DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NORTHWESTERN DIVISION
P.O. BOX 2870
PORTLAND, OREGON 97208-2870

March 8, 2019

Mr. Barry Thom
Regional Administrator
National Oceanic and Atmospheric Administration
NOAA Fisheries, West Coast Region
1201 NE Lloyd Blvd, Suite 1100
Portland, Oregon 97232

Dear Mr. Thom:

The U.S. Army Corps of Engineers (Corps) is submitting, on behalf of the Bureau of Reclamation (Reclamation) and the Bonneville Power Administration (Bonneville) (collectively termed the Action Agencies) additions to the proposed action submitted to you November 2, 2018 as part of the consultation package. The Action Agencies are responsible for consulting with the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) on proposed Federal actions that may affect species listed under the Endangered Species Act (ESA) or their designated critical habitat. As you are aware, on November 2, 2018, the Action Agencies requested initiation of formal consultation with NOAA Fisheries under Section 7(a)(2) of the ESA, and submitted a consultation package entitled *ESA Section 7(a)(2) Initiation of Formal Consultation for the Operations and Maintenance of the Columbia River System on NOAA Fisheries Listed Species and Designated Critical Habitat*. The Action Agencies also requested consultation under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson Stevens Act).

Subsequently, on December 19, 2018, the Action Agencies submitted a partial modification to the November 2, 2018 proposed action to include a flexible spill operation at the lower four Snake River and lower four Columbia River dams and requested preparation of a Biological Opinion on that basis by March 31, 2019. We also requested consultation under the Magnuson-Stevens Fishery Conservation and Management Act be based on this partial modification of the proposed action.

As coordination with your staff has progressed since initiating formal consultation, four additional conservation measures have been identified that the Action Agencies would like to add to the existing proposed action.

First, the Action Agencies would like to add the action of land-based hazing of pinnipeds at The Dalles Dam. Currently, only land-based hazing of pinnipeds below

Bonneville Dam is included in the November 2 proposed action, however, some pinnipeds are also present below The Dalles Dam during key times of the year when large numbers of adult salmon and steelhead are migrating. Adding this action at The Dalles Dam would enable the Action Agencies to haze individuals at this project with the intent of reducing the predation of adult salmon and steelhead by these individuals.

Second, the Action Agencies propose to initiate limited monitoring of Total Dissolved Gas (TDG) levels in holding raceways at collector projects where fish are held after collection for loading onto transport barges and in the barges themselves during transportation. Subject to a short-term water quality standard modification by the State of Washington, the Action Agencies anticipate that spill up to the 120% total dissolved gas (TDG) cap for 16 hours per day under flex spill operations will increase ambient river TDG levels below the eight fish passage dams. Additionally, in 2020, spill levels could increase up to the 125% TDG cap, further increasing ambient TDG levels. Since river water is circulated through both the holding raceways and the transport barges, the Action Agencies propose this limited monitoring to determine if fish entering either the raceways and/or barges are exposed to elevated levels of TDG.

Third, the design, construction, and installation of a spillway PIT tag monitoring system is currently underway at Lower Granite Dam. It was anticipated that this project would be completed prior to the 2019 fish passage season, but delays have extended the completion date at least into 2020. The November 2 proposed action anticipated that construction of the monitoring system would have been completed and proposed only post-construction evaluation monitoring of the system as part of the action. The Action Agencies request that the proposed action include the ongoing design, construction, and installation of the monitoring system.

Finally, the Action Agencies are proposing a study to evaluate the effectiveness of providing a limited amount of surface spill at McNary Dam in September and October to pass adult steelhead that overshoot the John Day River and pass back over the dam through surface spill so they can return to their spawning tributary. A study design is currently under development within the Studies Review Work Group and will be initiated in September 2019 utilizing one spillbay equipped with a spillway weir.

The Action Agencies do not anticipate these measures will alter the proposed system operations submitted to you on November 2, 2018 and partially modified on December 19, 2018. These conservation measures are intended to be beneficial to salmonids and informative in nature. Please consider these additional conservation measures as you complete your Section 7 ESA and Magnuson Stevens Act analysis of the proposed action.

I am forwarding a copy of this letter to Mr. Michael P. Tehan, Assistant Regional Administrator, NOAA Fisheries Interior Columbia Basin Office, 1201 NE Lloyd Blvd., Suite 1100, Portland, Oregon 97232; Mr. Scott Armentrout, Vice President, Environment, Fish and Wildlife, Bonneville Power Administration, P.O. Box 3621, Portland, Oregon 97208-3621; Mr. Kieran Connolly, Vice President, Generation Asset Management, Bonneville Power Administration, P.O. Box 3621, Portland, Oregon 97208-3621; Ms. Lorri Gray, Regional Director, Bureau of Reclamation, Pacific Northwest Regional Office, 1150 North Curtis Rd. Suite 100, Boise, Idaho 83706-1234; and Mr. David Mabe, Deputy Regional Director, Bureau of Reclamation, Pacific Northwest Regional Office, 1150 North Curtis Rd. Suite 100, Boise, Idaho 83706-1234.

If you have any questions or would like to discuss our request, please contact Mr. Timothy A. Dykstra of my staff at 503-808-3726 or timothy.a.dykstra@usace.army.mil, Ms. Lesa Stark of Reclamation at 208-378-5378 or lstark@usbr.gov, or Mr. Benjamin D. Zelinsky of Bonneville at 503-230-4737 or bdzelinsky@bpa.gov. Thank you for your consideration of our request. We look forward to our continued work with NOAA Fisheries on the consultation regarding the effects of the operation and maintenance of the Columbia River System.

Sincerely,

David J. Ponganis, SES
Director, Programs

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, NORTHWESTERN DIVISION
P.O. BOX 2870
PORTLAND, OREGON 97208-2870

Mr. Barry Thom
Regional Administrator
National Oceanic and Atmospheric Administration
NOAA Fisheries, West Coast Region
1201 NE Lloyd Blvd, Suite 1100
Portland, Oregon 97232

Dear Mr. Thom:

The U.S. Army Corps of Engineers (Corps) makes the following request on behalf of the Bureau of Reclamation (Reclamation) and the Bonneville Power Administration (Bonneville) (collectively termed the Action Agencies). The Action Agencies are responsible for consulting with the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) on proposed Federal actions that may affect species listed under the Endangered Species Act (ESA) or their designated critical habitat. As you are aware, NOAA Fisheries' 2008 Biological Opinion (as supplemented in 2010/2014) and incidental take coverage for the Action Agencies' management of the Columbia River System expire December 31, 2018.

On November 2, 2018, the Action Agencies requested initiation of formal consultation with NOAA Fisheries under Section 7(a)(2) of the ESA, and submitted a consultation package entitled *ESA Section 7(a)(2) Initiation of Formal Consultation for the Operations and Maintenance of the Columbia River System on NOAA Fisheries Listed Species and Designated Critical Habitat*. The Action Agencies also requested consultation under the Magnuson-Stevens Fishery Conservation and Management Act.

That request for initiation of consultation noted the Action Agencies were engaged in "discussions with regional sovereigns to explore alignment around a potential alternative spring spill operation, the goal of which is to find a balance between increased spill for listed salmon and steelhead, increased power generation during periods of high demand, and increased implementation feasibility for the operation of the Columbia River System." As a result of those discussions, the Action Agencies, with the states of Oregon and Washington and the Nez Perce Tribe, have developed a *2019-2021 Spill Operation Agreement*, a copy of which is attached. This agreement affects only the spill and hydropower operations at the lower Snake River and lower Columbia River projects, together with a provision calling for cessation of transport operations in July and parts of June and August of 2020 and 2021 with an allowance for adaptive management through the established Regional Forum processes. The agreement does not alter any other aspect of the November 2, 2018, consultation package.

The Action Agencies are submitting the attached agreement as a partial modification to the proposed action in the November 2, 2018, consultation package, and request preparation of a Biological Opinion on that basis by March 31, 2019. We also request consultation under the Magnuson-Stevens Fishery Conservation and Management Act be based on this partial modification of the proposed action.

The Action Agencies understand this change to the proposed action will impact NOAA Fisheries' intent to prepare a new Biological Opinion prior to the expiration of the existing 2008 Biological Opinion. The Action Agencies have made no significant changes to dam operations for January through March analyzed in the 2008 Biological Opinion (as supplemented). The Action Agencies are implementing the operations and complying with the reasonable and prudent measures and terms and conditions of the applicable Incidental Take Statement (ITS). The Action Agencies also are not aware of any significant changes in the information and analyses relied upon during the previous consultation. We therefore request that NOAA Fisheries ensure that incidental take associated with continued operation of the Columbia River System in the interim can be exempt from ESA section 9 prohibitions. Doing so will allow sufficient time for NOAA Fisheries to incorporate analysis of the spill, hydropower, and transport operations in the attached agreement into the current consultation on the Columbia River System.

I am forwarding a copy of this letter to Mr. Michael P. Tehan, Assistant Regional Administrator, NOAA Fisheries Interior Columbia Basin Office, 1201 NE Lloyd Blvd., Suite 1100, Portland, Oregon 97232; Mr. Scott Armentrout, Vice President, Environment, Fish and Wildlife, Bonneville Power Administration, P.O. Box 3621, Portland, Oregon 97208-3621; Mr. Kieran Connolly, Vice President, Generation Asset Management, Bonneville Power Administration, P.O. Box 3621, Portland, Oregon 97208-3621; Ms. Lorri Gray, Regional Director, Bureau of Reclamation, Pacific Northwest Regional Office, 1150 North Curtis Rd. Suite 100, Boise, Idaho 83706-1234; and Mr. David Mabe, Deputy Regional Director, Bureau of Reclamation, Pacific Northwest Regional Office, 1150 North Curtis Rd. Suite 100, Boise, Idaho 83706-1234.

If you have any questions or would like to discuss our request, please contact Mr. Timothy A. Dykstra of my staff at 503-808-3726 or timothy.a.dykstra@usace.army.mil, Ms. Lesa Stark of Reclamation at 208-378-5378 or lstark@usbr.gov, or Mr. Benjamin D. Zelinsky of BPA at 503-230-4737 or bdzelinsky@bpa.gov. Thank you for your consideration of our request. We look forward to our continued work with NOAA Fisheries on the consultation regarding the effects of the operation and maintenance of the Columbia River System.

Sincerely,

David J. Ponganis, SES
Director, Programs

Enclosure

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Attorneys for Federal Defendants

UNITED STATES DISTRICT COURT
DISTRICT OF OREGON
PORTLAND DIVISION

NATIONAL WILDLIFE FEDERATION, et al.,

Plaintiffs,

v.

NATIONAL MARINE FISHERIES SERVICE, et al.,

Defendants.

Case No.: 3:01-CV-00640-SI

STATUS REPORT RE: 2019-2021 SPILL OPERATIONS AGREEMENT DURING THE NEPA REMAND PERIOD

Federal Defendants, Oregon, Washington, and the Nez Perce Tribe submit this status report to notify the Court that the U.S. Army Corps of Engineers, the Bonneville Power Administration, the U.S. Bureau of Reclamation, Oregon, Washington, and the Nez Perce Tribe ("signatory parties") have reached an agreement on fish passage spill operations and related matters during the remainder of the National Environmental Policy Act (NEPA) remand period. For context and informational purposes only,[1] the agreement is attached as Exhibit 1 ("Agreement"). The Agreement reflects the intent of the signatory parties to set aside differing positions and work collaboratively on fish passage spill operations during the NEPA remand period. *See generally* Exhibit 1. The Agreement has two other effects that relate to this litigation:

1. The U.S. Army Corps of Engineers, Bonneville Power Administration, and the U.S. Bureau of Reclamation (Action Agencies) will modify their proposed action that is the subject of an ongoing Section 7(a)(2) Endangered Species Act (ESA) consultation with the National Marine Fisheries Service (NMFS). The modified proposed action will identify the fish passage spill operations documented in the Agreement, and NMFS intends to complete an ESA consultation before spring fish passage spill operations begin in April 2019.[2] In the interim, the Action Agencies and NMFS will take any necessary administrative steps to address incidental take occurring between the expiration of the 2008/2014 biological opinion and NMFS's completion of consultation in April

[1] As the signatory parties provided in the Agreement, the Agreement is not intended to constitute a consent decree, be entered as a Court order, or be enforceable in this action. Exhibit 1 at IX.C.2, X.C. If the Court enters any of the provisions of the Agreement as a Court order, the Agreement automatically terminates. *Id.* Federal Defendants, moreover, object to the entry of an order adopting or modifying any of the provisions of the Agreement, and Federal Defendants request an opportunity to be heard if the Court considers entering an order adopting or modifying any of the terms of the Agreement.

[2] The agencies previously anticipated completing the ESA consultation process by the end of December 2018. *See* ECF 2271 (discussing the ongoing ESA consultation and Federal Defendants' intent to complete that consultation on or before December 31, 2018).

2019. The signatory parties believe these procedural adjustments are compatible with the Court's April 17, 2018, Order that removed the December 31, 2018, consultation deadline. *See* ECF 2288.

2. While this Agreement is in effect, the signatory parties agree not to engage in any litigation—including filing supplemental complaints or seeking declaratory or injunctive relief—during the NEPA remand period as described in Exhibit 1 at X.A. The undersigned parties conferred with the other parties consistent with LR 7-1(a). The National Wildlife Federation, *et al.*, Plaintiffs represented that they also do not intend to engage in any litigation in the above-captioned case during the NEPA remand period—including filing supplemental complaints or seeking declaratory or injunctive relief—while this Agreement is in effect.[3]

In sum, the Agreement reflects that the signatory parties are working collaboratively on fish passage spill operations and related matters during the NEPA remand period. While this Agreement is in effect, the signatory parties and the National Wildlife Federation, *et al.*, Plaintiffs do not intend to engage in any litigation. If these circumstances change (*e.g.*, the Agreement terminates), the signatory parties will notify the Court.

Dated: December 18, 2018

BILLY J. WILLIAMS, OSB #901366
United States Attorney
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U.S. Department of Justice
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[3] The Confederated Tribes of the Umatilla Reservation, the Confederated Tribes of the Warm Springs, and the State of Idaho indicated that they support the Agreement. The Confederated Salish and Kootenai Tribes, the Kootenai Tribe of Idaho, and the State of Montana collectively do not oppose the Agreement so long as its implementation does not adversely affect or preclude the improvement of the Montana Operations. The remaining defendant-intervenors or amici indicated that they do not oppose/take no position (Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Colville Reservation, Northwest RiverPartners, Inland Ports and Navigation Group) or did not respond.

JEAN E. WILLIAMS
Deputy Assistant Attorney General
SETH M. BARSKY, Section Chief

/s/ Michael R. Eitel
MICHAEL R. EITEL, Senior Trial Attorney
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Senior Counsel
Attorneys for Intervenor-Defendant State of Washington

CERTIFICATE OF SERVICE

I certify that on December 18, 2018, the foregoing was electronically filed through the Court's electronic filing system, which will generate automatic service on all Parties enrolled to receive such notice. I also certify that the following will be manually served via overnight mail:

Dr. Howard F. Horton, Ph.D.
Professor Emeritus of Fisheries
Department of Fisheries and Wildlife
104 Nash Hall
Corvallis, Oregon, 97331-3803
Tel: (541) 737-1974

/s/ Michael R. Eitel
Michael R. Eitel
Trial Attorney, U.S. Department of Justice

2019-2021 Spill Operation Agreement

December 2018

I. PARTIES

For purposes of this 2019-2021 Spill Operation Agreement (Agreement), the "Parties" means the State of Oregon, the State of Washington, the Nez Perce Tribe, the U.S. Army Corps of Engineers (Corps), the U.S. Bureau of Reclamation (Reclamation), and the Bonneville Power Administration (Bonneville).

II. PURPOSE

This Agreement describes planned 2019-2021 spring fish passage spill operations, using the flexible spill and power principle and objectives described below, and is intended to avoid litigation until the National Environmental Policy Act remand process (commonly referred to as the Columbia River System Operations Environmental Impact Statement and associated Records of Decision) ordered by the United States District Court for the District of Oregon in *National Wildlife Federation v. National Marine Fisheries Service*, Case No. 3:01-cv-00640, (*NWF et al v. NMFS*) is completed.

The Parties have entered into this Agreement in the spirit of regional collaboration with the shared goal of meeting the principles and objectives described below. In order for this collaboration to be possible, the Parties emphasize that, when this Agreement is not in effect, this Agreement is not intended to be used in any litigation or other forum as precedent for, or an endorsement of, any operation, and this Agreement does not represent an endorsement of any biological opinion NOAA Fisheries issues regarding the Columbia River System.

III. FLEXIBLE SPILL AND POWER PRINCIPLE AND OBJECTIVES

A. The principle central to this Agreement is implementing a flexible approach to providing spill to benefit juvenile spring fish passage in concert with managing the Columbia River System for multiple congressionally-authorized purposes, including power generation to assure the Pacific Northwest of an adequate, efficient, economical, and reliable power supply.

B. To fulfill this principle, and solely for purposes of this Agreement, the Parties have adhered, and will continue to adhere, to the following objectives in establishing the planned fish passage spill operations described in this Agreement:

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 of

improved smolt-to-adult returns, e.g., PITPH, reservoir reach survival, fish travel time); and

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;[1] 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.[2]

IV. DEFINITIONS

A. "Action Agencies" means the Corps, Reclamation, and Bonneville. These agencies jointly manage Columbia River System operations.

B. "Columbia River System" refers to the fourteen federal dam and reservoir projects within the Federal Columbia River Power System that are operated as a coordinated water management system for multiple congressionally-authorized project purposes.

C. "Fish" means salmon and steelhead species listed under the Endangered Species Act.

D. "Gas cap" refers to the applicable state Total Dissolved Gas (TDG) water quality standards (in percent TDG).

E. "Gas cap spill" means spill to the maximum spill level that meets, but does not exceed, the TDG criteria allowed under the applicable state water quality standard at the four Lower Snake River and four Lower Columbia River projects.

F. "Lower Columbia River projects" refers to McNary, John Day, The Dalles, and Bonneville dams.

G. "Lower Snake River projects" refers to Lower Granite, Little Goose, Lower Monumental and Ice Harbor dams.

H. "NEPA Remand Process" refers to development of the Columbia River System Operations Environmental Impact Statement. This Process will conclude upon the signature of Records of Decision by the Action Agencies.

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[1] Bonneville shall have sole discretion over how it conducts its financial analysis. Bonneville measured the financial cost of the 2018 Court-ordered operations using the methodology in Bonneville's rate proceedings for calculating the estimated average annual cost of additional planned spring fish passage spill in excess of planned spill levels in the Corps' 2017 Fish Operations Plan.

[2] As described in Section VI.A.

I. "PITPH" is the calculated probability, based on Passive Integrated Transponder (PIT) tag detections, that a juvenile fish will pass through one or more powerhouse routes on its outmigration. A PITPH of 0 signifies the fish is projected to pass through 0 of 8 turbines/bypasses and a PITPH of 8 signifies the fish passed through 8 of 8 turbines/bypasses.

J. "Spill cap" means the spill level (flow through the spillway measured in kcfs) at each project that the Corps estimates will maximize spill to a level that meets, but does not exceed, the Gas cap.

K. "120% TDG spill" means planned juvenile fish passage spill targeting the maximum level that meets, but does not exceed, the Gas cap for 120% TDG in the tailrace, with Spill caps derived by the Corps using the procedures referenced in Section VI.A, below.

L. "125% TDG spill" means planned juvenile fish passage spill targeting the maximum level that meets, but does not exceed, the Gas cap for 125% TDG in the tailrace, with Spill caps derived by the Corps using the procedures referenced in Section VI.A, below.

V. STATE WATER QUALITY STANDARDS

A. The TDG standard for the states of Washington and Oregon is 110%. Both states have provided exceptions to the TDG standard for juvenile fish passage spill operations on the lower Snake River and lower Columbia River. Oregon and Washington intend to work to harmonize their respective methodologies for measuring TDG for the duration of this Agreement. To the extent standards and/or methodologies differ between the two states, the Corps will apply the more stringent standard and/or methodology when operating under all applicable state TDG water quality standards. Oregon and Washington are responsible for any modifications to water quality standards that result from the processes contemplated below.

B. Washington:

1. Washington's current criteria adjustment standard provides that 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. WAC § 173-201A-200(l)(f)(ii).

2. Washington Department of Ecology (Ecology) is in the process of considering a short-term modification that eliminates Washington's current forebay TDG standard at the Lower Snake River projects and Lower Columbia River projects

and aligns Washington's calculation methodology with Oregon's current methodology. Ecology acknowledges that there is a desire for this short-term modification to be in effect on or before April 3, 2019, and will work to render a timely decision.

3. Ecology also intends to consider whether to allow spring juvenile fish passage spill up to 125% TDG (as read in the tailrace) under certain conditions. Ecology expects to make a decision on the modification up to 125% TDG prior to the beginning of the 2020 spring juvenile fish passage spill season.

C. Oregon:

1. Oregon's current standard modification provides that spill must be reduced when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 120% of saturation at monitoring stations in the tailraces of McNary, John Day, The Dalles, and Bonneville dams, and spill must be reduced when instantaneous TDG levels exceed 125% of saturation for any 2 hours during the 12 highest hourly measurements per calendar day at monitoring stations in the tailraces of McNary, John Day, The Dalles, and Bonneville dams. OR. ADMIN. R. 340-041-0031 and 340-041-104(3).

2. The Oregon Department of Environmental Quality (ODEQ) will ask the Oregon Environmental Quality Commission (EQC) to consider changing the current standard modification to allow spring juvenile fish passage spill up to 125% TDG (as read in the tailrace) at the four Lower Columbia River dams. This issue will be presented to the EQC in time for any potential modification to be in effect for the 2020 spring juvenile fish passage spill season.

VI. SPILL OPERATION

A. General Provisions for Implementing Planned Fish Passage Spill Operations

1. In implementing the planned fish passage spill operations, the Corps will use the process and procedures set forth in the annual Fish Operations Plan and Current Procedures for Setting Spill Caps to establish Spill caps and target spill levels.

2. In-Season Adjustments: In managing the Columbia River System for multiple congressionally-authorized project purposes, the Corps may adjust the planned fish passage spill operations to address conditions set forth in the section of the annual Fish Operations Plan entitled "Modifications to Planned Operations and In-Season Management."

B. 2019 Fish Passage Spill Operations

1. Spring Operations

a. To meet the flexible spill and power principle and objectives in Section III above, and if the conditions in Section IX.A and Section X are met, the Action Agencies will implement planned juvenile fish passage spring spill operations targeting the spill levels and times provided in **Attachment Table 1.1** in a manner consistent with the general spill implementation provisions in Section VI.A, above.

b. The Parties acknowledge that the 2019 spring spill operations set forth in this Agreement are contingent upon securing a modification to Washington's water quality standard as described in Section V.B, above.

2. Summer Operations

a. After implementing the juvenile fish passage spring spill operations in **Attachment Table 1.1**, the Action Agencies will then implement the 2019 planned juvenile fish passage summer operation shown in **Attachment Table 1.2**.

C. 2020 and 2021 Fish Passage Spill Operations

1. If the conditions in Sections V.B.3, V.C.2, IX.A, and X are met, and consistent with Section III, the Parties agree that 2020 and 2021 operations will incorporate spill up to and including 125% TDG as a tool for spring fish passage spill season. Collaborative technical work performed to date has identified representative spring spill operation scenarios. Preliminary analyses indicate these scenarios, which incorporate 125% TDG spill as a tool, meet the Section III principle and objectives (see **Attachment Tables 1.3a-b**).[3]

Building on further analysis of these representative scenarios and in consideration of 2019 results, the Parties will continue in good faith to evaluate the effect of different variables, such as project-specific spill levels and duration (both daily and seasonal), to refine 2020-2021 spring operations, and complete a final specific operations plan by September 1, 2019. If the Parties cannot agree on a refined operation, one of the two representative spring spill operations shown in **Attachment Tables 1.3.a-b** will be implemented in the 2020-2021 spill seasons

[3] Bonneville's analysis, in particular, is especially preliminary and has a high level of uncertainty. Bonneville's financial models were not designed to handle the data associated with daily changes in spill at 125% TDG spill. As a result, Bonneville does not yet have full confidence in the results of the models. Accordingly, the Parties recognize Bonneville will continue to revise its evaluation of the financial implications of any 125% TDG scenarios.

for such time as this Agreement remains in effect, or until the Parties can agree on refinements.

The representative operations shown in Attachment Tables 1.3.a-b do not incorporate 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.

2. The Parties presume that adjustments to summer spill operations in 2020-2021 will likely be necessary to meet the power-cost objective in Section III.B.2. To that end, the Parties have developed the operation reflected in **Attachment Table 1.4**. This operation is designed to meet the power-cost objective, while limiting potential reductions in spill to the last two weeks of August. The Parties agree that, subject to the iterative process specified in Section VI.C.1 above, this operation represents the maximum reduction in summer spill that is compatible with the Section III principle and objectives.

3. The Parties commit to ensuring their analyses are transparent and collaborative. For example, the Parties will continue to share and explain the assumptions and outputs of the biological and financial models, as well as information on any structural or operational constraints that may affect implementation of this Agreement.

4. The Parties acknowledge that implementation of 2020-2021 spring spill operations is contingent upon securing a modification to Washington and Oregon's water quality standards to allow for spill up to 125% TDG as described in Section V above.

VII. MONITORING

With regard to monitoring associated with this Agreement, the Parties agree that:

A. Monitoring activities for juvenile and adult salmon and steelhead relative to mainstem hydrosystem operations and conditions are generally in place. In addition, the Parties support the installation of a PIT tag detection array on the Lower Granite Removable Spillway Weir as soon as feasible, currently anticipated for use in 2020.

B. No additional PIT tagging is needed for analyses for spring/summer Chinook and steelhead. Additional PIT tagging, above current levels, may be desired for summer migrating fall Chinook and sockeye.

C. Enhanced sampling of resident fish, invertebrates, and amphibians may be desirable in 2019. Enhanced sampling activities that meet monitoring needs may be required in 2020-

2021. Existing monitoring of TDG and Gas Bubble Trauma in salmonids will continue. TDG and Gas Bubble Trauma monitoring may be enhanced if deemed necessary and funded.

D. Validation of fish behavior assumptions inherent in the modeled fish benefits relative to Spill Passage Efficiency are important and may require additional evaluation.

E. Possible approaches, study designs and funding sources of any new monitoring activities discussed in this Section VII are being explored and discussed, but any additional monitoring Bonneville agrees to fund for the purposes of this Agreement must be within Bonneville's existing overall Fish and Wildlife Program budget. The Corps will continue current monitoring commitments in furtherance of this Agreement.

VIII. REPORTING

A. The Fish Operations Plans for 2019, 2020 and 2021 will include the same reporting provisions as those set forth in the 2018 Fish Operations Plans. The Corps will provide status updates at the regularly scheduled Technical Management Team (TMT) meetings about the spring fish passage spill operations including review of the project Spill caps and resultant TDG level during the relevant time period. The Corps will address clarifying questions of the status update at the TMT meeting. In the event that a dispute results from the Corps' status update of the project Spill caps and resultant TDG level, that dispute should be expeditiously elevated by the Party seeking resolution of the dispute to the Regional Implementation Oversight Group (RIOG) in accordance with the established Regional Forum process.

B. Parties to this Agreement agree to participate in the Regional Forum process in a manner that is consistent with the established processes of those groups and is respectful to all participants.

IX. EFFECTIVE DATE, WITHDRAWAL AND TERMINATION

A. Effective Date.

This Agreement shall become effective where the following two conditions are met:

1. Signatures by the Parties to this Agreement, and

2. The filing of a notice with the U.S. District Court for the District of Oregon in *NWF et al v. NMFS*, that contains representations by the Parties to this Agreement and the National Wildlife Federation, et al., plaintiffs that they do not intend to file or engage in any litigation in *NWF et al v. NMFS* while this Agreement is in effect.

B. Withdrawal.

Any Party may withdraw following conferral and notice pursuant to Section XI below, upon the occurrence of any of the following:

1. The Action Agencies do not continue to implement habitat, hatchery, and monitoring and evaluation actions that provide an equivalent level of protection to fish and wildlife as they are currently implementing under the Action Agencies' 2008 Records of Decision or Record of Consultation and Statement of Decision for the Columbia River System, as supplemented in 2010 and 2014, to the satisfaction of Oregon, Washington or the Nez Perce Tribe.

2. Failure to satisfy any of the conditions or commitments set forth in this Agreement.

3. A Reasonable and Prudent Alternative action providing a fish passage spill operation inconsistent with the provisions of this Agreement, which either U.S. Fish and Wildlife Service or NOAA Fisheries issues following an ESA consultation.

4. While this Agreement is in effect, the filing of any complaint or motion for declaratory, injunctive, or other relief in *NWF et al v. NMFS*, or the initiation of any new action in any court that relates to actions or operations addressed in NOAA Fisheries' 2008 Columbia River System biological opinion and the Action Agencies' 2008 Records of Decision or Record of Consultation and Statement of Decision, as supplemented in 2010 and 2014.

C. Termination.

1. The Agreement terminates automatically upon the completion of the NEPA Remand Process.

2. The Agreement terminates automatically should the Court in *NWF et al v. NMFS* modify the terms of this Agreement in any manner, including adopting some or all of the terms of the Agreement as a court order.

3. If modification of Washington or Oregon's water quality standards does not occur, any Party may terminate this Agreement.

4. If any Party withdraws from this Agreement pursuant to Section IX.B., above, the Agreement may be terminated by any Party following conferral and notice of termination pursuant to Section XI below.

X. FORBEARANCE, RESERVATION OF RIGHTS, NO PRECEDENTIAL EFFECT

A. While this Agreement is in effect, the State of Oregon and Nez Perce Tribe agree to forbear from filing motions or seeking relief (including declaratory or injunctive relief) in *NWF et al v. NMFS*, and from filing any new action in any court that relates to actions or operations addressed in NOAA Fisheries' 2008 Columbia River System biological opinion and the Action Agencies' 2008 Records of Decision or Record of Consultation and Statement of Decision, as supplemented in 2010 and 2014.

B. Nothing in this Agreement alters or modifies the Parties' rights (including any claims or defenses) in *NWF et al v. NMFS* or any other forum, and no Party makes any concessions regarding the legal validity, scientific validity, or economic cost/benefit of the spill operations contemplated in this Agreement, the Columbia River System Operations Environmental Impact Statement, or any biological opinion NOAA Fisheries issues on the Columbia River System.

C. The Parties agree that this Agreement is not intended to be construed as a consent decree enforceable as a court order in *NWF et al v. NMFS*, or otherwise cited or used as precedential on any legal or factual matter in *NWF et al v. NMFS*. The sole and exclusive remedy for any alleged breach or unresolved dispute under this Agreement (following good faith efforts by the Parties to resolve the dispute pursuant to Section XI below) is to withdraw from the Agreement.

D. Nothing in this Agreement shall be interpreted as or constitutes a commitment or requirement that Reclamation, the Corps, or Bonneville pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. § 1341.

E. Nothing in this Agreement shall be interpreted as limiting the authority granted to, or retained by, the State of Oregon or the State of Washington under the Federal Water Pollution Control Act (Clean Water Act) (33 U.S.C.§§ 1251-1387).

F. Nothing in this Agreement shall be construed as a waiver of any Party's sovereign immunity.

XI. MEET AND CONFER

A. The Parties agree to communicate the provisions of the Agreement to appropriate staff and work in good faith through existing RIOG coordination and adaptive management processes to implement the terms of this Agreement.

B. The Parties agree that a Party may exercise its withdrawal or termination options only after: (1) informing the Parties in writing of the issue to be addressed; (2) working in good faith with the Parties to resolve the issue; and (3), where the issue cannot be resolved, provide written notice to the Parties that the Party is withdrawing from or terminating the Agreement.

C. As detailed in Section VIII, any disputes arising out of the Corps' status updates on project spill caps and resultant TDG level from spring fish passage spill operations at the regularly scheduled TMT meetings should be immediately elevated to the RIOG in accordance with the established Regional Forum process by the Party seeking resolution of a dispute. RIOG meetings to resolve any disputes will be conducted as appropriate under that established process.

XII. SIGNATURES

By signing below, the Parties represent they affirmatively support this Agreement and its implementation.

The signatures of the State of Oregon, the State of Washington, the Nez Perce Tribe, Reclamation, the Corps, and Bonneville appear on the following pages 11-16.

OREGON

December 13, 2018

Kate Brown
Governor
State of Oregon

Date

NEZ PERCE TRIBE

12-14-18

Shannon F. Wheeler
Chairman
Nez Perce Tribe

Date

12-14-18

Casey L. Mitchell
Secretary
Nez Perce Tribe

Date

WASHINGTON

Dec 12, 2018

Jay Inslee
Governor
State of Washington

Date

BUREAU OF RECLAMATION

Lorri Gray 12/14/18
Lorri Gray
Regional Director
Bureau of Reclamation

Date

U.S. ARMY CORPS OF ENGINEERS

12 DEC 2018

Brigadier General D. Peter Helmlinger
Commander, Northwestern Division
U.S. Army Corps of Engineers

Date

BONNEVILLE POWER ADMINISTRATION

12/14/18

Elliot Mainzer
Administrator
Bonneville Power Administration

Date

Attachment

Table 1.1.

Planned 2019 spring spill operation, applying estimated 120% mean total dissolved gas spill caps and performance standard spill[4] flex operations.

Location	COE Estimated Mean 120% Total Dissolved Gas Spill Cap (16 hours)	Performance Standard Spill (8 hours)
Lower Granite	45 kcfs	20 kcfs
Little Goose	52 kcfs	30%
Lower Monumental	44 kcfs	30 kcfs (bulk spill pattern)
Ice Harbor	87 kcfs	30%
McNary	180 kcfs	48%
John Day	146 kcfs	32%
The Dalles	135 kcfs	40%
Bonneville	122 kcfs	100 kcfs

Key points:

- Spring spill operations would be initiated April 3 and April 10th and transition to summer spill operations on June 21 and June 16 at Lower Snake River projects and at Lower Columbia River projects, respectively.
- The 8 hours of performance standard spill would occur with some flexibility. Only Little Goose would be set to at least 4 hours in the a.m. (beginning near dawn and not to exceed 5 hours in the a.m.) and no more than 4 hours in the p.m. (generally near dusk) to help with adult passage issues. All other projects could spill either 3 or 4 hours for the performance standard spill a.m. time period and then up to a max of 5 hours in the performance standard spill p.m. period (not to exceed 8 hours in the day).
- No ponding above current MOP assumptions: Snake River - MOP+1.5 ft (to provide 1 ft. of useable space); John Day - MIP+2 ft (to provide 1.5 ft. of useable space).
- Controlled spill at Bonneville Dam capped at 150 kcfs due to erosion concerns.
- Controlled spill at The Dalles contained between the walls (Bays 1-8) unless river flows were over 350 kcfs then spill outside the walls would be permitted.
- Existing adaptive management processes will be employed to help address any unintended consequences that may arise in-season as a result of implementing these proposed spill operations.
- Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability.

[4] "Performance standard" spill is a NOAA Fisheries term and refers to spill levels intended to meet NOAA's performance standard testing, as described in the 2008 Biological Opinion and accompanying administrative record.

Table 1.2.

Planned summer spill operations, starting June 21 at Lower Snake River projects and June 16 at the Lower Columbia River projects through August 31, 2019; no spill curtailment criteria. Table 1.1 key points apply.

Location	Summer Spill Operation: Volume/Percent of Total Flow Routed to Spillway (June 21/16 – Aug 31)
Lower Granite	18 kcfs
Little Goose	30%
Lower Monumental	17 kcfs
Ice Harbor	30%
McNary	57%
John Day	35%
The Dalles	40%
Bonneville	95 kcfs

Table 1.3.a.

Representative spring spill alternative one, for implementation in 2020 and 2021. Six projects using 125% TDG flexible spill, John Day (JDD) using 120% TDG flexible spill and The Dalles (TDA) using 24 hour performance standard spill. Table 1.1 key points apply.

Location	COE Estimated mean 125% Total Dissolved Gas Spill Cap (16 hours), with alternative operation at JDD and TDA.	Performance Standard Spill (8 hours).
Lower Granite (125 flex)	72 kcfs	20 kcfs
Little Goose (125 flex)	79 kcfs	30%
Lower Monumental (125 flex)	98 kcfs	30 kcfs (bulk spill pattern)
Ice Harbor (125 flex)	119 kcfs	30%
McNary (125 flex)	265 kcfs	48%
John Day (120 flex)	146 kcfs	32%
The Dalles (Performance Standard)	40%	40%
Bonneville (125 flex)	150 kcfs	100 kcfs

Table 1.3.b.

Representative spring spill alternative two, for implementation in 2020 and 2021. Six projects using 125% TDG flexible spill with JDD and TDA using 24-hour performance standard spill. Table 1.1 key points apply.

Location	COE Estimated mean 125% Total Dissolved Gas Spill Cap (16 hours), with alternative operation at JDD and TDA.	Performance Standard Spill (8 hours)
Lower Granite (125 flex)	72 kcfs	20 kcfs
Little Goose (125 flex)	79 kcfs	30%
Lower Monumental (125 flex)	98 kcfs	30 kcfs (bulk spill pattern)
Ice Harbor (125 flex)	119 kcfs	30%
McNary (125 flex)	265 kcfs	48%
John Day (Performance Standard)	32%	32%
The Dalles (Performance Standard)	40%	40%
Bonneville (125 flex)	150 kcfs	100 kcfs

Table 1.4.

Planned summer spill operations for 2020 and 2021. Cessation of juvenile transportation June 21 through August 14 with allowance for Technical Management Team adaptive management adjustments.

Location	Initial Summer Spill Operation: Volume/Percent of Total Flow Routed to Spillway (June 21/16 – August 14)	Late Summer Transitional Spill Operation: Volume/Percent of Total Flow Routed to Spillway (August 15 – August 31)
Lower Granite	18 kcfs	RSW or 7 kcfs
Little Goose	30%	ASW or 7 kcfs
Lower Monumental	17 kcfs	RSW or 7 kcfs
Ice Harbor	30%	RSW or 8.5 kcfs
McNary	57%	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	55 kcfs - includes 5k corner collector

United States Department of the Interior

BUREAU OF RECLAMATION
Pacific Northwest Regional Office
1150 North Curtis Road
Boise, ID 83706-1234

PN-1700
3.1.03

VIA ELECTRONIC MAIL ONLY

Mr. Barry Thom
Regional Administrator
National Oceanic and Atmospheric Administration
NOAA Fisheries West Coast Region
1201 NE Lloyd Blvd., Suite 1100
Portland, OR 97232

Subject: Requesting Initiation of Formal Consultation with NOAA Fisheries for the Operations and Maintenance of the Fourteen Federal Multiple Use Projects in the Columbia River System

Dear Mr. Thom:

The U.S. Army Corps of Engineers (USACE), the Bureau of Reclamation, and the Bonneville Power Administration (BPA) (collectively termed the Action Agencies) are responsible for consulting with the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) on proposed Federal actions that may affect species listed under the Endangered Species Act (ESA) or their designated critical habitat. As you are aware, NOAA Fisheries' 2008 Biological Opinion (as supplemented in 2010/2014) and incidental take coverage for the Action Agencies' management of the Columbia River System expire December 31, 2018.

The Action Agencies have prepared a consultation package entitled *ESA Section 7(a)(2) Initiation of Formal Consultation for the Operations and Maintenance of the Columbia River System on NOAA Fisheries Listed Species and Designated Critical Habitat*. BPA is submitting these documents to NOAA Fisheries on behalf of the Action Agencies to initiate formal consultation under Section 7(a)(2) of the ESA, and request preparation of a Biological Opinion in fulfillment of interagency consultation responsibilities under the ESA by December 31, 2018. The Action Agencies are also requesting consultation under the Magnuson-Stevens Fishery Conservation and Management Act.

These documents were prepared after extensive discussion and collaboration with NOAA Fisheries. The information in these documents describes the coordinated water management function of these projects, including water storage, release, and withdrawals to meet congressionally authorized project purposes. In addition to these operational measures, the Action Agencies are proposing non-operational conservation measures as offsite mitigation to help address uncertainty related to any residual adverse effects of system management. These non-operational measures include support for conservation hatchery programs, predation management, habitat improvement actions in the Columbia River estuary and various tributaries, and kelt reconditioning.

The Action Agencies have provided information in this consultation package on the status of system operations and configuration improvements as well as habitat protection and improvement actions, through calendar year 2017, in fulfillment of annual reporting commitments under the 2008 Biological Opinion.

In parallel with the development of the Proposed Action in this consultation package, the Action Agencies have been engaging in discussions with regional sovereigns to explore alignment around a potential alternative spring spill operation, the goal of which is to find a balance between increased spill for listed salmon and steelhead, increased power generation during periods of high demand, and increased implementation feasibility for the operation of the Columbia River System. If adequate progress can be made on this alternative, the Action Agencies will formally notify NOAA Fisheries of their intent to modify spring spill operations and work with NOAA to evaluate whether reinitiation of consultation is required pursuant to 50 C.F.R. Section 402.16.

The Action Agencies look forward to continued collaboration and are available to address any issues or concerns concerning the consultation. Please feel free to call Tim Dykstra (USACE) at 503-808-3828, Lesa Stark (Reclamation) at 208-378-5378, or Ben Zelinsky (BPA) at 503-230-4737 if you have questions.

Sincerely,

David Mabe
Deputy Regional Director for Natural Resources and External Affairs

Enclosures:
1. ESA Section 7(a)(2) Initiation of Formal Consultation for the Operations and Maintenance of the Columbia River System on NOAA Fisheries Listed Species and Designated Critical Habitat
2. Appendix A: Columbia River System Project Authorizations and Descriptions
3. Appendix B: Actions Taken by Bonneville Power Administration in Managing the Federal Transmission System that can Influence Water Management Actions at the Projects Consulted on in this Document
4. Appendix C: Columbia River Mainstem Depletions Associated with Reclamation's Columbia Basin Project and other Tributary Irrigation Projects
5. Appendix D: Columbia River System Operational and Structural Improvements under the Endangered Species Act – 2017 Progress Update
6. Appendix E: References for the Snake River Spring/Summer Chinook Salmon Example Survivals by Life Stage

cc: Mr. Michael Tehan, NOAA Fisheries
Mr. Roy Elicker, U.S. Fish and Wildlife Service
Mr. Rollie White, U.S. Fish and Wildlife Service
Mr. David J. Ponganis, U.S. Army Corps of Engineers
Mr. Tim Dykstra, U.S. Army Corps of Engineers
Ms. Lesa Stark, Bureau of Reclamation
Mr. Scott Armentrout, Bonneville Power Administration
Mr. Dan James, Bonneville Power Administration
Mr. Benjamin Zelinsky, Bonneville Power Administration

ESA Section 7(a)(2) Initiation of Formal Consultation for the Operations and Maintenance of the Columbia River System on NOAA Fisheries Listed Species and Designated Critical Habitat

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Bonneville Power Administration

Bureau of Reclamation

U.S. Army Corps of Engineers

November 2, 2018

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Acronyms and Abbreviations

Acronym or Abbreviation	Description
Accords	Columbia Basin Fish Accords
BA	biological assessment
BAA	balancing authority area
BiOp	biological opinion
BPA	Bonneville Power Administration (also referred to as Bonneville)
CBP	Columbia Basin Project
cfs	cubic feet per second
CHU	critical habitat unit
Corps	United States Army Corps of Engineers
CRITFC	Columbia River Inter-Tribal Fish Commission
DPS	distinct population segment
ESA	Endangered Species Act
FCOP	Flood Control Operating Plan
FCRC	Flood Control Refill Curve
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FFDRWG	Fish Facility Design Review Working Group
FFRAG	Fish Facilities Design Review Work Group
FPC	Fish Passage Center
FPOM	Fish Passage Operations and Maintenance
FRM	flood risk management
HCP	habitat conservation plan
HMU	habitat management area
ICF	initial controlled flow
IDFG	Idaho Department of Fish and Game
JWKIII	John W. Keys III pump/generating plant
kcfs	thousand cfs
LCRE	Lower Columbia River Estuary
LRISRP	Lake Roosevelt Incremental Storage Release Program
M&E	monitoring and evaluation
M&I	municipal and industrial
MAF	million acre-feet

Acronym or Abbreviation	Description
MCE	minimum control elevation
MFWP	Montana Fish, Wildlife and Parks
MOP	minimum operating pool
MW	megawatt
NERC/WECC	North American Electric Reliability Corporation/Western Electricity Coordinating Council
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	NOAA National Marine Fisheries Service
NPCC	Northwest Power and Conservation Council
O&M	operations and maintenance
ODFW	Oregon Department of Fish and Wildlife
PIT	passive integrated transponder
Reclamation	United States Bureau of Reclamation
RIOG	Regional Implementation Oversight Group
RM	river mile
RME	research, monitoring, and evaluation
RMJOC-II	River Management Joint Operating Committee
RPA	reasonable and prudent alternative
SCT	Systems Configuration Team
SOR	system operation review
SRD	storage reservation diagram
SRWG	Studies Review Work Group
STS	submerged traveling screen
TDG	total dissolved gas
TMT	Technical Management Team
TPP	Third Power Plant
URC	upper rule curve
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
VARQ	variable discharge
VDL	variable draft limit
WCM	Water Control Manual
WDFW	Washington Department of Fish and Wildlife

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1 Introduction

The United States Army Corps of Engineers (the Corps), the Bureau of Reclamation (Reclamation), and Bonneville Power Administration (Bonneville) jointly manage the operation and maintenance of the fourteen federal multiple-use projects in the Federal Columbia River Power System that are operated as a coordinated water management system (referred to herein as the Columbia River System[1]). Coordinated water management of this dynamic system requires collaboration among these three federal entities (referred to in this document as the Action Agencies). Over the years, the Action Agencies, along with other federal and state agencies, tribal sovereigns, and stakeholders, have developed a sophisticated and complex system of operations, some managed at the system-wide level, and some others specific to the individual facilities. In addition, this complex water management system requires facility maintenance that ensures that the projects can be operated in a safe and efficient manner. The proposed future operations and maintenance (referred to herein as system management) detailed in Chapter 2, take into consideration the need to integrate multiple statutory project purposes while continuing to provide improved conditions for ESA-listed species affected by system management.

1.1 Purpose

Under ESA Section 7(a)(2), the Action Agencies are responsible for ensuring that their actions are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of designated critical habitat. To satisfy that mandate, the federal agencies consult with the United States Fish and Wildlife Service or the National Marine Fisheries Service (NOAA Fisheries) (collectively known as the Services), as appropriate, on proposed federal actions that may affect ESA-listed species. Federal agencies must ensure their actions do not "reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species."[2] Action Agencies are not, however, obliged under Section 7(a)(2) to contribute affirmatively toward recovery achievement, which is an important but distinct public policy objective that is furthered through a separate planning process governed by ESA Section 4(f) to guide societal actions by both federal and non-federal actors.

The environmental baseline for this consultation includes the existence and ongoing effects of the project structures and past system management, other federal, state, and private actions that are completed or have undergone consultation, and past conservation actions implemented by the Action Agencies and others in the Columbia River basin. Over the past several decades, in managing the Columbia River System, the Action Agencies have instituted numerous changes to system management

[1] In the past, for the purposes of Endangered Species Act (ESA) consultations, the Action Agencies used the term "FCRPS" to refer to the federal dams that are operated as a coordinated system. However, the Federal Columbia River Power System, or FCRPS, is comprised of thirty-one multi-purpose dam and reservoir projects in the Pacific Northwest region, constructed and operated by the Corps and Reclamation, and a transmission system built and operated by Bonneville to market and deliver electric power. The Columbia River System comprises a subset of the FCRPS projects that are operated as a coordinated water management system.

[2] 50 C.F.R. § 402.02.

designed to benefit affected fish and wildlife, with substantial improvements for fish passage and survival through implementation of conservation actions called for in past NOAA Fisheries' biological opinions.

These beneficial actions in the migratory corridor, combined with habitat actions in the tributaries and the estuary, have contributed to improving the environmental baseline for ESA-listed species under NOAA Fisheries' jurisdiction. Recent returns of salmon and steelhead reflect the relatively poor ocean conditions experienced by juveniles entering the ocean after 2014, when marine conditions for these species are considered to be much less favorable, with all runs seeing declines from the peak runs observed from 2009-2015. Nonetheless, these returns remain above the low numbers observed in the 1990s and indicate stable or increasing abundance trends since that time.

The Action Agencies have developed this consultation package to facilitate Section 7(a)(2) consultation with NOAA Fisheries to obtain its biological opinion on the effects of future system management, which builds on the agencies' past improvements to the environmental baseline and the status of the ESA-listed species.

The proposed action consists of system operations for multiple project purposes, including the protection of affected fish and wildlife, combined with additional conservation actions as offsite mitigation that, collectively, are designed to protect ESA-listed species and designated critical habitat and help address uncertainty related to any residual adverse effects of Columbia River System management, including uncertainty regarding such effects in the face of climate change.

1.2 Background

The Columbia River begins in Columbia Lake on the west slope of the Rocky Mountains in Canada. It follows a circuitous path for more than 1,200 miles before emptying into the Pacific Ocean near Astoria, Oregon. The river drains about 219,000 square miles in the United States and 39,500 square miles in Canada. Its annual average runoff is nearly 200 million acre-feet (Maf), as measured at the river's mouth. The river and its tributaries form the dominant water system in the Pacific Northwest and are heavily used regional resources.

Since the 1880s, numerous dams—both federal and private—have been built. The first dam spanning the Columbia River, Rock Island, was built by a private power company in 1932. Construction of the federal projects that comprise the Columbia River System began not long after and continued through the 1970s.

The first two federal Columbia River System projects, Bonneville on the lower Columbia and Grand Coulee on the upper Columbia, were completed in 1938 and 1942, respectively. Unlike many earlier private dams, Bonneville was constructed to allow salmon passage. Grand Coulee, a high head dam, was not designed for fish passage.

As the region's population increased, the U.S. government developed comprehensive plans for water resources of the Columbia River Basin.[3] These plans provided for additional storage projects to capture water from rain and snowmelt for flood control (hereinafter referred to as flood risk management or

[3] Flood Control Act of 1950, which adopted House Document 531, and Flood Control Act of 1962, which adopted House Document 403.

FRM), as well as for power generation, irrigation, and other purposes including fish and wildlife conservation and recreation.

The U.S. government also developed run-of-river projects on the mainstem lower Columbia and lower Snake rivers. These projects were designed to provide for navigation from the mouth of the Columbia to the Port of Lewiston in Idaho, as well as for hydropower generation and other purposes including fish and wildlife conservation and recreation. Most of these run-of-river projects have minimal storage capacity and are not considered flood storage projects; however, John Day Dam on the lower Columbia has flood storage and is used for system FRM. The final system project, Lower Granite on the lower Snake River, was completed in 1975.

1.3 Historical context

Over the last two centuries, human activities have detrimentally impacted the numerous species of salmon that rely on the Columbia River and its tributaries in multiple ways. Many of these historical activities have had lasting impacts that continue to negatively affect salmon today. Throughout the 1800s and early 1900s, logging, mining, and irrigation in the Columbia River basin expanded rapidly. Logging occurred throughout the basin, ranging from the Columbia River Gorge to high-mountain tributary basins. Logging, for years an economic cornerstone of the region, increased erosion and decreased water quality. Splash dam log transportation practices, which were prevalent throughout the basin, destroyed tributary stream habitat salmon require for spawning and rearing. Mining, often for gold, likewise proved harmful to salmon, often occurring through mechanical dredge practices that destroyed salmon spawning and rearing areas. The Clearwater and Yankee Fork rivers were among the many impacted by such human activities.

Early private irrigation efforts and construction of private dams also harmed Columbia River basin salmon populations. Direct diversions of water to farms dewatered tributaries and entrained juvenile salmon. Private dams, such as Long Lake Dam on the Spokane River and Lewiston Dam on the Clearwater River, blocked fish passage and virtually eliminated salmon from areas upstream.

During the same period, humans harvested Columbia River salmon at unsustainable rates. As early as the 1820s, European settlers, led by the Hudson’s Bay Company, harvested salmon for commercial trade. By 1861, commercial salmon fishing was an industry on the lower Columbia. The first commercial cannery was established on the Columbia in 1866, canning almost 200,000 pounds of salmon that year. Canneries proliferated in ensuing years. At first, canneries used only spring Chinook. However, within ten years the spring Chinook runs had declined substantially. In an effort to stave off the decline, Oregon and Washington both imposed fishing closures in 1877 and 1878, but in 1879, widespread use of fish wheels and traps began and would continue for the next five decades.

The most famous fish wheel on the Columbia River, Seufert’s No. 5 near The Dalles, would harvest an average of 146,000 pounds of salmon per year. Facing spring Chinook runs inadequate to meet demands, canneries began taking summer and then fall Chinook. In 1889, with Chinook runs continuing to decline, canneries on the lower Columbia began processing sockeye and steelhead. A few years later the canneries added coho and chum salmon.

The harvest of additional runs and species, together with the development of a troll fishery, kept total harvest high until about 1920. Between 1891 and 1895, Columbia River salmon canneries processed an average of more than 20 million pounds of salmon per year. In 1911, salmon harvests peaked at 49.5 million pounds. Cannery production peaked between 1916 and 1920 at an annual average of 26 million pounds of salmon processed. Total harvest and cannery production then began to decline.

By 1938, the year Bonneville Dam was completed, total commercial harvest on the Columbia had declined significantly from its peak, to about 19 million pounds.

Between 1932 and 1983, 27 major dams were constructed on the Columbia River and its largest tributaries, including the fourteen Columbia River System projects. Although many of the projects included fish ladders for adult salmon to pass the dams on the returning migration to spawn, limited provisions were made at the time to aid juvenile outmigration. This era of water development was followed by periods of poor ocean conditions and regional urbanization and population growth, and already-depressed salmon species declined even further. In 1980, Congress passed the Northwest Power Act, initiating the Act's Columbia Basin Fish and Wildlife Program.

In 1991, NOAA Fisheries listed Snake River Sockeye salmon as endangered under the Endangered Species Act. NOAA Fisheries eventually listed twelve more Columbia River basin salmonids as either threatened or endangered. Of those thirteen listed species, seven migrate to the interior Columbia River Basin, while the remaining six migrate through the lower Columbia River. Two of the interior species are listed as endangered (Snake River sockeye and Upper Columbia spring Chinook). The remaining eleven are listed as threatened. There are a total of eighteen salmon ESUs and steelhead DPSs in the Columbia River basin, five of which are not listed as endangered or threatened under the Endangered Species Act.

This consultation focuses on the effects of system management on ESA-listed species and designated critical habitat under NOAA Fisheries' jurisdiction. These species have been, and continue to be affected, by multiple factors in addition to Columbia River System management.

1.4 Salmon survival by life stage

The Columbia River Basin is home to several different types of salmon and steelhead, each with different life cycles and habitats. This section provides an example of survival by life stage for one specific ESU in order to place the effects of Columbia River System operations in the context of the salmon's full life cycle. Many factors, both natural and anthropogenic, affect the salmon survival rates reported here; it is safe to say that each life stage is affected by multiple anthropogenic factors, most of which are not related to ongoing operations of the Columbia River System.

Snake River spring/summer Chinook salmon have two particularly vulnerable life stages (Federal Caucus 2000; NOAA Fisheries 2014; Healey, 1991). The first is the egg-to-smolt life stage, where survivals are often below 18 percent (Corps et al. 2007).

This was part of the reasoning, more than a century ago, for the development of hatcheries. This is also one reason the Action Agencies and others have invested in tributary habitat improvements. The second particularly vulnerable life stage is first-year ocean survival, explaining in part why scientists can use ocean indicators to predict adult salmon returns to the Columbia River (Peterson et al. 2012). Although every listed species is slightly different, we estimated Snake River Spring/Summer Chinook ESU survival rates by life stage in Figure 1-1 to illustrate survivals by life stage. The width of each bar corresponds to the approximate time salmon spend in that life stage, and the height of each bar corresponds to approximate survival during that life stage. The green bars indicate the part of their life stage when the salmon are in contact with eight mainstem dams and reservoirs that are part of the Columbia River System management that is the subject of this consultation.

The figure illustrates that salmon spend most of their life cycle in the ocean and the tributaries, and only a small fraction of their life cycle migrating through the Columbia River System facilities. The figure splits the juvenile migration period into three sections: the time it takes for Snake River Spring-Summer Chinook to migrate from their natal tributaries to the Columbia River System mainstem; time migrating through the Columbia River System mainstem dams; and time migrating below the mainstem before they enter the ocean.

The figure also shows that juvenile survival during migration through the Columbia River System (the first green column in Figure 1-1) is comparable to juvenile survival migrating over a similar migration distance upstream of the Columbia River System dams where no dams are present (the adjacent "to CRS" stippled column).

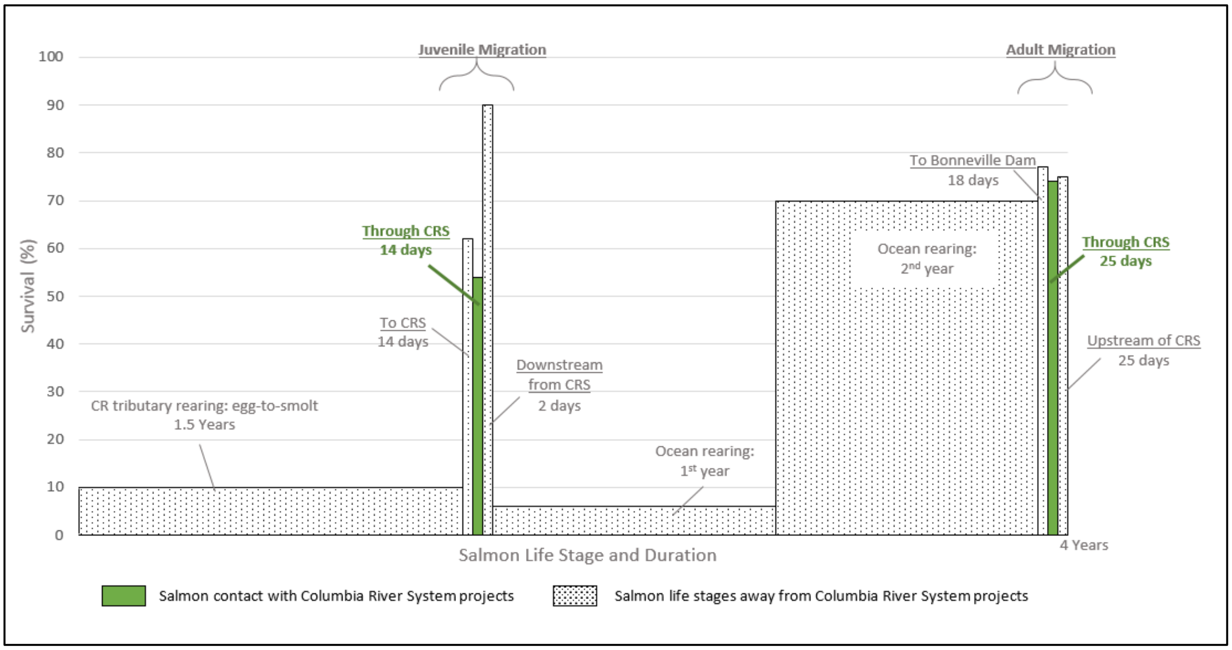

Figure 1-1. Snake River spring/summer Chinook salmon example survivals by life stage.

The y-axis shows approximate percent salmon survival by life stage. The x-axis and bar widths represent the approximate duration of each life stage. Life stages shown here include juvenile rearing in Columbia River tributaries (egg-to-smolt), juvenile migration to the most upstream Columbia River System dam, juvenile migration through the Columbia River System, juvenile migration below the Columbia River System to the ocean, first year ocean rearing, second year ocean rearing, adult migration from the ocean to the most downstream Columbia River System dam, adult migration through the Columbia River System (incorporating harvest and straying), and adult migration upstream of Lower Granite Dam. We assumed a four-year life cycle for this example. See Appendix E for further details.

1.5 Columbia River System management

Congress authorized the Corps and Reclamation to construct, operate, and maintain the 14 federal multiple-use projects within the Columbia River System to satisfy multiple public purposes to meet the needs of the region's growing population (Figure 1-2). Bonneville markets and transmits hydroelectric power from the projects. The three Action Agencies coordinate system management of the Columbia River System. The Corps operates 12 of the projects in this system, including Bonneville Dam, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Dworshak, Chief Joseph, Albeni Falls, and Libby dams. Reclamation operates Grand Coulee Dam, including the Columbia Basin Project, and Hungry Horse Dam. This document describes the system management of the 14 Federal projects and associated conservation actions.

1.5.1 Flood risk management

The Columbia River Basin reservoir projects are operated as a system for flood risk management. These projects include the Columbia River System storage projects at Hungry Horse, Grand Coulee, Libby, Albeni Falls and Dworshak, as well as the Columbia River Treaty dams in Canada. FRM operations can result in substantial decreases in flood crest elevation. As an example, during the spring snowmelt event in 1997, the peak flow at The Dalles would have been 896,000 cfs and the peak stage at Vancouver, Washington, would have been 28.4 feet. Because of FRM operations, observed peak flow at The Dalles was 570,700 cfs, while peak stage at Vancouver was only 19.0 feet.

1.5.2 Irrigation and water supply (M&I)

Lake Roosevelt (behind Grand Coulee Dam) is operated for the storage and delivery of irrigation water under the purview of Reclamation. The Corps and Reclamation support operations for both federal and non-federal irrigation at Columbia River System projects through operation of reservoir pools within authorized operating ranges. The proposed action includes mainstem depletions from the Columbia Basin [irrigation] Project, and, as a matter of convenience, the action also includes the mainstem depletions of six other irrigation projects. These include two that divert directly from the Columbia River (Chief Joseph Dam Project and The Dalles Project), three that divert wholly from tributaries (Yakima Project, Deschutes Project and Crooked River Project) and one that diverts partially from the Columbia River and partially from the Tributary (Umatilla Project and Phase I and II of the Umatilla Project).

Figure 1-2. Locations of the 14 Columbia River System dams within the Columbia Basin.

Storage dam locations are identified by solid black squares and run-of-river dam locations are identified by black vertical marks. Other major dams in the Columbia Basin (non-Columbia River System) are not shown in this figure and include the Hells Canyon Complex on the Snake River, the Public Utility District dams on the Columbia River, and the large Canadian dams on the Columbia.

1.5.3 Carbon-free hydroelectric power generation

The Corps and Reclamation operate the Columbia River System for generation of electricity at the hydropower facilities at all fourteen dams. The Columbia River System dams in the Pacific Northwest supply more than one-third of the region's electrical power. These agencies coordinate management of system operation and maintenance with Bonneville, which markets and transmits power generated by the fourteen Columbia River System projects that are the subject of this consultation along with other resources in the Pacific Northwest that collectively form part of the Federal Columbia River Power System.

The Columbia River System has, for many decades, provided the Pacific Northwest with a substantial source of cost-effective, carbon-free power. Northwest electricity has half the carbon intensity as the rest of the United States due in large part to hydroelectric power generation (PNUCC 2014). In high water years, CO_2 emissions in the region tend to be even lower because the extra hydropower reduces the need to operate gas and coal plants. However, even in a dry water year, the Columbia River System alone produces about 7,000 average megawatts of hydroelectricity, enabling the region to sustain this relatively small carbon footprint. Columbia River System hydroelectric efficiency improvements achieved to date avoid between 1.7 and 2.7 million tons per year of CO_2 emissions with annual variances based on the amount of water available for hydropower generation. Additional efficiency improvements planned through 2030 are estimated to achieve CO_2 reductions between 0.4 and 0.7 million tons per year (Northwest Power Council 2015).

The Columbia River System is also a crucial part of integrating and backing up other types of intermittent, carbon-free resources into the homes of businesses in the Pacific Northwest. Bonneville has connected almost 5,100 MW of wind energy to its transmission system – enough to power a city three times the size of Seattle. Bonneville expects to connect another 3,000 to 4,000 MW of wind energy to its system by 2025, setting Northwest states well on their way to achieving long-term renewable energy targets.

1.5.4 Navigation

The Corps operates certain Columbia River System projects to provide for navigation. In addition, Congress required the Corps to maintain the federal navigation channel through the lower Columbia and lower Snake Rivers. Accordingly, the Corps constructed four lower Columbia River projects and the four lower Snake River projects with navigation locks to allow passage for boats and barges to transport products from the Pacific Ocean to inland ports as far upstream as Lewiston, Idaho.

The Columbia River System supports international trade of an estimated value over $20 billion annually and carries about 56.9 million tons of cargo, making it the second largest export gateway on the West Coast. The average annual (2010-2014) tonnage passing through The Dalles Lock and Ice Harbor Lock was 7,719,748 and 3,475,104, respectively. This equates to approximately six commercial vessels per day at Lower Columbia River dams and three per day at Lower Snake River dams.

1.5.5 Recreation

The reservoirs and project lands provide recreational opportunities for boaters, anglers, swimmers, hunters, hikers, and campers throughout the year. The Action Agencies take into consideration recreational values when defining system management.

1.5.6 Fish and wildlife

The Action Agencies jointly manage the Columbia River System to support the conservation of fish and wildlife species in the Columbia River Basin. The Action Agencies coordinate system management to reduce adverse effects on ESA-listed and non-listed species both in the reservoirs, as well as in the rivers downstream from the reservoirs and on the mainstem Columbia River and lower Snake River.

1.5.7 Water quality

The Action Agencies manage the Columbia River System to maintain water quality, to the extent feasible, by managing releases of water to avoid excessive total dissolved gas and to meet downstream flow and temperature objectives.

1.6 Consultation history

The Action Agencies have consulted with NOAA Fisheries on the effects of system management on ESA-listed species since the first anadromous fish species (Snake River sockeye salmon) was listed in the Columbia River Basin in November 1991. Since this first listing, NOAA Fisheries has issued numerous consecutive biological opinions and supplemental biological opinions on the effects of the operation and maintenance of the FCRPS projects, including in 1992, 1993, 1994, 1995, 1998, 2000, 2004, 2008, 2010, and 2014. Nearly every one of these biological opinions was challenged in federal court and modified on remand with new conservation measures and new analyses in an effort to comply with evolving court directives.

Most recently, following a comprehensive, multi-year regional collaboration effort in the mid-2000s, in interagency consultation with NOAA Fisheries, the Action Agencies committed to implementation of a multi-faceted suite of conservation actions over a ten-year period in the 2008 BiOp. Those actions were designed to improve the freshwater component of the lifecycle for listed salmon affected by system management. These actions included operating the system to improve salmon survival during migration, enhancing and creating salmon spawning, rearing, and migration habitat, and reducing predation on salmonids.

After NOAA Fisheries issued the 2008 BiOp, the Obama Administration conducted an extensive review of the scientific bases of the 2008 BiOp. This review led to the development of an Adaptive Management Implementation Plan (AMIP), which, among other things, enhanced the BiOp’s adaptive management and contingency provisions to address uncertainties about the effects of climate change on salmonids and their habitat, and was officially incorporated into the consultation through a supplemental BiOp in 2010. In 2011, the District Court once again remanded the 2010 Supplemental BiOp. On remand, the Action Agencies worked with regional implementation partners, including Fish Accord partners, to identify habitat mitigation projects for the remaining five years of the biological opinion, and further consultation on remand culminated in NOAA Fisheries’ 2014 Supplemental BiOp.

In May 2016, the United States District Court for the District of Oregon invalidated the 2008 NOAA Fisheries BiOp, as supplemented in 2010 and 2014, holding that NOAA did not provide an adequate explanation for its analysis in the BiOp that operation of the Columbia River System is not likely to jeopardize listed salmon and steelhead species. The court ordered the Corps and Reclamation to continue funding and implementing the 2014 BiOp until NOAA Fisheries issues a new BiOp, by December 31, 2018 (the court subsequently modified the remand deadline to a later date). The Action Agencies are proceeding with this consultation to address ESA compliance and incidental take coverage.

1.7 Improved environmental baseline conditions

Multiple actions completed by the Action Agencies have improved environmental baseline conditions. Habitat actions implemented under previous BiOps, beginning in the mid-1990s, have been synthesized and assessed (Hillman et al. 2016; Diefenderfer 2013), and have considerably improved many aspects of baseline conditions for salmon survival in the Columbia River Basin. The substantial improvements to operational and structural components of the system, combined with predator control actions, have increased fish passage survival through the mainstem corridor over the last two decades (see Appendix D). In addition, the Action Agencies have improved and greatly expanded important spawning and rearing habitat in tributaries far removed from Columbia River System facilities, and in the estuary.

The Action Agencies constructed structural improvements, such as spillway weirs, replaced some turbines with ones that are less harmful to fish, and made improvements to juvenile bypass facilities. The Action Agencies also made water management changes, including flow augmentation, targeted fish passage spill, and the release of cool water from Dworshak, which have resulted in improved passage conditions for juvenile and adult salmonids. These baseline improvements, which continue to provide benefits to the species, undergird the current consultation package.

1.7.1 Columbia River System operational changes

The Action Agencies altered storage project operations each year to augment flows and help manage water temperatures during the juvenile salmon and steelhead migrations.

Over the course of implementing the most recent BiOp, the Action Agencies implemented a scientifically based spill program to facilitate juvenile fish passage. The Action Agencies focused on achieving 96 percent passage survival for spring-migrating juvenile fish, and 93 percent passage survival for summer-migrating juvenile fish (Figure 1-2). Spill levels and patterns were tailored to each dam’s unique configuration in order to avoid creating adverse tailrace hydraulic conditions that can delay juvenile fish egress and expose them to increased predation and cause delay of adult fish migrating upstream. These spill operations in combination with structural improvements completed at each dam have reduced the percentage of fish that pass through turbines, increased the overall survival of juveniles, and combined with flow augmentation operations, substantially decreased juvenile fish travel time passing through the system.

1.7.2 Columbia River System improvements

Surface passage improvements

The Action Agencies have made efforts to improve the survival of juvenile fish passing through the Columbia River System by developing surface passage at the dams to safely and efficiently pass juvenile fish downstream (Figure 1-3). Beginning in 1995, a research program was initiated to investigate juvenile fish behavior as they approach dams and that information was used to develop and design surface passage routes at the Corps' fish passage dams. As a direct result of these investigations, the first spillway weir was designed and installed at Lower Granite Dam in 2001.

Juvenile salmon and steelhead are surface-oriented and generally tend to migrate in the upper portion of the water column. Spillway weirs transform conventional spillbays into surface passage routes by spilling water near the surface, rather than at 40 to 60 feet below the surface.

These structures afford a more natural river passage route for surface-oriented juvenile salmonids, rather than migrating juvenile fish locating and sounding to depths of 40 to 60 feet in order to enter conventional spillbays, screened bypass systems, and turbines when passing a dam. Subsequent to the initial successful installation at Lower Granite Dam, additional spillway weirs were designed and installed at Ice Harbor (2005), McNary (2007), John Day (2010), Lower Monumental (2008), and Little Goose (2009) dams. In addition, surface passage routes were developed at The Dalles and Bonneville dams utilizing the existing sluiceways at each project. The conversion of these sluiceways to surface passage routes for juvenile fish proved successful, with fish survival through these routes spanning from the mid to high 90 percent range (see Figure 1-3).

By 2010, all eight fish passage dams had surface passage routes available to migrating juvenile fish. These particular structural modifications have substantially reduced passage delay of juvenile fish at each dam, reduced travel time through the Columbia River System and substantially improved juvenile passage survival, in part, by further reducing the proportion of fish that pass through turbines.

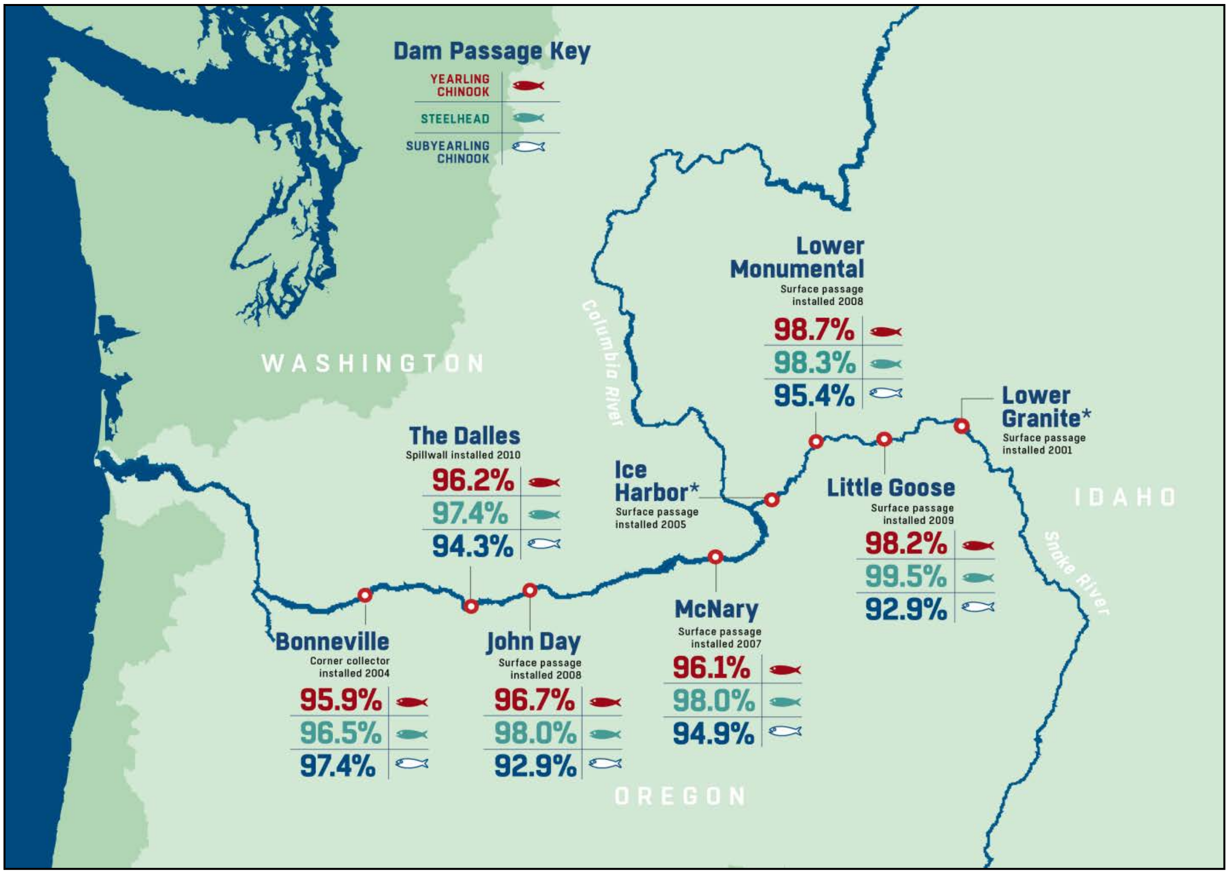

Figure 1-3. Dates of surface passage installation and average estimates of dam passage survival for yearling Chinook salmon, steelhead, and subyearling Chinook salmon at dams on the lower Columbia and lower Snake rivers.

Average estimate values are from tests carried out in 2010 through 2014, as found in Skalski et al. 2016.

Juvenile bypass system improvements

Early efforts to improve juvenile fish survival, dating back to the 1980s, included developing screened turbine intake fish bypass systems designed to divert fish away from turbine intakes and route them into a bypass channel to either safely deliver them into the tailrace below the dam or into holding facilities for loading into barges or trucks specifically designed for transporting the fish downstream past the remaining dams. Several years of development of these systems resulted in the installation of screened bypass systems at seven of the eight fish passage dams.[4] Recent bypass system improvements have included relocating system outfall pipes at Little Goose, Lower Monumental, and McNary dams to improve safe fish conveyance and egress once exiting the bypass system, thereby minimizing exposure to predation in the dam tailrace. The most recent efforts focused on improving conditions to reduce fish injury within the Bonneville Dam Powerhouse II screened bypass system, and a complete rehabilitation of the Lower Granite Dam screened bypass system and juvenile fish facility. Fish survival through

[4] The Dalles Dam does not have a juvenile fish screened bypass system.

screened bypass systems has generally been higher than survival through turbines[5] and is therefore, another important tool for increasing juvenile fish survival as they pass through the Columbia River System.

Other structural improvements

Another example of structural modifications made at the dams to increase overall juvenile fish survival is completion of a spillwall at The Dalles Dam in 2010 (Corps et al. 2017). Prior to construction of the spillwall at The Dalles Dam, spill provided for fish passage was spread out across the entire spillway. This operation caused many juvenile fish that passed the dam via the spillway (approximately 80 percent) to be routed over shallow, rocky areas where high concentrations of avian and piscivorous predators contributed to high predation rates of juvenile fish. To remedy this, the Corps designed and constructed an 800-foot wall extending from the face of the spillway downstream so that spill through the first eight spillbays at the dam directs spill-passed juvenile fish into the natural river channel below the dam, rather than over the shallow, rocky areas where predation rates are high. An avian wire array was also installed below the spillway tailrace to deter avian predators from preying on spillway passed fish. The spillwall/avian wire array combination increased overall juvenile survival by roughly 3 to 8 percent, depending on species.

In addition to The Dalles spillwall, Ice Harbor Dam's spillway weir bay (spillbay 2) was modified in order to reduce injury and improve survival of fish that pass through the spillway weir. The slope of chute was decreased and deflector radius was increased. Sensor packages with accelerometers that were passed over the spillway weir documented a significant decrease ($p = 0.015$) in collision events, from 47 percent to 27 percent following spillway modifications (Deng et al. 2015). The direct injury rate on juvenile Chinook salmon decreased from 15.8 percent down to 1.8 percent (Normandeau 2015). Results indicated a significantly improved route of passage for the spillway weir bay.

Adult fish passage improvements

All eight lower Snake and Columbia River dams included adult fish passage facilities in their original design and construction. Significant research and development to optimize the design and operation of these facilities occurred from the 1950s through the 1980s. Since then, most fish ladders at lower Snake and lower Columbia River dams have performed well. At John Day Dam, slower adult fish passage times and count accuracy problems were observed, prompting modifications to be made to the John Day north ladder between 2011 and 2013. These modifications reduced adult passage times so that the John Day north ladder adult passage times are in line with passage times observed at other dams. In addition to renovating the John Day north ladder, the Corps has completed several studies and modifications to other ladders aimed at increasing the reliability of these systems to ensure good upstream passage conditions are provided for returning adult salmon and steelhead. Most recently, higher river temperatures have caused periodic passage delay of adult salmon at Lower Granite Dam. The Corps has remedied the issue by pumping cooler water from deeper in the reservoir into the ladder system. In 2015, a permanent system was completed with the extension of the two intake chimneys to pull cooler water from deeper in the forebay. The cooler water, which can be partially attributed to cold

[5] Except at Bonneville Dam Powerhouse I. In this example fish survival through Powerhouse I turbines was higher than through the screened bypass system, therefore, through regional coordination, the bypass system screens were removed from Powerhouse I turbine intakes.

water the Corps releases from Dworshak Dam, was used to cool the ladder and to cool the exit area in the forebay. Observations suggested a positive benefit from another temporary pump system used at Little Goose Dam in 2016; the Corps installed a permanent pump system at Little Goose in 2017 for use in 2018.

Turbine design improvements

Most juvenile salmon and steelhead migrating in-river pass the Columbia and Snake River dams via spillway weirs, spillways or juvenile-bypass systems; the remaining fish that pass through turbines are at an increased risk of injury or disorientation (see Corps et al. 2014, 2017, for more detailed information on passage survival and routes). To address this risk, the Corps is currently installing innovative turbines designed specifically to provide safer passage for fish that pass through turbines at Ice Harbor Dam, further improving juvenile survival.

Fish transportation

Hatchery and wild juvenile salmon and steelhead that migrate through the Snake and Columbia rivers to the ocean can migrate "in river" or they can be collected and transported. Juvenile fish transportation is an ongoing program to improve fish survival by collecting fish from juvenile bypass facilities at Lower Granite, Little Goose, and Lower Monumental dams and transporting them by either barge or truck to release sites below Bonneville Dam.

