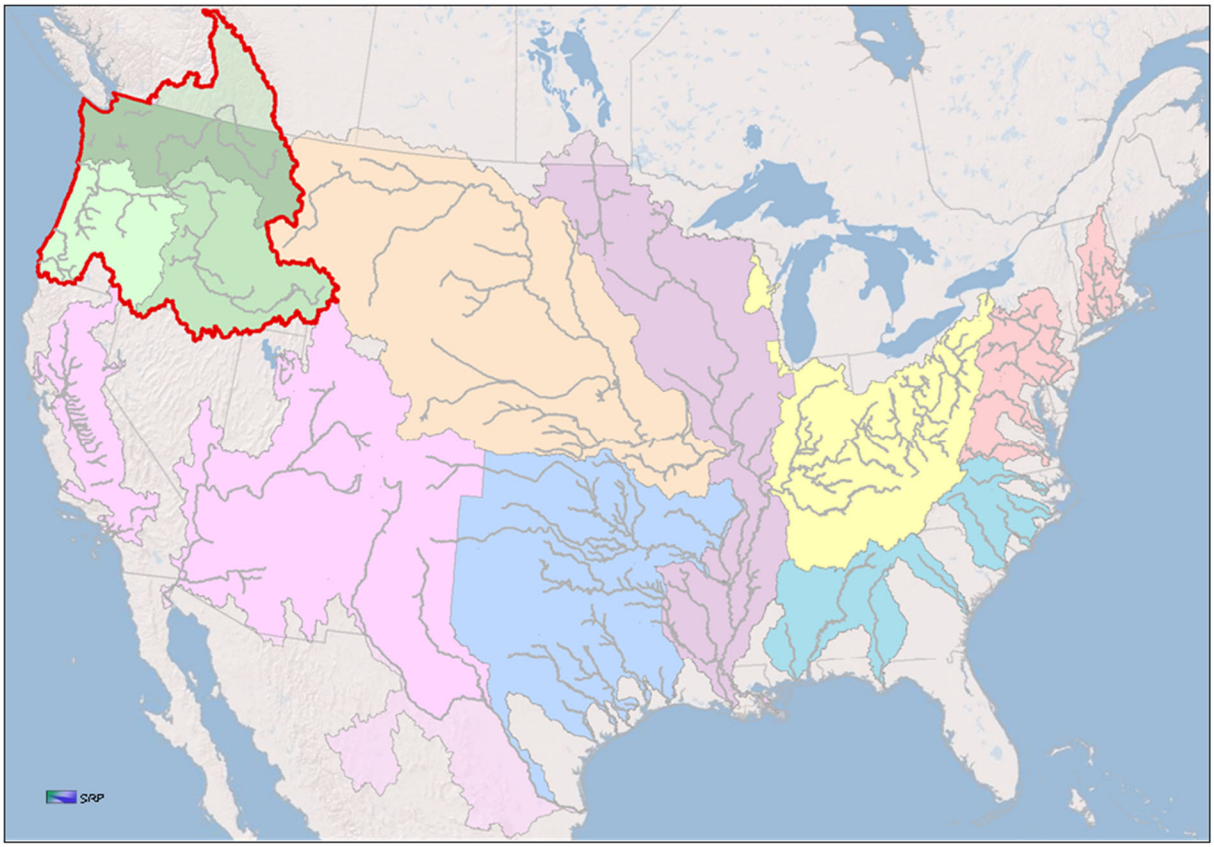
Sustainable Rivers Program

Environmental Opportunities for Rivers and Reservoirs in the Northwest



Regional Operations and Water Management Meeting

Northwestern Division and Seattle, Portland, and Walla Walla Districts

July 14, 2021

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Executive Summary

The Northwest Operations and Water Management Meeting was conducted virtually, November 18-19, 2020. The purpose of the meeting was to identify environmental opportunities at reservoirs and related Civil Works water resources infrastructure in the Pacific Northwest that are feasible to implement with compelling potential benefits. This report documents the meeting and the discussions held in plenary and breakouts sessions. This is not a decision document; no specific recommendations are made. However, this report is intended for use by district and regional Corps staff considering opportunities and priorities for environmental improvement at water resources infrastructure in the Northwest.

The Northwest region is defined as the geographic areas of 3 Corps Districts within Northwestern Division (NWD): Portland (NWP), Seattle (NWP), and Walla Walla (NWW). Those districts are responsible for Corps Civil Works water resource projects within a geographic area that encompasses the portions of Columbia River and its tributaries in the United States (including the Willamette, Snake, Pend Oreille and Kootenai River basins) as well coastal portions of Oregon and Washington, including the Puget Sound Trough (Figure 1). More than 45 reservoirs, affecting flows for 4,500 river miles within the region, were considered.

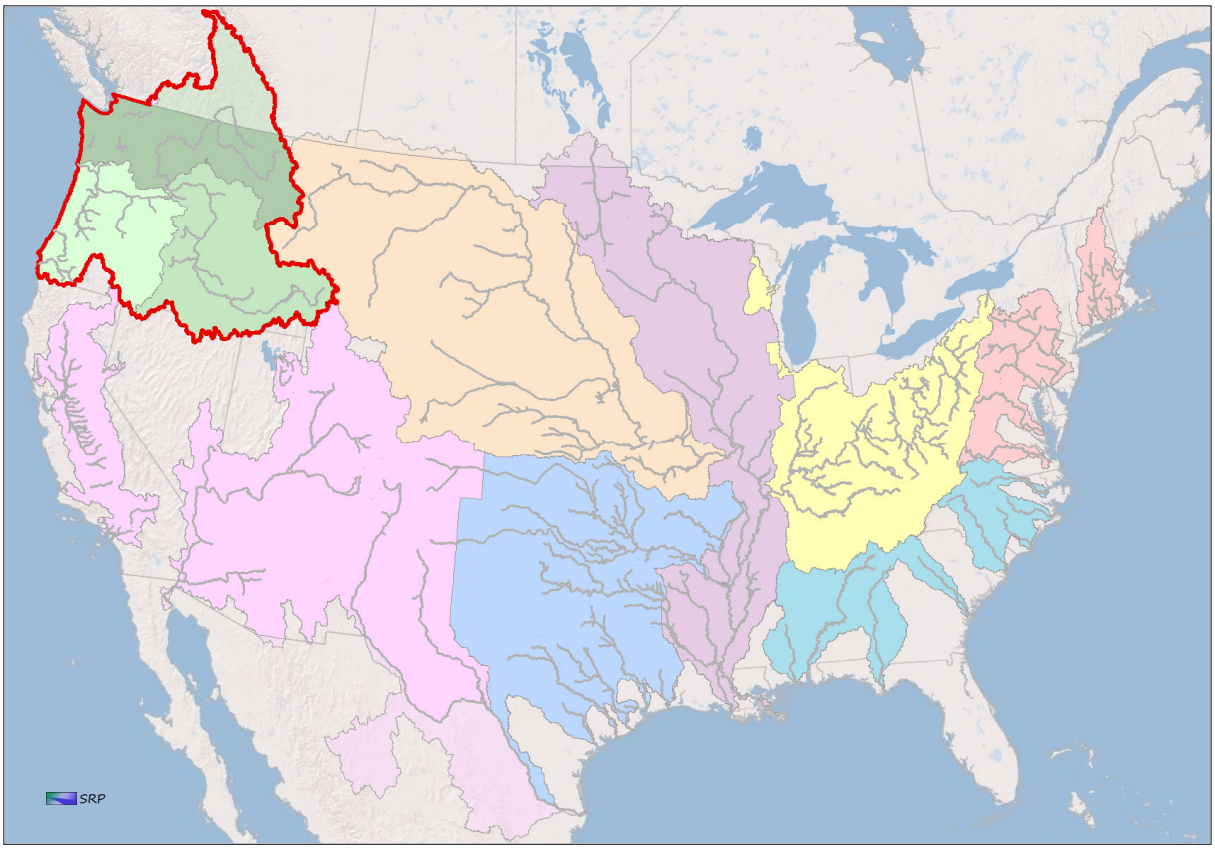


Figure 1 – Geographic scope of the Northwest Regional Meeting

Table 1 – Priority actionable ideas, Northwest region

Location-based team	Environmental Action	Reservoir(s)
Portland	Environmental flows for salmonids and other species	Willamette River Basin (continued for Detroit, Green Peter and Foster dams on the Santiam River, Cougar and Blue River dams on the McKenzie River, and Lookout Point and Hills Creek dams on the Middle Fork Willamette River) and Rogue River basin (Lost Creek and Applegate dams)
Portland	Management of Harmful Aquatic Blooms (HABs)	Detroit, Cougar, Willow Creek Lakes
Portland	Pool level management for invasive species	John Day Dam, Lake Umatilla (Rock Creek Arm)
Portland	Floodplain connectivity and wetland restoration	Willamette River Basin
Portland	Fish passage improvement	Willamette River Basin, Columbia River mainstem
Seattle	Water quality improvements for temperature, nutrients, and HABs	Libby Dam and Lake Koocanusa, Chief Joseph Dam and Lake Rufus Woods, Lake Washington Ship Canal
Seattle	Debris management	Libby Dam and the Kootenai River, Albeni Falls Dam, and the Pend Oreille River
Seattle	Cottonwood recruitment and regeneration	Libby Dam and the Kootenai River, Albeni Falls Dam, and the Pend Oreille River
Seattle	Invasive species management	Chief Joseph Dam and Lake Rufus Woods, Albeni Falls Dam, and the Pend Oreille River
Walla Walla	Environmental flows	Lucky Peak Dam and the Boise River, Mill Creek Dam and Mill Creek
Walla Walla	Pool elevation management for environmental benefits	Mill Creek Dam and Lake Bennington, McNary Dam and Lake Umatilla
Walla Walla	Temperature management	Mill Creek Dam, Lake Bennington, and Mill Creek
Walla Walla	Debris management (sediments and wood material)	Multiple projects

The meeting was sponsored and hosted by the Sustainable Rivers Program (SRP). Participants (listed in appendix A) were comprised of staff from the U.S. Army Corps of Engineers (Corps), including representatives of NWD and the three regional districts, and The Nature Conservancy (TNC). Following COVID-19 Protocols, all meeting plenary and breakout sessions were conducted virtually.

In formulating and evaluating environmental opportunities, location-based (by district) teams followed these steps:

1) list possible environmental actions associated with reservoirs;
2) rate environmental potential of each action;
3) rate degree to which each action has been implemented;
4) select environmental actions with unrealized implementation; and,
5) rank reservoirs according to which are most promising for operational changes related to selected actions.

One characteristic of the Corps projects in the Northwest that distinguishes the region from other parts of the country is the high degree of existing and ongoing consultation under the Endangered Species Act. Virtually all the projects are operating under Biological Opinions (BiOps) negotiated with National Marine Fisheries Service (NMFS) and/or U.S. Fish and Wildlife Service (USFWS) that include conservation actions for flow management and related actions that are already integrated into project operations. Regardless, the District teams were able to identify combinations of environmental action that could be implemented at candidate reservoirs. These are highlighted in the report and summarized in table 1.

This report details content of the meeting and is structured to follow the meeting agenda (appendix B).

Introduction and Objective

The goal of the Northwest Operations and Water Management meeting was to identify environmental opportunities at Corps-involved reservoirs that are feasible to implement with compelling potential benefits.

By many measures (e.g., number of reservoirs, total storage, geographic distribution), the Corps is the largest water management organization in the nation. A reservoir survey completed in 2013 identified 465 reservoirs with federally authorized flood storage. The majority (356) of these reservoirs were owned and operated by the Corps. Additionally, the Corps has approximately 180 Corps lock and dam reservoirs. Considering environmental opportunities for all these reservoirs is daunting given their diversity of size, location, and purpose.

Contemplating opportunities at finer spatial scales becomes more practical as similarities in hydrology, landscape, reservoirs, and water resources management create a common context for sharing experiences and formulating alternative management strategies. Environmental opportunities and challenges also trend regionally, as considerations begin to focus on shared ecological community types, flyways, and habitats. The Northwest Operations and Water Management meeting was convened with this premise – that regional characteristics of water and ecological systems can underpin a productive dialogue about reservoir operations for environmental benefits.

Meeting participants provided expertise in reservoir operations, water management, water quality, natural resources management, environmental planning, and ecology. Collectively, the group began the formulation process by listing key environmental actions associated with reservoirs. Participants then split into location-based teams (based on geographical areas of responsibility of the three participating Corps districts and experience). Each team scored the potential benefits and current implementation level of each environmental action (for all reservoirs, collectively). Teams then selected specific actions with unrealized environmental benefits and ranked the reservoirs within their area, individually, according to which were the most promising candidates for operational changes related to each selected action.

