be consistent with daily flexible spill operations until June 20, 2021.

Potential Impacts

Alternative 4 is similar to Alternative 3 except that the higher levels of spill for fish passage would occur for most of the day (~16 hours), while lower "performance" spill would occur for shorter periods of the day (~8 hours) and maximize power generation at most dams. Furthermore, Alternative 4 would adhere to the Spill Agreement and therefore sunset at the end of the spring spill season in 2021.

This alternative may present slightly less risk than Alternative 3, given that TDG levels are temporarily reduced for a portion of the day at most dams under the current Spill Agreement. The short reprieve during "performance spill" (increased powerhouse flows) has the potential to reduce or provide reprieve for aquatic life that may be impacted by TDG levels. Studies have demonstrated the quick dissipation of gas bubbles in tissues after short periods of relief from high TDG levels. However, it is anticipated that during the daily lower spill levels, TDG levels will remain elevated above saturation. The daily flexible spill levels in the Spill Agreement were designed to partially mitigate the loss of energy generation resulting from higher spill levels. The current daily periods of lower spill applied at some dams were not designed as a relief to aquatic life from dissolved gases. Therefore, the extent of relief to aquatic life from these daily periods of reduced TDG is unknown.

This alternative considers reverting back to current TDG criteria after the spring spill season of 2021. A temporary adjustment of the TDG criteria through the 2021 spill season aligns with the Spill Agreement. However, Alternative 4 does not align with the ORCA Task Force recommendations.

Chapter 5: Conclusions

Total Dissolved Gas Analysis

Given that the Snake and Columbia rivers are heavily modified for hydropower and that spilling water over dams benefits the passing of juvenile fish downstream, adjustments have been made to the statewide TDG criterion of 110% in the Snake and Columbia rivers. The relationship between spill and TDG is important in evaluating risk and benefits to aquatic life. The greater amount of spill over dams, the greater the risk of potential TDG related impacts to aquatic life. The notion of increased spill and increased survival of juvenile salmonids has been demonstrated in models. However, continuing to increase spill may eventually lead to diminishing benefits.

Water depths in the Snake and Columbia rivers broadly provide adequate depth to circumvent TDG related impacts, but uncertainties exist on the adverse impacts of high TDG levels to resident species, survival of early developmental stages of resident fish and salmonids, prolonged exposures to elevated TDG levels, and the mechanism of depth compensation for aquatic life.

The current criteria adjustment of 115% TDG in the forebay and 120% TDG in the tailrace, presents a marginal risk when considering depth compensation. The removal of the forebay criterion may increase the duration of exposure to higher TDG levels but would not change the maximum allowable TDG level in the tailrace. Studies demonstrate that the effects of TDG and the incidence of GBT in aquatic life are greater at 125% compared with 120% TDG. Spilling to 125% TDG relies on the ability of aquatic organisms to depth compensate to minimize TDG effects. When evaluating risk to aquatic life at 125% TDG, additional monitoring that addresses the uncertainties of risk to aquatic life would help to determine if the potential benefits of spill at 125% TDG outweigh the adverse effects of TDG.

Reasonable Alternatives Analysis Summary

Alternative 1

The no action alternative does not change the risk to aquatic life but also does not provide potential additional survival benefits to out-migrating salmonids and steelhead. This alternative does not meet the requirements of the Spill Agreement that hinges upon Washington State adjusting the TDG criteria to 125% for the spring spill season of 2020 and 2021. This alternative also does not fulfill the Orca Task Force Recommendations to increase spill to benefit orca prey items by adjusting allowable TDG levels to 125%.

Alternative 2

Removal of the 115% forebay criterion and maintaining the 120% tailrace criterion and maximum TDG level of 125% marginally increases risk to aquatic life by slightly increasing TDG levels. This change has the potential to provide some survival benefits to out-migrating salmonids and steelhead. A short-term modification of the TDG criteria on the Snake and Columbia rivers is currently in place that utilizes Alternative 2. However, this alternative does not meet the requirements of the Spill Agreement that hinges upon Washington State adjusting TDG criteria to 125% for the spring spill season of 2020 and 2021. This alternative also does not fulfill the Orca Task Force Recommendations to increase spill to benefit orca prey items by adjusting allowable TDG levels to 125%.

Alternative 3

Removal of the 115% forebay and 120% tailrace criterion and maintaining a 125% tailrace criterion increases risk to aquatic life by increasing TDG levels. However, this change has the potential to provide greater survival benefits to out-migrating salmonids and steelhead compared with Alternative 2. This alternative meets the requirements of the Spill Agreement that hinges upon Washington State adjusting TDG to 125% for the spring spill season of 2020 and 2021. This alternative meets the Orca Task Force Recommendations to increase spill to benefit orca prey items by adjusting allowable TDG levels to 125%.

Alternative 4

Removal of the 115% forebay and 120% tailrace criterion and setting a 125% tailrace criterion has the potential to increase risk to aquatic life for two years by increasing TDG levels in the Snake and Columbia rivers through the 2021 spring spill season. This alternative meets the requirements of the Spill Agreement that hinges upon Washington State adjusting TDG to 125% for the spring spill season of 2020 and 2021. This change has the potential to provide greater survival benefits to out-migrating salmonids and steelhead compared with Alternative 2 but less benefit than Alternative 3. Requiring Flexible Spill operations would be expected to have less benefit for fish passage than 24 hours of spill.

This alternative temporarily (2020 and 2021) and partially meets the Orca Task Force Recommendations to increase spill to benefit orca prey items by adjusting allowable TDG levels to 125%. The Orca Task Force Recommendation does not specify Flexible Spill operations and thus, the intended salmon survival benefit of the recommendation would be expected to be less if Flexible Spill operations are implemented.

The Spill Agreement ends after the 2021 spill season leaving uncertainty surrounding future spill regimes. A permanent Washington rule that includes rule language adopted directly from the Spill Agreement would need to be amended in 2021. When a rule is submitted to EPA they will evaluate aquatic life protection in perpetuity under the Clean Water Act. Alternative 3 provides flexibility on implementation of different spill configurations for future agreements and also meets the intent of the Clean Water Act that requires that biological thresholds be based on aquatic life protections in perpetuity. If EPA approves Alternative 3, different spill configurations may be used that result in spill durations less than 24 hours. Furthermore, a rule that directly follows Flexible Spill operations provides little flexibility to hydropower operators under unforeseen circumstances that could otherwise be provided in Alternative 3.