Currently, fish transport operations are adaptively managed on an annual basis. The timing and conditions for fish transportation are based on annual monitoring, comparing adult returns to Lower Granite Dam of transported fish versus fish that migrated in-river. In general, evaluation of migration is showing that Chinook return as adults at higher rates when migrating in-river in early April, but return at higher rates when transported beginning in late April or early May. Also, steelhead generally return at higher rates when transported during the spring migration.

Habitat, hatchery, and predator control improvements

Productive habitat in the Columbia River estuary and tributaries is critical to the life cycle of salmon and steelhead. Over the last decade, the Action Agencies have spent tens of millions of dollars to improve the quantity and quality of salmon habitat in the estuary and tributaries as “offsite mitigation” for the residual adverse effects of system water management on migrating salmon and steelheads. These actions typically address impacts to fish not caused by the Columbia River System, but are things the Action Agencies can do to improve the overall conditions for fish to help address uncertainty related to any residual adverse effects of Columbia River System management on migrating listed salmon and steelhead species. Table 1 2 displays the types and quantities of tributary habitat actions completed through 2017 by species. Overall, from 2007-2017, the Action Agencies have secured water rights for over 1,745 CFS for instream flow and protected over 231,000 acre feet to enhance stream flows in the Columbia River Basin; improved the complexity of 442 miles of stream; improved over 17,254 acres of riparian habitat; improved or installed 494 fish screens; and opened or protected access to over 3,415 miles of fish habitat. From 2007-2017, the Action Agencies improved over 9,200 acres of estuary floodplain habitat and over 49 miles of estuary riparian habitat.

Table 1-1. 2007-2017 Tributary habitat implementation metrics for salmon and steelhead completed across the Columbia River Basin.

	Flow Protected (CFS)	Flow Enhanced (Acre feet)	Entrainment Screening (# screens)	Habitat Access (Miles)	Habitat Complexity (Miles)	Riparian Habitat Improved (Acres)
2007-2017 Total Improvements	More than 1,745	More than 231,000	494	More than 3,415	More than 422	17,254

The Action Agencies have funded an extensive hatchery program, including conservation hatcheries for ESA-listed fish and other mitigation hatcheries to support tribal, commercial, and sport harvest. Many of these hatchery fish are also part of the listed ESU/DPS, providing essential genetic resources and enhancement potential. To ensure that these programs did not impede recovery of naturally spawning ESA-listed salmon and steelhead, the Action Agencies worked with hatchery operators to prepare updated hatchery and genetic management plans (HGMPs) for these facilities and programs, which were all submitted to NOAA Fisheries. The HGMPs identified operations to meet production requirements and to reduce or eliminate detrimental genetic and ecological effects on listed species.

The Action Agencies implemented several predator control actions to help manage predator species that caused mortality of ESA-listed fish in the Columbia River System. These actions are summarized below:

Caspian Terns in the estuary - The Action Agencies created Caspian tern nesting habitat outside of the Columbia River Basin to allow a reduction in the amount of nesting habitat on East Sand Island, decreasing the number of birds there and thereby decreasing predation on juvenile salmonids in the estuary. Due to the increase in the acreage of alternative nest sites, the area made available for tern nesting at East Sand Island was reduced to 1.0 acre, the minimum size considered in the Caspian Tern Management Plan.

Caspian Terns in the inland Columbia Basin - The Action Agencies developed and continued implementation of the Inland Avian Predation Management Plan (IAPMP). The IAPMP is a 5-year, phased, habitat-based management plan primarily addressing Caspian tern predation within the Columbia River Basin upstream of Bonneville Dam.

Double-crested cormorants - After conducting its NEPA process, the Corps published its Double-Crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary: Final Environmental Impact Statement in the Federal Register on February 6, 2015, and on March 19, 2015, the Corps' Record of Decision was signed. The alternative selected for the recommended management plan included a combination of culling adult birds and oiling eggs.

Northern pikeminnow - The NPMP removed more than 4.5 million pikeminnow from the Columbia River since 1990. Evaluation indicates that, as a result, pikeminnow predation on juvenile salmon has declined 38 percent in that time, saving 3 to 5 million juvenile salmon annually that otherwise would have been eaten by this predator species.

Sea lions - The Corps again contracted with U.S. Department of Agriculture (USDA) Wildlife Services to harass sea lions away from fishways and other dam structures, as they have each year since 2006.

1.8 Managing the Columbia River System in the face of climate variability

Global climate variability may affect regional temperatures, precipitation, and resulting streamflow patterns. These changes are likely to present challenges, both to system management functions on the largest river system in the Pacific Northwest, and to the conservation of species, habitat, and ecosystem functions. Existing and expanding partnerships between the Action Agencies, NOAA Fisheries, USFWS, tribal nations, and other public, private, and nongovernmental stakeholders are essential to avoid, minimize or mitigate the potential effects (direct, indirect and cumulative) of climate variability on species abundance, distribution, and habitat fragmentation.

Existing and ongoing climate change studies indicate that as temperatures warm through the middle of this century, winter precipitation that historically fell as snow in mountainous areas across the Columbia River Basin, particularly in the U.S. portion of the basin, will instead fall as rain. This will result in higher winter flows in lower- and mid-elevation streams, an earlier snowmelt peak, and a slight decrease in summer flows[6]. In Chapter 2, the Action Agencies describe how they plan for and adapt to climate variability in the development and implementation of the proposed action.

1.9 Action area

The action area for an ESA consultation is "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action." (50 CFR §402.02). The action area is not delineated by the migratory range of the species affected by the project unless that area is also directly or indirectly affected by the proposed action.

This proposed action focuses on the aquatic and riparian environments relevant to the ESA-listed species and designated critical habitat that the proposed action may affect. Generally, the Action Area begins at the location of the farthest upstream effects of the proposed action (e.g., the uppermost extent of the storage reservoirs) and continues to the location of its farthest downstream effect (the Columbia River estuary).

Therefore, the proposed Action Area for this consultation includes the United States portions of the following:

- The mainstem Columbia River, including the Libby Reservoir (Lake Koocanusa) and the Kootenai River downstream of Libby Dam; and the Hungry Horse Reservoir and downstream of Hungry Horse Dam to Albeni Falls Dam and Pend Oreille River downstream to the confluence with the mainstem Columbia, down to and including the Columbia River estuary and plume (i.e., near-shore ocean adjacent to the river mouth); the Snake River below the confluence with the Salmon River; Dworshak Reservoir and downstream of the dam in the North Fork Clearwater River, flowing into the Clearwater River to its confluence with the lower Snake River.

[6] RMJOC Climate Change Study, 2011: available on line at: http://www.usbr.gov/pn/climate/planning/reports.

- The tributary reaches that are the focus of additional habitat restoration actions in this Proposed Action.
- All additional spawning areas above Bonneville Dam that are accessible to listed adult salmon or steelhead that are affected by the proposed action.
- Areas off the Pacific Coast where salmonid species from the Columbia River, which are affected by Columbia River System management and related conservation actions included in this Consultation Package, are available as prey for listed southern resident killer whales, generally within 50 km of the coast from the river's mouth and plume south to southern Oregon and north to the Queen Charlotte Islands.

1.10 Request for consultation

With this consultation package, the Action Agencies are requesting consultation with NOAA Fisheries on the Proposed Action for the ESA-listed species and critical habitat that may be affected (Table 1-2). Because the current biological opinion expires on December 31, 2018, the Action Agencies request a new biological opinion by that date. The Action Agencies are also requesting consultation under the Magnusson-Stevens Fishery Conservation and Management Act.

Based on previous BiOps and effect determinations, the Action Agencies anticipate that the proposed action is not likely to adversely affect (NLAA) Southern Resident Killer Whale, Southern DPS Green Sturgeon, or their designated critical habitat. The reasoning for the determination on SRKW is provided 1.10.1 below. The proposed action is likely to adversely affect (LAA) all other species and their critical habitat listed in Table 1-2. Additionally, the Action Agencies believe the conservation actions described in the Proposed Action will provide beneficial effects to some or all of these species.

Action Agency actions such as the implementation of surface passage routes at the eight lower river dams, efforts to reduce predation by birds, fish, and pinnipeds, and tributary and estuary habitat improvements, have substantially improved the functioning of many physical and biological features in the environmental baseline. A number of actions in the mainstem migration corridor as well as “offsite” in tributary and estuarine areas also help address uncertainty regarding any residual adverse effects of system management and support species resiliency in the face of climate variability. There have been short-term, negative effects on physical and biological figures at the habitat restoration project scale during construction, but the long-term effects will be positive. Therefore, the Action Agencies expect that the effects of the proposed Columbia River System operations are largely similar to those previously analyzed, and not likely to adversely affect the designated critical habitat for salmonid species.

Table 1-2. ESA-Listed Species and designated critical habitat, which may be affected by the Columbia River System.

ESA-Listed Species	ESA Listing Status	ESA Critical Habitat Designated?	Action Agency Determination
Interior Columbia Basin Species			
Snake River (SR) fall Chinook salmon ESU	Threatened	Yes	LAA

ESA-Listed Species	ESA Listing Status	ESA Critical Habitat Designated?	Action Agency Determination
SR spring/summer Chinook salmon ESU	Threatened	Yes	LAA
SR steelhead DPS	Threatened	Yes	LAA
Upper Columbia River (UCR) spring Chinook salmon ESU	Endangered	Yes	LAA
UCR steelhead DPS	Threatened [2]	Yes	LAA
Middle Columbia River steelhead DPS	Threatened	Yes	LAA
SR sockeye salmon ESU	Endangered	Yes	LAA
Lower Columbia Basin Species			
Columbia River chum salmon ESU	Threatened	Yes	LAA
Lower Columbia River (LCR) Chinook salmon ESU	Threatened	Yes	LAA
LCR coho salmon ESU	Threatened	Yes	LAA
LCR steelhead DPS	Threatened	Yes	LAA
Upper Willamette River (UWR) Chinook salmon ESU	Threatened	Yes	LAA
UWR steelhead DPS	Threatened	Yes	LAA
Non-Salmonid Species			
Southern Resident Killer Whale	Endangered	Yes[3]	NLAA
Southern DPS Green Sturgeon	Threatened	Yes	NLAA
Southern DPS Eulachon	Threatened	Yes	LAA

[1] Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation. 16 U.S.C. § 1532(5)(A)(i)&(ii).

[2] UCR steelhead listing status was changed from Endangered to Threatened on June 18, 2009 by court order.

[3] While critical habitat has been designated for the Southern Resident DPS, that habitat is not within the action area for the Columbia River System.

1.10.1 Southern resident killer whale

The Southern Resident killer whales (SRKW) distinct population segment (DPS) was listed as endangered on February 16, 2006 (final rule effective – listed in FR November 18, 2005). SRKW is comprised of three pods, designated J, K, and L. During the spring, summer, and fall months, the SKRW can be found in the inland waters of Puget Sound, the Northwest Straights, and southern Georgia Strait. In the winter, they range as far south as Monterey Bay, California and as far north as the Queen Charlotte Islands. The current population is estimated at 74 (https://www.whaleresearch.com/orca-population, last accessed October 4, 2018).

The final recovery plan for the SRKW identified numerous external factors that may be limiting recovery of this species (NMFS 2008). These included toxic contaminants that accumulate in top predators, disturbance from marine vessel traffic/noise, and quantity and quality of prey (NMFS 2008). While management of the Columbia River System does not directly affect SRKW, operations do directly affect Chinook salmon (both natural origin and hatchery) that migrate past these federal dam and reservoir projects. This may indirectly affect SRKW by influencing some proportion of prey availability originating from the Columbia River basin.

NOAA Fisheries has analyzed Chinook salmon stocks based on their estimated importance to the whales and found that the most crucial stocks are those returning to the Fraser River in British Columbia, other rivers draining into Puget Sound and the Salish Sea, and the Columbia, Snake, Klamath, and Sacramento rivers. NOAA Fisheries' analysis showed that Puget Sound Chinook salmon stocks are one of the most important salmon stocks for Southern Resident killer whales, since they surround the heart of the whales' habitat, and the whales have access to them for a greater part of the year than fish from the Columbia, Snake, and Fraser rivers. In the Columbia River basin, different stocks vary in overall importance for the diet of SRKW. For example, Snake River spring-summer Chinook salmon are mainly available to SRKW when the fish gather off the mouth of the Columbia, whereas Snake River fall Chinook remain closer to the coast and would be available for a longer period before migrating upriver in the fall. (NOAA Fisheries and WDFW 2018; NOAA Fisheries 2014; NOAA Fisheries 2018).

In 2008, NOAA Fisheries concurred with the Action Agencies' determination that system management may affect, but was not likely to adversely affect SRKW (NOAA Fisheries 2008; Reclamation 2008). This determination was based on expected status improvements for prey originating from the Columbia as a result of three key factors: (1) previous modifications to system operations and configuration to benefit salmonids; (2) ongoing artificial production programs in the Columbia River Basin; and (3) implementation of the 2008 BiOp's RPA actions, with further improvements to mainstem migration conditions, spawning and rearing habitat, predator management, and hatchery reforms (Reclamation 2008).

In light of the complexities inherent in parsing sources of mortality associated with system management from other anthropogenic as well as natural sources, NOAA conservatively calculated total mortality for fall Chinook, a key prey species, through the mainstem and compared this estimate to increased numbers of Chinook salmon produced from hatchery programs supported by the Action Agencies. NOAA concluded this production "more than mitigates for" total mortality in the mainstem migratory corridor from all sources (NMFS 2008b, p.9-17). In light of further expected improvements to the status of listed Chinook stocks in the long term as a result of the 2008 RPA, and the near-term offsets to all sources of mainstem mortality provided by artificial production, NOAA Fisheries concurred with the Action Agencies' determination that system operations may affect, but were not likely to adversely affect SRKW (NMFS 2008b).

In 2014, NOAA confirmed the continuing validity of the analyses and conclusions from the 2008 consultation, once again based in part (and conservatively) on the fact that Chinook salmon hatchery production supported by the Action Agencies more than offsets near-term losses to the SRKW prey base resulting from all sources of mortality through the mainstem migratory corridor (NOAA Fisheries 2014 – see page 487).

For the Columbia and Snake River Chinook salmon prey source, past improvements to the configuration and operation of the Columbia River System described in this chapter, additional improvements to the environmental baseline as a result of completed estuary and tributary habitat actions, and the prospective conservation measures proposed in Chapter 2, all contribute towards maintaining and improving Chinook abundance. Relevant conservation measures include, among other things, a commitment to continue funding the conservation and safety net hatchery programs listed in Table 2-8. With respect to the environmental baseline, the Action Agencies have continued independent responsibilities to fund existing hatchery programs that help fulfill mitigation objectives established by Congress in the authorizations to construct and operate individual dam and reservoir projects within the Columbia River System, including Grand Coulee Mitigation, John Day Mitigation, and programs funded and administered by other entities, such as the Lower Snake River Compensation Plan. The Action Agencies will fulfill congressionally authorized hatchery mitigation objectives through the funding of hatchery programs that are operated consistent with their independent hatchery program consultations during the term covered by this consultation. Based on those hatchery program consultations, the production levels associated with congressionally authorized hatchery mitigation objectives will continue, at minimum, to be consistent with levels previously analyzed by NOAA in the system consultations in 2008 and 2014.

For this consultation, therefore, the Action Agencies expect that collectively, all of the actions described above (substantial modifications to migration conditions designed to benefit key prey species, combined with improvements to Chinook spawning and rearing habitat in the tributaries and Columbia River estuary ,and continued hatchery production) ensure that remaining Chinook mortality from all sources in the mainstem migratory corridor will continue to be more than offset, resulting in a net gain in Chinook abundance available as a prey source for SRKW.

Any remaining Chinook mortality attributable to management of the Columbia River System is only a subset of the total mortality from all sources within the mainstem migratory corridor. Therefore, the Action Agencies have determined that management of the Columbia River System may affect, but is not likely to adversely affect the SRKW species.

2 Description of Proposed Action

The purpose of this ESA Section 7(a)(2) consultation is to evaluate the effects of the management of an ongoing federal action: the operation, maintenance, and configuration (management) of the fourteen federal dam and reservoir projects in the Columbia River System that are managed as a coordinated system for multiple congressionally authorized public purposes by the U.S. Army Corps of Engineers (Corps), the Department of Interior's Bureau of Reclamation (Reclamation), and Bonneville Power Administration (Bonneville) (collectively, the Action Agencies). The core of the Proposed Action therefore consists of the coordinated water management of these projects.

Improvements in system operations to benefit fish, in particular fish passage, over the last two decades have substantially increased juvenile and adult fish survival. In light of these improvements resulting in high dam passage survival and faster fish travel times, the Action Agencies propose to continue operations that support ESA-listed species. In addition, the Action Agencies propose to test the hypothesis that further increasing system-wide spill levels (up to the current applicable state water quality standards of 115/120 total dissolved gas) will have the effect of substantially increasing adult salmonid return rates. The most recent Comparative Survival Study (CSS) 2017 Annual Report hypothesizes increases of 23 percent or more. To help address uncertainty related to any residual adverse effects of system management, the Proposed Action also includes commitments for additional non-operational conservation measures, which serve as offsite mitigation and are described further in Section 2.2, below.

This chapter also describes system management actions taken at the dams to maintain the reliability of the federal transmission system (see Appendix B) operated by Bonneville in accordance with statutory and regulatory requirements. Additionally, this chapter describes irrigation withdrawals from the Columbia River for the Columbia Basin Project, and as a matter of convenience, describes the cumulative hydrologic effects (depletions) on the mainstem Columbia River from some of Reclamation's tributary irrigation projects covered under separate consultations (Appendix C). This chapter is organized by authorized project purposes, beginning with the storage projects and working downstream.

The Columbia River System provides multiple public services to Pacific Northwest communities in particular and the nation as a whole. Beginning in the 1930s, both federal and private entities have constructed numerous dams throughout the basin to serve multiple purposes, including flood risk management (FRM), irrigation, navigation, carbon-free power generation, fish and wildlife conservation, recreation, industrial and municipal water supply, and water quality.

As part of that effort, Congress authorized the Corps and Reclamation to construct, operate, and maintain the 14 federal dams and reservoirs in the Columbia River Basin that are the subject of this consultation, for the aforementioned multiple public purposes. Bonneville is a federal power marketing administration with the U.S. Department of Energy responsible for marketing and distributing the power generated at the federal hydroelectric projects in the Columbia River Basin that comprise the Federal Columbia River Power System (FCRPS). This includes the fourteen multiple-use projects that are the subject of this consultation. The Corps, Reclamation, and Bonneville coordinate system water management functions to fulfill multiple authorized project purposes in accordance with all relevant laws, including the ESA. The Action Agencies also operate these federal projects in coordination with certain Canadian reservoir projects consistent with the Columbia River Treaty between the United States and Canada,[7] as well as several public utility district projects on the mid-Columbia River.

The Corps and Reclamation are responsible for operating and maintaining the projects to support the purposes identified in the project authorizations. Neither the Corps nor Reclamation may significantly diminish these project purposes unless otherwise authorized by law. Brief descriptions of the purposes and authorities for the projects included in this consultation can be found in Appendix A.

The Corps operates and maintains 12 of the 14 Columbia River System projects: Bonneville Dam, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Dworshak, Chief Joseph, Albeni Falls, and Libby dams. The Corps operates and maintains these projects for FRM, navigation, hydropower generation, fish and wildlife conservation, irrigation, recreation, water quality, and municipal and industrial water supply, though not every project is authorized for every one of these purposes.

Reclamation operates and maintains the remaining two of the 14 Columbia River System projects: Grand Coulee and Hungry Horse dams. Reclamation operates these projects to support multiple legally mandated purposes that differ among the projects, including irrigation, hydropower generation, FRM, navigation, and municipal and industrial water supply.

Bonneville markets and distributes power generated at these fourteen federal projects on the Columbia River and its tributaries. Transmission facilities owned and operated by Bonneville interconnect and integrate electric power generated at the federal projects to the regional transmission grid. Certain transmission system needs can impact water management functions at the projects. For example, Bonneville's management of its transmission system in response to a transmission line outage can influence the location and amount of power generation required to maintain system reliability, which impacts when, where, and through which outlets the Action Agencies pass river flows at the dams. These water management actions triggered by transmission system reliability and related needs are included in the Proposed Action and are therefore described further in Appendix B.

Climate considerations in the Proposed Action

There are several ways the Action Agencies are both currently managing the Columbia River System and preparing to respond to emerging changes in environmental conditions that are anticipated as part of a changing climate. As climate alters the hydrologic regime, reservoir operations (e.g., refill schedules, FRM curves, and flood operating criteria) may need to be adjusted in order to maintain reliable water deliveries, power system management, support for environmental needs, and management of flood risk. In response, the Action Agencies, working through their River Management Joint Operating Committee (RMJOC), convened a team of regional reservoir operations experts, planners, climate scientists, and hydrologists to develop a process for evaluating the impacts to basin hydrology and system operations from climate variability (RMJOC 2011). The Action Agencies will continue to fund

[7] Treaty between Canada and the United States of America Relating to Cooperative Development of Water Resources of the Columbia River Basin, U.S.-Canada, Sept. 16, 1964, 15 U.S.T. 1555. The Canadian Entity (B.C. Hydro) and the U.S. Entity (the Administrator of the Bonneville Power Administration and the Northwestern Division Commander of the U.S. Army Corps of Engineers) are charged with the duty to formulate and carry out the operating arrangements necessary to implement the Columbia River Treaty.

studies to improve our understanding of climate impacts, and to improve hydrologic and water quality models and methodologies. In 2013, the Action Agencies in coordination with the University of Washington, Oregon State University, and other research partners, undertook the RMJOC-II climate variability project to update streamflow datasets using the latest global climate models from the Coupled Model Intercomparison Project Phase 5 (CMIP5). The results of these studies and models will provide a realistic range of possible future scenarios for long range planning while taking into account warmer global trends. Part I of the RMJOC-II report, unregulated dataset development and analysis, was completed in September 2017 (RMJOC 2018).

As part of system operations, the Action Agencies propose to continue managing upriver projects to provide flow during salmon and steelhead migration seasons and to provide cooler flows at key locations and time periods where feasible. Habitat improvement actions implemented under past BiOps will continue to protect and improve streamflows, and riparian areas will continue to help reduce or maintain stream temperatures to protect cold-water refugia, and provide improved salmon rearing and spawning habitat within key parts of the Columbia Basin. The activities included in this Proposed Action help to improve species resiliency by addressing risks from variable climate and improve the chance that salmon and steelhead can migrate through the mainstem corridor safely and find suitable spawning and rearing habitat.

2.1 System operations for congressionally authorized project purposes

2.1.1 Operations for flood risk management

In the first half of the 20th century, in response to a request from Congress, the Corps and Reclamation developed comprehensive plans for water resources of the Columbia River Basin. In addition, the U.S. and Canadian governments entered into the Columbia River Treaty to address the international aspects of managing transboundary waters through coordinating operations for FRM and hydroelectric power and other benefits for both countries.

Managing water in the Columbia River System for its many purposes is particularly challenging given the relatively small portion of the annual runoff volume that can actually be stored in reservoirs. The system produces an annual average of about 200 MAF of runoff water measured at Astoria, Oregon, but only about 20 percent of it can be impounded in storage reservoirs. U.S. reservoirs in the Columbia River System and Columbia River Treaty storage in Canadian reservoirs can only store approximately 42 MAF for coordinated operations. The Columbia River System, with its large annual volume-to-usable-storage ratio, must evacuate on a yearly basis to accommodate water supply conditions in the Columbia River Basin. This means that operators cannot use stored water to transform a dry year’s water supply into an average flow year.

Columbia River System storage projects operate as a coordinated system to meet regional flood risk management (FRM) objectives.[8] This section provides a general description of the actions relative to Columbia River System FRM operations (see Appendix A for more detail on FRM).

The Columbia River System FRM operations are designed to reduce flood damages and minimize the risk of flooding in the upper basin and for the lower river, including the Portland, Oregon, and Vancouver, Washington, areas. Although no dam or system of dams and levees can eliminate all downstream flooding, the overall goal of FRM in the Columbia River Basin is to protect life and property by minimizing flood consequences or risk of damages, regardless of the conditions presented in any given water year.

System operations for flood risk management

To meet Columbia River System FRM objectives, all storage projects in the system generally operate in a coordinated manner. Storage projects that are operated for U.S. FRM purposes include congressionally authorized Federal projects, Columbia River Treaty projects in Canada,[9] and non-federal projects in the United States.[10] For this consultation, the Action Agencies are only consulting on the effects of the operation and maintenance of the 14 Federal projects described in this Proposed Action.

The required FRM draft and refill operations at the Canadian Treaty dams are described in the Columbia River Treaty Flood Control Operating Plan (FCOP).[11] Federal dams operate in accordance with their Water Control Manuals (WCM), and the non-federal projects with system flood storage in the United States are addressed through the Federal Energy Regulatory Commission (FERC) licenses issued to these project operators. FERC must consult with the Corps to ensure the non-federal projects with flood storage are operated in accordance with Corps regulations, including the development and implementation of FRM operating criteria.

The Corps' responsibility for FRM is to protect the general safety and welfare of the public by managing the risks and consequences associated with floods. As stated in the FCOP, "[t]he basic objective for flood regulation is to operate reservoirs to reduce to non-damaging levels the stages at all potential flood damage areas in Canada and the United States insofar as possible, and to regulate larger floods that cannot be controlled to non-damaging levels to the lowest possible level with the available storage space." Through the previous ESA consultations with both NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS), FRM requirements have been accounted for; however, operational flexibility has been reduced to increase the amount of water available through flow augmentation for ESA-listed fish species. System FRM operations are briefly described below.

Fall operations: September – December

Generally, there are minimal system FRM operations during the September-through-December period. Some storage projects have end-of-December target elevations requiring lowering, or drafting, the

[8] The Flood Control Act of 1936 established the federal government's authority to improve navigable waters for the purpose of flood control, now referred to as flood risk management, or FRM.

[9] Mica, Duncan, and Hugh Keenleyside dams in British Columbia

[10] Brownlee and Se¿lis¿ Ksanka Ql¿ispe¿ (formerly known as Kerr) Dam.

[11] The FCOP is available online at http://www.nwd-wc.usace.army.mil/cafe/forecast/FCOP/FCOP2003.pdf

reservoir levels in order to achieve the specific FRM objectives that are unique to each dam. Dworshak and Hungry Horse Dams have fixed rule curves[12] requiring end-of-December drafts for managing winter flood events, however other operational purposes will generally bring the reservoir levels lower than the December FRM requirements. Grand Coulee Dam does not have a fall FRM requirement. At Albeni Falls Dam, the target date to be within a half a foot of the minimum control elevation (MCE) is November 15. This date is at the request of the Idaho Department of Fish and Game to protect kokanee spawning and incubation. In the case of unusual hydrologic conditions, Albeni Falls does have the flexibility to be within a half a foot of the MCE by November 20. At Libby Dam, end-of-December FRM draft requirements are variable and set by the December 1 water supply forecast. John Day is operated within the minimum irrigation pool (MIP) through September, followed by an expanded operating range during the fall and winter months for FRM on the lower Columbia River.

Storage evacuation operations: January – April

During the January-through-April period, the Columbia River System and Canadian Treaty storage projects operate to the storage reservation diagram (SRD) unique to each dam. The SRDs determine the maximum allowable elevation for each reservoir based on a given water supply forecast. Within the first 10 days of each month, from January through April, an official water-supply forecast is prepared for each storage project and many locations throughout the Columbia River Basin, including The Dalles Dam. In very wet winters when there is abundant snowpack, the objective is to have appropriate storage space to accommodate the expected runoff and provide flows for ESA-listed and other fish; in dry winters with less snowpack, the objective is to manage storage space to ensure the reservoirs refill while maintaining reservoir space for unexpected spring rain events, similar to the flood events of 2012. Every year, the reservoirs are operated to maximize available water for fish during the migration season while also ensuring that FRM objectives are met.

In general, the storage projects are operated to meet FRM draft requirements to prepare for high spring flows and reduce the potential for flooding. The FRM operations end-date varies depending on the hydrologic characteristics of sub-basin and operational constraints, and as the forecasts are updated each month, the storage reservoirs will be drafted to their final FRM elevation by the end of March, April, or early May. Canadian Treaty projects in the northerly areas of the Columbia River Basin are drafted to the lowest elevation by the end of April.

Refill operations: May – July

During the May-through-July period, the Columbia River System storage projects are operated to target refill, limited by system and local FRM guidance. The projects on the Columbia River operate together to meet the initial controlled flow (ICF) at The Dalles while refilling reservoirs during the refill period.

The ICF is a calculated flow used in conjunction with the forecasts and available reservoir storage to determine when to start refill to ensure a high probability of achieving total refill while managing flood risks. During the refill period, the outflow from the reservoir is kept lower than the inflow to the reservoir, allowing the water level in the reservoir to increase and refill, eventually reaching its targeted refill elevation when the risk of flooding has significantly decreased. The procedure and tools for these

12 A fixed rule curve means that the FRM requirement is the same for each year.

periods of regulation are presented in the FCOP and Water Control Manuals for the individual reservoirs.

The FCOP (Section 5-5) states, “The ICF established by Chart 1 (Figure 2-1) will be maintained by the regulation of upstream reservoirs until the end of the flood control period, or until revised forecasts indicate the necessity for the controlled flow to be changed. Change in the controlled flow at The Dalles will be made based primarily upon day-to-day forecasts of streamflow and reservoir regulation by computer simulations together with the latest volume forecasts of runoff.” Additional guidance in adjusting the controlled flow during the period of flood regulation can be obtained by referring to Chart 3 (Figure 2-2). The forecasted basin inflow volume is continuously monitored and compared to available remaining reservoir storage space, and the regulated controlled flow is adjusted so that reservoir refill and flood risk are balanced, based on the latest forecasts and observed information until the refill operation is completed.

Columbia River System reservoir operations generally target refill by June 30, but basin characteristics or other constraints may delay the peak elevation until sometime in July. For example, Lake Koocanusa, the reservoir behind Libby Dam in Montana, typically fills after June 30 because much of the snowmelt that feeds the lake occurs later in the season, and often there are local rain events that require adequate storage space.

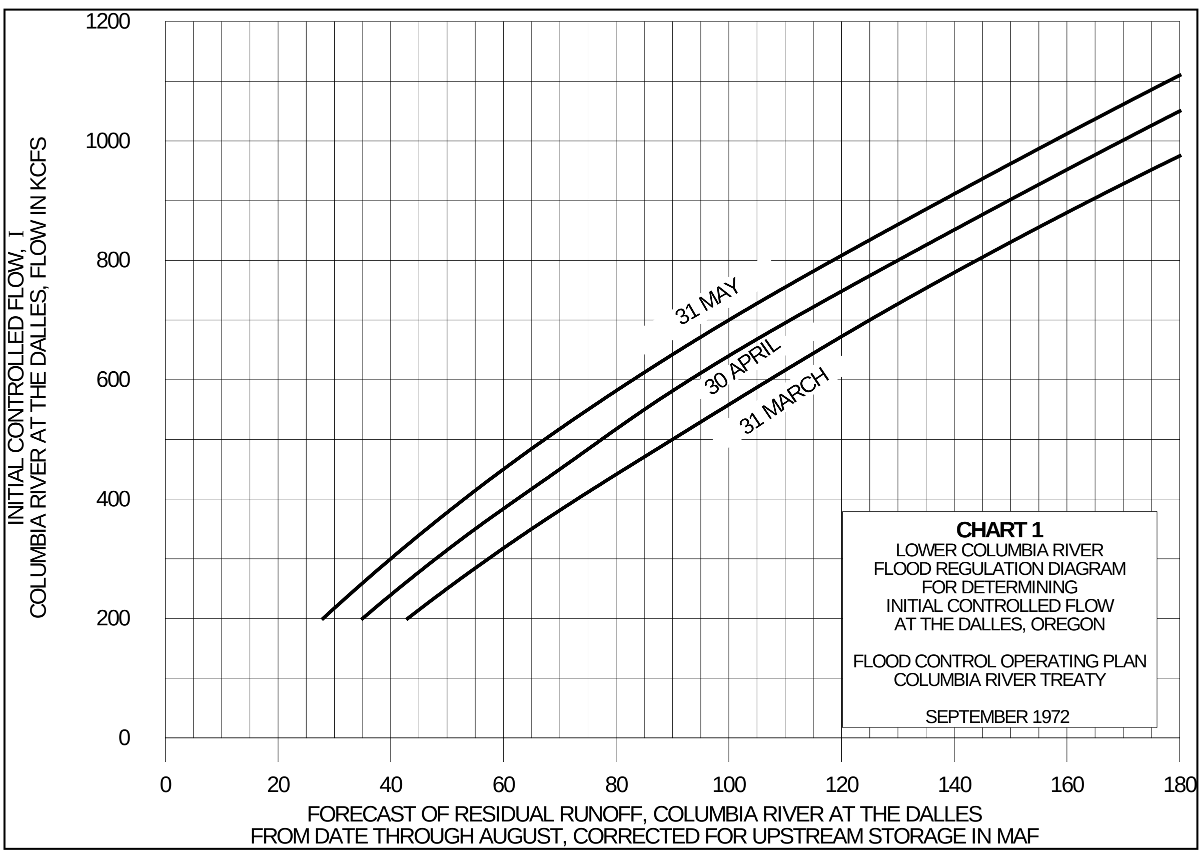

Figure 2-1. Lower Columbia River flood regulation diagram for determining initial controlled flow at The Dalles, Oregon.

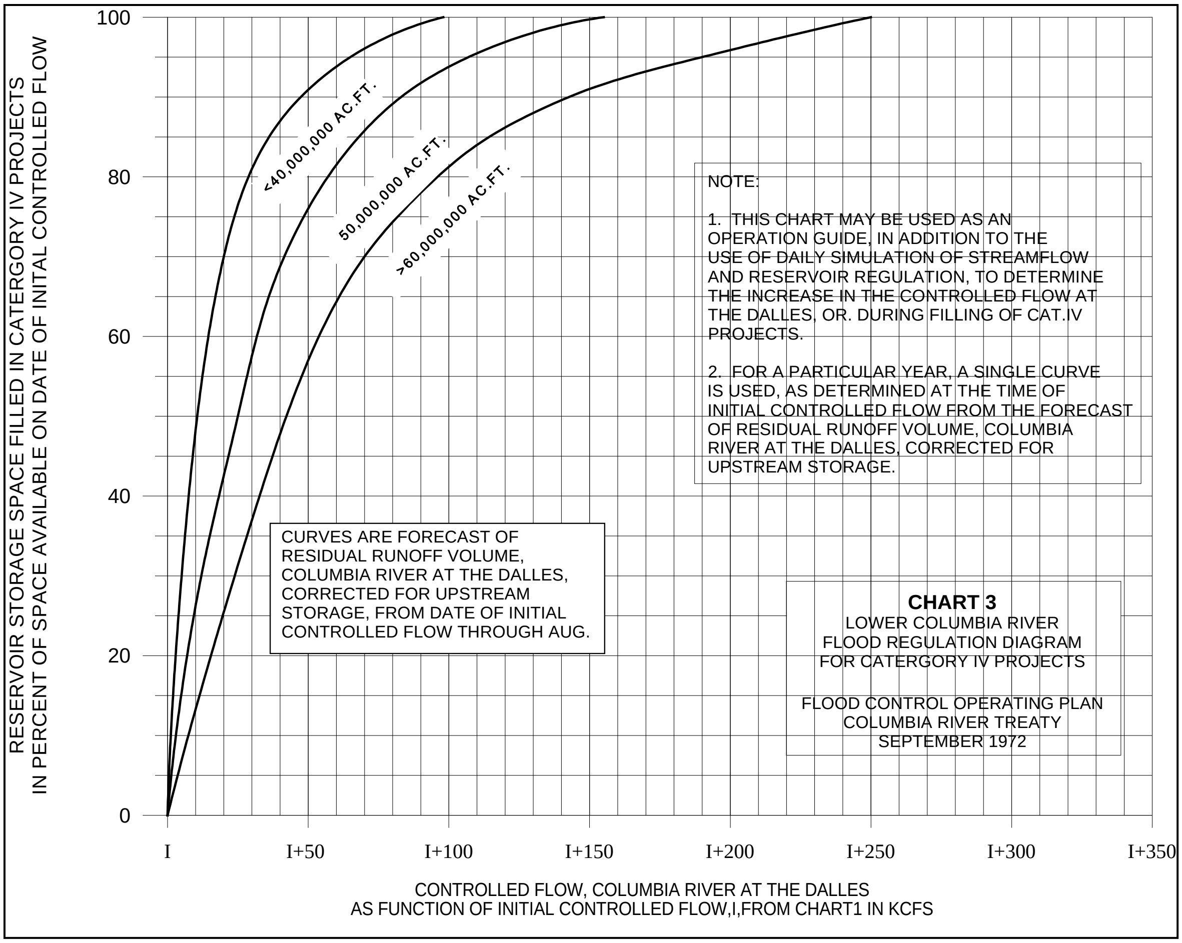

Figure 2-2. Lower Columbia River flood regulation diagram

Libby Dam flood risk management

Libby Dam operations provide local and system FRM through regulation of spring flows in the Kootenai River valley, as measured at Bonners Ferry, Idaho, and in the mainstem Columbia River, as measured at The Dalles, Oregon. Currently, Libby Dam is operated consistent with variable discharge (or VARQ)[13] FRM procedures. Libby Dam operations for FRM are consistent with the requirements of the Columbia River Treaty and the International Joint Commission Order of 1938 on Kootenay Lake. The Corps' Libby WCM is the main reference source for dam operations to meet water management requirements.

[13] The VARQ FRM procedure was developed to improve the multi-purpose operation of Libby and Hungry Horse while not reducing the level of flood protection in the Columbia River. VARQ FRM reduces the contribution of reservoir space at Libby and Hungry Horse for system flood risk management addressing spring runoff in the Columbia River in years when the potential for flooding is moderate. Correspondingly, the procedure was designed to provide higher outflows from the projects during the spring runoff than were made under the standard FRM operation. These outflows are more consistent with releases made to meet flow objectives for the ESA-listed Kootenai River white sturgeon and Columbia and Snake River salmon and steelhead.

Fall operations: October – November

The October and November elevation targets are set to reach the December 31 FRM elevation by using the powerhouse capacity at Libby Dam. The reservoir is required to be below elevation 2448 feet (0.5 MAF of space) by November 30.

Storage evacuation operations: December – March

Libby Dam operations follow a variable end-of-December FRM rule curve based on the water supply forecast; in most years, the target elevation is 2411 feet, but this target may be relaxed to 2426.7 feet when the water supply forecast is below normal. The project is operated during the December-through-March period (into April if the start of refill has not been declared) to the VARQ FRM SRD, as shown in Figure 2-3. The winter draft, or drawdown, is based on the first of month April-August water supply forecast, which then sets the end of month draft or drawdown targets. The use of the SRD and the forecast result in higher water supply forecasts corresponding to deeper reservoir drafts and years that are forecasted to be low with shallower reservoir drafts.

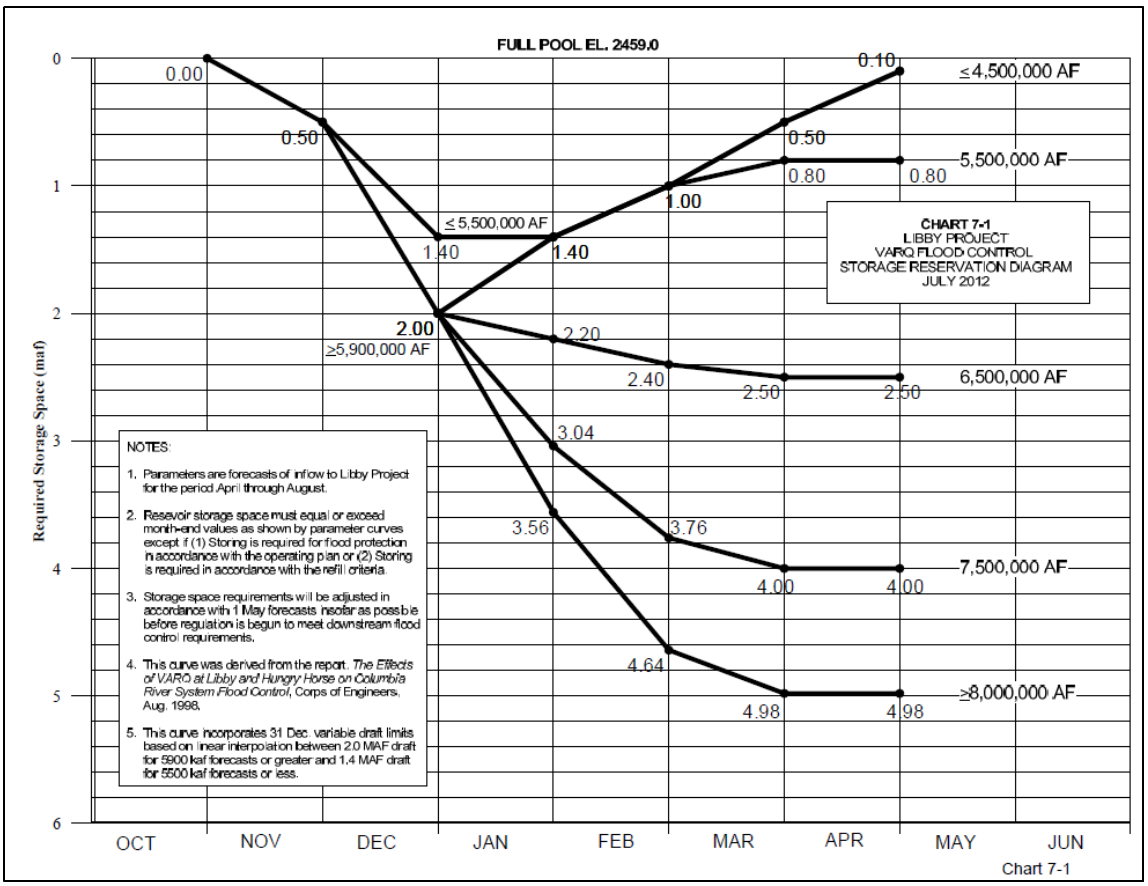

Figure 2-3. Libby Dam VARQ storage reservation diagram (SRD), July 2012

Refill operations: April – June

During the refill period (which can start as early as April and goes through June), Libby Dam will release flow in accordance with VARQ FRM operating procedures at Libby Dam for refill. Refill at Libby Dam will begin either approximately 10 days prior to when the forecasted unregulated flow at The Dalles is expected to exceed the ICF, or may be initiated when the forebay at Libby Dam is anticipated to fall below the Flood Control Refill Curve (FCRC[14]). Once refill begins, Libby Dam outflow will be no lower than the computed VARQ flow (or inflow, if that is lower than the VARQ flow), unless otherwise allowed by the VARQ operating procedures. For example, changes to reduce the VARQ flow can occur to protect human life and safety during the final stages of refill, or through a deviation request. During flood season, Corps reservoir regulators operate Libby Dam for system FRM and to minimize flood consequences by trying not to exceed, insofar as is possible, a river stage of 1764 feet at Bonners Ferry, Idaho. Control of runoff during wet years relies on a use of storage space provided by Canadian and U.S. storage reservoirs under the Columbia River Treaty.

Summer operations: July – September

After the refill period, Libby Dam releases are managed to meet the September 30 targets (draft to 10 feet from full, elevation 2449 feet) by the end of September, except in the lowest 20th percentile water years, as measured at The Dalles, when draft will increase to 20 feet from full (i.e., elevation 2439 feet) by the end of September. If the project is forecasted to fail to refill 20 feet from full, Libby will operate to pass inflow or operate to maintain minimum flows through the summer months. The summer releases allow the project to refill to its maximum elevation generally during late July to early August (Figure 2-4.)

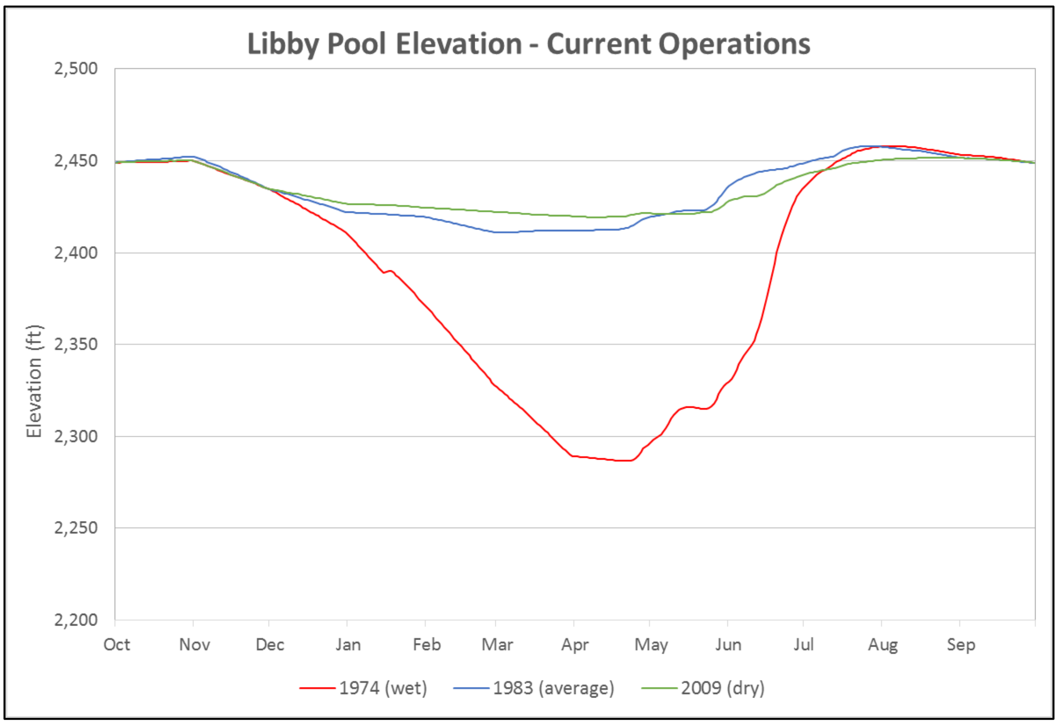

Figure 2-4. Modeled pool elevations at Libby Dam for representative dry, average, and wet years using a period of record of 1949-2014

[14] Flood Control Refill Curves (FCRC) are curves to help guide the refill of reservoirs and ensure the flood control regulation does not adversely affect refill insofar as is possible. These curves define the lower limit of reservoir drawdown that can be filled with a 95 percent assurance.

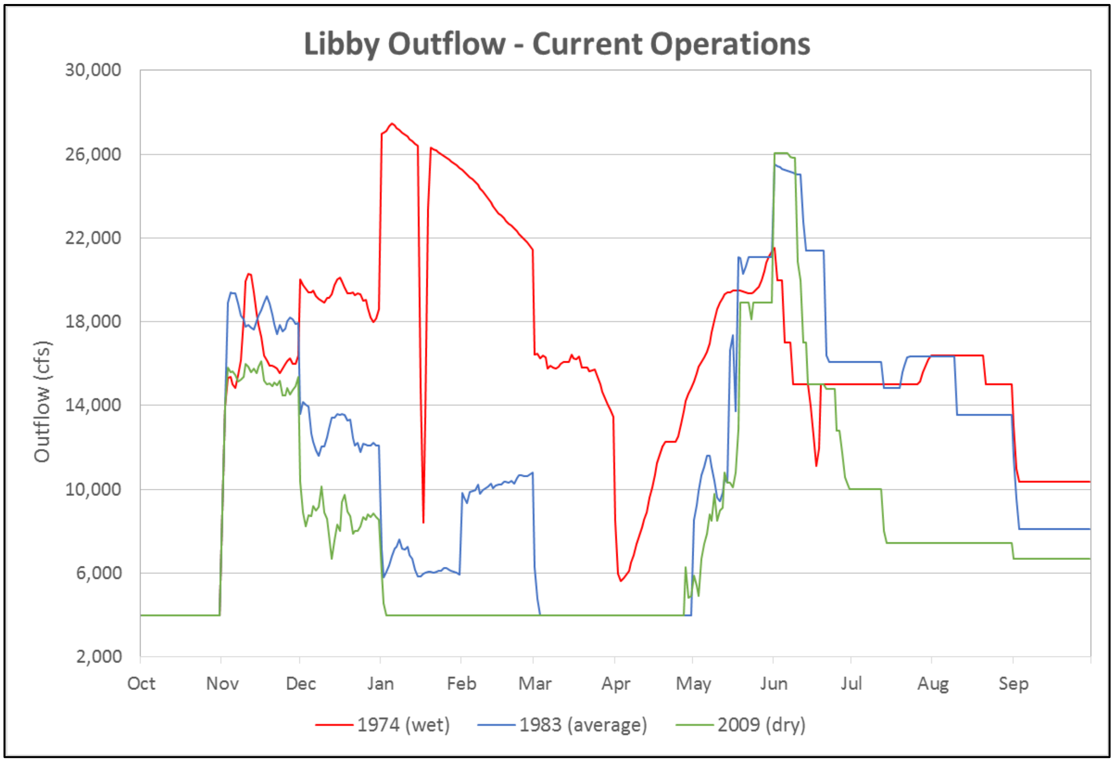

Figure 2-5. Modeled outflow at Libby Dam for representative dry, average, and wet years using a period of record of 1949-2014.

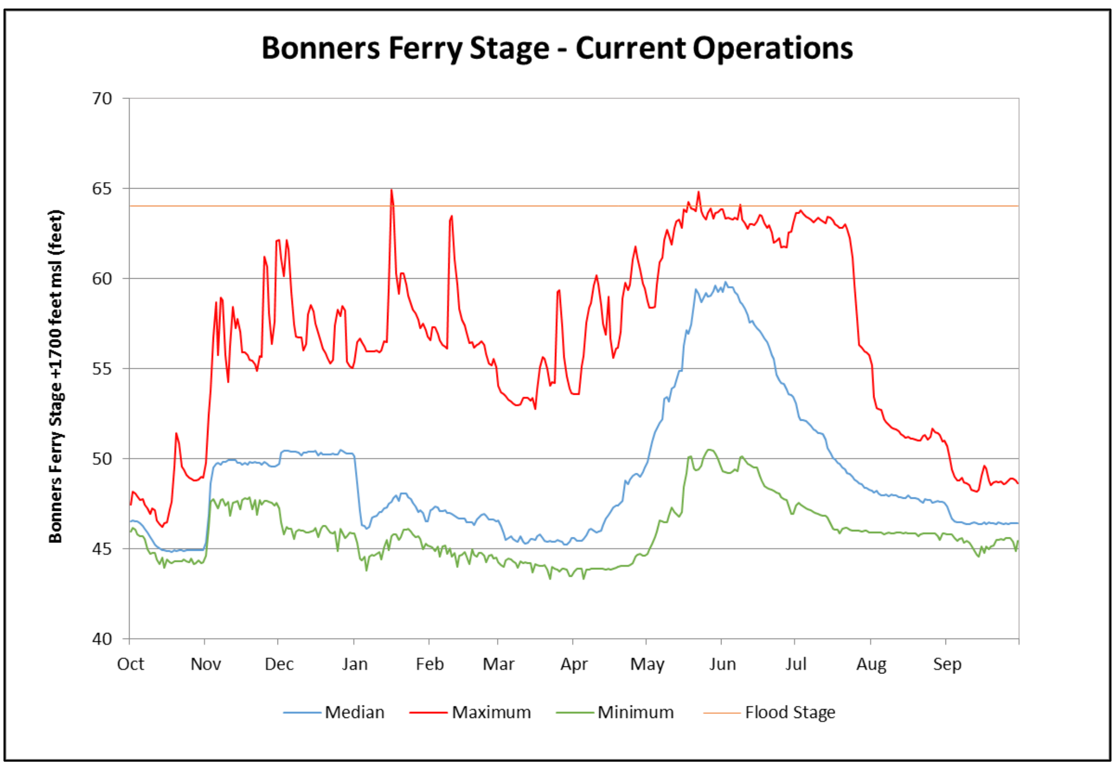

Figure 2-6. Modeled river stages at Bonners Ferry under median, maximum, and minimum flow years using a period of record of 1949–2014.

Hungry Horse Dam flood risk management

Hungry Horse Dam operations provide local and system FRM through regulation of flows in the mainstem Flathead River, as measured at Columbia Falls, Montana, and in the mainstem Columbia River. Hungry Horse Dam is operated consistent with its VARQ FRM[7] procedures. The Corps developed a WCM for Hungry Horse Dam that Reclamation uses as guidance for dam operations to meet FRM needs.

Fall operations: October – December

Hungry Horse Reservoir typically drafts throughout the fall to meet minimum flows at Columbia Falls on the mainstem Flathead River; by the end of December, the reservoir can be an additional 15 to 20 feet below the end-of-September elevation target (3540 feet in 20 percent driest years, 3550 feet all other years ; see section 2.1.2 for additional information). The reservoir is required to be below elevation 3555.7 feet (0.10 MAF of space) from October 31 through November 30 and below elevation 3549.2 feet (0.25 MAF of space) by December 31.

Storage evacuation operations: January – April

Reclamation generally drafts Hungry Horse Reservoir below the required FRM elevations to meet minimum flow requirements at Columbia Falls for resident ESA-listed fish. In water years when minimum flows do not draft the reservoir below the required FRM elevations, Hungry Horse operates to the VARQ FRM rule curves SRD (Figure 2-7). Hungry Horse Dam is operated for both local and system FRM, based on the May-September water supply forecast for Hungry Horse Dam.

On April 30, Hungry Horse Reservoir is typically at its lowest seasonal elevation in order to capture the high flows during spring runoff and to reduce the risk of downstream flooding.

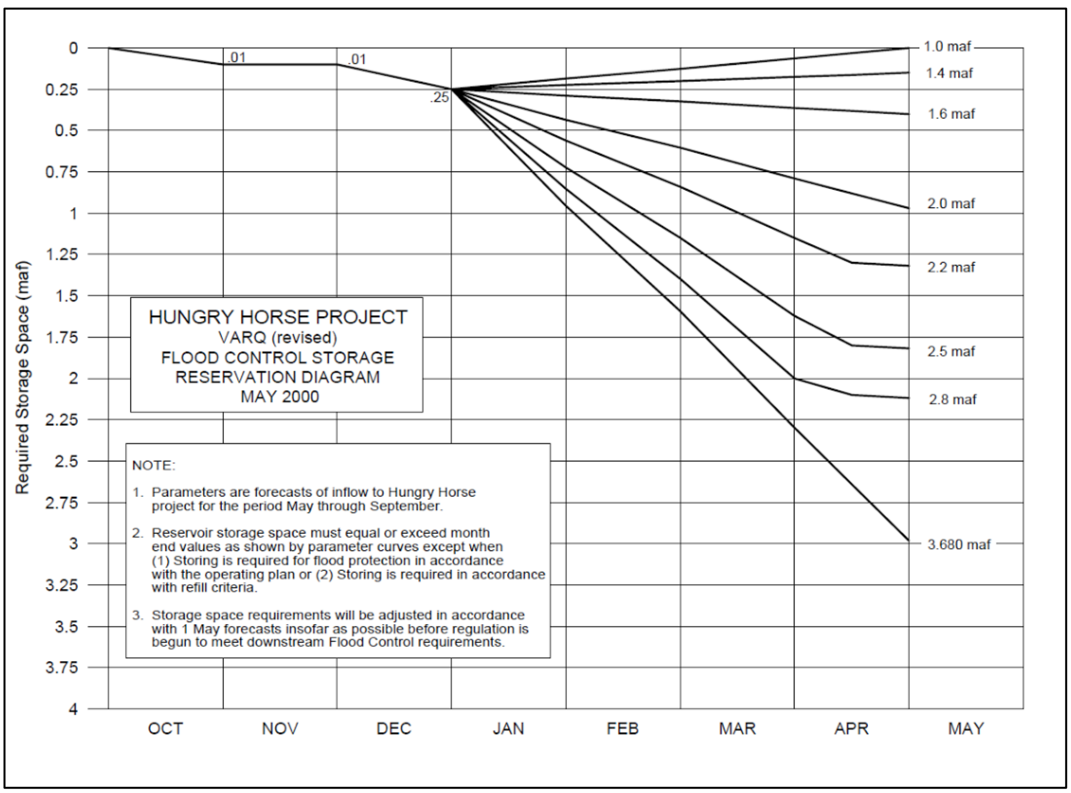

Figure 2-7. Hungry Horse Dam VARQ FRM storage reservation diagram.

Refill operations: May – June

Hungry Horse SRDs are designed for both local and system FRM. For the system flood protection, Reclamation coordinates with the Corps regarding when to begin refill of Hungry Horse Reservoir in the spring.

During refill, discharges from Hungry Horse are determined using inflow volume forecasts, streamflow forecasts, weather forecasts, and the VARQ Operating Procedures.

The Corps computes the ICF at The Dalles and estimates the day that the controlled flow is expected to be reached. When unregulated flows at The Dalles are equal to the ICF, they can start refill of the reservoirs. Refill of Hungry Horse Reservoir can actually start 10 days prior to the date that the initial controlled flow is expected to be met, which typically does not occur before May 1.

As spring flows increase, Reclamation typically does not need to make releases to meet minimum flows at Columbia Falls but releases either the VARQ discharge flow or the minimum flow requirement below the project on the South Fork Flathead River. As flows in the mainstem Flathead River increase, Reclamation must balance refill of Hungry Horse Reservoir while attempting to maintain water levels at Columbia Falls below the flood stage of 14 feet (approximately 51,000 cubic feet per second (cfs)) when the elevation of Flathead Lake is below the top foot (lower than elevation 2892 feet), and below a stage of 13 feet (approximately 44,000 cfs) when the elevation of Flathead Lake is within 1 foot of full (at or above elevation 2892 feet).

Reclamation typically tries to refill Hungry Horse Reservoir by approximately June 30. However, the timing and shape of the spring runoff may result in reservoir refill a few days before or after the June 30 target date.

Summer operations: July – September

In wetter years, refill can be delayed until mid- July. After the refill period, Hungry Horse Dam releases are set to meet the September 30 targets of elevation 3540 feet in the driest 20 percentile of water years and elevation 3550 feet in all other years. These reservoir drafts are meant to support summer flows for juvenile salmon migration downstream of Chief Joseph Dam. In some dry years, Hungry Horse will need to draft below the end of September target to meet minimum flows at Columbia Falls.

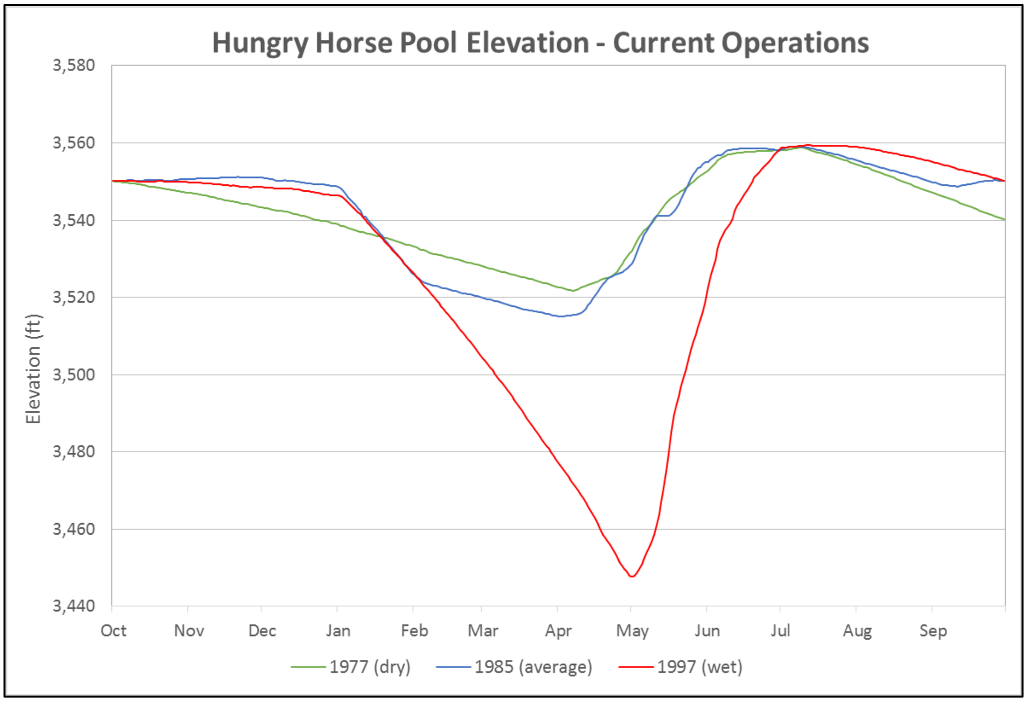

Figure 2-8. Modeled pool elevations at Hungry Horse Dam for representative dry, average, and wet years using a period of record of 1929-2013.

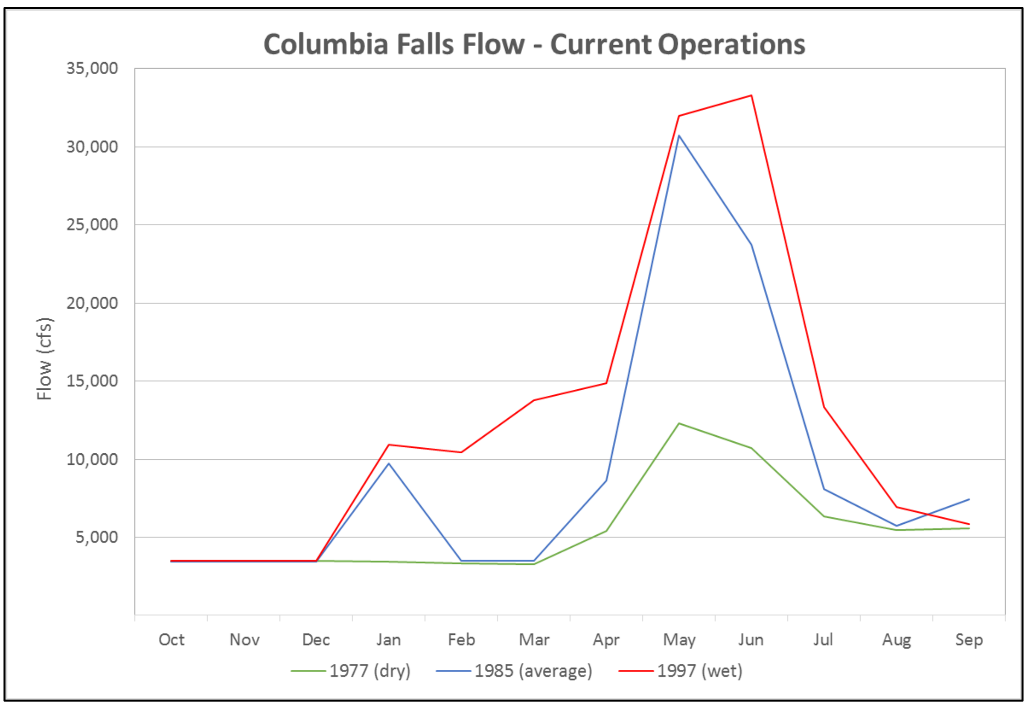

Figure 2-9. Modeled Flow at Columbia Falls during representative dry, wet, and average years using a period of record of 1929-2008.

Albeni Falls Dam flood risk management

Albeni Falls Dam operates to standard FRM criteria. Flood damage reduction benefits of the Albeni Falls project are realized for Lake Pend Oreille and the portion of the Pend Oreille River impounded by Albeni Falls Dam by lowering the maximum stage of Lake Pend Oreille for peak floods between 80,000 cfs and 220,000 cfs. Figure 2-10 shows the annual operating limits for Lake Pend Oreille within the solid black lines.

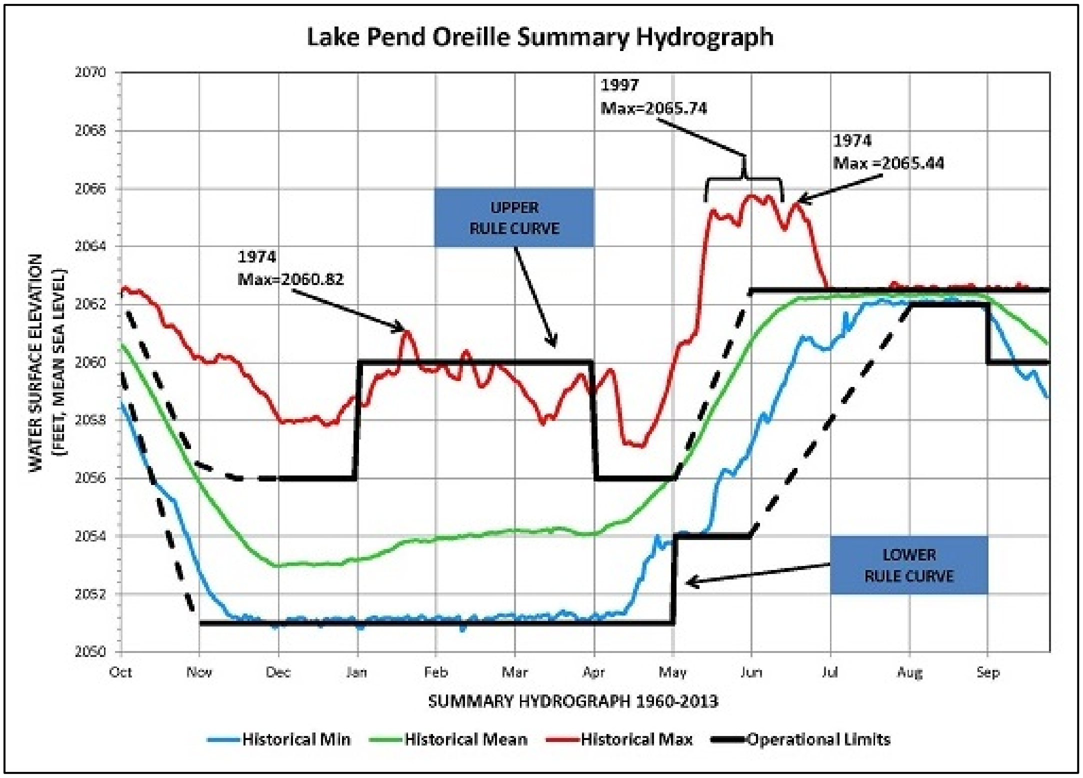

Figure 2-10. Summary hydrograph for Lake Pend Oreille.

Fall operations: October – November

Drafting at Lake Pend Oreille begins in mid-September, and Lake Pend Oreille is drafted down to the winter minimum control elevation (MCE) of 2051 feet by mid-November. During the month of October and through the first week of November, the Corps drafts the project, targeting to be within a half-foot of 2051 feet, targeting reaching the MCE by November 15 in response to IDFG's request to provide spawning grounds for early spawning kokanee and no later than November 20 depending on hydrologic conditions.

Winter holding period and power operations: December – March

The Corps holds Lake Pend Oreille within a half-foot of the MCE after mid-November until IDFG declares that kokanee spawning is over, or by a certain date (i.e., December 31), whichever occurs first.[15] The Corps coordinates with IDFG to determine the best time that water can be stored in Lake Pend Oreille for Flexible Winter Power Operations without affecting kokanee redds. After kokanee spawning has

[15] An exception applies when hydrologic conditions preclude the Corps from attaining this elevation.

stopped, the Corps can operate the lake to 1 foot above the MCE. The 1-foot operating band can only be exceeded for FRM or power requests. Flexible Winter Power Operations may occur after IDFG has declared the end of kokanee spawning and remains in effect through the end of March. During this period, the elevation of Lake Pend Oreille can fluctuate between 2051 and 2056 feet at Bonneville's request and the Corps approval, in consideration of downstream power system needs. The lake can be operated in the winter up to elevation 2060 feet for FRM needs locally and on the mainstem of the Columbia River if the project is not on freeflow.

Refill operations: April – June

The Corps monitors snowpack status leading up to and during the spring flood season from April to mid-July. In years that are forecasted to be above average, the lake elevation is held as low as possible until the channel restriction forces freeflow (all spillway gates are taken out to minimize FRM upstream and downstream of the dam). Under these conditions, the dam will operate on freeflow until the flood threat is over. Throughout the month of June, the Corps monitors snowpack and weather forecasts to best determine timing to refill the reservoir to the summer operating range of 2062.0 to 2062.5 feet.

Summer operations: July – September

During the summer, Albeni Falls Dam is operated to pass water through and maintain a pool elevation between 2062 and 2062.5 feet (the summer operating pool). The summer operating pool is often held through Labor Day, after which the lake elevation operating band increases to 2060 to 2062.5 feet through the month of September. Lake levels through the month of September are based on in-season recreation, biological, and power generation needs for the Columbia River mainstem.

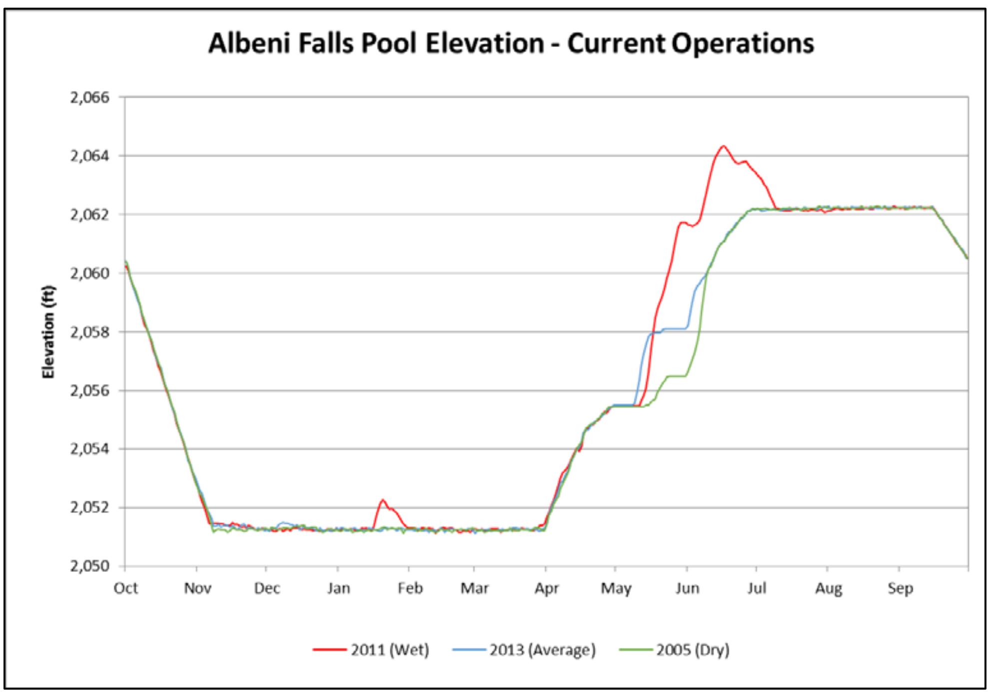

Figure 2-11. Modeled pool elevations at Albeni Falls Dam for representative dry, average, and wet years.

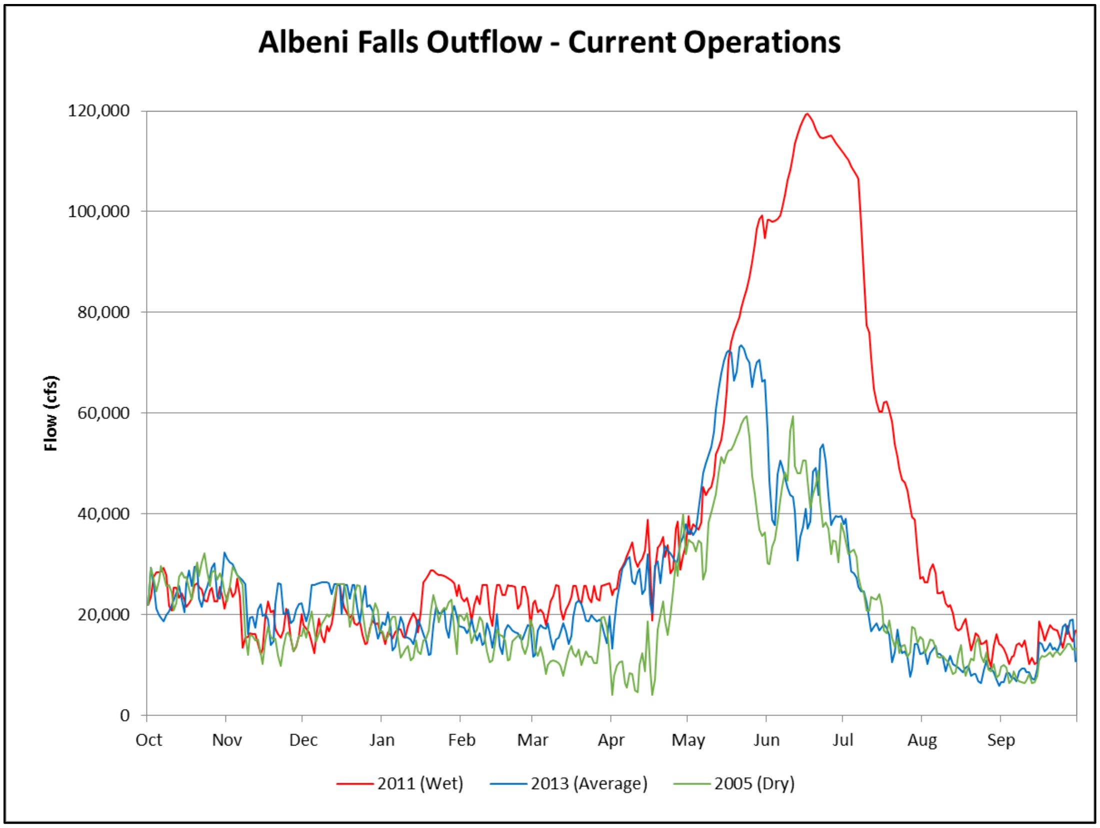

Figure 2-12. Modeled outflow at Albeni Falls Dam for representative dry, average, and wet years.

Grand Coulee Dam flood risk management

Grand Coulee Dam is operated to standard FRM criteria to provide FRM through regulation of flows for the Columbia River at The Dalles.

Fall operations: September – December

Grand Coulee Dam operates to the August 31 target elevation based on the water supply forecast. Grand Coulee Dam does not have an end-of-December FRM upper rule curve draft requirement; however, operations for other purposes, including power generation and water releases to help benefit chum salmon spawning and rearing areas in the mainstem Columbia River, typically draw down Lake Roosevelt below full pool by the end of December.

Storage evacuation: January – April

Grand Coulee Dam is operated from January through April to the standard FRM requirements, based on the April-August volume water supply forecast for The Dalles. The Corps has established the Grand Coulee Dam SRD (Figure 2-13), which includes space requirements at Lake Roosevelt that are determined from The Dalles' runoff water supply forecast minus system storage space available upstream of The Dalles, other than at Lake Roosevelt.

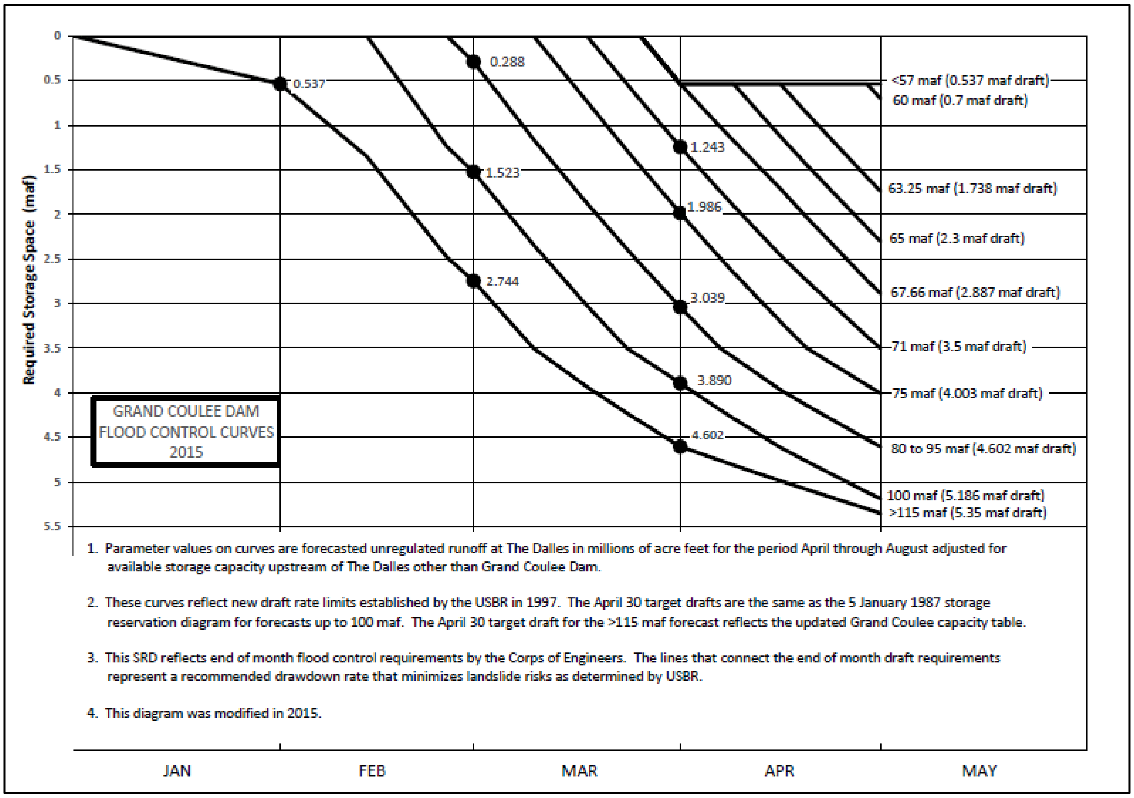

Figure 2-13. Flood risk management curves at Grand Coulee Dam, 2015.

Refill operations: May – June

The Corps computes the ICF at The Dalles and estimates the day that controlled flow is expected to be reached. When unregulated flows at The Dalles are equal to the ICF, the reservoirs can start refill. Refill at Lake Roosevelt can actually start two days prior to the date that the initial controlled flow is expected to be met.

Summer operations: July – August

Reclamation targets refill after the Fourth of July holiday; however, in wetter water years, refill can be delayed until mid-July to manage flows at The Dalles.

Dworshak Dam flood risk management

Dworshak Dam operations provide local and system FRM through regulation of winter and spring flows in the Clearwater River, lower Snake River, and lower Columbia River. Dworshak Dam is operated consistent with the Corps' Dworshak Dam WCM. This operation includes following operational rule curves and SRDs for both local and system FRM based on the runoff volume forecast.

Dworshak is operated to meet minimum releases, which are performed during the fall operation period, and the reservoir elevation is maintained below the 1558 end-of-December FRM target. The reservoir is required to be below elevation 1558 feet (0.7 MAF of space) by December 15.

Storage evacuation period: January – April

Dworshak Dam is operated for both local and system FRM, based on the April-July water supply forecast for Dworshak Dam. Dworshak Dam operates to the standard FRM SRD (Figure 2-14). At the beginning of

January, Dworshak is at or below elevation 1558 feet, which provides a minimum 700,000 acre-feet of available storage. This represents the minimum end-of-December FRM space.

Releases from Dworshak are regulated so as not to exceed 25,000 cfs immediately below the dam in the North Fork Clearwater River or 115,000 cfs at Spalding, Idaho, whichever is most restrictive. As needed for system FRM, Dworshak releases can be reduced to a minimum of 1,600 cfs to maintain the Columbia River at Vancouver, Washington, below flood stage (16 feet), as long as other project operating requirements are met.