At the start of the meeting, several other key assumptions relative to the prioritization of environmental opportunities in the Northwest Region were identified and discussed.

1. The focus of the Northwest Regional Meeting will be on the potential for environmental actions at Corps multiple-purpose storage reservoirs in the region. However, opportunities for environmental improvements at other types of Civil Works water resources infrastructure are open for discussion.

2. Columbia and Snake River mainstem projects fall into the category of "Big River" projects. Given the level of complexity of operation for those projects and the degree of coordination that already exists through ESA consultation and related regional forums, ongoing NEPA compliance activities, and oversight by the courts, these projects may be outside of the scope of SRP. Individual district may decide whether or not to include these projects in their individual evaluations of environmental opportunity and priority.

3. One characteristic of Corps projects in the Northwest that differs from other parts of the country is the high degree of existing and ongoing consultation under the Endangered Species Act. Most of these projects are operating under BiOps negotiated with NMFS and/or USFWS that include conservation actions for flow management and related operations. Given that status, a key challenge for this meeting will be to determine whether additional environmental flows work has potential to yield more benefits and, if so, how to identify, prioritize, and implement that work within the context of existing and ongoing consultations.

Agenda Overview

The Northwest Regional Meeting was conducted virtually, November 18-19, 2020. Appendix B contains a detailed agenda for the meeting. This report closely follows the meeting agenda. In summary, meeting sessions occurred as follows:

<u>Day 1: November 18, 2020</u>

<u>Plenary Session #1: Introductions and Objectives</u>. Host team facilitated introductions and a discussion of the meeting overview and objectives, including the history and status of the SRP. Results from ongoing GIS analyses were presented to summarize rivers and reservoir systems of the

Northwest (see “Introduction and Objective”, “Sustainable Rivers Program”, and “Northwest Regional Rivers and Reservoirs” sections).

Representatives from the three districts presented overviews of their portfolios of multiple purpose reservoirs and related Civil Works infrastructure, including existing ongoing environmental stewardship and ecosystem restoration projects within region (see “Reservoir-centric Environmental Efforts within the PNW Region” section).

In closing the initial plenary session, the Environmental Opportunity Matrix was introduced and revised per participant input for use in the first breakout session.

Breakout Session #1: Identify Opportunities for Environmental Improvement. Each location-based team met independently to evaluate and formulate opportunities for ecological improvement actions within their own portfolios of projects. Three topics or questions were explored:

1) Identify environmental opportunities at reservoirs. Define potential and implementation.
2) What opportunities are underrepresented and feasible?
3) What are limitations to implementation?

Using this information, the location-based teams began filling out the Environmental Opportunity Matrix for their respective areas of responsibility (see “Environmental Opportunity Matrix and Ongoing Environmental Work” section)

Plenary Session #2: Regional Reservoir’s Authorizations and Capabilities. A review of project authorizations and basic capabilities of Corps reservoirs in the Northwest to operate for environmental purposes was presented, including which reservoirs have fish and wildlife, water quality, and/or recreation as an authorized purpose (see “Illustration of Reservoir Review” section). This information was used as background for the second breakout session.

Breakout Session #2: Prioritize Environmental Opportunities. Using the populated Environmental Opportunity Matrix and background information on project authorizations and capabilities, location-based teams selected approximately 3 to 4 promising environmental actions and then prioritized individual reservoir projects as potential candidates for each action. Emphasis was on identifying key “actionable” ideas for environmental improvement at reservoirs (see “Prioritization of Reservoirs by Location-based Teams” section).

Plenary Session #3: Wrap for day 1. Participants reconvened in a plenary session to answer questions and discuss details for day 2.

Day 2: November 19, 2020

Plenary Session #4: Revisit of Meeting Objectives. Participants convened Day 2 with a review of the previous day’s breakout sessions and an overview of Day 2 activities. In the meeting agenda, Plenary Session #4 was to be followed by a series of parallel sessions in which participants would discuss nominated topics about environmental opportunities related to water infrastructure. However, participants agreed to reduce this session in the interests of having more time to continue location-based team efforts to prioritize projects per environmental action.

The one topic discussed in plenary was the importance of Endangered Species Act compliance as a critical driver for identifying and prioritizing environmental opportunity in the Northwest.

Breakout Session #3: Finalize Location-Based Priorities. Location-based teams reconvened to finalize thoughts and prepare materials for report out to the group on their respective location-based priorities for actionable environmental ideas in Plenary Session 5.

Plenary Session #5: Final Team Reports. Location-based teams reported to group on select environmental actions and associated candidate reservoirs. Actionable ideas were highlighted (see "Actionable Ideas and Discussion" section).

Before adjourning the meeting, participants had an open discussion about meeting products, follow-up tasks, and concluding thoughts. The group reviewed overall agenda and revisited key components to discuss effectiveness and generate ideas for future meetings.

Sustainable Rivers Program

The Sustainable Rivers Program (SRP) is a national partnership between the Corps and TNC. The mission of SRP is to improve the health and life of rivers by changing dam operations to restore and protect ecosystems, while maintaining or enhancing other project benefits.

SRP began in 1998 with an initial collaboration to improve the ecological condition of Green River, Kentucky. The Program was formally established in 2002 and involved 8 river systems. SRP now (2019) involves work on 66 Corps reservoirs in 16 river systems and 5,083 river miles (Figure 2). It is the largest scale and most comprehensive program for implementing environmental flows below Corps reservoirs.

Environmental flows are defined as the quantity, timing, and quality of water flows required to sustain ecosystems. For reservoir operators, environmental flows manifest as management decisions that manipulate water and land-water interactions to achieve ecological or environmental goals. The SRP process for environmental flows has three phases: (1) advance; (2) implement; and (3) incorporate. Advancing e-flows involves engaging stakeholders in a science-based process to define the flow needs of riverine ecosystems. Implementation involves testing the effectiveness and feasibility of the defined flows. Incorporation involves including environmental flow strategies in reservoir operations policy such as water control manuals. Environmental flows were the founding objective of SRP and remain the key focus. In recent years, the Program began exploring other reservoir-oriented actions with potential to

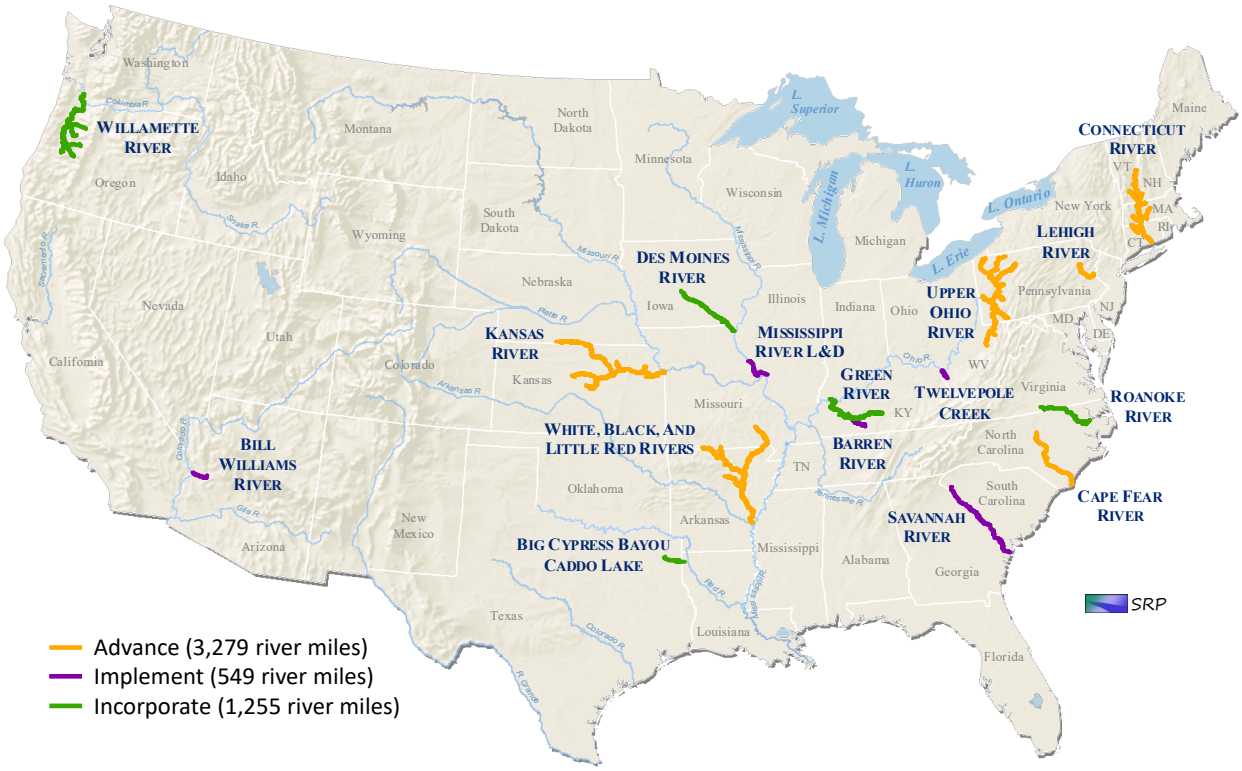


Figure 2 -- Status of rivers engaged in the Sustainable Rivers Program, 2019.

produce environmental benefits. While the focus of the meeting was on the potential for environmental flow operations and related ecosystem restoration management actions at Corps multiple-purpose storage reservoirs in the Northwest region, opportunities for environmental improvements at other types of Civil Works water resources infrastructure are open for discussion.

Importantly, this report and associated meeting are not about SRP. SRP has promoted the concept of regional meetings for several years with the intent of providing a venue for broad consideration of environmental actions at rivers and reservoirs. The Northwest meeting was the third in a series of regional Operations and Water Management meetings sponsored by the Sustainable Rivers Program. Previous regional meetings were conducted in the Upper Midwest (involving Kansas City, Omaha, Rock Island, St. Paul, and St. Louis districts) in September 2019) and South (involving New Orleans, Memphis, Vicksburg, Galveston, Little Rock, Fort Worth, and Tulsa districts) in September 2020.

As with the previous meetings, the emphasis in the Northwest Regional Meeting has been on going through a process of identifying and prioritizing possible actions that could be undertaken to provide environmental improvement. It is possible that some of the resulting identified environmental opportunities may be addressed through SRP. Alternatively, they may also be addressed through other Corps programs and authorities or by actions taken by other sponsors and stakeholders.

Northwest Regional Rivers and Reservoirs

For the purposes of this report and associated meeting, the Northwest region is comprised of the geographic areas of 3 Corps Districts, Portland (NWP), Seattle (NWS), and Walla Walla (NWW), which are part of the Corps' Northwestern Division (NWD). Collectively, those districts are involved in management of water resources at 53 dams and reservoirs. Of those, the Corps owns and operates 34 projects and has responsibility for flood risk management operations on 19 projects owned by others under Section 7 authority. On the mainstem Columbia and Snake River system, crossing through all three districts, are nine large mainstem run-of-river dams owned and operated by the Corps primarily for navigation and hydropower purposes. Only one of those, John Day Dam, has flood control storage. There is one other small navigation lock and dam, Ballard Locks, located in Seattle District. Tables 2 and 3 provide a summary of all the Corps-affiliated dams and reservoirs in the Northwest region, including name, location (by state and river basin), owner/operator, project type and primary operating purposes.

The Columbia and Snake River mainstem and several other Federal Columbia River Power System (FCRPS) projects fall into the category of "Big River" projects. These projects are characterized by a high level of operational complexity and coordination that already exists through ESA consultation and related regional forums, ongoing NEPA compliance activities, and oversight by the courts. For the purposes of the regional workshop, these projects were considered outside of the scope of the meeting. District teams were given the option of deciding whether to include or exclude them from their project-specific considerations of environmental opportunity (it is worth noting that all three districts did identify actionable environmental opportunities at one of their respective Big River projects, although the focus remained with the general storage reservoirs).

Most Corps-involved reservoirs in the Northwest have multiple-purpose conservation storage and flood control storage. In this report, this type of reservoir is referred to as "General". The remainder of this section focuses on general dams and describes their locations within the region, the volumes of storage they provide, and the affected river reaches. The intent of this section is to provide a sense of the degree of hydrologic modification of rivers in the region.