Decision on TDG Rulemaking

Ecology's decision is to allow for an adjusted tailrace criterion of 125% (Alternative 3) that may be applied at any time during the spring spill season in the Snake and Columbia rivers. An Ecology approved biological monitoring plan focused on non-salmonids would be required in addition to the continuance of the Smolt Monitoring Program that examines GBT in salmonids. This action coincides with the Spill Agreement that aims to benefit salmon and hydropower and also aligns with the Orca Task Force Recommendation for increased water spill for the benefit of Chinook salmon, a vital prey item for the orca. Ecology also is adjusting the averaging method for TDG criteria in an effort to better align with the State of Oregon's TDG averaging method on the Columbia River, in order to ease implementation of the water quality standards. Adjusting the averaging period would have little effect on spill operations, TDG monitoring, or reporting requirements. The averaging period for 125% TDG would change from a one hour average to a two hour average as measured in a calendar day.

Hydropower operators on the Snake and Columbia River that do not wish to submit a biological monitoring plan must meet the 115% forebay criterion, 120% tailrace criterion, and 125% maximum TDG level. Ecology intends to adjust the 12 h averaging method to match the State of Oregon's method. The averaging period for the 115% forebay and 120% tailrace criteria would change from the 12 highest consecutive hourly readings in a day to the 12 highest hourly readings in any one day. The averaging period for the maximum TDG level of 125% would change from a one hour average to a two hour average in a calendar day. This would have little effect in the operations of the federal dams and would ease the spill operations, as well as TDG monitoring and reporting requirements.

Given that dam and salmon managers have not previously provided fish passage spill to 125% due to the potential for higher TDG levels to increase symptoms of GBT in juvenile salmon, steelhead, and non-listed aquatic species; monitoring for GBT would be expanded and continue to be required.

Appendix A

The SEPA scoping process began on May 8, 2019, when Ecology issued a threshold determination of significance on the rulemaking actions. SEPA scoping is the process of soliciting input on a proposal to define the scope of the EIS. Public notice of SEPA scoping was provided via the SEPA Register, Ecology's Water Quality Info ListServ notice, and on our website.

The comments received during the scoping process were considered as the agency identified significant issues, noted elements of the environment that could be affected, developed alternatives, and prepared the draft environmental documents.

Nine public comment letters were received as part of the 21-day comment period that ended May 29, 2019. Eight public comment letters were submitted electronically or via postal mail postmarked by May 29, 2019. One comment letter was received vial postal mail after the comment period, postmarked June 3, 2019. All EIS scoping comments are provided, in full, in this appendix.

Scoping comments were received from the following (in the order received):

- Defenders of Wildlife
- Northwest RiverPartners
- U.S. Fish and Wildlife Service
- National Marine Fisheries Service
- Sierra Club (on behalf of Columbia Riverkeeper, Save Our Wild Salmon, and Northwest Sportfishing Industry Assoc.)
- Oregon Department of Fish and Wildlife
- Columbia River Inter-Tribal Fish Commission
- Nez Perce Tribe
- U.S. Army Corps of Engineers (on behalf of Bureau of Reclamation and Bonneville Power Administration)

Defenders of Wildlife

Please find our comments in the attached letter. Thank you for the opportunity to provide public comments.

Northwest Office
1402 Third Avenue, Suite #930 Seattle, Washington 98101
tel 206.508.5474 www.defenders.org

May 21, 2019

Heather R. Bartlett
Water Quality Program Manager
Department of Ecology
Water Quality Program
P.O. Box 47600
Olympia, WA 98501

Comments submitted electronically

RE: Scoping Comments for Environmental Impact Statement for rulemaking to Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington.

Dear Director Bartlett,

Thank you for the opportunity to provide scoping comments to the Department of Ecology (Ecology) on rulemaking for Chapter 173-201A concerning a proposed increase to the state's total dissolved gas (TDG) standards at dams on the Snake and Columbia Rivers. Increasing these standards to 125% TDG will allow more water to be spilled over dams on the Lower Columbia and Snake rivers. The most recent, best available science suggests that increasing spill over these dams will help restore salmon runs that highly endangered southern resident orcas rely on.

Defenders of Wildlife (Defenders) is a national non-profit conservation organization with over 1.8 million members and supporters nationwide, including more than 24,000 members and supporters in Washington state. Founded in 1947, Defenders is a science-based advocacy organization focused on conserving and restoring native species and the habitat upon which they depend. We have a long history of contributing to agency-led recovery for endangered species. This past year, our staff participated in the Orca Task Force's Prey Work Group, which helped develop the recommendation to increase the state's TDG standards to 125%. We have also worked with schools, cities, counties, and state agencies on programs to reduce toxic pollution throughout the Salish Sea, helping to recover orcas and the salmon they depend on.

As you prepare the Environmental Impact Statement (EIS), we ask that you consider the following in your analysis:

<u>Southern resident orcas</u>

Southern resident orcas are among the most endangered marine mammals in the world, and their decline is driven by a lack of their primary prey, chinook salmon. Perhaps the greatest change in the orcas' diet has occurred in the Columbia Basin. Prior to European colonization, the Columbia Basin supported millions of salmon, half of which were from the Snake River, providing orcas with a critical source of food. After these rivers were dammed, salmon runs throughout the basin collapsed. Despite billions of dollars invested in recovery, no salmon runs have recovered, further jeopardizing orcas.

Increasing spill to 125% TDG over the Snake and Columbia river dams would benefit seven of the fifteen most important salmon runs in the orcas' current diet[1], and was a recommendation from Governor Inslee's Orca Task Force. In its previous EIS on Short-Term Modification to Adjust Total Dissolved Gas Levels in the Columbia and Snake River, Ecology did not explicitly mention the historical and current importance of Columbia Basin salmon runs to southern resident orcas. We suggest this be added to this EIS along with an analysis of the anticipated benefits spill at 125% would have for southern resident orcas.

Discussion of the most recent, best available science supports increasing TDG standards to 125%

In its previous EIS, Ecology cited several studies suggesting that increasing TDG and prolonged exposure to saturated water is detrimental to aquatic life. It is worth noting that that vast majority of those studies are from the 1990s or earlier. The scientific community's understanding of spill and TDG has significantly advanced in the last two decades. The most recent, best available science supports efforts to increase TDG standards to 125%. The older studies cited by Ecology do not provide a holistic analysis of the impact of increased spill and TDG on salmonids and other aquatic life. We recommend that Ecology incorporate the most recent, best available science to guide its management decisions. Studies we recommend Ecology review and include in its EIS are listed below under the section titled "References."

Impacts to non-native fish species would further benefit salmon

In Ecology's previous EIS, the department discussed the potential impacts of increased spill on non-salmonids. As that EIS stated, there are no studies indicating that 125% TDG impacts invertebrates or native amphibians. The species that increased TDG would impact are non-native species, several of which predate on juvenile salmon, including northern pikeminnow, largemouth bass, and smallmouth bass. These three species are non-native predators of chinook salmon and other salmonids that the state is actively working to extirpate. While increased TDG is expected to negatively impact these species, this would further advance the state's goal of recovering salmon and orcas. The EIS should analyze this as a potential benefit, and the agency should explicitly state if an impacted species is native or not.