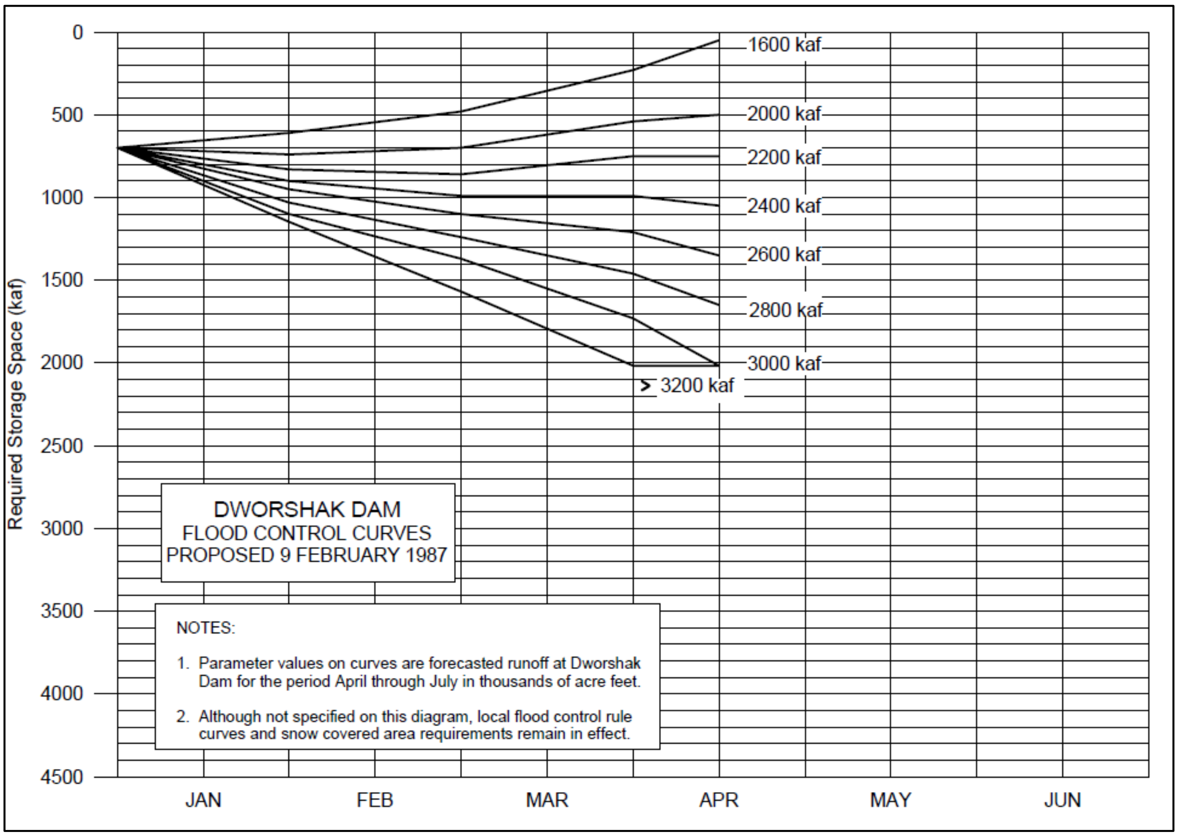

Figure 2-14. System flood risk management curves at Dworshak Dam.

Spring operations: May – June

When the system SRD intersects the FCRC, normally during the month of April, Dworshak begins refill. The FCRC uses an April-July runoff volume forecast and an estimated reservoir release to determine refill target elevations.

Efforts are made to fill Dworshak to elevation 1600 feet by the end of June, or earlier (if possible), following the FCRC.

Similar to the winter flood requirements described in the section above spring floods are regulated to meet the same requirements for peak project outflows as well as flows at Spalding and Vancouver.

Summer operations: July – September

Once the reservoir is refilled, Dworshak is operated in the summer for the gradual evacuation of water through a combination of temperature objectives to maintain Lower Granite Dam tailwater temperatures below 68° F and reach an elevation of 1535 feet by August 31 and elevation 1520 feet by September 30.

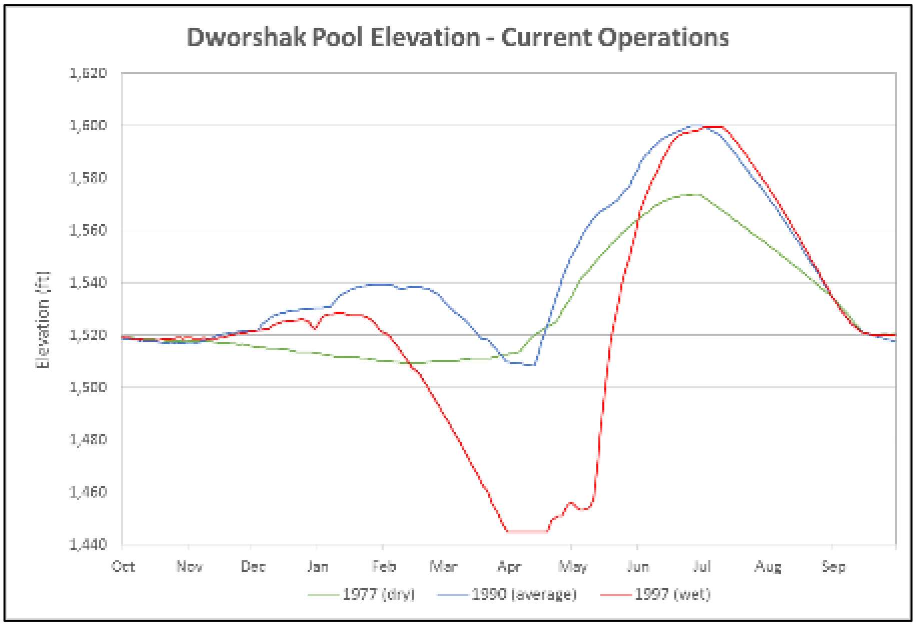

Figure 2-15. Modeled pool elevation at Dworshak Dam for representative dry, average, and wet years using a period of record of 1929–1998.

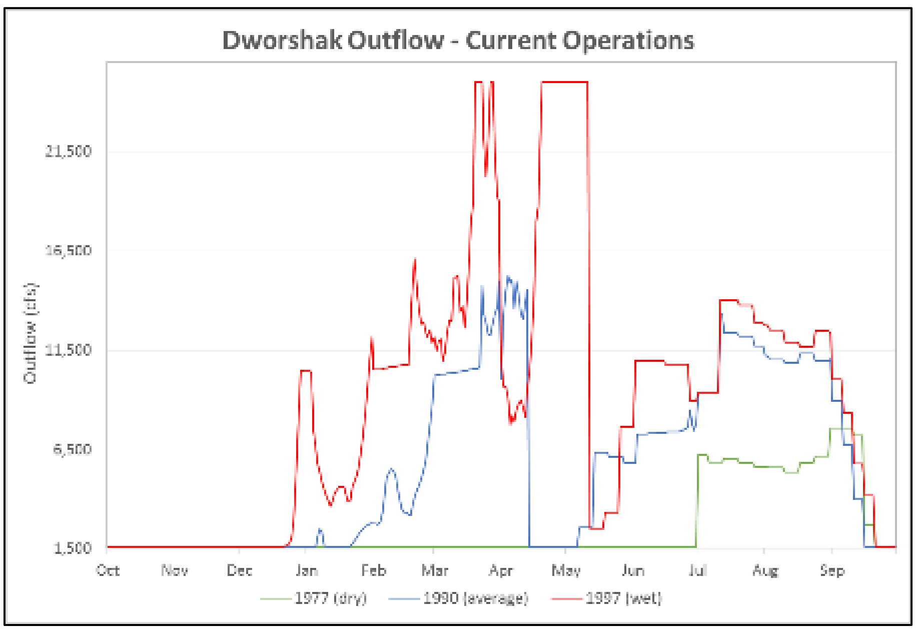

Figure 2-16. Modeled outflow at Dworshak Dam for representative dry, average, and wet years using a period of record of 1929–1998.

John Day Dam flood risk management

While routinely operated as run-of-river, the project has approximately 0.5 MAF of flood storage between the minimum elevation of 257.0 feet and the maximum elevation of 268.0 feet. The reservoir storage is primarily designed to be used during winter and spring flooding to reduce flood stage at the

Portland Harbor, but can also be used for similar purposes during peak spring freshet flows. During the winter period, FRM evacuation requirements are tied to the forecasted stage at Vancouver, Washington. From April 10 through September 30, John Day Reservoir will be operated at the lowest elevation (elevation 262.5 feet to 264.5 feet, with a 2.0-foot operating range) that continues to allow irrigation withdrawals. Beginning in October and going through December, the project is operated in a broader forebay range, usually 262.0 to 266.5 feet (after irrigation is complete). In November and December, the storage flexibility allowed at John Day can be used to adjust the system for tailwater control below Bonneville Dam during chum salmon spawning. From January until April 10, the project is generally operated in a 3-foot band, between 262.0 feet and 265.0 feet.

2.1.2 Operations for conservation of fish and wildlife

One of the authorized purposes for Columbia River System projects addressed in this consultation involves managing system operations to support the conservation of fish and wildlife species affected by the Columbia River System. This section describes system operations included in the Proposed Action for the purpose of benefitting both anadromous and resident ESA-listed fish species and designated critical habitat, as well as other fish species, such as non-listed salmonids, burbot, and lamprey. Operations for ESA-listed species are fully incorporated into day-to-day, seasonal, and annual system operations. The Action Agencies use the best available scientific information to identify and carry out actions that are expected to protect and improve conditions for ESA-listed fish species. Additionally, the Action Agencies coordinate many operations for fish and wildlife management with regional sovereigns through the regional forum, including adaptively managing system operations, consistent with the Proposed Action, as described in more detail in Section 2.3.2.

System operations for fish and wildlife conservation are described below with an emphasis on the ESA-listed salmon and steelhead addressed in this consultation, while avoiding conflicts with operations for ESA-listed resident species. These operations are designed to maintain and potentially further improve juvenile and adult fish survival through the Columbia River System, while managing the system to fulfil its multiple congressionally authorized project purposes.

Storage project operations for fish and wildlife

The Action Agencies use a variety of objectives to inform management of the Columbia River System throughout the year for various fishery needs. Available storage—water that actually can be managed—is limited relative to total annual runoff in the Columbia River Basin. One of the purposes of the storage projects in the Columbia River Basin is to reduce peak flood flows. These projects, however, do not have sufficient storage to alter the overall shape of the natural hydrograph. Flow objectives have been identified for the purpose of planning and implementing annual, seasonal, and shorter time-step operations to best meet biological needs of salmon and steelhead within the context of also meeting flood risk management objectives.

Although there is a limited amount of water available for flow, augmentation of flow and flow objectives provide guidelines for how that water should be shaped to benefit fish migration. It should be recognized, however, that there are tradeoffs associated with operating for each flow objective. The use of the available water to improve flows for one ESU could affect the water available for another. For example, the chum salmon and Hanford reach protection levels are set in November and December prior to any useful knowledge about water supply forecasts. Significant volumes of water released from storage may be required to maintain these protection levels through emergence and can affect the ability to achieve spring refill objectives that are set to aid migrating juvenile salmon April through June. Additionally, operations in May and June at a storage project to meet a downstream objective can diminish the availability of water available in July and August due to variability in the volume and shape of the runoff.

The purpose of the flow objectives shown in Table 2-1 are intended to be used for purposes of pre-season planning and in-season water management, but are not achievable in all years or periods because they are largely dependent on annual and seasonal water conditions, including natural runoff volume and shape.

Table 2-1 Seasonal Flow Objectives and Planning Dates for the Mainstem Columbia and Snake Rivers

Location	Spring		Summer	
	Dates	Objective (kcfs)	Dates	Objective (kcfs)
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100 1/	6/21 to 8/31	50 to 55 1/
Columbia River at McNary Dam	4/10 – 6/30	220 to 260 1/	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 – 6/30	135	N/A	N/A
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160 2/	N/A	N/A

1/ Objective varies according to water volume forecasts
2/ Objective varies based on actual and forecasted water conditions.

The seasonal objective will be shaped each week for particular reaches through the Regional Forum TMT. To help meet the weekly flow objectives, the seasonal flow augmentation volumes in the storage projects will be used.

The Action Agencies will seek to meet these weekly flow requests based on optimal overall use of available volumes in storage reservoirs to benefit migrants and spawners, as necessary throughout the seasons. These requests will take into account the needs of resident fish and other reservoir objectives through implementation of the water management provisions that determine the actual managed flows that can be provided at a given time. For example, available storage will not necessarily be used to achieve weekly flow objectives if available storage would be prematurely depleted; rather, the available water would be distributed across the expected migration season to optimize biological benefits/fish survival.

Providing operations that benefit multiple fish species is an important component of water management in the Columbia River Basin. The Action Agencies manage Columbia River System storage projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak) for flows and river temperatures, and to protect riparian habitat.

The Action Agencies will continue to operate the Columbia River System storage projects to more closely approximate the shape of the natural hydrograph, to enhance flows and water quality, and to improve juvenile and adult fish survival where discretionary flexibility exists. Operations specific to each storage project are identified and described in the sections immediately below.[16]

Providing flows for fish is an important component of water management in the Columbia River Basin. Today, the Action Agencies manage the storage reservoirs very differently than they did a few decades ago. Winter drafts are limited so that there is a high probability that the storage reservoirs could be as full as possible (considering FRM requirements) by April 10. This allows for higher flows during the spring juvenile salmon migration when storage reservoirs are refilling. Columbia River flows are primarily driven by snowmelt, with more than 60 percent of the annual runoff occurring between April and June. Natural flows drop significantly by late July and into August.

The Action Agencies manage water and reservoir operations for both anadromous and resident fish using the specific operations described below. These operations determine the amount of water available to shape the hydrograph for benefits to anadromous migrants and spawners, while taking into account the needs of resident fish. While projects vary, in general, this includes the following:

- Operate storage projects to be at their FRM elevation in early April (the exact date to be determined during in-season management) to maximize flows for the spring out-migration of juvenile salmon.
- Attempt to refill the storage projects by the end of June/early July (exact date to be determined during in season management) to provide summer flow augmentation consistent with available water supply, spring operations, and FRM requirements.
- Draft storage projects to their August 31 or September 30 elevation targets based on water supply volume forecast to support summer flow augmentation for juvenile fall Chinook migration.
- Provide fall and winter tailwater elevations/flows to support chum salmon spawning and incubation in the Ives Island area below Bonneville Dam and to provide access for chum spawning in Hamilton and Hardy Creeks.
- Balance the consideration of these priorities for various listed fish (resident and anadromous).

Facilities

Libby Dam

Libby Dam will be operated in accordance with the Action Agencies' annual Water Management Plan, which includes specific provisions for fish and wildlife. Operations for fish and wildlife will generally include the following:

- Operate consistent with the Columbia River Treaty, the International Joint Commission, and the 1938 Order on Kootenay Lake.

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[16] More detailed information related to operations for resident ESA-listed species under the jurisdiction of the USFWS can be found in the 2016 USFWS Biological Assessment (Bonneville et al. 2016, as clarified December 2017).

- Follow variable December 31 FRM draft based on early season water supply forecast. The December 31 FRM target elevation for Libby Dam is 2411 feet, but implementation of the variable end-of-December FRM draft may occur when the December 1 water supply forecast is substantially less than average (maximum FRM end-of-December elevation is 2426 feet).
- Follow VARQ FRM procedures. When not operating to minimum flows, the Corps will operate Libby Dam to achieve a 75 percent probability of reaching the upper FRM rule curve on or about April 10 (the exact date will be determined in season) to provide spring flows.
- Operate to provide tiered Kootenai River white sturgeon augmentation volumes to achieve habitat attributes for sturgeon spawning/recruitment in May, June, and July, shaped in coordination with the Regional Forum and Technical Management Team (See Section 2.3.2 for information on the Regional Forum). Following sturgeon pulse, operate to provide even or gradually declining flows during the summer months (avoid or minimize double peak), as determined through TMT in-season management. (A double peak operation at Libby Dam is defined as a change in discharge of greater than 2,000 cfs while discharges are between 9,000 and 16,000 cfs, and a change in discharge of greater than 5,000 cfs while discharge is 16,000 cfs or greater.)
- To provide for summer flow augmentation, attempt to refill within 5 feet of full (full is 2,459 feet) in July or early August (exact date to be determined in-season), based on available water supply and spring flow operations, while also managing total dissolved gas and meeting flood risk management objectives.
- Draft to 10 feet from full (i.e., to elevation 2449 feet) by the end of September, except in the lowest 20th percentile water years, as measured at The Dalles, when draft will increase to 20 feet from full (i.e., to elevation 2439) by the end of September. If the project fails to refill to 20 feet from full, release inflows or operate to meet minimum flows through the summer months.
- From May 15 to September 30, the minimum flow will be 6,000 cfs. After the sturgeon pulse and through August 31, release a minimum of 6,000 to 9,000 cfs, based on the first-of-May water supply forecast.
- From October 1 through May 14, release a minimum of 4,000 cfs for resident fish.
- Limit spill to avoid exceeding the Montana State total dissolved gas (TDG) standard of 110 percent, when practicable, and in a manner consistent with the Action Agencies' responsibilities for ESA-listed resident fish.
- Limit outflow fluctuations by operating to ramping rates called for in the current USFWS Biological Opinion, to avoid stranding bull trout.

Hungry Horse Dam

Hungry Horse Dam will be operated in accordance with the annual Water Management Plan, which includes specific provisions for fish and wildlife. Operations for fish and wildlife will generally include the following:

- Follow VARQ FRM procedures. VARQ FRM procedures are designed to enable more flexible multi-purpose operations that allow higher spring releases for ESA-listed migrating salmon and steelhead while maintaining current FRM protection levels and improving ability to refill the reservoirs. When not operating to minimum flows, Reclamation will operate Hungry Horse Dam to achieve a 75 percent probability of reaching the upper FRM rule curve on or about April 10 (the exact date will be determined in-season) to provide spring flows.

- Refill by about June 30 each year (exact date to be determined during in-season management).
- Draft to 10 feet from full (i.e., to elevation 3550 feet) by the end of September, except in the lowest 20th percentile water years, as forecasted at The Dalles, when draft will increase to 20 feet from full (i.e., to elevation 3540) by the end of September to support flows in the lower Columbia River.
- Provide even or gradually declining flows during summer months (avoid or minimize double peak).
- Maintain minimum flows all year for listed bull trout, with a sliding scale based on the forecast. Operate to meet minimum flows of 3,200–3,500 cfs at Columbia Falls on the mainstem Flathead River and 400–900 cfs in the South Fork Flathead River.
- Limit outflow fluctuations by operating to ramping rates set in the current USFWS BiOp to avoid stranding bull trout.

Albeni Falls Dam

Albeni Falls Dam will be operated in accordance with the annual Water Management Plan. Operations for fish and wildlife will generally include the following:

- Operate to standard FRM criteria.
- Operate to provide Lake Pend Oreille shoreline spawning conditions for kokanee, as determined through interagency coordination, consistent with the current USFWS BiOp. This will generally include a minimum control elevation of 2051 feet from December 1 to March 31.
- Maintain current lake and downstream ramping rates, as specified in the WCM.

Grand Coulee Dam

Grand Coulee Dam will be operated in accordance with the annual Water Management Plan. Operations for fish and wildlife will generally include the following:

- Use standard FRM criteria including adjustments for FRM shifts from Dworshak and Brownlee (this operation typically affects dry water years) to increase the probability of higher flows for the spring salmon migration in the Snake River.
- Operate to achieve 85 percent probability of reaching upper rule curve (URC) elevation by about April 10 to help support flows during the spring salmon migration.
- Refill after the Fourth of July holiday each year (exact date to be determined during in-season management).
- Draft to support salmon flow objectives during July and August with variable draft limit of 1278 to 1280 feet by August 31 based on the water supply forecast.

- Use Lake Roosevelt Incremental Storage Release draft of up to an additional 1 to 1.8 feet by the end of August based on forecast to enhance stream flows to benefit fish, and for water supply purposes.
- Reduce pumping into Banks Lake and allow Banks Lake to operate up to 5 feet from full pool (elevation 1565 feet) during August to support salmon flow objectives.
- Operate to support tailwater elevations below Bonneville Dam from November through April to support chum spawning and incubation.
- Operate to support Priest Rapids fall Chinook flow objective.

Dworshak Dam

Dworshak Dam will be operated in accordance with the annual Water Management Plan. Operations for fish and wildlife will generally include the following:

- Operate to standard FRM criteria; shift system FRM to Grand Coulee when possible, unless modified by procedures under dry-water-year operations.
- When not operating to minimum flows, operate to reach the upper FRM rule curve on or about April 10 (the exact date to be determined during in-season management), to increase flows for spring flow management.
- Provide minimum flows while not exceeding the state of Idaho TDG water quality standard of 110 percent.
- Refill by about June 30 (exact date to be determined during in-season management.)
- Draft to elevation 1535 feet by the end of August and to elevation 1520 feet (80 feet from full) by the end of September, unless modified per the agreement between the United States and the Nez Perce Tribe for water use in the Dworshak Reservoir.
- Regulate outflow temperatures to attempt to maintain water temperatures at Lower Granite tailwater at or below the water quality standard of 68° F, typically from July 1 through the end of September.
- Limit the project discharge for salmon flow augmentation to not exceed the State of Idaho TDG water quality standard of 110 percent.

Chum spawning flows

To provide adequate conditions for chum spawning in the mainstem Columbia River in the area of the Ives Island complex and/or access to the Hamilton and Hardy Creeks for this spawning population, the Action Agencies will provide a tailwater elevation below Bonneville Dam of approximately 11.5 feet beginning the first week of November (or when chum arrive) and ending by December 31, if reservoir elevations and climate forecasts indicate this operation can be maintained through incubation and emergence. If water supply is deemed insufficient to provide adequate mainstem spawning or continuous tributary access, the Action Agencies will provide, as appropriate, mainstem flow intermittently to allow chum access to tributary spawning sites, if adequate spawning habitat is available in the tributaries. In coordination with TMT, the Action Agencies will adjust the tailwater elevation consistent with the size of the spawning population and water supply forecasts.

After chum spawning completes, the Action Agencies will manage tailwater elevation to protect mainstem chum redds through incubation and the end of emergence. If the emergence period extends beyond April 10 (the date spring spill begins for juvenile fish passage at Bonneville Dam), and the decision is made to maintain the tailwater, the Action Agencies will coordinate with TMT to address the impacts of TDG for fish in the gravel. In those circumstances, a delay in the start of spill may be necessary to avoid spill-induced TDG impacts.

The Action Agencies will revisit the chum-protection-level decision at least monthly through the TMT process to ensure it is consistent with the need to provide spring flows for ESA-listed Columbia and Snake River salmon and steelhead species.

Forecasting and climate variability

The Action Agencies will continue to work collaboratively with the Columbia River Forecast Group to promote and support the advancement of forecasting skill, products, and techniques in the Columbia River Basin, with the goal of improving reservoir operations for the benefit of the region. The Columbia River Forecast Group provides an avenue for sharing, discussing, evaluating, and potentially implementing new forecasting techniques for the planning and operation of the Columbia River System. The Columbia River Forecast Group also coordinates with RMJOC and provides a technical review of the RMJOC-II climate variability streamflow datasets. In June 2018, the University of Washington published the unregulated streamflow dataset from the RMJOC-II project (RMJOC 2018).

Columbia River Treaty Storage

The use of the Columbia River Treaty Canadian storage projects (Mica, Duncan, and Keenleyside in Canada), in coordination with the Columbia River System storage projects, for ecosystem benefits, is contingent on the development of mutually beneficial agreements between the United States and Canada. In recent Columbia River Treaty annual agreements, Canada has agreed to provide storage for flow augmentation water (1.0 MAF) for U.S. fish benefits in exchange for flow shaping to meet fish objectives in Canada. The objective is to release 1.0 MAF within the May-through-July period to benefit fish in the United States. Use of Canadian storage not included in the Columbia River Treaty, referred to as non-Treaty storage, requires negotiating separate agreements.

Non-Treaty storage agreement

Bonneville and BC Hydro executed a long-term Non-Treaty Storage Agreement effective April 10, 2012, through September 15, 2024. The Agreement allows use of non-Treaty storage space in Canada to shape flows within existing downstream requirements and create additional mutual power and non-power benefits for the parties. The agreement was crafted to ensure that operations of non-Treaty storage in Canada complies with the Columbia River Treaty requirement that power and flood control benefits under Treaty operating plans may not be reduced by non-Treaty operations. Under terms of the Agreement, either party may limit Non-Treaty Storage Agreement transactions to protect power or non-power requirements, such as FRM and fish, with the exception of dry-period firm-release rights. The Agreement provides Bonneville a firm release right of up to 0.5 MAF of water in the spring to benefit fish in the lowest 20th percentile of water conditions, if not used in the prior year. In addition, the agreement provides the opportunity by mutual agreement to store water when it is abundant and exceeds fish objectives and/or state standards for TDG levels in the spring, and then release that water in the summer to provide water when the Columbia River flows are typically lower.

Run-of-river project operations for fish and wildlife

Middle Columbia River Project – Chief Joseph Dam

Flow deflectors were installed in all 19 spillbays at Chief Joseph Dam in 2008, for the purpose of managing TDG both locally and system-wide. This allows for maintaining power generation at Grand Coulee, which provides a critical source of hydropower for energy needs, as well as transmission reliability services, while Chief Joseph diverts more water to spill when necessary. Even when Grand Coulee is spilling and TDG concentrations in the Chief Joseph Dam forebay exceed 130 percent saturation, the deflectors are capable of keeping TDG concentrations to no more than about 120 percent saturation in spilled water below Chief Joseph Dam.

Lower Snake River projects

The Action Agencies will operate the run-of-river lower Snake River projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, hydroelectric power, and recreation.

During the spring and summer juvenile fish migration, the Action Agencies will continue to provide spill to facilitate juvenile fish passage for ESA-listed salmon and steelhead species, while seeking to minimize any adverse effects on adult migrants (Table 2-2 and Table 2-3). Each year, spill levels and timing will be specified in the annual Fish Operations Plan (included in the Fish Passage Plan as Appendix E). As described further below, the operation may be adjusted both year-to-year and in-season to take into account changed environmental condition or new information, or updated proposals that are determined to have effects already considered in the biological opinion.

to accommodate research studies.

The Action Agencies have reviewed historical data on the passage and migration behavior patterns of ESA-listed Snake River subyearling fall Chinook from the past decade. Based on this information, the Action Agencies propose to adjust summer spill timing according to when this species is actively migrating past the lower Snake River projects. In the 2008 BiOp, NOAA recommended providing spill for subyearling fall Chinook passage in August until the numbers of fish passing lower Snake River dams nears completion (i.e., up to 300 fish for 3 consecutive days).

Juveniles that pass Lower Granite and Little Goose dams slow or stop migrating through the system in late July, and current juvenile fall Chinook passage data at Snake River dams indicate that numbers of juveniles passing through the system in August remain low. Furthermore, subyearling Chinook juveniles that are transported later in the season (August) tend to return as adults at higher rates than fish that remain in river to migrate (this information is described in further detail in Appendix D). Taking this information into account, the Action Agencies are including a modified provision to better adapt spill operations to juvenile outmigration timing.

For this consultation, the Action Agencies propose to implement this provision beginning in 2019, as follows:

- Spill will continue at each project until the criteria below are met for that dam, or until August 31, whichever comes first.

- The Action Agencies will provide juvenile fish passage spill in August at Lower Granite Dam until subyearling fall Chinook collection counts at that dam fall below 300 fish per day for 4 consecutive days (with counting beginning on July 28). Spill will end at Lower Granite Dam at 0600 hours on the day after the necessary criteria are met.
- The Action Agencies will provide juvenile fish passage spill in August at Little Goose Dam until subyearling fall Chinook collection counts at that dam fall below 300 fish per day for 4 consecutive days (with counting beginning on July 28). Spill will end at Little Goose Dam at 0600 hours on the day after the necessary criteria are met.
- The Action Agencies will provide spill in August at Lower Monumental and Ice Harbor Dams[17] until subyearling fall Chinook collection counts at Lower Monumental Dam fall below 300 fish per day for 4 consecutive days (with counting beginning on July 28). Spill will end at Lower Monumental and Ice Harbor Dams at 0600 hours on the day after the necessary criteria are met.
- In any year when natural-origin adult returns of Snake River fall Chinook salmon are equal to or less than 400 fish, however, summer spill in the following year would continue at Snake River projects through August 31, even in years when subyearling Chinook counts fall below 300 fish per day for 4 consecutive days, as stated above.
- Transport operations will continue through the end of October at Lower Granite and Little Goose dams and through the end of September at Lower Monumental Dam, regardless of when spill ends.

[17] Daily collection does not occur at Ice Harbor Dam, so spill at that project will follow criteria for Lower Monumental Dam and end the same day.

Table 2-2. Initial juvenile fish passage spill operations at lower Snake River dams.

Project	Spring base spill operation	Spring test spill operation[18,19]	Spring dates	Summer operation	Summer dates[20]
Lower Granite	20 kcfs	TDG Spill Cap	April 3 – June 20	18 kcfs	June 21-Aug 31
Little Goose	30%	TDG Spill Cap	April 3 – June 20	30%	June 21-Aug 31
Lower Monumental	TDG Spill Cap	TDG Spill Cap	April 3 – June 20	17 kcfs	June 21- Aug 31
Ice Harbor	30%	TDG Spill Cap	April 3 – June 20	30%	June 21 – Aug 31

Over the last two decades, the Action Agencies have operated the lower Snake River project reservoirs during the spring and summer juvenile fish passage season with 1 foot of operating range, within the lowest foot of the minimum operating pool (MOP), which is adjusted in real-time for navigation. Operating the reservoirs at the lowest 1 foot has been hypothesized to reduce travel time for downstream-migrating juvenile salmon. Additionally, modified spill operations and the construction of surface passage structures over the most recent decade have resulted in reduced travel time delays throughout the lower Snake River projects (Appendix D).

The Action Agencies propose to increase the useable forebay range by 6 inches to allow a full usable foot (MOP +1.5-foot). Currently, project operators limit actual operations to the middle two-thirds of the MOP +1.0-foot range to avoid unintentionally going above or below the prescribed elevation. The proposed increase will provide options for the Columbia River System to accommodate the changing needs in the regional and western energy grids more effectively, based on an evolving portfolio of renewable power generation resources such as wind and solar energy. It will also provide more ability to

[18] Spring spill levels will be systematically alternated between "base spill" and "test spill" as part of a latent mortality study. See the research section for more detail.

[19] If adult delay at any project is observed, existing adaptive management processes will be used to address the issue.

[20] The Action Agencies will adjust the timing of August spill based on the timing of the juvenile fall Chinook migration according to the following criteria. Beginning August 1, the Action Agencies will adjust summer spill operations to juvenile outmigration at Lower Granite, Little Goose, Lower Monumental, or Ice Harbor Dams if subyearling Chinook collection counts fall below 300 fish per day for four consecutive days (beginning July 28, 29, 30, and 31 for August 1 summer spill completion). Spill will continue at Ice Harbor until the same day as at Lower Monumental, since daily collection does not occur at that project. Spill will occur until 0600 hours on the day after the necessary criteria are met or August 31, whichever occurs first. Additionally, in any year where natural-origin adult returns of Snake River fall Chinook salmon are equal to or less than 400 fish, summer spill in the following year would continue at Snake River projects through August 31, even in years where subyearling Chinook counts fall below the 300 fish per day for four consecutive days as stated above.

adjust to uncertainty in stream flows inherent in the lower reaches of the Snake River. See Appendix D for additional information on this modification to reservoir operations.

Beginning April 3, all Lower Snake River projects (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite projects) will be operated within the MOP +1.5-foot reservoir operations identified in Table 2-3 with very limited instances in which the pool would be within 0.25 feet of the bottom or top of the MOP range. The MOP +1.5-foot operation will continue until small numbers of juvenile migrants are present (consistent with summer spill operations) unless otherwise adjusted to meet authorized project purposes, primarily ensuring safe navigation and transmission reliability needs. The Lower Granite reservoir may be raised as needed after September 1, in order to operate the adult fish holding facilities to support brood stock collection. These operations will be included in the annual Water Management Plan.

The effectiveness of limiting the operating range of pool elevations as a means of improving fish travel time has likely diminished with increased spill operations and the installation of surface passage structures; however, the travel times of PIT tagged juvenile salmonids will continue to be monitored during the proposed increase in useable forebay range. Monitoring fish travel times will assist the Action Agencies as they continue to identify power system management tools that preserve and enhance the multiple public services provided by the Columbia River System while using best available science to provide meaningful benefits for ESA-listed species.

Table 2-3. Lower Snake River projects forebay elevation ranges (feet) during juvenile downstream migration.

Project	Full Operating Range		Current 1.0-foot Pool Operating Range (2008-2018)		Proposed 1.5-foot[21] Pool Operating Range	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Lower Granite	733.0	738.0	733.0	734.0	733.0	734.5
Little Goose	633.0	638.0	633.0	634.0	633.0	634.5
Lower Monumental	537.0	540.0	537.0	538.0	537.0	538.5
Ice Harbor	437.0	440.0	437.0	438.0	437.0	438.5

As defined in the Fish Passage Plan, from April 1 to October 31 as a hard constraint, and from November 1 to March 31 as a soft constraint, turbines will be operated within a range thought to be most beneficial for turbine passage survival. At most units, that range is currently identified as ± 1 percent of peak efficiency. However, at some units, best fish passage survival may occur outside that range.

Juvenile bypass systems (JBSs) at the lower Snake River projects will be operated in accordance with the Fish Passage Plan. Juvenile bypass systems will typically be operated from early April through December 15, when they are taken out of service for maintenance. As project maintenance and/or construction schedules allow, earlier operation of a bypass system at one lower Snake River project during March

[21] Minimum elevations are subject to change based on flow and sedimentation; operating range is above the minimum navigation elevation. Full utilization of the 1.0-foot operating range requires a total operating range of 1.5-foot (MOP +1.5-foot), which allows for a buffer of up to 0.25 feet from the minimum and maximum forebay elevation.

may be further coordinated through the Fish Passage and Maintenance (FPOM) group to gather updated information on juvenile fish migration timing.

Juvenile fish transportation

The Corps will continue the transport of juvenile Snake River salmon and steelhead during both spring and summer migrations. To improve survival of juvenile migrants, NOAA will conduct an annual review of data on juvenile fish survival, adult returns, current year in-river conditions, and water supply forecast, which will be reviewed with the Regional Implementation Oversight Group (RIOG). In addition, the Technical Management Team (TMT) will review the results of transport studies annually and provide an annual recommendation to the Corps on how to operate the juvenile transport program. Achieving the "spread the risk" target for steelhead transport is no longer practicable given the proposed spill operations, the operation of spillway weirs at collector projects, and the issue of debris loading on bypass system screens. The Corps will develop an annual plan to implement the juvenile fish transportation program operations at the Snake River collector projects, taking into consideration the recommendations provided by regional sovereigns. Detailed descriptions of project and transport facility operations to implement the juvenile fish transportation program will be contained in Appendix B of the Fish Passage Plan.

Juvenile fish transportation – timing and duration

Transportation will be initiated at Lower Granite, Little Goose, and Lower Monumental Dams no later than May 1, or as coordinated with the RIOG and TMT, with a collection start target date of April 23. After coordination with RIOG and TMT, the Corps will set the collection start date. Transport will begin the day following the collection start date. Collected juvenile fish will be transported from each facility on a daily or every-other-day basis (depending on the number of fish) throughout the migration season. Transportation operations will be carried out at each project in accordance with all relevant Fish Passage Plan operating criteria.

Transportation operations may be adjusted due to research, conditions at fish collection facilities such as disease outbreaks (e.g., Columnaris disease), overcrowding, or temperature extremes, coordinated through the adaptive management process with FPOM, RIOG and/or TMT to match juvenile outmigration timing or achieve/maintain juvenile fish survival. Transport operations will continue until approximately September 30 at Lower Monumental Dam and through October 31 at Lower Granite and Little Goose Dams, in accordance with all relevant Fish Passage Plan operating criteria. Transition from barge to truck transport as specified in Fish Passage Plan Appendix B may be reexamined and coordinated through the FPOM to align more closely with juvenile fish run timing and may result in an earlier transition to truck transport. The effectiveness of transportation will be assessed on an annual basis. Start and end dates of transportation operations may be adaptively modified, if warranted.

Juvenile fish transportation – monitoring and evaluation

Monitoring and evaluation efforts will continue in an effort to determine the seasonal effects of transporting fish from the Snake River and optimize the transportation strategy. At Lower Granite Dam, fish will be collected for marking beginning in early April. Depending on the number of fish available, fish will be collected 1 to 2 days each week, with tagging occurring on the day following collection.[22]

A barge will leave each Thursday morning, with all fish collected during the previous 1 to 3 days.

[22] Fish tagged at traps upstream of Lower Granite Dam are also used in the assessment of the effectiveness of transport operations.

By barging all fish (minus the in-river group) during 1 to 3 days of collection, barge densities will be maintained at a level similar to what would occur under transport operations that time of year. This pattern will occur in the weeks preceding general transportation and will be incorporated into general transportation once that operation begins. The desired transported sample size is 6,000 wild Chinook, 4,000 to 6,000 wild steelhead, and 4,000 to 6,000 hatchery steelhead weekly for approximately 8 weeks.

Adult fish operations and facilities

The Corps will continue to operate adult fishways and facilities to facilitate adult passage at each lower Snake River project, as necessary, and in accordance with the operating criteria outlined in the annual Fish Passage Plan. This includes fishway exit cooling pumps at Lower Granite and Little Goose Dams. Generally, spill operations for juvenile fish passage and spill patterns have been developed to take into account adult passage requirements at each project to minimize causing adult passage delay and minimizing fallback over the spillway.

Lower Columbia River projects

The Action Agencies will operate the run-of-river lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited FRM.

As with the Snake River projects, the Action Agencies have reviewed ESA listed Snake River subyearling fall Chinook passage data from the past decade. The Action Agencies will continue to monitor (or develop supplemental monitoring programs, if needed) to determine if a timing modification to summer spill at the lower Columbia River dams is warranted for consideration in future consultations. (More information on the biological justification of August spill for Snake River fall Chinook can be found in Appendix D.) The initial spill operation and timing for lower Columbia River projects beginning in 2019 is shown in Table 2-4.

Table 2-4. Initial juvenile fish passage spill operations at Columbia River dams

Project	Spring base spill operation	Spring test spill operation[23,24]	Spring dates	Summer spill operation	Summer dates
McNary	48%	TDG Spill Cap	April 10 – June 15	57%	June 16 – Aug 31
John Day	32%	TDG Spill Cap	April 10 – June 15	35%	June 16 – Aug 31
The Dalles	40%	TDG Spill Cap	April 10 – June 15	40%	June 16 – Aug 31
Bonneville	100 kcfs	TDG Spill Cap[25]	April 10 – June 15	95 kcfs	June 16 – Aug 31

McNary, The Dalles, and Bonneville Dams will be operated within the normal forebay operating range for each project. As with the 6-inch expansion of operating range described above for the lower Snake River projects, the John Day Dam forebay will be operated within 2 feet of the lowest elevation range (minimum irrigation pool level or MIP). This will allow full use of the 1.5-foot operating range (e.g., 262.5 to 264.5 feet) that will continue to allow irrigation withdrawals from April 10 through September 30. Slight deviations from these levels, based on navigation needs, load following, and operation sensitivity may be required on occasion. These operations will be included in the annual Water Management Plan.

As defined in the Fish Passage Plan, from April 1 to October 31 as a hard constraint, and from November 1 to March 31 as a soft constraint, turbines will be operated within a range thought to be most beneficial for turbine passage survival. At most units, that range is currently identified as ± 1 percent of peak efficiency. However, at some units, best fish passage survival may occur outside that range.

The Corps will operate juvenile bypass systems at the lower Columbia River projects in accordance with the Fish Passage Plan. As project maintenance and/or construction schedules allow and while taking into account juvenile lamprey passage timing, the operation of a bypass system at one lower Columbia River project during March may be further coordinated through the Fish Passage and Maintenance (FPOM) group to gather updated information on juvenile fish migration timing.

Adult fish operations and facilities

The Corps will continue to operate adult fishways and facilities and provide attraction spill to facilitate adult passage at each lower Columbia River project, as necessary, and in accordance with the operating criteria outlined in the annual Fish Passage Plan. Generally, spill operations for juvenile fish passage and spill patterns have been developed to take into account adult passage requirements at each project to minimize adult passage delay, as well as taking adult fallback into consideration.

At Bonneville Dam, the second powerhouse Corner Collector will begin operation no later than April 10 and continue through the remainder of the spill season. To provide downstream passage for steelhead

[23] Spring spill levels will be systematically alternated between "base spill" and "test spill" as part of the Action Agencies' latent mortality research plan. See the section Research Actions at the Dams below for more detail.

[24] If adult delay at any project is observed, existing adaptive management processes will be used to address the issue.

[25] Spill to the TDG Spill Cap, not to exceed 150 kcfs.

kelts, operation may begin as early as March 1 if criteria specified in the Fish Passage Plan are met. Adult fish passage will be provided, and adult fish counted, in accordance with the Fish Passage Plan.

System-wide operations and adaptive management for fish and wildlife

The Action Agencies will continue to use an adaptive management framework for system operations and maintenance. Under this framework, targeted monitoring and evaluation, study results, and other new information, or updated operational proposals that are determined to have effects already considered in the biological opinion, will help inform coordinated adjustments to fish operations based on best available scientific information. The ability to respond flexibly is a critical tool for managing this complex multi-purpose system in the face of uncertainty and natural variability. In coordination with NOAA Fisheries, the Regional Forum, and other workgroups, the Action Agencies will continue to develop planning documents to guide the implementation of system operations and planned maintenance activities in a manner that benefits ESA-listed species and other affected fish and wildlife, including the Water Management Plan, the Fish Passage Plan and Fish Operations Plan, and the Water Quality Plan. (More detail on the Regional Forum can be found in Section 2.3.2.)

Water Management Plan

The Action Agencies will prepare an annual Water Management Plan and seasonal updates that describe planned system operations for each water year (October through September). The Water Management Plan will be developed in coordination with the Regional Forum, through the Technical Management Team (TMT). In the Water Management Plan, the Action Agencies will strive to achieve the best possible conditions, recognizing the priorities established in this document and the need to balance the limited water and storage resources available in the region.

A draft of the Water Management Plan will be prepared by October 1 each year, with a final plan completed by December 31. Seasonal updates will be prepared as data become available in-season on the water conditions for the year. At a minimum, seasonal updates will be posted twice per year.

Within each water year, regional sovereigns[26] can make operational requests through the TMT and Regional Forum to adjust water management, recognizing that this may require tradeoffs among priorities under some conditions. The Action Agencies seek to meet these requests by optimizing the overall use of available volumes in storage reservoirs to benefit migrants and spawners, as necessary throughout the seasons, taking into account the needs of resident fish and other reservoir objectives.

Fish Passage Plan

The Corps will prepare an annual Fish Passage Plan in coordination with Bonneville, NOAA Fisheries, and the Regional Forum through the Fish Passage Operations and Maintenance (FPOM) coordination team. The Corps will operate its projects (including juvenile and adult fish passage facilities) year-round in accordance with the criteria in the Fish Passage Plan. Key elements of the plan will include:

- Operate according to project-specific criteria and dates to operate and maintain fish facilities, turbine operating priorities, and spill patterns;
- Operate according to fish transportation criteria;

[26] *Sovereign* is used here to denote governments at federal, state, or tribal level.

- Operate the turbines within a range generally thought to benefit fish passage survival;
- Project spill operations in the spring and summer for fish juvenile passage;
- Implement TDG monitoring plan;
- Operate according to protocols for fish trapping and handling;
- To the extent practicable, take advantage of low river conditions, low reservoir elevations, or periods outside the salmon and steelhead migration season to accomplish repairs, maintenance, or inspections to minimize effects on juvenile and adult fish;
- Coordinate routine and non-routine maintenance that affects fish operations or structures through FPOM to avoid or minimize impacts to fish;
- To the extent practicable, schedule routine maintenance during non-fish passage periods;
- Conduct non-routine maintenance activities as needed; and
- Coordinate criteria changes and emergency operations with FPOM.

Water Quality Plan

The Action Agencies will periodically update the *Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers* (Water Quality Plan) and implement water quality measures to enhance ESA-listed juvenile and adult fish survival and mainstem spawning and rearing habitat, to the extent practicable.

In-season adjustments for system operations

To manage this multi-purpose system, the Action Agencies may adjust planned system operations described in this Proposed Action for brief periods of time to accommodate varying runoff conditions and other routinely-observed conditions as they arise at any of the 14 projects. For unanticipated and unplanned conditions, the Action Agencies will respond as necessary to redress the condition, and when possible, will use the existing regional coordination process to adaptively manage and make necessary in-season adjustments in fish operations (e.g., spill operations and resident fish operations). Emergency operations will be managed in accordance with TMT protocols, the Fish Passage Plan, and other appropriate Action Agency emergency procedures. The Action Agencies will take all reasonable steps to limit the duration of any emergency changes in system operations that may adversely affect ESA-listed species. Where emergency changes to system operations cause significant adverse effects on ESA-listed species of more than short duration, the Action Agencies, in coordination with NOAA,[27] will develop and implement appropriate adaptive management actions to address the situation.

Dry water year operations

A dry year is defined as a year when the Northwest River Forecast Center (NWRFC) May final forecast for April-August runoff at The Dalles Dam is below the 20th percentile for the NWRFC statistical period of record. The statistical 30-year period of record is currently 1981 to 2010, for which the 20th percentile value is 72.5 MAF. Consistent with prior recommendations from NOAA, the Action Agencies propose the

[27] The same process applies to resident fish operations with the US Fish and Wildlife Service.

following system management actions, where practicable, to benefit migrating salmon and steelhead in dry water years:

- Within the defined draft limits for flow augmentation (i.e., the reservoir elevations described for storage projects above), flexibility will be exercised in a dry water year to distribute available water across the expected migration season to optimize biological benefits and anadromous fish survival. The Action Agencies will coordinate use of this flexibility with the Regional Forum through the TMT.
- In dry water years, operating plans developed under the Treaty may result in Treaty reservoirs being operated below their normal refill levels in the late spring and summer, increasing flows during that period relative to a standard refill operation.
- Annual agreements between the U.S. and Canadian entities to provide flow augmentation from Treaty storage in Canada will include provisions that allow flexibility for the release of any stored water to provide U.S. fisheries benefits in dry water years, to the extent possible.
- The non-Treaty storage agreement is in place for an additional 0.5 MAF of non-Treaty storage for use in dry water years (but not in consecutive years).
- Bonneville will implement, as appropriate, measures recommended in the *Guide to Tools and Principles for a Dry Year Strategy* (BPA 2016) to reduce the effect that energy requirements may pose to ESA-listed species.
- Transport operations will be adaptively managed in dry years for low-flow conditions and coordinated through the Regional Forum process.

Avian predation deterrence operations at the dams

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Snake and Columbia River dams. This program will be coordinated through the FPOM Team and included in the Fish Passage Plan. Avian monitoring and deterrence action plans are implemented annually at lower Snake and Columbia River dams and are included in the Fish Passage Plan (see Appendix L in the 2018 Fish Passage Plan for an example). The objective of avian predator deterrence is to reduce avian predation on juvenile salmonids. At each dam, bird numbers are monitored, feeding birds are hazed, and passive predation deterrents, such as irrigation sprinklers and bird wires are deployed. Hazing typically involves launching long-range pyrotechnics at concentrations of feeding birds and occurs primarily near the spillway and powerhouse discharge areas, and juvenile bypass outfall areas.

Monitoring and evaluation actions at the dams

Action effectiveness evaluations planned by the Action Agencies for the period covered by this consultation include:

- Evaluation of improvements to the juvenile bypass system at Lower Granite Dam completed in 2018;
- Post-construction evaluation of Lower Granite spill PIT detection, to ensure that survival rates of salmon passage over the reshaped ogee is high and the injury rate is low; and

- An evaluation of fish survival and injury through the new Turbine Units 2 and 3 at Ice Harbor Dam. An estimate of total survival through the units may occur once all three are completed.

These studies have been developed in coordination with the Studies Review Work Group (SRWG).

Biological performance for system operations will be tracked through juvenile and adult fish survival and passage monitoring. Additionally, the Action Agencies will continue to monitor for signs of spill levels designed to benefit juvenile passage having adverse effects upon adult passage, such as delays in passage or increased fallback.

- Juvenile fish monitoring
  - Smolt monitoring program – The Action Agencies will monitor and evaluate the following biological and physical attributes of anadromous fish species migrating through the Columbia River System dams on an annual basis: Abundance and migration timing of smolts passing index dams; smolt condition (e.g. descaling and injury) at all dams with juvenile bypass systems; identify potential problems, and evaluate and implement solutions.
  - Annually measure the survival of in-river migrating juvenile salmonids and compare these numbers with COMPASS model estimates that are based on the environmental conditions experienced.
  - If warranted, the Action Agencies will also investigate and monitor any potential problems with juvenile travel time associated with proposed Columbia River System operations.
  - The Action Agencies, in coordination with NOAA Fisheries and other regional sovereigns, will assess any significant changes to Columbia River System operations and/or structures and, if warranted, evaluate their effects on juvenile salmon survival and condition.
    - Implement and maintain the Columbia River Basin passive integrated transponder (PIT) tag information system.
    - Assess the feasibility of improving PIT detection capability to maintain or improve in-river system survival precision under increased spill levels, and implement if warranted.
    - The Action Agencies will continue to monitor fish travel time through the Columbia River System as a result of the Proposed Action.
  - The Action Agencies will work with NOAA Fisheries and other sovereigns to develop any additional monitoring for the effects of increased TDG as a result of the block design Test Operation during the spring fish passage season, if warranted.
  - The Actions Agencies will work with NOAA Fisheries to evaluate other emerging issues on an as needed, site-specific basis. Examples of emerging issues that may warrant addition site specific monitoring include new turbine testing at Ice Harbor and/or alternate methods of implementing spill programs (e.g. 24 hour spill averaging) while allowing for integration of intermittent power sources, such as solar or wind, which could also potentially be tested at a single project like Ice Harbor. Any of these types of RM&E efforts would need to be further developed and defined so that they could be integrated into and be complementary with the block design spill operation.

- Adult fish monitoring
  - Visually count adult salmon and steelhead passing mainstem Columbia River System dams, per the schedule provided in Table 2-5. One of the primary reasons for counting adult fish at Columbia River System dams is to identify potential passage problems and evaluate any solutions that are implemented.
  - Monitor adult survival through the Columbia River System to confirm that the relatively high levels of adult survival currently observed are maintained and to compare survival rates of different stocks.
  - Monitor adult ladder counts and PIT based re-ascension rates to identify any potential delay or fallback issues associated with proposed Columbia River System operations or delays related to temperatures in the exit section of the fishways.
  - If necessary, conduct adult fallback and delay evaluations at dams identified as potential problems (based on monitoring data and/or physical model studies). This may include assessing the effects of actions intended to benefit juvenile salmonids on adult salmonid passage and adaptively managing to address adult passage concerns.
  - The Action Agencies will work with NOAA Fisheries and other sovereigns to develop any additional monitoring for the effects of increased TDG as a result of the block design Test Operation during the spring fish passage season, if warranted.
  - Monitor predation of adult fish by pinnipeds, as described in section *2.2.2 Predator management and monitoring actions*, below.

Consistent with the recommendations presented in NOAA Fisheries' *2015 Adult Sockeye Salmon Passage Report* (2016a), the Corps will also complete the following actions, already underway:

- Improve monitoring and reporting of all mainstem fish ladder temperatures and identify ladders with substantial temperature differentials (>1.0°C).
- Investigate methods to reduce maximum temperatures and temperature differentials in adult fish ladders at mainstem lower Snake and Columbia dams identified as having these problems (either through reviews of existing data or through monitoring), and implement if feasible.
- Prepare an alternatives study assessing the potential to trap and haul adult sockeye salmon at lower Snake River projects to meet the goal and objectives of a contingency plan developed by NOAA and the Regional Forum.
- Develop water temperature models, or similar tools, to assess the effect of alternative project operations at Lower Granite and Little Goose dams on ladder and tailrace temperatures or implement a study to empirically assess the effect of proposed operations.

Table 2-5. Adult fish counting schedule

Project	Period	Time	Method
Bonneville	January 1 – March 31	0400 – 2000	Video
	April 1 – May 14	0400 – 2000	Visual
	May 15 – September 30	0400 - 2000 2000 – 0400	Visual Video
	October 1 – November 30	0400 – 2000	Visual
	December 1 – December 31	0400 – 2000	Video
The Dalles	April 1 – June 14	0400 – 2000	Visual
	June 15 – September 30	0400 – 2000 2000 - 0400	Visual Video
	October 1 – October 31	0400 – 2000	Visual
John Day	April 1 – June 14	0400 – 2000	Visual
	June 15 – September 30	0400 – 2000 2000 – 0400	Visual Video
	October 1 – October 31	0400 - 2000	Visual
McNary	April 1 – June 14	0400 – 2000	Visual
	June 15 – September 30	0400 – 2000 2000 – 0400	Visual Video
	October 1 – October 31	0400 – 2000	Visual
Ice Harbor	April 1 – October 31	0400 – 2000	Visual
Lower Monumental	April 1 – October 31	0400 – 2000	Visual

Project	Period	Time	Method
Little Goose	April 1 – October 31	0400 – 2000	Visual
Lower Granite	March 1 – March 31	0400 - 2000	Video
	April 1 – May 31	0400 - 2000	Visual
	June 1 – September 30	0400 – 2000 2000 - 0400	Visual Video
	October 1 – October 31	0400 - 2000	Visual
	November 1 – December 30	0400 - 2000	Video

Note: All times are shown in Pacific *Standard* Time. Schedules at Bonneville and Lower Granite Dams do not vary from year to year. At the other six dams, daytime video counts are conducted from March 1 to March 31 and November 1 to February 28/29 at two dams each year, on a rotating basis.

Research actions at the dams

There continues to be uncertainty around the biological effects of increased spill. The COMPASS and CSS models suggest a wide range of potential outcomes ranging from a substantial hypothesized benefit through reduced latent mortality to a negative impact through a reduction in beneficial transport rates. Neither model takes into account the effect of increased TDG. Given this uncertainty and the range of potential outcomes, the Action Agencies are proposing a scientifically rigorous study to test the biological effects of increased spill.

The Action Agencies are working with NOAA Fisheries and other interested regional parties to develop and implement a test of the relative influence of system operations on any direct or indirect effects on fish passage, survival, and condition.

Specific study design elements are being developed collaboratively and may include considerations such as: spill operations to be studied; expected power of proposed study or studies to detect an effect; potential duration of experiment(s); number of fish and the source of fish to be studied in experiment(s); decision framework under which to evaluate results; means of monitoring for potential adverse effects on both juvenile and adult migrants; means of assessing potential other factors such as condition of fish selecting various routes of passage; and other topics that may be identified.

The Action Agencies will conduct research to test the hypothesis that increased system-wide spill levels have the effect of increasing adult salmonid return rates (i.e., increased SARs due to decreased latent mortality). The proposal is based on alternating spill levels between Base Operation (informed by performance standard test results 2008-2018) and the Test Operation (spill to meet but not exceed the

115 percent/120 percent gas cap[28] limits). Additional details on the study design for a block design spill operation will be developed with NOAA Fisheries based on the Independent Scientific Advisory Board (ISAB) review of the Columbia River latent mortality test power analysis that was completed in the spring of 2018.

The indicators collected under juvenile monitoring will be useful for bolstering monitoring in addition to tracking SARs (e.g., in-river survival, travel time, transport to in-river ratios).

2.1.3 Operations for power system management

One of the authorized purposes of all the Columbia River System projects is the generation of hydroelectric power. Hydropower at these projects is generated by water passing through turbine-generator units. To produce electricity, a turbine converts the potential energy of falling water into mechanical energy, which a generator converts into electrical energy. The coordinated water management of the Columbia River System includes managing the amount of water used to generate hydropower passing through turbines.

The 14 Columbia River System projects can be classified as either run-of-river dams or storage dams. This distinction is important for power generation, because run-of-river projects generate electricity based on inflows, with minimal ability to shape flows and thus minimal ability to control the timing of when electricity is generated; some generation can be adjusted from one hour to the next, and perhaps to the subsequent day, whereas the storage projects may store the water until there is a need to generate electricity. Storage projects may store inflows for a week, a month, or even another season, depending on available storage capacity and overall system flexibility, given other constraints such as FRM and operations for fish.

Power generation

The amount of electricity generated at the Columbia River System projects depends on a variety of factors, including operational constraints, ESA responsibilities, regional load,[29] and river flows. Seasonally, river flow determines when power is generated (i.e., peak hydroelectric generation typically coincides with spring runoff, while low flows and low generation generally occur in late summer and fall). For system operations, the Action Agencies generally prioritize FRM and environmental responsibilities, such as conservation actions for protected fish species, before Bonneville uses any remaining flexibility to manage water flow for power generation to meet the daily and seasonal demand for electricity.

In managing the system to address or avoid emergencies, however, power system operations are prioritized to protect human health and safety, as well as the safety and reliability of the power grid. Energy supply (including generation, imports, and exports) must equal load (demand for electricity) at all times. Bonneville participates in the wholesale electricity market to buy and sell electricity to ensure

[28] "Gas cap" refers to the applicable State TDG Water Quality Standard (in percent TDG). The TDG standard for the states of Washington and Oregon is 110%. Both states have provided exceptions to the TDG standard for juvenile fish passage spill operations on the lower Snake and lower Columbia Rivers. Each state has different calculation methodologies for the different standards, and the Corps applies the more stringent standard when operating under all applicable state TDG standards.

[29] Load refers to electricity that is being consumed in the region. It is also known as demand.

that electricity demand and supply on the Federal system are always balanced. Peak hydroelectric generation tends to occur during daytime hours to meet peak power demand, if not constrained by other requirements.[30]

There are seasonal peaks of energy demand, as well. In the Pacific Northwest, energy demands have typically peaked in the wintertime as the need for heating increases. Ensuring a sufficient supply of electricity in the winter can be a challenge, particularly during extreme cold spells, when demand increases dramatically region-wide and little or no electricity is available in the wholesale market. More recently, with higher regional temperatures, summer demands for energy have also been increasing over historical trends as demand for air conditioning increases. The demands for regulating and balancing power generation from the projects from which Bonneville markets power increased dramatically with the restructuring of electricity markets in the mid-1990s and the renewable resource boom in the Pacific Northwest that started in the mid-2000s.

Because most renewable resources generate when the wind blows or the sun shines, regardless of when residents and businesses in the Northwest need the electricity, other generators (typically hydropower and gas-fired power plants) must adjust their power generation to compensate for fluctuations in energy produced by these variable resources (i.e., to integrate the renewable power sources). Within normal operating limits and other project requirements, Bonneville uses the capacity of the Columbia River System projects to support the integration of these additional carbon-free energy resources into the regional and western electrical grid.

Operating reserves

In addition to marketing the power generated at these projects and other facilities, Bonneville, as the North American Electric Reliability Corporation (NERC)-registered balancing authority, is responsible for maintaining the balance between generation and load within the Bonneville balancing authority area.[31] Figure 2-17 below shows the area for which Bonneville is a balancing authority.

Bonneville manages and provides operating reserves based on a required reserve obligation using dispatchable energy generation[32] to ensure generation within the balancing authority area matches load at all times. The most common dispatchable powerplants for reserve obligations in the Northwest are hydropower and natural gas.

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[30] For example, Bonneville Dam generates more power at night during the late fall and early winter months due to the requirement for relatively low flows during daylight hours below the dam to encourage daytime chum spawning at elevations that will not be dewatered later in the winter.

[31] A balancing authority is the responsible entity that schedules generation on transmission paths ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports interconnection frequency in real time. The balancing authority area is the collection of generation, transmission, and loads within the metered boundaries of the designated balancing authority. The balancing authority maintains load-resource balance within this area.

[32] Dispatchable generation refers to sources of electricity that can be dispatched (generation is increased or decreased) at the request of power grid operators or of the plant owner to meet fluctuations in demand or supply. Often, baseload power plants such as nuclear or coal cannot be turned on and off in less than several hours. The time periods in which a dispatchable generation plant may be turned on or off may vary in time frames of seconds, minutes or hours.

Hydropower is dispatchable as long as there is flexibility to increase or decrease generation, which often means having the ability to increase or decrease flows coming from an upstream reservoir. For example, there is little capacity to hold reserves at the lower Snake River dams when the forebays are maintained within a narrow operating range at minimum operating pool (MOP). This restriction in operating range constrains reservoir storage capability and therefore limits the ability to hold many reserves. Therefore, Bonneville sets aside a certain portion of hydropower generation capability to meet its reserves obligation for unexpected increases or decreases in generation or load in the Bonneville balancing authority area. These unexpected changes in generation can come from variable energy generation like wind, sudden generation outages, or transmission constraints.

The Columbia River System projects cannot all operate simultaneously at full capability, in order to reserve some dispatchable generation to increase generation, as needed. At certain times, Bonneville's obligation to balance power generation to match load within the balancing authority area, including maintaining operating reserves, may take priority over other water management functions in coordinating Columbia River System operations. This is mostly likely to occur during high flows.

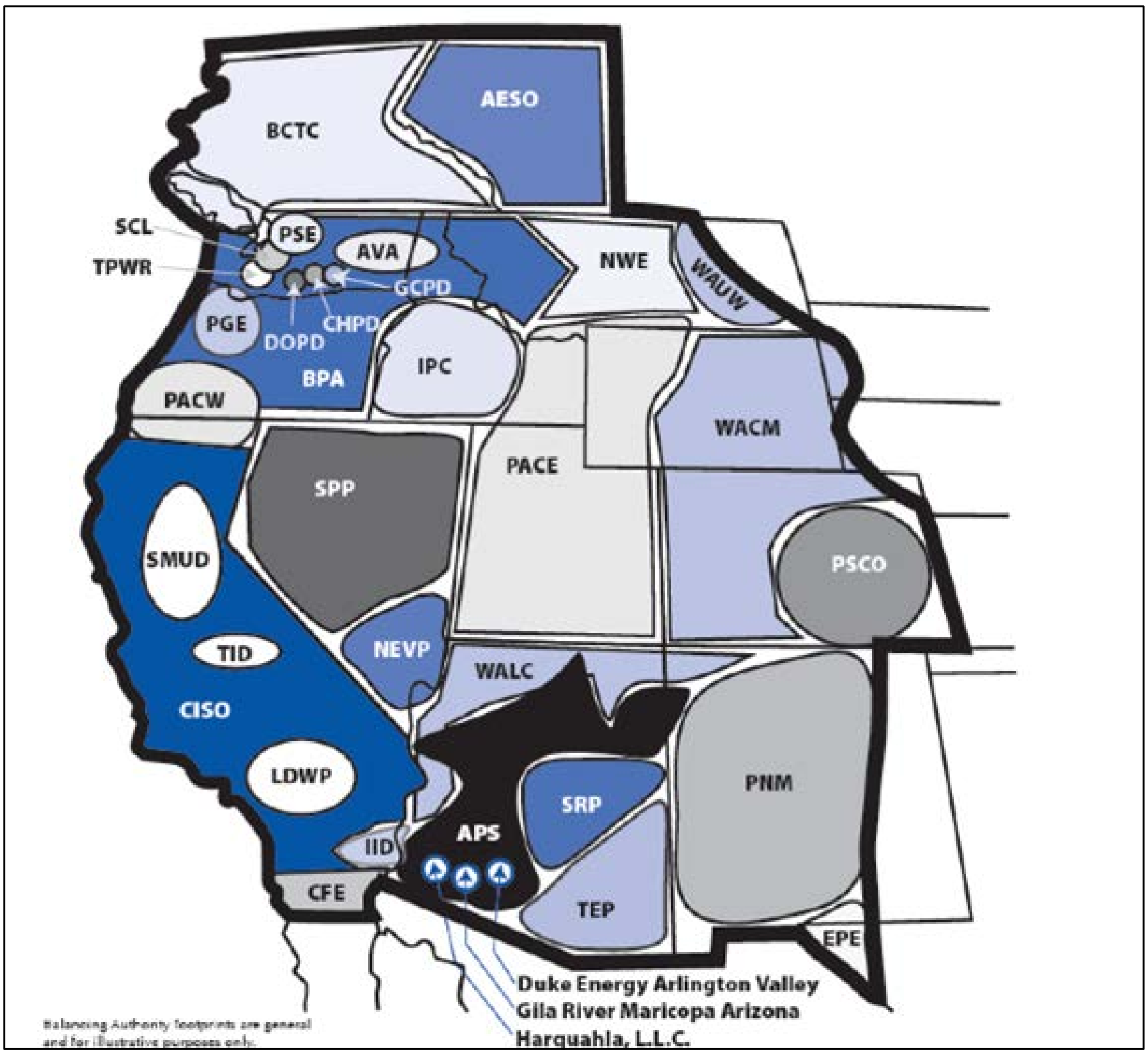

Figure 2-17. West Coast balancing authorities (or control areas)

Transmission

Bonneville, as the NERC-registered transmission operator, is also responsible for maintaining the safety and reliability of the transmission grid. The Proposed Action includes water management actions taken at the dams to increase or decrease hydropower generation in response to needs on the interconnected transmission system, for example to address transmission reliability needs. (See Appendix B for more details.)

2.1.4 Operations for irrigation/water supply

While Grand Coulee Dam is an integral part of the Columbia River System operations, it is also the primary storage and diversion structure for the Columbia Basin Project, a Reclamation irrigation project on the upper Columbia River in central Washington. In addition to Grand Coulee Dam and its impoundment (Lake Roosevelt), the major facilities of the Columbia Basin Project are the Grand Coulee Powerplant complex, Banks Lake (an off-stream reservoir), and John W. Keys III (JWKIII) pump/generating plant (which pumps from Lake Roosevelt behind Grand Coulee Dam to Banks Lake). In this proposed action, Reclamation is consulting on the mainstem Columbia River diversion to the Columbia Basin Project. The majority of this water is diverted through the JWKIII. More detail on the operations of the Columbia Basin Project and the timing and location of the diversion can be found in Appendices A and C.

Additionally, as a matter of convenience, Reclamation is consulting on mainstem Columbia River hydrologic effects of several Reclamation irrigation projects that are not coordinated with the Columbia River System. The flow effects to the mainstem Columbia River for The Dalles Project, The Chief Joseph Dam Project, Umatilla Projects (including Phase I and Phase II), Yakima Project, Deschutes Project, and the Crooked River Project are included in this consultation. Depletions from these non-Columbia River System irrigation projects are included in the Columbia River hydrologic models for the Columbia River System. The Chief Joseph Dam project, The Dalles Project, and Umatilla Phase I and Phase II pump directly from the Columbia River. The Umatilla Project (excluding Phase I and Phase II), Yakima Project, Deschutes Project, and the Crooked River Project are located on tributaries to the Columbia River. The operation and maintenance of these Reclamation tributary irrigation projects are addressed under separate ongoing or completed consultations. Reclamation has described the timing and cumulative volume of these non-Columbia River System irrigation project depletions in Appendix C.

The Corps manages the Lower Snake River Project and some Columbia River System reservoir levels to provide irrigation water by maintaining stabilized reservoir levels that enable the installation and operation of pumping stations allow for irrigation on private agricultural lands. The Corps' Northwestern Division Reservoir Control Center coordinates and modifies operations to benefit irrigation at both John Day and McNary Projects. The Lower Snake River Project also provides irrigation water by maintaining stabilized reservoir levels that enable the installation and operation of pumping stations. More detail on Corps irrigation operations along the lower Columbia and lower Snake Rivers can be found in Appendix A.

2.1.5 Operations for navigation

The Columbia River System is the Northwest's river highway. The 465-mile Columbia-Snake Inland Waterway represents a key link to the Columbia-Snake River Basin interior region. It facilitates barge transport from the Pacific Ocean to Lewiston, Idaho, the most inland port. This transportation system consists of the Federal navigation channel and locks, port facilities, and shipping operations. The system is used for commodity shipments from the inland northwest and as far away as North Dakota. Today, the Corps maintains a Federal navigation channel between the Pacific Ocean and Lewiston, Idaho.

The system supports international trade of an estimated value of more than $20 billion annually and carries about 56.9 million tons of cargo, making it the second largest export gateway on the West Coast. The average annual (2010–2014) tonnage passing through The Dalles Lock and Ice Harbor Lock was 7,719,748 and 3,475,104, respectively. This equates to approximately six commercial vessels per day at lower Columbia River dams and three per day at lower Snake River dams.

This Proposed Action includes the operation of the projects for navigation, including managing reservoir elevations, filling and draining navigation locks, and maintaining navigation locks. Adjustments in spill or reservoir operating ranges may be required at any of the lower Snake or lower Columbia projects to address navigation safety concerns and to maintain the authorized depth in the federal navigation channel. This may include changes in spill patterns, reductions in spill, including short-term spill cessation, or operating above MOP. These adjustments may sometimes be necessary during the spring or summer fish passage season and possibly during periods of low or high flows. Other federal activities associated with navigation not related to operations (e.g., dredging) are covered under completed consultations (NOAA Fisheries 2012, 2014a, 2014b) and are not covered here.

Navigation locks

Navigation locks at the four lower Columbia and four lower Snake River projects are available for locking commercial boat traffic past the dams almost continually, 24 hours per day, 7 days a week, approximately 50 weeks of the year. For the 2012-2016 period, daily average lockages for lower Columbia River Dams ranged from five to seven, and for the lower Snake River Dams, daily average lockages ranged from two to four. Lockages for recreational boat traffic are provided from May 15 through September 15. Unscheduled recreational lockages are allowed during the remaining period of the year. During boat passage and lock operation, the lock either fills with water or drains and then remains at that position until the next passage. The filling or draining operation takes approximately 20 minutes. Total time to lock a boat through takes about 30 minutes.

Navigation locks were designed to allow 15 feet of depth over the concrete sills on the upstream and downstream entrances to the locks. This depth is provided at upstream entrances of the locks within normal operating ranges (between maximum and minimum operating pool) for the reservoirs. Depth over downstream entrance sills, however, can be affected by reduced operating pool elevations on the lower Snake River and at low river flows (approximately 50,000 cfs or less).[33] If this happens, reservoir elevations may be raised to provide safe clearance for vessels entering and leaving the navigation locks.

[33] Over the last two decades, the Action Agencies have operated the lower Snake River projects at minimum operating pool (MOP) as a management tool during the fish passage season. As noted above, for operations

2.1.6 Operations for recreation

In general, the storage and run-of-river projects are operated within normal operating limits, in part to provide for recreational opportunities at these projects. There are numerous recreation sites, access sites, state parks, and boat launches associated with the Corps' and Reclamation's project lands throughout the Columbia River System. Nearly all of these sites provide recreation opportunities that either depend on water or are enhanced by the proximity of water. Several of the sites were constructed by the Corps but are operated by other Federal agencies, counties, port districts, or through commercial leases. Sites on Reclamation lands were constructed and are operated in partnership with Washington State and several municipalities. In this PA, the Action Agencies are consulting on the operation of the projects to support recreational activities. This includes managing reservoir elevation and river flows. Both recurring and one-time requests for special operations to support recreation are considered, within normal operating limits and other project requirements including FRM and fish conservation operations. Any other federal activities associated with recreation are not included in the scope of this Proposed Action.

Libby Dam

Recreation facilities provide both water-based and land-based recreational opportunities. Water-based recreation opportunities include primarily boating, fishing, swimming, and sightseeing. Boat-launching ramps, swim beaches, marinas, and other facilities have been developed to support these activities. The Corps, the U.S. Forest Service (USFS), and private enterprises operate a mix of recreational facilities associated with the reservoir and river. The range of usability for reservoir boat ramps is from full pool to approximately elevation 2300 feet.

Hungry Horse Dam

Hungry Horse Dam is authorized for recreation, but Reclamation does not operate specifically for this purpose at Hungry Horse Dam.

Albeni Falls Dam

At Lake Pend Oreille, boat launching ramps, swim beaches, marinas, and other facilities have been developed to support recreational activities. The summer lake elevation is generally held between 2062.0 and 2062.5 feet. Generally, from June through Labor Day, the Corps decides when the Lake will reach the summer operating range, depending on FRM concerns. The lake may be held within the summer operating range after Labor Day, but the September operating range is from 2060 to 2062.5 feet.

Grand Coulee Dam

Lake Roosevelt is typically filled following the Fourth of July holiday. The desired operation is to have Lake Roosevelt 3 to 4 feet below full pool going into the holiday to provide beaches for recreation.

Lake Roosevelt offers a wide variety of recreation opportunities, and is one of the few large lakes in the region that has an extensive amount of shoreline and adjacent lands available for public recreation. The

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beginning in 2019, the maximum range of effective operating pool elevations is currently being reevaluated for meeting all authorized project purposes.

shorelands of the Lake Roosevelt National Recreation Area, managed by the National Park Service, consist primarily of a narrow band of land above the maximum high-water elevation (1290 feet). In most cases, the minimum amount is determined by the elevation 1310-foot contour, while the maximum ranges up to almost ½-mile from the high water line in a few locations.

Lower Snake and Columbia Rivers

Waterfowl hunting operations are provided Wednesdays, weekends, and holidays from mid-September through January at McNary, Ice Harbor, and Little Goose Dams. The pools are operated in the upper end of their operating range to provide better access for hunters.

In addition to requests for operations that support waterfowl hunting, there are annually recurring operation requests to support recreation at McNary and Bonneville Dam. These requests involve professional boat races, performances, and spectator sports that have been growing in importance as a recreation activity and as a source of economic growth in the Columbia River Gorge and Tri-Cities areas. These activities came to the Columbia River in the early 1980s, and have grown to draw hundreds of thousands of participants and spectators annually. These requests fall within the authorized operating range of these projects.

2.1.7 System maintenance

Preventive and corrective maintenance that is coordinated and planned to occur at regular intervals is referred to as scheduled, or routine, maintenance. This type of routine maintenance is performed at regular intervals on all fish facilities, spillway components, navigation locks, generating units, and supporting systems to ensure project reliability and to comply with North American Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) regulatory requirements. A strong routine maintenance program allows the staff at the Corps, Reclamation, and Bonneville to plan and schedule their capital improvement programs proactively based on equipment condition and degradation to ensure system operations remain safe, reliable, and compliant with applicable laws and regulations. Schedules for certain NERC-required maintenance may necessitate planning for 2 to 3 years in advance of the actual outage and for the work to begin.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of the project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated through the appropriate teams under the Regional Forum, such as the FPOM and TMT, to minimize negative effects on fish.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance is not performed at a regular pre-determined frequency and includes tasks that are more significant in nature than routine scheduled maintenance. Non-routine maintenance examples include power plant modernization and major rehabilitations of Columbia River System project features. Additionally, any work being conducted either by the project operator or by Bonneville on transmission equipment that takes a powerhouse line out of service will generally affect several generators at one time. These types of outages are planned and coordinated in advance, when possible.

Grand Coulee Dam

Drum gate maintenance

Reclamation's Operations and Maintenance Program requires annual inspections and dam safety maintenance for the eleven 135-foot-long, 30-foot-high drum gates. Inspection and maintenance activities can only occur when Lake Roosevelt is at or below elevation 1255 feet for at least 8 weeks. Drum gate maintenance is planned to occur during a period between March and May annually, to coincide with the FRM drawdown of the lake. However, during dry years, FRM operations will not draft Lake Roosevelt low enough for a long enough period of time to perform necessary maintenance on the drum gates. During extended droughts or even in normal water years, when FRM operations do not require the reservoir to draft below elevation 1255 feet for at least 8 weeks, a forced draft may be required to perform maintenance. A forced draft can reduce the chance of reaching the April 10 elevation objective and reduce downstream flows during refill, which could have negative impacts on ESA-listed species. For this reason, Reclamation agreed to criteria that would reduce the risk to ESA-listed salmon in dry years, by allowing deferral of maintenance in some dry years, to the extent possible. The criteria are as follows:

- Drum gate maintenance may be deferred in some dry water years; however, drum gate maintenance must occur a minimum of one time in a 3-year period, two times in a 5-year period, and three times in a 7-year period.
- To reduce the likelihood of having a forced draft occur in a dry year, in-season criteria were developed to guide operations in normal and wet years to accomplish drum gate maintenance. The in-season criteria are based on the FRM requirement for the April 30 maximum Grand Coulee elevation, as determined by the February final of the April-August water supply forecast. The February forecast is used to allow sufficient time to draft the reservoir below 1255 feet by March 15. These criteria are summarized in Table 2-6 and described in greater detail below.
    - If the February forecast sets the Grand Coulee April 30 FRM elevation is at or below 1255 feet, Grand Coulee will be drafted to perform drum gate maintenance.
    - When the February forecast sets the April 30 FRM requirement above 1265 feet, drum gate maintenance will be forced only if needed to meet the requirements of the 1 in 3, 2 in 5, and 3 in 7 criteria.
    - If the April 30 FRM requirement is between 1255 and 1265 feet, then maintenance will only be done if the following year would be a forced drum gate maintenance year. For example, if maintenance is deferred in year 1 due to dry conditions, and the forecasted FRM elevation is between 1255 feet and 1265 feet in year 2, then drum gate maintenance would be accomplished in year 2 in order to avoid forced drum gate maintenance in year 3, regardless of water supply conditions. The example above illustrates the 1 in 3 criteria, but the 2 in 5 and 3 in 7 criteria would also need to be checked.

Table 2-6. Grand Coulee Dam criteria for drum gate maintenance

February FRM Requirement for Maximum April 30 GCL Elevation (feet) [1]	Drum gate Maintenance[2]
≤ 1255 feet	Yes
1255 – 1265 feet	If following year would be a forced drum gate maintenance year: Yes If following year would not be a forced drum gate maintenance year: No
> 1265 feet	If in forced drum gate maintenance year: Yes If not in forced drum gate maintenance year: No

[1] Maximum April 30 GCL Elevation based on the February official April-August water supply forecast for The Dalles using the 5-day QPF median values published by the NWRFC on February 5, 2018 adjusted for available storage capacity upstream of The Dalles other than Grand Coulee Dam. Monthly FRM requirements are available online at: http://www.nwd-wc.usace.army.mil/report/flood_risk/

[2] Drum gate Maintenance is required to meet the 1 in 3, 2 in 5, and 3 in 7 criteria

John Keys III pump-generating plant

The pumping plant consists of six pumps that pump water from Lake Roosevelt, behind Grand Coulee Dam, to Banks Lake, and six pump generators that can pump water to Banks Lake or generate power with water released from Banks Lake back to Lake Roosevelt. Maintenance falls under two categories, scheduled and unscheduled. The majority of the scheduled maintenance of the pumps and pump generators occurs outside of the irrigation season, to the extent practicable. Typically, one or more pumps and/or pump generators are offline during any given time during the year. However, during the irrigation season, when pumping demand is much higher, it is desirable to have the majority of the pumps and pump generators online and available.

Non-routine maintenance at facilities on and around Banks Lake

Banks Lake, an off-site equalizing reservoir, is located in the upper Grand Coulee (an ancient abandoned river bed) and was built to store and supply irrigation water to the Columbia Basin Project. Banks Lake is formed by the construction of two dams: North Dam, which is near Grand Coulee Dam, and Dry Falls Dam, which is at the south end of the reservoir. Water is pumped from Lake Roosevelt through a set of pumps and pump/generators up to the Feeder Canal, which then discharges into Banks Lake. Water is released for irrigation to the Columbia Basin Project from Banks Lake through a set of gates at the headworks of the Main Canal at Dry Falls Dam.

Bulkheads are available to isolate the canal headworks and reduce the need for drawdowns to perform maintenance on the canal headworks. However, other maintenance needs may require that Banks Lake be significantly drafted, up to 35 feet. The full hydrologic effects of the maintenance operations would start in August by reducing pumping or shutting off the pumps from Lake Roosevelt and allowing irrigation withdrawals to draft the lake by the end of October. This would result in a slight increase in flows at McNary Dam during drawdown, as water typically pumped to Banks Lake would be passed downstream. Increases in Grand Coulee Dam discharges, resulting in a slight increase in flows at McNary Dam, would be necessary to meet elevation requirements in Lake Roosevelt. Maintenance would be performed during the winter and would be completed by March 1. Refill would be coordinated with Bonneville to take advantage of high flows and low power demand to refill Banks Lake by April 15.

Scheduled maintenance

Reclamation must perform routine maintenance at regular intervals on all units in order to comply with NERC/WECC regulatory requirements and to ensure project reliability. With peak discharge occurring in the spring, routine maintenance is limited, to the extent possible, to minimize the number of units that must be worked on so that as much water as possible can be passed through the turbines and not spilled. Scheduled maintenance does not affect flow; however, increased spill could result in elevated TDG saturations above the maximum standard of 110 percent saturation.

At Grand Coulee, 24 generating units discharge flow to the Columbia River. Units G-1 through G-18 in the left and right powerhouses have a hydraulic capacity of around 6,000 cfs each. Units G-19 through G-21 and G-22 through G-24 in the Third Powerhouse have capacities of about 25,000 cfs and 30,000 cfs each, respectively. The total hydraulic capacity of the project is determined by how many generators are online. There are typically multiple generators offline during any given time during the year for either scheduled or unscheduled maintenance.