Collectively, the Districts are involved with 46 reservoirs with federally authorized flood space. Roughly half (22) of these reservoirs are owned and operated by the Corps. The others are owned and operated by entities other than the Corps, with the Corps prescribing guidance for the management of the federal authorized flood space (Figure 3). These reservoirs are often referred to as Section 7 reservoirs in reference to the portion of the Flood Control Act of 1944 that authorized the Corps to prescribe regulations for the use of reservoir storage dedicated to flood risk management for all facilities constructed wholly or in part with federal funds.

Table 2 – Corps-involved Dams and Reservoirs in Portland District

Project name	State	Owner / Operator	River Basin	Project Type	Primary Operating purpose(s)
Applegate Dam and Lake	OR	Corps	Applegate River (Rogue River Basin)	Multiple -Purpose Storage	Flood Risk Management, Fish and Wildlife
Big Cliff Dam and Lake	OR	Corps	N. Santiam River (Willamette River)	Re-Regulating	Hydropower
Blue River Dam and Lake	OR	Corps	Blue River (Willamette River Basin)	Multiple -Purpose Storage	Flood Risk Management
Bonneville Lock & Dam and Lake	OR / WA	Corps	Columbia River	Mainstem run-of-river	Navigation and Hydropower
Cottage Grove Dam and Lake	OR	Corps	Coast Fork Willamette River	Multiple -Purpose Storage	Flood Risk Management
Cougar Dam and Lake	OR	Corps	S. Fk. McKenzie River (Willamette River Basin)	Multiple -Purpose Storage	Flood Risk Management
Detroit Dam and Lake	OR	Corps	N. Santiam River (Willamette River)	Multiple-purpose Storage	Flood Risk Management
Dexter Dam and Lake	OR	Corps	M. Fk. Willamette River	Re-Regulating	Hydropower
Dorena Dam and Lake	OR	Corps	Row River (Willamette River Basin)	Multiple -Purpose Storage	Flood Risk Management
Elk Creek Dam	OR	Corps	Elk Creek (Rogue River Basin)	Incomplete	Deauthorized
Emigrant Dam and Lake	OR	Section 7, USBR	Emigrant Creek (Rogue River Basin)	Multiple -Purpose Storage	Irrigation, Flood Risk Management
Fern Ridge Dam and Lake	OR	Corps	Long Tom River (Willamette River Basin)	Multiple -Purpose Storage	Flood Risk Management
Foster Dam and Lake	OR	Corps	S. Santiam River (Willamette River)	Multiple-purpose Storage	Flood Risk Management
Galesville Dam and Lake Lake	OR	Section 7, Douglas	Upper Cow Creek (Umpqua River Basin)	Multiple -Purpose Storage	Irrigation, Flood Risk Management
Green Peter Dam and Lake	OR	Corps	S. Santiam River (Willamette River)	Multiple -Purpose Storage	Flood Risk Management
Hills Creek Dam and Lake	OR	Corps	M. Fk. Willamette River	Multiple -Purpose Storage	Flood Risk Management
John Day Lock & Dam and Lake Ur	OR/WA	Corps	Columbia River	Mainstem run-of-river	Navigation, Hydropower and Flood Risk Management
Lookout Point Dam and Lake	OR	Corps	M. Fk. Willamette River	Multiple -Purpose Storage	Flood Risk Management
Lost Creek Dam and Lake	OR	Corps	Rogue River	Multiple -Purpose Storage	Flood Risk Management, Fish and Wildlife
Mayfield Dam and Lake	WA	Section 7, Tacoma Power	Cowlitz River	Multiple -Purpose Storage	Hydropower
Mossyrock Dam and Lake	WA	Section 7, Tacoma Power	Cowlitz River	Multiple -Purpose Storage	Hydropower
Mt. St. Helens Sediment Retentic	WA	Corps	Toutle River (Cowlitz River Basin)	Sediment Retention Dam	Flood Risk Management
Ochoco Dam and Lake	OR	Section 7, USBR	Ochoco Creek (Crooked River Basin)	Multiple -Purpose Storage	Irrigstion, Flood Risk Management
Scoggins Dam and Henry Hagg Lal	OR	Section 7, USBR	Tualatin River (Willamette River Basin)	Multiple -Purpose Storage	Irrigation, Flood Risk Management
The Dalles Lock & Dam and Lake (	OR/WA	Corps	Columbia River	Mainstem run-of-river	Navigation and Hydropower
Willamette Falls Locks	OR	Corps	Willamette River	Multiple -Purpose Storage	Flood Risk Management
Willow Creek Dam and Lake	OR	Corps	Willow Creek (Columbia River)	Multiple -Purpose Storage	Flood Risk Management

Table 3 – Corps-involved Dams and Reservoirs in Seattle and Walla Walla Districts

Project name	State	Owner / Operator	River Basin	Project Type	Primary Operating purpose(s)
Seattle District					
Albeni Falls Dam and Lake Pend Oreille	ID	Corps	Pend Oreille River	Multiple -Purpose Storage	Flood Risk Management, Hydropower
Chief Joseph Dam and Lake Rufus Woods	WA	Corps	Columbia River	Mainstem run-of-river	Hydropower
Hiram M. Chittenden Locks	WA	Corps	Lake Washington Ship Canal	Lock and Dam	Navigation
Howard Hanson Dam and Eagle Gorge Reservoir	WA	Corps	Green River	Multiple -Purpose Storage	Flood Risk Management, Water Supply and Ecosystem Restoration
Libby Dam and Lake Koocanusa	MT	Corps	Kootenai River	Multiple -Purpose Storage	Flood Risk Management, Hydropower
Mud Mountain Dam and Lake	WA	Corps	Puyallup River	Dry Dam	Flood Risk Maagement
Ross Dam and Lake	WA	Section 7, Seattle City	Skagit River	Multiple -Purpose Storage	Hydropower
Upper Baker Dam and Baker Lake	WA	Section 7, Puget Sound	Skagit River	Multiple -Purpose Storage	Hydropower
Wynoochee Dam and Lake	WA	Section 7, City of Aberdeen	Wynoochee River	Multiple -Purpose Storage	Hydropower, Flood Risk Management
Walla Walla District					
Agency Valley Dam	OR	Section 7, USBR	N. Fk. Malhuer River	Multiple-Purpose Storage	Irrigation, Flood Risk Management
Anderson Ranch	ID	Section 7, USBR	Boise River	Multiple-Purpose Storage	Irrigation, Flood Risk Management
Arrowrock	ID	Section 7, USBR	Boise River	Multiple-Purpose Storage	Irrigation, Flood Risk Management
Bully Creek Dam	OR	Section 7, USBR	Bully Creek (Malhuer River)	Multiple-Purpose Storage	Irrigation, Flood Risk Management
Dworshak Dam and Lake	ID	Corps	Clearwater River	Multiple-Purpose Storage	Flood Risk Management
Ice Harbor Lock and Dam	WA	Corps	Snake River	Mainstem run-of-river	Navigation and Hydropower
Jackson Lake Dam	WY	Section 7, USBR	Snake River	Multiple-Purpose Storage	Irrigation, Flood Risk Management
Little Goose Lock and Dam	WA	Corps	Snake River	Mainstem run-of-river	Navigation and Hydropower
Little Wood	ID	Section 7, USBR	Little Wood River (Snake River)	Multiple-Purpose Storage	Irrigation, Flood Risk Management
Lower Granite Lock and Dam	WA	Corps	Snake River	Mainstem run-of-river	Navigation and Hydropower
Lower Monumental Lock and Dar	WA	Corps	Snake River	Mainstem run-of-river	Navigation and Hydropower
Lucky Peak Dam and Lake	ID	Corps	Boise River	Multiple-Purpose Storage	Flood Risk Management
Mason Dam and Phillips Lake	OR	Section 7, USBR	Powder River	Multiple-Purpose Storage	Irrigation, Flood Risk Management
McNary Lock and Dam	OR /WA	Corps	Columbia River	Mainstem run-of-river	Navigation and Hydropower
Mill Creek Flood Control Project	WA	Corps	Mill Creek (Walla Walla River)	Off-channel dam with small conservation pool	Flood Risk Management
Palisades Dam	ID	Section 7, USBR	Snake River	Multiple-Purpose Storage	Irrigation, Flood Risk Management
Ririe Dam	ID	Section 7, USBR	Snake River	Multiple-Purpose Storage	Irrigation, Flood Risk Management
Warm Springs Dam	OR	Section 7, USBR	M. Fk. Malheur River	Multiple-Purpose Storage	Irrigation, Flood Risk Management

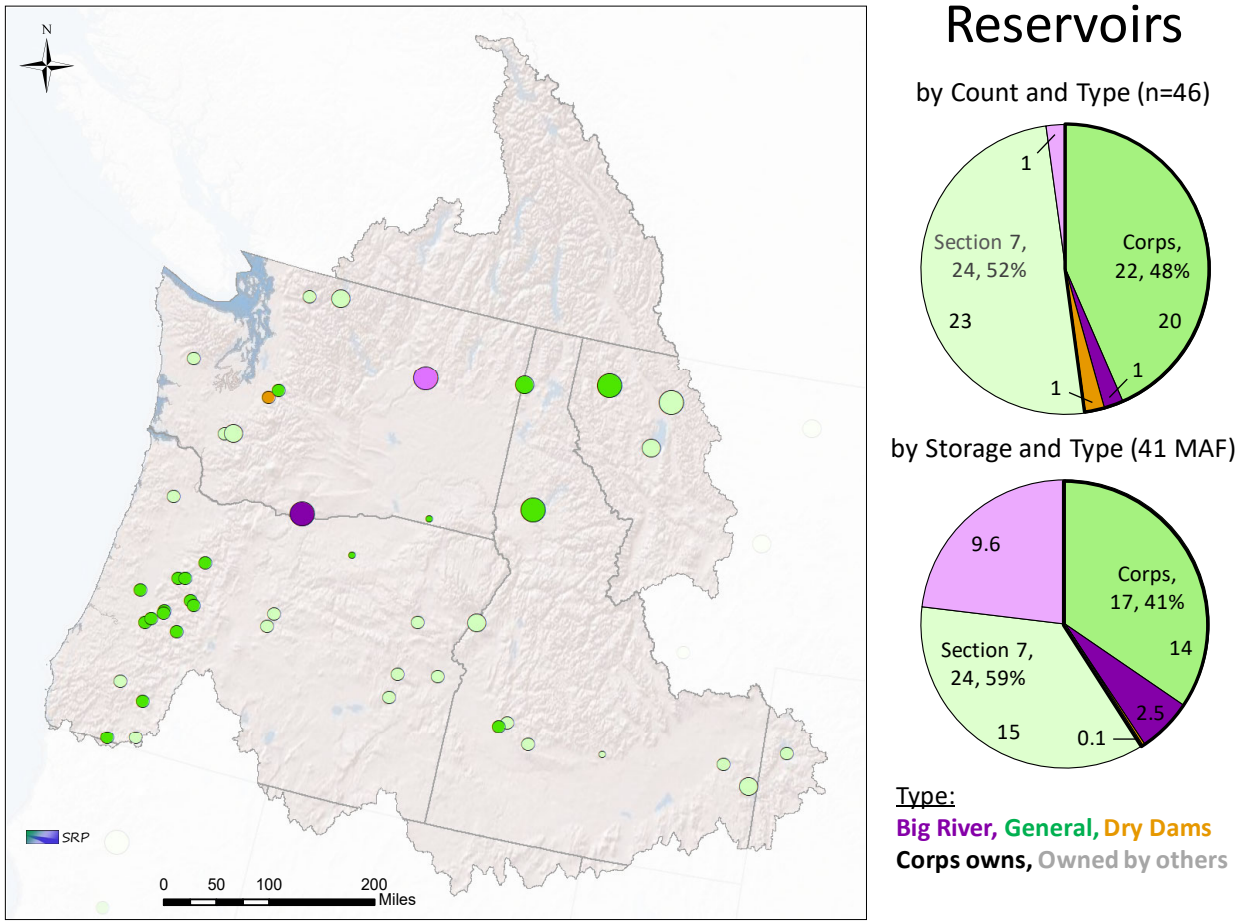


Figure 3 – Corps-involved reservoirs in the Northwest region. Excludes Corps locks and dams.