Conclusion

We greatly appreciate your efforts to recover both salmon and orcas by increasing spill on the Snake and Columbia Rivers. We are pleased to see the state pursuing TDG standards of 125%. We look forward to seeing the draft EIS and providing additional comments.

Sincerely,

Robb Krehbiel
Northwest Representative
Defenders of Wildlife

[1] Priority salmon runs were identified by NOAA and WDFW. A list of those priority runs can be found here: https://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/killer_whales/recovery/srkw_priority_chinook_stocks_conceptual_model_report___list_22june2018.pdf

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Northwest RiverPartners

Please see the attached PDF file.

Northwest RiverPartners
For salmon, our economy and quality of life

Kurt Miller
Northwest RiverPartners
9817 Northeast 54th St, Suite 103
Vancouver, WA 98662

May 24, 2019

Ms. Susan Braley
Washington State Department of Ecology
PO Box 47600
Olympia, WA 98504-7600

RE: Comments on Scope of EIS for Revisions to Chapter 173-201A WAC, Water Quality Standards for Surface Water of the State of Washington

Dear Ms. Braley:

Thank you for the opportunity to comment on behalf of Northwest RiverPartners ("RiverPartners") regarding the Scoping for a Rulemaking for Revisions to Chapter 173-201A WAC, Water Quality Standards for Surface Water of the State of Washington. RiverPartners is an alliance of farmers, utilities, ports and businesses that promotes the economic and environmental benefits of the Columbia and Snake rivers; fish and wildlife policies and programs based on sound science; and clean, renewable, reliable hydropower. RiverPartners' 120 member organizations represent more than 4 million electric utility customers, 40,000 farmers, thousands of port employees, and large and small businesses that provide hundreds of thousands of Northwest jobs. The focus of this letter, is Ecology's consideration of amending the numeric criteria for total dissolved gas in the Snake and Columbia rivers (WAC 173-201A-200(1)(f)(ii).

Background
On March 29, 2019, Ecology issued an Administrative Order to modify TDG criteria at lower Columbia River and lower Snake River dams, in accordance with a 2019-2021 Spill Operation Agreement ("Spill Agreement"). The Administrative Order was a short-term modification of the adjusted criteria for areas on the lower Snake and lower Columbia rivers during the spring spill season that typically occurs April 3 through June 20 (April 3-June 20 on the lower Snake River and April 10-June15 on the lower Columbia River). This Administrative Order is effective for the spring spill seasons in 2019, 2020, and 2021 unless and until the short-term modification is superseded by a rulemaking or other action that revises WAC 173-201A-200 (1)(f) TDG criteria prior to the end of the 2021 spring spill season.[1]

Description of Current Scoping Proposal
Per Ecology's May 7, 2019 scoping letter, "Ecology has determined that amending the numeric criteria for total dissolved gas ("TDG") in the Snake and Columbia rivers may have a significant adverse impact on the environment. This rulemaking is considering amending the TDG limit to allow for greater water flow through

[1] Washington State Department of Ecology Administrative Order to Modify TDG criteria at lower Columbia River and lower Snake River dams, in accordance with the 2019-2021 Spill Operation (March 29, 2019).

spillways for improved salmon migration, while ensuring that TDG limits minimize negative impacts to all aquatic life through sufficient biological monitoring."

Specifically, "revisions to the TDG criteria would:

- Provide a new adjusted TDG criteria that could be applied at dams that operate increased spills for the purpose of improving downstream juvenile salmon and steelhead migration in the Snake and Columbia rivers.
- Establish biological thresholds that must be met to apply an adjusted criteria up to 125% TDG."

Proposed Scope
Given the ongoing Columbia River System Operations Environmental Impact Statement ("CRSO EIS") process and recently adopted Spill Agreement, **the scope of this EIS should be limited specifically to the terms of the Spill Agreement based on well supported science and not pre-empt the findings of the National Environmental Policy Act ("NEPA") analysis.**

- **Revisions to state water quality standards should be informed by the CRSO EIS NEPA analysis.** The U.S. Army Corps of Engineers ("the Corps"), the Bureau of Reclamation ("Reclamation"), and the Bonneville Power Administration ("BPA") are midway through a multi-year effort to update a plan for long-term system operations, maintenance, and configuration of the Columbia River System. Considering the significant breadth of this analysis, evidenced by the wide range of alternatives being contemplated, it would be premature to permanently adjust TDG criteria for the Snake and Columbia rivers. According to the Army Corps of Engineers, "The EIS will look at new information, such as that associated with implementing flexible spill in 2019, so that this information could be incorporated into our future decision making and used in the EIS."

  Indeed spill is a tool utilized in all four CRSO EIS alternatives, and is also utilized in the no-action alternative, which follows the 2016 Fish Operations Plan. Significantly however, there is only one multi-objective alternative that contemplates juvenile fish passage spill up to 125% TDG at the four lower Columbia and four lower Snake River dams – the eight fish passage projects, from March 1 to August 31.[2] Ecology should let the NEPA review process run its course before making a final, permanent decision on a significant state water quality adjustment.

- **Revisions to state water quality standards being contemplated in this EIS should be temporary, limited to the terms of the Spill Agreement, and based on well supported science. Additionally, revisions should take into consideration Ecology's findings from its 2009 TDG evaluation.** Washington State played a key role in the recently adopted Spill Agreement. In support of this work, Ecology should narrow environmental review of the water quality standards in question to the terms of the "2020 and 2021 Fish Passage Spill Operations," monitoring and reporting outlined in the Spill Agreement. Any changes in TDG standards – even those within the operational confines of the Spill Agreement – should be based well supported science.

  An important data point to flag as Ecology considers the scope of this rulemaking, is that in the agency's "Evaluation of the 115 Percent Total Dissolved Gas Forebay Requirement" document from 2009, Ecology stated:

[2] U.S. Army Corps of Engineers Northwest Division. https://www.nwd.usace.army.mil/Media/News-Stories/Article/1850311/webcast-outlines-reasonable-range-of-alternatives/

"The weight of all the evidence from available scientific studies clearly points to detrimental effects on aquatic life near the surface when TDG approaches 120%. The detrimental effects ranged from behavior changes to high levels of mortality after a few days. There were fewer effects on aquatic life at 115% TDG. Ecology strongly encourages implementing actions that increase salmonid survival without further increasing total dissolved gas."[3]

With this prior evaluation's warning against TDG increases firmly in mind, the scoping for future increases up to 125% should only be as broad as recommended to meet the requirements of the Spill Agreement. This review process's consideration of spill levels beyond those imagined by the Spill Agreement could be detrimental to aquatic life as determined by Ecology's own 2009 analysis.