Chief Joseph Dam

Powerplant maintenance

Turbine and generator maintenance at Chief Joseph Dam is conducted on regular schedules ranging from annually to every 5 years, though this can vary. Five or more of the 27 units may be offline at a time, and maintenance outages may happen at any time of year. A protocol has been developed that requires that when a turbine is dewatered for maintenance, it is checked for stranded fish in the remaining pool of water at the bottom of the draft tube. Any fish found are netted, placed in water-filled coolers that are hoisted and carried out through the galleries, and lowered, still submerged, into the river downstream of the project, where they are allowed to swim free. The protocol has been coordinated with FPOM and is included as an appendix in the annual Fish Passage Plan.

Spillway gate maintenance

Spillway gates (generally only about four per year, one at a time with one on each side for safety) may be out of service for painting or other maintenance. This may coincide with spill season, but there are 19 total spill bays, leaving 16 available, and all are equipped with flow deflectors, which provide TDG abatement downstream, should spill be needed.

Dworshak Dam

Powerplant maintenance

At Dworshak Dam, there are three generating units, which discharge into the North Fork of the Clearwater River. During the months of September through January, units are taken down, one at a time, to perform annual maintenance. Similar to turbine maintenance at Chief Joseph Dam, fish protection protocols have been developed for turbine dewaterings at Dworshak Dam. These protocols are included in the Fish Passage Plan and coordinated through FPOM. Fish protection protocols for unit operation testing are also being developed, in coordination with NOAA Fisheries. The Corps will continue to develop and finalize those protocols.

Scheduled maintenance

Every year, one of the generating units is brought down for 6 weeks for cavitation repair. This outage is scheduled first, as the submerged turbines must be dewatered to provide access. Maintenance is performed in the fall, and the overhaul unit is always scheduled first so that it can be dewatered when there are fewer fish in the river (this minimizes the risk of trapping fish inside the unit when it is dewatered). Appendix I of the Fish Passage Plan describes details of turbine maintenance at Dworshak to minimize impacts to fish. During the 6-week outage, the turbine is completely dewatered under the supervision of Corps fish biologists to ensure that any entrained fish are properly returned to the river, and weld repair is performed on the blades of the turbines. This weld repair is performed to ensure that the turbine remains in optimal operating condition. In addition to the weld repair, preventative maintenance and calibration is performed on all generator controls, auxiliary systems, and protective devices to ensure that they are operating properly and are not exhibiting any abnormal wear. The two generating units that do not receive the cavitation repair also undergo the same system maintenance.

Several constraints throughout the year impact maintenance scheduling at Dworshak. In the spring, the project is required to adhere to a published FRM curve. In the summer, Dworshak's water is used to regulate downstream river temperature and improve flows for fish passage. For both operations, to the maximum extent possible, water is passed though the three generating units and is not spilled, in order to avoid elevating TDG saturations above the maximum standard of 110 percent saturation. This means routine turbine maintenance cannot be scheduled during spring or summer.

Lower Columbia River and Lower Snake River projects

Powerplant maintenance

Maintenance of turbine-generator units, transformers, and other associated equipment is normally timed to minimize the interruption of operation of the units to meet hydraulic and electrical generation needs. To the extent practicable, maintenance scheduling is also designed to minimize impacts to adult and juvenile fish passage for salmon and steelhead during spring and summer spill (April-August), so that units are available when their operation may be needed for fish passage (e.g., attraction flow for adult ladders). Annual outages for maintenance and testing of turbine-generator units and related equipment are therefore normally scheduled in late summer and fall. The Corps' Fish Passage Plan, which is updated annually, contains operating criteria that govern turbine unit operations, including operating with fish screens, raking trashracks, unit priorities or operating sequences, operating ranges during fish passage seasons, and turbine unit outages. The Fish Passage Plan contains criteria that require all turbine unit trashracks to be raked prior to installing fish screens and periodically during the fish passage season when warranted by the criteria. During the juvenile fish passage season for salmon and steelhead during spring and summer spill (April-August), turbine units at each project are operated within specific ranges. This criterion is described in Appendix C of the Fish Passage Plan and in the individual project operating criteria. Deviations from operating criteria may be coordinated for fish research, maintenance, or other purposes. Annual outage schedules are prepared each winter and discussed with the region. Schedules detail outages for each turbine unit for installation and removal of fish screens, monthly inspections of fish screens, installation of fish research equipment, and testing and maintenance of turbine units and related equipment. Schedules are updated throughout the year to reflect maintenance requirements and are provided to the Corps' Reservoir Control Center for regional coordination through the appropriate teams under the Regional Forum, such as the FPOM and TMT.

Maintenance of turbine units may or may not require them to be dewatered. Dewatering is normally conducted only when personnel need to enter the waterways of the turbine intake to inspect or work on the turbine itself, or if the turbine and generator must be disassembled for major repair work. Stoplogs and operating (intake) gates are installed for safety precautions when maintenance activities require that the turbine units not turn for any reason. Projects have written dewatering plans that detail how to dewater turbine units to minimize impacts to fish. These plans detail how to operate the turbine units and install stoplogs to minimize fish entrainment in the units, and how to handle fish when they are encountered during the dewatering process. Project fishery biologists or trained natural resources personnel monitor the dewatering and oversee the fish removal process.

Many hydroelectric turbines are approaching the end of their design life and will continue to be replaced in sequence. The Action Agencies are able to design more efficient,[34] fish-friendly (if applicable) turbine units when the time comes for the units to be replaced due to advances in turbine design and more information about fish-friendly design features in recent years. At projects designed with fish passage facilities, turbine routes were traditionally the dam passage route with lowest fish survival, but the new turbine designs are closing the gap, and, in the case of Bonneville Powerhouse 1, turbine routes can exceed survival through other passage routes (Ploskey et al 2012). These new units installed at Bonneville Powerhouse 1 include changes to the runner and discharge ring that reduce the probability of mechanical injury (i.e., fish pinching between the runner blades and discharge ring). Three new turbine units have been designed for Ice Harbor Dam, which include similar modifications to Bonneville Dam's new minimum gap runners, plus modifications that reduce the likelihood of pressure-related fish injuries, strike, sheer, and turbulence through the entire turbine, and improved egress from the draft tube. Ice Harbor Turbine Unit 2 is currently being installed and is scheduled to be operational by summer of 2018. Unit 3 is estimated to be operational by fall of 2019, and Unit 1 is estimated to be operational by 2021.

Testing of major generating equipment may require special project operations. Electrical testing of generator step-up transformers requires that the transformers be disconnected from the transmission lines. With the exception of the first powerhouse at Bonneville Dam, all of the lower Columbia River projects have two or more transmission lines per powerhouse, so an outage required for transformer insulation testing does not require an outage of more than four turbine-generators. Dams on the lower Snake River, other than Ice Harbor, take the entire powerhouse offline for Doble (transformer performance) testing. Testing is normally scheduled in late summer due to the requirement of warm and dry conditions and a 5-day outage to complete the tests. The timing of the test is set to minimize impacts on migrating fish and to keep local dissolved gas levels within allowable standards. Periodic testing of other generation-related equipment may require short-term departure from normal operating criteria.

Over the last several years, the Corps has taken steps to address concerns about releases of oils and greases from the lower Columbia and lower Snake River dams. The Corps has applied for National Pollutant Discharge Elimination System (NPDES) permits for discharges of pollutants, including oil or grease, from appropriate point sources. For equipment in contact with the water, the Corps implements

[34] For example, at Ice Harbor the new units currently being installed will provide 3 to 4 percent more power from the same volume of water.

best management practices to avoid accidental releases and to minimize any adverse effects in case of an accidental release. The Corps has begun using "environmentally acceptable lubricant" greases where technically feasible, and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and is implementing oil accountability plans with enhanced inspection protocols and preparation of annual oil accountability reports. In light of these best management practices with respect to the use of oils and greases to maintain equipment at the dams, any effects on migrating salmon and steelhead are both discountable and insignificant.

Navigation lock maintenance

As previously stated, navigation locks are operated approximately 50 weeks each year. A 2-week annual maintenance outage for all eight lower Columbia River and lower Snake River locks normally occurs in March. Both routine and non-routine lock maintenance occurs at this time. Work includes inspections and maintenance of underwater filling and emptying conduits, tainter valves, gates, and gate operating equipment. Each lock is dewatered on a 5-year rotation for major inspection. Other inspections take place yearly. Special reservoir levels may be required prior to and after lock outages in order to move floating bulkheads out of and back into their mooring berths. Routine maintenance that does not require outages takes place during other times of the year as well. Additional non-routine inspections or maintenance may take place during the year if problems are encountered with any of the locks' operating equipment. If gate problems are encountered during the year, floating bulkheads may need to be used to lock vessels through while repairs are made. This may require a short-term full-pool operation of the reservoir (potentially including a deviation from the maximum range of effective operating pool elevations implemented during fish passage season) in order to move the floating bulkheads into or out of position. Once in position, the floating bulkhead can be used for locking vessels through the lock at any normal pool elevation. Periodic maintenance dredging is performed to maintain the federal navigation channel at authorized dimensions.

Fish passage facility maintenance

Powerhouse or control room operators or project fish biologists inspect the operations of fish passage facilities several times per day. Project biologists inspect the facilities in a quality control role at least three times per week. Any deficiencies observed during inspections are corrected as soon as is practicable.

Maintenance activities to support fish passage operations, structures, and passage facilities are completed in accordance with the Fish Passage Plan. Both routine and non-routine maintenance activities are considered and described in the Fish Passage Plan and are addressed either directly in the Plan or through the regional coordination process. Typically, these maintenance activities occur during the winter months, but they can occur at other times following established regional coordination through groups such as FPOM and/or TMT. The range of activities varies based on the specific project facilities and fish passage features, but generally includes activities to maintain, repair, or replace structures or features, which are attributable to fish passage at the specific project. Maintenance of features not specific to fish passage (e.g., turbines, draft tubes, spillways, and structural repairs in the forebay or stilling basin) will also be necessary.

Both adult and juvenile fish passage facilities have established winter maintenance seasons outlined in the Fish Passage Plan. These maintenance windows are developed in coordination with NOAA Fisheries and regional parties, and may vary from year to year. All routine maintenance activities or facility modifications that require the dewatering of facilities or that may affect the operation of facilities are scheduled for these periods (Table 2-7).

Table 2-7. Fish facilities 2017-2018 winter maintenance timing, as shown in the 2017 Fish Passage Plan.

Dam	Winter in-water maintenance window (adult)	Winter in-water maintenance window (juvenile)
Bonneville	12/01/2017 – 02/28/2018	12/15/2017 – 02/28/2018
The Dalles	12/01/2017 – 02/28/2018	12/01/2017 – 03/31/2018
John Day	12/01/2017 – 02/28/2018	12/15/2017 – 02/28/2018
McNary	01/01/2018 – 02/28/2018	12/16/2017 – 03/31/2018
Ice Harbor	01/01/2018 – 02/28/2018	12/16/2017 – 03/31/2018
Lower Monumental	01/01/2018 – 02/28/2018	12/16/2017 – 03/31/18
Little Goose	01/01/2018 – 02/28/2018	12/16/2017 – 02/28/2018
Lower Granite	01/01/2018 – 02/28/2018	12/16/2017 – 03/24/2018

The Fish Passage Plan contains criteria on how to operate fish passage facilities during the normal operating season in the event that a facility component fails and there may be an impact on facility operations or fish passage. The Plan also contains criteria for coordinating facility operations or fish passage issues with regional parties and how to operate facilities during major component failures.

Generally, all adult fish ladders are dewatered for a brief period each winter. During the outages, project personnel inspect the fish passageways, remove any debris encountered, and maintain all ladder and fish counting equipment. Annual maintenance on auxiliary water supply pumps and fish turbines is also conducted during the winter maintenance period. Project personnel inspect diffuser gratings each year, either by dewatering the collection channels and inspecting directly or by using an underwater camera or divers. Any deficiencies found during winter maintenance periods are repaired or corrected. For those projects with two or more adult ladders (i.e., all projects except Little Goose and Lower Granite), one ladder is kept in operation at all times.

Periodic maintenance of adult fishway equipment that does not seriously affect facility operations or fish passage may also be performed during the fish passage season. Some fishway equipment requires periodic lubrication, adjustment, or other preventative maintenance type of work that must be done during the fish passage season for continued operations. Other maintenance activities, such as cleaning debris off fish ladder exit trashracks or fish counting station picketed leads, are done on an as-needed basis to maintain the facilities within established operating criteria.

Annual maintenance of juvenile bypass systems requires the removal of fish screens from turbine intakes and the dewatering of juvenile fish collection channels, dewatering structures, and various fish transportation and/or sampling facilities. After the facilities are removed from service, they are inspected, and repairs and annual maintenance are performed. Overhauls and/or modification of facilities take place during the annual maintenance period, as well. At projects with juvenile fish transportation facilities, those facilities, along with transport barges and trucks, are also maintained. The fish passage equipment is all placed back in service prior to the beginning of the next operating season.

Juvenile bypass systems require almost continual oversight and maintenance during the operating season. Juvenile fish transportation facilities and monitoring facilities are manned either 24 hours per day or when they are collecting fish for sampling, to ensure they operate according to established operating criteria. Fishway passages (gatewell orifices, flumes, separators, and piping) must be checked for debris and other obstacles that may injure juvenile fish. Some fish screens (submersible traveling screens and extended-length submersible bar screens) have automated systems connected to them to ensure that they are operating as programmed. The automated systems ensure that mesh rotates as planned on submersible traveling screens or the cleaning brushes cycle on extended-length submersible bar screens to keep screens free of debris.

At the Bonneville Dam second powerhouse, the vertical barrier screens in the units modified for fish guidance efficiency improvements require drawdown monitoring to detect plugging of the vertical barrier screens. Water level monitors relay drawdown information to the control room and an alarm is activated when drawdown criteria are exceeded, meaning the vertical barrier screens need to be cleaned. When automated systems indicate a screen failure, the associated turbine unit is operated according to criteria in the Fish Passage Plan, and the screen repaired as soon as practicable. Fish screens are also inspected by either maintenance personnel or biologists, using underwater cameras, on a monthly basis to ensure they are operating correctly.

2.2 Non-operational conservation measures to benefit ESA-listed salmon and steelhead

Improvements in system operations and fish passage have increased juvenile and adult fish survival through the system, with higher dam passage survival rates and faster fish travel times (Corps et al. 2017). In addition to the operational measures described above, the Action Agencies are proposing non-operational conservation measures as offsite mitigation to help address uncertainty related to any residual adverse effects of system management. These non-operational measures include support for conservation hatchery programs, predation management, habitat improvement actions in the Columbia River estuary and various tributaries, and kelt reconditioning. The Action Agencies' approach to mitigating the effects of Columbia River System management on ESA-listed salmon and steelhead is consistent with conservation strategies established in regional salmon recovery planning processes.

2.2.1 Conservation and safety net hatchery actions

To support ESA-listed salmon and steelhead species affected by Columbia River System management, the Action Agencies will continue to fund the operation and maintenance of safety net and conservation hatchery programs that preserve and rebuild the genetic resources of ESA listed salmon and steelhead in the Columbia and Snake River basins. The purposes of conservation programs are to rebuild and enhance the naturally reproducing ESA-listed fish in their native habitats using locally adapted broodstock, while maintaining genetic and ecologic integrity, and supporting harvest where and when consistent with conservation objectives. Safety-net programs are focused on preventing extinction and preserving the unique genetics of a population using captive broodstock to increase the abundance of the species at risk.

The conservation and safety net hatcheries included in this proposed action are listed in Table 2-8. The operation and maintenance of these programs have undergone separate, program-specific ESA consultations with NOAA Fisheries (Table 2-8). The programs will be operated in accordance with those BiOps. NOAA has determined through these consultations that these hatchery programs provide mitigation or conservation benefits for listed ESUs and DPSs across the Columbia and Snake River basins. Additionally, as a result of these consultations, some hatchery programs have been improved through reform actions such as transitioning to local broodstock and managing hatchery adults, and these reforms are reflected in the site-specific hatchery program BiOps.

Research, monitoring, and evaluation (RME) relevant to each hatchery program has been incorporated into the relevant hatchery program BiOp(s). The Action Agencies will continue to discuss broader, basin-wide, hatchery monitoring needs as they come up and collaborate with NOAA Fisheries to evaluate ways to support these needs to the extent practicable.

Table 2-8 Conservation and safety net hatchery programs included in this consultation

Species	Hatchery Program	Population	Program Type	Operator	Action Agency Funding Source	BiOp Status	Production level approved in NMFS BiOp
Upper Columbia spring Chinook	Winthrop NFH spring Chinook Program[35]	Methow spring Chinook	Integrated conservation	USFWS	Reclamation	Final BiOp 10/13/2016	Up to 400,000 smolts
Upper Columbia steelhead	Winthrop steelhead Program[29]	Winthrop steelhead	Integrated conservation	USFWS	Reclamation	Final BiOp 10/10/2017	Up to 200,00 smolts
Upper Columbia spring Chinook	Chief Joseph Hatchery (CJH) Program/ Winthrop NFH[29]	Okanogan spring Chinook	Isolated conservation (10j)	Colville Tribe/USFWS	Bonneville/ Reclamation	Final CJH BiOp 10/27/2014 Final BiOp WNFH 10/13/2016	Up to 200,000 smolts
Snake River spring Chinook	Yankee Fork/Panther Creek spring Chinook	Yankee Fork/Panther Creek	Integrated Recovery	SBT	Bonneville	Final BiOp 12/26/2017	Up to 1,000,000 smolts; 600k in Yankee Fork and 400k in Panther Creek
Snake River spring Chinook	Johnson Creek spring Chinook	Johnson Creek	Integrated Recovery	NPT	Bonneville	Final BiOp 11/27/2017	Up to 150,000 smolts

[35] The upper Columbia spring Chinook and steelhead hatchery programs included in this table serve as both conservation programs as well as the Grand Coulee mitigation programs.

Species	Hatchery Program	Population	Program Type	Operator	Action Agency Funding Source	BiOp Status	Production level approved in NMFS BiOp
Snake River fall Chinook	Nez Perce Tribal Hatchery fall Chinook salmon Program	Clearwater basin	Integrated Recovery	NPT	Bonneville	Final BiOp 10/9/2012	Up to 1,400,000 yearlings
Snake River sockeye	Snake River Sockeye Salmon Captive Broodstock Program	Redfish Lake	Integrated Recovery	IDFG	Bonneville	Final BiOp 9/28/2013	Up to 1,000,000 smolts

For the purposes of NOAA Fisheries' environmental baseline analysis in this consultation, the Action Agencies also note the continued existence of their respective independent Congressionally authorized hatchery mitigation responsibilities, including Grand Coulee mitigation, John Day mitigation and programs funded and administered by other entities, such as Lower Snake River Compensation Plan (LSRCP), which is administered by the U.S. Fish and Wildlife Service. Similar to the conservation and safety–net programs, where appropriate the Action Agencies will, or have conducted, separate consultations to cover the operations and maintenance, as well as associated monitoring and evaluation (including tagging) for these programs.[36]

Kelt reconditioning

The Action Agencies propose to fund kelt reconditioning in the upper Columbia, mid-Columbia and the Snake River basins. Kelts are steelhead that survive to spawn again in subsequent years. Kelt reconditioning as a conservation tool is intended to enhance populations that have suffered decline. A near-term improvement in productivity can be a means to offset long and short-term demographic perils and minimize loss of genetic and life history diversity. Action Agency-funded kelt reconditioning programs can work in conjunction with restoration or remediation efforts. Re-establishment or enhancement of repeat spawning in listed steelhead populations can improve productivity, diversity, and demographic stability and is particularly important during times of low steelhead abundance. Since 2008, the Action Agency-funded kelt reconditioning projects have successfully reconditioned and released over 2,500 repeat spawning steelhead in the upper Columbia, mid-Columbia and the Snake River basins.

[36] Over the last two decades, techniques have evolved for tagging fish to support the monitoring and evaluation of salmon and steelhead in the Columbia River Basin for multiple purposes, with the development of newer methodologies such as genetic tagging that are less impactful to fish handled for this purpose. Bonneville is supporting regional transition to utilize more effective tagging techniques, including genetic tagging, to inform fish population status and trend monitoring, with separate, site-specific environmental compliance processes covering these tagging activities. While Bonneville has supported these efforts in recent years, long term, the region will need to identify sustainable sources of funding to implement these activities in the future.

2.2.2 Predator management and monitoring actions

Pinniped management at Bonneville Dam

To reduce the number of ESA listed salmon and steelhead impacted by pinnipeds, the Action Agencies will continue the actions that have been demonstrated to be effective. The Corps will continue to install, and improve as needed, sea lion excluder gates at all adult fish ladder entrances at Bonneville Dam annually. In addition, the Corps and Bonneville will continue to support land and water based harassment efforts by Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), and Columbia River Inter-Tribal Fish Commission (CRITFC) to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually from early August through May 31. Collection of predation data will occur when sea lion abundance is greater than or equal to 20 animals. Through the FPOM and Sea Lion Task Force, the Corps will continue to use adaptive management to address changing circumstances as they relate to supporting sea lion harassment efforts and monitoring of sea lion predation at Bonneville Dam.

Pikeminnow predation management

Since its inception in the early 1990s, the NPMP has removed over 4.9 million Northern pikeminnow from the Columbia and Snake Rivers. Evaluation indicates that pikeminnow predation on juvenile salmon has declined by about 40 percent, saving three to five million juvenile salmon annually that would otherwise have been consumed by pikeminnow. Bonneville will continue to implement the Northern Pikeminnow Management Program, consisting of the Northern Pikeminnow Sport Reward Fishery and the Dam Angling program. The area included in the Northern Pikeminnow Sport Reward Fishery is the mainstem Columbia River from the estuary to Priest Rapids Dam, and the Snake River up to Hells Canyon Dam. This Fishery depends on the public to provide fishing effort to remove 10 to 20 percent of predatory-sized pikeminnow per year and is open from May through September. The fishery is administered technically and fiscally by the Pacific States Marine Fisheries Commission in cooperation with WDFW and ODFW. Program evaluation, population indexing, tagging, and monitoring of other predator response is conducted by ODFW, while WDFW implements the public fishery by staffing the registration stations, collecting and disposing of pikeminnows caught and issuing reward vouchers. The Dam Angling program consists of two crews of anglers, hired by WDFW to fish for Northern pikeminnow from the dam faces of The Dalles and John Day dams from May through October.

During the period covered by this consultation, the Action Agencies will work with partners to understand new management opportunities and adaptively manage the Dam Angling Program component to address new site-specific predation concerns, where feasible.

Avian predation management

Avian predation synthesis report

The Action Agencies will synthesize avian predation data collected throughout planning and implementation of the three avian predation management plans: Inland Avian Predation Management Plan (IAPMP), the East Sand Island Caspian Tern Management Plan, and the East Sand Island Double Crested Cormorant Management Plan. The intent of the synthesis report is to provide the Action Agencies, Cooperating Agencies, and NOAA with a summary of predation by piscivorous waterbirds on

ESA-listed salmonids in the Columbia River Basin before, during, and after management actions, in order to assist in assessing the effectiveness of these actions on a basin-wide scale.

Data and other research, monitoring, and evaluation results from these plans currently exist in various annual reports. The synthesis report will include all relevant research, monitoring, and evaluation data and studies conducted by the Action Agencies and others, to the extent made publicly available, in the Columbia River Basin. The report will summarize studies conducted to date and describe the spatiotemporal variability of metrics pertinent to the following:

- Colony size, locations, nesting areas, and productivity (nesting success) for piscivorous colonial water birds in the Columbia River Basin (Lower Columbia River, Estuary, Columbia River Plateau) and Corps' managed alternate Caspian tern nesting sites;
- Bird movement studies (leg banding studies, RF and satellite telemetry studies for Caspian terns and Double-crested Cormorants);
- Impacts of piscivorous waterbirds on native anadromous salmonids in the Columbia River Basin (predation rate studies, bioenergetics/diet studies, etc.) where sufficient data exist;
- Management plan implementation and effectiveness monitoring.

Inland avian predation management

In 2018, the Corps and Reclamation will have completed implementation of the FCRPS Inland Avian Predation Management Plan (IAPMP) for Corps and Reclamation-managed lands and associated shallow water habitat on the Columbia River plateau upstream of Bonneville Dam. Final reporting, including a report for 2018 implementation and monitoring activities, and a final summary report describing 2014-2018 implementation activities, will be completed in 2019. The Corps will continue to monitor tern use of Crescent Island on an annual basis following implementation of the IAPMP. If tern use of the island resumes, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. Monitoring will be discontinued after 3 years if no tern nesting use of concern is identified.

Reclamation will continue passive dissuasion effort on Goose Island and continue to monitor for tern presence on a regular basis from late February to early July. If tern use on Goose Island resumes and exceeds those metrics identified in the Inland Avian Predation Management Plan (Corps 2014), Reclamation will work with NMFS to identify management actions to dissuade tern use of the island before the next nesting season.

Caspian tern predation management in the estuary

The Action Agencies will continue to implement the Caspian Tern Management Plan described in the Final EIS (USFWS 2005). In 2015, coastal nesting habitat was constructed in San Francisco Bay and the minimum acreage target for East Sand Island tern nesting habitat (one acre) was reached. This was followed by three years of monitoring and evaluation (2015-2017). East Sand Island tern habitat will continue to be maintained at no less than one acre for the period covered under this consultation. The Action Agencies, in coordination with NMFS and FWS, will review the most recent monitoring and effectiveness evaluation information once 2017 results are available and determine future management actions.

Double-crested cormorant predation management in the estuary

The Action Agencies will continue to implement the management plan as described the *Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary Final Environmental Impact Statement* (FEIS) (Corps 2015). The selected alternative from the FEIS includes two phases.

- Phase I, 2015 – 2018: manage the East Sand Island double-crested cormorant (DCCO) colony annually over 4 years to achieve 5,380 to 5,939 breeding pairs via culling and egg oiling according to the management plan and revise take numbers inter-annually if adaptive management is warranted. In support of Phase I, PIT detection at East Sand Island to assess predation rates will continue through 2018, as will monitoring of: the response of non-target bird species to DCCO management activities; East Sand Island peak DCCO colony size; potential dispersal of DCCO from East Sand Island in response to management activities to other areas in the lower Columbia River estuary; and Western DCCO population in the Pacific Flyway. Phase I will also include actions to ensure DCCOs from East Sand Island do not relocate and nest on other dredged material disposal sites under the Corps' Channel and Harbors Program in other areas of the Columbia River estuary, and conducting management activities on East Sand Island in a manner that minimizes the potential for DCCO dispersal or colony abandonment. Phase I was completed in 2017 when the colony was abandoned (which meant the colony size fell below the management objective for 2017 and the Phase I population target).
- Phase II, 2018 – 2023: initiated after the 2018 breeding season (4th year of Phase 1). Phase II includes primarily non-lethal management actions to ensure the number of DCCOs on East Sand Island does not exceed 5,380 to 5,939 breeding pairs by modifying habitat to limit availability, supplemented with some hazing as necessary to prevent DCCOs from nesting in new areas on East Sand Island. No management actions would be taken to ensure a minimum colony size or to reduce DCCO abundance below the target size. While Phase II management activities would primarily be non-lethal, limited egg take (up to 500 eggs) may be requested from USFWS in an annual depredation permit application to ensure hazing efforts can continue during the nesting season to preclude DCCO from nesting in new or different areas on East Sand Island. The amount of available nesting habitat on East Sand Island could be reduced to 1.04–1.15 acres (or less) in order to retain colony size objectives. Annual monitoring to support Phase II activities includes estimating DCCO abundance, nesting density, and PIT detection on East Sand Island, as necessary. An average 3-year peak colony size estimate would be used to evaluate management activities relative to plan objectives (2019–2021); the management plan would be considered successful when the average 3-year peak colony size estimate does not exceed 5,939 nesting pairs while no management actions are conducted. Annual PIT detection would continue for 5 to 10 years to assess overall trends in predation rates (through the 2023 breeding season, at minimum), accounting for annual variability in predation impacts. The Corps would also continue to coordinate with USFWS to monitor the Pacific Flyway during the peak breeding season as needed.

2.2.3 Habitat actions

Estuary habitat

This section describes the process that the Action Agencies use to identify, prioritize, and implement habitat improvement actions in the Lower Columbia River estuary (Figure 2-18). The Action Agencies propose to implement targeted estuary habitat improvements during the period covered under this consultation as offsite mitigation to help address uncertainty related to any residual adverse effects of managing the Columbia River System on migrating listed salmon and steelhead, including uncertainty regarding such effects in the face of climate variability.

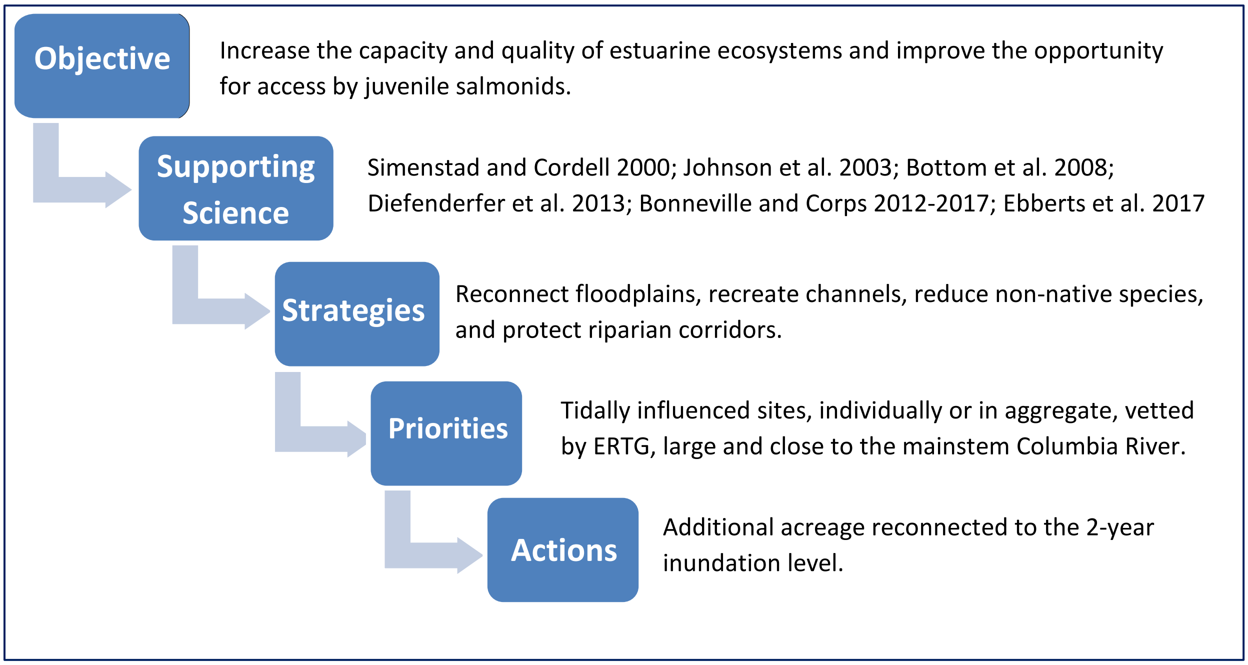

Figure 2-18. Overview of approach to implementing estuary habitat actions.

<u>Objective</u>

The Action Agencies will implement the Columbia Estuary Ecosystem Restoration Program (Bonneville and Corps 2012a, 2012b, 2014, 2015, 2016, 2017) to increase the capacity and quality of estuarine ecosystems and improve the opportunity for access by juvenile salmonids. The estuary is the final stretch of the Columbia where all out-migrating juvenile salmon and steelhead species affected by the Columbia River System transition from freshwater to ocean conditions. Increasing the accessibility, capacity, and quality of estuarine ecosystems provides the final opportunity for growth and improved condition to prepare juvenile salmonids for their ocean life-history stage.

<u>Supporting science</u>

It has been well documented that subyearling Chinook (Bottom et al. 2008) and to some extent chum salmon (Bottom et al. 2008, Sather et al. 2017) rear and grow in the estuary (Bottom et. al. 2008). The primary hypothesis driving estuary habitat improvement is that these actions will improve fish habitat and ultimately the growth and fitness of all salmonids, including yearling fish, as they move from Bonneville Dam to the ocean (Weitkamp et al. 2017, McNatt et al. 2017). The results of an evidence-based approach, which evaluated seven different lines of evidence, tested and confirmed this hypothesis (Diefenderfer et al. 2016). The paper also discusses how opposing forces, outside of the Action Agencies' control, such as increased urbanization, industrial development, and loss of forest cover, can negatively impact such efforts and make it challenging to quantify cumulative effects of these actions. Employing an ecosystem-based approach to habitat improvement actions remains paramount to ensuring projects can adapt to a dynamic environment (Johnson et al. 2003). The Expert Regional Technical Group (ERTG), which was developed under the 2008 BiOp, reviews proposed estuary actions by independent scientific experts in estuarine ecology.

Strategies

The ERTG leverages the best available science and expertise in fish and estuarine improvement ecology to evaluate project proposals (Krueger et al. 2017). To that end, the ERTG helped the Action Agencies and their partners focus on the key actions for successful estuarine habitat improvement (ERTG 2012). Adopted from NOAA's estuary module, key actions include reconnecting floodplains, recreating channels, controlling non-native vegetation, and protecting riparian corridors (NOAA Fisheries 2011). The evidence-based evaluation referred to above found links between these actions and direct and indirect benefits to fish. For instance, actions to reconnect floodplains, such as removing tide gates and breaching levees, eliminates or minimizes the physical barriers that disconnect historic floodplain habitat – allowing migrating fish to access the habitat directly. Actions such as recreating channels serve as conduits both to fish entering the site, and a way for nutrients, macro-detritus, and invertebrate prey to be exported from the site. Prey export provides a mechanism for yearling Chinook salmon and steelhead in the mainstem to benefit from improvement actions without directly accessing the reconnected habitat (Johnson et al. 2018). Reducing non-native species, and subsequent native re-vegetation, increases habitat diversity. This improves the site's resiliency to the dynamic nature of the estuarine environment and creates a more robust food web for juveniles. Since 2008, the Action Agencies identified the appropriate actions and implemented them across over 50 sites throughout the estuary (Johnson et al. 2018, Figure 2-19). Because of this work, the Action Agencies are able to aggregate the locations and future opportunities for viable estuary improvement projects into focal areas across the lower 146 miles of the estuary, allowing ERTG, practitioners and the Action Agencies to prioritize these opportunities.

Priorities

The Action Agencies propose to fund and provide technical assistance to restore floodplain ecosystems in the tidally influenced waters of the Lower Columbia River estuary (LCRE). We will prioritize improvement sites by identifying specific regions with the greatest potential to benefit the yearling and subyearling life history types of ESA-listed Chinook salmon and steelhead, both directly, while on a floodplain site, and indirectly, while in the mainstem (Figure 2-19). The science continues to support prioritizing larger parcels closer to the main stem to provide the greatest direct and indirect benefit to juvenile salmonids as they out-migrate to the ocean (Johnson et al. 2003; Bonneville and Corps 2012).

The ERTG periodically reviews completed projects, both at the individual and landscape scale. From 2011 to the present, the ERTG has refined understanding of what constitutes an effective estuary habitat improvement project, investigating key uncertainties (the role of floodplain lakes, appropriate number of channel outlets/project), revisiting implemented projects, and staying aware of ongoing monitoring efforts sponsored by the Action Agencies and others (ERTG 2013a; ERTG 2016). The group continues to advise that the most effective type of action, in terms of restoring the greatest functionality to a site, is reconnecting floodplain acreage to the estuary. The Action Agencies will continue to pursue those projects incorporating floodplain reconnection and already evaluated by ERTG during the implementation period under the 2008 BiOp and its supplements.

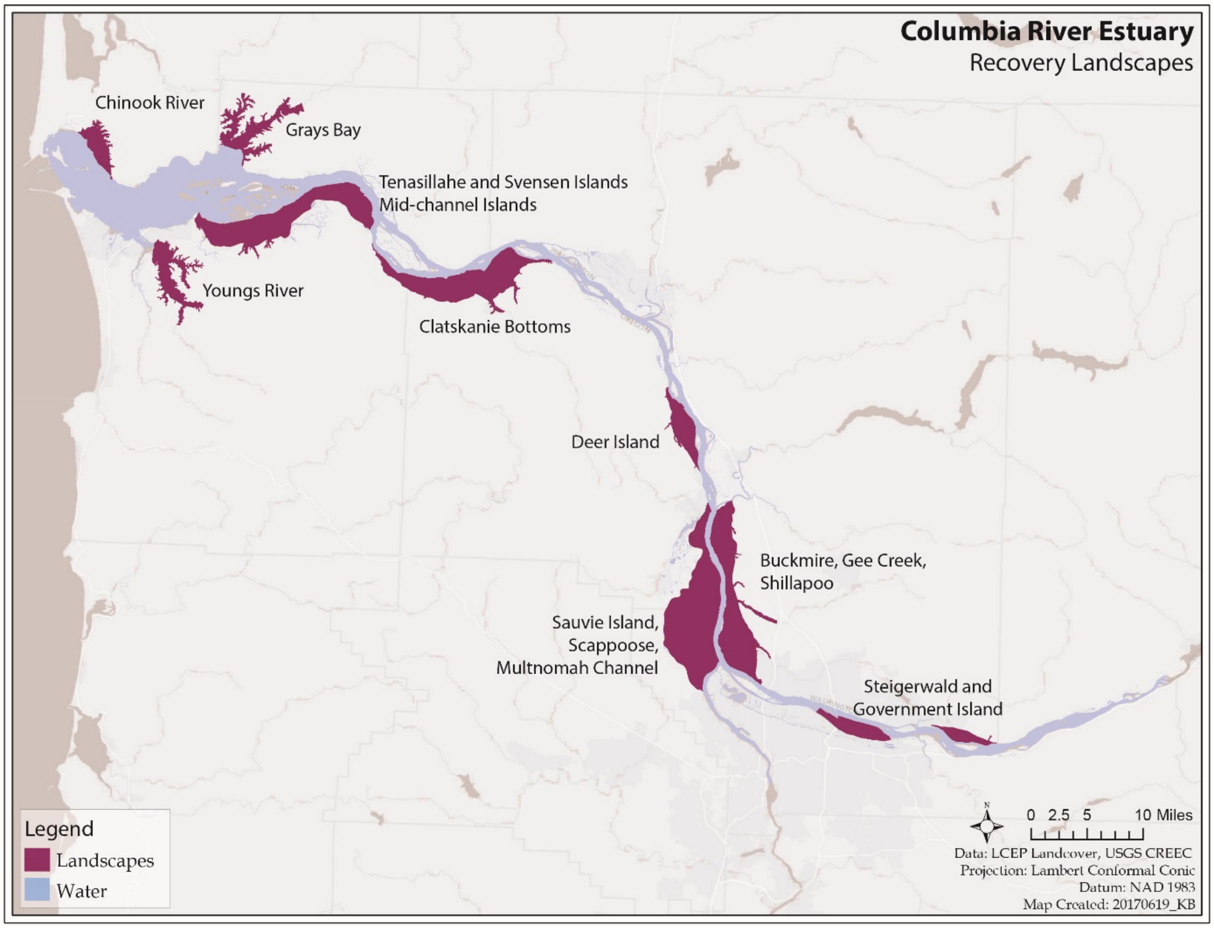

Figure 2-19. Future improvement sites are concentrated within the identified purple landscape areas.

Actions and metrics

Under the 2008 BiOp, the Survival Benefit Unit (SBU) served as the metric for demonstrating estuary habitat improvement accomplishments (ERTG 2011). The construct of SBUs originated with NOAA's *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NOAA Fisheries 2011), a document that was appended to ESA recovery plans for the entire Columbia River Basin. As noted above, its purpose was to indicate the types of actions and their estimated biological benefits to improve the condition of juvenile salmonids as they moved through the estuary and complement conservation actions elsewhere in the basin. The Action Agencies and NOAA Fisheries used this approach as a foundation to estimate benefits for site-specific actions implemented beginning in the 2008 BiOp.

When the ERTG formed in 2009, they enhanced the initial SBU approach by revising scoring criteria and developing a calculator (a form of model) to produce repeatable and transparent results. This approach helped ensure that high-quality actions were implemented in the estuary, but it has served as an imperfect proxy for estimating the expected biological response to specific habitat improvement actions at an ESU level.

The ISAB expressed concerns with using the SBU metric to estimate survival improvements, but affirmed that SBUs were a useful tool to inform the relative comparison and prioritization of habitat actions (ISAB 2014). The Action Agencies agree with this assessment regarding the limits of current available science to predict fish survival with reliable precision. The structure of the ERTG process nevertheless remains useful to the selection of high value actions (e.g., breaching levees, reconnecting channels, and restoring native vegetation). This includes ERTG's scoring criteria and weighting among the diverse potential actions considered for implementation by the Action Agencies. Therefore, the Action Agencies intend to continue using the ERTG to evaluate proposed projects both as a method of evaluating the relative benefit among individual projects and prioritizing projects in the landscape areas identified in Figure 2-19.

The Action Agencies and NOAA will continue to use the adaptive management framework under the Columbia River Estuary Ecosystem Restoration Program to evaluate and improve the way projects are prioritized and measured. As indicated above, key actions have been identified and the ERTG's methodology to evaluate a project's potential benefit remains scientifically valid (Krueger et al. 2017). The ERTG evaluates each project's ability to improve a site's habitat capacity and access for juvenile salmonids, as well as whether the project design is likely to be resilient and self-sustaining. These factors remain useful indicators of a project's potential to improve estuarine ecosystem function. The calculator employed by the ERTG has been calibrated to differentially weight the value of each action at a proposed site.

Projects scored to date consistently show that hydrologic reconnection of floodplains provides the greatest contribution to the ecological benefit of any given project. Logically, if other actions such as recreating channels, reducing non-native species, and protecting riparian corridors occurred without reconnecting floodplains, the project would be unlikely to provide any potential benefit assuming the site is fully disconnected from the floodplain. Conversely, should a project already be connected to the floodplain, it is unlikely to result in as much potential benefit. Combining the ERTG evaluation process with the principle that hydrologic floodplain reconnection provides the greatest ecological benefit to a restoration site will ensure that the Action Agencies prioritize the highest quality projects. The Action Agencies will demonstrate progress in estuary habitat improvement implementation by reporting the acres of floodplain reconnected (inundated at the 2-year flood elevation). The Action Agencies will continue to use the ERTG to inform selection and prioritization of biologically effective projects (ERTG 2013b). This approach builds upon ERTG's designation of the 2-year flood elevation for direct and indirect benefits to juvenile salmonids and their process for scoring projects.

Feasibility of implementation is a key consideration when selecting project sites. A more mature estuary program comes with valuable lessons learned regarding the amount of time and effort required to accomplish effective habitat improvement projects, as well as a better understanding of constraints that may render a project site infeasible. Working with the practitioners and ERTG, the Action Agencies have identified high ecological value areas with potential for habitat improvement. In many of those areas, one or more habitat improvement projects have already been implemented, a result of the steady progress of the estuary program. However, those areas have the potential for additional development or expansion of existing projects, or for implementation of entirely new projects during the new BiOp period.

The Action Agencies will continue to emphasize reconnection of floodplain areas in tidally influenced waters of the lower Columbia River and estuary, primarily through modifying levees. Additional actions at habitat improvement sites will include re-creating historical channel networks, reducing the presence of non-native species, and re-vegetating habitat improvement sites with native vegetation to ensure a site's resiliency. The estuary program has steadily increased the quality and quantity of habitat improvement measures, reconnecting an average of roughly 300 acres a year of floodplain habitat since 2008. Based on this annual average and the ongoing development and forecasting of future projects, the Action Agencies have concluded that reconnecting an annual average of 300 acres to the tidal regime is a reasonable target for the period covered under this consultation.

Monitoring and evaluation

The monitoring and evaluation efforts of the Action Agencies' estuary program have standardized and hierarchically organized the intensity of monitoring across sites. These actions ensure a statistically sound sampling plan to inform adaptive management at the site and landscape levels (Bonneville and Corps 2017a). This programmatic action effectiveness monitoring and research (AEMR) plan builds on related planning that Bonneville and the Corps have already conducted (e.g., Johnson et al. 2008, Roegner et al. 2009, Diefenderfer et al. 2011, Johnson et al. 2012, Sather et al. 2013).

The estuary program annually updates its monitoring strategy and will continue to monitor indicators of ecosystem health. These indicators include abiotic metrics, such as temperature, water surface elevation, and sediment accretion rates; and biotic metrics, such as plant community structure, biomass, fish density, and residence time. The indicators will inform practitioners, and the Action Agencies, of any adjustment in strategy needed to optimize floodplain reconnections (Bonneville and Corps 2017b).

The Action Agencies and NOAA will continue to coordinate and implement the Columbia Estuary Ecosystem Restoration Program (CEERP). With an institutionalized adaptive management framework, the Program will continue to provide forums to revisit the habitat improvement actions and pair them with the action-effectiveness monitoring results to date, to facilitate a discussion between practitioners, ERTG, and the Action Agencies (Ebberts et al. 2017). These efforts will continually evaluate the effectiveness of habitat improvement actions and inform any necessary adjustments to the current habitat improvement and monitoring strategies.

Future monitoring efforts

Action effectiveness

There are three levels of AEMR, beginning with level 3 and moving up in intensity to level 1. It is also important to note that these levels are nested, that is, Level 1 includes Level 2 and Level 3, and Level 2 includes Level 3:

- *Level 3*, "standard AEMR," monitors key controlling factors and other indicators, e.g., photo points, water surface elevation, and salinity;

- *Level 2,* "core AEMR," assesses core indicators of ecosystem structures and controlling factors such as plant species composition, percent cover, and biomass (Roegner et al., 2009); and,
- *Level 1,* "intensive AEMR," examines ecosystem processes and functions, e.g., juvenile salmon species composition, density, diet, and growth, along with structures and controlling factors.

The Action Agencies consistently coordinate with NOAA, ERTG, and resource practitioners to discuss the appropriate level of monitoring for a given site and for addressing critical or new uncertainties. Annual review of projects eligible for monitoring is evaluated across a number of environmental and practical variables. The result is a monitoring matrix that identifies the level of monitoring appropriate for each site and a designation of the entity responsible. This matrix is updated as part of the annual update to the estuary program's habitat improvement and monitoring plans (Bonneville and Corps 2017a). This is consistent with how the Action Agencies implemented the AEMR strategy under the past BiOp.

Programmatic adaptive management

In addition to ongoing AEMR, the Action Agencies continue to collaborate with NOAA, project sponsors, and the ERTG through the CEERP program to refine the approach to restoring estuary habitat. Several efforts underway address both current and future uncertainties:

- Synthesis memorandum #2: Every 5 years, CEERP re-evaluates the state of the science, the accomplishments to date, and the effects and trends of habitat improvement actions. This memorandum was finalized in August 2018 and is currently being relied upon by the Action Agencies, NOAA, practitioners, and ERTG to improve the estuary program.
- Oncor database: The goal of this project is to provide the Action Agencies, resource managers, and stakeholders a web-accessible, geospatial database for ecosystem improvement and associated RM&E in the LCRE. The database will inform future RM&E and habitat improvement priorities at the project and program scales. Products will support regional CEERP adaptive management, program-level decision making, and comprehensive BiOp reporting.
- ERTG's landscape perspectives: With 56 projects now implemented throughout the estuary, the Action Agencies and NOAA have asked the ERTG to consider additional landscape ecology concepts and principles that can factor in to project selection.
- Implementation forecasting: After a number of years of implementing projects on the ground, the Action Agencies, along with their implementation partners, are attempting to identify the viability of restoration projects that could contribute to more robust estuary ecosystem. Understanding a realistic landscape of what can possibly be restored is an essential component for the ERTG to consider in the task noted above.

The collaborative opportunities for Action Agencies, NOAA, restoration and research practitioners, and other stakeholders interested in improving estuary habitats are captured in the adaptive management framework of CEERP. The goal of these endeavors and the continued on-the-ground habitat improvement is a commitment and willingness to analyze the outcomes and results of these actions to improve our understanding and effectiveness of habitat improvement in the estuary (Ebberts et al. 2017).

Climate variability considerations

The Actions Agencies' approach to habitat improvement in the estuary incorporates climate considerations in the way projects are prioritized, designed, and evaluated. The ERTG project evaluation process emphasizes landscape ecology principles and provides guidance to restoration practitioners as they design projects. Factors considered include habitat complexity, connectivity, and capacity for self-maintenance. These same factors increase the overall resiliency of a habitat improvement project to climate variability stressors, most notably temperature increase and sea level rise. Improving floodplain and stream flow connectivity have recently been documented as some of the most effective actions for counteracting the effects of temperature increase (Beechie et al. 2013). This provides further support for the estuary program's emphasis on reconnecting historic floodplain. As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate science with ERTG and regional partners, to evaluate future estuary projects for resiliency in the face of climate change (i.e., sea level rise, increasing air and water temperatures, and changes to mainstem flow levels). The agencies' annual update of both restoration and monitoring plans in the estuary will document any adjustments necessary such as changes in design, location, or other elements of a given project, that would help make the project more resilient to climate change impacts, both during the period covered by this consultation and beyond.

Tributary habitat improvements

The Action Agencies propose to implement targeted tributary habitat improvements during the period covered under this consultation as offsite mitigation to help address uncertainty related to any residual adverse effects of Columbia River System management on ESA-listed migrating salmon and steelhead, including uncertainty regarding such effects in the face of climate variability.[37] The Action Agencies will implement targeted tributary habitat actions that provide meaningful biological benefits for the interior basin ESA-listed species in this consultation. The Action Agencies will implement tributary habitat actions in collaboration with local experts and utilizing the best scientific and commercial data available to develop strategies, priorities, and specific actions (Figure 2-20).

[37] These tributary habitats are located upstream of Columbia River System facilities, and with the exception of mainstem confluences, are not hydraulically affected by management of the system. Rather, many of these tributary habitats have experienced historical degradation due to numerous anthropogenic and environmental influences on the landscape. Human impacts have been wide spread and include land development and road building, agriculture and water diversions, impaired or blocked passage, etc.

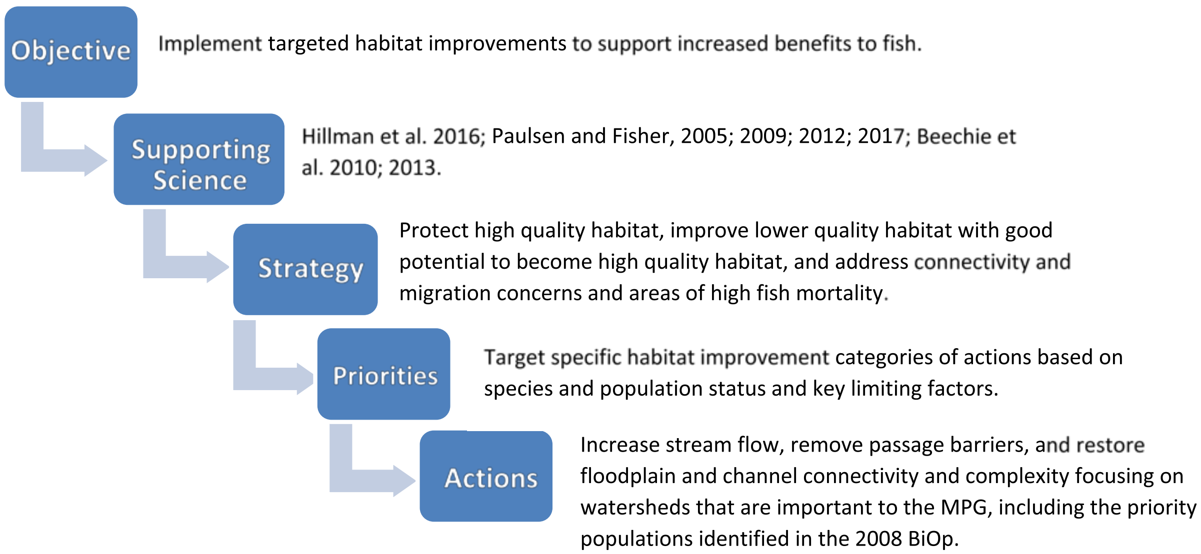

Figure 2-20. Overview of approach to implementing tributary habitat actions.

Supporting science

Conservation value of tributary habitat

In addition to safe, reliable passage through the Columbia River System and favorable ocean conditions, anadromous salmonids require an abundance of accessible, suitable, high quality spawning and rearing habitat (see sidebar). Recovery Plans for listed salmon and steelhead in the Columbia River Basin acknowledge the importance of high quality tributary habitat to provide spawning and rearing habitat and recommend habitat improvement actions as a key element of salmonid recovery (NOAA Fisheries 1995, 2007, 2009, 2015b, 2017a, 2017b).

Recovery is an important broader societal responsibility under Section 4(f) of the Endangered Species Act, administered by NOAA Fisheries through its separate recovery planning processes for each species, and is not the responsibility of the Action Agencies as part of this Section 7(a)(2) consultation. The conservation strategies in species recovery plans serve as important guidance, however, in identifying the best mix of actions to mitigate most effectively for remaining adverse effects on salmon and steelhead associated with managing the Columbia River System. For example, recovery plans identify key limiting factors, as well as recovery scenarios that target different populations for different levels of viability, thus providing a basis for prioritizing populations in the context of overall risk to the ESU or DPS. Informed by recovery plans and best scientific and commercial data available, the Action Agencies and NOAA have determined that habitat improvements in watersheds that are biologically significant for the listed species as a whole will serve as an important component in the mix of conservation measures for interior basin listed species in this consultation.

Consistent with conservation strategies identified in these regional recovery-planning processes, over the last two decades the Action Agencies have taken a life cycle approach to remedial measures for salmon and steelhead affected by federal management of the Columbia River System. As part of this effort, the Action Agencies have improved tributary habitat conditions throughout the Columbia River basin. (Figure 2-21).

The importance of adequate spawning and rearing habitat was recognized as early as March 1995 in the first Proposed Recovery Plan for Snake River Salmon that stated:

> Ultimately, the recovery of anadromous fish species will depend principally upon ameliorating passage problems in the mainstem Snake and Columbia Rivers. Assuming these improvements are made and mainstem juvenile and adult survival rates increase, more returning adults can be expected. When they do, adequate spawning and rearing areas must be provided to ensure full recovery of the species. (NOAA 1995, p. V-1-1)

Twenty years after the Proposed Recovery Plan for Snake River Salmon and after passage improvements at the Columbia River System dams, the Independent Science Advisory Board found:

> Many salmon populations throughout the interior of the Columbia River Basin are experiencing reduced productivity associated with recent increases in natural spawning abundance, even though current abundance remains far below historical levels. Density dependence is now evident in most of the ESA-listed populations examined and appears strong enough to constrain their recovery. (ISAB 2015, p.1)

Actions that increase population productivity by improving, for example, habitat quality for spawning, incubation, and early juvenile rearing, or by alleviating hydrosystem impacts during migration, can help a population escape the potentially destabilizing effects of depensatory predation at low density. Understanding density dependence at particular life stages is useful for guiding actions to help increase population productivity. However, ensemble density dependence over the entire life cycle is what really matters for determining a population's overall productivity and resilience. (ISAB 2015, p 125).

According to the Independent Science Advisory Board (ISAB), many tributary populations within the interior basin listed species that migrate through the Columbia River System are experiencing density dependence in their tributary spawning grounds (ISAB 2015). The ISAB found "evidence for strong density dependence at current abundance suggests that habitat capacity has been greatly diminished." Reduced carrying capacity is likely a result, at least in part, of long-standing effects from human development in the tributary reaches, and is not directly caused by federal management of the Columbia River System. Nevertheless, if spawning and rearing habitat capacity in the tributaries remains limited by other human impacts, this will hinder improvements in fish status for salmon and steelhead, notwithstanding the substantial fish passage survival improvements through the Columbia River System. Therefore, the package of conservation measures included in this proposed action includes offsite mitigation in the form of tributary habitat actions. (As noted previously, these actions are intended to help address uncertainty related to any residual adverse effects of Columbia River System management.) Continued implementation of tributary habitat actions, in concert with ongoing benefits of habitat improvements implemented to date, are expected to help address current habitat conditions that limit natural production in watersheds that are biologically significant for these interior listed species.

Under the 2008 BiOp, the Action Agencies greatly increased investments in tributary habitat conservation and improvement for the benefit of ESA-listed salmon and steelhead – in scope, biological rigor, and collaborative regional science review. During 2007 to 2017, the Action Agencies implemented substantial habitat improvement actions throughout the Columbia River Basin (Figure 2-21 and Table 2-9). During the period covered by this consultation, the Action Agencies will implement similar actions based upon the best scientific and commercial data available in collaboration with tribes, states, and other local and regional experts. The Action Agencies will plan and implement tributary habitat actions focusing on the science-based strategies used and refined through research and adaptive management from 2007 to 2018: assessing habitat conditions, identifying key limiting factors, and working toward ameliorating those limiting conditions.

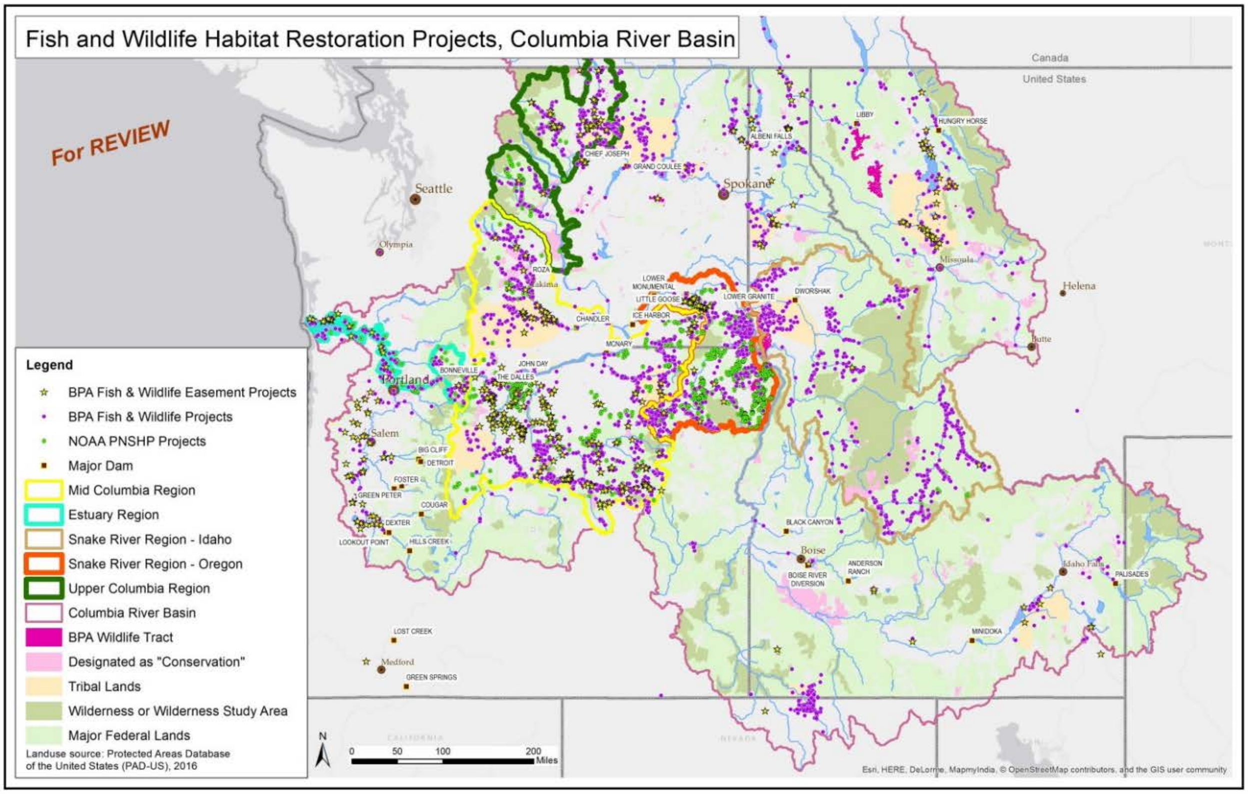

Figure 2-21. Tributary habitat actions completed in the Columbia River Basin (2007-2017).

Table 2-9. 2007–2017 Tributary Habitat Improvement Metrics by ESU/DPS*

Habitat Improvement Metric	Snake River Spring/ Summer Chinook	Snake River Steelhead	Upper Columbia River Spring Chinook	Upper Columbia River Spring Steelhead	Middle Columbia River Steelhead
Acre-feet/year of water protected	76,318	76,808	23,709	40,373	114,709
Acres protected	2,955	3,076	298	393	47,764
Acres treated	5,988	7,114	421	1,589	8,550
Miles of enhanced or newly accessible habitat	1,175	1,238	117	231	1,947
Miles of improved stream complexity	171	194	25	31	197
Miles of steam protected by easements	169	211	9	16	1,389
Screens installed or addressed	79	79	11	94	321

*Note: Some projects benefit multiple species. In those instances, therefore, metrics by species shown above include numbers for both steelhead and Chinook ESUs/DPSs present in the same watershed.

Benefits of habitat improvements

Current research shows increases in quantity and quality of tributary habitat conditions can meaningfully improve freshwater life-stage survival and overall abundance and productivity of salmon and steelhead. Many studies have been undertaken and funded by the Action Agencies to show these relationships. One of the most detailed has been the Intensively Monitored Watershed concept summarized in the *Effectiveness of Tributary Habitat Enhancement Projects* for a number of populations in the Columbia River basin (Hillman et al. 2016, Bonneville and Reclamation 2013, Bonneville 2014, Bouwes et al. 2016, and Bennett et al. 2016). Successful habitat improvement actions follow lessons learned, including: 1) identify habitat limiting factors directly associated with target species life-history characteristics; 2) address physical processes influencing limiting factors; 3) coordinate among stakeholders, landowners, funding and monitoring entities and implementers; and 4) develop explicit implementation and prioritization plans.

One example of reconnecting habitat during the previous consultation period was a series of habitat improvement actions on the Pahsimeroi River, Idaho. The goals were to remove barriers, increase instream flow, and screen irrigation diversions. These actions effectively double the amount of spawning and rearing habitat available to salmon and steelhead, resulting in an increase in juvenile Chinook salmon survival and productivity (Apperson et al. 2016). Similar efforts have been taking place in each of the priority locations under the 2008 BiOp.

Knowledge gained from previous tributary habitat improvement actions have helped shape our proposed tributary habitat conservation measures for this consultation.

Future benefits of completed habitat actions

Most completed habitat actions by the Action Agencies and others will continue to accrue benefits over time. This is especially true for riparian enhancements that will provide increasing benefits as they mature and produce more shade. The meaningful tributary habitat improvements implemented by the Action Agencies under previous FCRPS biological opinions, as well as habitat improvement actions implemented by other federal agencies form part of the environmental baseline. These completed actions will provide ongoing benefits into the future, and best available science indicates that these tributary spawning and rearing habitat improvements will result in benefits to abundance and survival of ESA-listed salmon and steelhead. These benefits are expected to increase over time as natural processes are improved and fully realized.

Lessons learned

The Action Agencies' implementation of tributary habitat actions has matured significantly over the past decade, resulting in established partnerships and efficient processes. This has led to improved prioritization, selection, design, and implementation of habitat improvement actions, which in turn have benefited listed salmonids by increasing abundance, distribution, and growth of salmonids (Hillman et al. 2016, pg. ES-3). Over the past decade, investigations into habitat improvement actions that address key limiting factors of salmon and steelhead have found carrying capacity limited by insufficient juvenile rearing habitat and large mortality of emigrating juveniles occurring before reaching the Columbia RiverSystem. As a result, the Action Agencies are working to complete habitat improvement actions that create more habitat capacity in key tributary watersheds for the listed species, based on multidisciplinary assessments.

During the 2008 BiOp implementation period, the Action Agencies supported the development of biologically-based prioritization processes to help inform tributary habitat improvement actions. Highlighted below are some examples of how those prioritization processes worked in particular tributary watersheds.

Snake River Region

Upper Salmon River spring/summer Chinook and Salmon River steelhead

To implement the tributary habitat actions recommended in the 2008 BiOp and its supplements, the Action Agencies, in collaboration with state and local partners, used a variety of tools, including the Screening and Habitat Improvement Prioritization for the Upper Salmon Subbasin, to prioritize and select projects to implement. This team utilized the guiding documents and information such as the NOAA Recovery Plan, NOAA's population prioritization plan, tributary assessments, and additional technical analysis to sequence actions and areas to implement habitat actions in priority watersheds within this MPG. The Action Agencies also worked with partners to complete extensive work in the Yankee Fork under the 2008 BiOp.

Grande Ronde/Imnaha spring/summer Chinook and steelhead

Beginning in 2011, the Action Agencies collaborated with partners to develop, implement, and adaptively manage a strategic, evidence-based habitat improvement prioritization framework known as Atlas in the Grande Ronde and Imnaha. Atlas is a multi-criteria decision analysis framework that utilizes the best available empirical fish and habitat data, peer reviewed, published research evidence, and local knowledge to determine the highest priority areas and actions for habitat improvement within a watershed (Beechie et al. 2008; Beechie et al. 2010; Roni et al. 2002). The Atlas framework has collectively resulted in implementation of habitat improvement actions that target high priority reaches for key focal populations, including the Upper Grande Ronde and Catherine Creek populations. Atlas serves as one of several models for regional habitat action prioritization that can be applied to additional watersheds in the Columbia River basin.

Lower Snake River spring/summer Chinook

In the Tucannon River subbasin, the Action Agencies have used a completed geomorphic assessment to strengthen the technical understanding of existing physical conditions and geomorphic processes in the basin in order to identify and prioritize habitat improvement opportunities. This assessment characterized channel and floodplain conditions, channel confinement, the historic channel occupations area, and the source, magnitude, and distribution of hydrologic and sediment inputs through the basin. This information was used to delineate discrete reaches throughout the river that offer potential improvement opportunities. Since 2012, the Action Agencies have consistently used the assessment to identify and prioritize the projects evaluated and selected for implementation in the Tucannon River.

Clearwater River steelhead

In the Clearwater Subbasin, the Action Agencies have collaborated with state, federal, and tribal partners to develop and implement habitat improvement actions in the various Clearwater River steelhead populations (e.g. lower Clearwater, South Fork Clearwater, Lochsa, and Selway rivers). More recently, the Action Agencies worked with their partners in the region to develop, implement, and adaptively manage a strategic, evidence-based habitat improvement prioritization framework known as Atlas in the Lochsa. Atlas is a multi-criteria decision analysis framework that utilizes the best available empirical fish and habitat data, peer reviewed, published research evidence, and local knowledge to determine the highest priority areas and actions for habitat improvement within a watershed (Beechie et al. 2008; Beechie et al. 2010; Roni et al. 2002). The Atlas framework has collectively resulted in the implementation of habitat improvement projects that target high priority reaches for Clearwater River steelhead. Atlas serves as one of several models for regional habitat action prioritization that can be applied to additional watersheds in the Columbia River Basin.

Upper Columbia River Region

Upper Columbia River spring Chinook and Upper Columbia River steelhead

In the Upper Columbia Regions, the Action Agencies, in coordination with the Upper Columbia Regional Technical Team, utilized the Upper Columbia Biological Strategy (UCRTT 2013) to document biological considerations for the protection and improvement of habitat, primarily in the Methow and Wenatchee rivers, and to a lesser degree in the Entiat and Okanogan rivers. This strategy provides a scientific basis for habitat enhancement action prioritization to guide the design, selection, and implementation of reach-based projects that achieve the highest biologic benefit and ensure project goals will be met. The Regional Technical Team (RTT) is currently working to update the Biological Strategy (expected 2018).

Strategies and priorities for this consultation

Based on the objectives, best available science, and lessons learned just described, the Action Agencies' approach emphasizes habitat improvements for listed species and their major population groups (MPGs). The Action Agencies will focus on watersheds that are important to the MPG (and thereby important to the ESU or DPS as well), including the priority populations identified in the 2008 BiOp. Future changes in these priorities will be informed by the regional prioritization practices described above. Lessons learned from those regional prioritization processes will also help the Action Agencies, and their implementation partners, to continue to improve the prioritization process going forward. To focus available resources effectively during the period covered under this consultation, the Action Agencies will use two criteria:

1) Geographic locations: identifying watersheds where additional habitat actions offer the greatest potential to contribute to the viability of the species as whole, as a means of most effectively offsetting remaining adverse effects of Columbia River System management on those species as a whole; and

2) Types of habitat actions: selecting actions to implement that are most effective at addressing key limiting factors and enhancement of natural processes within those watersheds. These include water transactions to augment instream flows, floodplain and side channel enhancement, fish screens for diversions, culvert improvements and passage barrier removals, riparian enhancement, and enhancement of habitat though easements and acquisitions.

Actions and metrics

For the period covered by this consultation, the Action Agencies will implement habitat improvement actions at the MPG level in order to achieve the metrics outlined in Table 2-10 and Table 2-11. Based on performance and accomplishments from 2007-2018, the Action Agencies determine this commitment is feasible. This commitment takes into account the implementation lessons learned over the last decade including the need to coordinate with local communities, identify willing landowners, coordinate cost share with other funding agencies, and secure all necessary permits.

NOAA has developed updated analytical tools, including models, since it issued the 2008 BiOp. Going forward, therefore, it will no longer be necessary for the Action Agencies to use the HQI methodology to identify priorities and estimate benefits. Instead, as in the estuary, the agencies will use biologically-based prioritization processes and report accomplishments using standard habitat implementation metrics, building on lessons learned from the efforts described above.

Table 2-10. Proposed habitat metrics (2019-2021) for major population groups in the Snake River spring/summer Chinook ESU and Snake River steelhead DPS.

	Flow protected (CFS)	Flow enhanced (acre-feet)	Entrainment screening (# screens)	Habitat access (miles)	Stream complexity (miles)	Riparian habitat improved (acres)
Snake River spring/summer Chinook major population groups[38, 39]						
Grande Ronde / Imnaha	16	1,484	0	23	8	109
Upper Salmon River	28	3,004	9	16	10	36
Lower Snake	0	0	0	2	2	34
Snake River spring/summer Chinook ESU Totals	44	4,488	9	41	20	179
Snake River steelhead DPS major population groups						
Clearwater River	0	0	0	10	0	138
Salmon River	28	3,004	0	8	0	27
Snake River steelhead DPS totals[31]	28	3,004	0	18	0	165

[38] The Action Agencies may use surpluses within an MPG from one metric category to augment other metric categories where the biological benefits are comparable.

[39] The metrics associated with habitat actions that benefit both Chinook and steelhead in the same basin are included in the rows for both species.

Table 2-11. Proposed habitat metrics (2019-2021) for major population groups in the Upper Columbia River Spring Chinook ESU and Upper Columbia River Steelhead DPS

	Flow protected (CFS)	Flow enhanced (acre-feet)	Entrainment screening (# screens)	Habitat access (miles)	Stream complexity (miles)	Riparian habitat improved (acres)
Upper Columbia River spring Chinook ESU major population group[40,41]	5	850	1	0	12	80
Upper Columbia River Steelhead DPS major population Group[32,33]						
Upper Columbia River /East Slope Cascades steelhead	5	850	0	0	12	80

For those middle Columbia steelhead populations that have been impacted by the Columbia River System management, the Action Agencies will provide funding and/or technical assistance for habitat improvement actions consistent with Recovery Plan implementation priorities and other regional efforts, as funding allows.

Similarly, for those lower Columbia ESUs/DPSs that have been impacted by Columbia River System management (specific populations of CR chum, LCR coho, LCR Chinook, and LCR steelhead), the Action Agencies will provide funding and/or technical assistance for habitat improvement actions consistent with Recovery Plan implementation priorities and other regional efforts, as funding allows.

Salmon and steelhead tributary habitat program steering committee

The Action Agencies will work with regional partners to refine biological-based prioritization and ongoing adaptive management for tributary habitat improvement actions. Similar to the steering committee for the ERTG developed as part of estuary implementation under the 2008 BiOp, the Action Agencies propose to convene a meeting of a Salmon and Steelhead Tributary Habitat Program Steering Committee (THPSC). The Steering Committee will include representatives from NOAA, Reclamation, and Bonneville. The Committee's goals will be to:

[40] Within an MPG, surpluses from one metric category can be used to augment other metric categories where the biological benefits are comparable.

[41] The metrics associated with habitat actions that benefit both Chinook and steelhead in the same basin are included in the rows for both species.

- Improve the tributary habitat program continuously by building from the successes of the past and considering cost/implementation efficiencies (e.g., the Grande Ronde Atlas process and the Upper Salmon Integrated Rehabilitation Assessment).
- Update the approach to prioritizing watersheds within the Columbia basin.
- Update the approach for collaborating with existing local and/or regional watershed partners to support reach and site-scale prioritization for future habitat improvement actions, and consider how to utilize the value provided by local experts.
- Update and clarify reporting for completed habitat actions (See Reporting section below).
- Coordinate and collaborate with the developing regional habitat RM&E strategy led by Bonneville, NOAA and Northwest Power and Conservation Council (NPCC), (see research, monitoring and evaluation section below).

Implementation process

The Action Agencies partner with local experts (i.e., states, tribes, regional technical teams, salmon recovery boards, etc.) to assess biological priorities and feasibility and select specific habitat improvement actions for implementation. All of the subbasins have habitat improvement action plans in place. These plans are a result of applying a multi-criteria decision analysis framework, leveraging empirical fish and habitat data, peer reviewed, published research evidence, and local knowledge and experience to determine the highest priority areas and actions for improvement within a watershed (Beechie et al. 2008; Beechie et al. 2010; Roni et al. 2002). Biologists, geomorphologists, engineers, and other implementation experts representing state, tribal, non-profit, county, and federal entities, periodically evaluate the continued implementation of these action plans to monitor their effectiveness in addressing limiting factors. The evaluation of such results allows the Action Agencies and their partners to adjust these plans continually as limiting factors and/or areas shift in priority and perform adaptive management on future actions implemented. In addition, Bonneville's programmatic habitat projects undergo regular review by the NPCC's Independent Science Review Panel under the Northwest Power Act.

Tributary habitat reporting

As part of the annual reporting described in Section 2.3.1, the Action Agencies will provide NOAA with the following information regarding completed habitat actions, including inputs for future life cycle modeling runs and for evaluation of the program's implementation and effectiveness:

- Action description (category, rationale, objectives)
- Flow – cubic feet per second or acre-feet increased in-stream flow acquired
- Screening – number of screens
- Access – miles of access
- Complexity – miles of stream complexity improved
- Riparian – miles or acres of riparian habitat enhanced
- Location and extent of action

- Implementation timing
- Habitat condition for the target reach, before and after implementation

If information needs to change during the period covered by this consultation, the Steering Committee will clarify and update reporting metrics to promote usefulness and efficiency.

The Action Agencies are dedicated to aligning current habitat database and system reporting efforts for the reporting elements above, where feasible, and exploring improvements in information reporting systems investments.

Information from completed projects can be used by NOAA Fisheries in life cycle models and other analyses that provide quantitative information that the Action Agencies expect NOAA will consider as part of its overall assessment of biological benefits.

Research, monitoring, and evaluation

The Action Agencies implement a tributary habitat research, monitoring, and evaluation (RM&E) program to assess tributary habitat conditions, limiting factors, habitat-improvement action effectiveness, and to address critical uncertainties associated with these offsite habitat mitigation actions. Generally, this habitat RM&E program is structured to include compliance, implementation, effectiveness, status and trends and validation monitoring, all prioritized within available budgets. The Action Agencies' efforts focus on addressing management decisions and informing needs for mitigation measures included in this proposed action. This work is concurrent to RM&E efforts funded by other federal, state, tribal, utility, and private parties that all contribute to larger basin-wide RM&E data and analyses.

Building on the findings from efforts funded under previous biological opinions, as well as knowledge gained from the Columbia Habitat Monitoring Program (CHaMP), the Action Agencies will develop a refined habitat RM&E strategy in collaboration with NOAA and other regional partners within the first two years of the period covered by this consultation. The goal is to better define needs, priorities, programmatic efficiencies, and implementation responsibilities going forward, during a time of increasing governmental funding limitations.

Future habitat RM&E implemented by the Action Agencies will be consistent with the revised habitat RM&E strategy and will explicitly link habitat RM&E to regional habitat management applications including: communicating the status of tributary habitat in the Columbia River Basin (habitat and fish status and trends monitoring), documenting habitat actions (implementation and compliance monitoring), guiding future tributary habitat improvement decisions (effectiveness monitoring), and reducing critical uncertainties to assess the benefit of tributary habitat actions to salmonid populations (research).

During the development of this habitat RM&E strategy, the Action Agencies will fund the following tributary habitat RM&E that meets interim needs and addresses habitat management applications during this consultation period. This interim habitat RM&E is described by RM&E type below.

Status and trends of habitat and fish

In order to track broad-scale changes in select habitat conditions, Bonneville will support the annual collection of a priority subset of habitat status and trends information, including stream temperature and flow across the Columbia River Basin. Bonneville will explore opportunities for programmatic approaches to the collection of such data with regional experts such as the US Forest Service Rocky Mountain Research NorWeST team. Additionally, a subset of watersheds within the Snake River, Upper Columbia, and Mid-Columbia ESUs will implement regional habitat data collection to support existing long-term habitat monitoring efforts.

Bonneville will support fish status and trend monitoring for one population per MPG as described in Section 2.2.4 Fish Status Monitoring Actions. Fish status and trends RM&E, including juvenile production monitoring, tributary PIT array, screw trapping and associated juvenile PIT tagging monitoring, will be made available through the region's Coordinated Assessments program. These data are useful for informing the effectiveness of habitat improvement actions, as further described below.

Additional monitoring for habitat or fish status and trends will be evaluated through the development of the regional habitat RM&E strategy during this consultation period. The Action Agencies will leverage existing efforts capturing habitat or fish status and trends information funded by regional partners and entities wherever possible to address additional or unmet needs. Any remaining status and trends needs that cannot be addressed by existing regional monitoring programs will be evaluated and prioritized for implementation through the forthcoming habitat RM&E strategy.

Implementation and compliance monitoring

To ensure habitat improvement actions are implemented as planned (e.g. meeting construction design and environmental compliance requirements), the Action Agencies fund ongoing implementation and compliance monitoring (I&C) for all of their completed habitat actions. Generally, I&C monitoring data are used to inform Action Agency habitat program management and can also be used to support science-based analytical tools such as life cycle modeling. Current I&C monitoring programs are unique to each of the Action Agencies and occur through numerous programs at varying levels of intensity and resolution (e.g., some I&C data are collected programmatically, while other I&C data are collected indirectly through effectiveness monitoring at the project level).

During the period covered by this consultation, the Action Agencies will implement I&C monitoring, including monitoring called for in the Bonneville HIP programmatic BiOp, in coordination with NOAA Fisheries and USFWS. The HIP programmatic BiOp ensures that standardized reporting processes are applied to all implemented habitat actions and provides technical assistance and quality assurance/quality control reviews during habitat action design development, construction, and post-implementation through the HIP review process. All habitat actions carried out under the HIP programmatic BiOp produce project completion reports that are collated and shared with the NMFS Habitat branch on an annual basis, in compliance with the terms and conditions of the HIP BiOp's Incidental Take Statement. This annual reporting is an assessment of program activity and will continue through the period covered by this consultation. Additionally, other complimentary Action Agency I&C monitoring will also occur, in coordination with federal partners and habitat implementation sponsors. Future I&C monitoring will be evaluated and prioritized through the development of the regional habitat RM&E strategy and will leverage existing efforts funded by the Action Agencies such as those under the HIP BiOp, as well as efforts of other regional partners.

Effectiveness monitoring

The Action Agencies will support effectiveness monitoring related to their habitat mitigation efforts across the Columbia River Basin at a variety of scales including the site, watershed and basinwide scales. This monitoring serves multiple purposes, including determining if habitat actions are meeting their physical and/or biological objectives, as well as revealing the benefit of actions on multiple scales. To date, many key management questions have been addressed through a variety of Action Agency, NOAA and regional effectiveness monitoring efforts, including site-scale programmatic monitoring and intensively monitored watersheds (IMWs).