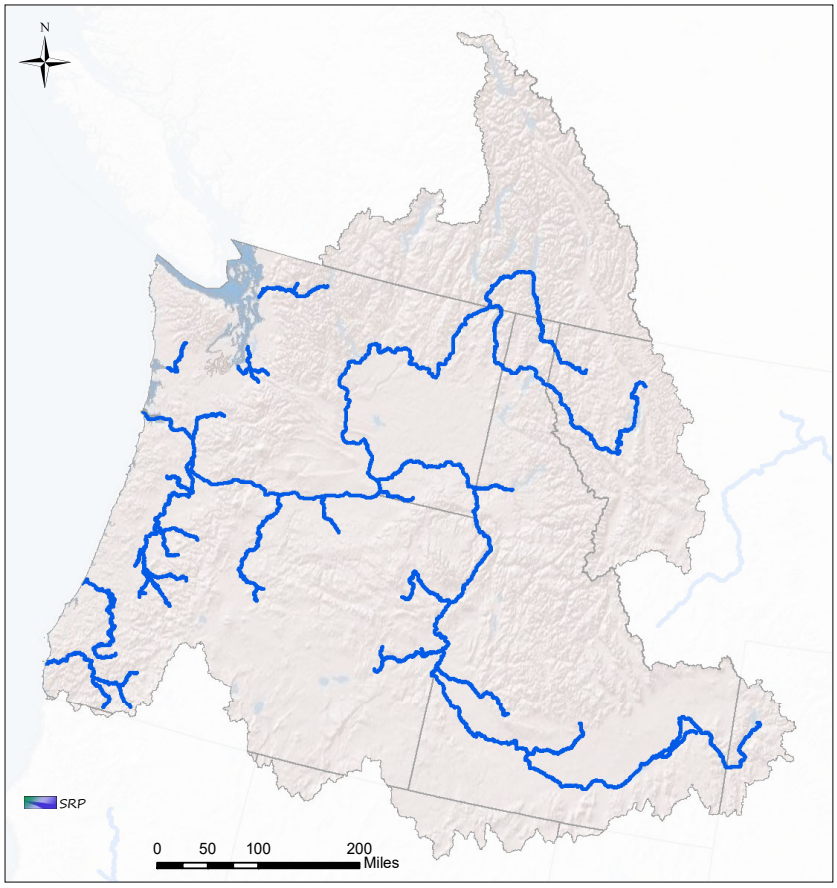
One of the reservoirs (Mud Mountain Dam, NWS) is a dry dam (it has no conservation storage pool – water is stored during a flood event and then released back downstream as soon as flood risk has passed). Big river reservoirs (Grand Coulee Dam and Franklin D. Roosevelt Lake – owned by the US Bureau of Reclamation and John Day Dam and Lake Umatilla – owned by the Corps) are reservoirs on the mainstem Columbia that differ from other reservoirs in the region based on amount of water and drainage area regulated (of the nine large run-of-river dams on the mainstem Columbia and Snake rivers operated by the Corps, only John Day dam has any authorized flood control storage space). Based on the National Inventory of Dams (NID 2016), Corps involved dams contain 41 MAF of storage, which is 59% of all surface water reservoir storage in the region. Table 4 provides a summary of the reservoirs.

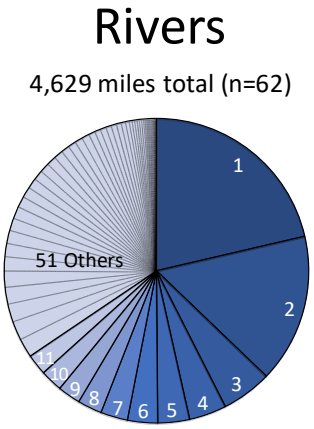
Corps reservoirs and locks are operated in accordance with water control manuals. Deviations to water control plans must be approved by the division after district study. Deviations to operating plans are only allowed for authorized purposes. Changes for other purposes can be studied and incorporated into the water control manuals but cannot be tested without an approved water control plan.

Table 4 – Northwest region reservoir count and storage. Corps locks and dams are excluded from the "Corps - Count" and "Corps - Storage" tallies. CBWM stands for Columbia Basin Water Management, which is a reservoir management group in the Corps Northwestern Division office.

	Count							Storage (millions of acre-feet; MAF)						
	Corps			Section 7			NID (all)	Corps			Section 7			NID (all)
	General	Big river	Dry dams	General	Big river	Dry dams		General	Big river	Dry dams	General	Big river	Dry dams	
NWP	14	-	-	7	-	-	693	3.1	-	-	2.6	-	-	14.1
NWS	3	-	1	3	-	-	817	7.3	-	0.1	1.8	-	-	37.0
NWW	3	-	-	10	-	-	637	3.9	-	-	3.6	-	-	19.2
CBWM	-	1	-	3	1	-	-	-	2.5	-	6.8	9.6	-	-
Total	20	1	1	23	1	-	2,147	14.3	2.5	0.1	14.9	9.6	-	70.4

The river network below the Corps-involved reservoirs consists of 62 different named rivers. The Snake is the longest with a total of 989 river miles from Jackson Lake in western Wyoming to its confluence with the Columbia River. The Columbia has the second longest length within the region with the Kootenai, Willamette, Rogue, Flathead, Powder, Malheur, Deschutes, and Umpqua completing the list of top ten longest rivers (Figure 4).





#	Name	Miles
1	Snake River	989
2	Columbia River	732
3	Kootenai River	248
4	Willamette River	183
5	Rogue River	157
6	Flathead River	148
7	Powder River	133
8	Malheur River	120
9	Deschutes River	113
10	Umpqua River	109
11	Clark Fork	103
12...	51 Others	1,595
Total		4,629

Figure 4 – Rivers below Corps-involved reservoirs in the Northwest region.

Table 5 – River miles below Corps involved dams. Tallies provided per ownership type and purpose.

	River Miles by Ownership			River Miles by Purpose				
	Corps	Section 7	Both	Enviro	Hydro	Both	Neither	Total
NWP	563	571	461	458	0	1,137	0	1,595
NWS	351	484	481	64	1,149	65	39	1,317
NWW	91	1,118	509	454	184	1,030	48	1,717
Total	1,004	2,174	1,451	976	1,333	2,232	87	4,629

The total number of river miles in the region below Corps involved dams is 4,629. Of these, 1,004 river miles are below Corps dams, 2,174 are below Section 7 dams, and 1,451 are below a combination of both Corps and Section 7 dams. Most of the total (3,209 river miles) are below reservoirs that have an authorized purpose related to the environment (fish and wildlife, water quality, or recreation). Table 5 provides a summary of the rivers.

Reservoir-centric Environmental Efforts within the PNW Region

This section provides a summary of presentations from the three participating districts about ongoing reservoir-centric environmental efforts in the region. Corps reservoir management and operation in the Pacific Northwest is characterized by extensive environmental considerations. Actions undertaken per consultations regarding species listed as threatened or endangered under the Endangered Species Act (ESA), particularly numerous listed salmonid fish species, are a critical driver for operation of Corps-involved reservoirs in the Northwest. Further, for several decades, ESA has been a strong driver for regional coordination between the Corps and other Federal agencies operating the Federal Columbia/Snake River system (Figure 5) – the U.S. Bureau of Reclamation and Bonneville Power Administration, as well as other Federal agencies with water resource management responsibilities (NMFS, USFWS, and others). The Corps also coordinates closely with the states of Oregon, Washington, Idaho and Montana, numerous tribes and many different stakeholder groups on environmental operations and action.

<u>Portland District (NWP)</u>

The NWP team provided an overview of water management within the Portland District area of responsibility (AOR), which encompasses much of the State of Oregon as well as small portions of the State of Washington draining into the lower Columbia River (Figure 6).

NWP operates and maintains three large run-of-river lock and dam projects on the lower Columbia River (Bonneville, The Dalles and John Day dams), a system of 11 multiple-purpose storage dams and 2 hydropower re-regulating dams in the Willamette River basin (the Willamette River is the largest tributary of the Columbia River by average annual runoff) and a system of two multiple-purpose storage dams in the Rogue River basin (Lost Creek and Applegate dams. A third dam in that system, Elk Creek Dam, was authorized and construction initiated but never completed and since deauthorized). Willow Creek Dam is a small multiple-purpose storage dam in northeast Oregon. The Mt. St. Helens Sediment

Retention Structure located on the Toutle River in southwestern Washington was designed to collect and retain sediments running off the volcano but has no active water storage capacity.