Along the way, RiverPartners has expressed cautious optimism around the out-year implementation of the Spill Agreement. Specifically, we have advocated for a steadfast commitment to good science, insisted on a two-step regulatory process – separating the evaluation of 120% TDG from the more environmental significant 125% TDG threshold, and asked for fidelity to the three objectives outlined at the Agreement's outset – provide additional fish benefits by increasing spill; manage power system costs and preserve hydro system flexibility; and retain operational flexibility. As long as these three objectives are met consistent with sounds science, Ecology should conform its rulemaking process to allow for the implementation of the narrowly crafted Spill Agreement. Any step further would be premature.

Thank you again for the opportunity to comment. RiverPartners looks forward to working with Ecology throughout this and other key regulatory processes.

Best,

Kurt Miller
Executive Director
Northwest RiverPartners

[3] Adaptive Management Team Total Dissolved Gas in the Columbia and Snake Rivers: Evaluation of the 115 Percent Total Dissolved Gas Forebay Requirement. Washington State Department of Ecology and State of Oregon Department of Environmental Quality. January 2009, Publication no. 09-10-002. Page 60.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
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In Reply Refer to:
FWS/R1/AES

MAY 24 2019

Heather Bartlett
Water Quality Program Manager
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Subject: Comments on the scope of the Washington Department of Ecology's Environmental Impact Statement relating to proposed rulemaking to revise the Numeric Criteria for total dissolved gas in the Snake and Columbia Rivers.

Dear Ms. Bartlett:

The U.S. Fish & Wildlife Service (Service) appreciates the opportunity to comment on the scope of the Washington Department of Ecology's Environmental Impact Statement (EIS) relating to proposed rulemaking for surface waters of the State of Washington. These comments specifically relate to the proposal to amend the numeric criteria for total dissolved gas (TDG) in the Snake and Columbia Rivers.

The Service recommends evaluating a modified criteria of up to 125% TDG consistent with the 2019-2021 Spill Operation Agreement (Agreement) collaboratively developed by the states of Washington and Oregon, the Nez Perce Tribe, U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration, and agreed upon in December 2018. This would limit the contemplated increase in TDG (up to 125%) to the juvenile spring migration period (April 3 to June 20) and to no more than 16 hours per day in the tailraces of each of the eight affected mainstem Snake and Columbia River dams.

From the Service's perspective, ultimately adopting a modified numeric criteria for TDG consistent with the Agreement as opposed to an alternative that would allow for 125% TDG year round would benefit bull trout in the Columbia River system by limiting their exposure to the higher TDG rates. A more limited scope would also align with several ongoing state and federal regulatory processes.

The Service looks forward to working with Washington Department of Ecology and other parties involved in this process. If you have any questions relating to these comments, please contact Eric Hein via phone (503-231-2013) or email (eric_hein@fws.gov).

Sincerely,

Rollie White

Rollie White
Assistant Regional Director
Ecological Services

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

May 28, 2019

Heather Bartlett
Water Quality Program Manager
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Subject: Comments on the scope of the Washington Department of Ecology's Environmental Impact Statement relating to proposed rulemaking to revise the Numeric Criteria for total dissolved gas in the Snake and Columbia Rivers.

Dear Ms. Bartlett:

The National Marine Fisheries Service (NMFS) appreciates the opportunity to comment on the scope of the Washington Department of Ecology's Environmental Impact Statement (EIS) relating to proposed rulemaking for surface waters of the State of Washington. These comments specifically relate to the proposal to amend the numeric criteria for total dissolved gas (TDG) in the Snake and Columbia Rivers.

NMFS recommends evaluating a modified criteria of up to 125% TDG consistent with the 2019-2021 Spill Operation Agreement (the Agreement) collaboratively developed by the states of Washington and Oregon, the Nez Perce Tribe, U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration, and agreed upon in December 2018. This would limit the contemplated increase in TDG (up to 125%) to the juvenile spring migration period (April 3 to June 20) and to no more than 16 hours per day in the tailraces of each of the eight affected mainstem Snake and Columbia River dams.

From NMFS' perspective, ultimately adopting a modified numeric criteria for TDG consistent with the Agreement as opposed to an alternative that would allow for 125% TDG year round would have several benefits:

1) It would limit the TDG increase to the juvenile spring migration period, allowing for the benefits hypothesized for increased spill to target the correct species and life history stages (primarily yearling Chinook salmon and steelhead smolts) and minimizing the potential for adverse effects of increased TDG to non-targeted species and life history stages as well as resident species;
2) It would limit the TDG increase (up to 125%) to no more than 16 hours per day, reducing the potential for spill operations to negatively affect tailrace conditions that affect adult fish passage (finding and entering adult fishway entrances), and reducing the exposure of adult salmon and steelhead (which can spend hours or days in the tailraces of mainstem dams before entering fishways) and resident species to 125% TDG; and

3) It would align the scope of the criteria modification with the Agreement and with the proposed action that NMFS analyzed in its March 29, 2019 biological opinion for the continued operation and maintenance of the Columbia River System, which would help align several ongoing state and federal regulatory processes.

NMFS looks forward to working with Washington Department of Ecology and other parties involved in this process. If you have any questions relating to these comments, please contact Ritchie Graves via phone (503-231-6891) or email (ritchie.graves@noaa.gov).

Sincerely,

Ritchie J. Graves

for Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Office
NOAA Fisheries, West Coast Region

Sierra Club, Columbia Riverkeeper, Save Our Wild Salmon, and Northwest Sportfishing Industry Assoc.

Please see attachment submitted in PDF form.

EARTHJUSTICE

May 29, 2019

VIA ONLINE COMMENT SUBMISSION PORTAL:

Maia Bellon, Director
Heather Bartlett, Water Quality Program Manager
P.O. Box 47600
Olympia, WA 98504-7600

Re: Comments on May 8, 2019, Scoping Notice re EIS to Consider Changing Total Dissolved Gas Standards for Lower Snake and Lower Columbia Rivers and Other Matters

Dear Director Bellon and Program Manager Bartlett:

On behalf of Sierra Club, Columbia Riverkeeper, Save Our Wild Salmon, Northwest Sportfishing Industry Association and their members, we submit these scoping comments for an EIS Ecology is preparing to address changing the water quality standards for total dissolved gas (TDG) in the lower Snake and lower Columbia Rivers to allow TDG of up to 125% under certain circumstances on a permanent basis. We support this modification for the reasons described below.