Site-scale effectiveness monitoring

Bonneville funds site and project-scale action effectiveness monitoring (AEM) to provide a comprehensive, consistent, efficient, and cost effective programmatic approach to monitor and evaluate the Action Agencies' salmon and steelhead tributary habitat improvement actions (e.g. fish passage, instream wood structures, floodplain enhancement and riparian improvement). The majority of Bonneville's implementation partners conduct effectiveness monitoring through the AEM Program, including multiple habitat actions distributed across the Snake River, Upper Columbia and Middle Columbia ESUs/DPSs. Results from this work are available on a rolling basis as action categories monitored in the AEM program are completed and evaluated. Future needs for AEM work that are identified through development of the regional Habitat RM&E strategy will be used to inform adaptive management of site-scale monitoring priorities.

Watershed-scale effectiveness monitoring

The Action Agencies will support the completion of summary analyses/reports for completed watershed effectiveness work including direct support for a CHaMP/IMW synthesis focused on a high-level summary of habitat benefits to guide management decisions on habitat priorities funded by Bonneville. This CHaMP/IMW synthesis is slated for completion during the first year of the period covered by this consultation. Additionally, Reclamation will finalize IMW investigations in the Methow River and complete a final report summarizing these results. Fish status and trend monitoring will occur within the Entiat, Lemhi, and John Day basins, all of which were identified as pilot IMWs in the 2008 BiOp, as a subset of the fish status monitoring actions described in Section 2.2.4. These monitoring results will be made available to inform future effectiveness monitoring called for in the regional Habitat RM&E strategy.

The Action Agencies will support ongoing habitat monitoring for a subset of readily available and high value habitat variables, including stream temperature and flow. The results of this monitoring will be evaluated through collaborative efforts with regional experts, including the US Forest Service Rocky Mountain Research NorWeST team, a group focused on aggregating stream temperature data from the Northwestern U.S. For example, Bonneville is funding the development of stream habitat linear networks to display habitat attributes (e.g. stream temperature, flow, and percent canopy cover) in GIS-based data displays and maps in the Grande Ronde watershed. Additionally, biologically-based fish linear networks (e.g. salmon densities) are being explored for use in conjunction with stream habitat linear networks to help guide future habitat improvement efforts.

Significant environmental events such as floods and fire present unique opportunities for strategic research and data collection that can be used to inform and adaptively manage future implementation of the Action Agencies' salmon and steelhead tributary habitat program in the face of climate variability. During the period covered by this consultation, data collection efforts will be prioritized and assessed following these types of natural events occurring within the basins identified as pilot IMWs in the 2008 BiOp. A subset of these data collection efforts will be implemented where feasible and consistent with RM&E principles outlined in the regional Habitat RM&E strategy.

Remaining key management questions that require additional data on fish-habitat relationships will be evaluated and prioritized as part of the regional habitat RM&E strategy development, in strategically suited watersheds that have existing fish monitoring infrastructure, habitat implementation success to date and occur within the Lemhi, Tucannon, and/or Grand Ronde basins at a geographic scale that enables the detection of significant results.

In addition, the Action Agencies recognize the value of strategically applied analytical tools and will support watershed-scale effectiveness monitoring to inform life cycle modeling. The Action Agencies will prioritize supporting analytical tools that can be broadly applied, are based on readily available data, are responsive to environmental change, are transparent and streamlined, and can be used to guide management decisions.

Results of site and watershed-scale effectiveness monitoring will continue to be used to guide future habitat action implementation to ensure the Action Agencies are investing in effective habitat improvement actions designed to help address uncertainty related to any residual adverse effects of Columbia River System management. Additionally, results will be used to help evaluate improvements in habitat and fish status resulting from completed habitat actions in the Columbia River Basin through regional science-based processes such as life cycle modeling. The development of the regional habitat RM&E strategy will include considerations and recommendations for future effectiveness monitoring.

Basin-wide analyses and summaries

Basin-wide analyses and summaries that address limiting factors, habitat-improvement action effectiveness, and critical uncertainties associated with offsite mitigation actions will continue to be updated periodically, such as habitat-fish survival correlation analyses (Paulsen and Fisher, 2005; 2012; 2017) and synthesis (Beechie et al. 2013; Hillman et al. 2016).

Research

The Action Agencies recognize the value of focused, cost-effective, time-limited research and validation monitoring that increases our understanding of the cause and effect relationships between habitat actions and biological fish responses. When directly applicable to management decisions, the Action Agencies will fund targeted fish and habitat research projects with regional partners as funding and priorities allow. Operating on that premise, the Action Agencies will participate in life cycle modeling efforts that explore habitat influences on salmon and steelhead species and communicate results that are explicitly transferable for broader benefit through collaborative regional processes for modeling such as AMIP. Bonneville will also support focused validation monitoring that allows for the analysis of key habitat and fish relationships that remain unknown, but are central to management decisions, in priority watersheds such as the Grande Ronde. In the Methow and upper Salmon rivers, Reclamation has initiated telemetry studies to track juvenile Chinook salmon to investigate detections of high mortalities and improve understanding of fall and winter habitat preferences and survival in order to target the most beneficial habitat improvement actions in the future.

Future habitat research and validation monitoring (to be developed as part of the regional habitat RM&E strategy) will prioritize common regional objectives, including investigating the influence of the Action Agencies' habitat program on fish abundance and productivity, as well as addressing a core set of habitat critical uncertainties.

The Action Agencies are committed to funding the RM&E described above as well as committed to a collaborative process, including capturing lessons learned from the findings of other habitat programs and studies, with NOAA and regional partners to develop a successful future habitat RM&E strategy. In the interim period covered by this consultation, the Action Agencies will work with NOAA and the Salmon and Steelhead Tributary Habitat Program Steering Committee to identify core habitat data objectives to support successful habitat program adaptive management and evaluate the success of the Action Agencies' program. Where feasible, the Action Agencies will align current habitat database and system reporting efforts to improve information reporting systems investments.

Climate variability considerations

While the Action Agencies alone are not responsible for – nor capable of – mitigating for the effects of climate variability as part of this interagency consultation under Section 7(a)(2) of the ESA, the effects of ongoing management of the Columbia River System must be analyzed within the broader context of the human and natural environment, including anticipated changes over time. This applies equally to other mitigation actions, including tributary habitat improvements included as conservation measures in this consultation.

Current literature indicates all habitats used by Pacific salmon will be affected by warmer temperatures and changed hydrology, but the impacts vary by habitat type. Some anticipated effects (e.g., increasing temperature) affect salmon at all life stages and in all habitats, while others are habitat specific, such as stream flow variation in freshwater, sea level rise in estuaries, and upwelling in the ocean.

Many of the habitat improvement actions planned, designed, funded and implemented by the Action Agencies help support resilient habitats with more flexibility to adjust to climate variability.

Actions implemented to date have provided, and will provide, immediate, near-term and long-term benefits, including those helping to ameliorate the effects of climate variability on salmonid habitat in the future (Williams et al. 2015). Specifically, actions that improve streamflow, reconnect and enhance floodplains and habitat complexity, enhance riparian areas, and improve upstream passage, will help provide a buffer against the effects of climate variability, as salmon and steelhead will have continued access to habitats with suitable conditions for their various life stages (Table 2-12). Additionally, enhanced watershed processes and mature riparian communities are collectively expected to establish habitat refuges for fish as some regions within the Columbia River Basin give way to environmental changes. The Action Agencies will emphasize actions that promote resiliency to climate variability in the prioritization processes.

The final column of Table 2-12 shows how the Action Agencies' tributary habitat conservation measures in this consultation align with the best available science related to climate variability effects, adaptation strategies, and suggested habitat improvement actions.

Table 2-12. Tributary habitat actions that help address climate variability effects (adapted from Williams et al. 2015).

Climate effects	Adaptation strategies	Habitat improvement action	Action Agency proposed and completed actions to support climate resiliency
Warmer summer temperatures	Increase stream shading and increase cool water habitat	Restore riparian areas; increase meanders, deep pool and undercut bank habitats	Riparian enhancement; habitat complexity; stream flow enhancement
Earlier peak flows, decreasing summer slows and more drought	Keep flows in headwaters longer; recharge aquifers; increase refuge habitats	Restore headwater meadows and wetlands; increase channel meanders; restore instream flows; increase number and size of deep pools	Riparian enhancement; habitat complexity; stream flow enhancement
More wildfires	Create large wet zones along stream that are resistant to burning	Increase width and lushness of riparian areas; slow flows and re-meander to increase shallow groundwater in meadows; introduce beavers	Riparian enhancement; habitat complexity; stream flow enhancement
More floods and higher flows in winter	Increase natural capacity of streamside habitats to absorb and dissipate flow energy	Reconnect and restore floodplains; expand and revegetate riparian areas; improve culvert designs and capacity	Riparian enhancement; habitat complexity; stream flow enhancement
Increase cumulative stress to stream systems	Reduce other sources of stress to minimize cumulative impact of increased climate stressors	Reduce or otherwise improve livestock use; reduce roads and/or improve their maintenance; reduce pollution sources	Riparian enhancement; enhance road systems

2.2.4 Fish status monitoring actions

The Action Agencies will support the following monitoring and evaluation activities in order to effectively track survival of ESA-listed species affected by Action Agency management:

- PIT-tag marking of Upper Columbia and Snake River stocks to provide ESU specific estimates of juvenile and adult survival through the federal mainstem dams;
- PIT-tag marking juvenile Snake River Sockeye Salmon for specific survival tracking of this ESU from the Stanley Basin to Lower Granite Dam and through the mainstem Columbia River System projects;
- Implement core elements of natural abundance monitoring for the Snake River fall Chinook ESU.

In addition, as noted previously, the Action Agencies will continue fish status and trend monitoring for selected populations in the upper basin. Ongoing efforts will also continue to improve the Action Agencies' approach to Columbia River System status monitoring (analytical approaches, tagging needs, methods, and protocols), with a focus on programmatic efficiencies and improved reporting though technology and elimination of duplication. This will be done in collaboration with the state, tribal, and federal fishery agencies and coordinated with other status monitoring needs and strategies for the region.

Ongoing support also includes Bonneville contributions to research involving the effects of near shore ocean conditions on adult returns, including the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.

2.3 Reporting, adaptive management, and regional coordination

The Action Agencies use the best available scientific information to identify and carry out actions that are expected to provide immediate and long-term benefits to listed fish, while continuing to operate for other authorized purposes set forth by Congress. To that end, the Action Agencies coordinate with NOAA Fisheries and other regional partners to inform and signal appropriate adaptations to changing circumstances.

2.3.1 Annual BiOp implementation reporting

The Action Agencies will report annually to NOAA on the following information:

- Configuration or operational changes at the dams
- Operations for juvenile fish (e.g., the placement of screens, the start and end of spill operations)
- Transport operations (start and end of transport operations, number of fish transported)
- Operations for adult fish
- Predation management actions
- Kelt reconditioning actions
- Results from monitoring operations, such as
    - adult fish counts
    - pinniped numbers and predation estimates at Bonneville Dam
    - juvenile fish in-river system survival estimates[42]
    - adult fish upstream conversion estimates

[42] NOAA Fisheries has historically produced estimates of juvenile in-river system survival and adult fish conversion rates. The Action Agencies provide tagged fish detection capability at dams, and maintain the PITagis database, while NOAA analyzes the data, generates the estimates and delivers them to the Action Agencies for inclusion in annual BiOp reporting. The Action Agencies assume this collaborative arrangement will continue.

- Tributary habitat
    - See section 2.2.3 for details on tributary habitat improvement reporting
- Estuary habitat
    - Acres of estuary floodplain improved
    - Miles of estuary riparian area improved

Results from individual research studies or effectiveness evaluations will be shared with NOAA Fisheries as they become available, through existing processes. For instance, for studies that are part of the Corps' Studies Review Work Group (SRWG) process, results would continue to be made available through the SRWG.

2.3.2 Adaptive management and regional coordination

The Action Agencies will continue to use an adaptive management framework to manage system operations and guide implementation of the additional non-operational measures to benefit ESA-listed salmon and steelhead. Under this framework, targeted monitoring and evaluation, study results, and other new information or updated operational proposals that are determined to have effects already considered in the biological opinion, will help inform coordinated adjustments to the Action based on best available scientific information. To assist in informing adaptive management decisions, the Action Agencies monitor and report near-real-time environmental conditions at all Columbia River System projects, including river flows, river temperatures, and total dissolved gas monitoring at all projects, and adult and juvenile fish passage at lower Snake and Columbia River projects. The ability to respond flexibly to new information is a critical tool for managing this complex multi-purpose system in the face of uncertainty and natural variability.

The Action Agencies continue to work collaboratively with regional sovereign parties to adaptively manage the implementation of system operations related to fish through various policy and technical teams, including those teams collectively referred to as the Regional Forum and other workgroups as appropriate, to implement year-round system operations related to fish and adaptively manage operations as necessary. Through Regional Forum team processes, various plans are developed collaboratively (e.g., Water Management Plan, Fish Operations Plan, Fish Passage Plan, etc.). These plans guide Columbia River System operations through a given water year, taking into account how best to manage conditions for the benefit of both ESA-listed anadromous and resident fish species, as well as other species of concern.

The Action Agencies also operate the Columbia River System in coordination with several public utility districts (on the middle Columbia River, the Snake River, and other tributaries), and with three Canadian projects pursuant to the Columbia River Treaty between the United States and Canada.

Regional coordination

The following teams are an integral part of informing fish operations and the related adaptive management of the Columbia River System and are described below.

Regional Implementation Oversight Group

The Regional Implementation Oversight Group (RIOG) was established to provide a policy level forum for discussion and coordination of the operation and maintenance of the Columbia River System by regional sovereign representatives. The RIOG and technical sub-teams include sovereign representatives from federal agencies, tribes, and states. The overall purpose of the group is to inform the federal, state, and tribal representatives that are actively engaged in efforts to benefit both anadromous and resident species regarding implementation issues from each sovereign's perspective.

Technical Management Team

The Technical Management Team's (TMT) mission is to develop recommendations from sovereign representatives to the Action Agencies on a variety of operations in-season to benefit fish, including spill, temperature, and flows as outlined in the BiOps for listed salmon, steelhead, sturgeon, and bull trout species within the Columbia River Basin, while taking into account the needs of (and effects on) other listed and non-listed species (such as lamprey). The TMT serves as a forum for broad technical participation and use of the best available technical information.

System Configuration Team

The System Configuration Team (SCT) is similar in composition to the TMT. It reviews and prioritizes projects for annual Corps funding for non-operations features at Corps projects in the lower Snake and lower Columbia rivers, and prioritizes and recommends to the Corps elements for implementation. The SCT interacts with the Studies Review Work Group (SRWG) and Fish Facility Design Review Work Group (FFDRWG) (see below), and RIOG as needed/assigned.

Fish passage coordination team

The teams described below are staffed by representatives from the Corps, Bonneville, USFWS, NOAA Fisheries, Idaho Department of Fish and Game (IDFG), Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), and Columbia Basin Indian Tribes. These teams coordinate with RIOG, TMT, and SCT, when appropriate.

Studies Review Work Group (SRWG)

This group is made up of representatives from IDFG, WDFW, ODFW, Columbia Basin Indian Tribes, CRITFC, Bonneville, USFWS, NOAA Fisheries, and the Corps. The SRWG develops and reviews research, monitoring, and evaluation studies. It works closely with SCT and FFDRWG to inform future studies funded through the Corps, and also interacts with FPOM.

Fish Facility Design Review Work Group (FFDRWG)

The FFDRWG comprises representatives from IDFG, WDFW, ODFW, Columbia Basin Indian Tribes, Bonneville, USFWS, NOAA Fisheries, and the Corps. This Work Group is organized into two functional teams, the Corps' Walla Walla District and the Portland District, and many representatives participate on both. The Work Group provides input to engineering and design of fish facility modifications and new passage technologies.

Fish Passage Operations and Maintenance (FPOM) Coordination Team

The Fish Passage Operations and Maintenance coordination team is composed of representatives of IDFG, WDFW, ODFW, Columbia Basin Indian Tribes, Bonneville, USFWS, NOAA Fisheries, and the Corps.

The team conducts coordination on fish passage operations and maintenance activities; makes in-season adaptive management recommendations related to the Fish Passage Plan; recommends annual revisions to the Fish Passage Plan; and interacts with other Fish Passage coordination teams, TMT, and RIOG, as needed.

Contingencies

The 2009 Adaptive Management Implementation Plan included triggers for: 1) unexpected declines in adult abundance and 2) environmental disasters or environmental degradation (either biological or environmental) in combination with preliminary abundance indicators. The Action Agencies propose to work with NOAA Fisheries and other salmon managers and will coordinate with other appropriate parties in any region-wide diagnostic effort, e.g., utilizing life cycle models, if the early warning or significant decline triggers are tripped as defined in the 2014 Biological Opinion (i.e., five-year abundance trends, rolling four-year averages of abundance, and where those metrics fall relative to particular percentiles).

The Action Agencies anticipate that all Biological Opinions regarding the effects of federal agency action on ESA-listed salmon and steelhead within the Columbia River Basin would include this same set of triggers for additional contingency actions, because the choice of appropriate response action(s) will depend upon the immediate limiting factor(s) diagnostics and may or may not be related to or addressed by the Action Agencies’ management of the Columbia River System.

An Early Warning indicator: This indicator will alert NOAA Fisheries and the Action Agencies to a decline in a species’ abundance level for natural-origin adults that warrants further scrutiny because it indicates that a Significant Decline (see below) may be reached in one to two years.

Within 120 days of NOAA Fisheries’ determining that the Early Warning Indicator abundance levels have been observed, NOAA Fisheries, coordinating with the Action Agencies, the RIOG, and other regional parties will determine whether the species in question is likely to decline to a level that will trip the Significant Decline Trigger. This evaluation will be based on additional indicators and predictors of status (e.g., jack counts, ocean conditions, and habitat disturbances). If the early implementation of Action(s) is warranted, this coordinated regional evaluation will help decision makers determine which actions to take. As part of this process, if the declines are related to system management, the Action Agencies will implement appropriate actions as soon as practicable.

A Significant Decline Trigger: Each year, the federal agencies will monitor for a significant decline in the natural abundance of the species.

If NOAA Fisheries determines that the Significant Decline Trigger has tripped for a listed species, the Action Agencies expect NOAA would initiate a region-wide life cycle diagnosis to determine all potential contingency actions by parties in the region, including but not limited to, the Action Agencies.

The Action Agencies would consider implementing the following contingency actions as soon as practicable if the significant decline trigger is met.

- Safety-net hatchery actions: potential long-term contingency actions include working with hatchery operators to reprogram safety-net programs to longer-term conservation hatchery programs, where appropriate; and reforming existing hatchery programs to meet conservation goals.

- Fish transportation: Currently, fish transport operations are adaptively managed on an annual basis. If system operations rapid response actions are considered potentially effective, a process will be initiated consistent with those outlined in the 2012 Rapid Response and Long-Term Contingency Plan for the Columbia River System Adaptive Management Implementation Plan. That process includes, among other things, convening special SRWG meetings in coordination with the HCT to review fish transportation strategy information.

  Juvenile fish transportation is an ongoing program to improve fish survival by collecting fish from juvenile bypass facilities at Lower Granite, Little Goose, and Lower Monumental dams and transporting them by either barge or truck to release sites below Bonneville Dam. Currently, fish transport operations are adaptively managed on an annual basis. The timing and conditions for fish transportation are based on annual monitoring, comparing adult returns to Lower Granite Dam of transported fish versus fish that migrated in-river.

Contingency Actions would be periodically reviewed to determine whether the actions continue to be necessary and if so, whether alternative actions might be more beneficial.

2.3.3 Government-to-government consultation

In addition to the specific regional coordination forums and processes described above, the Action Agencies also engage in sovereign coordination with tribes in other ways. Consistent with the unique relationship between the federal government and federally recognized Indian tribes, the Action Agencies also engage in government-to-government consultations with tribes on a case-by-case basis on a wide variety of matters, including matters related to the implementation of the Columbia River System biological opinions. Government-to-government consultations can occur at the request of either a tribe or an Action Agency. Consultation is typically between the governing body of the tribe and the senior executive of the relevant Action Agency.

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4 Appendices

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Consultation Package for
Operations and Maintenance of the
Columbia River System

Appendix A
Columbia River System Project Authorizations and Descriptions

Bonneville Power Administration

Bureau of Reclamation

U.S. Army Corps of Engineers

A.1. U.S. Army Corps of Engineers Storage Projects

General Description

The U.S. Army Corps of Engineers (Corps) operates three storage projects that function as part of the Columbia River System . These three projects are Libby Dam, Dworshak Dam, and Albeni Falls Dam.

Libby Dam is located on the Kootenai River at river mile (RM) 221.9 in Lincoln County in northwestern Montana. The project is about 15 miles northeast of Libby, Montana. Lake Koocanusa, Libby Dam's reservoir, is about 90 miles long and extends about 42 miles into Canada. The dam regulates stream flow for 17 downstream hydroelectric projects in the United States and Canada.

Dworshak Dam is located at RM 1.9 on the North Fork Clearwater River, near Ashaka in Clearwater County, Idaho. The Dworshak project has a watershed of approximately 2,440 square miles and provides flood risk management (FRM) for the Clearwater, Snake, and Columbia River basins. The reservoir formed by the dam (Dworshak Reservoir) extends 53.6 miles upstream.

Albeni Falls Dam is located at RM 90 on the Pend Oreille River in Bonner County, Idaho, 2.5 miles east of Newport, Washington, and 50 miles northeast of Spokane, Washington. Lake Pend Oreille is a natural lake, 68 miles long and one of the largest and deepest lakes in the western United States. Albeni Falls Dam impounds and regulates the top 11.5 feet of the lake, as well as approximately 25 miles of the Pend Oreille River between the lake and the dam.

Authorization and Project Purposes

Construction of the Libby Dam Project was authorized for hydroelectric power (hydropower) generation, FRM, navigation, and fish and wildlife conservation by the Flood Control Act of 1950 (Public Law 81-516, 81st Congress, 2nd Session) in accordance with a plan set forth in House Doc. 531, 81st Congress, 2nd Session. The dam was constructed in accordance with the Columbia River Treaty between the United States and Canada. Recreation was authorized in the Flood Control Act of 1944, Section 4 (Public Law 78-534).

Construction of Dworshak Dam was authorized for the purpose of FRM under Public Law 85-500, Public Law 87-874, and Public Law 78-534. Additional authorized project purposes include hydropower generation, recreation, navigation, and fish and wildlife conservation.

Construction of the Albeni Falls multipurpose dam and powerhouse was authorized by the Flood Control Act of 1950 (Public Law 81-516, 81st Congress, 2nd Session). Project authorized purposes include FRM, hydropower, navigation, and fish and wildlife conservation.

Description of Projects

In addition to fulfilling the above listed authorized purposes, Libby, Dworshak, and Albeni Falls Dams provide additional specific benefits. Libby Dam provides FRM storage for 17 downstream hydroelectric projects in the United States and Canada. Dworshak operates as a storage project to protect downstream areas from flood damage. The operation of Albeni Falls primarily benefits FRM of Lake

Pend Oreille, power generation, and regulation of streamflow for 15 downstream Federal and non-Federal hydroelectric projects. Summary information is presented for the three projects in Table A-1.

Table A-1. Corps storage projects summary information

Facility	Type of Facility	Year Completed	River	River Mile	Reservoir Name	Useable Reservoir Capacity (million acre feet)
Libby	Storage	1977[1/]	Kootenai	221.9	Lake Koocanusa	4.9
Dworshak	Storage	1973	North Fork Clearwater	1.9	Dworshak Reservoir	2.0
Albeni Falls	Storage	1955	Pend Oreille	90	Lake Pend Oreille	1.2

1/ FRM operations were initiated in 1972, power generation came online in 1975. Four generators were completed in 1977, with a fifth unit completed in 1984.

Libby Dam

Construction of Libby Dam began in 1966 and FRM operations began in 1972. Power generation came online in 1975, and initial powerhouse construction with four generators (with Francis-type turbines) was completed in 1977. A fifth unit was completed and brought online in 1984. The powerhouse was built to accept eight units, and the remaining three units are partially installed but were not finished when the planned reregulation dam immediately downstream was not recognized within the project's authorization.

Libby Dam is a concrete gravity dam with 47 monoliths, a total length of 2,887 feet, and a maximum height of 432 feet from bedrock to the roadway deck at the top of the dam. The elevation of the roadway deck is 2,472 feet elevation above mean sea level[43].

The powerhouse contains eight unit bays, with operable units in the five bays closest to the right bank. Each generator unit has a 120-megawatt (MW) capacity. The routine electrical generating capacity at Libby Dam is 600 MW under optimal head conditions.

The turbine units are operated as the primary outlets from the project and contribute to meeting the electrical needs of the region. Depending on river flows and limited project operating constraints, which include protections for resident fish, turbine operations can be varied to more closely match energy demand. Peak generation typically occurs coincident with the November–December draft of the reservoir and in May–June during the release of water for Kootenai River white sturgeon. Additionally, generation may increase during cold-snap periods in January and February if sufficient reservoir volume is available. Normally, all turbine units are made available for spring operations to pass high flows and winter periods when very cold weather may result in emergency generation requirements. When not operating to minimum flows, hydropower operations will operate to achieve a 75 percent chance of reaching the April 10 objective elevation to increase flows for spring flow management.

[43] All elevations in this document are relative to mean sea level unless stated otherwise.

Transmission limitations in the Flathead Valley can, under certain conditions, require Libby Dam to either reduce or increase generation. The Bonneville Power Administration (BPA) has implemented transmission system protection measures to minimize the occurrence of modifications to generation at Libby Dam. These limitations are required to maintain reliability of the power system to within required standards. The limits are also a function of the amount of energy that is consumed in the Flathead Valley. During periods when high outflows from Libby are required and the amount of energy consumed in the Flathead Valley is low, the current combined generation limit of 920 MW for Libby Dam and Hungry Horse Dam may be reduced until the condition is alleviated.

A multiple-bulkhead intake system permits selective withdrawal of water from the reservoir above elevation 2222 feet. The selective withdrawal system helps regulate water temperature of powerhouse releases. The system consists of a concrete housing for bulkheads and guides attached to the upstream side of the dam over the penstock intakes. Each guide accommodates up to 22 10-foot-high steel bulkheads, which allows withdrawal of water from the reservoir as high as elevation 2442 feet. Bulkheads are placed or removed manually using a crane hoist in response to temperature release requirements and reservoir forebay levels.

The dam includes a spillway with two bays and two spillway tainter gates; the spillway crest elevation is 2405 feet. A sluice outlet system includes three sluices individually regulated by separate tainter gates. The sluices have an intake invert (bottom elevation) at elevation 2201.5 feet and empty into the spillway stilling basin. The stilling basin is a conventional hydraulic-jump type that provides energy dissipation for both sluice and spillway flow. The stilling basin is defined by training walls leading from the spillway and has a width of 116 feet, a length of 275 feet, and a floor elevation of 2073 feet. Spill may be necessary in circumstances during which river flows exceed powerhouse hydraulic capacity, due to equipment malfunction or modeling and forecasting uncertainties, or for other purposes, such as ensuring power and transmission system stability, passing debris, or FRM in spring. Spill could involve use of the sluiceway.

Lake Koocanusa, Libby Dam's reservoir, is about 90 miles long and extends about 42 miles into Canada at full pool. Normal full pool and minimum reservoir elevations are 2459 feet and 2287 feet, respectively. The maximum water surface elevation of Lake Koocanusa permitted by the Columbia River Treaty is 2459 feet. Under extreme or emergency situations, Lake Koocanusa may be filled up to elevation 2461 feet. Lake Koocanusa has 4.9 million acre-feet of usable storage for local (i.e., primarily along the Kootenai River near Bonners Ferry, Idaho) and system FRM (i.e., primarily along the lower Columbia River near Portland, Oregon). At full pool, the reservoir area is 46,456 acres (about 62 percent of the reservoir acreage is in the United States).

The majority of public recreation facilities associated with the Libby Dam Project are administered by the U.S. Forest Service (USFS) under a Memorandum of Agreement. The Corps and USFS operate and maintain 11 campgrounds and 13 boat launches on the U.S. side of the lake. The Corps administers the recreation area on Lake Koocanusa by Libby Dam, as well as some small recreation areas downstream from the dam on the Kootenai River. The Canadian portion of Lake Koocanusa is administered by British Columbia Parks; the British Columbia Ministry of Forests, Lands and Natural Resource Operations; and private Canadian citizens.

The Libby Dam Project also includes the Murray Springs Fish Hatchery, built in 1978, which mitigates project-related fishery losses in the Kootenai River. Montana Fish, Wildlife and Parks (MFWP) operates and maintains the hatchery under Cooperative Agreement and funding by the Corps. MFWP stocks fish from the hatchery into the reservoir, closed-basin lakes, or elsewhere in the state.

Dworshak Dam and Reservoir

The Dworshak Project was placed into service in March 1973. It has a watershed of approximately 2,440 square miles and provides FRM for the Snake and Columbia River basins. The hydraulic height of the dam is 632 feet at full pool. The dam has a crest length of 3,287 feet, and a maximum base width of 574 feet. The spillway is located on the left side of the dam, extends down the front of the dam, and consists of a concrete chute with two tainter gates. Two low-level regulating outlets provide spill discharge at lower lake levels. The reservoir elevations range from 1600 feet at full pool to 1445 feet at minimum pool elevation.

Dworshak Dam is equipped with a water intake structure that has selector gates for selective withdrawal of water from various levels of the lake to provide temperature control of released water through the turbines. The powerhouse encloses two 90 MW generating units and one 220 MW generating unit. Vacant generator spaces and penstocks adjacent to the powerhouse are provided for the possible installation of three additional generating units.

Dworshak Reservoir extends 53.6 miles upstream to RM 55.5 when the reservoir is at full pool at elevation 1600 feet. The water surface area is 16,417 acres at full pool elevation of 1600 feet and 9,050 at minimum pool elevation of 1445. The reservoir has a shoreline length of 175 miles at full pool. When full, the reservoir contains 3.453 MAF (million acre-feet) of water. The difference between full and minimum operating pool levels provides 2 MAF of usable water storage for FRM and/or power generation. Authorized and operating purposes for Dworshak include FRM, hydropower, navigation, recreation, and fish and wildlife conservation.

There are no fish passage facilities at Dworshak Dam, and migrations of anadromous fish are blocked by the dam. The Dworshak National Fish Hatchery was constructed as mitigation for the dam and is located downstream of the dam on the left bank, at the confluence of the North Fork Clearwater River and the Clearwater River. The primary water supply for the hatchery is provided by pumps on the North Fork Clearwater River, and water temperatures for the hatchery are set by using the selector gates on the turbine intakes to control the temperature of water released from the dam. During time intervals when excess reservoir water is available at adjacent Clearwater Hatchery, that water is used to rear steelhead in order to minimize exposure to the infectious hematopoietic necrosis virus.

There are 29,318 acres of fee-owned project lands surrounding Dworshak Reservoir. The majority of the Corps-managed lands are used for public recreation, wildlife habitat, wildlife mitigation, and project structures. There are 14 developed recreation areas and 121 boat access mini-camps around Dworshak Reservoir. Two camping areas are licensed to the Idaho Department of Parks and Recreation and are operated as Dworshak State Park. A total of 5,033 acres are managed for mitigation for elk wintering habitat and an additional 4,541 acres are managed specifically for wildlife. Other project acreages are managed under environmental stewardship principles for wildlife habitat and other environmental concerns.

Albeni Falls Dam

Albeni Falls Dam is constructed on the granite rock outcropping that formed the original Albeni Falls. The dam and spillway are embedded and tied into the granite rock, and the surface rock was cut and shaped to increase conveyance and provide an improved natural tailrace for the spillway and powerhouse discharge.

Albeni Falls Dam was placed in operation in 1955. Authorized purposes include FRM, hydropower, navigation, recreation, and fish and wildlife conservation. Albeni Falls Dam is a concrete gravity, gate-controlled structure with a submerged spillway 472 feet long, and a net opening of 400 feet. The overall length, including the non-overflow abutment section, is 755 feet. The height is 90 feet, with a crest elevation of 2033 feet. The elevation at the top of the gates is 2065 feet, while the elevation at the top of the operating deck is 2097 feet. The spillway has 10 roller-chain, two-leaf, vertical-lift gates, each 40 feet wide and 32 feet high.

The powerhouse is 206 feet wide and 301 feet long, with three Kaplan turbines, each with a rated capacity of 19,600 horsepower at 22-foot head. Total powerplant rated nameplate capacity is 42.6 MW, with an annual production of approximately 200,000 megawatt-hours. In case of a commercial power outage, a 350 kilowatt diesel-electric generator provides emergency power for operating the spillway crane, operation of pumps to prevent flooding in the powerhouse, and other critical loads.

Albeni Falls Dam powerhouse hydraulic capacity ranges from 900 cfs with one unit at speed-no-load, up to the maximum powerhouse capacity of 35,000 cfs. Except during freeflow conditions, the powerhouse discharge is the primary outlet used to maintain the lake elevations, discharge, and rate-of-change requirements. During periods when outflow is between 50,000 and 70,000 cfs, depending on the lake elevation, the river stage downstream of the dam reduces powerplant hydraulic head below 8 feet, the minimum head for power generation. The powerhouse generation is then curtailed and the spillway is operated in a freeflow condition until streamflows subside enough to provide sufficient head at the powerhouse.

Powerhouse generation is normally scheduled by the Albeni Falls Dam powerhouse operator based on actual or coordinated outflow conditions. The powerhouse status is reported hourly to BPA. Peak generation at the project occurs during the FRM draft October through November and before and after the freeflow operations.

In case of emergency or powerplant outage, Albeni Falls Dam discharge may be reduced below 4,000 cfs. If conditions indicate the discharge will remain below 4,000 cfs beyond 1 hour, Albeni Falls Dam must immediately notify the Corps' Northwestern Division Reservoir Control Center, BPA, Seattle City Light, Box Canyon Dam, and the Pend Oreille Public Utility District, and increase discharge above 4,000 cfs as quickly as possible, using spillway releases if necessary.

The spillway structure contains 10 bays and 10 roller train, vertical lift, span-type gates. Each gate has an upper and lower leaf that are latched together for normal operation. The spillway crest elevation is 2033 feet. The spillway is operated to pass flow above the available turbine capacity. Additionally, during high flows, the downstream river stage increases, reducing the net hydraulic head at the project such that there is insufficient head to operate the powerhouse. At this point, the outflow from the project transitions to a freeflow condition in which the spillway gates are raised above the water surface, allowing the river to freeflow through the project. This condition can occur at flows at a range of 50,000 cfs to 70,000 cfs, depending on the lake elevation. Outflow from the lake during freeflow conditions is controlled by the hydraulic conveyance capacity of the Pend Oreille River between the Lake and the Albeni Falls Dam. There are no sluiceways.

The Corps has real estate interests in approximately 18,627 acres surrounding Lake Pend Oreille, of which approximately 14,390 acres are in the form of flowage easements and withdrawn lands from other Federal agencies. The remaining 4,237 acres are held in fee for authorized purposes, including recreation, project operations, and wildlife conservation (approximately 4,000 acres are in conservation easements).

A.2. U.S. Bureau of Reclamation Storage Projects

General Description

The Bureau of Reclamation (Reclamation) operates two projects that function as part of the Columbia River System. These two projects are the Columbia Basin Project and the Hungry Horse Project.

The Columbia Basin Project is a multipurpose development on the Upper Columbia River in central Washington. The major facilities of the project are Grand Coulee Dam and its impoundment (Lake Roosevelt), the Grand Coulee Powerplant complex that includes the John W. Keys III pump/generating plant, Banks Lake, and Potholes Reservoir. In addition, the project includes a well-developed system of canals, dams, reservoirs, drains, wasteways, laterals, and other structures.

The Hungry Horse Project, on the South Fork of the Flathead River in northwestern Montana, is operated primarily for FRM and power generation as part of the Columbia River System. The dam is situated in a deep, narrow canyon, approximately 5 miles southeast of the South Fork's confluence with the mainstem Flathead River. The project includes a dam, reservoir, powerplant, and switchyard.

The projects play an important role in meeting the need for power in the Pacific Northwest and in providing storage for FRM.

Authorization

Congress authorized Reclamation to operate Grand Coulee Dam for the multiple purposes of FRM, navigation, generation of electricity, storage and delivery of water for irrigation, and other beneficial uses.

The authorized purposes of the Hungry Horse Project are irrigation, FRM, navigation, streamflow regulation, hydroelectric generation, and other beneficial uses including fish and wildlife conservation. The project's irrigation component has not yet been developed.

Table A- 2. Columbia Basin Project and Hungry Horse Project authorizations

Feature	Authorization
Construction of Grand Coulee Dam	Congress allocated funds under National Industrial Recovery Act of June 16, 1933
Columbia Basin Project	Public Law 74-409 on August 30, 1935

Feature	Authorization
	Reauthorized Public Law 78-8 to bring provisions under the Reclamation Project Act of 1939
Units 7, 8, and 9 of Right Power Plant	Approved by the Secretary on January 5, 1949
Third Power Plant	Public Law 89-448 on June 14, 1966, and Public Law 89-561 on September 7, 1966
Construction of Hungry Horse	Public Law 78-329 on June 5, 1944

The projects described here are authorized, funded, or carried out by Reclamation by virtue of Congressional or Secretarial authorizations, Congressional appropriations, and contracts with Reclamation. Reclamation received authorization for each of its projects from either Congress or the Secretary of the Interior, who has authority under the 1902 Reclamation Act to approve construction after a finding of feasibility. The Congressional and Secretarial authorizations state the purposes to be served by each project. Congress has directed in the Reclamation laws that Reclamation enter into contracts with project water users. These contracts set out, among other things, Reclamation's obligations to store and deliver project water to irrigation districts, municipalities, and other entities. Additionally, the 1902 Reclamation Act requires that Reclamation comply with state law with regard to control, appropriation, use, and distribution of waters. Water can be stored and delivered by a project only for authorized purposes for which Reclamation has asserted or obtained a state water right in accordance with Section 8 of the Reclamation Act of 1902 and applicable Federal law. Reclamation must honor senior or prior water rights in storing and diverting project water. Conversely, project water is protected by state watermasters from diversion by junior appropriators. The active cooperation of the state water rights administrators is essential in ensuring that any water Reclamation delivers for flow augmentation or any other purpose reaches the targeted points of delivery.

Authorized Purposes and Description of Projects

Grand Coulee Dam, the primary storage and diversion structure for the Columbia Basin Project, was constructed from 1933 to 1941 and modified from 1967 to 1974 and 1982 to 1988. Hydroelectric generating units were installed to supply electric power for the war effort. After the war, construction centered on the associated pumping plant and irrigation facilities.

The first irrigation water was delivered to about 5,400 acres in 1948 from the Pasco Pumping Plant on the Columbia River (now takes water from Potholes Canal). In 1950, the Burbank Pumping Plant began delivering water to about 1,200 acres on the Snake River south of Pasco. In 1952, the Grand Coulee Pumping Plant (now called John W. Keys III pump/generating plant, or JWKIII) began delivering irrigation water to about 66,000 acres. The original plans anticipated about 1.1 million irrigated acres. These lands produce potatoes, sweet corn, onions, seed and other specialty crops, grapes, fruit, dry beans, grain, alfalfa hay, and ensilage crops.

The Grand Coulee Dam Powerplant complex consists of three powerhouses and 27 generating units, with a total generating capacity of 7,079 MW, including the six pump-generators (at about 50 MW each). The average annual generation of the Grand Coulee powerplants is about 20 billion kilowatt-hours, which is a large share of the power requirements of the Northwest. The third powerplant alone can produce enough energy to meet the needs of Portland, Oregon, and Seattle, Washington.

Hungry Horse Dam and Powerplant were constructed between 1948 and 1953. The dam creates a large reservoir by withholding water in times of heavy runoff to minimize downstream flooding. This stored water is released for power generation and flow augmentation when the natural flow of the river is low. Downstream power benefits are of major importance since more than five times as much power can be produced from water releases downstream than is produced at Hungry Horse Powerplant.

The Hungry Horse Powerplant consists of four 107 MW generators with a total installed capacity of 428 MW. However, current transmission limitations restrict generation to 310 MW.

Summary information is presented for the two projects in Table A- 3.

Table A- 3. Reclamation storage projects summary information

Facility	Type of Facility	Year Completed	River	River Mile	Reservoir Name	Total Reservoir Capacity (million acre-feet)
Grand Coulee	Storage	1941[1/]	Columbia	596.6	Franklin D. Roosevelt Lake (Lake Roosevelt)	10.1[2/]
Hungry Horse	Storage	1953	South Fork of the Flathead River	5	Hungry Horse Reservoir	3.46

1/ Grand Coulee Dam was constructed from 1933 to 1941 and modified from 1967 to 1974 and 1982 to 1988.

2/ This total includes both Lake Roosevelt (9.4 million acre-feet) and Banks Lake (0.7 million acre-feet). Water is pumped from Lake Roosevelt to Banks Lake for irrigation delivery and then diverted from Banks Lake.

Columbia Basin Project

Grand Coulee Dam is the primary storage and diversion structure for the Columbia Basin Project. The dam, one of the largest concrete structures ever constructed, is 550 feet high and 5,673 feet long. The dam was constructed from 1933 to 1941 and was modified from 1967 to 1975 by constructing a 1,170-foot-long and 210-foot-high forebay dam along the right abutment as part of the construction for the Third Powerplant (TPP). The lake elevation is 1208 feet at minimum pool and 1290 feet at full pool. Lake Roosevelt has a total storage capacity of 9.4 million acre-feet (5.2 million acre-feet of active space) and extends more than 151 miles upstream to the Canadian border. Reclamation operates Grand Coulee Dam in coordination with other projects in the Columbia River Basin to provide system FRM space in Lake Roosevelt to help manage flow of the Columbia River at The Dalles.

The Grand Coulee Powerplant complex consists of powerplants on the right and left sides of the spillway and the TPP on the right bank of the dam. The right and left powerplants have a total of 18 units of 125 MW capacity plus 3 units of 10-MW capacity, for a total capacity of 2,280 MW. The TPP contains three units of 690 MW capacity and three units of 805 MW capacity.

The John W. Keys III pump/generating plant (JWKIII) on the left bank was designed to accommodate 12 pumping units to pump water from Lake Roosevelt to Banks Lake for irrigation delivery. Six pumps, each with a capacity of 1,600 cfs, were installed by 1951, two pump/generators with a pumping capacity of 1,605 cfs each and a generating capacity of 50 MW were installed in 1973, and four pump/generators units with a pumping capacity of 1,700 cfs each and a generating capacity of 53.5 MW were installed between 1983 and 1994. The pumping/generating plant lifts water to the 1.6-mile-long feeder canal that leads to Banks Lake. If Lake Roosevelt is below elevation 1240 feet, Reclamation cannot use the pump/generators and therefore may not be able to meet the full pumping demand.

Banks Lake, located in an old ice-age channel called the Grand Coulee, is a re-regulating reservoir. This 27-mile-long reservoir is formed by the North Dam, which is located about 2 miles southwest of Grand Coulee Dam, and the Dry Falls Dam, which is located about 29 miles south of Grand Coulee Dam. Banks Lake has an active storage capacity of 715,000 acre-feet, feeds water to the Columbia Basin Project through the Main Canal at Dry Falls Dam and provides water to operate the pump/generators in generation mode at JWKIII.

The irrigation season extends from about mid-March to November 1. More detail on depletions from the Columbia River for the Columbia Basin Project can be found in Appendix C.

Hungry Horse Dam

Facilities at the Hungry Horse Project include the dam, reservoir, and powerplant. The 564-foot-high dam is a variable-thickness concrete arch structure with a 2,115-foot-long crest. There are three hollow jet valves with a combined capacity of 13,980 cfs at elevation 3,560 feet and a glory hole spillway[44] with a capacity of 50,000 cfs at elevation 3565 feet. The total storage capacity of the reservoir is 3.5 million acre-feet.

The Hungry Horse Powerplant originally included four 71.25 MW generators (a total of 285 MW installed capacity). The capacity of the generators was up-rated to 107 MW each in the 1990s, which increased the installed capacity from 285 MW to 428 MW. However, current transmission limitations restrict generation to around 310 MW. The hydraulic capacity of the powerplant is about 12,000 cfs if generating at full capacity, but with current transmission limitations the hydraulic capacity of the powerplant is limited to a maximum approaching 9,000 cfs.

Project Activities

Columbia Basin Project

Operation and Maintenance

Reclamation operates and maintains the Columbia Basin Project's major facilities. The Quincy-Columbia Basin Irrigation District, East Columbia Basin Irrigation District, and South Columbia Basin Irrigation District operate and maintain the irrigation distribution facilities within their geographic areas.

Operations for the Columbia Basin Project primarily include:

- Storage in and release of water from Lake Roosevelt, Banks Lake, Billy Clapp Lake, Potholes Reservoir, Scooteney Reservoir, and Soda Lake
- Diversion of water at the John W. Keys III Pump/Generating Plant and subsequent diversions into the Main, West, East Low, and Potholes Canals
- Power generation, transmission, and marketing (by BPA) at the Grand Coulee Left, Right, and Third Powerplants and the John W. Keys III Pump/Generation Plant

[44] Characterized by an intake that functions like a standpipe in the reservoir forebay.

- Routine maintenance of project facilities.

The section below on Grand Coulee Dam's multipurpose operations more fully describe the operations of Grand Coulee Dam and its associated facilities. Aside from operations of Grand Coulee Dam and flow augmentation from Banks Lake, Reclamation does not further coordinate the operation of the Columbia Basin Project with the Columbia River System.

Grand Coulee Dam Multi-purpose Operations

Congress has authorized Reclamation to operate Grand Coulee Dam for the multiple purposes of FRM, navigation, generation of electricity, storage and delivery of water for irrigation, and other beneficial uses, including fish and wildlife conservation. Reclamation also operates the dam in coordination with the Mid-Columbia Public Utility District projects and other Columbia River System facilities. Not only does Grand Coulee Dam's operation reflect multiple factors, such as water supply conditions, hydroelectric power generation requirements, and flow needs for fish, but the specific operating purposes also change from month to month and season to season. Reclamation seeks to balance the needs of the multiple purposes. This section discusses the general operating scheme for the project, by month and season.

Fall Operations: September – December

During the fall season, Reclamation's operating priorities are minimum flows for anadromous fish and power generation. Reclamation will attempt to refill Lake Roosevelt to a minimum elevation of 1283 feet by the end of September to support resident fish in the reservoir.

By the beginning of October, Reclamation will have attempted to refill Lake Roosevelt to elevation 1283 feet or higher. Reclamation then operates Grand Coulee Dam for two purposes: to provide augmentation flows for fish, if necessary, and to meet hydropower operational targets for these months. Reclamation limits any drafts for power to elevation 1283 feet in October, elevation 1275 feet in November, and elevation 1270 feet in December. The release of these flows provides spawning and incubation flows for lower Columbia River chum salmon and also spawning and protection flows for Hanford Reach fall Chinook salmon.

Banks Lake is drafted to elevation 1565 feet for flow augmentation by the end of August, which is 5 feet from full pool. Banks Lake is typically refilled between Labor Day and Thanksgiving by pumping from Lake Roosevelt.

Winter Operations: January – March

During the winter season, Reclamation's operating priorities are FRM, minimum flows for fish and power operations. Reclamation generally drafts Lake Roosevelt below the required FRM elevations to generate power. The draft of Lake Roosevelt can help provide protection flows for Hanford Reach fall Chinook salmon redds, and for chum redds below Bonneville Dam. The Corps has established the Lake Roosevelt Storage Reservation Diagrams (SRDs), which include space requirements at Lake Roosevelt that are determined from the runoff forecast for The Dalles minus the space available upstream of The Dalles other than at Lake Roosevelt.

During these 3 months, Reclamation releases water while maintaining the reservoir elevation at or above the higher of two figures: the winter draft limits (elevation 1260 feet at the end of January, elevation 1250 feet at the end of February, and elevation 1240 feet at the end of March) or the Variable

Draft Limit (VDL)[45] for winter power flexibility. The VDL is set based on an assumed inflow volume that has an 85 percent probability of occurrence while still providing the required flows at Vernita Bar for salmon. The VDL is calculated each month after the official water supply forecasts and FRM elevations are issued. This winter power flexibility is an important tool that is used to meet the winter power demands in the Northwest without affecting minimum fish flows or Reclamation's ability to be at the 2014 NOAA BiOp elevation objective for April 10.[46]

Spring Operations: April – June

During the spring season, most of Grand Coulee Dam's authorized purposes come into play as Reclamation operates the facilities for FRM, spring flow augmentation for fish, irrigation storage and delivery and power generation. During early and mid-spring, Reclamation operates Grand Coulee Dam primarily for FRM, flow augmentation for juvenile salmon and steelhead migration, and power generation. Irrigation withdrawals for the Columbia Basin Project typically begin in late March, but pumping from Lake Roosevelt to Banks Lake is relatively light until April. On April 30, Lake Roosevelt is typically at its lowest elevation to maintain adequate space to capture high flows to reduce downstream flooding. The reservoir's minimum pool is at elevation 1208 feet.

If Lake Roosevelt is drafted below elevation 1240 feet, numerous inundated cultural resource sites become exposed and susceptible to damage from wave action, vandalism, and looting. At this elevation, the Keller Ferry dock site must be moved, which adds 12 to 15 minutes travel each way.

The Inchelium Ferry, an important transportation connection for medical services and local schools, is inoperable below 1229 feet. FRM caused the ferry to be inoperable 39 days in 1997, 33 days in 1999, and 34 days in 2011, 7 days in 2012 and 3 days in 2014; power emergencies caused the ferry to go out in 1 year (60 days in 2001).

As spring flow increases, Reclamation captures some of this flow to help refill the reservoir and releases flow to provide flow augmentation to help juvenile salmon and steelhead travel downstream. From April 30 through the end of May, Reclamation may continue to draft Lake Roosevelt below the April 30 FRM elevation to support Priest Rapids and McNary flow objectives that have been coordinated with the TMT (Technical Management Team, a regional coordination group comprised of federal agencies and non-federal sovereigns).

[45] A VDL is a computed end-of-month elevation limit for drafting Grand Coulee Dam for the periods January, February, and March. The VDLs are used to provide winter power flexibility while maintaining an 85 percent probability of achieving refill of the project to its 2014 NOAA BiOp elevation objective for April 10 (see April 10 URC definition). The VDLs have lower limits and are set at elevations 1260 feet for January, 1250 feet for February, and 1240 feet for March. The basic computation assumes an inflow that has an 85 percent probability of occurrence from which the volume needed to meet minimum flows at Vernita Bar is subtracted. The remainder is the volume available for winter power flexibility.

[46] The FRM elevation is based on water supply forecasts. It is a common misconception that maintaining reservoirs at their FRM elevations from January through March would provide 100 percent probability of achieving refill to the April 10 Upper Rule Curve (URC). Modeling has shown that there is very little difference in the likelihood of achieving refill to the April 10 URC between an operation that drafts the project only to the URC or to meet the minimum flow requirements downstream and an operation that allows a measured draft for winter power flexibility.

Reclamation pumps water from the Lake Roosevelt forebay to Banks Lake through six pumps and six pump/generators to supply the project's irrigation water. Lake Roosevelt must be at elevation 1240 feet by the end of May for the pumping plant to deliver full irrigation demand to Banks Lake. When Lake Roosevelt is below elevation 1240 feet, all six of the pump/generators are unavailable to deliver water to Banks Lake. In years when the water surface elevation is not high enough to allow sufficient irrigation water delivery from Lake Roosevelt, Reclamation must draft Banks Lake water to meet irrigation demands and then replace this water when Lake Roosevelt is above elevation 1240 feet.

By June 1, Reclamation attempts to have Lake Roosevelt at or above elevation 1265 feet to benefit the net pen program for rainbow trout, if FRM operations and conditions allow, which must be released by this date to minimize susceptibility to diseases associated with warmer water. During the month of June, Reclamation shapes releases to support the Priest Rapids and McNary flow objectives for salmon and steelhead. The reservoir is typically refilled after the Fourth of July holiday. In order to demonstrate that water was released from Lake Roosevelt during the spring under the LRISRP, Reclamation will target a refill elevation following a recommendation from the Fish Flow Release Advisory Group (FFRAG).[47]

When Lake Roosevelt is above elevation 1265.5 feet, when necessary, Grand Coulee will spill water evenly across the 11 spillway gates, which produces significantly lower TDG than spilling water through the outlet tubes. Spilling over the drum gates can even reduce TDG for lower levels of spill.

Summer Operations: July – August

During the summer season, Reclamation's operating priorities are irrigation, flow augmentation for fish, and power generation. In July and August, Reclamation continues to supply irrigation water to Banks Lake for the Columbia Basin Project. In August, Reclamation will reduce pumping to Banks Lake and allow the reservoir to draft 5 feet to elevation 1265 feet; this operation, in combination with the end-of-August draft of Lake Roosevelt, is to document the summer flow augmentation for fish.

Reclamation will draft Lake Roosevelt to as low as elevation 1278 feet to support McNary Dam salmon flow objectives. If the July final forecasted (as defined in the Water Management Plan) runoff volume for the April-through-August period at The Dalles is less than 92 million acre-feet, the draft limit is elevation 1278 feet; otherwise, the draft limit is elevation 1280 feet. To implement the LRISRP, the August 31 draft limit will be adjusted an additional amount, up to 1 foot in non-drought years and 1.8 feet in drought years (as defined by Washington Administrative Code 173-563-056). The drought years occur when the March 1 forecast for April-through-September runoff at The Dalles Dam is less than 60 MAF.

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[47] LRISRP identified up to 1.8 feet of Lake Roosevelt's elevation to supply water for municipal and industrial use, streamflow enhancement, and as an alternative source to irrigators and others pumping from the Odessa aquifer and interruptables along the Columbia River. FFRAG has worked to develop a framework for shaping LRISRP instream flow augmentation for the benefit of anadromous species from April through August. Members of the FFRAG include the Confederated Tribes of the Colville Reservation, the Yakama Nation, the Upper Columbia River United Tribes, Bureau of Reclamation, Washington Department of Ecology, Washington Department of Fish and Wildlife, Columbia River Inter-Tribal Fish Commission, NOAA Fisheries, and Bonneville Power Administration.

Daily Operations

The above sections describe how Reclamation operates Grand Coulee Dam across months and seasons to meet a variety of authorized purposes. Reclamation's daily operations also show how Reclamation meets the multiple purposes of power generation, safety, and resource protection while shaping flows to benefit anadromous fish.

Reclamation's hourly coordination on regional power generation can cause releases from Grand Coulee to vary widely during the day. The Mid-Columbia projects, Chief Joseph Dam, and Grand Coulee Dam are operated as one system to provide the reliability required to meet the regional power demand. Reclamation also operates Grand Coulee Dam to meet peaking operations, so it runs high during heavy load hours and reduces flow during light load hours.

Reclamation limits the daily draft of Lake Roosevelt to 1.5 feet, measured on a rolling 24-hour period to preserve reservoir bank stability. During periods of high demand, BPA may request a draft rate exceedance in order to meet the increased power requirements. If approved by Reclamation, draft rates may be as high as 2 feet per day, but only after BPA has clearly demonstrated that all other reasonable actions have been taken to meet the increased power demand.

Grand Coulee Dam also has limits to the minimum tailbay elevation and hourly tailbay drawdown rates that help maintain the river banks' stability.

Although there are no flow restrictions at Grand Coulee Dam to reduce gas levels, there are priorities for how the water is released when spill is necessary. The purpose of the actions below is to reduce TDG that could harm resident fish below Grand Coulee and anadromous fish Salmon downstream of Chief Joseph Dam:

1. If the water elevation is above 1265.5 feet, Reclamation releases the water evenly across the 11 spillway drumgates.
2. If the water surface elevation is below elevation 1265.5 feet, Grand Coulee is moved to the bottom of the regional spill priority list.
3. If water is to be released through the outlets, then it is released evenly through the upper and lower gates. If only two gates are required, then an upper gate and the mid-level gate immediately below will be used (and not two side-by-side gates).

Lake Roosevelt Incremental Storage Release Program

When fully implemented, the Lake Roosevelt Incremental Storage Release Program (LRISRP) will result in an additional foot of water to be released from Lake Roosevelt (beyond the 1278 and 1280 foot elevations set for the end of August to augment flow) in most years and 1.8 feet additional when the March final April-through-August water supply forecast falls below 60 MAF (which is the driest 4 percent of water years). The LRISRP drawdown would result in a net increase to instream flows from Grand Coulee Dam during the April-through-August flow augmentation period. This is a very small increase in stream flow; however, the purpose of the drawdown is to ensure that there is no flow reduction during the juvenile salmon migration period. The timing of releases is based on the water supply forecast. Water will be delivered to the Odessa Subarea through Banks Lake, and for municipal and industrial (M&I) uses and instream flows downstream of Grand Coulee Dam. The additional foot of water released from Lake Roosevelt will be refilled in September. For more detail on the release of this water, see the Action Agencies' Water Management Plan.

Odessa Special Study

On April 2, 2013, Reclamation issued a Record of Decision for the Odessa Subarea Special Study (not to be confused with the water delivered to the Odessa Subarea under the LRISRP) Final Environmental Impact Statement. The preferred alternative would provide surface water supplies to about 70,000 acres of land presently irrigated with water pumped from the Odessa aquifer. At full development, this will be approximately 164,000 acre-feet. Development of the Odessa Subarea will occur in phases over approximately 10 years. This water would be delivered to the project primarily by drawing down Banks Lake during the juvenile migration season, then refilling Banks Lake from the Columbia River from October through March.

This operation was covered under separate ESA consultation.

Routine Maintenance

The range of routine or scheduled maintenance activities are discussed in Chapter 2, including drum gate maintenance and scheduled power plant maintenance. The following maintenance descriptions provide further detail for selected activities.

John W. Keys III Pump-Generating Plant

The pumping plant consists of six pumps that pump water from Lake Roosevelt to Banks Lake and six pump generators that can pump water from Lake Roosevelt to Banks Lake or generate power by pumping water from Banks Lake back to Lake Roosevelt. Maintenance falls under two categories, scheduled and unscheduled. The majority of the scheduled maintenance of the pumps and pump generators generally occurs outside of the irrigation season, to the extent practicable. At all times of the year, there are usually one or more pumps and/or pump generators offline. However, during the irrigation season, when pumping demand is much higher, it is desirable to have the majority of the pumps and pump generators online and available. Pump outages during the fill or irrigation season may affect Columbia River flows during juvenile fish migration, if pump capacity is less than irrigation demand.

Maintenance of Facilities on and around Banks Lake

Banks Lake Equalizing Reservoir is located in the upper Grand Coulee and was built to store and supply irrigation water for the Columbia Basin Project. Banks Lake is formed by the construction of two dams: North Dam, which is near Grand Coulee Dam, and Dry Falls Dam, which is at the south end of the reservoir. Water is pumped from Lake Roosevelt through a set of pumps and pump/generators up to the Feeder Canal, which then discharges into Banks Lake. Water is released for irrigation to the Columbia Basin Project from Banks Lake through a set of gates at the headworks of the Main Canal at Dry Falls Dam.

Historically, Banks Lake has been operated with water surface fluctuation of as much as 27 feet on an annual basis. Routine maintenance was generally coordinated within this annual cycle. Reclamation voluntarily changed this operation during the 1980s, when facilities such as the Second Bacon Siphon and Tunnel and the third powerplant were completed. This increased the opportunity for recreation but reduced the opportunity to perform routine maintenance on project-reserved works. Since the

1980s, Reclamation has had to draft Banks Lake up to 35 feet in order to perform routine maintenance. The last major drawdown of Banks Lake for maintenance occurred in 2011 through 2012. During this latest drawdown period, foundations were constructed to allow for bulkheads to be used to isolate the canal headworks. The use of bulkheads should diminish the need for drawdowns to perform maintenance on the canal headworks. However, other maintenance issues or requirements may still require that Banks Lake be drafted substantially below the normal operating range on occasion.

During these significant drawdowns, Reclamation will coordinate with other agencies, facilities, etc., with interest around Banks Lake so that all can take advantage of the drawdown to perform any necessary maintenance activities. The full hydrologic effects of the maintenance operations would span two different water years, with drawdown starting in August of the first water year, by shutting off the pumps from Lake Roosevelt and allowing irrigation withdrawals to draft the lake. This would result in a slight increase in flows at McNary during drawdown, as water typically pumped to Banks Lake would be released from Lake Roosevelt during August. Banks Lake would be down by the end of irrigation season, approximately the end of October. Maintenance would be performed during the winter and would be completed by March 1. Refill would be coordinated with BPA to take advantage of high flows and low power demand to refill Banks Lake by April 15. In most years, there would be no effect to the Columbia River flow objectives during refill of Banks Lake. Adaptive management coordinated through the TMT would be necessary in dry years to balance the requirements to meet chum flows, minimum flows through the Hanford Reach, and avoid impacting the spring flows during the refill period. In 24 percent of years, based on a HYDSIM computer model scenario in which Grand Coulee is drafted to meet minimum flows through the Hanford Reach, there would be a decrease in spring flows of up to 4,800 cfs during the refill of Lake Roosevelt.

At this time, there are no procedures developed that would forecast water supply prior to the first of January. As drawdown would need to be done from August through October, it would need to be scheduled without prior knowledge of what the water supply forecast might be during refill. Every effort will be made to complete maintenance in a timely manner to allow time to refill with minimal effects on spring flows.

Extraordinary Maintenance

Over the next 20+ years, Grand Coulee will be upgrading many of its major facilities, including all four power plants and its drumgates. Each maintenance activity has separate National Environmental Policy Act (NEPA) and ESA coverage. This section addresses each action individually and jointly. For more detail on a given action, see the NEPA document for that action.

Routine maintenance must continue through the overhaul. During the Extraordinary Maintenance period, two units in the Third Power Plant and two each in the Left and Right Power Plants will be out of service. In addition to these outages, there may be an additional forced outage of one unit in each of the Third, Left, and Right Power Plants. More details about the Third, Left, and Right Power Plant extraordinary maintenance activities are described below. These outages have the potential to affect spill and water quality (total dissolved gas, or TDG) when required releases exceed the power plant hydraulic capacity, resulting in spill (bypass the turbines) through outlet tubes or over the spillway, depending on pool elevation.

Third Power Plant Overhaul

The Third Power Plant (TPP) units 19-24 have reached their design life and are scheduled to be overhauled over an 18-year period between 2009 and 2027. The objective of the overhauls is to repair and restore these machines to ensure reliable operations for an additional 30 years. In 2010, Reclamation completed an Environmental Assessment for this extraordinary maintenance (Reclamation 2010).

This activity by itself is not likely to affect streamflow, but cumulative effects of all extraordinary maintenance could impact flows under some conditions. If flows are high and fewer units are in service, it will likely result in more spill, which can elevate TDG levels, particularly if the project is spilling through the outlet tubes. There is no designated critical habitat in Rufus Woods Lake, so the only likely impact of increased spill at Grand Coulee to ESA-listed fish is the potential for higher TDG levels below Chief Joseph Dam. This is mitigated in part by flow deflectors that were installed at Chief Joseph Dam. As described in the 2008 NOAA BiOp, the flow deflectors were installed as the most cost-effective alternative for gas abatement at these two dams. These flow deflectors have been shown to reduce gas levels from water spilled at Chief Joseph Dam when TDG levels from Grand Coulee are high. The Review of 2008 BiOp Modeling, a review of HYDSIM computer modeling, describes changes in generating characteristics that have occurred within the Federal Columbia River Power System, including maintenance of the Third Power Plant. This review confirms that the changes in generating characteristics are within the range of variability analyzed for the BiOp.

Left and Right Powerplants Overhaul

The Left and Right Powerplants units 1-18 have reached their design life and are scheduled to be overhauled over a ten-year period starting 2019 or later. The objective of the overhauls is to repair and restore these machines to ensure reliable operations for an additional 30 years. In 2018, Reclamation completed an Environmental Assessment for this extraordinary maintenance (Reclamation 2018).

John W. Keys III Pump-Generating Plant Modernization

The 12 units that comprise the JWKIII show problems stemming from wear and design that require more frequent maintenance, more challenging repairs, and longer down times. As a result, these and other components contribute to growing safety-related concerns at the plant, increase the plant operational costs, create limitations on day-to-day plant operations, and impose risks to sustained long-term operation of the plant. These issues threaten Reclamation’s contractual obligations to provide on-demand delivery of irrigation water and accommodate pumped storage at Banks Lake for balancing reserves and electrical load shaping. Modernization improvements and upgrades will not change the essential operation of Banks Lake, according to existing protocols for irrigation, load shaping, and balancing reserves; however, they may enable more rapid transitions and/or more frequent incremental changes in daily reservoir levels while the overall reservoir levels remain within established operating norms.

Modeling to support the modernization of the JWKIII (Reclamation 2012) demonstrates that pump/generating scheduled to take advantage of off-peak hour pricing to increase inflows, and then generate with the pumps/generators when power demands are high, results in more fluctuation of lake elevation but still maintains the elevation within the normal operating range. Model results show that the proposed modernization of the JWKIII would not significantly change Banks Lake elevations. Banks

Lake elevations would remain within the operating range of elevation 1565 feet to elevation 1570 feet throughout the year. Irrigation deliveries to the Columbia Basin Project would be unaffected. The summer draft to elevation 1565 feet for flow augmentation would be unaffected.

Hungry Horse Project

Operation and Maintenance

Reclamation operates and maintains all of the project's major facilities. Operations for the Hungry Horse Project primarily include:

- Storage and release of water from Hungry Horse Reservoir
- Power generation at the Hungry Horse Powerplant
- Routine maintenance of project facilities.

The following discussion more fully describes the operations of Hungry Horse Dam and its associated facilities. Reclamation also incorporates by reference the standing operating procedures for Hungry Horse Dam, which more fully describe the physical facilities, operational criteria, and operating thresholds.

Hungry Horse Dam Multi-Purpose Operations

Congress has authorized Reclamation to operate Hungry Horse Dam for the multiple purposes of irrigation, FRM, navigation, streamflow regulation, hydroelectric generation, and other beneficial uses. Reclamation also operates the dam in coordination with other Columbia River System facilities. Not only does Hungry Horse Dam's operating range reflect variability in multiple affecting factors, such as water supply condition, hydroelectric power generation requirements, and flow needs for downstream anadromous and resident fish, but the specific operating purposes also change from month to month and season to season.

Fall Operations: September – December

During the fall season, Reclamation has two operating priorities: minimum flows at Columbia Falls for fish and FRM. The Action Agencies will implement the Northwest Power and Conservation Council's (NPCC) 2003 mainstem amendment, as it pertains to the end-of-September draft. Under the mainstem amendments, the summer reservoir draft limit at Hungry Horse is 3550 feet (10 feet from full) by September 30, except in the lowest 20th percent of years (less than 72.2 MAF), when the draft limit is elevation 3540 feet (20 feet from full) by September 30.

Since implementation of the 2000 U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NOAA Fisheries) BiOps, ramping rates, minimum flows, and the need to meet refill dates have limited the power operations at Hungry Horse Dam. In many years, Hungry Horse Reservoir continues to draft throughout the fall to meet minimum flows at Columbia Falls and can be an additional 15 to 20 feet down by the end of December. Ramping rates for Hungry Horse are described in detail in Chapter 2.

To provide local flood protection in wetter falls, the Corps has established FRM criteria for Hungry Horse Reservoir. The reservoir is required not to exceed elevation 3555.7 feet from October 31 through November 30 and elevation 3549.2 feet by December 31. Also, in wetter years, Hungry Horse can be operated to help meet hydropower operational targets; however, Reclamation limits any drafts for power to the FRM elevation of 3549.2 feet by the end of December to maintain a 75 percent probability of being at the 2014 NOAA BiOp elevation objective for April 10.

Winter Operations: January – March

During the winter season, Reclamation's operating priorities are FRM, minimum flows for resident listed fish, and power generation. Reclamation generally drafts Hungry Horse Reservoir below the required FRM elevations to meet minimum flow requirements at Columbia Falls for resident listed fish. In water years when minimum flows do not require Reclamation to draft the reservoir below the required FRM elevations, there is some flexibility to operate for power generation. The limits to this winter power flexibility are set to provide a 75 percent probability of refilling to the April 10 elevation objective for salmon. Hungry Horse operates to VARQ (variable flow) FRM rule curves.

During January through March, Reclamation releases water while maintaining the reservoir elevation at or between the variable draft limit (VDL)[48] and the Upper Rule Curve (URC). The VDL is set based an assumed inflow volume that has a 75 percent probability of occurrence while still providing the required flows at Columbia Falls. The VDL is calculated each month after the official water supply forecasts and FRM elevations are issued. This winter power flexibility is an important tool that is used to meet the winter power demands in the Northwest without affecting minimum fish flows or Reclamation's ability to be at the April 10 elevation objective for salmon.

Spring Operations: April – June

During early and mid-spring, Reclamation typically operates Hungry Horse Dam for FRM, minimum flow requirements, and power generation. On April 30, Hungry Horse Reservoir is typically at its lowest seasonal elevation in order to capture the high flows from spring runoff and to reduce downstream flooding.

Hungry Horse FRM rule curves are designed for both local and system FRM. For the system flood protection, Reclamation coordinates with the Corps on when Hungry Horse Reservoir can begin refill in the spring. The Corps computes the initial controlled flow (ICF) at The Dalles and estimates the day that level of flow is expected to be reached. When unregulated flows at The Dalles are equal to the ICF, the

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[48] The variable draft limit is a computed end-of-month elevation limit for drafting Hungry Horse Dam for the periods January, February, and March. The VDLs are used to provide winter power flexibility while maintaining a 75 percent probability of achieving refill of the project to its April 10 elevation objective (see April 10 URC definition).

The only variable in the computation of the VDLs is the FRM elevations. The basic computation assumes an inflow that has a 75 percent probability of occurring. The volumes needed to meet minimum flows at the project and at Columbia Falls are subtracted from the assumed inflow. The remainder is the volume available for winter power flexibility. The minimum flow required at Columbia Falls is computed based on flows in the Middle and North Forks of the Flathead River that have a 75 percent probability of occurring.

The FRM elevations are computed based on water supply forecasts; however, minimum flow requirements often draft the reservoir below the computed FRM elevation. It is a common misconception that maintaining reservoirs at their FRM elevations in January through March would provide 100 percent probability of achieving refill to the April 10 elevation objective. Modeling has shown that there is very little difference in the likelihood of achieving refill to April 10 elevation objective between an operation that limits drafts to URC or minimum flow and an operation that allows a measured draft for winter power flexibility.

reservoirs can start refill. Hungry Horse Reservoir can actually start refill 10 days prior to the date the ICF is expected to be met.

As spring flows increase, Reclamation no longer needs to make releases to meet minimum flows at Columbia Falls but does have a minimum flow requirement below the project on the South Fork Flathead River. As flows in the mainstem Flathead River increase, Reclamation must balance refill of Hungry Horse while attempting to control flows at Columbia Falls at or below the flood stage of 14 feet (52,000 cfs) when the elevation of Flathead Lake is below the top foot (lower than 2892 feet) and at or below a stage of 13 feet (45,000 cfs) when the elevation of Flathead Lake is within 1 foot of full (between elevation 2892 and 2893 feet). At the same time, Reclamation attempts to limit spill (flows that bypass the power plant) from the project in order to maintain TDG below the State of Montana standard of 110 percent. With the current transmission limit in the valley, this sometimes requires delaying refill to the first week in July, when inflows drop below what can be put through the generators, due to unit availability or transmission limitations. Hungry Horse may also be operated to be below the April 30 FRM point so that it can reduce the outflows during refill to prevent spills that would result in TDG above the limit.

Reclamation typically tries to refill Hungry Horse Reservoir by June 30. However, as mentioned previously, the timing and shape of the spring runoff may result in reservoir refill a few days before or after the June 30 target date. For example, a late snowmelt runoff may delay refill to sometime after June 30 in order to avoid excessive spill and/or surcharge of the reservoir. Local weather conditions such as precipitation may also have an influence.

Summer Operations: July – August

During the summer season, Reclamation's operating priorities are flow augmentation for fish, and refill for resident fish. In accordance with the NPCC's 2003 mainstem amendments recommendation, Reclamation will draft Hungry Horse Reservoir to as low as elevation 3550 feet in the top 80 percent of water years and to elevation 3540 feet in the lowest 20 percent of water years by September 30 to support Priest Rapids and McNary flow augmentation targets. Hungry Horse releases are calculated to either operate at a constant release from July through September or to gradually decline outflows in an attempt to provide a beneficial flow regime for resident fisheries below the project. Occasionally, Reclamation will not fill completely (to elevation 3560 feet) in order to transition from FRM releases to flow augmentation releases; this prevents dropping outflows to a minimum (900 cfs) just to fill to elevation 3560 feet, then immediately increasing discharges to start the summer flow augmentation regime.

Plant Modernization

The hydroelectric generating units at Hungry Horse Dam are approaching the end of their design life. The proposed projects to modernize the units and associated equipment are tentatively scheduled to take place over a 13-year period between 2019 and 2032. Work currently scheduled between 2019 and 2026 is not expected to affect operations significantly, as the work will take advantage of existing hydropower generation outages, to the extent possible. Routine scheduled maintenance will continue along with the modernization projects, and will require up to two hydropower generating units out of service for a portion of one year. Whenever practicable, maintenance on the units not directly involved in the modernization will be scheduled outside of the typical high flow period (May-June) to help reduce probabilities of spill (USBR in review).

Kerr Drought Management Plan

In 1996, Kerr Dam (renamed Sèliš Ksanka Ql̓ispè[49] in 2015) went through a Federal Energy Regulatory Commission (FERC) relicensing process, authorized under the Federal Power Act. Under Section 4(e) of the Federal Power Act, FERC must consider environmental requirements within the Federal reservation. Through the licensing process, it was discovered that during low-water years, there is insufficient water to achieve FERC license Article 43 lake levels at Flathead Lake and maintain the flow requirements downstream under Article 56, which were developed by the Secretary of the Interior, acting under Section 4(e) of the Federal Power Act. Article 60 under the license required the development of a Drought Management Plan to address these concerns.

The Drought Management Plan established operational provisions to avoid and resolve potential water-use conflicts in years where there is insufficient water to meet the requirements of Articles 43 and 56 (when inflow to Flathead Lake is less than 72.6 percent of normal [about 1 in 18 years])

The Bureau of Indian Afairs prepared a Drought Management Plan Final EIS in 2009 (BIA 2009); under Article 61 of the license, Reclamation will coordinate releases required under the ESA. Reclamation will coordinate operations with the Corps and the Confederated Salish Kootenai Tribes in accordance with the Drought Management plan should water supply conditions result in not being able to meet the criteria listed in Articles 43 and 56.

A.3. U.S. Army Corps of Engineers Mid-Columbia River Run-of-River Project – Chief Joseph Dam

General Description

The Corps operates a run-of-river project on the middle Columbia River. Chief Joseph Dam is located at RM 545, approximately 1.5 miles upstream from Bridgeport, Washington, and 51 miles downstream from Grand Coulee Dam. The reservoir created by Chief Joseph Dam is called Rufus Woods Lake. It extends 51 miles upstream (to Grand Coulee Dam) and has a shoreline length of 106 miles.

Authorization

The River and Harbor Act of 1946 authorized the construction, repair, and preservation of certain public works on rivers and harbors for hydropower generation, navigation, irrigation, and other purposes. Chief Joseph Dam was initially authorized as Foster Creek Dam and Powerhouse under this Act dated July 24, 1946 (H. Doc 693; PL 79-525, 79th Congress, 2nd Session), and in accordance with the survey report dated April 9, 1946, submitted by the Chief of Engineers in House Document 693 (79th Congress, 2nd Session July 3, 1946). Recreation is authorized under the Flood Control Act of 1944 (PL 78-534).

[49] The Confederated Salish Kootenai Tribes took over operations of Kerr Dam in 2015. They renamed it Sèliš Ksanka Ql̓ispè (pronounced SHE-leesh k-SAHN-kah qw-leese-PEH), which means *Salish Kootenai Pend Oreille* in their language.

Fish and wildlife conservation is authorized under the Fish and Wildlife Conservation Act of 1946 (PL79 – 732).

On July 11, 1969, eleven additional generating units were recommended, along with a 10-foot pool raise to a maximum pool elevation of 956 feet. Authorization for this expansion was provided in House Document 693 (PL 94-587 and PL 95-26). Phase I construction of the dam and units 1 through 16 began in 1949 and was completed in 1958. Phase II construction for units 17 through 27 began in 1973 and was completed in 1979.

Authorizations for fish and wildlife conservation and water quality were granted under Public Laws 85-624 and 92-500, respectively.

Authorized Purposes and Description of Projects

Congressional authorization was provided to allow Chief Joseph Dam to operate for multiple purposes, including hydropower generation and navigation. Subsequent legislation has augmented the missions of the Corps, and Chief Joseph Dam currently also operates in the interest of recreation and fish and wildlife conservation.

The elevation of Rufus Woods Lake fluctuates very little throughout the year. The normal operating range is between elevation 950 feet and 956 feet. Although the project was authorized to fluctuate between elevation 930 feet and 958.8 feet, a number of constraints make actual operation over that full range unlikely, and elevation 950 feet is considered the year-round normal minimum forebay elevation for Chief Joseph project.

Chief Joseph Dam is a run-of-river project, and while FRM was not an initial objective, the dam and Rufus Woods Lake have been, and continue to be, regulated to help provide FRM, though on a limited scale. Summary information for Chief Joseph Dam is presented in Table A- 4.

Table A- 4. Chief Joseph Dam summary information

Dam	Type of Dam	Year Completed[1/]	River Mile	Reservoir Name	Usable Capacity (acre-feet)
Chief Joseph	Run-of-River	1979	545	Rufus Woods Lake	116,000

1/ Chief Joseph Dam was constructed in two phases. Phase I was completed in 1958; Phase II was completed in 1979.

The dam consists of a 19-bay gated concrete gravity spillway that abuts the right bank and connects to a curved non-overflow concrete section founded on a rock outcropping. The intake structure and powerhouse follow a downstream alignment and connect with the left abutment by means of a curved concrete gravity non-overflow dam. The 2,047-foot-long powerhouse encloses 27 main generators, two station service generators, maintenance shops and control room, and the visitor center. The area of Rufus Woods Lake at full pool is 8,400 acres, and its gross capacity at full pool is 593,000 acre-feet. The reservoir is 51 miles long and has a shoreline length of 106 miles.

Chief Joseph Dam was constructed primarily to provide hydroelectric power. Based on historical information, the minimum gross hydropower head is 162 feet. Assuming all 27 units are operating at their highest output, the maximum output is estimated to be 2,440 megawatts (MW). This estimate is based on recent index tests and historical model tests. Maximum powerhouse discharge is estimated to be approximately 215,000 cubic feet per second.

Total project real estate interest administered by the Corps is 16,123 acres, of which 12,006 acres are easement lands. The balance is primarily designated wildlife mitigation lands and public domain lands; 318.18 acres of Corps fee and easement lands are managed for recreation. The Confederated Tribes of the Colville Reservation exercise control over portions of the north shoreline in Okanogan County, which lies within Colville Indian Reservation boundaries. Reclamation has jurisdiction over lands upstream from RM 590.4. In addition, the U.S. Bureau of Land Management administers substantial areas of public land adjoining the lake in Douglas County on the south bank. Several state-managed parcels of land also exist in Douglas County.

A.4. U.S. Army Corps of Engineers Lower Snake River Projects

General Description

The Lower Snake River Project is the name for the Corps' series of four dams on the lower Snake River: Lower Granite, Little Goose, Lower Monumental, and Ice Harbor.

The Snake River projects include a navigation channel 250 feet wide by 14 feet deep, measured at minimum operating pool (MOP) in each reservoir, which extends from the confluence of the Snake and Columbia Rivers to a point at RM 1.3 on the Clearwater River at Lewiston, Idaho. This channel is the upper end of the Columbia-Snake River Inland Waterway, which includes the deep draft navigation channel on the lower Columbia River and is an important link for regional, national, and international commerce.

All four lower Snake River dams are run-of-river facilities, meaning that they are not authorized, designed, or operated for FRM. These facilities have limited storage capacity and pass water at nearly the same rate as the water enters each reservoir. Reservoir levels behind these dams vary only a few feet during normal operations. This limited storage is used for regulation of powerhouse discharges to follow hourly, daily, and weekly demand patterns, but is not enough to allow seasonal regulation of streamflows.