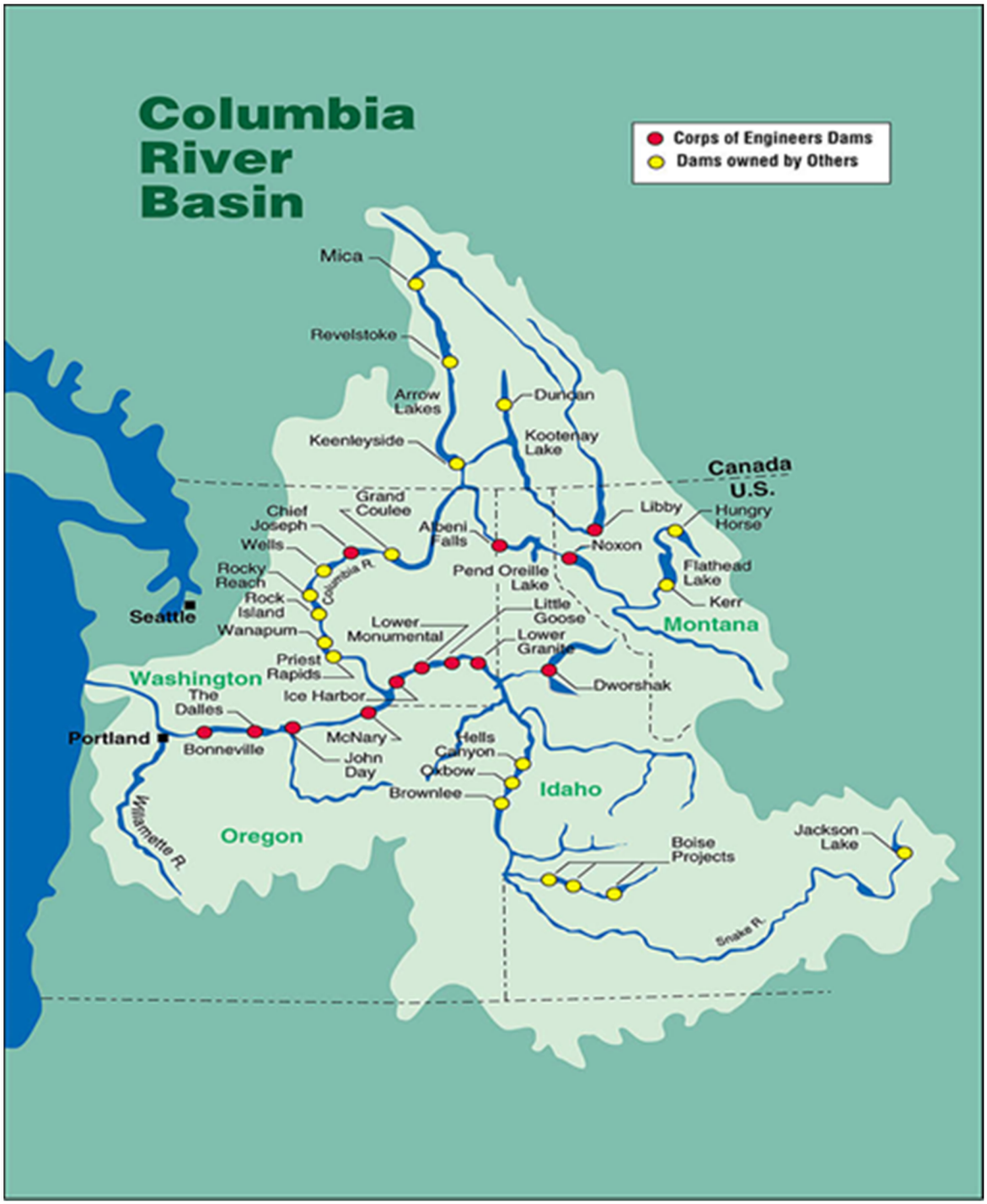


Figure 5 – Federal Columbia River System

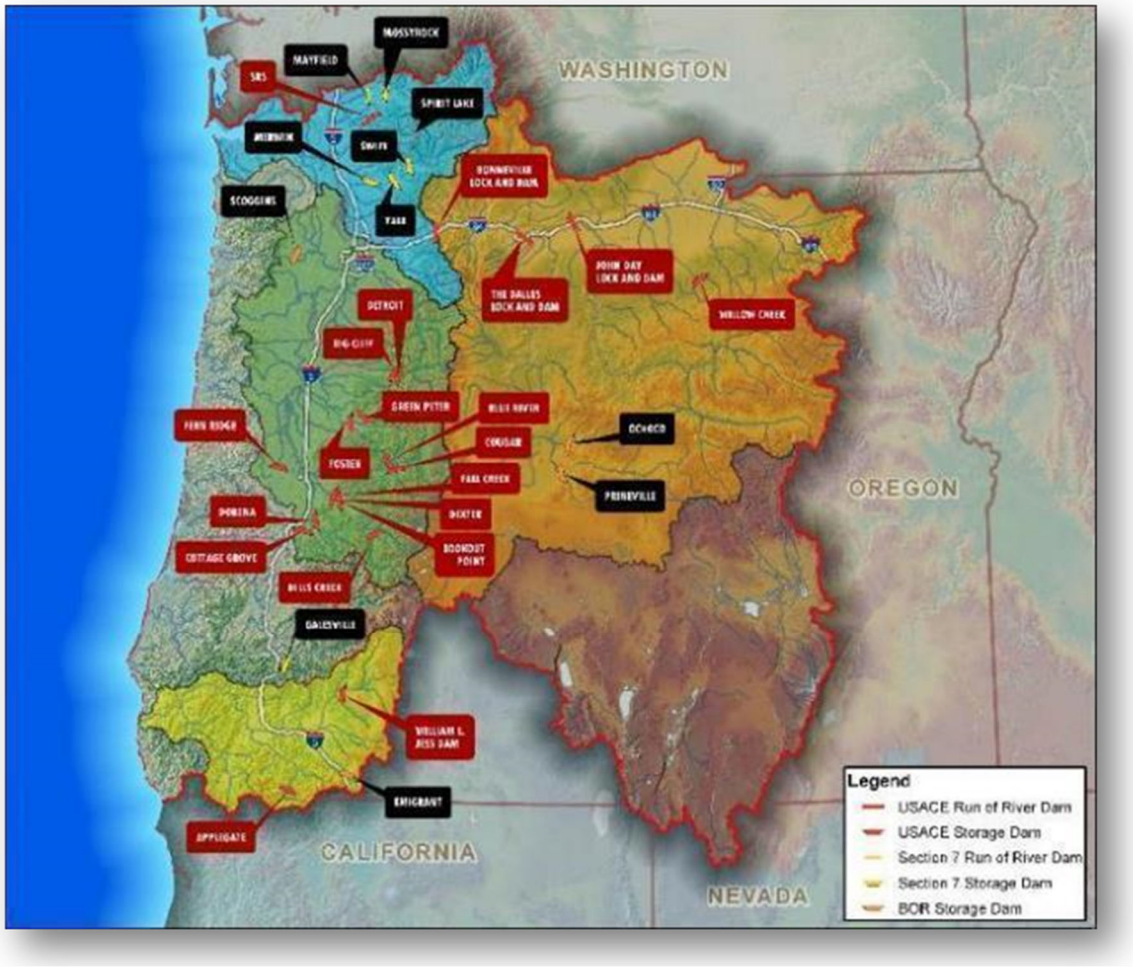


Figure 6 – Portland District geographic area of responsibility

Columbia River. Three mainstem Columbia River reservoirs are within the Portland District AOR: John Day, The Dalles, and Bonneville. All are routinely operated as run of river projects (i.e., inflow equals outflow). John Day Dam has a small amount of authorized flood risk management storage space. The other two dams, though run-of-river, have some minimal storage that has been operated in the past for emergency purposes. The 3 projects are operated as part of the Federal Columbia River Power System (FCRPS) and are subject to the FCRPS Biological Opinion (BiOp). The system operation BiOp affects eulachon, an anadromous smelt, and 13 species of Columbia River Basin salmon and steelhead. From that standpoint, new environmental ideas related to water resources infrastructure must advance within the context of the system operation and the BiOp.

Willamette River and SRP. The Willamette River (Photo 1; Figure 7) is currently the only SRP site in the Northwest region. The Willamette was an early SRP effort, initiated in 2006. As of July 2015, NWP had implemented environmental flow (e-flow) recommendations in 3 tributaries of the Willamette: Middle Fork Willamette, McKenzie, and Santiam Rivers. Implementation of e-flow targets from the SRP effort affects 10 of 13 dams of the Willamette River Basin Project. The SRP e-flow operation is designed to

produce more environmentally beneficial flow rates and patterns (Figure 8). SRP e-flow recommendations were formalized in and incorporated into NWP water control manuals (WCMs). Winter and spring e-flow recommendations were codified in the WCMs. Flow releases are shaped by how stored water was released by Corps water managers. E-flow releases are opportunity driven and depend on sufficiently large hydrologic events to provide needed water volumes. E-flow releases are constrained by Corps authorities which serve to minimize such things as local and system flood risk.

The Endangered Species Act (ESA) drives much of the day-to-day water management decisions in the Willamette as well as other Portland District regulated watersheds.

Photo 1 – Willamette River Floodplain, OR

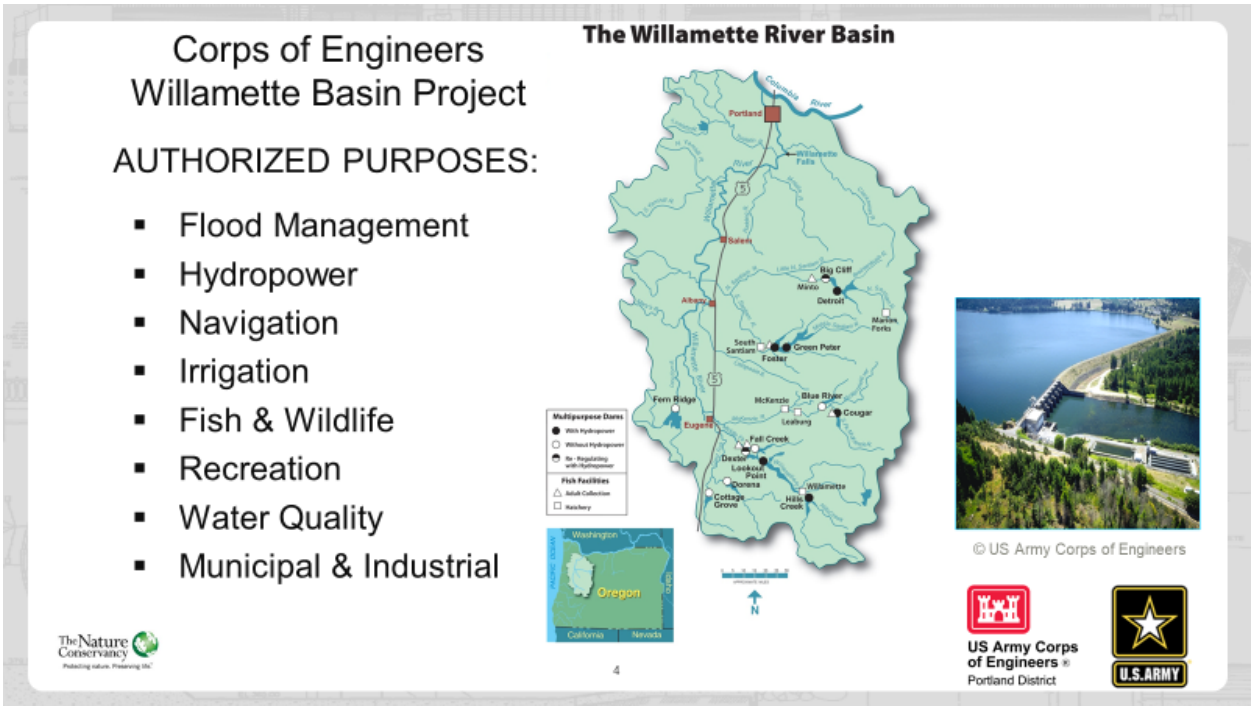


Figure 7 – Willamette River Basin Project

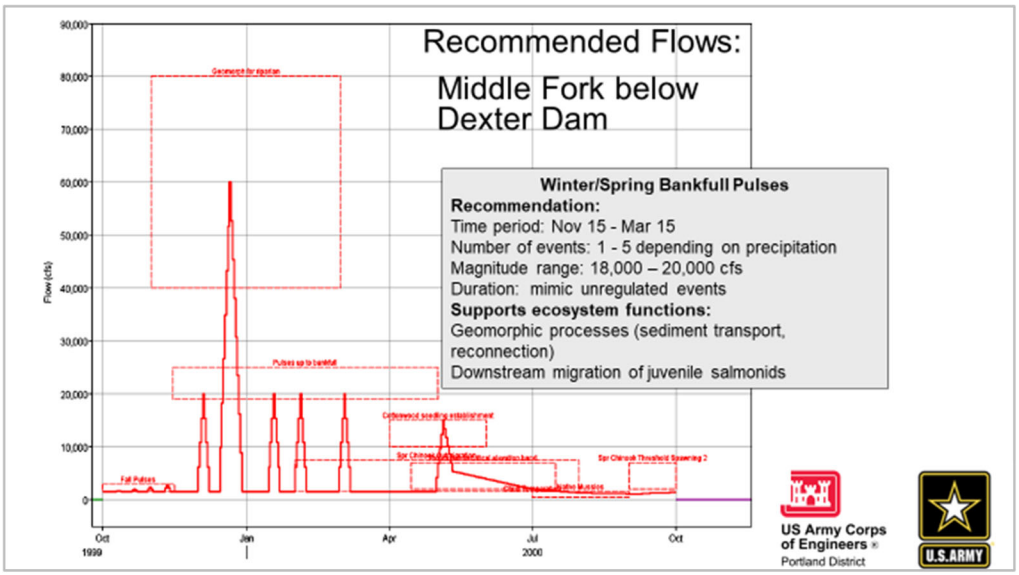


Figure 8 – Middle Fork Willamette e-flow targets

Willow Creek. Willow Creek Dam (Figure 9) is located near Heppner, Oregon, and was built primarily for flood risk management but has fish and wildlife authorizations. Willow Creek is a tributary to the Columbia River. Recently health alerts have been issued for HABs at Willow Creek Reservoir. It was noted that HABs are very much of a concern for reservoir operators in the Willow Creek and Willamette and Rogue River basins. From an ecosystem standpoint, there are 44 known fish passage restrictions along the 45-mile-long reach between Willow Creek Dam and the Columbia River.

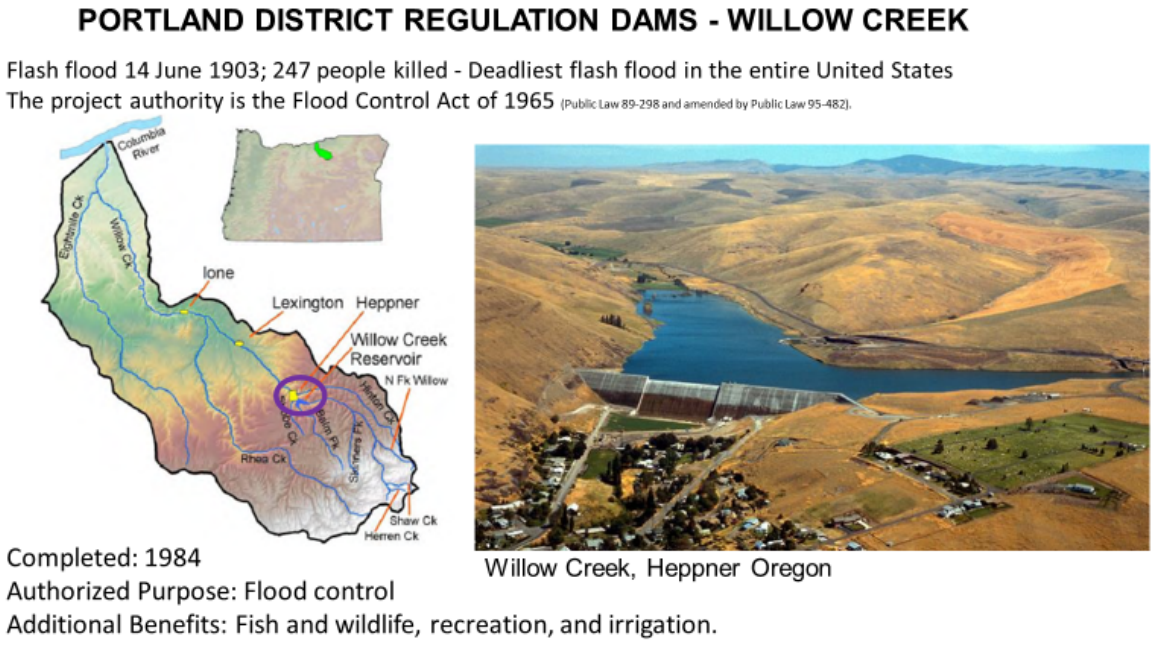


Figure 9 – Willow Creek Dam and Reservoir

Rogue River. Water management on the Rogue (Photo 2; Figure 10) involves dam operations at Lost Creek, Applegate, and Emigrant Reservoirs. These projects are managed heavily to benefit ESA-listed fish. The Oregon Department of Fish and Wildlife largely sets release flow rates for ESA-listed fish species such as Chinook, Coho salmon, steelhead, and Cutthroat trout as well as lamprey. The Rogue eco-flow operations are characterized as being nuanced and graduated in terms of fine tuning the range of flow released. This contrasts to Willamette Valley fish flow operations which are perceived to be peakier and intense. Opportunity was discussed by using Rogue basin experiences as potential examples in other areas, NWS and Willamette Basin being examples.