The TDG standard change Ecology is considering would replace the current TDG standard for dams on the lower Snake and Columbia Rivers with a tailrace TDG standard of 125% of saturation subject to the biological limitations of the current water quality standards (e.g., triggers for gas bubble trauma or GBT). This would be a permanent change in the water quality standards for TDG, not a limited, short-term modification such as the one Ecology adopted for the Spring of 2019.

A number of organizations, including some of the organizations signing this letter, submitted to you a request for a change to the TDG standards on September 13, 2018. We believe that request continues to describe the legal and scientific basis for modification of the TDG standards at the lower Snake and lower Columbia River dams to allow voluntary spill to benefit salmon up to 125% TDG. We believe this TDG standard is biologically appropriate for both the spring and summer voluntary spill seasons and should be adopted as a permanent, year-round standard. Such a standard, by itself, would not require spill to 125% TDG in either spring or summer or for any particular period of time during the day, but would allow for spill up to that level during the juvenile salmon migration seasons and for longer periods of time than the current short-term modification of the TDG standards.

Such a change to the water quality standards for TDG is entirely consistent with the current interim Flexible Spill Agreement as it would not conflict with the dam operations during

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the Spring juvenile salmon migration season contemplated for the spring of 2020 and 2021 under the Agreement.

As explained in prior letters and comments, there is compelling evidence and a sound legal basis for Ecology to eliminate the current 115% forebay TDG limit at each dam and replace the existing 120% tailrace TDG limit with a limit of 125%.

We believe that upon examination of the best currently available scientific information about the effects of TDG levels up to 125% in the dam tailraces, and analysis of any other alternatives you choose to consider, you will conclude that modification of the TDG standards to allow TDG up to 125% in the dam tailraces beginning in 2020 is the best alternative to protect beneficial uses in the lower Snake and lower Columbia Rivers and that such a standard poses minimal or no risks to any designated use. It also will not have significant adverse environmental impacts.

We offer the following comments and observations in support of this conclusion:

First, as noted above, a modification of the TDG standards to allow TDG levels up to 125% in the tailrace at each dam is consistent with the current Interim Spill Agreement and important to support alternatives for dam operations that the federal agencies are considering and may select in their ongoing CRSO EIS process. The Interim Agreement is based on elimination of Washington's 115% forebay TDG standard starting in 2019 and continuing through 2021, flexible spill to a 120% tailrace TDG standard in 2019, and similar flexible spill to a 125% TDG tailrace standard in 2020 and 2021 (or until the federal agencies complete new records of decision for dam operations). It is important to recognize that this Agreement does not purport to limit in any way Ecology's authority to consider and adopt a permanent change to water quality standards that would allow spill to a 125% tailrace TDG standard starting in 2020, nor would such a modification conflict with the Spill Agreement.

Second, the long-running Comparative Survival Study (CSS) provides a sound biological basis for setting a TDG standard of 125% of saturation. Ecology's description of this extensive study and analysis in the DEIS and FEIS for the current short-term modification, however, understates the level of support the CSS analyses provide for a 125% tailrace TDG standard in potentially significant ways. First, while the CSS analyses focus on reducing "powerhouse encounters" through increased spill, the analyses omits at least two additional benefits of increased spill: (1) reduced predation of juvenile migrants in reservoirs from faster migration travel time and reduced holding time above dams; and, (2) reduced water temperatures from faster water transit time, especially as the spring season progresses, in summer, and in lower water years in spring and summer. While the CSS analysis does not attempt to quantify these survival benefits, they do exist as the analyses recognize, and they may be significant. The recent DEIS/FEIS for a short-term modification of water quality standards suggests that the only benefit of increased spill addressed by CSS is a reduction in "delayed mortality." This is very likely not the only benefit of increased spill for downstream juvenile migrants. And this characterization of the CSS study is potentially confusing and unreasonably limiting given the longstanding discussion of the precise amount of "delayed mortality" that occurs.

Third, recent DEIS/FEIS fails to clearly and adequately acknowledge that the CSS analyses are based on decades of empirical evidence about the effects of spill and TDG levels on juvenile spring migrants, including effects at TDG levels well above 125% (during, for example, frequent periods of involuntary spring spill). This empirical evidence includes results measured against well-established "action levels" for GBT. This empirical evidence on GBT indicates that spill to 125% TDG is safe for juvenile salmon. All of this evidence makes it clear that establishing a 125% TDG water quality standard would be both legally and biologically appropriate.

Fourth, there is extensive evidence of the effects of spill and the incidence of GBT at TDG levels well above 125%. This evidence comes from actual data collected during frequent periods of involuntary spring spill over many years. This evidence shows quite clearly that the incidence of GBT in juvenile salmonids is well below existing action levels (which are quite conservative) at spill that causes TDG up to 125%. Above 125%, the incidence of GBT increases somewhat in some circumstances but usually does not reach levels of concern until TDG is at or above 130%. This evidence confirms that a TDG standard of 125% at the dam tailraces would be appropriate.

Fifth, Ecology should take care in this EIS to explicitly recognize the difference between laboratory studies with extended exposures and no depth compensation, and field studies and other empirical evidence about the effects of spill and TDG levels up to 125% on salmonids or other aquatic life. This will avoid leaving the potentially misleading impression that there is considerably more uncertainty about the benefits and risks of spill than the data warrants. For example, in the past, Ecology has described a number of laboratory studies reporting high incidences of GBT but failed to discuss how these conditions relate to conditions juvenile salmon are likely to experience in the Snake and Columbia rivers during periods of voluntary spill. Many of these studies involve continuous exposure to elevated levels of TDG for 60 days, 50-55 days, 40 days, 22 days and so on. Many of these studies also provide limited opportunities for depth compensation. It is not clear that this kind of continuous exposure to TDG at 125% in laboratory conditions is likely to occur during actual voluntary spill operations.

Sixth, in the past, Ecology has also said that NOAA Fisheries' COMPASS model is "less optimistic about the benefits of additional spill" and attributes this to Ecology's understanding that the COMPASS model "does not factor in the same assumptions about delayed mortality as the CSS model." It is not immediately apparent that the CSS model makes any assumptions about delayed mortality. It is based on empirical data about juvenile downstream survival and associated smolt-to-adult return rates. Ecology may want to seek clarification from the authors of the CSS model regarding this statement. Similar statements about the CSS model that may reflect a misunderstanding of it have appeared in other places in Ecology's past analyses and also should be checked and corrected as appropriate.