Authorization

The Lower Snake River Project was constructed and is operated and maintained under laws that may be grouped into three categories: 1) laws initially authorizing construction of the project; 2) laws specific to the project passed subsequent to construction; and 3) laws that generally apply to all Corps projects within the United States. Using these and other authorities, the Corps operates multiple-use water resource development projects to balance operation of individual functions with operations for all functions. This operation is coordinated with BPA, Reclamation, and other regional interests. Authorized uses for the Lower Snake River Project are hydropower generation, inland navigation, fish and wildlife conservation, irrigation, and recreation. These facilities operate as run-of-river dams and are not authorized for FRM. Project uses have been authorized under several public laws.

Authorized Purposes and Description of Projects

The four lower Snake River dams are multiple-use facilities that provide public benefits in a number of different ways. Project facilities include dams and reservoirs, hydroelectric powerplants and high-voltage transmission lines, navigation channels and locks, juvenile and adult fish passage structures, fish hatcheries, parks and recreational facilities, levee systems, lands dedicated to project operations, and areas set aside as wildlife habitat. While it is physically possible to draw run-of-river reservoirs well below their normal minimum pool levels, the four lower Snake River facilities are not designed to operate below minimum pool levels.

Summary information is presented for the four lower Snake River projects in Table A- 5. More detailed information is presented for each project in Table A- 6.

Table A- 5. Lower Snake River Project summary information

Facility	Type of Dam	Year Completed	Snake River Mile	Reservoir Name	Usable Capacity[1/] (acre-feet)
Ice Harbor	Run-of-River	1961	9.7	Lake Sacajawea	25,000
Lower Monumental	Run-of-River	1969	41.6	Lake Herbert G. West	20,000
Little Goose	Run-of-River	1970[2/]	70.3	Lake Bryan	49,000
Lower Granite	Run-of-River	1975[3/]	107.5	Lower Granite Lake	49,000

Source: Corps and NMFS 1994
1/Normal operating range
2/The Little Goose facility was open to navigation in May 1970. The installation of power generating units 1 through 3 was completed in March 1970. Additional power units 4 through 6 were installed, and power came online in July 1978.
3/Additional power units 4 through 6 were installed, and power came online in April 1978.

Table A- 6. Lower Snake River Project Facility operations and structures

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Reservoir				
Normal Pool Operating Range (feet above NGVD)[1/]	437 - 440	537 - 540	633 - 638	733 - 738
Total Length (miles)	31.9	28.7	37.2	43.9
Surface Area (acres)[2/]	9,002	4,960	10,825	8,448
General (Dam)				
Dam Length (feet)	2,822	3,791	2,655	3,200
Hydraulic Head (feet)	100	100	98	100
Powerhouse				
Powerhouse Length (feet)	671	656	656	656
Nameplate Capacity (MW)	600	810	810	810
Total Number of Units Installed	6	6	6	6
Spillway				
Spillway Length (feet)	590	498	512	512
Number of Spillway Bays	10	8	8	8
Stilling Basin Length (feet)	168	180	118	188
Navigation Lock and Channels				
Lock Chamber Length (feet)	675	666	668	675

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Lock Chamber Width (feet)	86	86	86	86
Maximum Operating Lock Lift (feet)	105	103	101	105
Navigation Channel (at MOP) extending from mouth of Snake River to Lewiston/Clarkston at Clearwater River Mile 1.3	250 feet wide by 14 feet deep	250 feet wide by 14 feet deep	250 feet wide by 14 feet deep	250 feet wide by 14 feet deep

1/ NGVD = National Geodetic Vertical Datum
2/ At normal operating pool elevation (highest level of range)

The Lower Snake River Project was originally designed and constructed with adult passage facilities at the four dams. These facilities include fish ladders, pumped attraction water supplies, and powerhouse fish collection systems, and have certain features in common. In general, there is a set of main fishway entrances near one end of the spillway, between the spillway and powerhouse, and at the other end of the powerhouse. Two entrances are typically used at each location, and additional smaller entrances (floating orifice gates) are provided across the face of the powerhouse.

Lower Granite Dam was the only dam on the Columbia and Snake rivers constructed to accommodate a screened juvenile bypass system. Improved facilities were added to Little Goose Dam in 1980. The Columbia River Fish Mitigation Program began in the late 1980s, leading to a system-wide project for evaluation of mitigation needs and implementation of improvements at the Corps' four lower Snake River and four lower Columbia River dams beginning in 1991. Under this program, new juvenile fish bypass/collection facilities were constructed at Ice Harbor (1996), Lower Monumental (1993), and Little Goose (1990) dams. Additional improvements have been made as new technology developed. Other improvements (i.e., spillway flow deflectors at Ice Harbor and Lower Monumental and extended submerged bar screens at Little Goose and Lower Granite) have also been added. Lower Granite, Little Goose, and Lower Monumental Dams have facilities for collecting and transporting juvenile fish. Spillway weirs have been installed at the facilities to improve in-river migration of juvenile fish through more effective spill programs. Weirs were installed at Lower Granite in 2001, at Ice Harbor in 2005, at Lower Monumental in 2008, and at Little Goose in 2009. Juvenile fish migrating downstream have several routes for passing the projects: through the spillway, through the juvenile bypass system, through a spillway weir, or through the turbine units. Spill for juvenile fish passage is provided at all lower Snake River dams during the passage season, usually from early April through the end of August. Spill for juvenile fish is developed annually in concert with the TMT and FPOM (Fish Passage Operations and Maintenance group, a regional coordination group having representatives of federal agencies and non-federal sovereigns) and described in the Fish Operating Plan (Appendix E of the Fish Passage Plan).

Lower Granite Dam

Lower Granite Dam is located on the Snake River at RM 107 near Almota, Washington. Lower Granite Lake, the reservoir behind Lower Granite Dam, extends 39.3 miles upstream on the Snake River and further 4.6 miles on the Clearwater River. Lewiston, Idaho, is located 33 miles upstream of the dam. Lower Granite Dam is authorized for navigation, hydroelectric power, recreation, and fish and wildlife conservation. Lower Granite Dam was placed into service in 1975 and includes, from south to north, five major components: fish passage facilities, powerhouse, spillway, navigation lock, and non-overflow embankment. The dam, located at the head of Lake Bryan, is 3,200 feet long, with an effective height of 100 feet.

The normal operating range of Lower Granite Lake extends from 733 to 738 feet. The powerhouse is 656 feet long and 243 feet wide, and houses six 135 MW generators. Next to the powerhouse is a 512-foot-long concrete spillway equipped with steel tainter gates, each 50 feet wide by 60 feet high. The spillway has eight spill bays, each 50 feet wide. A concrete-lined stilling basin extends 188 feet downstream from the spillway along the river bottom.

The navigation lock at Lower Granite is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the 756-foot-long north dam embankment.

Juvenile fish passage facilities at Lower Granite consist of a bypass system, spillway weir, and transportation facilities. Adult fish passage facilities include one fish ladder on the south shore, a powerhouse collection system, adult fish trap, and an auxiliary water supply system.

There are 9,220.4 acres of project lands surrounding Lower Granite Lake, including fee lands that are Federally owned and managed by the Corps, as well as easement lands on which the Corps has designated rights (i.e., flowage or access). Approximately 515 acres are leased to state or local public agencies. Port districts own lands adjacent to the project for industrial development. The majority of these project lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

There are 13 developed recreation areas adjacent to Lower Granite Lake, with boat ramps, moorage/marina facilities, day-use facilities, and campgrounds.

There are several habitat management units (HMUs) totaling 5,002 acres along Lower Granite Lake. Water pumped from the reservoir is used to irrigate one of these HMUs.

Water is withdrawn from Lower Granite Lake by municipal and industrial pump stations. The water is used for municipal water system backup, irrigation, and industrial purposes. There are three port facilities on Lower Granite Lake (Lewiston, Clarkston, and Wilma).

Little Goose Dam

Little Goose Dam is located on the Snake River at RM 70.3 near Starbuck, Washington. Little Goose Reservoir, known as Lake Bryan, extends 37.2 miles upstream to Lower Granite Dam. The project is authorized for hydroelectric power, navigation, recreation, irrigation, and fish and wildlife conservation.

Little Goose Dam was placed into service in 1970, and includes, from south to north, several major components: navigation lock, fish passage facilities, powerhouse, spillway, and non-overflow embankment. The dam, located at the head of Lake Herbert G. West, is 2,655 feet long with an effective height of 98 feet. The normal operating range of Lake Bryan extends from 633 feet to 638 feet. The powerhouse is 656 feet long and 243 feet wide, and houses six 135-MW generators. Next to the powerhouse is a 512-foot-long concrete spillway equipped with steel tainter gates, each 50 feet wide by 60 feet high. The spillway has eight spill bays. A concrete-lined stilling basin extends 118 feet downstream from the spillway along the river bottom.

The navigation lock at Little Goose project is a single-lift type facility; it is 668 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 101 feet. Next to the navigation lock is the north dam embankment.

Juvenile fish passage facilities at Little Goose consist of a bypass system, spillway weir, and transportation facilities. Adult fish passage facilities are composed of one fish ladder on the south shore, a powerhouse collection system, and an auxiliary water supply system.

There are 4,859.6 acres of project lands surrounding Lake Bryan, including both fee and easement lands. The majority of the Corps-managed lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Currently, two areas of approximately 150 acres each are leased either to the state or local ports for recreation.

There are seven developed recreation areas adjacent to Lake Bryan with boat ramps, a marina, day-use facilities, and campgrounds. There are multiple HMUs, totaling 3,019 acres, along the reservoir. Water pumped from the pool is used to irrigate two of these HMUs. There are three port facilities on Lake Bryan (Almota, Central Ferry, and Garfield).

Little Monumental Dam

Lower Monumental Dam is located on the Snake River at RM 41.6 near Kahlotus, Washington. The reservoir at Lower Monumental, known as Lake Herbert G. West, extends 28.7 miles upstream to Little Goose Dam. The project is authorized for hydroelectric power, navigation, recreation, fish and wildlife conservation, and irrigation.

Lower Monumental was placed into service in 1969 and includes, from south to north, the following major components: south non-overflow embankment, navigation lock, fish passage facilities (also located between the powerhouse and the north non-overflow embankment), spillway, powerhouse, and the north non-overflow embankment. The dam, located at the head of Lake Sacajawea, is 3,791 feet long, with an effective height of 100 feet. The normal operating range of Lake West is from 537 to 540 feet. The powerhouse is 656 feet long and houses six 135 MW generators. Next to the powerhouse is a 498-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays, each 50 feet wide. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 180 feet downstream from the spillway on the river bottom.

The navigation lock at Lower Monumental is a single-lift type structure, and is 666 feet long by 86 feet wide, with a 14-foot minimum operating depth and a maximum lift of 103 feet. Next to the navigation lock is the 968-foot-long north dam embankment. Juvenile fish passage facilities at Lower Monumental consist of a bypass system, spillway weir, and transportation facilities. Adult fish passage facilities include north and south shore fish ladders, a powerhouse collection system, and an auxiliary water supply system.

There are 9,143.6 acres of project lands surrounding Lake West, including both fee and easement lands. Port districts own land for industrial development both on and adjacent to project lands. The majority of Corps-managed lands, 7,024.0 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Approximately 1,177 acres are leased to the State of Washington for Lyons Ferry State Park.

There are six developed recreation areas adjacent to the Lake West, with boat ramps, a marina, day-use facilities, and a campground. There are multiple HMUs totaling 4,381 acres along the reservoir. Water pumped from the Lower Monumental pool is used to irrigate two of these HMUs. There is one port on the reservoir (Lyons Ferry).

Ice Harbor Dam

Ice Harbor Dam is located on the Snake River at RM 9.7 near Burbank, Washington. Major cities in the local vicinity include Kennewick and Pasco, which are located upstream of the confluence of the lower Snake and Columbia Rivers, and Richland, which is located at the confluence of the Yakima and Columbia Rivers. Ice Harbor Lock and Dam is authorized for hydroelectric power, navigation, irrigation, recreation, and fish and wildlife conservation.

The reservoir at Ice Harbor Dam, known as Lake Sacajawea, extends 31.9 miles upstream to Lower Monumental Dam. Ice Harbor Dam was placed into service in 1961 and includes, from south to north, the following major components: fish passage facilities (located between the spillway and the navigation lock), powerhouse, spillway, navigation lock, and non-overflow embankment. The dam is 2,822 feet long, with an effective height of 100 feet. The normal operating range of Lake Sacajawea extends from 437 to 440 feet. The powerhouse is 671 feet long and houses three 90 MW and three 110 MW generators. Next to the powerhouse is a 590-foot-long concrete spillway equipped with steel tainter gates. The spillway has 10 spillbays, each 50 feet wide. The tainter gates are each 50 feet wide by 52.9 feet high. A concrete-lined stilling basin extends 168 feet downstream from the spillway along the river bottom.

The navigation lock at Ice Harbor Dam is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the north dam embankment, which is 624 feet long.

Juvenile fish passage facilities at Ice Harbor Dam consist of a bypass system, juvenile sampling facilities, and a spillway weir. Adult fish passage facilities are made up of separate north and south shore facilities. The north shore facilities include a fish ladder, a small collection system, and an auxiliary water supply system. The south shore facilities comprise a fish ladder, a powerhouse collection system, and an auxiliary water supply system.

There are 4,037.7 acres of project lands surrounding Lake Sacajawea, including both fee and easement lands. The majority of the Corps-managed lands, 3,517.3 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

Seven developed recreation areas lie adjacent to Lake Sacajawea, including boat ramps, a marina, moorage facilities, and campgrounds. There are several HMUs totaling 2,032 acres along the reservoir. Water pumped from the pool is used to irrigate three of these HMUs. There are two ports on Lake Sacajawea (Windust and Sheffler).

Approximately 37,000 acres of non-Federal land are presently irrigated with water pumped from Lake Sacajawea. There are approximately 75 pumps located at the 14 irrigation pumping stations along the reservoir.

A.5. U.S. Army Corps of Engineers Lower Columbia River Projects

General Description

The Corps operates four projects on the lower Columbia River: Bonneville, The Dalles, John Day, and McNary Dams.

Bonneville, The Dalles, and McNary are run-of-river projects and are not operated for FRM. These projects have limited storage capacity and pass water at nearly the same rate as the water enters each reservoir. Reservoir levels behind these dams vary only a few feet during normal operations. This limited storage is used for regulation of powerhouse discharges to follow daily and weekly demand patterns. This storage is not enough to allow seasonal regulation of streamflows. John Day Dam was developed for FRM, as well as for hydropower and navigation, and is considered a storage facility. While John Day Dam has allocated FRM storage, it is typically operated in a manner that is similar to other mainstem dams that are run-of-river projects.

Authorization

The Columbia River projects were constructed and are operated and maintained under laws that may be grouped into three general categories: 1) laws initially authorizing project construction; 2) laws specific to the projects passed subsequent to construction; and 3) laws that generally apply to all Corps projects within the United States. Using these and other authorities, the Corps operates multiple-use water resource development projects to balance operation of individual functions with operations for all functions. This operation is coordinated with BPA, Reclamation, and other regional interests. Authorized uses for the lower Columbia River dams are FRM, power generation, navigation, fish and wildlife conservation, irrigation, and recreation.

Authorized Purposes and Description of Projects

The lower Columbia River dams are multiple-use projects that provide public benefits in a number of different ways. Project facilities include dams and reservoirs, hydroelectric powerplants and high-voltage transmission lines, navigation channels and locks, juvenile and adult fish passage structures, fish hatcheries, parks and recreational facilities, lands dedicated to project operations, and areas set aside as wildlife habitat. The projects' primary functions are to produce hydroelectric power and provide navigation on the Columbia River as part of the Columbia-Snake River Inland Waterway. Land for public access, recreation development, and wildlife management is limited at Bonneville and The Dalles due to minimal Corps ownership and physical constraints (i.e., topography and highway and railroad development paralleling both shores). The John Day and McNary projects have fewer limitations and more land under Corps ownership.

Summary information is presented for the four lower Columbia River projects in Table A- 7. More detailed information is presented for each project in Table A- 8.

Table A- 7. Lower Columbia River Projects summary information

Dams	Type of Dam	Year Completed	River Mile	Reservoir Name	Usable Capacity (acre-feet)1/
Bonneville	Run-of-River	1938	145.5	Lake Bonneville	100,000
The Dalles	Run-of-River	1960	192.5	Lake Celilo	53,000
John Day	Storage	1971	215.6	Lake Umatilla	535,000
McNary	Run-of-River	1957	292.0	Lake Wallula	185,000

1/ Usable capacity = water occupying active storage capacity of a reservoir

Table A- 8. Lower Columbia River Projects facility operations and structures

	Bonneville (B1)1/	Bonneville (B2)1/	The Dalles	John Day	McNary
Reservoir					
Normal Pool Operating Range (feet above NGVD)	70 - 77	-	155 – 160	257 - 268	335-340
Total Length (miles)	48	-	23.6	76.4	61.6
Surface Area (acres)	20,600	-	9,400	49,300	38,800
FRM Storage (acre-feet)	0	-	0	500,000	0
General (Dam)					
Dam Length (feet)	2,477	-	8,735	5,900	7,365
Hydraulic Head (feet)	50	-	85	105	83
Powerhouse					
Powerhouse Length (feet)	1,027	986	2,089	1,975	1,422
Nameplate Capacity (MW)	612.5	612	1,807	2,160	986
Total Number of Units Installed	10	8	24	16	14
Spillway					
Spillway Length (feet)	1,070	-	1,467	1,288	1,320
Number of Spillway Bays	18	-	23	20	22
Stilling Basin Length (feet)	147	-	170	182	276
Navigation Lock and Channels					
Lock Chamber Length (feet)	500	675	650	675	675
Lock Chamber Width (feet)	76	86	86	86	86
Maximum Operating Lock Lift (feet)	70	70	90	113	84

1/ Data for Bonneville Dam are presented by powerhouse. The first powerhouse (B1) went into operation in 1938. The second powerhouse (B2) was completed in 1981.

Juvenile fish migrating downstream have several routes for passing lower Columbia River projects: through the spillway, through the juvenile bypass system, through a surface flow outlet, or through the turbine units. Spill for juvenile fish passage is provided at all lower Columbia River dams during the passage season, usually from April 10 through the end of August. Spill for juvenile fish is developed annually in concert with the TMT and FPOM and described in the Fish Operating Plan. See Table 2-4 in Chapter 2 of this Proposed Action.

McNary Dam

McNary Dam is located on the Columbia River at RM 292 near Umatilla, Oregon. Major cities in the local vicinity include Umatilla and Hermiston, which are near the dam; Kennewick and Pasco, located upstream of the confluence of the Snake and Columbia Rivers; and Richland, located at the confluence of the Yakima and Columbia Rivers. Authorized purposes for McNary Dam are hydropower, navigation, irrigation, recreation, and fish and wildlife conservation.

Lake Wallula, the reservoir behind McNary Dam, extends 42.7 miles upstream to Ice Harbor Dam on the Snake River and 58 miles upstream to Columbia River mile 350. McNary Dam was placed into service in November 1954.

McNary Dam has several major components. From south to north, they are: the south non-overflow embankment and adult fish passage facilities (also located between the spillway and the navigation lock), the powerhouse, spillway, navigation lock, and north non-overflow embankment.

The powerhouse, with 986,000 kilowatts of installed generating capacity, has 14 main generators rated at 70,000 kilowatts and two auxiliary station service units of 3,000 kilowatts each.

Juvenile fish passage facilities at McNary Dam consist of a bypass system, two spillway weirs, and transportation facilities. Adult fish passage facilities are made up of separate north and south shore facilities. The north shore facilities include a fish ladder, a small collection system, and an auxiliary water supply system. The south shore facilities include a fish ladder, powerhouse collection system, and auxiliary water supply system.

Juvenile fish passage facilities were added to McNary Dam in the early 1980s. The facilities were modified in 1994, with the construction of a new juvenile bypass system and transportation facilities. Extended-length bar screens were installed in 1996 and 1997. A new juvenile bypass outfall was completed in early 2012 to improve the survival of juvenile fish passing through the juvenile bypass system.

Two spillway weirs were constructed in 2007 to provide more efficient passage and improve the survival of juvenile salmonids passing McNary Dam.

The adult fish passage facilities at McNary Dam include a north shore fish ladder that passes fish from entrances at the north end of the spillway, and a north shore gravity auxiliary water supply system. Northern Wasco County People’s Utility District installed a turbine unit on this auxiliary water supply in the 1990s, changing the system from a high-head system to a low-head system. Fish passage on the south side of the river is accomplished with a south shore fish ladder that passes fish from entrances along a collection channel that extends the full length of the powerhouse. Auxiliary water is provided by a combination of gravity flow from the forebay and pumped water from the tailrace. Counting stations are provided in both fish ladders.

There are 13,562 acres of fee-owned project lands surrounding Lake Wallula. An additional 5,530 acres of privately owned lands have flowage easements. The majority of Corps-managed lands are used for public recreation, wildlife habitat, project structures and levees, and water-connected industrial development. There are 17 HMUs totaling 8,414 acres managed for wildlife habitat. A total of 3,530 acres are leased to the USFWS as part of McNary National Wildlife Refuge. Water pumped from the pool is used to irrigate two of these HMUs.

There are 22 developed recreation areas adjacent to Lake Wallula. Ten of these areas are managed by the Corps, while others are managed by the USFWS, Oregon State Parks, Washington State Parks, Benton County, and the cities of Richland, Kennewick, and Pasco (Tri-Cities).

There are eight port sites on Lake Wallula used for the transportation of grain, wood products, fertilizers, fuel, and other commodities. McNary project lands are adjacent to agricultural, municipal, and commercial developments, and therefore, there are numerous agricultural, industrial, and municipal pumping stations along the reservoir, along with stormwater and sewer outfalls. Reclamation maintains two facilities on McNary project lands for providing water to local irrigation districts as part of the Umatilla River water exchange program.

John Day Dam

John Day Dam is located 24 miles upstream from The Dalles Dam at the head of Lake Celilo at RM 215.6. The authorized purposes of the project are FRM, navigation, irrigation, recreation, fish and wildlife conservation, and hydropower generation. The facility consists of a navigation lock, spillway, powerhouse, non-overflow sections, and fish passage facilities on both shores. Construction began in 1958 and the first power generator went into operation in 1968. Lake Umatilla is the second largest reservoir on the Columbia River and provides for navigation, with a minimum 14-foot depth in the main channel. The navigation lock, located on the Washington shore, is 86 feet wide and 669 feet long, and provides 15 feet of water depth over the sills, with a 113-foot maximum lift.

The powerhouse, with 16 main generators of 135 MW capacity each, has a total generating capacity of 2,160 MW. The last of the 16 generators went online in November 1971.

Unlike the other dams on the lower Columbia River, John Day Dam is also operated for FRM. When high runoff is forecast, the Lake Umatilla pool is lowered to provide space for control of about 500,000 acre-feet of floodwaters.

Juvenile fish passage facilities at John Day Dam consist of a screened juvenile bypass system and two spillways weirs. The adult fish passage facilities at John Day are composed of north and south shore fish ladders.

Juvenile fish bypass facilities at John Day Dam, completed in 1987, include one vertical barrier screen, one submerged traveling screen (STS), and one 14-inch-diameter orifice per gatewell, with three gatewells for each of the 16 turbine units, for a total of 48 orifices. The new smolt monitoring facility was completed in 1998. The bypass collection conduit leads to a transport channel that carries collected juvenile fish to the river below the dam when the smolt monitoring facility is not in operation (bypass mode). Water level differential between the forebay and bypass conduit is controlled by the tainter gate, and has a criterion of 4 to 5 feet (water level in the conduit is measured at unit 16).

In 2010, two spillway weirs were constructed to facilitate downstream juvenile fish passage at the spillway. In addition, an extended-length flow deflector was added to spill bay 20 to improve tailrace juvenile fish egress and reduce total dissolved gas production during spill operations.

The adult fish passage facilities at John Day Dam include a north shore fish ladder that passes fish from entrances at the north end of the spillway, and a south shore fish ladder that passes fish from entrances along a collection channel that extends the full length of the powerhouse. Auxiliary water is provided to all collection systems by pumping from the tailrace. Counting stations are provided in both fishways.

In addition to the two visitor areas at John Day Dam, recreation is available at more than a dozen areas along Lake Umatilla. Most of the areas are managed by the Corps, but there are also parks operated by local entities in several locations. Total acreage for the John Day Project, including pool, fee lands, and lesser interests, is more than 52,000 acres.

The Dalles Dam

The Dalles Dam is located on the Columbia River at RM 192.5, approximately 90 miles east of Portland, Oregon, and 3 miles upstream from the city of The Dalles, Oregon. The development and construction of The Dalles Lock and Dam Project was authorized by the Flood Control Act of 1950. Construction began in 1952 and was completed in 1960. Project authorized purposes include irrigation, navigation, recreation, fish and wildlife, and hydropower.

The Dalles Dam extends 1.5 miles from the Oregon shore to the navigation lock on the Washington shore. The project consists of a navigation lock, spillway, powerhouse, fish-passage facilities, and the non-overflow sections of the dam. Various recreational facilities are provided along Lake Celilo, the 24-mile-long impoundment behind the dam.

Lake Celilo provides navigation at a minimum depth of 15 feet in the main channel. The facility's navigation lock, on the Washington shore, is 86 feet wide and 675 feet long. It has an 88-foot normal lift and provides a 15-foot minimum depth over the sills.

The powerhouse, with 1,807 MW of installed generating capacity, has 22 main generators—14 original units rated at 78 MW and eight newer units rated at 86 MW—and two auxiliary units of 13.5 MW each. The auxiliary units also provide water to attract adult migrating fish to the fish ladders.

Juvenile and adult fish are able to pass downstream at The Dalles Dam via a sluiceway and the spillway. Turbine units at The Dalles are not screened. Upstream migrant passage facilities consist of a north shore fish ladder and an east fish ladder.

Turbine units at The Dalles Dam are not screened. Juvenile fish passage consists of the modified former sluiceway and one 6-inch orifice in each gatewell. The sluiceway is a rectangular channel extending along the total length of the 22-unit powerhouse and is located in the forebay side of the powerhouse. Gatewell orifices allow flow into the sluiceway, providing a potential means of passing fish from the gatewells to the sluiceway. When any of the sluiceway gates (located in the forebay side of the sluiceway) are opened, water and juvenile migrants are skimmed from the forebay into the sluiceway and deposited in the tailrace downstream of the project. In 2004, a spillway divider wall (spillwall) was constructed between spillbays 6 and 7 in order to improve the survival of juvenile fish that pass through the spillway. In 2010, an extended-length spillwall was constructed between spillbays 9 and 10 to further improve the survival of juvenile fish passing the spillway.

Adult fish passage facilities at The Dalles Dam include a north shore fish ladder, which passes fish collected at the north end of the spillway, and an east fish ladder that passes those fish collected at the south end of the spillway and across the downstream face of the powerhouse. A small hydropower facility, utilizing the north fishway ladder auxiliary water supply, was constructed in 1991 and is operated by the Northern Wasco County Public Utility District. Adult fishway criteria associated with this facility are monitored and maintained during the daily fishway inspections. A backup auxiliary water supply system, unscreened for juveniles, has been upgraded to facilitate its use, if required.

There are several recreation sites on both the Washington and Oregon shores at The Dalles Dam. Some are operated by the Corps; others are operated by the states of Oregon or Washington. Total acreage for The Dalles Project, including pool, fee lands, and lesser interests, is more than 12,000 acres.

Bonneville Lock and Dam

Bonneville Lock and Dam is located at the head of tidewater on the Columbia River at RM 145.5, in the heart of the Columbia River Gorge, approximately 42 highway miles east of Portland, Oregon. The Oregon-Washington state boundary lies along the main Columbia River channel, dividing the project between the two states. The facility includes two navigation locks, two powerhouses, spillway, fish passage facilities, fish hatchery, and one of the largest visitor complexes administered by the Corps.

In 1937, the 75th Congress authorized the completion, maintenance, and operation of the facility under the Corps' supervision and, in 1938, the first powerhouse went into operation. The original authorized project purposes are navigation, fish and wildlife, and hydropower, with recreational opportunities added as an authorized use later. A second powerhouse was completed in 1981, which more than doubled generating capacity. Bonneville Lock and Dam was placed on the National Register of Historic Places in June 1986. At present, the 1938 lock on the first powerhouse is being recommended for decommissioning, but that has not been authorized by Congress, and a request has not yet been made. The old navigation lock no longer operates. The new navigation lock at Bonneville opened to traffic in 1993. The new navigation lock is 675 feet long by 86 feet wide, with a maximum lift of 70 feet.

Juvenile fish passage facilities for downstream-migrating fish at Bonneville Dam are powerhouse and spillway specific. Fish entering the first powerhouse (B1) pass either deep through turbine units or may pass through a shallower route over lowered gates into a debris-type sluiceway. The spillway, sited between the Bradford and Cascades Islands, has 18 vertical lift gates used for passing flow in excess of powerhouse discharge and/or for smolt passage. The second powerhouse (B2) connects to the Washington shore on the north end and is separated from the spillway on the south end by Cascades Island. The second powerhouse contains eight screened turbine units (i.e., juvenile bypass system). A modified sluiceway, referred to as the B2 corner collector, is the result of extensive modification of the original B2 chute. Adult fish passage facilities for upstream migrants include the Bradford Island ladder, the Cascades Island ladder, and the Washington Shore ladder. Some upstream migrating fish pass via the navigation lock as well.

Juvenile fish passage facilities at the first Bonneville powerhouse (B1) consist of chain gates and a sluiceway converted in 2010 to a surface flow outlet for downstream juvenile fish passage. In addition, the First Powerhouse has been retrofitted with new main turbine units that have incorporated features to increase survival of fish passing through them.

Juvenile fish passage facilities at the second Bonneville powerhouse (B2) include streamlined trash racks, STSs, and vertical barrier screens. There are two 12.5 inch orifices per gatewell in units 11 to 14 and in fish unit 2, and one 12.5-inch orifice in all other gatewells, all flowing into a fish bypass channel, a dewatering facility, and a 48-inch fish transport pipe that connects the bypass channel to a mid-river release point approximately 1.5 miles downstream. Transport pipes (48 inches) at the high and low outfall transport fish to the tailrace at the outfall location. A juvenile fish sampling facility is included in the bypass. Two smaller turbines that supply adult fishway auxiliary water do not have STSs or streamlined trashracks; however, they have a fine trashrack with a 0.75 inch clear opening. B2 is also equipped with a surface flow outlet to provide a safe and efficient passage route for downstream-migrating fish. The B2 corner collector is located on the south side of the powerhouse. The associated flume extends several thousand feet west on the south side of the B2 tailrace, and empties at the tip of Cascades Island.

Adult fish passage facilities at Bonneville Dam consist of two main fishway segments. The B1 collection channel and A-branch ladder join the south spillway entrance and B-branch ladder at the junction pool at the Bradford Island ladder to form the Bradford Island fishway. The Cascades Island ladder at the north side of the spillway is connected to the Washington shore ladder by the upstream migrant transportation channel. The B2 collection channel and north and south monoliths join the upstream migrant transportation channel to form the Washington shore fishway. Bradford Island, Cascades Island, and the Washington shore fishways have counting stations. The Washington Shore ladder has an adult fish sampling facility. All four collection systems have auxiliary water supplies for fish attraction. The B1 auxiliary system is gravity supplied, while the B2 system is fed by two 15 MW fish turbines and water is introduced at the B2 junction pool.

Developed recreation areas around Bonneville Lock and Dam and Lake Bonneville include the dam visitor center, campground, state parks, and boat basins. The Bonneville Dam facilities drew nearly 2.74 million recreational visits in fiscal year 2005. Total acreage for the Bonneville Project, including pool, fee lands, and lesser interests, is more than 25,000 acres.

A.6. References

Citation	Reference
BIA 2009	Bureau of Indian Affairs. 2009. Final Environmental Impact Statement for a Drought Management Plan for Operation of the Kerr Hydroelectric Project on Flathead Lake, Montana.
Corps 2005	U.S. Army Corps of Engineers. 2005. Hungry Horse Dam and Reservoir Water Control Manual (Table 4-10 and Chart 4-6). Seattle District.
FERC 2006	Federal Energy Regulatory Commission. 2006. Kerr Project License Ordering Paragraphs & Articles (as amended through August 11, 2006). Retrieved August 14, 2017 from http://energykeepersinc.com/wp-content/uploads/2013/08/Kerr_License-Public_Web.pdf.
Reclamation 2010	U.S. Bureau of Reclamation. 2010. Finding of No Significant Impact Final Environmental Assessment: Third Powerplant Generating Units Overhaul Activities. Pacific Northwest Region, Boise, ID and Grand Coulee Power Office, Grand Coulee, Washington.
Reclamation 2012	U.S. Bureau of Reclamation. 2012. Finding of No Significant Impact Final Environmental Assessment: John W. Keys III Pump-Generating Plant Modernization Project. U.S. Department of Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho, and Ephrata, Washington. March 2012.
Reclamation 2018	U.S. Bureau of Reclamation. 2018. Finding of No Significant Impact and Final Environmental Assessment: Grand Coulee G1 through G18 Generating Units Modernization and Overhaul. Pacific Northwest Region, Boise, ID and Grand Coulee Power Office, Grand Coulee, Washington.
USBR in review	Biological Assessment Hungry Horse Overhaul and Modernization Project. Pacific Northwest Region, Boise, ID.

Consultation Package for
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Appendix B
Actions Taken by Bonneville Power Administration in Managing the Federal Transmission System that can Influence Water Management Actions at the Projects Consulted on in this Document

Bonneville Power Administration

Bureau of Reclamation

U.S. Army Corps of Engineers

B.1. General Description

Hydroelectric power generation is one of the authorized purposes for the fourteen dam and reservoir projects in the Columbia River System that are operated as a coordinated water management system. Transmission facilities owned and operated by Bonneville Power Administration (Bonneville) interconnect and integrate electric power generated at the dams to the regional transmission grid, enabling the transmission of power produced at Columbia River System dams to serve loads (demand for electricity) in the Pacific Northwest and to be exported to other regions. Bonneville owns, operates, and maintains 75 percent of the high-voltage transmission system in the Pacific Northwest, which is interconnected with regional utilities and generators, as well as with Canada to the north, California to the south, and Utah and other states to the east. Bonneville's transmission system also interconnects, integrates, and transmits the electric power generated from non-Federal generating plants in the Pacific Northwest, including non-Federal dams, nuclear, thermal, gas and coal plants, wind and solar generation projects, and transmits power generated outside the Northwest into or through the region.

B.2. Authorization

Bonneville is authorized by the Bonneville Project Act, the Flood Control Act, the Federal Columbia River Transmission System Act, and the Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act) to construct, operate, maintain, and improve the Federal transmission system in the Pacific Northwest. The Energy Policy Acts of 1993 and 2005 authorized the Federal Energy Regulatory Commission (FERC) to order Bonneville to provide transmission access, and established the NERC ERO and mandatory reliability standards applicable to Bonneville, respectively. NERC established a functional model for reliability entities responsible for implementing the reliability standards. These functional entities include Reliability Coordinators,[50] Balancing Authorities,[51] and Transmission Operators,[52] among other entities. Bonneville is certified as both a Balancing Authority and a Transmission Operator, in addition to other functions. Peak Reliability currently serves as the Reliability Coordinator for the Western interconnection within the United States, but will no longer provide RC services after December 2019. Bonneville intends to take RC services from the California Independent System Operator (CAISO) starting as early as November 2019.

[50] The Reliability Coordinator is the entity responsible for the real-time reliability of the Bulk Electric System within its Reliability Coordinator Area. The Reliability Coordinator monitors the entire Reliability Coordinator Area and has authority to direct other functional entities, including Balancing Authorities and Transmission Operators, to take action to ensure reliable operations of the Bulk Electric System.

[51] The Balancing Authority is the entity responsible for maintaining generation-load-interchange balance within its Balancing Authority Area and monitoring interconnection frequency in real-time.

[52] The Transmission Operator is the entity responsible for the real-time reliable operation of transmission system assets and load, generation and inter-system interconnections in its Transmission Operator Area. The Transmission Operator has authority to direct certain actions to ensure reliable operations.

B.3. Relationship between the Federal Transmission System and Water Management at Columbia River System Projects

Bonneville, as both the Balancing Authority and the Transmission Operator, must operate according to mandatory reliability requirements set by various Federal laws and regulations and guidelines, or by operating instructions from the regional Reliability Coordinator. At certain times, transmission system operations for reliability or Bonneville's obligation to balance power generation to match load within the Balancing Authority Area to comply with the mandatory reliability standard requirements, including maintaining operating reserves, may have an impact on the coordinated water management of the Columbia River System. Actions to ensure electrical transmission system reliability, including water management responses to planned and emergency transmission outages and operating power reserve obligations that may affect the coordinated water management at the projects are described below.

Transmission Operations

Periodically, to ensure the reliability of the transmission system when system conditions warrant, it is necessary to increase or decrease the amount of water flowing through a project's turbines and spillbays at one or more of the affected Columbia River System projects. If any of the transmission system conditions listed below are present and can be alleviated by temporarily modifying generation levels at one or more federal projects, the Action Agencies will adjust generation and spill levels to avoid the transmission system impact. These events could result in actual spill being temporarily higher or lower than the target fish passage spill level. Such events may occur in anticipation of or coincident with the transmission system event or in subsequent hour(s) should the event impact water balance at a specific hydro project or river reach. Bonneville will work to restore conditions to support target spill operations as soon as practicable. These actions are taken to minimize the risk and/or scope of a transmission system emergency.

Standard Operations for Transmission Reliability

The Action Agencies manage the fourteen Columbia River System projects to be prepared to provide electric reliability support as follows:

1. Ensuring sufficient range of generation capability is available to provide the Bonneville balancing authority area with contingency reserves required by North American Electric Reliability Corporation (NERC) reliability standards.
2. Ensuring generation is available to increase or decrease in order to balance load and generation within the Bonneville balancing authority area to support reliability and comply with related balancing authority area reliability standards.
3. Ensuring enough generating units are online and have sufficient capability to increase or decrease generation to meet the Bonneville balancing authority area frequency response obligations, consistent with reliability standard requirements.
4. Ensuring that there is generation operating at projects in specific locations sufficient for arming for Remedial Action Schemes (RAS). RAS schemes allow the transmission system to automatically respond to unplanned events on the power system by immediately dropping or reducing generation at those specified locations.

5. Maintaining minimum generation levels at generators in specific locations to maintain correct voltage levels on the power system to ensure reliability.
6. Maintaining enough generation units online in diverse locations on the electrical grid to ensure system stability through rotating inertia.

Contingency Operations for Transmission Reliability

If the routine reliability tools described above are insufficient to resolve the transmission condition, the Action Agencies will implement the preemptive actions detailed in the Power System Emergency Action Plan (Attachment 1 to the Technical Management Team Emergency Protocols) if time permits. Where necessary, the fourteen Columbia River System projects will be called upon to relieve the following conditions:

1. Increasing or decreasing generation at projects (redispatch) in specific geographic locations to relieve heavily loaded transmission lines if required by system conditions. This includes adjusting generation that flows over specific transmission facilities in order to keep flows over those paths within the requirements of NERC reliability standards.
2. Increasing or decreasing generation to ensure transmission system stability and/or reliable load service in local areas under specific system conditions. (For example, increasing generation at Ice Harbor Dam to support transmission stability, including providing load service to the Tri-Cities area of Washington, when system conditions require.)
3. Responding to unanticipated significant events, including NERC Energy Emergency Alerts or other system emergencies, consistent with the Power System Emergency Action Plan included as Attachment 1 to the TMT Emergency Protocols.
4. Other unanticipated significant events (e.g. powerhouse fires, earthquakes, etc.)

Planned and Unplanned Transmission Outages

Bonneville owns, operates, and maintains the Federal transmission system. This includes responsibility for maintaining the electrical reliability of the system, which requires continual monitoring and maintenance to meet applicable reliability standards.

The North American Electric Reliability Corporation (NERC) has been certified by the Federal Energy Regulatory Commission (FERC) as the Electric Reliability Organization under Section 215 of the Federal Power Act, with authority to develop and enforce mandatory reliability standards on all users, owners, and operators of the Bulk-Electric System, including Bonneville. NERC has delegated some of its authority to the Western Electricity Coordinating Council (WECC) to monitor and enforce reliability standards and create regional variances in the Western interconnection.

NERC reliability standards also establish minimum maintenance requirements. To comply with these maintenance requirements and to accommodate necessary additions, improvements, or reinforcements, including repair to or replacement of damaged equipment, outages may be required to take the transmission equipment out of service to perform the necessary work. A planned outage is scheduled to repair or replace equipment as needed, before it fails, or to accommodate interconnections or new or upgraded transmission facilities. Unplanned outages occur when automatic devices detect a problem, such as lightning, storm or ice damage, fires, fallen trees, equipment failure, or human-caused events, any of which may require removal of the equipment from service for repair or replacement. This is necessary for safety purposes and for the protection of the grid and interconnected generation or loads. The loss of transmission capacity due to outages may create conditions that necessitate altering reservoir operations to reduce or increase the amount of water passing through a project's hydroelectric turbines to ensure that adequate energy is provided to the system at the right locations to meet demand without overloading the transmission system or violating NERC standards.

Bonneville performs continuous outage analyses to identify the optimal timing for planned outages, manage risks, and communicate the likelihood of outages and probable effects. Bonneville also coordinates transmission and generation outages as part of the regional outage coordination process required by the applicable Reliability Coordinator procedures implementing certain of the mandatory reliability standards.[53] The Action Agencies have long-term and short-term planning procedures in place to avoid or minimize the effects of planned transmission outages on operations at the Federal dam and reservoir projects to conserve fish and wildlife, as described in Chapter 2, Sections 2.1.3 and 2.1.7. This includes scheduling planned outages outside of the spring and summer fish passage seasons, where practicable. That said, conducting timely transmission maintenance and making needed upgrades or additions to the transmission system are necessary activities to maintain system reliability. These planned maintenance activities are designed to reduce the risk of unplanned outages that could take longer to resolve and/or be more difficult to control and therefore could potentially have a greater adverse effect on both the transmission system and on fish operations. Restoration of the system after unplanned interruptions may also take longer than returning the system to normal conditions for planned transmission outages because, among other things, the crews and equipment necessary to respond were not anticipated. Under certain circumstances, therefore, it is better to schedule planned outages to conduct maintenance or install upgrades or additions, even if those activities may affect fish operations (e.g., during the spring and summer migration seasons for salmon and steelhead) than to delay transmission system maintenance actions and risk unplanned and potentially more extensive outages.

In circumstances where a planned or unplanned outage may constrain fish operations at the Columbia River System projects, Bonneville will coordinate any necessary adjustments to fish spill operations per the procedures described above and in the annual Fish Operations Plan

Voltage Stability

Additionally, generation at the Columbia River System dam and reservoir projects operates to maintain the voltage profile across the Federal transmission system through each plant's automatic voltage control. A time-of-day voltage schedule is set at all projects to ensure optimal voltage to support power transfers, as well as to maintain reactive capability at the generators for contingency response. This results in minimum generation requirements at Columbia River System projects that are essential to maintain proper voltage regulation under a wide variety of outage conditions, as well as the varying load and power transfer conditions.

Reliability Congestion Management

Bonneville must also manage congestion and constraints on the transmission system. At times, this may require the Bonneville transmission operator to issue transmission schedule curtailments and generation redispatch to reduce excessive power flows on the transmission system. Schedule curtailments have the effect of reducing generation that is the source of the schedule. The Bonneville transmission operator may

[53] Peak Reliability currently administers the Outage Coordination Process in compliance with NERC Reliability Standard IRO-017-1. Bonneville also has been working with the California ISO on Outage Coordination Procedures that it will implement as a Reliability Coordinator.

also increase or decrease Federal generation in specific locations of the transmission system (redispatch) to relieve and redirect the power flows that are contributing to the transmission constraints for reliable transmission operations.

Remedial Action Schemes

Bonneville also supports the transfer capability of certain internal transmission paths and major regional interties through the use of remedial action schemes (RAS). One type of Bonneville RAS involves generation dropping, which allows Bonneville transmission operators to automatically offload areas of the transmission system to quickly mitigate transient, voltage, and thermal constraints for a range of contingency events.

For example, the largest generation-dropping RAS requires 2,850 megawatts (MW) to support 3,100 MW of the total transfer capability at the Nevada-Oregon border of the High Voltage Direct Current (DC) Intertie between Celilo, Oregon, and Sylmar, California. If the DC Intertie is operating at the full 3,100 MW export total transfer capacity at the Nevada-Oregon border and it is lost, then 2,850 MW of generation must be dropped or shed to protect the parallel alternating-current transmission system. In other words, if there is a sudden outage reducing capacity on the Intertie, generation at some Columbia River System projects must be reduced. This RAS is tied to four Federal projects (Grand Coulee, Chief Joseph, McNary, and The Dalles).[54] If the DC Intertie is required for full export of energy to California, which is likely during the spring freshet, then these Federal plants may be required to support up to the full 2,850 MW of generation dropping RAS. If RAS is tripped, then the turbine units in the Columbia River System that are armed for RAS events will automatically drop, taking the generation to zero. The system may have to adjust the amount of water passing through a project's hydroelectric turbine if generation is tripped by a RAS event.

Balancing Authority

In addition to transmitting and marketing the power generated at the Columbia River System projects and other facilities, Bonneville is also responsible for maintaining the balance between generation and load within Bonneville's Balancing Authority Area. Energy supply, including generation, imports, and exports, must equal load (demand for electricity) at all times. To accomplish this, Bonneville manages and provides operating reserves based on required reserve obligations using dispatchable generation. The most common dispatchable power plants for meeting reserve obligations in the Northwest are hydropower and natural gas. Therefore, Bonneville sets aside a certain portion of hydropower generation capability to meet its reserve obligations for unexpected increases or decreases in generation or load in its Balancing Authority Area. These unexpected changes in generation can come from variable energy generation like wind, sudden generation outages, or sudden transmission congestion mitigation. As of July 31, 2018, Bonneville has approximately 2,764 MW of wind capacity installed in its Balancing Authority Area.55 Over the last two years, several wind project owners electronically moved their projects to other Balancing Authority Areas, decreasing Bonneville's reserve

[54] Additional DC Intertie RAS capacity is provided by 15 wind farms, if generation is available.

[55] The total installed generation capacity in the Bonneville Balancing Authority as of July 31, 2018 is 28,443 MW. Additional Information about interconnected and integrated wind generation can be found at http://transmission.bpa.gov/business/operations/Wind/WIND_InstalledCapacity_Plot.pdf.

requirements. These reserve requirements continue to change with the amount of resources that choose to be located in the Bonneville Balancing Authority. Adjustments to water management to ensure adequate reserves from the Columbia River System are most likely to occur during high spring flows in the months of May and June.

Balancing Reserves

Balancing reserves are necessary to deal with the inherent variability between scheduled and delivered energy and demand within a Balancing Authority Area. Certain reliability standards developed by NERC and adopted by FERC set requirements governing the actions of balancing authority entities. Like other utilities, Bonneville is required to comply with reliability standards developed in accordance with the Federal Power Act.[56] As the balancing authority, Bonneville is required to carry balancing reserves to meet unanticipated power demands, including deployment of those reserves by adjusting certain Columbia River System projects in response to schedule variations for generation and load, both increases or decreases, within its Balancing Authority Area. Having these reserves available is vital to maintain system reliability. Without such reserves, system reliability issues necessitating generation or schedule curtailments would be more common. Almost all loads and generators have some amount of variation between their actual hourly energy used or provided and the amount scheduled. Currently, Bonneville relies primarily on the Columbia River System to meet its balancing reserve obligations.

To maintain the reliability of the transmission system, Bonneville deploys the reserves at the Columbia River System projects to ensure generation-load balance and support interconnection frequency. Deployment is primarily accomplished using automatic generation control (AGC). AGC is a computerized management system that instructs specified hydroelectric generators to follow variations in load demand and generation production in the Balancing Authority Area by increasing or decreasing the amount of water passing through the turbines, down to 2-second intervals.

The actual output of variable generation such as wind power frequently varies from the scheduled amount in greater magnitudes than loads or traditional dispatchable generators such as thermal or hydro resources. Variable generation therefore requires a wider range of balancing reserves. In part due to this variability and the increase in wind generation in the system since 2008 (from about 1,500 MW to 2764 MW, as of July 312018), the amount of Columbia River System capacity Bonneville must set aside to provide balancing reserves has more than doubled.

For most of the spring and summer fish passage season, Bonneville can meet balancing reserve requirements without interfering with fish operations at the Columbia River System projects. During periods of high river flows, however, which may last for weeks at a time during the spring season, maintaining capacity on the Columbia River System to comply with balancing reserve requirements may result in an adjustment from planned fish passage spill levels and/or higher total dissolved gas (TDG) levels. There may also be several hours each year when deploying balancing reserves could result in temporary adjustments to planned fish spill operations. This condition generally occurs at Columbia River System projects during periods when planned fish passage spill levels constitute a percentage of hourly flow.

[55] The total installed generation capacity in the Bonneville Balancing Authority as of July 31, 2018 is 28,443 MW. Additional Information about interconnected and integrated wind generation can be found at http://transmission.bpa.gov/business/operations/Wind/WIND_InstalledCapacity_Plot.pdf.

[56] 16 U.S.C. § 824o(b)(1).

In certain conditions it may be necessary to reduce the level of reserves provided by the Columbia River System for short durations due to unexpected outages at these projects or other interruptions. In such circumstances, to maintain load and resource balance on the transmission system in compliance with applicable reliability standards, Bonneville may limit generation to schedules or initiate actual curtailments to generation schedules for short durations. Bonneville may also attempt to purchase replacement reserves from non-Federal resources, where practicable.

Oversupply Conditions

Large amounts of variable generation, combined with surplus quantities of hydropower generation, a condition which is most likely to occur during the spring runoff, may result in electricity generated in excess of total regional and extra-regional market demands, leading to a potential oversupply of energy generated in the Bonneville Balancing Authority Area and in the region. Oversupply on Bonneville's system occurs most frequently during hours of low electricity use, such as early in the morning. In these conditions, the river flow in excess of the amounts needed to generate electricity for regional load and export market needs that cannot be stored in reservoirs must be spilled. This can result in TDG levels that exceed water quality standards.

To manage TDG levels in such circumstances, Bonneville maximizes hydropower generation to meet regional and extra-regional market demands and offers low-cost or free Federal power generation to displace other electric power generators, such as coal, natural gas, and other dispatchable power plants, as well as variable generators.

Typically, under circumstances when Federal power is available at low or no cost, the thermal plants shut down to save fuel costs. With renewable energy incentives and the level of installed variable generation in Bonneville's Balancing Authority Area, many variable generators have chosen to meet their market demands and not to shut down voluntarily without receiving payment to cover their costs to take their generation offline, including the loss of these incentives or other contractual delivery requirements.

Therefore, Bonneville has adopted the Oversupply Management Protocol, which allows Bonneville to displace generation within the Balancing Authority Area with Federal energy during periods of oversupply. For variable generation, Bonneville displaces these generators in exchange for compensation for the variable generators' economic losses. The Protocol serves as a tool to help manage TDG levels within applicable water quality standards for the protection of both ESA-listed and non-listed fish and other aquatic biota.

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Appendix C
Columbia River Mainstem Depletions Associated with Reclamation's Columbia Basin Project and Other Tributary Irrigation Projects

Bonneville Power Administration

Bureau of Reclamation

U.S. Army Corps of Engineers

C.1. Introduction

The Columbia River drains about 219,000 square miles in the United States and 39,500 square miles in Canada. Observed outflow of the Columbia River averages about 198 million acre-feet (MAF) per year. Irrigation (both Federal and non-Federal) accounts for most surface water withdrawals in the Columbia River Basin. This Appendix describes Reclamation's Federal irrigation project depletions on the mainstem Columbia River. The action includes the mainstem Columbia River hydrologic depletions for the Columbia Basin [irrigation] Project (CBP). Also, as a matter of convenience Reclamation is including cumulative depletions on the mainstem Columbia River for six (6) of Reclamation's irrigation projects that are not operated in coordination with the Columbia River System. Four of these irrigation projects are located on tributaries to the Columbia River and have been, or are in the process of being, consulted on separately (see Table C 2); however, the analysis in these separate consultations ends at the confluence of the Columbia River and does not include mainstem effects. Two of the irrigation projects are simply pump facilities located on the mainstem Columbia River. Depletions from all these irrigation projects are included in the Columbia River System mainstem flow models and accounted for in the Columbia River System modeling.

C.2. Hydrologic Effects of Reclamation's Columbia Basin Project

Columbia Basin Project

Grand Coulee Dam is the primary storage and diversion structure for the Columbia Basin Project (CBP). Irrigation diversions are pumped from Lake Roosevelt to Banks Lake via the John W. Keys III Pump/Generating Plant (JWKIII). Operation for the CBP irrigation diversions are coordinated with other authorized project purposes in a complex operational regime. For more information on operations of Grand Coulee Dam for multiple purposes, including FRM, see Appendix A.

The irrigation season extends from about mid-March to November 1. For the purposes of this consultation, the action diverts 2.9 MAF[56] through the JWKIII on average annually. (Depletions by month are provided in Table C- 3**.**)

In addition, a small section (3,460 acres) of the CBP is served by the Burbank Pumps at Blocks 2 and 3, which pump from the Snake River (John Day pool) near the confluence with the Columbia River to lands located south of the Snake River. The maximum pumping rate at the Burbank pumps is about 60 cfs, with a total diversion of about 23,000 acre-feet of water, of which about 10,000 acre-feet returns to the river through seepage and surface return flows.

There are other irrigation diversions for the CBP that are already part of the environmental baseline; these include 164,000 acre-feet covered by the Odessa Subarea Special Study 2012 Final Environmental

[56] This includes 30,000 acre-feet diverted through JWKIII for LRISRP covered under a June 2009 Environmental Assessment (EA).

Impact Statement and corresponding Section 7 ESA consultation (Reclamation 2012a). These diversions occur at the JWKIII.

General Project Description

Reclamation operates and maintains all the CBP's major facilities. Operations for the CBP primarily include storage in and release of water from Lake Roosevelt by operations of Grand Coulee Dam, and storage and release of water to Banks Lake by diversion of water at the JWKIII. Aside from operations of Grand Coulee Dam, diversions at the JWKIII and flow augmentation from Banks Lake, Reclamation does not further coordinate the operation of the CBP with the Columbia River System.

Water Supply

Lake Roosevelt has an active capacity of 5.2 MAF and a total capacity of 9.4 MAF. The average annual Columbia River inflow to Lake Roosevelt is approximately 77 MAF.

The JWKIII on the left bank of Lake Roosevelt, just upstream from Grand Coulee Dam, was designed to accommodate 12 pumping units to pump water for irrigation delivery from Lake Roosevelt to the 1.6-mile long Feeder Canal that leads to Banks Lake. The JWKIII features:

- Six pumps, each with a capacity of 1,600 cfs
- Two pump/generators with a pumping capacity of 1,605 cfs each and a generating capacity of 50 MW, and
- Four pump/generators units with a pumping capacity of 1,700 cfs each and a generating capacity of 53.5 MW

If Lake Roosevelt is below elevation 1240 feet, the pump/generators are not available, leaving only the six pumps to deliver water to Banks Lake. The six pumps do not have the capacity to meet full demand, so when demand exceeds the capacity of the six pumps, water must be drafted from Banks Lake to supplement flows. Banks Lake is then refilled when Lake Roosevelt elevation is high enough to allow use of the pump/generators.

Banks Lake, located in an old ice-age channel called the Grand Coulee, is a re-regulating reservoir. This 27-mile-long reservoir is formed by the North Dam, which is located about 2 miles southwest of Grand Coulee Dam, and the Dry Falls Dam, which is located about 29 miles south of Grand Coulee Dam. Banks Lake has an active storage capacity of 715,000 acre-feet, feeds water to the CBP through the Main Canal at Dry Falls Dam, and provides water to operate the pump/generators in generation mode at JWKIII. Return flows from the CBP are routed back to the Columbia River through several wasteways; Table C- 1 reports the return flows lumped as returns to the pools above Wanapum, Priest Rapids, and McNary Dams as they appear in the Modified Flows Report. These points were selected as they are points where NOAA Fisheries has established flow objectives.

Depletion Effects on the Mainstem Columbia River

This appendix only addresses the diversions for irrigation; impacts due to FRM at Grand Coulee Dam are reflected in Chapter 2 and in Appendix A.

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Table C- 1. Average monthly Columbia River diversions and return flows (in cfs) from the Columbia Basin Project

Project	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Columbia River												
Columbia Basin Project withdrawals at JWKIII[1]	-2,940	-420	-200	-30	-160	-1,490	-7,080	-7,490	-7,640	-9,100	-5,830	-6,330
Return Flows at Wanapum[2]	110	80	70	60	60	60	70	70	70	80	100	120
Return Flows at Priest Rapids[2]	360	220	180	180	220	230	310	280	220	210	260	360
Sum of depletions at Priest Rapids	*-2,470*	*-120*	*50*	*210*	*120*	*-1,200*	*-6,700*	*-7,140*	*-7,350*	*-8,810*	*-5,470*	*-5,850*
Flow at Priest Rapids[3]	**71,540**	**98,860**	**105,270**	**125,490**	**117,720**	**94,910**	**111,690**	**164,500**	**183,840**	**146,620**	**118,780**	**72,200**
depletions as a percent of PRS Flows	*-3%*	*0%*	*0%*	*0%*	*0%*	*-1%*	*-6%*	*-4%*	*-4%*	*-6%*	*-5%*	*-8%*
Lower Columbia River												
Return Flows at McNary[2]	710	510	390	380	370	460	630	600	640	660	670	740
CBP Withdrawals at Blocks 2 and 3[4]	-10	10	10	10	10	-5	-20	-40	-50	-60	-50	-30
Sum of depletions at McNary in cfs	*-1,770*	*400*	*450*	*600*	*500*	*-750*	*-6,090*	*-6,590*	*-6,760*	*-8,210*	*-4,850*	*-5,140*
Flow at McNary[3]	**93,800**	**125,480**	**140,300**	**167,790**	**169,170**	**155,170**	**193,530**	**267,600**	**285,700**	**199,000**	**150,550**	**97,710**
Depletions as a Percent of MCN Flows	*-2%*	*0%*	*0%*	*0%*	*0%*	*0%*	*-3%*	*-2%*	*-2%*	*-4%*	*-3%*	*-5%*
Sum of depletions at Bonneville in cfs	*-1,770*	*400*	*450*	*600*	*500*	*-750*	*-6,090*	*-6,590*	*-6,760*	*-8,210*	*-4,850*	*-5,140*
Flow at Bonneville[3]	**99,560**	**136,690**	**154,940**	**184,660**	**187,800**	**174,120**	**213,970**	**281,970**	**296,980**	**206,950**	**157,070**	**104,500**
Depletions as a Percent of BON flows	*-2%*	*0%*	*0%*	*0%*	*0%*	*0%*	*-3%*	*-2%*	*-2%*	*-4%*	*-3%*	*-6%*

Appendix B [1]Source: 2017 Pacific Northwest Coordination Agreement Data Submittal. Average monthly diversions over previous 5-year period.
Appendix C [2]Source: 2010 Modified flows
Appendix D [3]Source: Modeled flows from BPA's 2018 proposed Action Priest Rapids, McNary and Bonneville dams are shown as points of reference as they are locations where NOAA Fisheries have identified flow objectives.
Appendix E [4]Source: 2010 Modified flows

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C.3. Hydrological Effect of Reclamation's Non-Columbia River System Irrigation Projects

In addition to the CBP and as a matter of convenience, Reclamation is including in this consultation the Columbia River mainstem hydrologic depletions of six of Reclamation's irrigation projects that are not operated in coordination with the Columbia River System. Depletions from two mainstem pump projects are included in this consultation, Chief Joseph Dam and The Dalles. These projects pump water directly from the Columbia River and operate for a single purpose, water delivery. In addition, mainstem impacts from four of Reclamation's tributary irrigation projects (Crooked River, Deschutes, Umatilla, and Yakima) are included in this consultation. These tributary irrigation projects operate to meet multiple purposes; the two main purposes that affect mainstem Columbia River flows are associated with irrigation water storage and delivery and reshaping of flows to provide for local flood risk management (FRM). Reclamation has ongoing or completed consultations with the National Marine Fisheries Service (NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS) for these projects to address tributary effects of operations to listed species (see Table C- 2 for the current status of tributary irrigation project consultations). The effects analysis for each tributary consultation was confined to the tributary and did not include mainstem effects. This consultation will evaluate the mainstem hydrologic depletions due to the projects' operation from the tributary's confluence with the Columbia River to the estuary.

The projects described here are authorized, funded, or carried out by Reclamation by virtue of Congressional or Secretarial authorizations, Congressional appropriations, and contracts with Reclamation.

Table C- 2. Summary of the status of Endangered Species Act (ESA) compliance for Reclamation tributary irrigation projects effects on species within the jurisdiction of USFWS and NOAA Fisheries

Project	Status of ESA Compliance	Source
Chief Joseph Dam	Completed consultation with USFWS for screen modification in 2001. No tributary effects.	US Fish and Wildlife Service BiOp 2000 NOAA Fisheries BiOp 2008, 2014
Crooked River and, Deschutes	Completed informal consultation with USFWS in 2004. Reinitiating consultation due to adult and juvenile fish passage at Pelton Round Butte and flow effect of operational change because of habitat conservation plan (HCP) associated with steelhead reintroduction. Anticipated date of HCP completion and consultation reinitiation with NOAA Fisheries and USFWS is July 2019.	NOAA Fisheries Biological Opinion for Deschutes River Basin Projects, February 2005 USFWS Letter of Concurrence for Deschutes Basin Projects, February 2004.
The Dalles	Completed informal consultation in 1992. No tributary effects.	US Fish and Wildlife Service BiOp 2000

Project	Status of ESA Compliance	Source
		NOAA Fisheries BiOp 2008, 2014
Umatilla	Completed ESA consultation with USFWS in 2008. Completed formal ESA consultation with NOAA Fisheries in April 2004. Reinitiate formal consultation with NOAA Fisheries September 15, 2016.	NOAA Fisheries Biological Opinion for Umatilla Project, April 2004 USFWS Biological Opinion for Umatilla Project, July 2008.
Yakima	In progress. Biological Assessment sent to NOAA Fisheries and USFWS in April 2015.	Biological Assessment for O&M of the Yakima Project, April 2015

This section describes depletions to the mainstem Columbia River due to specific Reclamation irrigation project operations. Table C- 3 provides a sum of all depletion data from those irrigation projects. There are three points that reflect the flow in the river after depletions. Those points include Priest Rapids, McNary, and Bonneville dams. These points were selected as they are points where NOAA Fisheries has established flow objectives. Flows at the dams came from the Bonneville Power Administration's HYDSIM model. The depletions are included in the system models through the 2010 Modified Flows.

Table C- 3. Average Monthly Mainstem depletions due to operations of Reclamation's non FCRPS irrigation Projects in cfs[1]

Project[2]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Columbia River												
Chief Joseph Dam Project depletions[4]	-5	0	0	0	0	0	-10	-70	-150	-200	-130	-30
Sum of effects at Priest Rapids	*-5*	*0*	*0*	*0*	*0*	*0*	*-10*	*-70*	*-150*	*-200*	*-130*	*-30*
Flow at Priest Rapids[3]	71,540	98,860	105,270	125,490	117,720	94,910	111,690	164,500	183,840	146,620	118,780	72,200
Depletions as a percent of PRS Flows	*-0.01%*	*0.00%*	*0.00%*	*0.00%*	*0,00%*	*0.00%*	*-0.01%*	*-0.04%*	*-0.09%*	*-0.12%*	*-0.11%*	*-0.04%*
Yakima Project depletions[5]	-900	-990	-950	-820	-970	-1,160	-4,600	-8,170	-6,310	-2,880	-1,180	-1,040
Lower Columbia River												
Umatilla Phase II Pump Exchange depletions	-30	0	0	0	0	-10	-40	-60	-100	-120	-110	-90
Sum of depletions at McNary in cfs	*-940*	*-990*	*-950*	*-820*	*-970*	*-1,170*	*-4,650*	*-8,300*	*-6,560*	*-3200*	*-1,420*	*-1,160*
Flow at McNary[3]	93,800	125,480	140,310	167,790	169,170	155,170	193,530	267,600	285,700	199,000	150,550	97,710
Depletions as a Percent of MCN Flows	*-1%*	*-1%*	*-1%*	*0%*	*-1%*	*-1%*	*-2%*	*-3%*	*-2%*	*-2%*	*-1%*	*-1%*
Umatilla Phase I Pump Exchange depletions	-40	0	0	0	0	-5	-5	-10	-60	-80	-80	-70
Umatilla Project depletion and return flows[5]	50	40	-15	-60	-130	-200	-300	-220	-100	-70	-40	30
Deschutes, and Crooked River Project depletions [5]	-420	-410	-380	-340	-290	-170	-1400	-1570	-1290	-770	-820	-550
The Dalles Project depletions[4]	-20	0	0	0	0	0	-10	-40	-40	-50	-50	-30
Sum of depletions at Bonneville in cfs	*-1,370*	*-1,360*	*-1,350*	*-1,220*	*-1,390*	*-1,600*	*-6,390*	*-10,140*	*-8,050*	*-4,350*	*-2,410*	*-1,780*
Flow at Bonneville[3]	99,560	136,690	154,940	184,660	187,800	174,120	213,970	281,970	296,980	206,950	157,070	104,500
Cumulative depletions as a Percent of BON flows	*-1%*	*-1%*	*-1%*	*-1%*	*-1%*	*-1%*	*-3%*	*-4%*	*-3%*	*-2%*	*-2%*	*-2%*

[1]Negative values imply a flow reduction (depletion) due to Reclamation activities. Natural flow diversions would still occur without Reclamation.

[2]Sources: Chief Joseph Dam -Reclamation 2016b.; Yakima –Reclamation 2016c ; Umatilla –Reclamation 2017b.; Deschutes- Reclamation 2017a.; The Dalles - 2016e.

[3]Source: Modeled flows from BPA's 2018 Proposed Action HydSim Model

[4]Not to be confused with the Corps' Columbia River System projects of the same name.

[5]Yakima, Umatilla, Deschutes and Crooked River projects show depletions at the mouth or confluence with the Columbia River. These depletions include those due to natural flow rights (not reclamation actions) as well as project operations. Therefore, depletions numbers shown here are higher than would actually be attributed to Reclamation actions. Positive numbers reflect return flows.

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Chief Joseph Dam Project

General Project Description

The Chief Joseph Dam Project occupies lands along the Columbia and Okanogan Rivers in north-central Washington and is not part of Chief Joseph Dam, which the Corps operates. There are four divisions and a total of seven units, five of which result in depletions to the Columbia River. All of the units are separate land areas with independent irrigation systems. The project serves about 16,760 irrigable acres.

The Chelan Division borders the north shore at the lower end of Lake Chelan. It has about 6,285 acres of land and delivers about 20,280 acre-feet of water. After return flows, depletions from the river are about 14,500 acre-feet.

The Foster Creek Division is near the confluence of the Okanogan River with the Columbia River. It has two units with a total acreage of about 2,907 and delivers about 9,970 acre-feet of water. After return flows, depletions from the river are about 6,500 acre-feet.

The Greater Wenatchee Division with its three units, Brays Landing, East, and Howard Flat, is in three separate areas along the Columbia River between Wells Dam and Rock Island Dam. Brays Landing and Howard Flat pump from groundwater. The division serves about 4,560 acres and delivers about 14,630 acre-feet of water. After return flows, depletions from the river are about 9,520 acre-feet.

The Whitestone Coulee Division is in the Spectacle Lake area, west of the Okanogan River near Loomis, between Oroville and Tonasket, Washington. The division serves about 3,009 acres and delivers about 10,120 acre-feet of water. After return flows, depletions from the river are about 6,630 acre-feet.

Depletion Effects on the Mainstem Columbia River

Facility operation is generally limited to the irrigation season, which begins sometime from about mid-April to mid-May and ends sometime from mid-September to October 1. The average annual depletions for the Chief Joseph Dam Project are about 37,150 acre-feet.

Table C- 4. Description of irrigation depletions (in cfs) from the mainstem Columbia River due to the Chief Joseph Dam Project

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total depletion	-5	0	0	0	0	0	-10	-70	-150	-180	-130	-30

Yakima Project

The tributary effects of the Yakima Project are being consulted on in a separate tributary consultation. A full description of the project facilities and operations can be found in the April 2015 Biological Assessment for O&M of the Yakima Project and Reclamation's Yakima Project Interim Comprehensive Basin Operating Plan (IOP) (Reclamation 2002). The tributary consultation ends at the confluence of the

Columbia River and does not include mainstem effects. Mainstem effects are included as part of this action.

General Project Description

The Yakima Project provides irrigation water for approximately 465,000 acres. The project operates six storage dams and reservoirs for both FRM and irrigation. Reservoirs include Bumping Lake, Clear Creek, Tieton, Cle Elum, Kachess, and Keechelus and have a total active capacity of approximately 1.07 MAF.

Depletion Effects on the Mainstem Columbia River

Reclamation's Yakima Project IOP (Reclamation 2002) is incorporated by reference. The IOP describes project operations in detail including water storage and diversion rights in the basin.

The IOP informed the computation of the Modified Flows Report (BPA 2010), which provides flows at the mouth of the Yakima River under current operations. Effects to flows at the mouth were estimated using unregulated flows (flows without human impacts) and the modified flows. Depletions include the effects of natural flow rights, as well as operations of Reclamation Project, so over-estimates the Federal effect on the mainstem Columbia River flows.

Table C- 5. Description of Reclamations depletions on the mainstem Columbia River from the Yakima Project (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total depletions	-900	-990	-950	-820	-970	-1,160	-4,600	-8,170	-6,310	-2,880	-1,180	-1,040

Note: (Depletions include natural flow rights, as well as operations of Reclamation Projects, so effects are greater than Reclamation actual impacts.)

Umatilla Project

General Project Description

The original Umatilla Project furnishes a full supply of irrigation water to more than 17,000 acres and a supplemental supply to approximately 22,500 acres. These lands, located in north-central Oregon, are divided into three divisions.

In addition, there are approximately 3,800 acres not included in an irrigation district that are provided either a full or supplemental water supply from McKay Reservoir under individual storage contracts.

Reclamation prepared a biological assessment (2001) with an additional supplement (2003c) that fully describes project operations. Consultation with NOAA Fisheries was completed on the Umatilla Project, with a BiOp dated April 23, 2004. Reclamation has reinitiated consultation with NOAA Fisheries on the operation of the Umatilla Project, as the April 23, 2004 BiOp was only issued for a 10-year duration. Reclamation prepared an operations plan for the Umatilla Basin Project (Reclamation 2011 and 2012b) that describes the project facilities and operations. Reclamation has prepared a new Biological Assessment for the Umatilla Project and has requested reinitiation of consultation on September 15, 2016 (Reclamation 2016a). Reclamation is awaiting a new BiOp from NOAA Fisheries at this time. The consultation ends at the confluence of the Columbia River and does not include mainstem effects. Mainstem effects are included as part of this action.

Depletion Effects on the Mainstem Columbia River

In addition to the mainstem depletions of Columbia River due to operations of the Umatilla Project in the Umatilla River, Reclamation is consulting on the operations of the Phase I and Phase II water exchange facilities that deliver water from the Columbia River (from Lake Wallula behind McNary Dam) for irrigation in exchange for Umatilla River flows that are not diverted for irrigation and left in the Umatilla River. The Columbia River mainstem flow effects from the operation and maintenance of the Umatilla Project are summarized in Table C- 6.

Table C- 6. Description of irrigation diversions and return flow impacts on the mainstem from the Umatilla Project.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Phase II	-30	0	0	0	0	-10	-40	-60	-100	-120	-110	-90
Phase I	-40	0	0	0	0	-5	-5	-10	-60	-80	-80	-70
Umatilla River	50	40	-15	-60	-130	-200	-300	-220	-100	-70	-40	30
Total Mainstem Effect	-20	40	-15	-60	-130	-220	-550	-290	-260	-270	-230	-130

Note: depletions include those for natural flow rights so effects are greater than impacts due just to project operations. Positive numbers reflect return flows.

Deschutes River

Tributary consultation for the Deschutes River included two Reclamation Projects including Crooked River, and Deschutes projects (Table C- 7; Reclamation 2005).

Reclamation prepared an operations report (2003b) and biological assessment (2003a) that describe in detail the authorizations, facilities, operations, and maintenance activities associated with these projects. Reclamation is reinitiating consultation due to adult and juvenile fish passage at Pelton Round Butte and flow effect of operational change because of the habitat conservation plan (HCP) associated with steelhead reintroduction. The anticipated date of HCP completion and consultation reinitiation with NOAA Fisheries and USFWS is July 2019. The tributary consultation ends at the confluence of the Columbia River and does not include mainstem effects. Mainstem effects are included as part of this action.

Deschutes Project

General Project Description

The Deschutes Project is located near Madras, Oregon. The project provides a full water supply to about 50,000 irrigable acres and a supplemental water supply for about 48,000 irrigable acres. Reservoirs include Wickiup, Haystack, and Crane Prairie, with a total storage of about 260,900 acre-feet. Reclamation prepared an operations report (2003b) and biological assessment (2003a) that describe in detail the authorizations, facilities, operations, and maintenance activities associated with the Deschutes Project. These documents are incorporated by reference.

Table C- 7. Description of mainstem flow effects from the Crooked River and Deschutes Projects.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total Depletions	-420	-410	-380	-340	-290	-170	-1,400	-1,570	-1,290	-770	-820	-550

Note: Depletions include natural flow rights in addition to operations of the project so effects are greater than actual impacts due to Reclamation actions.

The Dalles Project

General Project Description

The Dalles Project, Western Division, is on the south side of the Columbia River adjacent to The Dalles, Oregon, about 80 miles east of Portland, Oregon. The Dalles Project is not part of The Dalles Dam, which the Corps operates. The Dalles Project pumps directly from Bonneville Dam forebay. Although the project includes about 6,000 irrigable acres, water from the Columbia River is supplied to an annual average of 5,600 acres that produce fruit, primarily sweet cherries.

Water Supply

Mill Creek Pumping Plant, on the Columbia River about 4 miles downstream from The Dalles Dam, consists of five pump units with a total capacity of 54.2 cfs, as originally constructed. Anadromous fish screens at the intakes of the pumps meet NOAA Fisheries fish protective criteria. The water supply for The Dalles Project is the Columbia River.

Depletion Effects on the Mainstem Columbia River

The Dalles Irrigation District operates and maintains the facilities of The Dalles Project. About 14,000 acre-feet are pumped annually during the irrigation season, March 1 to October 31.

Table C- 8. Description of irrigation diversions and return flow impacts on the mainstem from The Dalles Project

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Depletions	-20	0	0	0	0	0	-10	-40	-40	-50	-50	-30

Table C- 9 below summarizes the cumulative hydrologic depletions from the Columbia Basin Project and the six other non-FCRPS Reclamation projects at three points on the Columbia River.

Table C- 9. Monthly average Total hydrologic effects (depletions) on the Columbia River (in cfs) due to the CBP and specific Reclamation Projects.

Project	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Columbia River												
Sum of effects at Priest Rapids	*-2,475*	*-120*	*50*	*210*	*120*	*-1,200*	*-6,710*	*-7,210*	*-7,500*	*-9,010*	*-5,600*	*-5,880*
Flow at Priest Rapids[3]	**72,390**	**95,750**	**105,660**	**122,170**	**110,100**	**101,740**	**119,820**	**163,240**	**172,040**	**153,390**	**120,340**	**73,900**
Effects as a percent of PRS Flows	*-3%*	*0%*	*0%*	*0%*	*0%*	*-1%*	*-6%*	*-4%*	*-4%*	*-6%*	*-5%*	*-8%*
Lower Columbia River												
Sum of effects at McNary in cfs	*-2,705*	*-590*	*-500*	*-220*	*-470*	*-19150*	*-10,740*	*-14,880*	*-13,320*	*-11,410*	*-6,270*	*-6,300*
Flow at McNary[3]	**96,780**	**121,670**	**141,710**	**164,530**	**160,370**	**161,560**	**201,350**	**267,140**	**273,990**	**205,870**	**152,210**	**97,960**
Effects as a Percent of MCN Flows	*-3%*	*0%*	*0%*	*0%*	*0%*	*-1%*	*-5%*	*-6%*	*-5%*	*-6%*	*-4%*	*-6%*
Sum of effects at Bonneville in cfs	*-3,135*	*-960*	*-895*	*-620*	*-890*	*-2,290*	*-12,455*	*-16,720*	*-14,810*	*-12,380*	*-7,260*	*-6,920*
Flow at Bonneville[3]	**102,560**	**132,890**	**156,340**	**181,400**	**178,990**	**180,520**	**221,750**	**281,570**	**282,270**	**213,820**	**158,740**	**104,720**
Effects as a Percent of BON flows	*-3%*	*0%*	*0%*	*0%*	*0%*	*-1%*	*-6%*	*-6%*	*-5%*	*-6%*	*-5%*	*-7%*

[3]Source: Modeled flows from BPA's 2018 proposed final rate case which includes the 2008 BiOp and the 2010 and 2014 Supplemental BiOps

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Projects included in the 2008 BiOp but removed because they have completed separate consultation and have no effect on the Mainstem Columbia River

Tualatin Project

The effects to the mainstem Columbia River due to the operations of the Tualatin Project were included in past FCRPS biological opinions. Since then, Reclamation has a completed consultation on the operations of the Tualatin Project. Operations of the Tualatin Project were considered to be unmeasurable in the Willamette River therefore are considered to be unmeasurable in the Columbia River. For that reason, the Tualatin Project has been removed from this consultation.

Wapinitia Project

The effects to the mainstem Columbia River due to the operations of the Wapinitia Project were included in past FCRPS biological opinions. An HCP on the operations in the Deschutes River is scheduled for completion in 2019. The Wapinitia Project is small such that effects of operations are unmeasurable in the Deschutes River and, therefore, are unmeasurable in the Columbia River. For that reason, it has been removed from this consultation.

Okanagan Project

The mainstem effects to the Columbia River from the Operations of the Okanogan Project were included in previous FCRPS BiOps. Reclamation is currently conducting separate consultation of the Okanogan Project. That consultation will include all impacts from the operation of the Okanogan Project. For that reason, it has been removed from this consultation.

References

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Reclamation 2016b – Chief Joseph Dam Project – Computed by Lori Postlethwait based on records supplied by Amy Rodman. Pacific Northwest Region, Columbia Cascade Area Office, Ephrata Field Office, 2016

Reclamation 2016c. Yakima Project Mainstem Depletions based on Communication between Lori Postlethwait of the Pacific Northwest Regional Office and Chris Lynch of the Columbia Cascades Area Office, Yakima, Washington.

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USFWS 2008 –Biological Opinion for the Continued Operation and Maintenance of the Bureau of Reclamation's Umatilla/Umatilla Basin Projects and Bonneville Power Administrations-funded Fish Passage and Screening Structures, Umatilla County Oregon. U.S. Fish and Wildlife Service, July 2008

Consultation Package for
Operations and Maintenance of the
Columbia River System

Appendix D
Columbia River System Operational and Structural Improvements under the Endangered Species Act – 2017 Progress Update

Bonneville Power Administration
Bureau of Reclamation
US Army Corps of Engineers

D.1. Purpose and Scope

When developing the action detailed in Chapter 2, the Action Agencies reviewed relevant data collected since the 2008 Biological Opinion was completed. This appendix updates many of the analyses and datasets discussed in their 2013 summary of hydro configuration and operations modifications (Bonneville Power Administration et al. 2013) to provide additional context and background to the actions proposed in Chapter 2 of this Proposed Action.