Photo 2 – Lost Creek Dam, Rogue River, OR

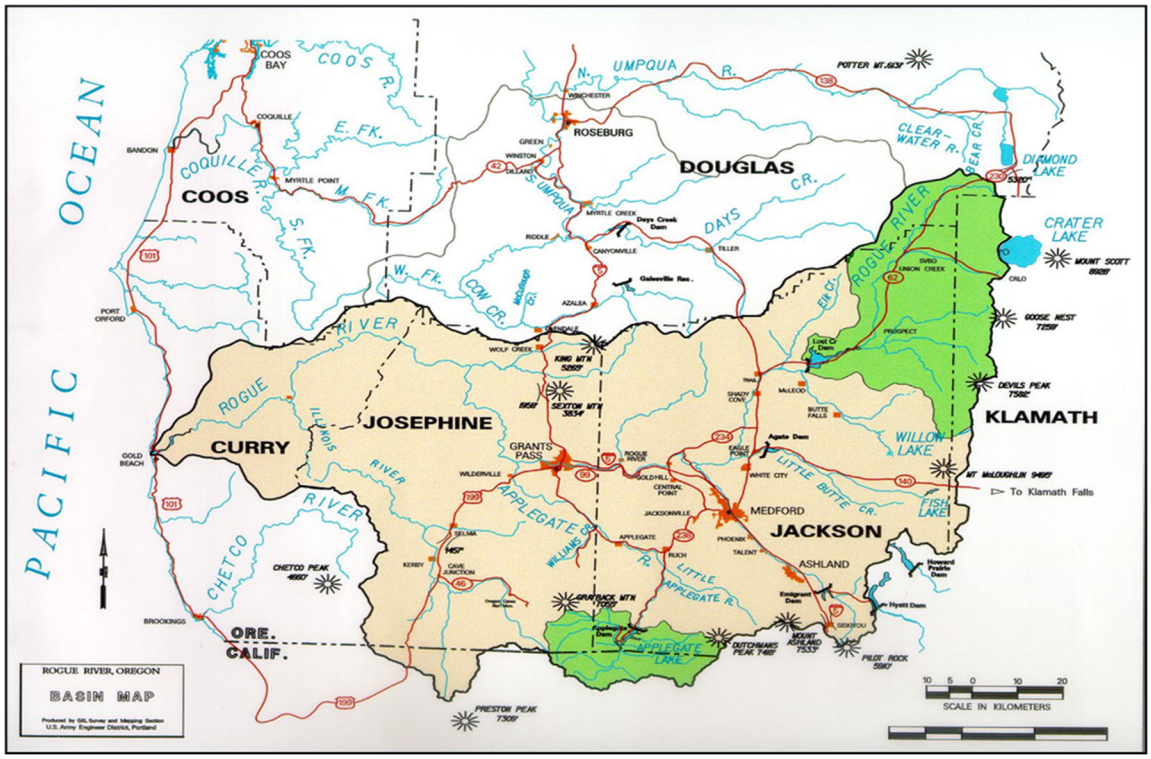


Figure 10 – Rogue River Basin, Oregon

Seattle District (NWS)

The NWS team provided an overview of water management within the Seattle District AOR. For water management purposes, the District's AOR is often split between "westside" and "eastside" watersheds (Figure 11). The westside includes all western Washington State from the Pacific Coast to the crest of the Cascade Mountain range (except for tributaries draining directly into the lower Columbia River which are in NWP) (Figure 12). NWS includes river basins draining into Puget Sound and directly into the Pacific Ocean. NWS operates and maintains three Corps dams on the westside.

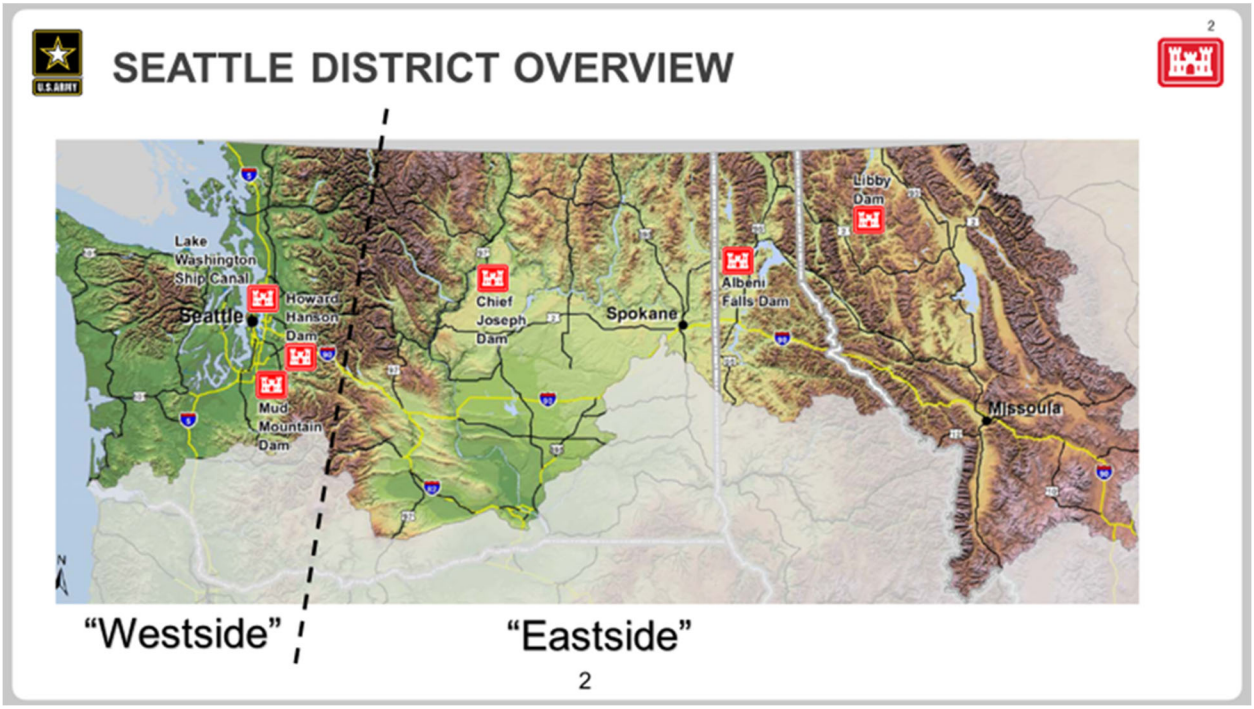


Figure 11 – Seattle District Area of Responsibility

Howard A. Hanson Dam (HAHD). HAHD is located on the Green River (Photo 3; Figure 12). HAHD was constructed principally for flood risk management. It is operated to limit flow at the downstream gage in Auburn, Washington, (in the Seattle metropolitan area) to a maximum of 12,000 cfs. HAHD is also specifically authorized to provide municipal water supply (City of Tacoma) and to provide flow augmentation to support fish migration. The reservoir follows a "guide curve" for augmentation storage to maintain minimum flows in summer/fall dry season at Palmer and Auburn gages. Use of flexible conservation storage to augment flows, particularly in the fall for Chinook migration and spawning, is coordinated in-season with local partners. NWS also operates a gravel nourishment program downstream of HAHD.

The Additional Water Supply Project (AWSP) was authorized to provide additional storage at HAHD for municipal water supply and conservation purposes. The AWSP also authorized the construction of fish passage at HAHD. There is currently no fish passage at the project although design efforts are underway. HAHD has also been selected as a pilot project for a Forecast Informed Reservoir Operation (FIRO) study.

Photo 3 – Howard A. Hanson Dam, Green River, WA

Figure 12 – Seattle District Westside Dams

Mud Mountain Dam (MMD). MMD is located on the White River, a tributary of the Puyallup River which drains into Puget Sound in the Tacoma metropolitan area (Photo 4). MMD is a dry dam with no conservation storage operated to provide flood risk management by limiting flow in the Puyallup River to a maximum of 50,000 cfs at the Puyallup gage. It also has a secondary objective to minimize flood risk on the White River. The White River, which drains off Mt. Rainier, is characterized by very high sediment load and large woody debris input into the reservoir. Recent loss of channel capacity has been increasing flood risk in the areas of Pacific and Sumner, Washington. At-risk locations are highly developed residential and industrial areas.

Although authorized as a single-purpose FRM dam, MMD has several important environmental considerations. The project is authorized for fish passage; there is a new (operational in 2021) barrier structure and fish passage facility downstream of MMD to replace the previous facility. Target salmonid species are collected at the facility for transport upstream of the dam. Downstream passage is provided through the existing outlet works in the dam and releases are managed to support downstream migration of juvenile anadromous fish.

Photo 4 – Mud Mountain Dam, White River, WA

Lake Washington Ship Canal (LWSC). LWSC was constructed by the Corps to provide navigation between saltwater Puget Sound and freshwater Lake Washington in Seattle. Ballard Locks provides navigation passage and maintains the elevation of Lake Union and Lake Washington. Ballard Locks also have fish passage facilities (fish ladder and smolt flumes) that are important for salmonid migration (Photo 5). There are water quality considerations (for temperature and salinity) associated with operation of LWSC.

NWS Water Management directs reservoir regulation during flood events under Section 7 Authority for three dams in western Washington. Wynoochee Dam on the Wynoochee River (a tributary of the Chehalis River on the Olympic Peninsula) was constructed by the Corps, turned over to the City of Aberdeen, and is operated by Tacoma Public Utilities. In the Skagit River basin in northern Puget Sound are two dams, Ross Dam owned by Seattle City Light and Upper Baker Dam owned by Puget Sound Energy. USACE flood risk management oversight for these three dams is enforced in hydropower licenses from the Federal Energy Regulatory Commission (FERC).

The "eastside" of NWS water management responsibilities extends from the east side of the Cascade Mountains and includes the river basins in eastern Washington, the northern Idaho panhandle, and northwestern Montana that drain into the upper and middle Columbia River (Figure 13). Important Columbia River tributaries in NWS include the Kootenai, Clark Fork, Flathead, Pend Oreille, Spokane, Wenatchee, and Yakima rivers.

NWS operates and maintains three Corps dams on the eastside: Chief Joseph Dam on the mainstem Columbia River, Libby Dam on the Kootenai River and Albeni Falls Dam on the Pend Oreille River. All three dams are part of the 14-dam system of Federal projects on the Columbia River. The Corps operates those dams in coordination with the U.S. Bureau of Reclamation (which owns and operates Hungry Horse and Grand Coulee dams) to store water to reduce flood damages downstream, produce hydropower and deliver water for irrigation, among other purposes. To aid migrating juvenile salmon, in accordance with the NMFS's BiOp, the Corps and Reclamation operate these dams to provide seasonal releases to improve flows. This is called flow augmentation.

Photo 5 – Ballard Locks at Lake Washington Ship Canal, Seattle, WA

Figure 13 – Seattle District Eastside Dams

Chief Joseph Dam (CHJ). CHJ is a run-of-river dam (Photo 6) located on the mainstem Columbia River below Grand Coulee Dam in northeastern Washington. It is operated primarily for hydropower production in coordination with the other Federal dams in the Columbia River System and is the largest Corps of Engineers hydropower producer in the nation. Regulation instruction for CHJ are issued by the Columbia Basin Water Management (CBWM) office out of the Corps Northwestern Division.

Photo 6 – Chief Joseph Dam, Columbia River, WA

CHJ has no fish passage facilities. It is the most downstream Columbia River mainstem dam that does not feature fish passage. However, Grand Coulee Dam, located a short distance upstream, blocked all Columbia River upstream fish passage prior to construction of CHJ. Spillway flow deflectors were completed at CHJ in 2008 to help improve water quality (reduction of Total Dissolved Gas) on the Columbia River downstream. Toxic algae blooms are a seasonal problem in the reservoir causing environmental and human health concerns.