Seventh, in the past Ecology has described and relied on a number of studies of the effects of TDG on early salmonid development and on juveniles. The relevance of these early stage studies to setting TDG levels at mainstem dams is not apparent. Ecology may want to explain exactly where early stage salmonids are likely to encounter elevated TDG levels of up to 125% from voluntary spill, other than chum salmon below Bonneville dam where there are already measures in place to protect them (which Ecology seems to accept as effective). The studies of the effects of TDG on juvenile salmonids also are not tied to conditions these fish are likely to experience during their downstream migration. For example, in a past analysis Ecology has identified one more relevant study which reports that data on the incidence of GBT from five unidentified Columbia and Snake River dams failed to show effects above action levels for GBT set in the 2000 FCRPS BiOp until TDG exceeded 130%, but this relevant information is simply reported along with other information and is not further addressed. At the same time, Ecology describes another study that reports a much higher incidence of GBT at two mid-Columbia dams where TDG levels apparently "exceeded 120% for approximately two months" but fails to describe when, how often, or how likely these extended conditions occur in the lower Snake and lower Columbia rivers under voluntary spill conditions and so does not provide a basis for assessing the relevance of this study to a TDG standard.

Eighth, to the extent Ecology again plans to consider studies on the effects of elevated TDG levels on smallmouth bass and other resident fish, including northern pike minnow, it should explain its basis for considering these studies. If Ecology is identifying these specific studies in order to use both smallmouth bass and northern pike minnow as stand-ins for species, which may or may not be native and may or may not be predators of salmon, it also should recognize that smallmouth bass and northern pike minnow (and presumably other native resident species which occupy the Snake and Columbia Rivers) are able to use depth compensation as well as or more effectively than juvenile salmonids to avoid potential adverse impacts from gas super saturation up to and including 125% TDG. This is especially important since these fish have thrived in the warm reservoirs above the dams in ways that would not occur in a free-flowing river and these species are significant predators of juvenile salmonids. Ecology may want to explain, for example, why it is concerned about impacts on smallmouth bass when they are not facing extinction and are actually contributors to the extinction risk facing salmonids, to a large extent because of the advantage an impounded river gives them.

Ninth, to the extent Ecology expects to address the effects of TDG on aquatic invertebrates in its EIS, it also should fully describe the numbers and spatial distribution of aquatic invertebrates as well as the likelihood that they will be present in significant numbers in dam tailraces where the current is strong and TDG levels are likely to approach 125% under a revised TDG standard.

Tenth, in its prior EIS for a short-term modification of the TDG standards, Ecology described a number of what it apparently considers relevant areas of uncertainty regarding the effects of allowing voluntary spill at levels of up to 125% TDG. As with most areas of scientific inquiry, there are always areas of uncertainty that can be identified. The issue is how relevant are these uncertainties to the decision at hand. Ecology's prior discussion of uncertainty does not address this and similar questions or describe the extent to which the CSS analyses (and other available information) indicate that the existing areas of uncertainty are not actually that material to a decision about whether to adopt a 125% tailrace TDG standard. For example, Ecology has stated that "further research may be necessary" to determine whether current levels of TDG are having an adverse impact on mainstem salmonid spawning but Ecology fails to identify where such spawning occurs and how and why a modification of tailrace TDG limits would affect TDG levels in these areas. As noted above, one of the most significant such areas is chum spawning below Bonneville dam where mitigation for potential TDG impacts is already in place.

Eleventh, Ecology has said in a prior EIS that eliminating the 115% forebay TDG standard and implementing a 120% TDG standard for 2019 on a flexible basis as proposed in the Spill Agreement would lead to a miniscule reduction in powerhouse encounters (and hence presumable a miniscule improvement in survival) as compared to 2018 spill and TDG levels. At the same time Ecology has reported that eliminating the forebay standard and allowing tailrace TDG up to 125%, even on a flexible basis, would reduce powerhouse encounters by about 20%, a larger (but still inadequate) change that should lead to correspondingly larger survival improvements. These statements support a modification of water quality standards to allow TDG levels up to 125% in the tailrace at each dam to better protect downstream migrating juveniles.

CONCLUSION

Voluntarily spilling water over the dams on the Snake and Columbia rivers during the juvenile migration seasons undeniably benefits salmon and steelhead. While spill can pose a risk to salmonids if TDG levels are too high, biological monitoring conducted over the last decade and more, as well as anecdotal evidence, demonstrates that tailrace TDG levels up to 125% do not negatively impact migrating salmonids, resident fish, or invertebrates. By contrast, the TDG levels currently allowed under Washington's water quality standards unnecessarily limit the benefits of spill for juvenile salmon and steelhead migrating downstream in the spring. We thus urge Ecology to analyze in its EIS and adopt a change to its water quality standards to eliminate a forebay TDG limit and allow TDG levels up to 125% of saturation in the tailrace of each of the eight dams on the lower Snake and lower Columbia Rivers beginning in 2020.

Thank you for your consideration of these comments.

Sincerely,

Todd D. True

cc: Bill Arthur, Sierra Club
Lauren Goldberg, Columbia Riverkeeper
Joseph Bogaard, Save Our Wild Salmon
Liz Hamilton, Northwest Sportfishing Industry Association

Oregon
Kate Brown, Governor

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29 May 2019

Heather Bartlett, Water Quality Program Manager
Washington Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Re:Comments on the Environmental Impact Statement scoping on the proposed amendment of the Total Dissolved Gas (TDG) criteria in the Snake and Columbia rivers

Dear Program Manager Bartlett:

On behalf of the Oregon Department of Fish and Wildlife (ODFW), I submit the following comments on the scope of the State of Washington's proposed rulemaking related to amending the TDG criteria for the lower Snake and lower Columbia rivers. Thank you for taking on this important process. This amendment by Ecology is vital for the successful full implementation the Columbia River Flexible Spill and Power Agreement (Agreement) supported by all regional state, tribal, and federal management partners.

The State of Oregon has long championed the documented benefits to outmigrating juvenile salmon of increased voluntary spill up to 125% TDG, as measured at the tailrace of the eight dams in the lower Snake and Columbia rivers. As spill increases, the number of powerhouses experienced by juvenile outmigrating salmon decreases as does the amount of time it takes to navigate the river, which leads to increased life-cycle survival. Even during periods of involuntary spill, empirical evidence gathered over the last 20+ years has not documented deleterious population level effects or exceedances of Gas Bubble Trauma criteria, at the 125% TDG levels under consideration by Ecology.

Oregon recognizes the importance of increased spill to improved salmon smolt-to-adult return rates (SARs) and is committed to the full implementation of the Agreement, which recognizes the importance of balancing fish and power benefits. In the first year of the Agreement, modeled fish benefits needed to be at least as good as those experienced during court ordered 2018 hydro-system operations. In the out-years of the agreement (2020-2021), modeled fish benefits need to be *greater* than the court ordered 2018 operations. For the Agreement to achieve those necessary fish benefits, increased tailrace TDG limits (to 125%) must be allowed; however, the agreement does not contemplate spill to 125% TDG 24-hours per day, 7-days per week at all 8 dams to achieve these benefits.