This appendix summarizes the results of actions taken by the Action Agencies under the 2008 NOAA Fisheries Federal Columbia River Power System Biological Opinion, as supplemented in 2010 and 2014 (collectively referred to herein as the 2008 BiOp) to improve survival of juvenile and adult Pacific salmon and steelhead (Oncorhynchus spp.) while operating the fourteen federal multi-purpose dams in the Columbia River System (Figure D- 1). These management actions and evaluations are the responsibility of the U.S. Army Corps of Engineers (Corps), Bureau of Reclamation (Reclamation) and the Bonneville Power Administration (Bonneville). This report primarily focuses on how the eight federal dams with fish passage in the lower Snake and lower Columbia rivers (fish passage dams) are configured and operated. It also examines the associated effects on juvenile and adult salmon and steelhead life stages, including the effects of smolt transportation.

Figure D- 1. The 14 Federal Columbia River System multiple-use projects, including four on the Lower Columbia River (Bonneville, John Day, The Dalles, McNary) and four on the lower Snake River (Ice Harbor, Lower Monumental, Little Goose, Lower Granite).

D.2. Configuration and operational improvements under the 2008 BiOp

The 2008 BiOp was broad in scope, and its RPA called for a variety of actions affecting salmon and steelhead throughout their life cycle, with the goal of improving the survival and productivity of each listed species (ESU or DPS). Actions included improving passage conditions through the Columbia River System, as well as additional conservation actions, such as improving habitat conditions in spawning tributaries and the Columbia River estuary, reducing predation in the migratory corridor, and completing updates to hatchery genetic management plans.

Survival standards in the 2008 BiOp called for 96 percent and 93 percent dam passage survival of spring- and summer-migrating juveniles, respectively, at each of the eight Columbia River System dams on the lower Columbia and Snake rivers. Actions to accomplish this have included installation of surface passage systems, improved turbine designs and upgrades of screened bypass systems to improve how and where fish are returned to the river below dams, as well as spill operations tailored to the unique structural configuration of each dam. Most of these modifications have now been designed, installed or implemented, and tested through a rigorous performance standard testing methodology. In their 2017 supplemental hydrosystem module for recovery planning NOAA found that survival studies show that with few exceptions, these measures are performing as expected and are very close to achieving, or are already achieving, the juvenile dam passage survival objectives of 96 percent for yearling Chinook salmon and steelhead and 93 percent for subyearling Chinook salmon in the 2014 BiOp (NOAA, 2017).

Dam-specific spill operations

Spill has long been an important tool employed by the Action Agencies to reduce the proportion of fish passing through turbines and increase overall dam passage survival. For example, spill was first used to pass juvenile fish at Bonneville, The Dalles, John Day, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams in 1983. Action Agency and regional scientists and engineers have since conducted many years of extensive engineering and biological studies to understand how to best operate spillways to accommodate downstream juvenile fish passage without excessive TDG generation or impeding upstream adult passage. In recent years, spill has become increasingly important because of the installation of spillway weirs. Because of their high fish passage effectiveness, surface passage structures such as spillway weirs pass large numbers of fish with less flow than conventional spillbays.[57] Since the early 2000s, much of the Action Agencies' focus has been on using spill in conjunction with surface passage structures to facilitate safer juvenile fish passage at dams. In general, the addition of surface passage structures at all eight dams, combined with refined spill operations, decreased the proportion of juveniles that passed through powerhouses and turbines, decreased forebay residence times, reduced the number of juvenile fish diverted through the fish bypass facilities at some dams, and increased overall dam survival.

Determining the appropriate spill level and pattern can involve balancing competing objectives. It is important to understand that more spill is not necessarily better for fish. For example, high spill volumes can delay the migration of adult fish moving upstream and generate increased dissolved gas levels in the river, which can be harmful to fish and other aquatic species in the water column. Spilling high volumes can increase the number of adults that fall back over the spillway (Reischel and Bjornn 2003). This forces fish to locate fish ladders again, increasing both dam passage times and the total amount of energy expended by the fish as they migrate through the fish passage projects. Fish that take longer to pass dams are less likely to complete the migration to their final spawning locations (Caudill et

[57] At some projects, increased spill also may increase the proportion of river flow going through conventional spill bays, drawing fish away from the spillway weir, which testing at the dams has demonstrated is typically the safest passage route. For example, NOAA noted in an assessment of passage in 2008 at Ice Harbor Dam, there exists a point of diminishing returns, where additional spill reduces the overall effectiveness of the spillway weir, as well as the spillway as a whole (Axel et al. 2010).

al. 2007). High TDG levels can be harmful to fish (salmonids and resident species), including adults, juveniles, embryos and larvae, and other aquatic species depending on water depth, temperature, and the physiological health of the organism (McGrath et al. 2006).

The effects of gas supersaturation on juvenile and adult salmon caused by spill at levels that result in higher TDG levels has been a concern since the mid-1960s (Ebel and Raymond 1976). The U.S. Environmental Protection Agency (EPA) water quality standards limit total dissolved gas to 110 percent saturation. However, the Oregon and Washington state regulatory agencies issued a standards modification (Oregon) or criteria adjustments (Washington) to allow higher TDG levels to facilitate higher levels of spill to aid passage of juvenile salmon, and spill levels are managed consistent with these applicable state water quality standards.[58]

Benefits of surface passage

The 2008 BiOp recommended project-specific spill operations to facilitate safe fish passage at each of the lower Snake and lower Columbia dams during the juvenile salmon migration. Along with these spill operations, spillway weirs and other surface passage routes were incorporated at all eight fish passage dams by 2010. Surface passage structures provide more natural passage conditions for juvenile salmon and steelhead and are designed to improve survival, reduce forebay residence time and use water more efficiently by passing more fish through a given unit of water. Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and John Day dams have spillway weirs in one or more spillbays (Figure D-2, Figure D-3). The Dalles Dam[59] and Bonneville Dam have surface passage systems at the powerhouses.

These spill operations, along with spillway weirs and other surface passage routes have reduced the percentage of fish that pass through turbines, decreased fish travel time and increased the overall survival of juveniles through the system. Importantly, effective locations for surface passage at each dam were selected based on detailed analysis involving hydraulic modeling and site-specific fish monitoring studies. With the addition of spillway weirs and other improvements, new spill patterns were developed using the expertise of regional scientists and engineers. These spill patterns are designed to improve conditions leading to and exiting the spillways under the spill levels called for in the 2008 BiOp.

[58] The Oregon TDG standard modification specifies that from April 1 through August 31 TDG levels are not to exceed 120 percent in the tailwater, measured as the average of the twelve highest hourly readings in any one day. The Washington criteria adjustment specifies that TDG levels are not to exceed either 120 percent in the project tailwater or 115 percent in the forebay of the next downstream dam. This is measured as the average of the twelve highest consecutive hourly readings in any one day. The criteria also specify that TDG levels are not to exceed 125 percent for more than one hour (State of Washington) or more than two hours (State of Oregon).

[59] The Dalles Dam does not have a screened bypass system, and has a unique configuration where a surface spillway weir would not provide the same benefit as at other projects. Surface passage is provided by a sluiceway, similar to Bonneville Dam's first powerhouse.

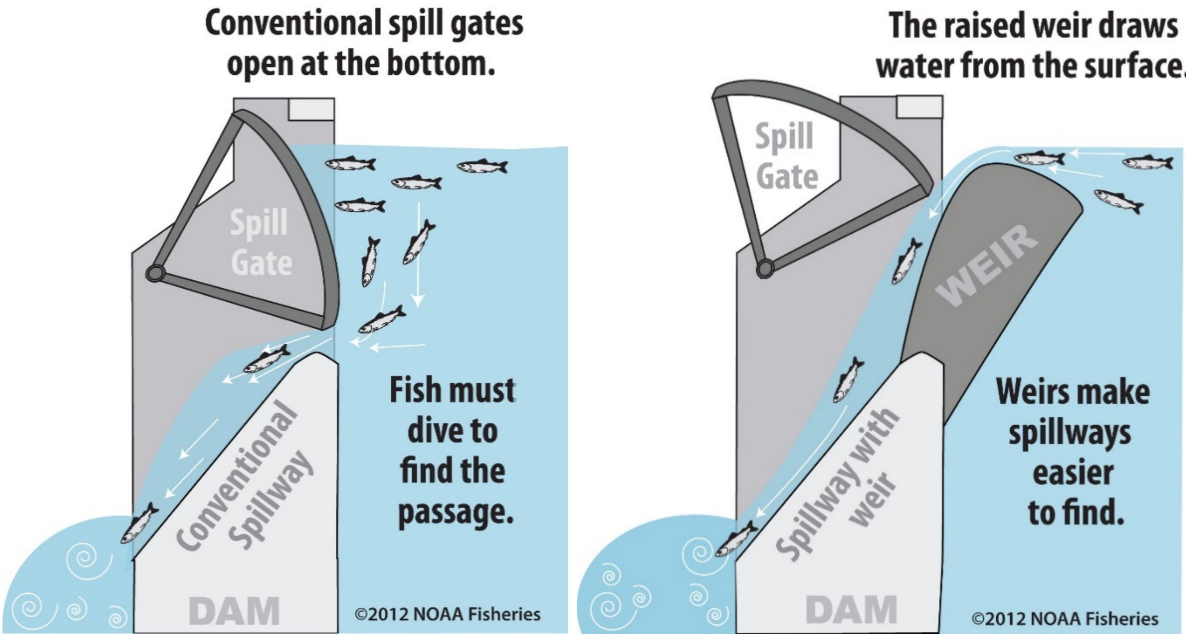

Figure D- 2. Spillway weirs allow fish to pass dams at the surface, where they naturally travel.

Figure D- 3. A spillway weir in operation at McNary Dam.

Improvements to powerhouse routes of passage

Fish can pass through the powerhouse at each dam through power-generating turbines or screened fish bypass systems. Although these two routes of passage are very different, some regional fish managers group them together to refer collectively as "powerhouse passage."

Screened juvenile bypass systems are incorporated into powerhouses at seven Columbia River System fish-passage dams to guide fish away from turbine intakes and into bypass channels.[60] Several of the systems can be operated in either bypass mode, routing fish directly to the downstream tailrace to return them to the river, or collection mode, so that fish can be collected, counted and evaluated, and released downstream or, in some cases, transported. Under the 2008 BiOp, screened bypass/collection systems have also undergone substantial modifications, including a complete overhaul of the juvenile bypass system at Lower Granite Dam and relocating the bypass exits at McNary, Lower Monumental, and Little Goose dams to reduce predation.

Additional juvenile bypass modifications have been made at Bonneville Dam. The Corps continued field investigations and design of fish survival upgrades to the Bonneville Dam second powerhouse (PH2) juvenile bypass system. Previous modifications to that system resulted in an increase in the percentage of juvenile fish going through the bypass system rather than the turbines, but also increased the incidence of injury to juvenile fish, particularly to smaller juveniles when the turbines were operated at the upper end of the 1 percent peak efficiency range. In 2014, the Corps completed the installation of a recommended gatewell flow reduction device mounted in a single PH2 gatewell behind the barrier screen. Hydraulic and biological evaluations in 2015 indicated that the device performed as expected and reduced turbulence in the gatewell, improving hydraulic conditions and juvenile fish survival when operating the turbine unit. That modification has now been made to all PH2 units.

In early 2018, the Corps completed a major overhaul of the juvenile bypass system at Lower Granite Dam. The upgrades included replacing 10-inch gatewell orifices with larger 14-inch orifices, widening the collection channel, daylighting the transport channel, adding new primary dewatering structures, and constructing new primary and emergency bypass outfall structures. These upgrades are expected to increase juvenile fish survival by providing more efficient control of flow, improving the removal and passage of debris, increasing attraction flow for juvenile fish and reducing risk of predation at the outfall release point.

In addition to spill improvements and bypass system improvements, the Action Agencies have implemented turbine operations designed to increase juvenile fish survival. All powerhouse units are operated within a range that is intended to reduce injury and mortality. In addition, the turbine runners in all ten units at Bonneville Dam Powerhouse 1 were replaced with a "minimum-gap" design which reduces both shear and impact injuries. At Ice Harbor Dam, the turbine runners are being replaced with new runners specifically designed to reduce injury and increase survival, and increase turbine efficiency. The runner in Unit 2 is currently being replaced, with completion expected during the summer of 2018. Unit 3 is scheduled to be completed by fall 2019, with Unit 1 scheduled for completion in 2021. Although the proportion of juveniles passing via turbines has decreased throughout the system with the

[60] The exception is The Dalles Dam where, because of its unique right-angle configuration, a very small proportion of juveniles pass through the turbines.

installation of surface passage routes at all eight dams, these upgrades at Bonneville and Ice Harbor reduce the risk of injury or mortality for those remaining fish that pass the dam through the turbines.

Other actions to improve fish passage

Structural modifications have also been completed in many dam tailraces to reduce TDG generation, improve juvenile egress away from the dam, and reduce losses from predation. A concrete wall was installed below The Dalles Dam to keep smolts in the main river channel and away from shallow areas where predation was a concern. Below The Dalles and John Day dams, improved aerial wire arrays were installed to reduce losses to avian predators. Flow deflectors were installed in most spillbays at the lower Snake and lower Columbia River dams to reduce TDG generation.

The Action Agencies have also employed additional actions to improve survival of salmon and steelhead by deterring or managing the number of piscivorous fish, marine mammals, and bird predators to reduce the impacts from predation on juvenile and adult salmon.

D.3. Juvenile fish response – spring migrants

Annual survival estimates indicate an upward trend in survival of juvenile steelhead and Chinook salmon migrating through the Snake and Columbia rivers over the last two decades. In most years, more adult fish—and more wild adult fish—are returning to the river. The current trend of the combined number of natural-origin and hatchery-origin adult fish returning from the ocean is higher than in the 1990s in nearly all years, and in several cases the highest since dam counts first began at Bonneville Dam in 1938. Ocean conditions and other factors have a significant impact on salmon returns, but analyses indicate that these upward trends in the survival of juvenile fish passing through the system and subsequent adult returns are at least partially attributable to the collective management actions implemented at individual dams.

Juvenile dam survival

Dam passage survival is defined as survival from the upstream face of a dam to a standardized reference point in the tailrace immediately below the dam. Successful performance tests for two years were required to meet the 2008 BiOp performance standards. Extensive testing has demonstrated that yearling Chinook salmon and steelhead survival rates past dams are at or near the BiOp performance standard of 96 percent survival through the dams tested to date.

A summary of dam survival test results conducted under the 2008 BiOp indicate the estimated survival of yearling Chinook ranged from 95.69 percent to 98.68 percent and estimates of steelhead survival ranged from 95.34 percent to 99.52 percent (Table D- 1). NOAA used information contained in Table D 1, to confirm that, with few exceptions, the measures the Action Agencies implemented under the 2008 BiOp are performing as expected and are achieving, or are very close to achieving, the juvenile dam passage survival objectives (NOAA 2017).

Table D- 1. Juvenile dam passage survival estimates, passage times, and spill passage efficiency for yearling Chinook salmon and juvenile steelhead derived from performance standard tests from 2010-2014.

Dam	Year	Species	Dam Passage Survival (percent with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (percent)	Spill Operation (Target / Actual)
Bonneville(1)	2010	Yearling Chinook Salmon	95.69 (0.42)	n/a	n/a	100 kcfs / 100 kcfs (30 Apr – 13 May)
Bonneville(2)	2011	Yearling Chinook Salmon	95.97 (1.76)	0.55	59.59	100 kcfs / 181 kcfs (season-wide)
Bonneville(1)	2010	Steelhead	97.55 (1.80)	n/a	n/a	100 kcfs / 100 kcfs (30 Apr – 13 May)
Bonneville(2)	2011	Steelhead	96.47 (2.12)	0.85	64.06	100 kcfs / 181 kcfs (season-wide)
The Dalles(3)	2010	Yearling Chinook Salmon	96.41 (0.96)	1.28	94.66	40% / 39.9%
The Dalles(3)	2010	Steelhead	95.34 (0.97)	1.28	95.36	40% / 39.9%
The Dalles(4)	2011	Yearling Chinook Salmon	96.00 (0.72)	0.97	83.1	40% / 43.1%
The Dalles(4)	2011	Steelhead	99.52 (0.83)	0.81	89.1	40% / 43.1%
John Day(5)	2011	Yearling Chinook Salmon	96.66 (1.03) 97.84 (1.07) 96.76 (0.71)	2.0 1.5 1.42	61.2 66.4 63.68	30% / 30% 40% / 40% Season-wide
John Day(5)	2011	Steelhead	98.36 (0.90) 98.97 (0.96) 98.67 (0.61)	4.3 3.2 2.91	61.2 66.4 62.78	30% / 30% 40% / 40% Season-wide
John Day(6)	2012	Yearling Chinook Salmon	96.73 (0.65)	1.15	74.56	30% / 37.1% 40% / 37.1%
John Day(6)	2012	Steelhead	97.44 (0.28)	2.39	74.52	30% / 37.1% 40% / 37.1%

Dam	Year	Species	Dam Passage Survival (percent with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (percent)	Spill Operation (Target / Actual)
McNary(7)	2012	Yearling Chinook Salmon	96.16 (1.40)	1.76	72.46	40% / 50.9%
McNary(7)	2012	Steelhead	99.08 (1.83)	1.78	83.15	40% / 50.9%
McNary(8)	2014	Yearling Chinook Salmon	96.10 (1.27)	1.73	71.40	40% / 52.6%
McNary(8)	2014	Steelhead	96.98 (1.36)	2.57	84.33	40% / 52.6%
Lower Monumental (9)	2012	Yearling Chinook Salmon	98.68 (0.90)	2.35	78.89	Gas Cap (26 kcfs) / 29.7 kcfs
Lower Monumental(9)	2012	Steelhead	98.26 (0.21)	2.17	65.85	Gas Cap (26 kcfs) / 29.7 kcfs
Little Goose (10)	2012	Yearling Chinook Salmon	98.22 (0.76)	2.58	65.28	30% / 31.8%
Little Goose(10)	2012	Steelhead	99.48 (0.81)	2.67	56.09	30% / 31.8%

There were no tests conducted in 2015, 2016 or 2017. Spill passage efficiency is the percent of all downstream migrating juvenile salmon and steelhead that pass a dam through the spillway and other surface passage routes.

(1)Ploskey et al. 2012, (2) Skalski et al. 2012b, (3) Carlson and Skalski et al. 2010, (4) Skalski et al. 2012a, (5) Skalski et al. 2012e, (6) Skalski et al. 2013d, (7)Skalski et al. 2012d, (8) Skalski et al. 2014, (9) Skalski et al. 2013a, (10) Skalski et al. 2013b

Relationship between juvenile dam survival and SAR

Salmon survival can be measured over different distances and periods. Survival from the smolt life stage to adulthood encompasses most of the salmon life cycle over a period of years and is often referred to as smolt-to-adult returns or SARs. This metric reflects the influence of many factors, most notably ocean conditions that may substantially increase or reduce returns. To provide a clear measure of improvements in dam passage survival at a single dam once a configuration or operational improvement has been completed, juvenile dam passage survival performance standard tests are conducted for two consecutive years to estimate juvenile dam passage survival. These estimates of survival differ from SARs in that the estimates are a snap shot of survival for juveniles passing a single dam whereas SARs span a greater portion of the fish's entire life cycle.

Monitoring protocols to estimate survival past each dam were developed by the Action Agencies in consultation with NMFS. These protocols have been peer reviewed and are standardized and systematic

(Skalski et al. 2016). The performance standard tests are based on state-of-the-art experimental designs, fish tag technologies, and analytical frameworks. The tests also employ standardized fish handling and marking procedures across test sites. The protocols are used to develop annual estimates of survival, which are compared against the 96 percent performance standard specified in the BiOp. The Northwest Power and Conservation Council's Independent Scientific Review Panel called the testing design "well-reasoned, justified and described" and said the testing would provide important information on how fish pass dams and help assess the benefits of structural changes made at dams (ISRP 2009). Prior to the 2008 BiOp, testing focused on evaluating specific configurations and operations. The tests conducted were statistically rigorous and provided valuable information. Although dam passage survival research was conducted at a majority of dams in the Columbia River System, researchers used a variety of tagging and mark-recapture experimental designs that varied across years and among dams. Early evaluations focused on testing specific configurations and operations. However, once the structural and operational improvements identified in the 2008 BiOp were in place, performance tests using standardized methods and techniques were recommended to estimate survival in a consistent manner across years and sites. Additionally, to ensure consistency, a single research team has monitored survival at Columbia River System dams. Performance testing using the new methods began in 2010. (Figure D- 4 and Figure D- 5)

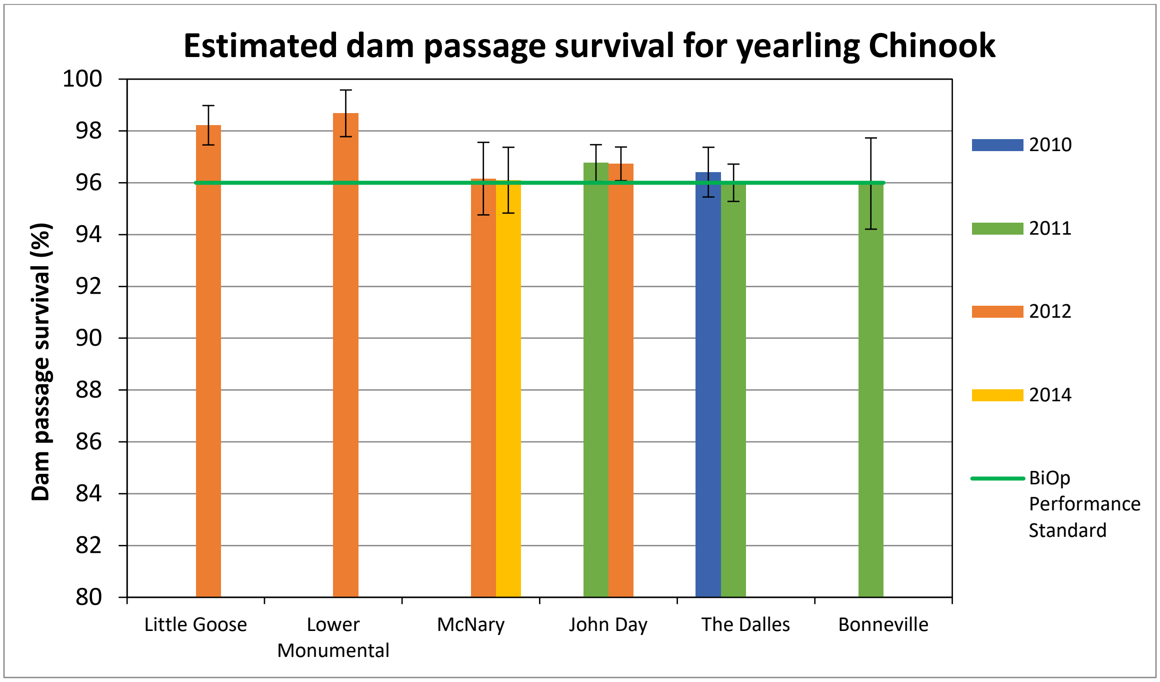

Figure D- 4. Estimated dam passage survival for yearling Chinook salmon. The BiOp performance standard for yearling Chinook salmon is 96 percent.

Bars represent annual mean survival estimates. Whisker plots represent standard error.

Skalski et al. 2012b, Carlson and Skalski et al. 2010, Skalski et al. 2012a, Skalski et al. 2012e, Skalski et al. 2013d, Skalski et al. 2012d, Skalski et al. 2014, Skalski et al. 2013a, Skalski et al. 2013b

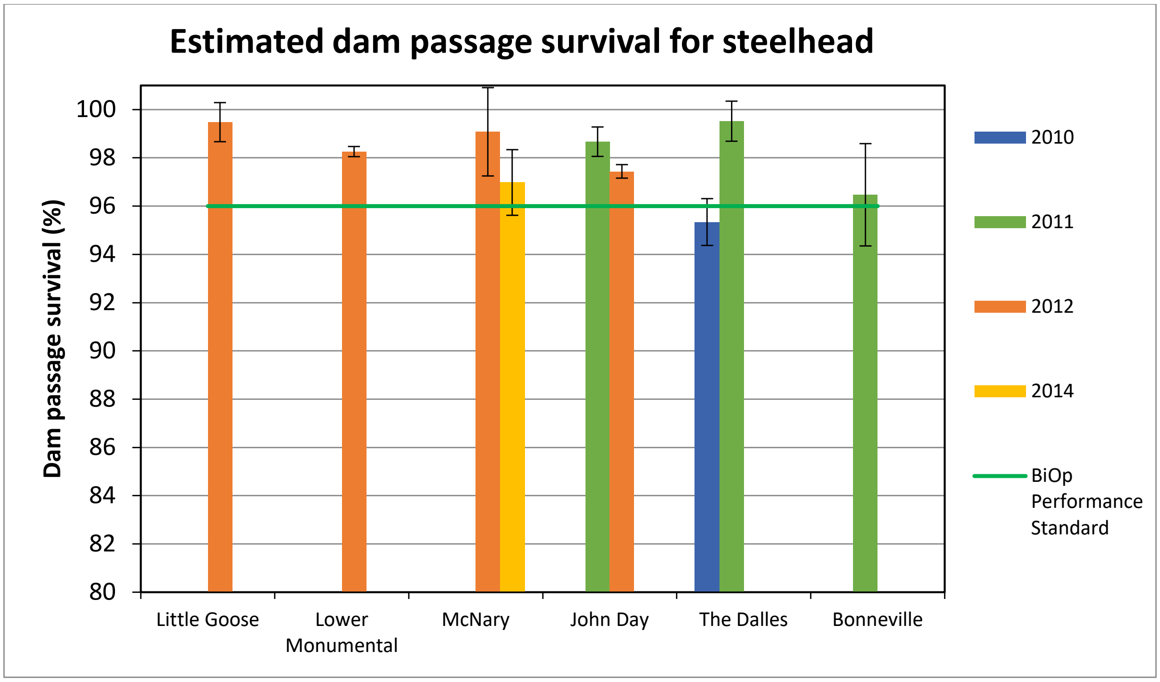

Figure D- 5. Estimated dam passage survival for steelhead. The BiOp performance standard for steelhead is 96 percent.

Bars represent annual mean survival estimates. Whisker plots represent standard error.

Skalski et al. 2012b, Carlson and Skalski et al. 2010, Skalski et al. 2012a, Weiland et al. 2011, Weiland et al. 2013, Skalski et al. 2012d, Skalski et al. 2014, Skalski et al. 2013a, Skalski et al. 2013b

Reductions in dam passage time

The installation and operation of surface passage structures, combined with spill operation modifications, has resulted in faster passage of juvenile fish past dams. Travel time through the Columbia River System (e.g. Lower Granite to Bonneville) is monitored using PIT tags. Acoustic-tagged fish released during performance standard tests were also used to monitor the transit time of juvenile salmon through the dam forebays. Forebays are the portion of reservoirs located immediately upstream from dams. Prior to the installation of surface passage structures, fish might spend several hours in a dam forebay before finding their way through standard spillway outlets, turbines, or screened bypass systems, all of which are 40 feet or more below the surface of the water. Prior to the 2008 BiOp forebay delays were especially prevalent under conditions of no spill and low river flows. Reducing passage timing delay in the forebay has been demonstrated to reduce fish exposure to predators (Ferguson et al. 2005). Results of the most recent testing indicate that median forebay passage times for yearling Chinook salmon were relatively short and ranged from 0.6 hour at Bonneville Dam (Skalski et al. 2012b) to 2.6 hours at Little Goose Dam (Skalski et al. 2013b) and were typically less than two hours. The 2.6-hour passage time at Little Goose was almost 30 percent less than the 3.6-hour passage time measured in the year prior to the installation of surface passage (Absolon et al. 2008). Median forebay passage times for steelhead were also relatively short and ranged from 0.8 hour at The Dalles Dam (Skalski et al. 2012a) to 2.7 hours at Little Goose Dam (Skalski et al. 2013b).

Turbine and bypass passage

The suite of 2008 BiOp actions implemented to date has reduced the proportion of fish passing through the powerhouse (i.e. turbines and bypass systems), and increased the proportion going through routes such as spillways and surface passage. The combined proportion of juvenile fish passing through non-turbine routes is known as fish passage efficiency (FPE). Based on the most recent testing, FPE has increased significantly since the 2008 BiOp and is now typically above 87 percent for spring migrants and 70 percent for summer migrants at all dams (Table D- 2). FPE estimates are generally higher at lower Snake River dams than those in the Columbia River. With the installation of spillway weirs and other surface passage structures coupled with spill for juvenile fish passage, more juvenile fish are using non-turbine passage routes. As a consequence, the proportion of fish passing dams through screened juvenile bypass systems has also decreased from pre-BiOp levels and is currently at or below 41 percent at all dams, and is typically less than 25 percent (Table D- 3).

Table D- 2. Estimated proportion (%) of juvenile fish migrating through non-turbine routes at mainstem Columbia and Snake River dams*

Location (Dam)	Year of Testing	Yearling Chinook Salmon FPE (%)	Steelhead FPE (%)	Subyearling Chinook Salmon FPE (%)
Bonneville[1]	2012	-	-	69.7
The Dalles[2]	2012	-	-	78.4
John Day[3]	2012	92.7	97.0	85.8
McNary[4]	2012	96.8	87.7	90.9
Lower Monumental[5]	2012	94.8	96.5	92.4
Little Goose[5]	2012	96.3	98.0	95.1
Lower Monumental[6]	2013	-	-	95.1
Little Goose[6]	2013	-	-	95.0
McNary[7]	2014	91.2	97.3	80.9

*(Note: Commonly defined as Fish Passage Efficiency (FPE))

1. Source: Skalski et al. (2013e), 2. Source: Skalski et al. 2013f, 3. Source: Skalski et al. (2013b), 4. Source: Skalski et al. (2012d), 5. Source: Skalski et al. (2013a) 6. Source: Skalski et al. (2013b). 7. Source: Skalski et al. (2015).

Table D- 3. Estimated proportion (%) of juvenile fish migrating through screened bypass systems at mainstem Columbia and Snake River dams

Location[1]	Year of Testing	Yearling Chinook Salmon (%)	Steelhead (%)	Subyearling Chinook Salmon (%)
Bonneville Dam[1]	2010	-	-	3
	2011	5	2	-
John Day[1]	2010	-	-	11
	2011	25	33	-
McNary[2]	2012	24	-	-
Ice Harbor[3]	2008	14	22	21
Lower Monumental[4]	2009	20	29	30
Little Goose[5]	2009	24	41	24

Source: 1.Ploskey et al. (2012), 2. Skalski et al. (2012d), 3. Axel et al. (2010), 4.Hockersmith et al. (2010), 5. Beeman et al. 2010

Spill, travel time, and survival

The proportion of water spilled at each project and how it affects juvenile travel times and overall system survival has been extensively studied since the 2008 BiOp. Travel time through the system is an important consideration for direct survival for salmon and steelhead. It is also hypothesized by some parties to affect subsequent adult return rates. An investigation by Haeseker et al. (2012) identified correlations between spill and water travel time through the Columbia River System and the rate of adult returns, as measured by SARs. They also found that higher juvenile fish survival through the Columbia River System was associated with higher ocean survival. They suggested that increased spill and reduced water travel time through the Columbia River System could provide more favorable river conditions that could further improve overall life-cycle survival. However, their analysis examined fish passage data and average Columbia River System spill from 1998 to 2006, before the installation of most of the surface passage systems that have reduced travel time and made spill more efficient. That period was also prior to the implementation of the 2008 BiOp spill program.

In fact, fish travel time has notably decreased since the 2008 BiOp with the advent of spillway weir surface passage relative to prior BiOps. Travel time for yearling Chinook and juvenile steelhead through the Columbia River System fish-passage dams during the spring of 2015 (a very low flow year) was shorter than the 2003-2007 average for most of the migration season. As in previous years, the difference between the 2003-2007 average and 2015 travel time was greater for steelhead than for yearling juvenile Chinook (Faulkner et al. 2016). This may indicate that juvenile steelhead, being more surface oriented, receive a greater benefit from surface passage routes than do yearling juvenile

Chinook. In general, even in low flow years such as 2015, fish travel times have improved, associated with the reduced forebay delay resulting from the combination of increased spill, spillway weirs, and other surface passage routes.

High spill levels can have unintended consequences for all life stages of fish and other aquatic biota. Season-long, system-wide spill levels to gas cap such as those ordered by the district court for the spring 2018 fish passage season are beyond the range of scientifically studied data, as were the projected spill level recommendations from Haeseker et al. (2012). These unintended consequences may include elevated levels of TDG causing gas bubble trauma in juveniles and adults, and delayed upstream passage of returning adult salmon and steelhead. Also, higher spill levels at low to medium river flow levels can create tailrace hydraulic conditions that may hinder juvenile fish egress downstream after passage at a given dam.

Uncertainty exists as to whether powerhouse passage (passage through the turbines or juvenile bypass systems) results in latent mortality of juvenile salmon and steelhead. As described above, the results of studies, using different methods during different time periods (before and after the overhaul of the system), have come to alternative conclusions.

Juvenile river reach survival estimates

In addition to tracking survival at the individual dams on the lower Snake and Columbia rivers, the Action Agencies have monitored survival of juvenile fish over longer reaches of the river; for example, survival from Lower Granite to Bonneville Dam has been measured in different forms since the mid-1960s.

The improvements in dam passage survival and reductions in fish travel time discussed above should have resulted in changes in juvenile fish survival detectable at the reach scale. This depends on whether the change is large enough to be detected relative to other factors that may affect survival each year, such as fish size, condition, and environmental variables. Since 1993, the availability of passive integrated transponder (PIT) tags, mass tagging of representative fish, installation of multiple detection systems, and the development of statistical models have enabled juvenile fish survival through the Columbia River System reach to be standardized and estimated with greater precision.

While estimated survival varies among years and species, important patterns in the data stand out for both species (Figure D- 6). First, the severe downward trend in survival observed in earlier decades has been arrested. Also, survival through the river reaches has generally been much higher than it was prior to ESA listing in the early 1990s.

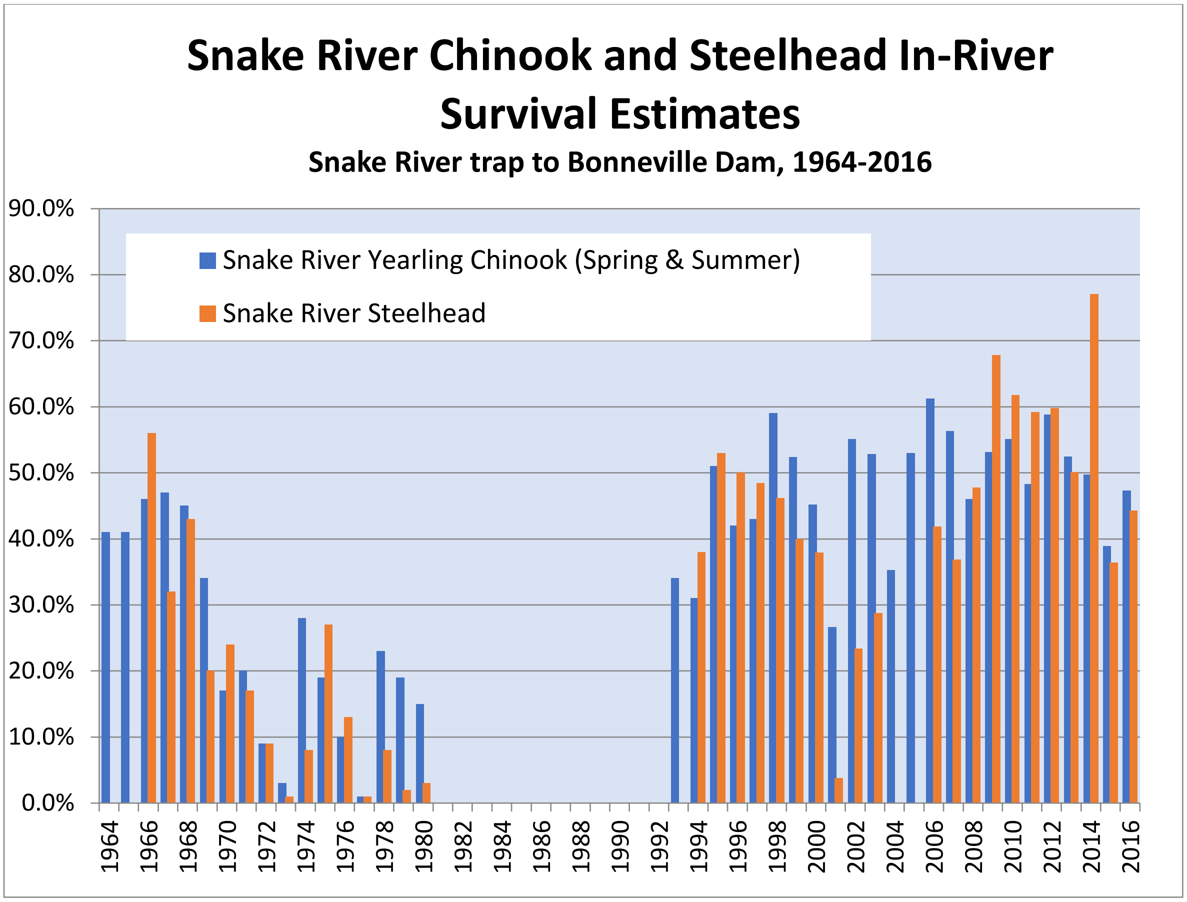

Figure D- 6. In-river survival estimates (hatchery and wild fish combined) for Snake River Chinook and steelhead, from the trap above Lower Granite Dam to Bonneville Dam.

Widener et al. 2018, Williams et al. (2001)

In-river survival through the Columbia River System today is higher than it was in the 1970s. The 1970s represent a period when most Columbia River System dams were in place and operating (the last, Lower Granite Dam, was completed in 1975), but significant improvements in passage conditions had not yet been made. It is important to recognize that any change in juvenile fish survival through the Columbia River System is the result of the overall migratory conditions encountered, including the volume and timing of runoff, the suite of management actions implemented under the 2008 BiOp, the condition of wild fish and those released from hatcheries, and the degree of predation that migrating fish are exposed to each year.

Two independent research groups estimate juvenile fish survival through dams and reservoirs on the lower Snake and Columbia rivers: NOAA's Northwest Fisheries Science Center (Science Center) (e.g., Faulkner et al. 2016) and the Comparative Survival Study (CSS) program (www.fpc.org; e.g., McCann et al. 2016). Estimates by both groups are based on PIT-tagged fish released from hatcheries throughout the basin or at traps at key locations in the migration corridor, and subsequently detected at one or more receivers while migrating downstream. PIT tag data are archived and made available to the research groups through the PIT Tag Information System.

The analyses generated by each group have different purposes and use different aggregates of fish groups in the estimates, making direct comparisons of the results challenging. In general, CSS estimates travel time and survival for both hatchery and wild-origin fish marked above Lower Granite Dam, and the Science Center use a composite population for estimates, including fish marked at Lower Granite Dam. Since this review focusses on survival trends for the composite population, much of the review below is based on Science Center estimates of reach survival from Faulkner et al. (2016).

Post-2008 BiOp Snake river reach survival (Lower Granite to Bonneville)

Snake River spring Chinook and steelhead

Since the 2008 BiOp, annual Science Center wild- and hatchery-origin Snake River salmon survival estimates from Lower Granite to Bonneville have ranged from 43 to 63 percent for yearling Chinook salmon, 42 to 76 percent for steelhead, and 12 to 71 percent for sockeye salmon. Comparing annual estimated survival during the post-BiOp period (2008-2016) to the pre-BiOp period (beginning in 1997, 1998 or 1999, through 2007; varies by species) indicates that the relative mean estimated survival has increased for all species (Figure D- 7). The mean estimated annual survival for each of the three species calculated by the Science Center for the post-BiOp period is 53.8 percent for Chinook salmon, 56.6 percent for steelhead, and 46.7 percent for sockeye (Figure D-7). Sockeye salmon (a 36.2 percent relative increase) and steelhead (a 57.2 percent relative increase) survival have increased more than for Chinook salmon (a 4.3 percent increase). However, Chinook salmon already experienced a relatively high mean estimated survival through the system before the suite of actions under the 2008 BiOp.

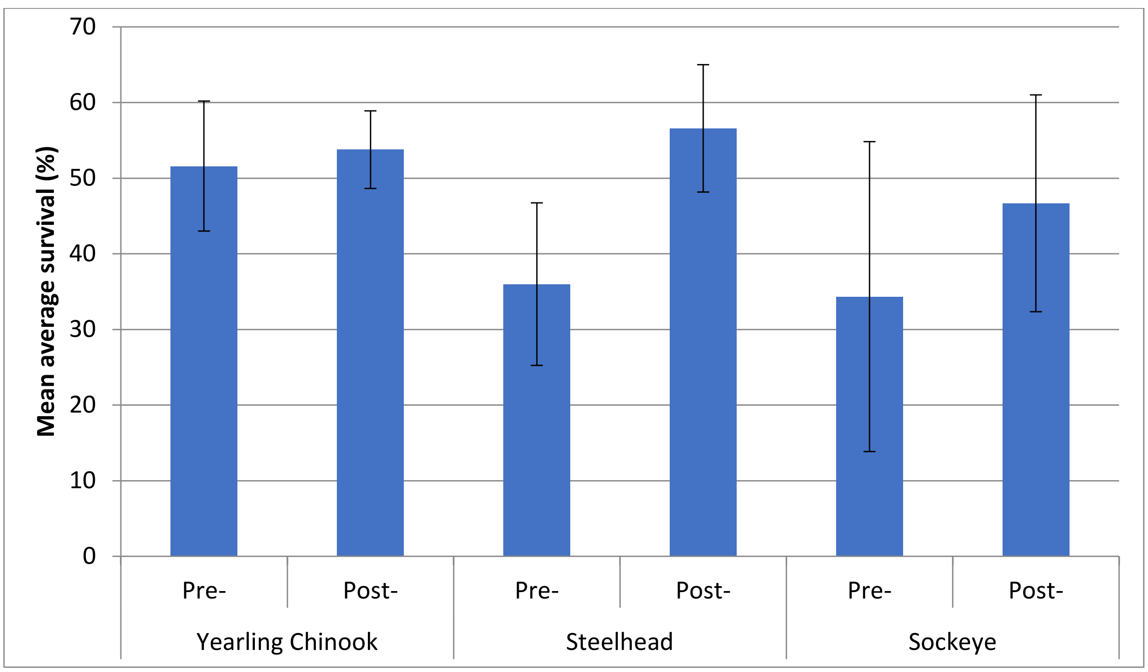

Figure D- 7. Estimated mean annual survival of hatchery and wild fish (with whiskers representing 95 percent confidence intervals) from Lower Granite tailrace to the Bonneville tailrace in pre-BiOp (1996-2007) and post-BiOp (2008-2016) time periods.

(Note: Data were obtained from Faulkner et al. 2016, as well as personal correspondence with Faulkner, April 10, 2016. Data include hatchery- and wild-origin fish.)

According to Faulkner et al. (2016), annual reach survival for yearling Chinook salmon have remained relatively stable since 1999, with the exception of 2001, 2004, and 2015, which were all lower-flow water years. The increase in steelhead survival since 2001 (a severe drought year) is notable. In 2001, most fish were transported around dams and the few fish remaining in the river were likely preyed upon heavily. Steelhead survival through the eight Columbia and Snake River fish passage dams was approximately 4 percent that year (Faulkner et al. 2016) (Figure D- 8).

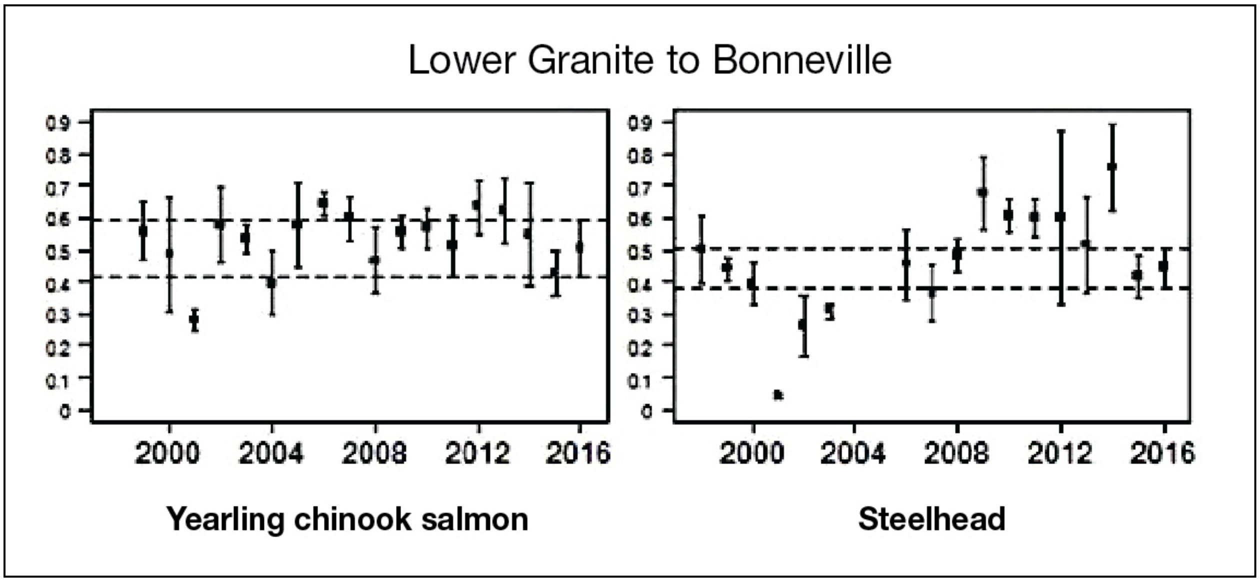

Figure D- 8. Annual average survival probability estimates for PIT-tagged Snake River yearling Chinook salmon and steelhead (hatchery and wild combined) from Lower Granite Dam to Bonneville Dam, 1993-2016.

Estimates are from tailrace to tailrace. Vertical axis runs from 0 to 0.9 probability. Vertical bars represent 95 percent CIs. Horizontal dashed lines are 95 percent CI endpoints for 2016 estimates. Figure from Faulkner et al. (2016).

Relatively high reach survival for yearling Chinook salmon and steelhead since the 2008 BiOp may be related to the operation of surface passage structures at dams (Hockersmith et al. 2010; Axel et al. 2010; Plumb et al. 2003). Surface passage structures such as spillway weirs particularly benefit juvenile steelhead, which tend to be more surface oriented during migration. Most recently, lower-than-average spill discharges in 2015 may have reduced some benefit of surface passage structures in expediting fish passage (Faulkner et al. 2016). However, the observed in-river survival in 2015 increased compared to other historic low-flow and drought years, such as 2001 and 2004, which may reflect improved passage efficiency since the 2008 BiOp.

Snake River sockeye salmon

The ability to estimate survival for sockeye salmon depends on detection rates and numbers of fish tagged each year. Recently, there has been an increased effort to PIT tag upper Columbia and Snake River sockeye. As a result, sufficient data have been available for annual estimates of survival for Snake River sockeye salmon. The long-term (1998-2016) mean estimated sockeye survival rate from the tailrace of Lower Granite Dam to the tailrace of Bonneville Dam is 40.5 percent, although with considerable year-to-year variation (Faulkner et al. 2016).Despite the increased tagging efforts, the detection rates of these fish remain low due to the increasing use of surface passage routes where fish are not detected. This decreases the precision of survival estimates. At present, we can only assume sockeye salmon survival is dependent on factors similar to those affecting survival of yearling Chinook salmon and steelhead.

While the survival probability estimates above were for wild- and hatchery-origin fish combined, Faulkner et al. (2016) also provided separate estimates for wild fish and for hatchery fish. While the patterns in survival are similar to those reported for wild and hatchery combined, wild yearling Chinook salmon fared slightly worse than the combined group, with 48 percent (versus 53 percent) average survival over the 1999-2016 period. Over the same period, wild steelhead showed the same trend, with 42 percent average survival (versus 46 percent for wild and hatchery combined).

Columbia River reach survival – McNary to Bonneville

Upper Columbia spring Chinook and steelhead

The Science Center has calculated survival estimates of hatchery-origin yearling Chinook salmon and steelhead migrating from the upper Columbia River through the four lower Columbia River fish-passage dams since the late 1990s (Faulkner et al. 2016). The annual estimated survival of upper Columbia River hatchery-origin yearling Chinook salmon between McNary Dam and Bonneville Dam has averaged approximately 81 percent since 1999, ranging from 62 to 106 percent.[61]

Annual survival estimates of hatchery-origin steelhead averaged 73 percent since 2003, and have ranged from approximately 49 to 107 percent. Though Faulkner et al. (2016) did not break out upper Columbia hatchery and wild sockeye salmon, the combined estimated survival from McNary to Bonneville tailrace was higher for sockeye originating in the upper Columbia River Basin (0.545) than for those from the Snake (0.227), and the difference was statistically significant.

Reach survival comparisons to COMPASS

Under the 2008 BiOp, the Action Agencies monitored in-river reach survival for Snake River and upper Columbia River Chinook salmon and steelhead and reported the results annually. The BiOp calls for the Action Agencies to measure in-river survival empirically over two reaches: Lower Granite to Bonneville and McNary to Bonneville. The results are then compared with the survival estimates derived from COMPASS modeling that incorporates improvements implemented under the BiOp. COMPASS is a Comprehensive Passage model developed under NOAA's leadership to predict the effect of alternative dam operations on salmon survival rates. The model is designed to simulate survival and travel time through the Columbia River System under various river and operational conditions and can simulate the effects of different management actions, producing results that agree with available data.

For the most recent comparison, for the 2015 migration season, the COMPASS model was run for the actions implemented at the start of the 2015 migration season using 2015 river conditions, fish migration patterns, and dam and transport operations. Figure D- 9 below shows the results of these comparisons.

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[61] For practical purposes, these estimates should be considered equal to 1.0 and to represent true survival probabilities that are certainly less than 1.0 by some amount.

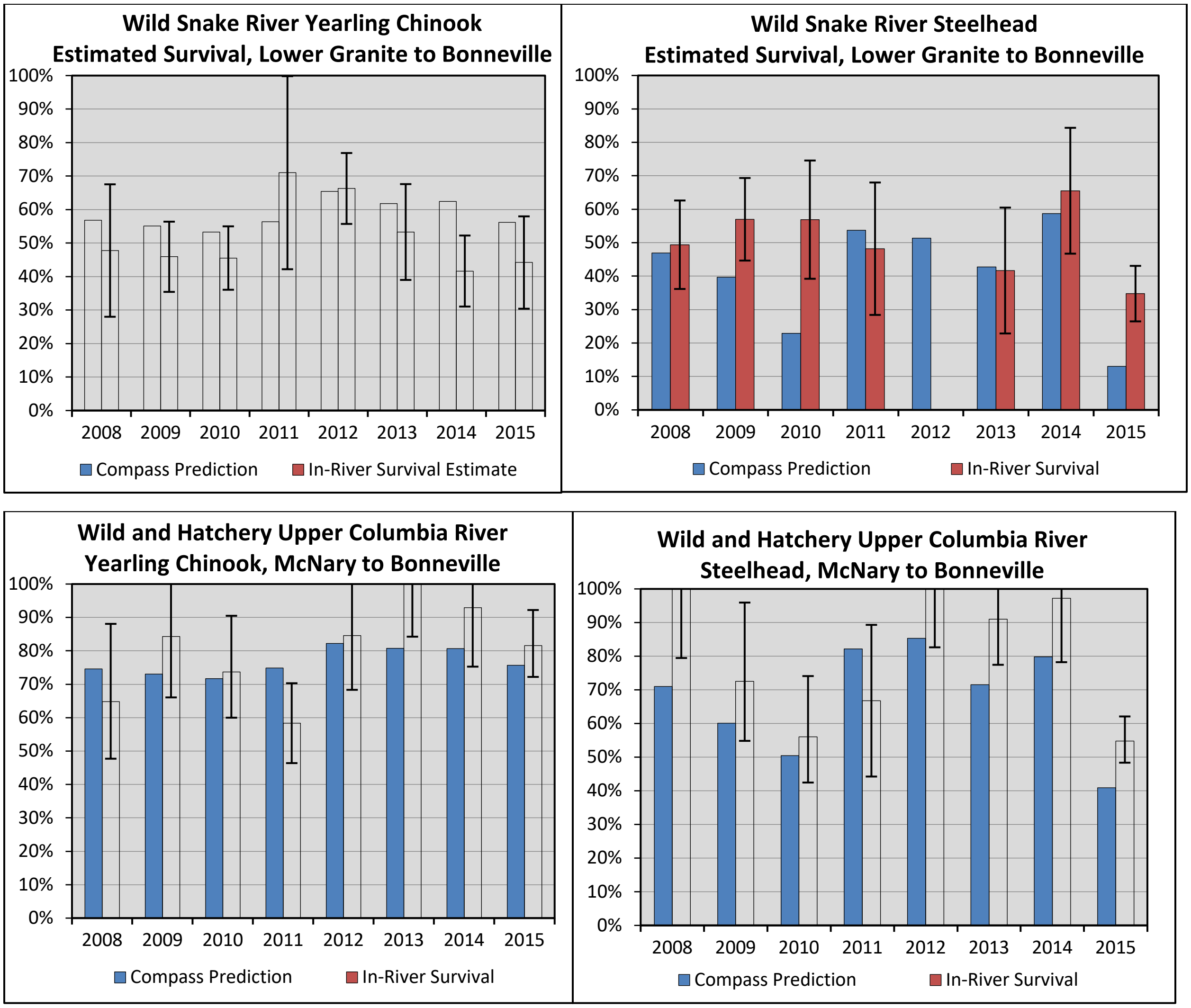


Figure D- 9. 2008–2015 COMPASS model predictions and PIT tag estimated in-river survival for juvenile Snake River (SR) wild spring/summer Chinook and steelhead and for upper Columbia River (UCR) wild/hatchery spring Chinook and steelhead.

Error whiskers indicate 95 percent confidence intervals. PIT estimate not available for wild Snake River steelhead for 2012.

Source: Widener et al. 2018

The results presented in Figure D- 9 indicate the benefits from improved system operations, passage improvements, and predation deterrent actions implemented to date are generally accruing at least as well as was expected in the BiOp analysis.

Water management and flow

In addition to dam-passage improvements discussed above, system-wide actions to improve conditions in the migration corridor have been implemented. These include flow augmentation and water management actions to shape flows to benefit the fish. These actions were initially designed to move fish downstream faster and limit their exposure to instream predators. This is also important because it assists juvenile fish in reaching marine waters when they can take advantage of optimum forage conditions and best avoid ocean predators. Scheuerell et al. (2009) analyzed data from more than 40,000 individually tagged yearling Chinook salmon and steelhead detected at Bonneville Dam on their downstream migration and at Lower Granite Dam when they returned as adults. Scheuerell et al. found that juveniles migrating from early to mid-May survived to return as adults at rates four to 50 times greater than those migrating in mid-June. They also found that the precise peak in smolt-to-adult survival varied among years, presumably reflecting variations in ocean conditions from year to year.

While one of the multiple authorized purposes of the Columbia River System projects is to manage flood risk, flow augmentation to enhance migratory conditions for juvenile and adult salmonids in the mainstem lower Snake and Columbia rivers is also important. In the upper Columbia River (downstream from Chief Joseph Dam), flow augmentation is available from upper basin storage reservoir projects in the Columbia River System, such as Grand Coulee Dam, Hungry Horse, Albeni Falls and Libby Dam, as well as other storage reservoirs in Canada. In the Snake River, river flows can be augmented using releases from Dworshak Dam, a storage project on the North Fork of the Clearwater River, as well as from releases from the non-federal, Idaho Power-owned Brownlee Dam in the Hells Canyon Complex. The foundation for flow augmentation measures was initially based on the following two premises (Giorgi et al. 2002):

- Increased water velocity → increases migration speed of smolts → increases survival.
- Lowering water temperature (summer) → improves migratory and rearing conditions for both juvenile and adult salmonids → improves survival.

Flow augmentation actions strive to meet multiple ecosystem objectives, including improved flows for anadromous fish, state and federal water quality standards that currently limit TDG concentrations; flow needs for other listed resident fish such as Kootenai River white sturgeon and bull trout; state and federal water quality standards for temperature; and reservoir refill for flow augmentation in subsequent years. Water management actions must also consider ecosystem needs as well as other public uses, including flood control, irrigation, recreation and power system management.

Hydrologic conditions in the Columbia River Basin vary among and within years and are primarily driven by the total amount and form of precipitation and the runoff pattern. This variability greatly influences Columbia River System operations and requires a process for coordinating pre-season and in-season water management decisions. The Columbia River System storage projects are operated in conjunction with Canadian projects to use the available stored volume and predicted runoff for the needs discussed above (Figure D- 10).

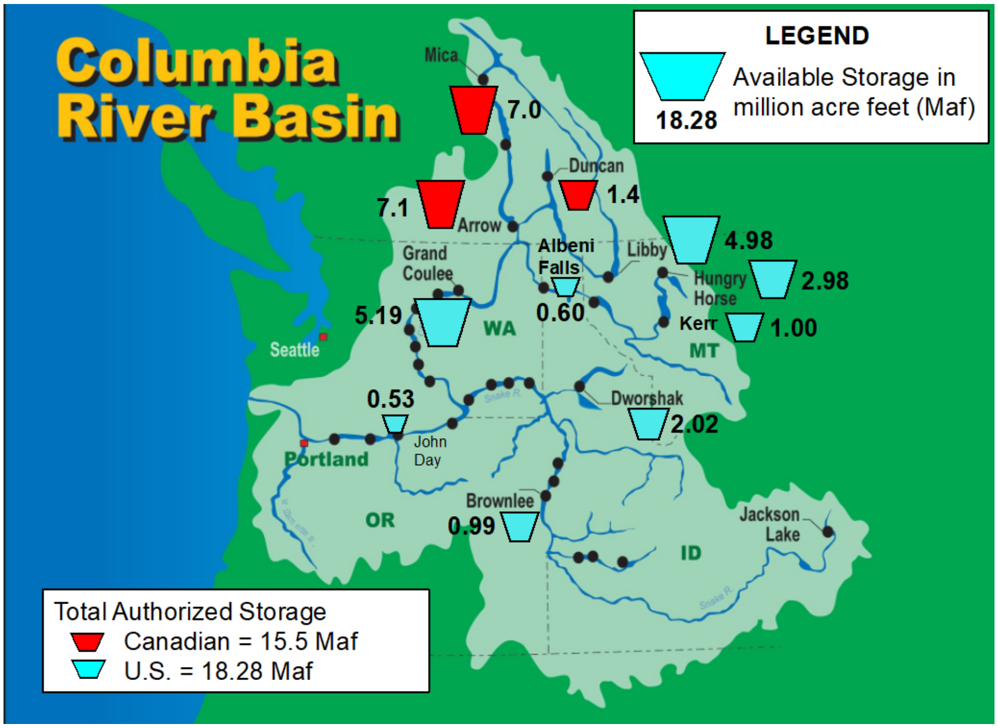


Figure D- 10. Active storage volumes at reservoirs in the Columbia River Basin

The flow objectives cannot physically be met every year given the limited storage capacity in the Columbia River System. The objectives serve as benchmarks, however, which are used to guide real-time water management decisions and maximize benefits for migrating salmon given annual conditions and stored water volumes.

Cool water releases from Dworshak Dam

During summer, when ambient river temperatures are high, flow augmentation is used to help moderate temperatures in the lower Snake River by releasing water from Dworshak Dam on the Clearwater River. This action primarily benefits juvenile fall Chinook salmon that rear and migrate in the lower Snake River during summer.

The release of cool water from Dworshak Dam also benefits adult sockeye, steelhead and fall Chinook migrating during summer. In 2015, low snow pack coupled with extremely high air temperatures throughout the interior Columbia basin resulted in warm water in the major tributaries to the lower Snake and Columbia rivers. Temperatures in the mainstem Columbia River were the highest recorded from roughly mid-June to mid-July. Recommendations from a NOAA review of river conditions in 2015 focused on continuing beneficial operations such as the cool water releases from Dworshak, and where possible, improving migration conditions for adult sockeye salmon, which experienced heavy losses in the Columbia River and tributaries (NOAA, 2016).

Lower Snake River and Lower Columbia River reservoir operations

Since 1995, Snake River projects have been operated within 1 foot of minimum operating pool (MOP) and John Day Dam has been operated within 1.5 feet of minimum irrigation pool (MIP), with the goal of reducing the cross-sectional area of these reservoirs, thereby reducing fish travel time. MOP refers to a project's lower operating range (the level below which fish facilities are no longer operational), while

MIP refers to the minimum level at which irrigation systems can effectively access water. The rationale for these operations was based on a hypothesis that reducing reservoir volume would expedite juvenile migration (Raymond 1979, Sims and Ossiander 1981; Giorgi et al. 2002).

However, under the current configuration of the eight lower river dams (e.g. with surface passage facilities) and performance-standard-based spill operations, fish travel time does not appear to change significantly under different river flow conditions. The action agencies are proposing to utilize the full 1 foot of operating range above MOP on the Snake River and 1.5 foot of range above MIP at John Day Dam by allowing for a 0.5-foot buffer in which project operators would use on a very infrequent basis. Based on the data reviewed below, it is unlikely that fish travel time would be affected by standard reservoir elevation operating differences of a few feet let alone a periodic 6-inch increase in reservoir elevations. This 6-inch potential increase in reservoir elevation would likely have no effect on overall reservoir water temperature either. The Action Agencies have reviewed previous water temperature modeling efforts and have not found any empirical information that would signal cause for concern regarding water temperature effects. The effects of alternate reservoir elevations will be reconsidered using updated water quality models that will be developed as part of the ongoing NEPA alternative analysis of Columbia River System Operations.

Since 2008, there has been a wide range in annual flow conditions experienced in the Columbia River System. For example, 2011 was a relatively high flow year, while 2015 was one of the lowest flow years on record. It is instructive to compare fish travel time between these high flow years and low flow years, as well as to compare similar flow years prior to 2008 with post-BiOp spill operations and configurations (e.g. 2001 compared to 2015). For Chinook, travel time for yearling Chinook and juvenile steelhead through the Columbia River System during the spring of 2015 was shorter than the 2003-2007 average for most of the migration season as noted previously (Faulkner et al. 2016) (Figure D- 11).

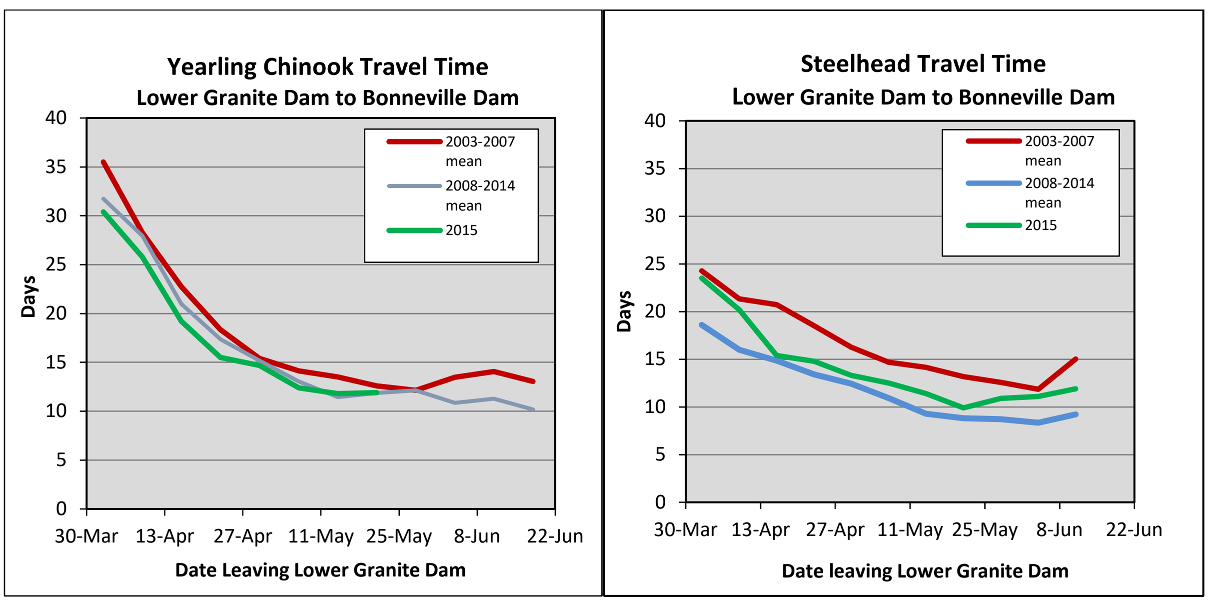


Figure D- 11. Median travel time from Lower Granite Dam to Bonneville Dam for weekly release groups of Snake River yearling Chinook salmon and steelhead. (Based on data from Faulkner et al. 2016)

Faulkner et al. (2016) evaluated fish travel time patterns within the outmigration season each year and concluded that the observed decreases in travel times for yearling Chinook salmon and steelhead later in the spring passage season generally coincided with increases in flow, and presumably with increased levels of smoltification (Figure D- 12). The fish benefits of flow augmentation or reservoir management alone cannot be estimated empirically, since juvenile fish migrations are affected by multiple factors simultaneously (e.g., climate, hydrology, and smolt characteristics such as the degree of smoltification and fish size).

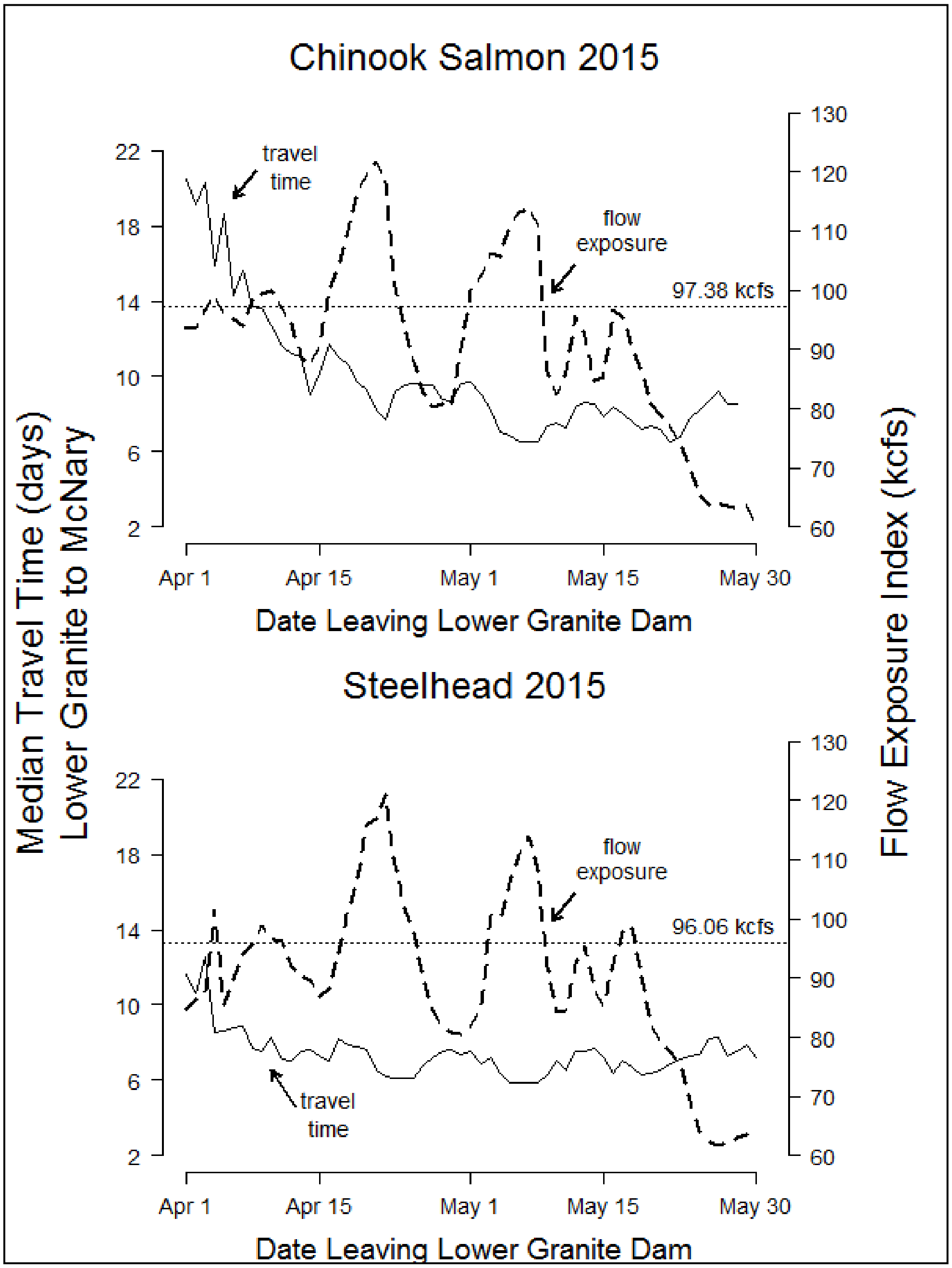


Figure D- 12. Travel time (days) for yearling Chinook salmon and steelhead from Lower Granite Dam to McNary Dam and index of flow exposure at Lower Monumental Dam (kcfs) for daily groups of PIT-tagged fish during 2016.

Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group. From Faulkner et al. (2016).

In the 2016 CSS annual report, McCann et al. (2016) used a model-based approach to assess the effects of environmental variables such as flow and spill, and found that fish travel time was most correlated to flow-based water travel time and spill. They posited that "the effect of [water travel time] most likely influences the amount of time required to transit the reservoirs, with faster [water travel time] resulting in faster fish travel time through the reservoirs."

More recent data presented by the Comparative Survival Study (McCann et al. 2017) suggests the highest survival rates are associated with lower flows. This was the case in estimates of both in-river migration survival (Figure D- 13) and predicted SARs (Figure D- 14). This effect is likely driven by CSS analysis that shows that powerhouse passage (a key factor for juvenile survival and adult returns in the CSS model) is lower under low flow conditions, when spill passage efficiency is greater than under moderate or high flows. Similarly, the modeled estimates of SARs under various flow conditions is estimated to be highest across the board with lower flows (Figure D- 14).

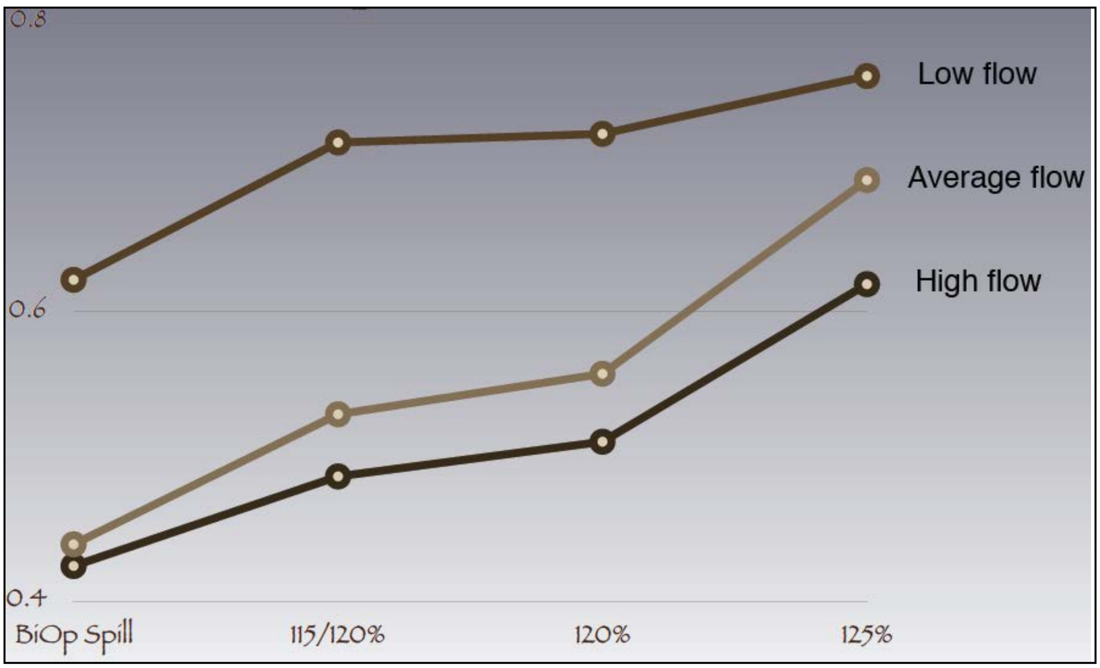


Figure D- 13. In-river migration survival (McCann et al, 2017)

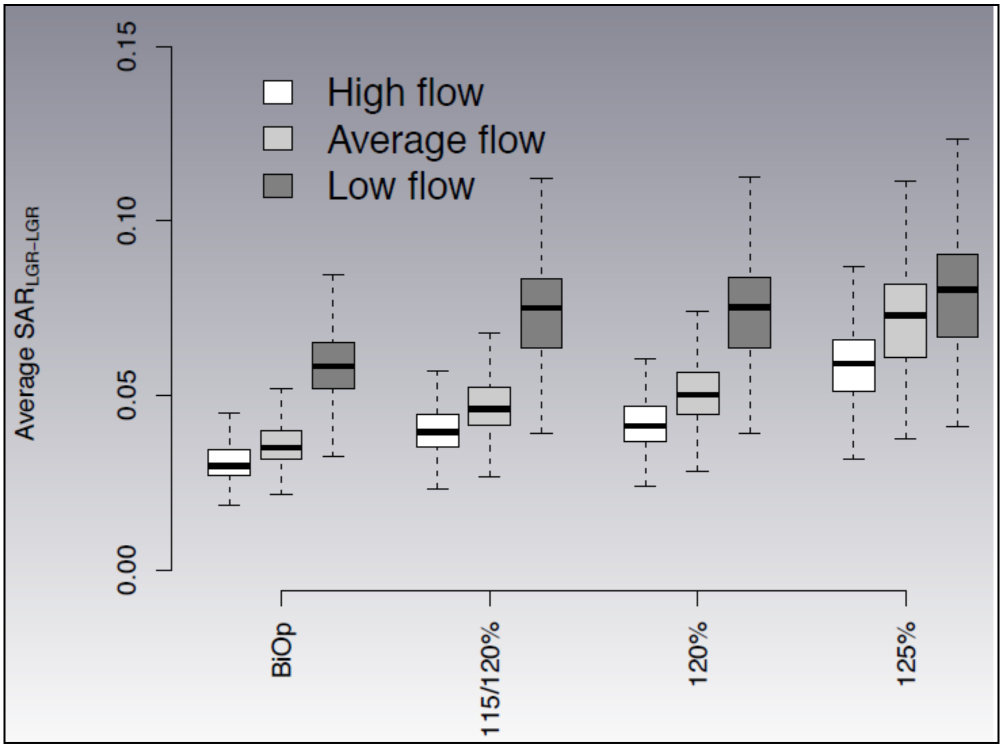


Figure D- 14. Predicted SARs (McCann et al. 2017)

Both groups that investigated relationships between flow and fish travel time determined that prior to implementation of the structural and operational improvements called for in the 2008 BiOp, targeted flow augmentation and reservoir operations contributed to increased smolt migration speed. Comparisons of fish travel time since 2010, the year in which all dams finally had surface passage routes installed, however, show that fish travel time now remains similar across widely varying flow levels. Comparisons between the low flow conditions of 2015 and high flow conditions in 2017 show very similar fish travel time despite widely divergent river conditions. Monitoring reported by NOAA (Faulkner et al. 2017) shows that under the current configuration of the Columbia River System, fish travel time does not appear to be influenced to the same degree by changes in water velocity compared to pre-2008 BiOp conditions. In other words, recent data indicate travel times for migrating salmon and steelhead are much more sensitive to passage routes at the dams (being able to pass near the surface of the water column rather than needing to sound deeper to find an outlet through the dam) than they are to changes in water particle travel time associated with river flow and reservoir elevations. Given the improved fish travel time, due to spill operations and surface passage identified in the 2008 BiOp, it is not expected that additional flow augmentation, (let alone reservoir operations that restrict elevation changes to a few feet, such as MIP and MOP), will affect fish survival substantially. Changes in fish travel time through the Columbia River System are instead, most influenced and associated with a range of actions apart from reservoir operations and flow augmentation, particularly dam passage improvements designed to achieve dam passage performance standards.

D.4. The question of latent mortality

Latent mortality remains one of the key uncertainties surrounding the operation of the eight fish passage dams on the lower Snake and lower Columbia Rivers. Reducing the uncertainty surrounding the question of whether latent mortality occurs as a result of dam passage, as well as its magnitude, and identifying any causal mechanisms, are key drivers behind the Action Agencies Proposed Action for the 2018 BiOp.

Juvenile fish passing through the eight dams in lower Snake and Columbia rivers may experience stress or other impacts that result in mortality at some point after they pass the dams, a concept that has been termed “delayed” or “latent” mortality. The theory behind latent mortality is that salmon and steelhead that migrate through the bypass systems are harmed in some manner that that is not directly observable, before they enter the estuary (where physical monitoring occurs). Proponents of this theory suggest that this harmful passage experience through the bypass system instead manifests at some point after those fish enter the ocean, resulting in substantially lower adult return rates than would have occurred had those same fish migrated through spillway passage routes instead.

The effect is often assessed by comparing the smolt to adult return (SAR) rate of groups of fish that experience different passage conditions. The comparisons of SARs can be complicated by other variables as well, such as ocean conditions and toxics in the freshwater migratory corridor, among other factors, which significantly influence life-cycle survival.

Whether latent mortality occurs as a result of dam passage route, as well as its magnitude and causal factors, have been debated for at least two decades, and investigations have produced conflicting results. The Independent Science Advisory Board has considered the topic of latent mortality many times and has continued to advise the region on efforts to understand more fully the effects of passage through the eight fish passage dams and whether any latent mortality is attributable to how the Action Agencies manage water through the system.

In 2006, NOAA requested that the ISAB review a number of hypotheses explaining the effect and causative factors thereof. The ISAB concluded that the Columbia River System causes some latent mortality, but strongly advised against continuing to try to measure absolute latent mortality, since it is not measurable relative to a pre-dam reference condition. Instead, they suggested the focus should be on the total mortality of in-river migrants and transported fish, which is the critical issue for recovery of listed salmonids (ISAB 2007).

In 2012 the ISAB again concluded that bypass systems are associated with some latent mortality, but cautioned that “the factors responsible for latent mortality remain poorly understood and inadequately evaluated” (ISAB 2012). The ISAB said the mortality may reflect a tendency for smaller and more vulnerable fish to pass through bypass systems, in which case the mortality could be related to fish condition rather than the effects of bypass systems themselves.

In their reviews of proposals intended to test the magnitude of latent mortality through alternate spill operations, the ISAB in 2014 and 2017 continued to advise the region to address study design elements to increase the likelihood that levels of spill could be isolated as a causative factor rather than a correlative influence on adult return rates (ISAB 2014, 2017).

Ongoing latent mortality research

Since the ISAB first offered its initial synthesis of latent mortality studies, several research groups have continued to delve into aspects of latent mortality hypothesized to be associated with in-river migration. Focal topics have included the effects of screened bypass systems, general migratory conditions in the Columbia River System, and the number of hydroelectric projects, particularly powerhouses, encountered. The effect is often assessed by comparing the survival of groups of fish that experience different passage conditions.

Earlier investigations focused on the impacts of screened bypass systems designed to divert fish away from turbines. Sandford et al. (2012) held juvenile fish in tanks for approximately seven months following their downstream migration through the Columbia River System but did not detect higher mortality among fish that had passed through more bypass systems. However, an analysis of 11 years of PIT-tag data by Buchanan et al. (2011) found that the more bypass systems Chinook smolts passed through, the lower the rate they returned as adults. Steelhead smolts showed similarly reduced returns after passing through two or more bypass systems. Another analysis by Rechisky et al. (2013) used acoustic tags to track two groups of hatchery fish through their downstream migration and their first month in the ocean. They found no difference in survival between juvenile fish that migrated through eight dams and others that migrated through only four. Some have questioned the validity of comparisons between different hatchery stocks and the limited period the fish were monitored in the ocean in these studies.

Recently, latent mortality research has focused on effects of “powerhouse passage” on subsequent adult returns. (Powerhouse passage refers to passage through the bypass systems and turbines, and until recently, apparently included surface passage routes at The Dalles and Bonneville as well, though that oversight was brought to the CSS researchers’ attention by the federal agencies in 2017). The CSS has developed several metrics to track the rate of powerhouse encounter rates. These metrics were originally based on the number of fish passing through the powerhouse on the proportion of flow moving through the powerhouse (NPH) and were then refined using PIT detection histories (PITPH).