Libby Dam (LIB). LIB is located on the Kootenai River in northeastern Montana (Photo 7). LIB is a very large multiple-purpose storage project operated for flood risk management, hydropower, fish and wildlife, and recreation. The dam was constructed and is operated under the Columbia River Treaty and the Libby Coordination Agreement with Canada. The Kootenai River flows out of Canada and the upper end of the reservoir (Lake Koocanusa) is within the province of British Columbia. The river downstream of the dam flows into Idaho and then into back into British Columbia. The dam is also operated in accordance with a 2006 BiOp from the U.S. Fish and Wildlife Service (for bull trout and sturgeon) and the 2019 BiOp from NMFS for the Federal Columbia River Power system for ESA listed anadromous fish species.

Environmental considerations for operation of LIB include ramping rates and minimum flow releases for downstream environmental conditions year-round, but in particular include providing flows to support sturgeon spawning (typically in May-June) and minimum flow releases for bull trout (May-September). Downstream temperatures are managed through a selective withdrawal system at the dam. NWS has been actively engaged in habitat restoration work in the vicinity of Bonner's Ferry, ID in coordination with the Kootenai Tribe of Idaho. Increased loadings of selenium and nitrate to Lake Koocanusa and the Kootenai River from coal mining operations in British Columbia are impacting the water quality in the reservoir and downstream river.

Photo 7 – Libby Dam, Kootenai River, ID

Albeni Falls Dam (AFD). AFD is located on the Pend Oreille River in northern Idaho (Photo 8). It is a multiple purpose storage project operated for flood risk management, hydropower, fish and wildlife, navigation and recreation. AFD is locate downstream of Lake Pend Oreille, a very large natural lake, and is used to manage lake elevations. Operational objectives include maintaining a stable pool elevation for summer recreation and drafting the reservoir in the fall prior to kokanee spawning (November to December). During the winter the dam operations provide system-wide power flexibility and flood storage. AFB is operated to reduce flooding around Lake Pend Oreille and downstream of the dam along the river during spring runoff.

Other environmental considerations in operation of the dam include minimizing total dissolved gas downstream from spill and a flexible winter power operation. The dam currently has no fish passage but passage facilities, designed principally for allowing adult bull trout to move above and below the dam, are currently being designed and are planned for construction.

Photo 8 – Albeni Falls Dam, Pend Oreille River, ID

Walla Walla District (NWW)

The NWW AOR (Figure 14) encompasses the Snake River basin from its mouth at the Columbia River near the tri-cities in Washington to its headwaters in Wyoming and including all of the tributary basins. This area includes all southern Idaho plus portions of eastern Oregon, southeastern Washington, and southwestern Wyoming plus small portions of northern Utah and Nevada. There are 8 USACE operated water control projects in the Walla Walla District. There are also 12 dams that fall under some sort of USACE control for flood, FERC licensing, or other involvement, but are managed by another entity.

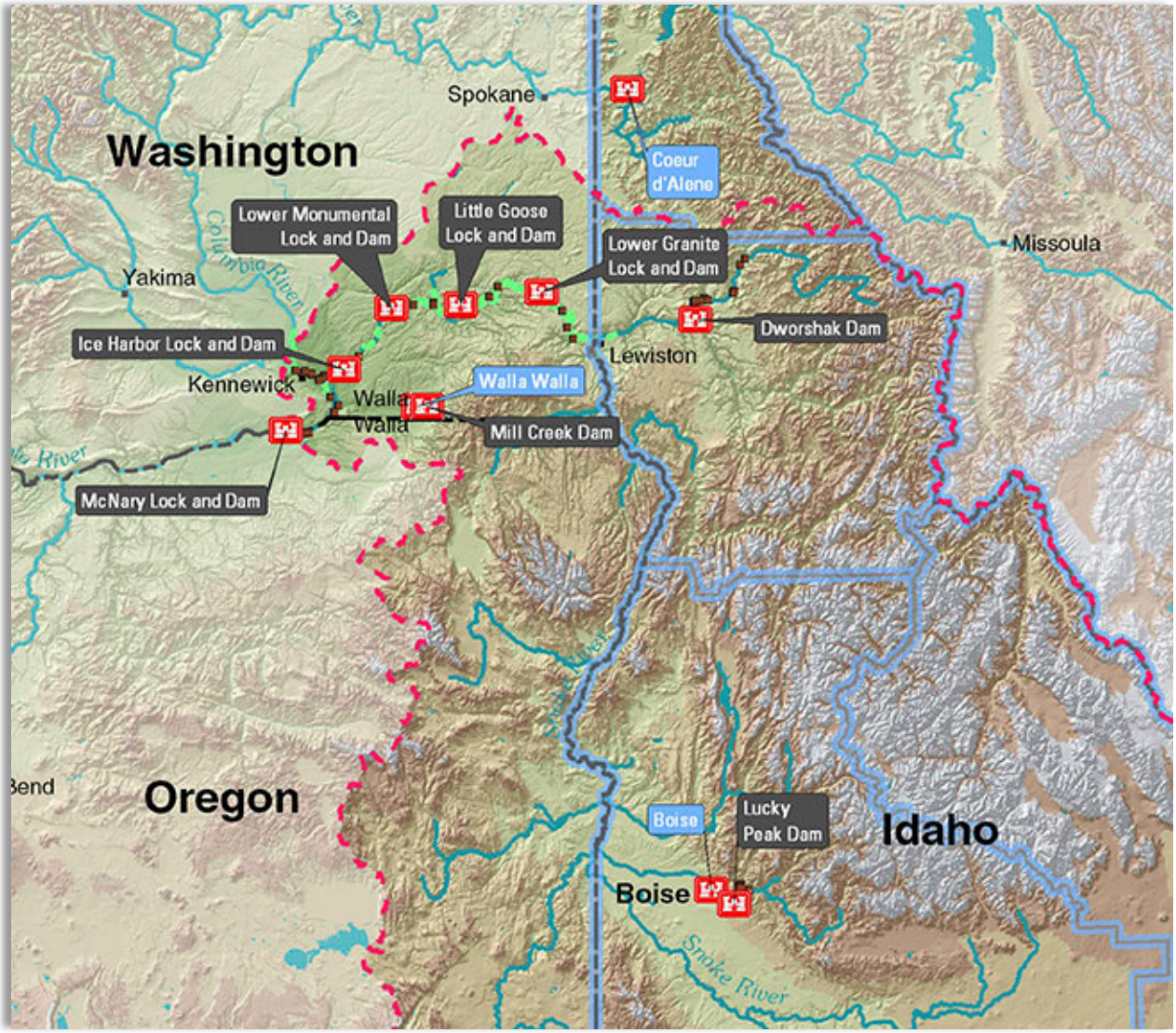


Figure 14 – Walla Walla District Area of Responsibility

Columbia / Snake River Mainstem Dams. NWW operates five large run-of-river dams on the Columbia /Snake River System (Figure 14). The lowermost of those, McNary Dam (MCN) is located on the mainstem Columbia River. Its pool backs up into the lower end of the Snake River. The other four dams are on the lower Snake River: Ice Harbor (ICE), Lower Monumental (LMO), Little Goose (LGO), and Lower Granite (LGR) Dams, from downstream to upstream. All are operated primarily for hydropower and navigation, providing an inland waterway up to Lewiston, Idaho.

Operation of the Columbia / Snake mainstem dams are highly coordinated with regional partners as part of the Federal Columbia River Power System and intertwined with BiOps and court rulings on how they are operated for ESA listed species. NWW staff do identify possible projects for improvement of environmental condition along the shorelines of these river reaches, particularly in conjunction with tributaries. Potential elevation changes may improve shoreline or upstream deltas (such as the Yakima or Walla Walla rivers)

The remaining three dams operated by Walla Walla District are storage projects on tributaries.

Mill Creek Dam (MCL). MCL is located on Mill Creek (a Walla Walla River tributary) in Walla Walla, WA (Figure 15). The project is somewhat unique as it consists of two small dams (a storage dam embankment and a diversion dam) with an off-channel storage reservoir (Lake Bennington). The project is operated for flood risk management, recreation, and environmental stewardship. The project functions similarly to a dry dam by diverting flood flows into the off-channel reservoir. Most flood volume is returned to the stream after a flood event peak, but a small conservation pool is maintained for fishing and other recreation. There is a fish ladder at the diversion dam. The Mill Creek project also includes local channel improvements downstream operated by the Corps and local sponsors. The Mill Creek federal section has ~100 engineered channel weirs (total weirs in channel over 300).

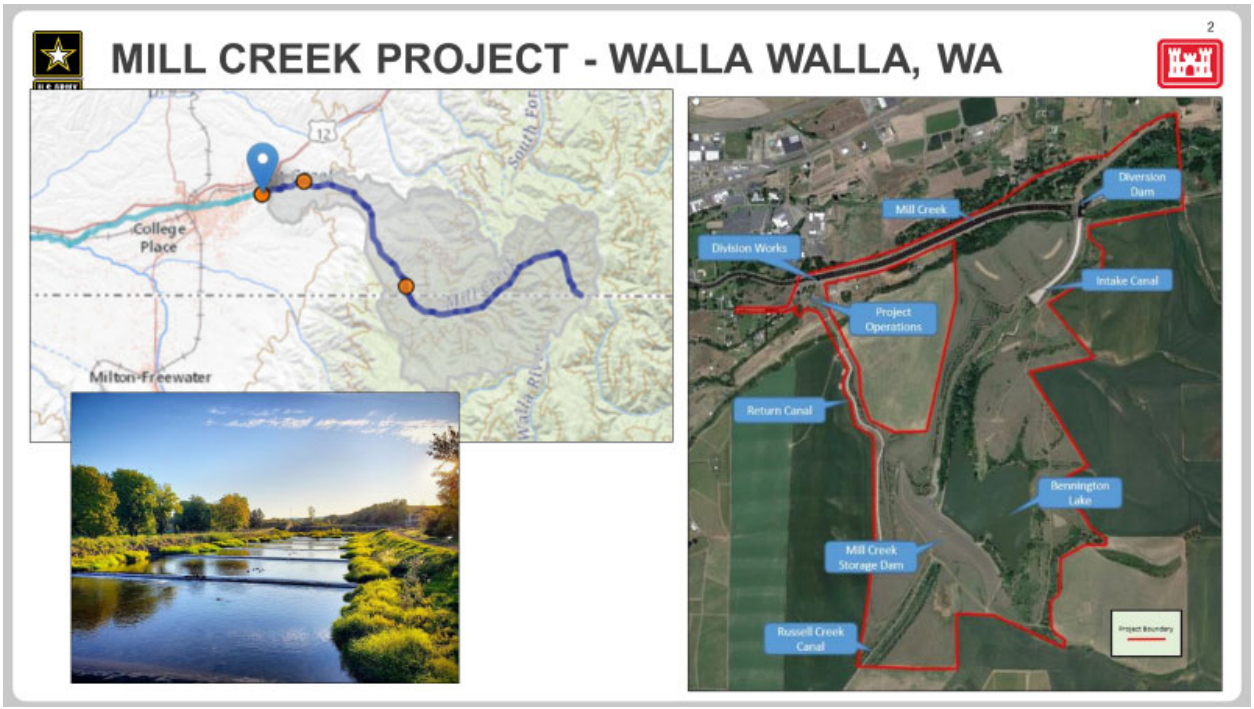


Figure 15 – Mill Creek Project

There are several environmental considerations at Mill Creek. The stream supports native species, including bull trout and steelhead which are both ESA listed. There is a signed USFWS BiOp for bull trout and a NMFS BiOp for steelhead is being written. Habitat in headwaters areas above the dam are in excellent condition. However, operation of the Mill Creek project affects fish passage. Mill Creek's two fish ladders were identified by the State of Washington as being in the top 10 barriers to recovery of Mid-Columbia Steelhead. The existing fish ladder was upgraded in 2020 and design for a larger facility is underway (estimated 10-year effort). Mill Creek is characterized by extremely low flows in the summer due to irrigation and water supply withdrawals. Temperature and low flows become a barrier to fish passage. Notching the weirs below the dam to create a low flow channel is seen as a means to improve fish passage. Flow ramping rates for releases from the dam may also be looked at as a way to address fish passage issues. There are many partners working to address environmental issues at Mill Creek, including the Corps and other Federal agencies, Washington Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation, Salmon Recovery Board, and private citizens.

Dworshak Dam (DWO). DWO is located on the Clearwater River at Orofino, Idaho (Photo 9). The reservoir is 53 miles long with 2 MAF of active storage and features 100 feet of elevation change in reservoir level during its annual operating cycle. The project is operated for flood risk management, hydropower, fish and wildlife, and recreation. DWO has no fish ladder. There are two fish hatcheries located below the dam. The Federal hatchery was constructed as mitigation for loss of habitat associated with the project. It is operated in collaboration with the USFWS and receives BPA Funding. The Nez Perce Tribe is heavily involved with operations of the hatchery and with flow management from the project. The second hatchery is operated by the state and receives water from DWO.