ODFW recognizes that Washington is evaluating many factors as it considers this rule change—e.g., increasing the forage base for critically endangered southern resident killer whales as well allowing for implementation of the Agreement—but we are also keenly interested in being able to increase spill up to 125% TDG in time for the 2020 spill season as laid out in the Agreement. To the extent that the permanent rule change process being considered by Ecology includes Environmental Protection Agency review, and may require additional coordination and consultation with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service, please consider this additional federal regulatory agency coordination when planning approval timelines, and use an appropriate scope to avoid any timing setbacks that could occur as a result of this additional coordination and approval. ODFW would also support short-term rulemaking or a separate process to ensure that the parties can continue to implement the Agreement.

Thank you for the opportunity to provide these comments, and for undertaking this important endeavor. As always, Oregon looks forward to working with Washington to help restore the iconic species and natural resources that define our region.

Sincerely,

Tucker A. Jones
Ocean Salmon and Columbia River Program Manager
Oregon Department of Fish and Wildlife

Attachments
c: Jason Miner, Natural Resources Policy Manager, Governor's Office
Richard Whitman, Director, Oregon Department of Environmental Quality
Curt Melcher, Director, Oregon Department of Fish and Wildlife

Columbia River Inter-Tribal Fish Commission

Please see attached comments from The Columbia River Inter-Tribal Fish Commission. Thank you for this opportunity to submit these comments.

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION

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May 29, 2019

Susan Braley
Water Quality Standards Coordinator
Washington Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Dear Ms. Braley:

The Columbia River Inter-Tribal Fish Commission (CRITFC) is looking forward to continuing to work with and assist Washington and Oregon to ensure that modifications of their current water quality standards voluntary spill for juvenile fish passage.

Increased spill levels 125% TDG as measured at the hydro project tailraces have proven to benefit migrating juvenile salmon and steelhead. Our conclusion is based on the best available scientific information about the results of spill and the effects of TDG levels. Significant benefits to salmon and steelhead adult-to-survival and adult abundance are anticipated from increased spill and subsequent decreased powerhouse encounter rate. There are frequent periods of involuntary spill at or exceeding 125% TDG, with the data showing that the incidence of Gas Bubble Trauma (GBT) increases do not reach levels of concern until TDG is at or above 130%.

CRITFC's scientists have documented these conclusions based on thorough collection and analyses of the best available information. Some of this work appears in the following reports, which we request to be included in your record:

CRITFC, *Wy-Kan-Ush-Mi Wa-Kish Wit* (2014 Update) p. 130. https://plan.critfc.org/assets/wy-kan-update.pdf

> Data collected from 1995 to the present still supports the original 1995 risk assessment that levels of TDG up to 125% pose little risk to aquatic species. The higher standard allows for more spill and associated passage survival benefits; the tribes continue to advocate for the higher levels of TDG up to 125% in the tailrace. p. 130

Comparative Survival Study Oversight Committee, Documentation of Experimental Spill Management: Models, Hypotheses, Study Design, and response to ISAB. May 8, 2017. http://www.fpc.org/documents/CSS/30-17.pdf

> Combined, these results show no evidence that TDG levels reduce in-river survival over the range of TDG levels that have been observed during 1998-2015, which have ranged up to average levels of 123% and maximum levels of 133% (Figures 3.3 and 3.4). p. 35

Putting fish back in the rivers and protecting the watersheds where fish live

Comparative Survival Study Oversight Committee and Fish Passage Center: Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye 2017 Annual Report, December 2017

> We have shown that increasing from BiOp to 115%/120% levels could lead to about a 50% increase in return abundances without breach, and spill to a 125% TDG level could lead to about a 2.5- to 3-fold increase depending on productivity and capacity. p. 60

CRITFC would be pleased to meet with the Washington Department of Ecology to address technical or policy matters associated with your proposed rulemaking. In addition, we reiterate CRITFC's commitment to assist with spill effects monitoring described in our letter of February 28, 2019.

Thank you very much for the opportunity to submit these comments.

Sincerely,

Jaime A. Pinkham
Executive Director

Cc: Richard Whitman, Director, ODEQ
Guy Norman, Washington Council Member, NPCC
Ed Bowles, Division Administrator, ODFW
Ben Zelinsky, Senior Policy Advisor, BPA
Tim Dykstra, Northwest Division, USACE

Nez Perce

TRIBAL EXECUTIVE COMMITTEE
P.O. BOX 305 • LAPWAI, IDAHO 83540 • (208) 843-2253

29 May 2019

Submitted at: http://ws.ecology.commentinput.com

Susan Braley
Water Quality Program
State of Washington Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Re: ***Nez Perce Tribe's Scoping Comments on Water Quality Standards Modification to the Total Dissolved Gas Criteria in the Snake and Columbia Rivers***

Dear Ms. Braley:

The Nez Perce Tribe (Tribe) is writing to submit the following scoping comments on the Washington State Department of Ecology's (Ecology's) consideration of modification of the total dissolved gas (TDG) criteria in the Snake and Columbia rivers. The Tribe is accepting Ecology's invitation to consult on a government-to-government basis, and submits these comments in addition to that process.

The Tribe and the Columbia River Inter-Tribal Fish Commission are among those who have requested a modification to this standard. The Tribe has long supported voluntary spill of up to 125% TDG as measured at the tailrace while salmon and steelhead are migrating downstream, based on the best available scientific information about the benefits of spill and the effects of TDG levels. Strong benefits to salmon and steelhead smolt-to-adult survival and adult abundance are anticipated from increased spill and subsequent decreased powerhouse encounter rate (PITPH). There are commonly periods of involuntary spill at and exceeding 125% TDG, with the data and evidence showing that the incidence of GBT increases do not reach levels of concern until TDG is at or above 130%.

The Tribe looks forward to continuing to work with and assist Washington and Oregon to ensure that modifications of the current standards up to 125% TDG are in place in advance of the 2020 spring spill season (approximately April 1 through June 20). The Tribe invites you to contact our staff (David B. Johnson, Manager, and Jay Hesse, Research Division Director, in the Tribe's Department of Fisheries Resources Management) to discuss this issue.