Powerhouse passage, whether through turbines or screened bypass systems, is hypothesized by the CSS to reduce subsequent SARs. This hypothesized relationship has led to several calls by CSS and its proponents for experimental spill operations since 2014. These proposals called for further increases in spill levels above those provided under the 2008 BiOp in an effort to increase the number of fish using non-powerhouse routes (increased use of spillways and sluiceways). The CSS has estimated that increasing spill from 2008 BiOp levels to the current state water quality standards of 115 percent/120percent TDG levels could lead to approximately a 20 percent increase in Snake River Chinook SARs (CSS Oversight Committee, 2017). It is unclear what the CSS’s predicted increase in Columbia River stocks would be under a higher spill cap operation.

In 2014, based on the CSS hypothesis, some regional parties asked for a spill operation higher than legal TDG levels, up to 125 percent. These requests were made to the Northwest Power and Conservation Council as the Council prepared their 2014 Fish and Wildlife Program and to NOAA as they developed the 2014 Supplemental BiOp. The Council asked the ISAB to review the proposal, which informed both groups as they finalized the Fish and Wildlife Program Amendments and the BiOp. When responding to comments on its 2014 BiOp, NOAA noted that there was too much uncertainty in the CSS hypothesis to justify the risk of unintended consequences of an operation to 125 percent. The ISAB's report that was released the following month reached a similar conclusion. In its review of the 2014 proposal to spill to 125 percent TDG, the ISAB noted among other issues:

- The correlation observed in the CSS modeling between high spill levels and increased SARS is not necessarily the result of a causal relationship.
- the potential for many unintended consequences to juvenile and adult salmon that must be considered;
- the challenge of isolating a change in SARs associated with changes in spill levels from many competing factors, such as ocean conditions;
- the need for an improved study design

In 2017, as noted above, the CSS Oversight Committee submitted additional information to the ISAB to attempt once again to justify the need for spill levels above the 2008 BiOp spill program. The updated CSS modeling shows that the average powerhouse encounter rate has declined by more than 50 percent since the early-1990s (Figure D- 15). The CSS models predict that further reductions in PITPH will significantly increase SARs depending on spill levels. Under 2008 BiOp spill levels and the current Columbia River System configuration, powerhouse passage rates for Snake River average slightly less than two out of eight dams in low flow conditions and nearly three out of eight dams under average to high flow conditions. Under spill operations to the gas cap legal limits of 115/120 percent TDG, that powerhouse encounter rate is predicted to drop to just under one power house encounter on average in low flow conditions and around two powerhouse encounters under average to high flow levels. This reduction of one powerhouse encounter is currently predicted by the CSS to improve SARs by approximately 20 percent. Further reductions in PITPH that may occur as a result of spill levels beyond the legal limits are predicted to reduce PITPH to less than 0.5 and are predicted to result in SARs that are 80 percent higher than the BiOp spill program. These predictions by the CSS have varied since 2014, sometimes substantially.

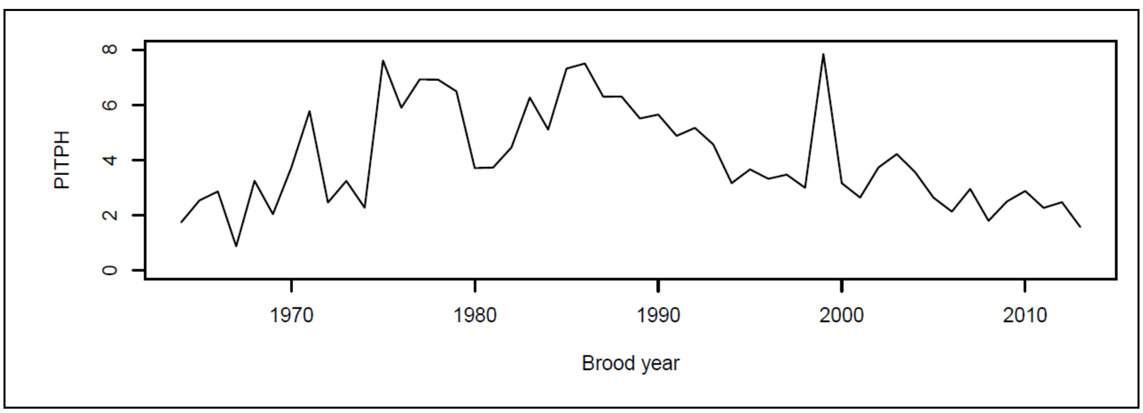
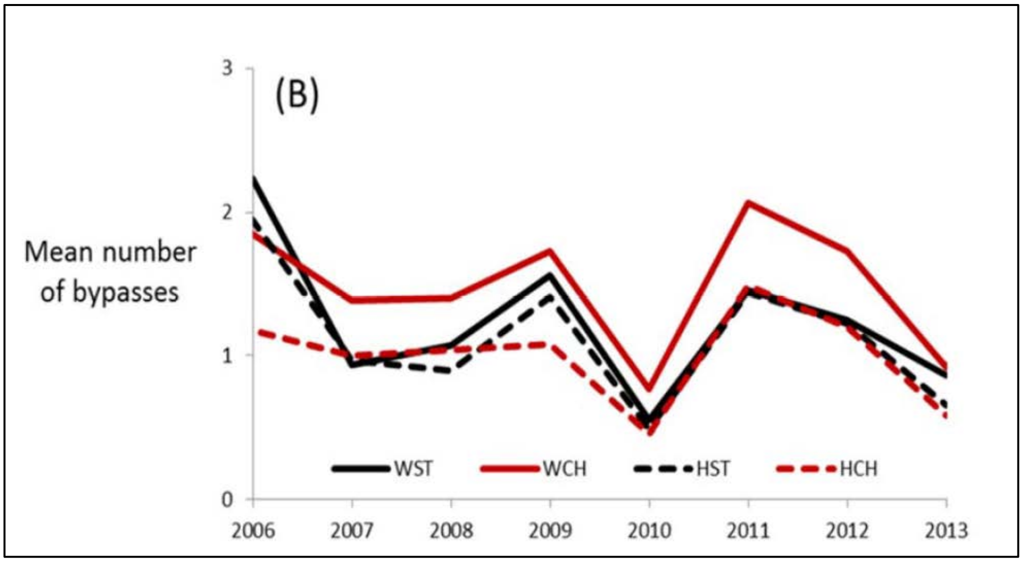


Figure D- 15. Estimates of powerhouse passage rates (PITPH) used in CSS modeling. (From Figure 2.1 in McCann et al. 2017)

Given the uncertainty surrounding the CSS predictions of potential benefit, however, as well as the many concerns that NOAA scientists and the Action Agencies continue to have regarding the transparency and accuracy of the CSS modeling, additional research and regional discussion appears to be warranted before the CSS hypothesis can reasonably be accepted as a basis for a permanent change in Columbia River System operations that affect residents through four western states and beyond.

The Action Agencies plan to continue to work with regional stakeholders to develop a test that will help elucidate some of the remaining critical uncertainties surrounding the issue of latent mortality, including evaluating whether the CSS-hypothesized benefits to SARS, in-river survival, and fish travel time materialize. This research effort will include a defined hypothesis to test and will identify expected levels of power to determine a difference between performances-standard-based and gas cap spill operations while reducing the associated potential for making Type II statistical errors. It will be a challenge to determine a definitive answer as to whether gas cap spill, and a subsequent reduction in the number powerhouse encounters, has a meaningful effect on SARs. The Action Agencies have documented many of the challenges associated with isolating a change in SARs to system operations like varying levels of spill. In addition to the challenges of detecting a difference and attributing that difference to increased spill levels, a high spill operation at all eight fish passage projects will also result in a reduced number of transported fish during times when transport has shown to be beneficial, and increased system-wide TDG loading with unknown effects on migrating salmon and steelhead and other aquatic species in the river.

NOAA developed an analysis of SARs (see Figure D- 16) of fish returning to Bonneville Dam based on the mean number of bypass passage events. Contrasting with the CSS model results, this analysis by NOAA did not show a significant effect.



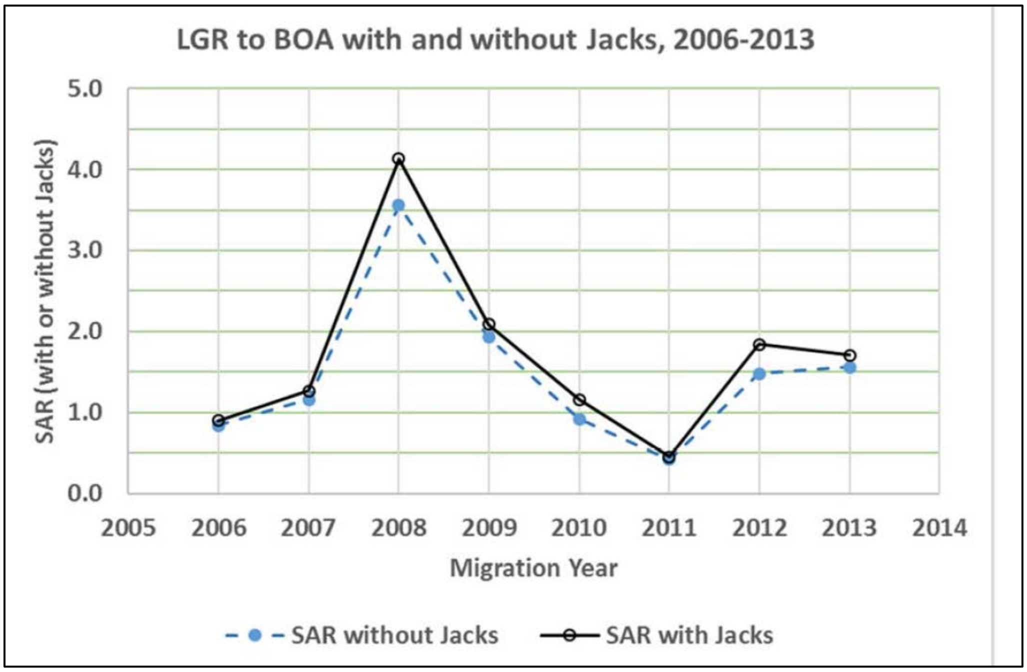


Figure D- 16. TOP: Estimated Mean Number of Bypasses upstream of Bonneville Dam (solid red line is wild yearling Chinook. (Source: Graves declaration Appendix 2, page 40.)

BOTTOM: Estimated SARs from Lower Granite to the ocean and back to Bonneville Dam with and without jacks.

Points:

1. SARs from 2011 migrants were very low (<0.5%) in a high flow / high spill year
2. SARs in 2006, 07, and 2010 were about the same, even though the estimated mean number of bypass was much lower in 2010 than in the other two years.

In addition to the CSS modeling and associated predictions of the effects of changes in Columbia River System operations, several researchers, including work by Hostetter et al. (2015) reported results suggesting that juvenile bypass facilities may selectively collect smaller, degraded individuals with lower overall probabilities of survival. The work by Hostetter et al. yielded results suggesting that the hypothesis raised by ISAB may still be valid – that juvenile bypass facilities may selectively collect smaller, degraded individuals with lower probabilities of survival, such that the passage route may be purely correlative, not a causal factor in subsequent mortality in the ocean. As discussed in the previous version of this report, bypass systems that selectively pass smaller fish could be an alternate source of any apparent latent mortality and rather than powerhouse passage rates, fish size and condition may contribute to the appearance of latent mortality the CSS authors have observed in their models.

Additional information on previous latent mortality studies is included in Attachment A.

D.5. Juvenile fish response – summer migrants

The dam passage survival performance testing that began in 2010 includes estimating survival for sub-yearling fall Chinook salmon, which typically migrate through the Columbia River System during the late spring and early summer. The results of performance standard testing have generally been positive and estimated survival has exceeded the 93 percent BiOp survival standard for this species during at least one test conducted at each dam evaluated to date (Table D- 4;Figure D- 17). When the results of the recent testing are considered together, this indicates that passage improvements implemented at the eight lower Columbia River System dams under the 2008 BiOp are reducing smolt mortality by providing safe, effective passage routes in the form of surface passage and conventional spill tailored to the unique configuration of each dam.

Test results show survival of sub-yearling fall Chinook ranging from 90.76 percent to 97.89 percent (Table D- 4). This review corroborates NOAA's analysis in the 2014 supplemental BiOp finding that, with few exceptions, BiOp measures are performing as expected and are very close to achieving, or are already achieving, the juvenile dam passage survival objectives (Figure D- 17).

There were no tests conducted in 2015, 2016 or 2017. Spill passage efficiency is the percent of all downstream migrating juvenile salmon and steelhead that pass a dam through the spillway and other surface passage routes.

Table D- 4. Juvenile dam passage survival estimates, passage times, and spill passage efficiency for subyearling Chinook salmon derived from performance standard tests conducted through 2014.

Dam	Year	Species	Dam Passage Survival (percent with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (percent)	Spill Operation (Target / Actual)
Bonneville	2012	Subyearling Chinook Salmon	97.39 (0.69)	0.48	57.06	85 kcfs day – 121 kcfs night / 149 kcfs 95 kcfs 24 hrs / 149 kcfs

Dam	Year	Species	Dam Passage Survival (percent with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (percent)	Spill Operation (Target / Actual)
The Dalles	2010	Subyearling Chinook Salmon	94.04 (0.91)	1.20	82.98	40% / 39.8%
The Dalles	2012	Subyearling Chinook Salmon	94.69 (0.59)	1.08	78.39	40% / 40.4%
John Day	2012	Subyearling Chinook Salmon	94.14 (0.31)	1.02	69.62	30% / 37.9% 40% / 37.9%
John Day	2014	Subyearling Chinook Salmon	91.96 (0.74) 91.31 (0.77)	2.28 1.91	55.52 71.26	30% / 30% 40% / 40%
McNary	2012	Subyearling Chinook Salmon	97.47 (1.14)	1.77	78.32	50% / 61.6%
McNary	2014	Subyearling Chinook Salmon	92.39 (1.80)	2.22	53.80	50% / 48.8%
Lower Monumental	2012	Subyearling Chinook Salmon	97.89 (0.79)	2.60	83.56	17 kcfs / 25.2 kcfs
Lower Monumental	2013	Subyearling Chinook Salmon	92.97 (1.05)	2.99	89.10	17 kcfs / 19.8 kcfs
Little Goose	2012	Subyearling Chinook Salmon	95.08 (0.97)	2.80	72.49	30% / 38.5%
Little Goose	2013	Subyearling Chinook Salmon	90.76 (1.39)	3.66	76.83	30% / 30%

Table D-4 data references by dam: Bonneville - Skalski et al. 2012b;; The Dalles - Johnson et al. 2011; Skalski et al. 2012a; 2013b; John Day - Skalski et al. 2013d; 2014a; McNary - Hughes et al. 2013; Skalski et al. 2012d, 2014b; Lower Monumental - Skalski et al. 2013a, 2013c; Little Goose - Skalski et al. 2013b, 2013c;.

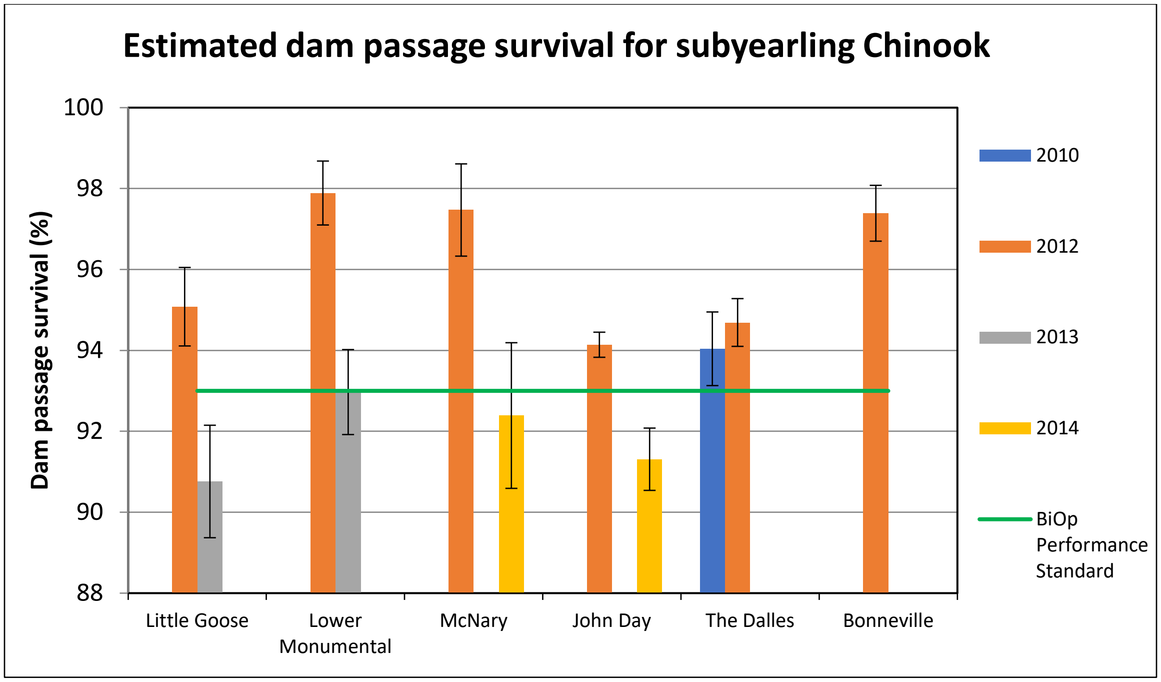


Figure D- 17. Estimated dam passage survival for subyearling fall Chinook salmon. Data is based on sources in Table D-4.

*Note: The 2008 BiOp spring performance standard is 93 percent for subyearling Chinook salmon. Bars represent dam passage survival. Whisker plots represent standard error.

Unlike the situation for spring migrants, direct estimates of survival through the Columbia River System reach for summer migrants such as Snake River fall Chinook salmon are limited. This is the result of complications associated with accurately estimating survival, given the complex life history strategies of subyearling Chinook. Some members of the population exhibit protracted migrations and rear as they slowly migrate downstream. Others hold over in reservoirs and continue their migration into the fall and winter, or even the following year (Connor et al. 2005). This complex pattern has been recognized more recently, and violates one of the standard assumptions of the statistical model used to estimate survival over extended river reaches.

Performance standard testing conducted by the Corps does provide estimates of fish residence time in dam forebays. Test results indicate that subyearling Chinook salmon spend a relatively brief period searching for passage routes. The median elapsed time from first arrival at the dam to passage has ranged from about half an hour at Bonneville (Skalski et al. 2012a) to over 3.66 hours at Little Goose (Skalski et al. 2014).

Tuomikoski et al. (2011) compared travel times of subyearling Snake River fall Chinook salmon from Lower Granite to McNary Dams between two different passage eras. For the period from 2005 to 2010 mean fish travel time was 11.2 days, compared to 21.3 days for the same reach during preceding era from 1998 to 2004. They attributed the reduction in travel time to the implementation of summer spill, which began in 2005. However, system monitoring also indicates that the faster migration of juvenile fish through the Columbia River System reflects the combined effects of flow augmentation, spill, and recently installed surface passage systems. This assessment is complicated by the apparent life history change in which some subyearling Chinook salmon cease active migration in midsummer and hold over in reservoirs. Operations designed to facilitate migration during this time may instead simply redistribute these fish within the system.

D.6. Effectiveness of August spill

When developing the action described in Chapter 2, the Action Agencies extensively reviewed existing data since the 2008 BiOp related to smolt migration timing through the lower Snake and lower Columbia Rivers during the summer months, particularly in August.

The current run timing of juvenile Snake River fall Chinook salmon is such that relatively few wild juvenile fish are migrating downstream through the Snake and Columbia rivers during the month of August. Consequently, only a small percentage of the overall juvenile population encounters August spill at the lower Snake and Columbia River dams. Rearing and migratory behavior of fall Chinook, both hatchery and natural production, is relevant when evaluating the effectiveness of August spill operations to improve passage through the fish passage dams.

Fall Chinook salmon from the Snake River are believed to have historically migrated downstream during summer months as subyearlings and have generally been considered in that context until recently. Research has found that this ESU now exhibits a variety of rearing and migratory strategies including subyearling and yearling migrants with ocean- and reservoir-type patterns, respectively (Connor et al. 2005, 2011). The reservoir-type life history strategy is a result of complex interactions between the thermal regimes fish are exposed to during incubation and rearing each year, water flow at dams and reservoirs in their migration corridor during the first one-third of summer migration (Waples et al. 2007; Connor et al. 2011), and variable hatchery practices. Cool water temperatures in the Clearwater River basin from flow augmentation at Dworshak Dam have resulted in slower growth rates that have resulted in delayed smoltification and migration rates of juvenile fall Chinook salmon (Tiffan et al. 2009).

The median date of subyearling fall Chinook passage through the Snake River is June 16 (Connor et al. 2013). Investigations indicate that fall Chinook salmon which do not actively migrate downstream beyond the month of July hold over in reservoirs or other parts of the river, feeding and growing before continuing their downstream migration later in the year or the following spring as yearlings (Tiffan et al. 2009; Zabel et al. 2012). The bulk of naturally produced fall Chinook salmon in the Clearwater River tend not to pass Lower Granite Dam until after August 31 when spill operations have concluded but when transportation via trucks is still ongoing.

The majority of subyearling fish that overwinter reside and forage in the Snake River; a small fraction of these fish have been recorded moving downstream and may overwinter in the Columbia River (Tiffan et al. 2009). Zabel et al. (2012) reported that 62 percent of returning adult fall Chinook salmon sampled at Lower Granite Dam in 2006-2008 had followed a yearling life history as juveniles and proposed that the high percentage provides circumstantial evidence of a survival advantage associated with the delayed migration.

In the 2008 BiOp, NOAA recommended spill be provided through at least July 31 at lower Snake River dams and through August 31 at Columbia River dams. At the lower Snake River dams, based on RPA Action 29 in the 2008 BiOp, summer spill can be adjusted based on the number of migrating juvenile fish observed by specifying that spill will continue at the four lower Snake River dams until daily passage counts of subyearling fall Chinook salmon fall below 300 fish for three consecutive days after August 1. The RPA also calls for restarting spill if fish numbers later increase above 500 fish for two consecutive days. This concept was further refined in the 2008 Columbia Basin Fish Accords (Accords), in which the Action Agencies agreed that if the trigger was met, spill would end at the four dams on a staggered basis, continuing longer at dams farther downstream to support fish migrating toward the ocean. To enhance the summer spill program even further, the Action Agencies developed a safeguard based on adult returns, whereby a low abundance of returning naturally produced Snake River fall Chinook adults would trigger continuing spill through the end of August at lower Snake River projects the following year, regardless of the number of juveniles migrating downstream that year. Although these criteria to adjust summer spill timing remain in place, the Action Agencies have continued to spill through August each year regardless of daily juvenile fish counts. Thus, this aspect of RPA Action 29 has never been implemented, nor has the site-specific staggered spill curtailment called for in the Accords occurred.

As discussed above, based on observed subyearling Chinook salmon collection counts at each lower Snake River dam since 2005, the timing of the Snake River fall Chinook salmon downstream migration is such that relatively few fish migrate past Snake and Columbia River dams during the month of August. Lower Granite Dam, the uppermost project, is included as an example (Figure D- 18) and illustrates the annual variability in passage. Since 2010, the proportion of the annual outmigration passing the three uppermost Snake River dams during August ranged from 0.23 to 5.06 percent (Table D- 5). If spill had ended when fish numbers declined as described in the 2008 BiOp and Accords guidelines, the ending date would have varied each year but could have occurred as early as August 1. Analysis shows that an average 1.4 percent of all migrating fall Chinook would have migrated past the Snake River dams after spill ended each year (Table D- 5).

The data indicate that if the 2008 BiOp provisions for implementing summer spill based on actual migration timing of the fish rather than calendar dates had been implemented, spill would have been provided for at least 97 percent of all juvenile Snake River fall Chinook salmon since 2005. Conversely, extending spill at Snake River dams through the month of August during this period has provided spillway passage for up to an additional 3 percent of this listed species during most years, depending on dam and year.

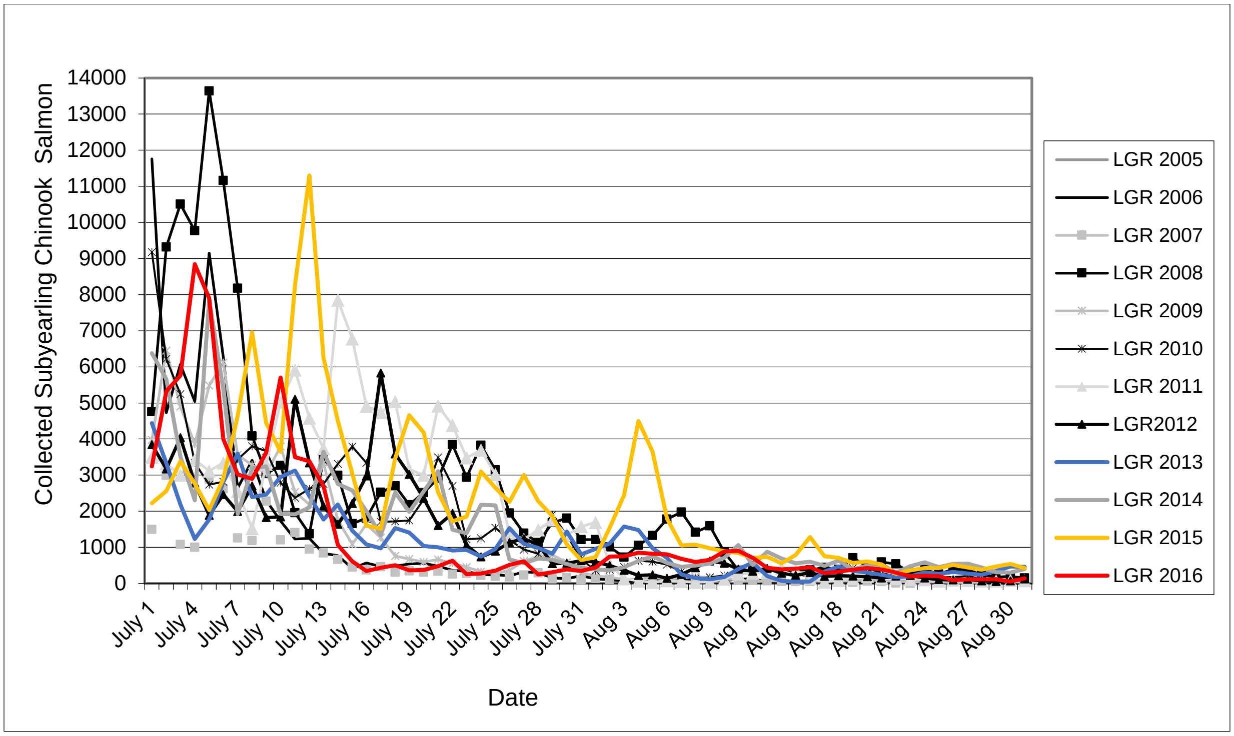


Figure D- 18. Annual collection counts of all subyearling Chinook at Lower Granite, 2005 – 2016.

Source: DART

Table D- 5. Proportion of summer migrants passing Snake River dams, 2010-2017

Year	Project	Proportion of Annual Outmigration Passing the Dam During August	Spill Completion Date Based on 2008 BiOp Criteria (RPA Action 29)	Proportion of Annual Outmigration Past the Dam by 2008 BiOp August Spill Completion Date	Spill Completion Date Based on Proposed Individual Dam Criteria: 4-day Consecutive <300 fish
2010	Lower Granite	2.00%	Aug. 11	96.88%	Aug. 12
	Little Goose	2.40%	Aug. 24	99.45%	Aug. 25
	Lower Monumental	1.02%	Aug. 27	99.92%	Aug. 8
2011	Lower Granite	1.77%	Aug. 6	97.46%	Aug. 7
	Little Goose	2.06%	Aug. 15	99.06%	Aug. 16
	Lower Monumental	4.89%	Aug. 18	98.10%	Aug. 19
2012	Lower Granite	1.65%	Aug. 7	98.06%	Aug. 8
	Little Goose	2.11%	Aug. 18	99.52%	Aug. 19
	Lower Monumental	1.45%	Aug. 21	99.37%	Aug. 8
2013	Lower Granite	3.56%	Aug. 10	92.77%	Aug. 11
	Little Goose	5.06%	Aug. 31	96.84%	Aug. 31

Year	Project	Proportion of Annual Outmigration Passing the Dam During August	Spill Completion Date Based on 2008 BiOp Criteria (RPA Action 29)	Proportion of Annual Outmigration Past the Dam by 2008 BiOp August Spill Completion Date	Spill Completion Date Based on Proposed Individual Dam Criteria: 4-day Consecutive <300 fish
	Lower Monumental	4.75%	Aug. 31	99.54%	Aug. 3
2014	Lower Granite	4.26%	Aug. 31	98.44%	Aug. 31
	Little Goose	5.03%	Aug. 31	99.74%	Aug. 30
	Lower Monumental	2.60%	Aug. 31	99.70%	Aug. 7
2015	Lower Granite	4.89%	Aug. 31	99.22%	Aug. 31
	Little Goose	1.17%	Aug. 31	99.68%	Aug. 10
	Lower Monumental	0.52%	Aug. 31	99.90%	Aug. 2
2016	Lower Granite	2.53%	Aug. 25	98.33%	Aug. 26
	Little Goose	1.58%	Aug. 28	98.90%	Aug. 16
	Lower Monumental	3.17%	Aug. 31	99.85%	Aug. 2
2017	Lower Granite	(not available)	(not available)	(not available)	(not available)
	Little Goose	1.07%	(not available)	(not available)	Aug. 20
	Lower Monumental	0.23%	(not available)	(not available)	Aug. 2
Avg. (2010-2017)	Lower Granite	2.95%	Aug. 17	97.31%	Aug. 18
	Little Goose	2.56%	Aug. 25	99.03%	Aug. 21
	Lower Monumental	2.33%	Aug. 27	99.48%	Aug. 6

Smolt monitoring counts and downstream PIT detections were examined (2010-2017) to consider the differences in run timing of natural versus hatchery-produced subyearling fall Chinook salmon in the lower Snake River (Figure D- 19). Three periods of increased passage of natural production fish from the Clearwater were observed at Lower Granite and Little Goose dams for all run types: these periods of increased passage occurred in April, July, and again in October-November (Figure D- 20). At Lower Granite Dam, the first peak of natural production origin were all fish migrating as yearlings (holdover), while the second and third peaks were comprised of only subyearling fish.[62]

During the month of August, an estimated 7 percent of naturally produced subyearling fall Chinook salmon pass downstream of Lower Granite Dam, most of which occurs during the first weeks of August when surface water temperatures reach 18-20°C. After the estimated three-consecutive day criteria of less than 300 fish trigger (est. August 18), approximately 1.5 percent of these fish would not be provided spill as a passage route at Lower Granite Dam. For comparison, only 0.2 percent of the hatchery-produced run was detected passing during the same period of time (August 19-31). Similar trends were

[62] The analysis of PIT tag detection at Lower Granite Dam juvenile bypass system is assumed to be representative of the run at large; however, relatively few natural origin fish from the Clearwater subbasin are PIT tagged as subyearlings.

observed in passage at Little Goose Dam but not at Lower Monumental Dam (2010-2017). At Lower Monumental Dam, August 6 was the average date when less than 300 fish were observed for at least four consecutive days, and less than 0.4 percent of the natural produced run was detected between August 4 and 31.

When developing the proposed action for the 2018 BiOp, the Action Agencies reviewed the data above and contemplated alternate scenarios for providing August spill at the Snake River fish passage dams versus transporting those remaining juvenile fish that may still be moving between reservoirs on the Snake River. The 300 fish collection count threshold that had been developed by biologists from the Action Agencies, Lower River Tribes, and NOAA Fisheries for the 2008 BiOp was reviewed and determined to still be an appropriate indicator that the vast majority of the ESU has migrated past the projects. Before selecting the trigger detailed in Chapter 2, the action agencies carefully considered different numbers of consecutive days of collection counts below 300 fish, whether the decision to provide spill at each project should be dependent on the project upstream, and whether to include a collection count threshold above which spill would be restarted after it had stopped. The Action Agencies were also mindful of alternate methods of passage that are provided during the month of August as well as later into the fall. As discussed further in the transportation review section of this report, it appears that beginning in August and continuing through the fall, Chinook salmon that are collected at the Snake River dams and transported to rear and potentially holdover in the estuary below Bonneville Dam return as adults at higher rates than those that were returned to the river to migrate instream.

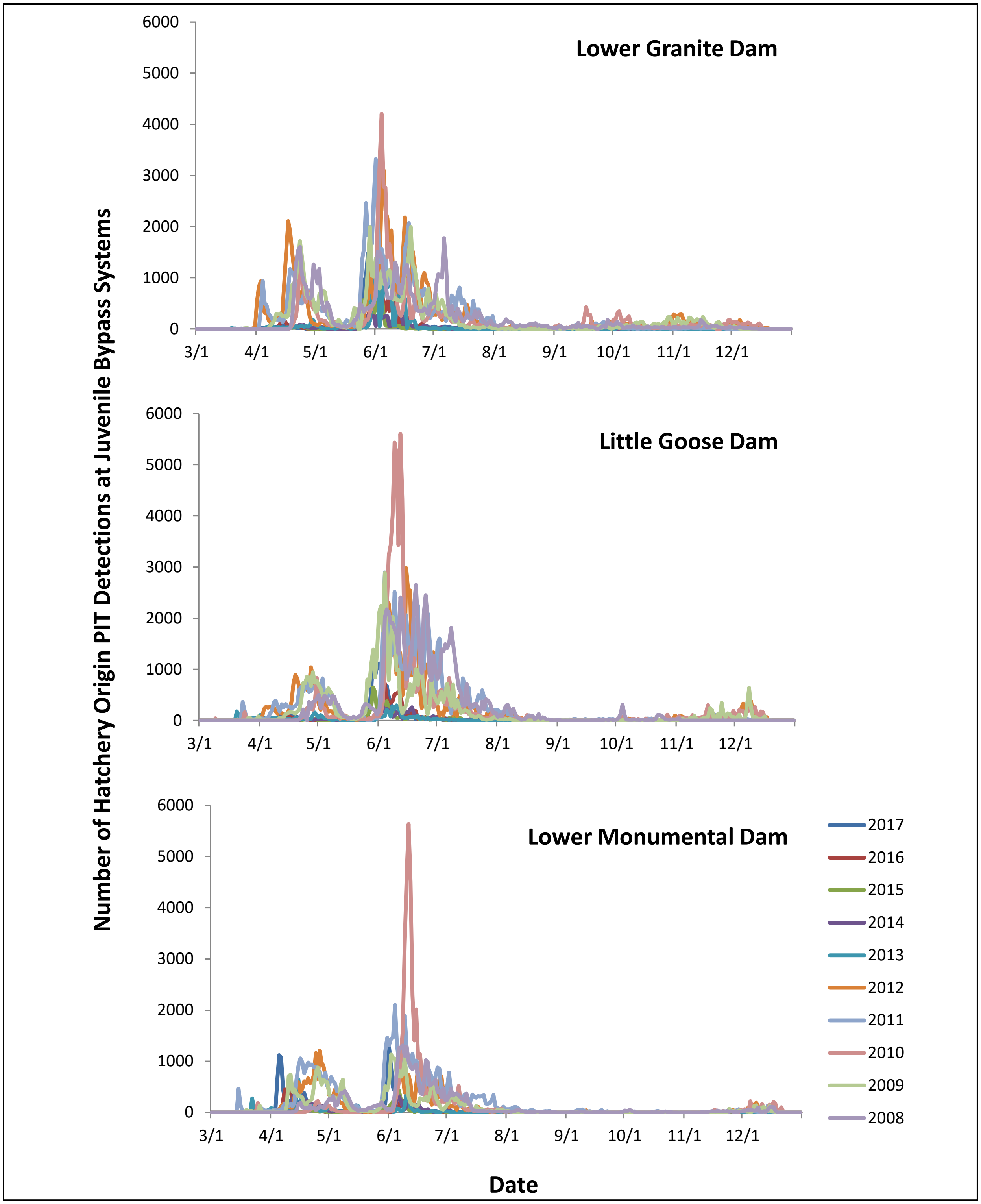


Figure D- 19. Distribution of hatchery-origin PIT-tagged subyearling Snake River fall Chinook salmon detected in the juvenile bypass systems at Lower Granite, Little Goose, and Lower Monumental dams over the past 10 years.

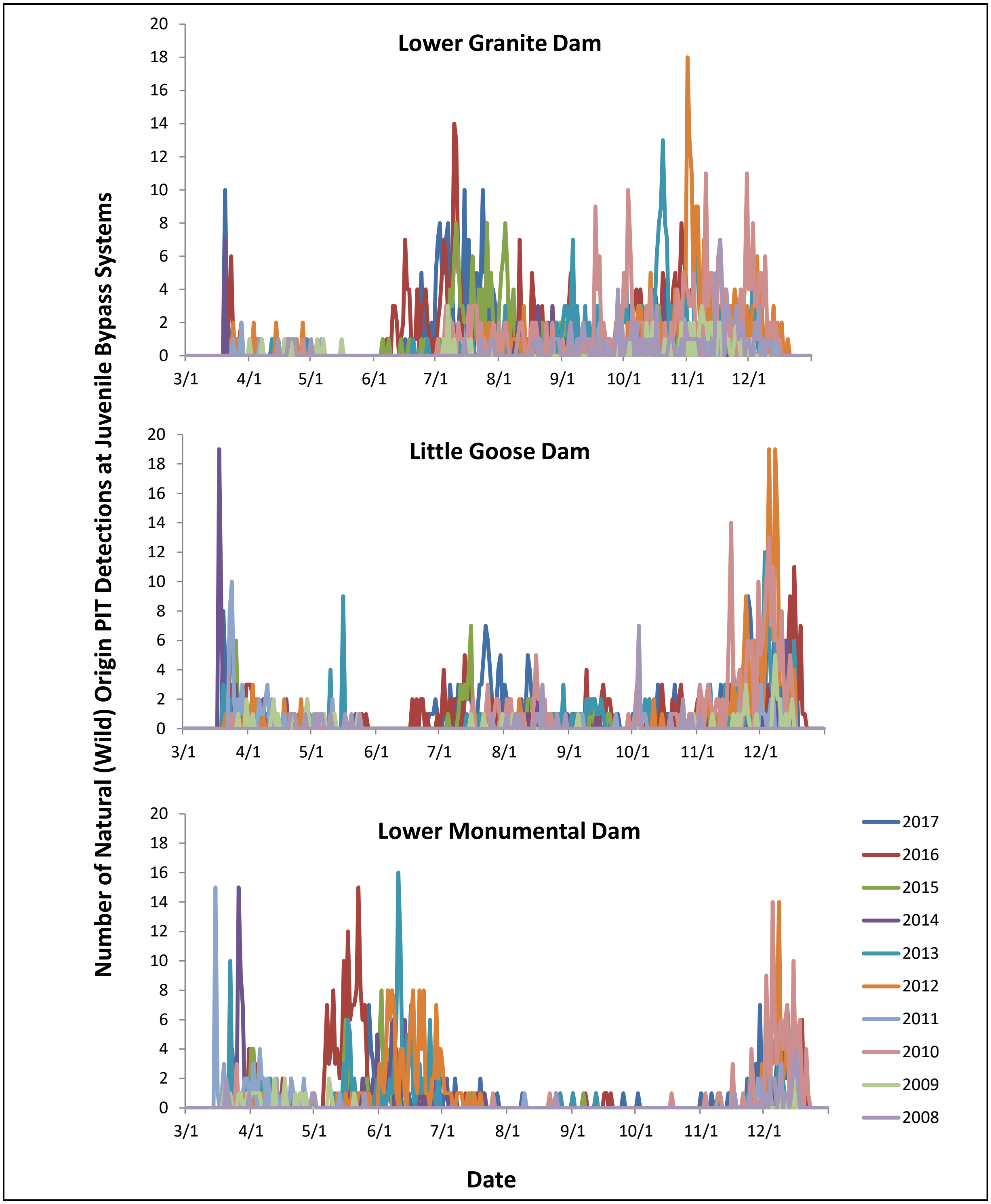


Figure D- 20. Distribution of natural- origin (Clearwater, wild) PIT-tagged subyearling Snake River fall Chinook salmon detected in the juvenile bypass systems at Lower Granite, Little Goose, and Lower Monumental dams over the past 10 years.

Source: DART

In the lower Columbia River, the run timing of juvenile fall Chinook salmon is composed of two ESUs: the ESA-listed Snake River Fall Chinook and non-listed mid-Columbia Fall Chinook, which migrate primarily out of the Hanford Reach of the Columbia River. The run-timing index of the combined runs (via the smolt monitoring program) depicts that 95% of the subyearling fall Chinook run has passed John Day and Bonneville dams by August 1 with few exceptions (2011 and 2012, both years experienced late run-timing). At McNary Dam, smolt monitoring counts and PIT detections over the past decade were more variable (Figure D- 21). Analysis of PIT detections at all three aforementioned dams found that Snake River and Columbia River juvenile fall Chinook in 2010-2017 have typically completed migrating through the lower Columbia River project by August 1 (Table D- 6). Additional monitoring and analysis may be necessary to determine the source of variability of subyearling fall Chinook passage timing at McNary Dam, more specifically, whether the detections of PIT-tagged fish at McNary Dam in August represent actively migrating fall Chinook or whether some portion of those fish represent reservoir-type behavior of smaller migrants that will migrate to the ocean during the winter months or as yearlings the following spring. Additional analysis may also be necessary of the total number of PIT-tagged fish that are migrating through the lower Columbia River in August and whether the distribution and sample size are adequate to make conclusions about the run at large.

In the 2008 BiOp, NOAA recommended August spill operations at the lower Columbia River dams continue through August 31 without reference to fish presence, unlike at the lower Snake River dams, where NOAA recommended the summer fish passage spill season duration be tailored to run timing using a biological trigger. Additional investigations may be required to improve our understanding of the movement characteristics of Snake River and mid-Columbia River fall Chinook salmon through the lower Columbia River projects, the temporal overlap between the two ESUs, any run-timing shifts to earlier migration, and the potential effect of any modifications to spill during the month of August on ESA-listed Snake River Fall Chinook.

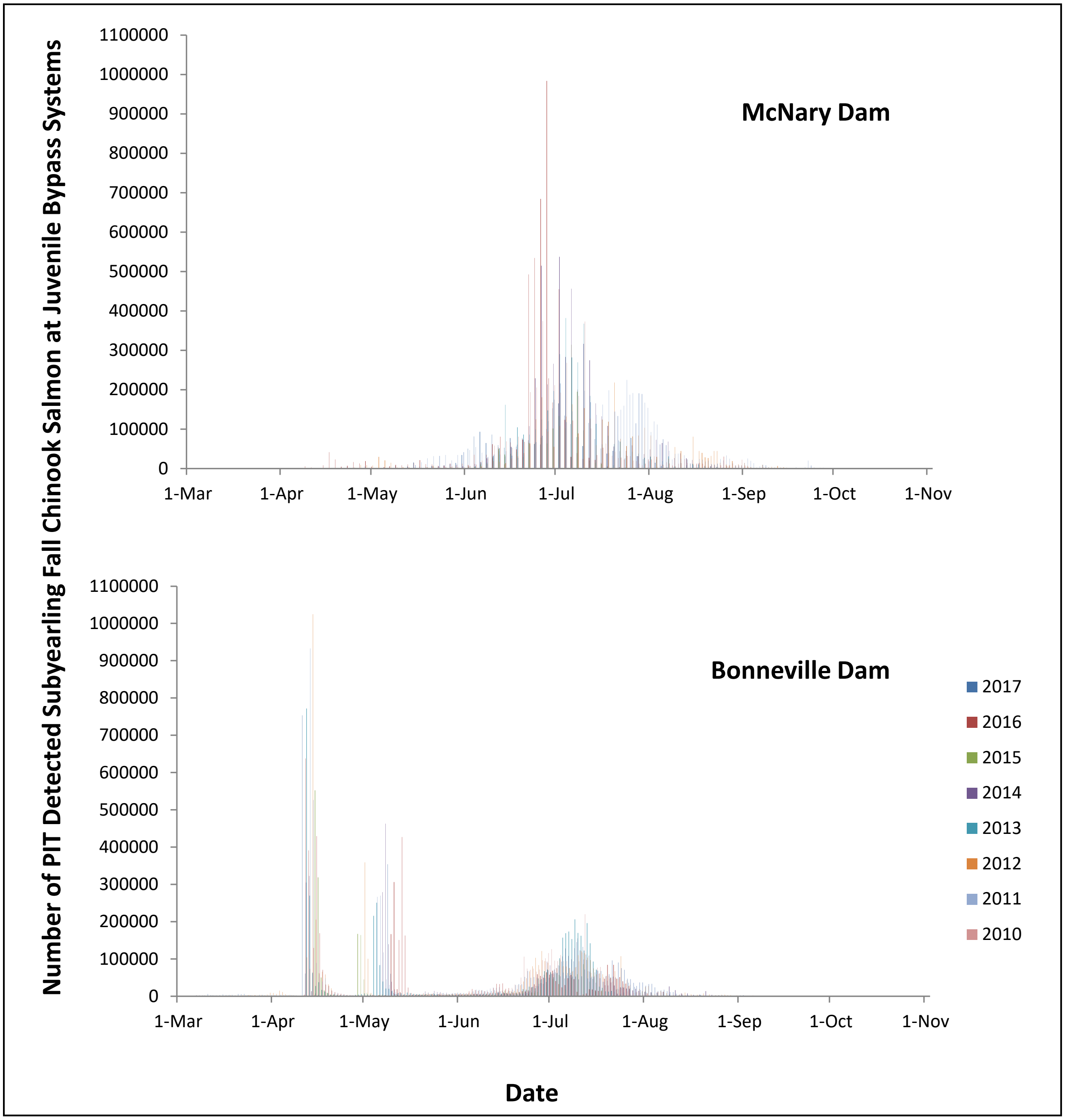


Figure D- 21. Distribution of PIT-tagged subyearling fall Chinook salmon detected at juvenile bypass systems at McNary (top figure) and Bonneville (bottom figure) dams (2010-2017).

Table D- 6. Number of PIT-tagged subyearling fall Chinook salmon detected at Juvenile Bypass Systems (JBS) at Bonneville, John Day, and McNary dams (2010-2017) by ESU and rear type.

DPS	Rear Type	Bonneville Dam			John Day Dam			McNary Dam		
			Detected			Detected			Detected	
		n	#	%	n	#	%	n	#	%
Snake River	Natural (Wild)	54	0	0	315	5	1.6	430	5	1.2
	Hatchery	8,665	107	1.2	47,342	603	1.3	59,801	976	1.6
Columbia River	Natural (Wild)	1,738	24	1.4	810	6	0.7	1,163	5	0.4
	Hatchery	2,693	0	0	20,986	2	0	24,172	1	0

D.7. Juvenile transportation

The transportation program has been operational in the lower Snake River for more than three decades. It involves diverting migrating smolts from turbine intakes at collector dams (Lower Granite, Little Goose, and Lower Monumental) and transporting the fish, primarily by barge, to release sites downstream from Bonneville Dam. The collection systems can also be operated in a bypass mode when transport is not warranted, returning fish directly to the river to continue their migration.

Juvenile fish are transported in accordance with the annual Fish Passage Plan. Protocols and criteria for collection, holding, and transport of juvenile fish are further defined in the Juvenile Fish Transportation Plan, included as Appendix B of the annual Fish Passage Plan, available online at: http://pweb.crohms.org/tmt/documents/fpp/. Implementation of the Juvenile Fish Transportation Plan, including deviation from the plan and criteria described in Appendix B of the Fish Passage Plan, is coordinated through the Regional Forum.

In the Snake River, there are two general passage options for smolts: 1) collection and transport from dams fitted with screened collection/bypass systems, or 2) in-river migration to the ocean via some combination of routes including conventional spillways, surface passage, screened bypasses or turbines. With full implementation of surface passage routes at all eight dams on the lower Columbia and lower Snake rivers coupled with spill for juvenile fish passage at each dam, the majority of juvenile fish migrate in-river.

The goal of the transportation program is to increase the proportion of fish that return as adults to spawn. The objective of the program is to improve smolt survival by avoiding the potential challenges associated with passing multiple Columbia River System projects. Research has also indicated potential benefits associated with arrival of fish in the lower Columbia River and estuary when increased productivity makes more food resources available (Scheuerell et al. 2009).

RIOG and TMT review transport studies and provides a recommendation each year to the Corps on how to operate the juvenile transport program. Planning dates to initiate juvenile transport detailed in Chapter 2 will be implemented, unless the Corps adopts a recommendation by TMT that proposes a later start date (no later than May 1) and accompanying alternative operation.

The timing and conditions for transport are empirically based, relying on data indicating that adult return rates are higher for juveniles that are transported at certain times than for their counterparts that migrate in-river through the Columbia River System. For example, results have shown that transportation in early April is generally not beneficial to Chinook salmon, while transportation in early May has shown consistent improvement compared with in-river migration for both Chinook and steelhead. The result is that transportation in early April has been curtailed in recent years. Additionally, recent results reported by Smith (2017) indicate that more wild Chinook adults transported as juveniles from Lower Granite return from all years between 2006 and 2014, except for 2011. For wild steelhead at the same dam, more transported adults returned for every year in that period. These findings appear to support the benefits of targeted implementation of transportation.

Key metrics used in these comparisons include the smolt-to-adult return rate (SAR) for each treatment group, along with various ratios derived from the SAR estimates, generally referred to as the transport to in-river migrant ratio (TIR). This ratio and its variants, described in Smith et al. (2013), are used to assess the effectiveness of transporting smolts:

- TIR > 1.0 indicates that transported fish survive to returning adult at rates exceeding in-river migrants (i.e., the SAR for transported fish was higher than for in-river fish).
- TIR < 1.0 indicates that in-river fish survive to returning adult at higher rates than those transported (the SAR for transported fish was lower than for in-river fish).

Spring migrants

Spring-summer Chinook salmon, steelhead, and sockeye migrate through the Snake River during the spring migration period, primarily April through early June. Their migration timing overlaps at varying degrees each year. Thus, the decision to transport, or not, affects all species present. These issues are discussed in the following sections by examining broad scale, species-specific annual responses to transport, as well as within-year variation in responses.

Transportation evaluations

Spring Chinook and steelhead

Two analytical groups regularly evaluate the effectiveness of transportation: the Fish Passage Center (FPC), which coordinates the Comparative Survival Study (CSS), and NOAA's Northwest Fisheries Science Center.

Analyses of annual performance indices for more than a decade conducted by NOAA Fisheries supporting the 2010 BiOp (2010) indicate that depending on the baseline used, transported wild spring Chinook salmon survived at about the same, or slightly higher rates than in-river migrants. Hatchery-origin yearling Chinook salmon exhibited even more significant transport-to-migrant (T:M) ratios that were typically greater than 1.0, regardless of the baseline examined. (The T:M ratio is a variant of TIR, discussed earlier.) Similarly, for the decade ending in 2009, both wild- and hatchery-origin steelhead that were transported survived to return as adults at higher rates than cohorts migrating in river (NOAA 2010), as evidenced by the TIR estimates well above 1.0.

Separately, Holsman et al. (2012) analyzed PIT-tag data from 1998-2006 and found that considering the marine component of the life cycle yielded very different results among rearing histories that were not apparent in the T:M ratio. The survival of transported wild Chinook salmon in the marine environment was about two-thirds less than that of counterparts migrating in-river. In contrast, transported hatchery Chinook survived their marine residence at approximately twice the rate of in-river migrants. The two studies, conducted by NOAA investigators, characterize wild Chinook responses to transportation somewhat differently, ranging from negative to slightly positive. This apparent discrepancy may depend in part on the different timeframes (years) included in the separate analyses.

Unintended consequences of barging smolts are also of concern when crafting a transportation program. Recently, the effect of barging on adult straying rates has received increased attention (Keefer and Caudill 2012). It remains unclear whether increased stray rates associated with transportation have been excessive.

Despite the results of these transportation studies to date, the most relevant and applicable information on the effects of transportation on survival is from the most recent years after the 2008 BiOp, when all of the dams in the Columbia River System have been fitted with surface passage routes and additional spill has been integrated into Columbia River System operations. Those actions appear to have substantially improved passage conditions for in-river migrants. Therefore, the most accurate comparison with transportation to current in-river survival experiences should be based on adult returns beginning in the 2009 juvenile out migration.

For more than a decade, the region has explored ways to balance transportation and in-river migration to increase the abundance and productivity for listed ESUs and minimize the risk of unforeseen negative conditions/effects during the juvenile migration in any particular year, given the vagaries of environmental conditions (i.e. temperature, flows, etc.). This balance is often referred to a “spread-the-risk” operation. It involves distributing the population between transportation and in-river migration, by tailoring operations between conventional sub-surface spill, surface passage routes and screened bypass systems.

A spread-the-risk operation presumes an approximate balance between the fish left to migrate in the river and those that are collected and transported. However, with the successful implementation of surface passage routes and the changes in spill operations under the 2008 BiOp, the majority of fish now pass through Columbia River System projects via spillways and a decreasing number are available for collection in juvenile bypass systems. This has translated into fewer yearling spring Chinook salmon and steelhead transported from the Snake River each year (Figure D- 22). Long-term data trends are evident, with an inflection point in 2006 clearly demonstrating when surface passage and spill effects on transport percentages became evident.

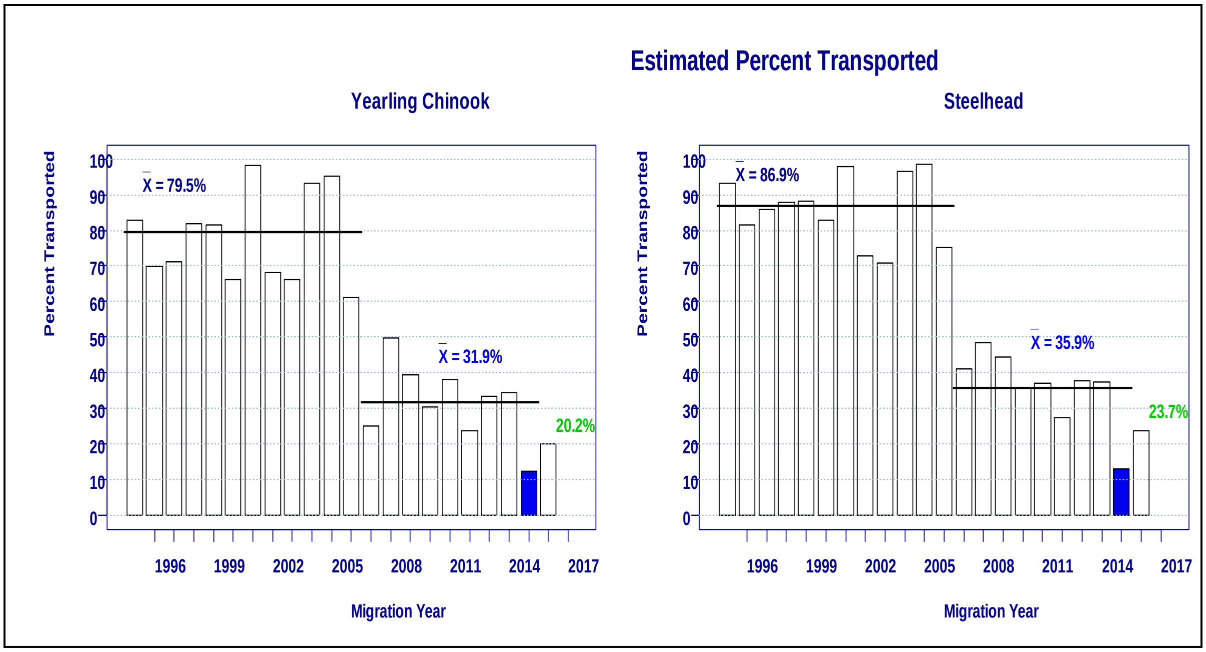


Figure D- 22. Estimated percent of yearling Chinook salmon and steelhead, respectively, transported to below Bonneville Dam, by year, 1995–2016 (data from Smith 2017).

Snake River sockeye salmon

For Snake River sockeye salmon, there are less data available to evaluate transportation effects. A study has been initiated to examine the relative survival of sockeye experiencing either transport or in-river migration conditions. For that study, sockeye salmon smolts were PIT tagged at Sawtooth Hatchery in Idaho and Oxbow Hatchery in Oregon. Results from 2009 suggest that transport is neutral for Sawtooth Hatchery-reared sockeye, but beneficial for Oxbow Hatchery-reared sockeye, which were larger than Sawtooth Hatchery fish (Biomark and Quantitative 2012). However, fish from each hatchery were also released at different sites, which could have influenced these results. Importantly, data from a single year are inadequate to provide a definitive evaluation of transportation for this species.

In its annual update on transportation effects, (Smith 2017) NOAA reported on transport effects on Snake River sockeye salmon between 2011 and 2016. Based on that data, it appears that sockeye salmon transported as juveniles from Lower Granite tend to return as adults to Bonneville Dam in greater numbers than their counterparts that were bypassed back to the river during their juvenile outmigration. However, once the adult sockeye from both groups make it back to Bonneville Dam, the transported group can have much lower migration success compared to the in-river bypassed group. Transported adults have increased stray rates and slower migration upstream, which increases their exposure to warmer river temperatures. Data analysis from the CSS also shows that TIR ratios from Lower Granite to Lower Granite tend to be less than 1 (negative impact).

Intra-annual variation in survival and SAR

Broad annual indices of transportation effects do not fully inform decisions facing fishery and Columbia River System managers. This is because within-year variation in survival makes the situation more complicated and must be considered when crafting a transport program. Management decisions involve identifying when within a year, and at which sites, transportation provides benefits. The decisions are complicated by the presence of three different salmon and steelhead species during the spring migration period, each of which seem to respond differently to transportation. Recent analyses by NOAA provide information useful for exploring these issues.

Annual analysis by NOAA (Smith et al. 2017) examined seasonal (intra-annual) patterns in SAR for various classes of transported and in-river migrating Snake River steelhead and spring-summer Chinook salmon. The NOAA results for 2006 to 2014 suggest that postponing transport until late April or the first week of May should improve survival for wild Chinook, hatchery steelhead and perhaps hatchery Chinook salmon. Findings by Holsman et al. (2012) support the decision to delay the onset of transportation until later in the spring migration, at least as a benefit for wild Chinook salmon. Recent adaptive management decisions to begin transport on May 1 reflect these findings. But the outcome is less certain for wild steelhead, which generally have improved survival when transported at any time during the spring migration.

With respect to transporting smolts after the first week in May, the data discussed above clearly show that in the majority of years included in the NOAA analyses, yearling Chinook salmon and steelhead that were transported from Lower Granite Dam had a SAR equal to or higher than their counterparts migrating in the river. In many cases, the difference was statistically significant. This was true regardless of natal origin. In NOAA's expanded dataset, SARs for smolts outmigrating in 2012 showed a weak (not statistically significant) negative impact from transporting wild Snake River Chinook salmon after the first week of May. SARs for 2014 outmigrants data also showed a shift from benefit to slight (not statistically significant) negative impact beginning in mid-May. Steelhead have always shown a positive but non-significant benefit from transporting wild Snake River steelhead after May 1.

The current practice of postponing transport until the first week of May appears to be advantageous to some, but not necessarily all Snake River ESUs. Responses vary by species and natal origin (wild or hatchery). This suggests that inter-species tradeoffs between Chinook salmon and steelhead may be in play during April. Managers may need to consider which ESUs are in most need of protection, given the current status of the ESU or sub-populations, and their migration timing through the system.

Summer migrants (early and late fall Chinook)

Subyearling fall Chinook salmon from the Snake River are regularly transported, although a thorough evaluation has yet to be completed. A decade-long, multi-agency investigation has been initiated and will have the final adult returns complete and analyzed in 2018. That study is designed to determine the best passage options for optimizing the survival of juvenile fall Chinook salmon through the Columbia River System. The complex life history of fall Chinook salmon has complicated investigations in previous decades. Those complications will be considered in the ongoing study. Initial results presented by NOAA Fisheries and the CSS appear to indicate that transportation neither significantly benefits nor has significant negative impacts to the Snake River fall Chinook ESU as a whole. There does appear to be a seasonal component where late migrating fall Chinook may benefit from transportation, but since the number of fish transported are very low, there does not appear to be a species (ESU) level effect.

As of 2017, both annual and long-term studies are ongoing by NOAA and CSS based on returning adult salmon that were tagged as juveniles. Current results from NOAA analysis comparing the smolt-to-adult ratio (SAR) of Snake River fall Chinook that outmigrated through bypass systems at the dams to SAR of fish that were transported is showing that the timing of migration and transport is important. In general, prior to June 15, bypassed fish that were returned to the river had a higher SAR than transported fish. However, after that date transported fish had a higher SAR than bypassed in-river fish (Smith et al. 2017). By contrast, results from the 2017 CSS report of annual, season-wide SARs that are not specific to week or month of passage, show that the benefit to fall Chinook is highly variable between years, release location, and hatchery/wild status.

D.8. Adult fish

Many of the 2008 BiOp actions have also been directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived difficult years at sea and are nearly at the point of spawning and giving rise to successive generations. The 2008 BiOp specifies performance standards for adult survival for most species and includes provisions for annually monitoring survival through the Columbia River System. This standard is equivalent to a juvenile reach survival standard and reflects combined impacts from a number of factors that affect adult survival through the freshwater migratory corridor that are beyond the Action Agencies' ability to manage or control.

Adult passage survival was consistently high through the mid-2000s and remains so for several species. However, adult passage survival unexpectedly declined for a period in certain Snake River species. More recent results in 2015 for Snake River spring/summer Chinook salmon and Snake River steelhead met the adult performance standards, but their 5-year averages were below the standards due to lower survival in earlier years (Figure D 23). In 2015, both the 5-year rolling averages (2011–2015) and 2015 specific results for Snake River fall Chinook, upper Columbia River spring Chinook and upper Columbia steelhead surpassed the BiOp performance standard. Improvements in PIT tag monitoring capabilities may help identify the location and potential causes of any downturns in adult survival, which could include high flows and spill leading to increased adult fallback, straying, and effects of harvest.

Columbia Basin salmon and steelhead migrating upstream during the spring face a serious threat from seals and sea lions that prey on fish from the mouth of the river up to Bonneville Dam. Adult fallback at Bonneville Dam also increases exposure to marine mammal predation, and evidence suggests spring Chinook fallback may increase in correlation with higher spring spill levels. Each year since 2002, pinnipeds have consumed thousands of migrating fish (ODFW, 2017), many from threatened and endangered runs protected under the ESA.

Once past Bonneville Dam, the ability of adult fish to reach their natal streams is influenced by many factors, including their successful migration through additional Columbia River System dams via fish ladders. The 2008 BiOp identified performance standards for adult passage through selected Columbia River System reaches (Figure D- 23). These data are based on known-source, PIT-tagged adults detected at Bonneville Dam and subsequently detected (or not) at McNary Dam and Lower Granite Dam. NOAA calculates the annual point estimates and rolling five-year averages for each ESU and applicable river reach. NOAA adjusts the rates of conversion between dams for estimated harvest and straying. New ladder PIT detectors were installed at The Dalles Dam in 2013 and at John Day Dam in 2016 to provide improved spatial resolution of adult survival in the Columbia River System and further inform analysis of adult survival.

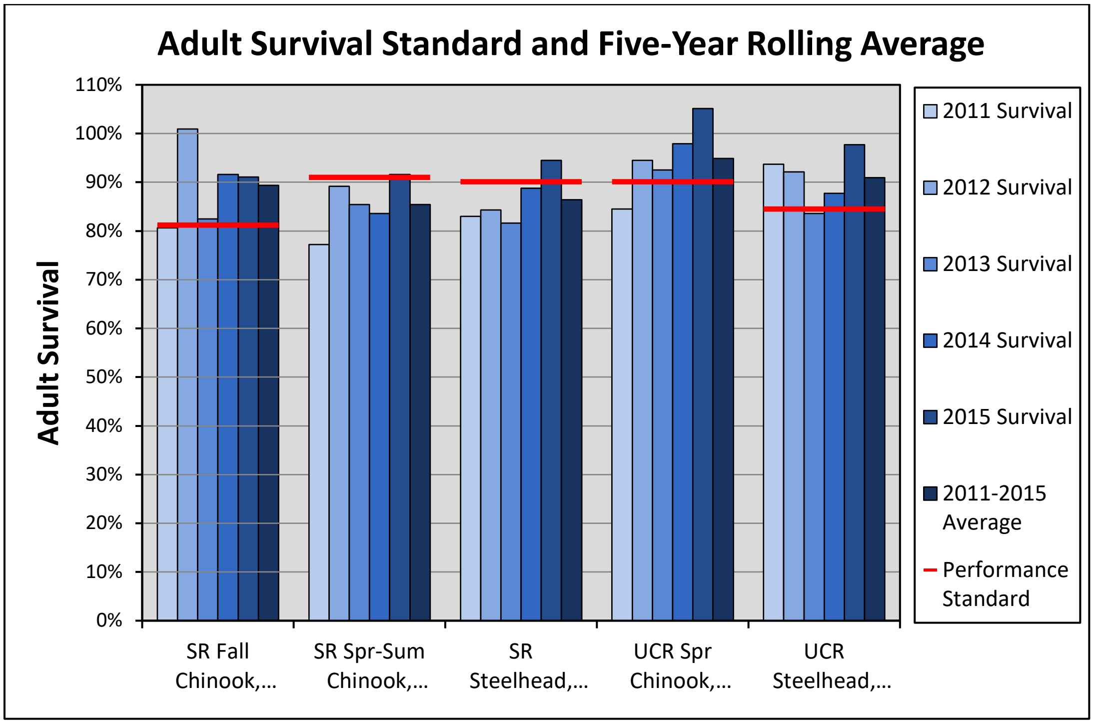


Figure D- 23. Adult survival standard and five-year rolling average survival of adults that migrated in-river as juveniles, based on PIT tag conversion rates of Snake River (SR) and upper Columbia River (UCR) ESUs.

(BON = Bonneville, MCN = McNary, LGR = Lower Granite). Data from NOAA Fisheries (Bellerud, 2016).

An adult performance standard specifically for Snake River sockeye salmon has not been developed. However, the 2008 BiOp considered that sockeye survival is adequate if the survival standards for Snake River spring-summer Chinook salmon and steelhead from Bonneville Dam to Lower Granite Dam are being met. Based on the NOAA data reported above, this has not been the case except for 2015. NOAA estimated that survival of sockeye salmon through the reach ranged from 80.6 to 100.9 percent the past 5 years.

An average of 50 sockeye salmon were counted at Lower Granite Dam from 2004 to 2007. The years 2008–2011 saw improved counts of 907, 1,219, 2,406, and 1,502 fish, respectively, at Lower Granite Dam (Figure D- 24). These were the largest sockeye counts since fish counting began at Lower Granite Dam in 1975. Counts were lower in 2012 and 2013, increasing again in 2014 and declining in 2015; the most recent 10-year average was 1,072 adult fish and the most recent four-year average return was 1,107 fish.

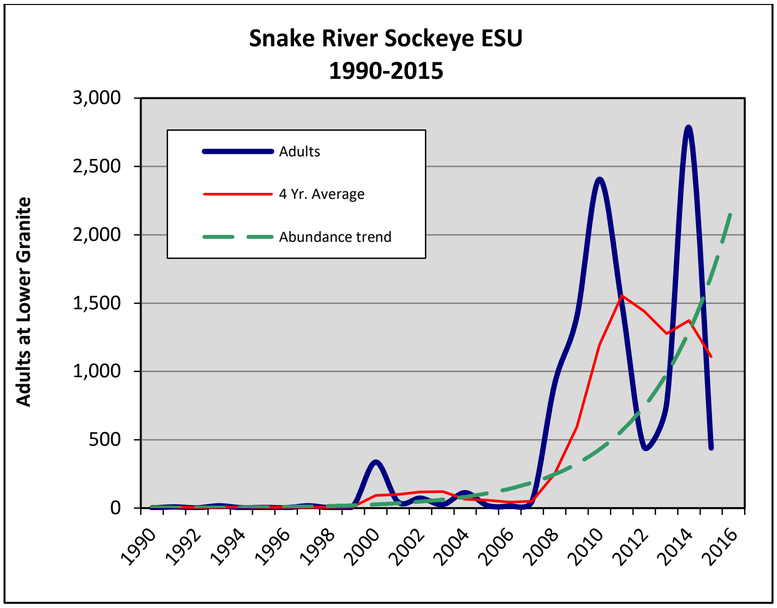


Figure D- 24. Returns of all Snake River sockeye salmon at Lower Granite Dam, 1990–2016. The ESU-level trend in abundance was positive during this period.

In 2015, an estimated 4,069 Snake River sockeye passed Bonneville Dam. A low snowpack and record-setting air temperatures in June and July throughout the Columbia River Basin created water temperatures in the lower Columbia and lower Snake rivers well above the range sockeye normally migrate through. This resulted in high mortality levels; only 1,052 adult sockeye were counted at Ice Harbor Dam, and 440 were counted at Lower Granite Dam. There was no quantifiable variation in return migration timing to Bonneville Dam in 2015 between the *adult* sockeye that had been transported as juveniles compared to those that migrated in-river as juveniles. However, the data suggest that adults that were transported as juveniles may have an impaired homing ability, which – as evidenced in 2015 – delayed their upstream progress and increased their exposure to elevated mainstem temperatures (NOAA, 2015). See Appendix D.7 for more discussion on juvenile salmon transportation.

BiOp actions for adult passage

At Little Goose Dam, it appears that installation and operation of a spillway weir that aids downstream passage of juveniles can, under certain spill conditions, hinder the upstream passage of adults. Beginning in 2011 a new spill pattern was implemented to reduce adult passage delay, which the Corps continued to use through 2017. Problems with adult passage delay have occurred periodically. The exact conditions that cause delay are not fully understood, but it appears that spill levels greater than 30 percent during the day can contribute to the problem. Even with the modified spill patterns noted above, passage delay was noted in 2017 during a period of high flow and high spill. The delay problem appeared to be alleviated when daytime spill levels were temporarily reduced by holding additional water behind the dam rather than spilling it. The Corps also continued design of a new adjustable spillway weir to allow rapid closure of the weir and provide more flexibility in meeting passage goals for adult and juvenile fish. Also at Little Goose Dam, warm river surface temperatures in the forebay during late summer can create a temperature difference between the adult ladder exit and the entrance, causing delays in adult passage. The Corps is scheduled to install permanent pumps to be operational in 2018.

At Lower Granite Dam, as at Little Goose, warm river surface temperatures in the forebay during late summer can create a temperature difference between the adult ladder exit and the entrance, causing delays in adult passage. Modifications to the juvenile bypass system route excess water to the adult trap. These improvements were completed and installed during the winter of 2015-2016 and successfully tested during the 2016 fish passage season.

These improvements notwithstanding, the survival for some Snake River species warrants continued investigation. Unfortunately, while NOAA can estimate the amount of mortality, existing data do not allow the precise causes to be determined. Candidate sources of mortality could include natural causes, impaired passage through the Columbia River System because of high flow or spill, direct and indirect effects of harvest, increased straying, and delayed effects of marine mammal attacks incurred below Bonneville Dam. Recent improvements in PIT tag monitoring capabilities in the Columbia River System will help identify the location and potential causes of the loss, and additional research or monitoring will likely be required to inform the formulation of solutions.

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Consultation Package for

Operations and Maintenance of the

Columbia River System

Appendix E
References for the Snake River Spring/Summer Chinook Salmon Example Survivals by Life Stage

Bonneville Power Administration

Bureau of Reclamation

U.S. Army Corps of Engineers

The table below documents the sources of scientific information and data that were used for Section 1.4 (Chapter 1) and (shown below as Figure E- 1). The figure is intended to illustrate typical survivals by life stage and typical amounts of time that Snake River spring/summer Chinook salmon spend migrating past the Columbia River System facilities and reservoirs in comparison to time away from the System. These types of biological data are often highly variable. For example, robust survival data are available for passage through the Columbia River System, whereas data for ocean survival are less available. Mortality from all sources is incorporated in the survival estimates because, in many cases, different sources of mortality cannot be identified. For example, juvenile survival through the Columbia River System reach from Lower Granite Dam to Bonneville Dam includes natural mortality, mortality related to the Columbia River System, and mortality from any other source, such as toxics or predation. Any latent or delayed mortality related to Columbia River System passage or any other source would be captured in juvenile migration survivals below the System, or in 1st year ocean survival.

Salmon mortality is related to multiple factors (National Research Council, 1996). One of those is distance traveled during migration. For example, Faulkner et al. 2017, Figure 7, showed a statistically significant inverse relationship between survival of yearling hatchery Chinook salmon and distance from the hatchery release site to Lower Granite Dam. In Figure E- 1, we used data for similar migration distances, where possible.

Mortality can also be a function of time; that is, higher mortality would be expected during longer life stages (a 1-year period vs a 2-week period). If the data shown in Figure E-1 were reported by equal time units, the mortality rate associated with juvenile salmon migration through the Columbia River System would be relatively high. This relatively high mortality rate in comparison to other life stages is mostly an artifact of the way the data are presented in this particular figure. Actual critical periods of high mortality (e.g., egg-to-emergence; ocean entry) are relatively short (typically on the order of a few weeks), but for figure purposes are lumped into longer life stages (e.g., egg-to-smolt; 1st year ocean). This has the effect of reducing the mortality rate during these longer periods. Again, the figure is intended to roughly illustrate time and survivals near Columbia River System facilities in contrast to time and survivals away from Columbia River System facilities.

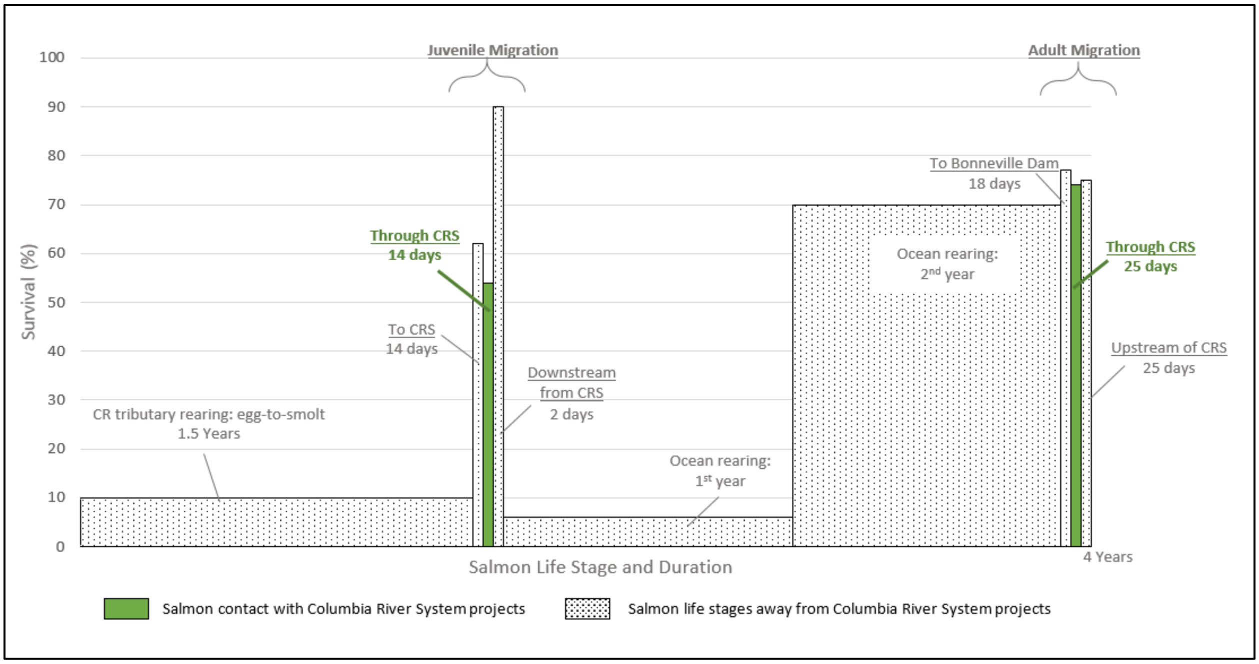

Figure E- 1. Snake River spring/summer Chinook salmon example survivals by life stage

The y-axis shows approximate percent salmon survival by life stage. The x-axis and bar widths represent the approximate duration of each life stage, from egg through adult migration to the spawning grounds. Life stages shown here include juvenile rearing in Columbia River tributaries (egg-to-smolt), juvenile migration to the most upstream Columbia River System dam, juvenile migration through the Columbia River System, juvenile migration below the Columbia River System to the ocean, first year ocean rearing, second year ocean rearing, adult migration from the ocean to the most downstream Columbia River System dam, adult migration through the Columbia River System, and adult migration upstream of Lower Granite Dam. We assumed a four-year life cycle for this example.

Table E- 1. Summary of reference material for Figure E- 1.

Life Stage	Duration	Survival
Egg-to-smolt	1.5 years (e.g., October 2016 to March 2018): NOAA Fisheries, 2008, page 8.3-11. Spawning is usually complete by second week of September.	10% average: Quinn, 2005, Table 15-1, p 254. The expert panel process used 18% as a *maximum* survival as explained/ documented in Corps et al. 2007, Appendix C, Attachment C-1, Annex 2, pages C-1-24 to C-1-26. Annex 2 reports a range of 1-22% for survivals. Paulsen and Fisher, 2005, Figure 2, Reports parr-to-smolt survivals for Snake River spring/summer Chinook of about 20%.

Life Stage	Duration	Survival
Juvenile migration to the Columbia River System	Assumed 14 days because the distance to Lower Granite Dam from the hatchery release site is similar to the distance through the Columbia River System: Faulkner et al., 2017, p 31.	62%: Faulkner et al., 2017, p 46. McCall hatchery was used because this distance, 457 km, is similar to the 461 km from Lower Granite to Bonneville. Data an average of 2007-2016. Means for this set of years ranged from 51-73%.
Juvenile migration thru the Columbia River System	14 days: Personal communication with Christine Peterson, BPA Faulkner et al., 2017, p 31, chart upper right. Variation is about 10-32 days depending upon time of year.	54%: Faulkner et al., 2017, p 49. Data an average of 2007-2016 data. This number incorporates natural mortality and all other sources of mortality (for example toxics from any source) – not just mortality related to Columbia River System operations. Means for this set of years ranged from 43-63%.
Juvenile migration downstream of Bonneville Dam to the ocean	2 days: NOAA Fisheries (Northwest Fisheries Science Center), 2014, p 19.	90%: Used 90% from range of 81-99% reported on p 41, Jacobson et al. 2012.
First year ocean	1 year	6%: Based on data presented on page 41, Jacobson et al. 2012, reporting ranges from 14-71% for survival in the plume (from the mouth of the Columbia to Willapa Bay) and 2-25% from Willapa Bay to Lippy Point, Vancouver Island. We used midpoints of these 2 values - 42.5%*13.5% = 6% And see page vi, last bullet. L. Weitkamp presentation to Northwest Power and Conservation Council, Jan 3, 2018, slide 4, says “This initial period is when most marine mortality occurs.”
Second year ocean	1 year	70%: Sharma et al. 2013, p 15

Life Stage	Duration	Survival
Adult migration to Bonneville Dam	18 d: NOAA Fisheries 2014, p 22.	77%: NOAA Fisheries 2017, p 34. 2017 supplemental recovery plan module for Snake River salmon and steelhead mainstem Columbia River hydropower projects. Represents an average for Snake River spring Chinook (2010-2016)
Adult migration thru the Columbia River System	Assumed 20 km/day or 25 days: NOAA Fisheries 2014, p 8, and Ferguson et al. 2005, p 103.	87%: P 9, NOAA Fisheries 2017. (Corrected for harvest and straying; otherwise 74%)
Adult migration upstream of the Columbia River System to the spawning ground	Assumed 20 km/day or 25 days: NOAA Fisheries 2014, p 8, and Ferguson et al. 2005. p 103.	75%, P 83, NMFS 2017 (this is an assumption used by NOAA; actual mortalities would vary with distance traveled and other factors)

E.1. References

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