Sincerely,

Mr. Shannon F. Wheeler
Chairman

cc: Maia D. Bellon, Director, WA State Dept. of Ecology
Heather R. Bartlett, Water Quality Program Manager, WA State Dept. of Ecology
Tom Laurie, Tribal and Environmental Affairs, WA State Dept. of Ecology
Chad Brown, Rulemaking Lead, WA State Dept. of Ecology
Richard Whitman, Director, OR State Dept. of Environmental Quality

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NORTHWESTERN DIVISION
PO BOX 2870
PORTLAND, OR 97208-2870

May 29, 2019

SUBJECT: Environmental Impact Statement scoping comments on the proposal to amend the Numeric Criteria for total dissolved gas (TDG) in the Snake and Columbia Rivers

Heather Bartlett
Water Quality Program Manager
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Dear Ms. Bartlett:

On behalf of the U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration, collectively referred to as the Action Agencies (AAs), I submit the following comments on the scope of the State of Washington's (Washington) proposed rulemaking related to amending the numeric criteria for total dissolved gas (TDG) in the lower Snake and lower Columbia rivers. The AAs believe that Washington should align the proposed rulemaking with the scope of the 2019-2021 Spill Operation Agreement (Agreement) (attached), to ensure that the parties to the Agreement can continue to implement the Agreement through the 2020 spring fish passage spill season. The Agreement, signed and endorsed by the AAs, the states of Oregon and Washington, and the Nez Perce Tribe, represents an innovative approach to managing the Columbia River System that balances and optimizes multiple important regional values. The AAs are committed to the principles underlying the Agreement – implementation of a flexible approach to providing spill intended to benefit salmonids while managing the Columbia River System for multiple congressionally-authorized purposes, including hydropower generation – and appreciate Washington's efforts to facilitate continued implementation of the Agreement. The Agreement expires upon the signature of the AAs Record of Decision on the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS).

In December 2018, the states of Washington and Oregon, the AAs, and the Nez Perce Tribe collaboratively developed the Agreement with the following objectives in mind:

1. Provide fish benefits, with the understanding that (i) in 2019, overall juvenile fish benefits associated with dam and reservoir passage through the lower Snake and Columbia rivers during the spring fish passage season must be at least equal to 2018 spring fish passage spill operations ordered by the Court, and (ii) in 2020 and 2021,

these fish benefits are improved further (as estimated through indices listed in the Agreement);

2. Provide federal power system benefits as determined by Bonneville, with the understanding that Bonneville must, at a minimum, be no worse financially compared to the 2018 spring fish passage spill operations ordered by the Court; and

3. Provide operational feasibility for the Corps implementation that will allow the Corps to make appropriate modifications to planned spring fish passage spill operations.

The Agreement contemplates incorporating "spill up to and including 125% TDG as a tool for spring fish passage spill season" into 2020 operations, subject to state TDG water quality standard changes. See Agreement Section VI.C.1. However, the Agreement does not contemplate 125% TDG spill on a 24-hour, 7-day basis simultaneously at all lower Columbia River projects and lower Snake River projects. "Such an operation would be inconsistent with the flexible spill and power objectives that are central to this Agreement." See Agreement Section VI.C.1. To avoid this result, the Agreement utilizes flexible periods of spill, with the daily cumulative duration of spill to the state TDG water quality standard limited to 16 hours per day. See Agreement Attachment Table 1.1 Key points and Tables 1.3a and b. For consistency with the Agreement and its underlying objectives, Washington should align the proposed rulemaking to be limited to a change for only the spring fish passage spill season (generally April 3-June 20) and to limit any potential increase in the TDG criteria up to 16 hours per day.

Additionally, Washington should limit the duration of the proposed rulemaking to be consistent with the duration of the Agreement, which expires upon the signature of the AAs' Records of Decision on the CRSO EIS. Three main reasons support this point. First, the AAs – in conjunction with Washington, as a cooperating agency – are currently analyzing the impacts to affected resources from varying levels of spill. This analysis will help identify a long-term strategy for Columbia River System operations. Given the uncertainty surrounding future Columbia River System operations, making a change to Washington's TDG water quality standard that will continue to apply following the conclusion of the CRSO EIS process is premature. In particular, the AAs are concerned with making assumptions about future Columbia River System operations before the CRSO EIS analysis is complete. Second, a limited duration would enable lessons learned from implementation of higher levels of spring fish passage spill to be incorporated into a longer term rule change, if warranted. This factor is particularly important given the potential adverse effects of high TDG levels on aquatic species. Third, the AAs are concerned that Washington's proposed process for a permanent rule change – including required EPA reviews and associated coordination with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service – realistically may not be completed in time to allow for federal implementation of the Agreement in 2020. Consistent with the Agreement, we request that Washington coordinate closely with the federal regulatory agencies to achieve the principles outlined in the Agreement.

The AAs have greatly appreciated Washington's participation in the CRSO EIS process as a cooperating agency, as well as our collaborations on many different issues impacting the Columbia River System. We look forward to continuing to work closely with Washington as we each complete our respective EIS processes.

Sincerely,

D. Peter Helmlinger, P.E.
Brigadier General, USA
Division Commander

Encls:
2019-2021 Spill Operation Agreement

cc:
Guy Norman, State of Washington Representative, Northwest Power and Conservation Council
Maia Bellon, Director, Washington Department of Ecology
Michael Garrity, Columbia River Water Policy Manager, Washington Department of Fish & Wildlife

Appendix B: Executive Summary of the Comparative Survival Study

Appendix B contains the Executive Summary of the annual report of smolt-to-adult salmon and steelhead survival through dams on the Snake and Columbia rivers completed by the Fish Passage Center. The full report, called “Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye, 2017 Annual Report” is available online at http://www.fpc.org/documents/CSS/CSS_2017_Final.pdf.

Appendix C: List of Native and Non-native Fish Species in the Columbia River

Native Fish Species:

- Pacific lamprey
- Western brook lamprey
- White sturgeon
- Mountain whitefish
- Bull trout
- Cutthroat trout
- Steelhead
- Rainbow trout
- Chinook salmon
- Coho salmon
- Sockeye salmon
- Chum salmon
- Chiselmouth
- Northern pikeminnow
- Redside shiner
- Peamouth
- Longnose dace
- Speckled dace
- Leopard dace
- Umatilla dace
- Tui chub
- Oregon chub
- Largemouth sucker
- Bridgelip sucker
- Longnose sucker
- Mountain sucker
- Eelpout
- Three-spine stickleback
- Sand roller
- Prickly sculpin
- Torrent sculpin
- Paiute sculpin
- Margined sculpin
- Mottled sculpin
- Reticulate sculpin
- Shorthead sculpin
- Slimy sculpin
- Coastrange sculpin

Non-native Fish Species

- American shad
- Lake whitefish
- Brown trout
- Brook trout
- Lake trout
- Northern pike
- Grass pickerel
- Carp
- Goldfish
- Tench
- Channel catfish
- Brown bullhead
- Yellow bullhead
- Black bullhead
- Tadpole madtom
- Banded killifish
- Western mosquitofish
- Smallmouth bass
- Largemouth bass
- Bluegill
- Pumpkinseed
- Black crappie
- White crappie
- Yellow perch
- Walleye
- Fathead minnow
- Grass carp
- Northern pike

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