There are several environmental considerations associated with operation of DWO. DWO has a selective withdrawal tower. Under coordinated operation of the Federal Columbia River System of dams, releases are made from the dam to maintain cooler temperatures (68 Degrees) in the Snake River and to augment Snake River flows for supporting passage of juvenile migrants downstream. Due to the location of the two hatcheries immediately below the dam, care must be taken to minimize spill releases to prevent dissolved gas. NWW has undertaken a nutrient supplementation program in the reservoir. The purpose of the program is to increase reservoir productivity and reduce algal blooms.

Photo 9 – Dworshak Dam, North Fork Clearwater River, ID

Lucky Peak Dam. Lucky Peak Dam is located on the Boise River just upstream of Boise, Idaho (Photo 10). It is the lowermost dam in a three-reservoir system. The two upstream projects, Arrowrock and Anderson Ranch Dams, are owned are operated by the US Bureau of Reclamation and the Corps has Section 7 authority for their flood risk management operations. Lucky Peak Dam is operated primarily for flood risk management, but operations are closely coordinated with the upstream reservoirs, particularly for meeting downstream water supply needs. The reservoir is also operated for hydropower, recreation, and fish and wildlife. It is a popular recreational lake for residents of Boise and other communities in southern Idaho.

Lucky Peak Reservoir has an “elk pool” target elevation designed to keep winter water levels low to provide elk habitat but there are challenges meeting that objective with coordination with upstream reservoirs. Dworshak maintains a winter minimum flow of 250 cfs. There may possibilities for flushing flows downstream to support cottonwood regeneration.

Non-USACE Dams within NWW Region. These dams include Agency Valley, Anderson Ranch, Arrowrock, Bully Creek, Jackson Lake, Little Wood, Mason, Palisades, Ririe, Warm Springs, Hells Canyon, and Brownlee Dams. All have competing needs for water outflows that include irrigation and flood control. Also, some of these dams interact as a system influencing each other or USACE managed dams.

Photo 10 – Lucky Peak Dam, Boise River, ID

Environmental Opportunity Matrix and Ongoing Environmental Work

The Environmental Opportunity Matrix was initially developed for use in the Upper Midwest Regional Operations and Water Management meeting. Its intended use is to help identify priority environmental actions and opportunities effectively and comprehensively for the region. The matrix evolved through the subsequent South and now Northwest regional meetings. Meeting participants were provided a copy of the matrix prior to the meeting and asked to review the list of potential environmental actions and objectives, particularly with a view toward adding any unlisted actions pertinent to reservoir projects in the Northwest. At the end of the first plenary session, the matrix was reviewed again by the entire group.

During the first breakout session, each district team was asked to use the matrix to consider environmental actions associated with Corps water resource infrastructure in their respective AORs. Each action was scored based on potential and implementation. Scores are per team; values reflect status for each team's entire portfolio of projects (per reservoir type).

Potential ("Pot.") is a measure of the degree to which an action is likely to produce benefits. **Implementation** ("Imp.") is a measure of how much of that potential has already been realized. Both measures are reported as either: 0 (none), 1 (low), 2 (moderate), or 3 (high). For potential, a "0" ranking is an activity that has no potential for providing environmental benefits even if it were implemented. For implementation, a "0" ranking means there has been no implementation. In interpreting the scoring, a "3-2" would be a very promising action with moderate fulfillment; a "1-3" would characterize an action with limited possibilities that has already been highly achieved. An implementation value less than 3 indicates that there are unrealized environmental benefits.

Table 6a addresses environmental opportunity at General dams with multiple purpose storage while Table 6b addresses Lock and Dam and Dry Dam projects (note that the only Corps-affiliated dry dam project in the northwest region is Mud Mountain Dam in Seattle District). Green highlighting identifies actions selected by each team for consideration during the next breakout session

Table 6a – Summary Environmental Opportunity Matrix for General Dams

Potential (Pot.): a measure of the degree to which an action is likely to produce benefits.
Implementation (Imp.): a measure of how much of that potential has already been realized.
Both measures are reported as either: 0 (none), 1 (low), 2 (medium), 3 (high), or not applicable (n.a.).
Values are per office. In other words, measures of potential and implementation are reported for each office's entire portfolio of projects.

	Denotes environmental flow actions and objectives--traditional focus of SRP
	Denotes environmental actions of high interest to location-based teams
BOLD	Denotes environmental actions selected by location-based teams for per project consideration

Reservoir Project Types		Environmental Action/Objectives	Portland		Seattle		Walla Walla	
			Pot.	Imp.	Pot.	Imp.	Pot.	Imp.
General Dams with multiple-purpose storage	In pool	Support - Water Level management for fisheries	3	1.5	2	2	3	2
		Support - Water level management for mussels	0	0	0	0	1	0
		Support - Water level management for overwinter biota	0	0	2	2	1	0
		Support - Water level management for vegetation (riparian)	0	1	2	2	2	0
		Support - Water level management for vegetation (wetlands)	0	0	0	0	2	0
		Support - Water level management for waterfowl	2	2	0	0	1	0
		Support - Water level management for shorebirds, gulls, other migrants	2	2	0	0	1	0
		Suppress - Level management for fisheries	3	1.5	2	2	1	0
		Suppress - Level management for mussels	0	0	0	0	1	0
		Suppress - Level management for overwinter biota	0	0	2	2	1	0
		Suppress - Level management for vegetation	2	1	2	2	3	0
		Suppress - Level management for waterfowl	2	1	0	0	1	0
		Suppress - Water level mgmt. for shorebirds, gulls, other migrants	0	0	1	0	1	0
		Suppress - Animal control (other than waterfowl)	1	1	1	0	0	0
		Pool rate of change management for bank integrity (WQ considerations)	2	1	1	1	2	0
		Water Quality - Pathogens	1	1	2	1	1	0
		Water Quality - Nutrients	1	1	**3**	**1**	2	2
		Water Quality - Temperature	3	1.5	**3**	**1**	**3**	**1**
		Water Quality - Management of harmful algal blooms	**3**	**1**	**3**	**1**	3	1
		Floodplain connectivity	0	0	2	1	1	1
	Connect Up and Down	Manage distribution of depositing sediments (encourage sediment flux)	2	1	2	1	2	0
		Reallocations	3	1	0	0	1	0
		Sediment management - bed and bank	2	1	0	0	1	0
		Restrict passage of invasives	2	1	3	1	1	2
		Invasive species management	0	0	**3**	**1**	1	1
		Debris management	2	2	**3**	**2**	**2**	**1**
	Downstream	Outflow temperature management for nature	2	1	3	1	**3**	**2**
		Outflow temperature management for humans	2	1	0	0	0	0
	Ecological flow targets	Geomorphic process support	**3**	**1**	2	1	**2**	**0**
	.	Floodplain connectivity	**3**	**1**	2	1	**1**	**0**
	.	Riparian Management	2	1	0	0	**2**	**0**
	.	Wetland management	2	1	2	1	**1**	**0**
	.	Life stage support - Fisheries	**3**	**1**	2	1	**3**	**2**
	.	Life stage support - Mussels	**3**	**1**	2	0	**1**	**0**
	.	Life stage support - Waterfowl	1	1	2	0	**2**	**0**
	.	Life stage support - Shorebirds, gulls, other migrants, riparian birds	0	1	2	0	**2**	**0**
	Ecological flow targets	Life stage support - Herps	1	1	2	0	**2**	**0**
		Rate of change management for bank integrity (WQ considerations)	1	0	2	2	2	1
		Physical habitat creation (use of dredged material, oxbow/floodplain restoration)	3	1	**2**	**1**	3	2
		Recreation	1	1	0	0	1	2
		Water Quality - Dissolved gas (management of gas bubble trauma)	3	1	3	1	1	3
		Water Quality - Nutrients	1	0	3	1	2	1
		Water Quality - Temperature	3	1	3	1	3	2
		Water Quality - Turbidity	1	1	3	1	1	1

Table 6b – Summary Environmental Opportunity Matrix; Locks and Dams and Dry Dams

Potential (Pot.): a measure of the degree to which an action is likely to produce benefits.
Implementation (Imp.): a measure of how much of that potential has already been realized.
Both measures are reported as either: 0 (none), 1 (low), 2 (medium), 3 (high), or not applicable (n.a.).
Values are per office. In other words, measures of potential and implementation are reported for each office's entire portfolio of projects.

	Denotes environmental flow actions and objectives--traditional focus of SRP
	Denotes environmental actions of high interest to location-based teams
BOLD	Denotes environmental actions selected by location-based teams for per project consideration

Reservoir Project Types		Environmental Action/Objectives	Portland		Seattle		Walla Walla	
			Pot.	Imp.	Pot.	Imp.	Pot.	Imp.
Lock and Dam Projects (usually run-of-river with limited storage)	***In pool***	Level management for fisheries	3	3	0	0	3	3
		Level management for mussels	0	0	0	0	1	0
		Level management for overwinter biota	0	0	0	0	**3**	**1**
		Level management for vegetation (riparian, woody, pioneer trees)	**2**	**1**	0	0	**3**	**1**
		Level management for waterfowl	2	1	0	0	**3**	**0**
		Level management for shorebirds, gulls, other migrants	0	1	0	0	**3**	**0**
		Level management for veg (wetland emergent)	2	1	0	0	1	2
		Water Quality - Nutrients	0	0	1	0	1	0
		Water Quality - Temperature	1	2	**3**	**1**	**2**	**1**
		Water Quality - Total dissolved gas	3	3	0	0	3	2
		Water Quality - Turbidity	0	0	0	0	2	0
		Fish Passage Operations	**3**	**3**	3	2	3	3
		Managing sediment	0	0	0	0	3	2
		Debris Management	0	0	0	0	2	1
	Connect Up and Down	Fish Passage	**3**	**2**	3	2	2	1
		Sediment Management -- Bed and Banks	3	2	0	0	2	1
Dry Dams (usually single-purpose flood control with no conservation storage) [Mud Mountain Dam in NWS is the only dry dam in the NW Region; NWP and NWW have no dry dams]	**In pool**	Subimpoundment/riffle	n.a	n.a	1	0	n.a	n.a
		Physical habitat creation (use of dredged material, oxbow/floodplain restoration)	n.a	n.a	1	0	n.a	n.a
		Permanent wetland creation	n.a	n.a	1	0	n.a	n.a
		Seasonal wetland creation - vernal pools / seasonal wetlands	n.a	n.a	0	0	n.a	n.a
		Life stage support - Amphibians (inundation of lands)	n.a	n.a	1	0	n.a	n.a
		Level management for fisheries	n.a	n.a	0	0	n.a	n.a
		Level management for vegetation - Encourage	n.a	n.a	1	1	n.a	n.a
		Level management for vegetation - Suppress or discourage	n.a	n.a	1	1	n.a	n.a
	Connect Up and Down	Upstream sediment management partnerships	n.a	n.a	3	3	n.a	n.a
		Manage distribution of depositing sediments	n.a	n.a	3	3	n.a	n.a
		Sediment management - bed and banks	n.a	n.a	0	0	n.a	n.a
		Debris management / containment	n.a	n.a	3	1	n.a	n.a
		Fish Passage -- Outlet tunnel management	n.a	n.a	3	1	n.a	n.a
		Fish Passage -- Mud Mountain Dam	n.a	n.a	3	*	n.a	n.a
		Groundwater recharge for downstream ecological benefits	n.a	n.a	0	0	n.a	n.a
	Downstream	Channel/floodplain disturbance - clearing downstream ground for recruitment	n.a	n.a	1	1	n.a	n.a
		Life stage support - Amphibians (inundation of lands)	n.a	n.a	2	0	n.a	n.a
		Permanent wetland creation - water quality / habitat improvements	n.a	n.a	0	0	n.a	n.a
		Seasonal wetland creation - vernal pools / seasonal wetlands	n.a	n.a	2	0	n.a	n.a
		Riparian management for habitat conditions	n.a	n.a	3	1	n.a	n.a
		Ecological flow targets (see tan highlighted cells in 6a above for examples)	n.a	n.a	0	0	n.a	n.a
		Recreation	n.a	n.a	0	0	n.a	n.a
		Water quality for nature	n.a	n.a	0	0	n.a	n.a
		Water Quality for humans	n.a	n.a	3	0	n.a	n.a

* Fish Passage at Mud Mountain Dam was under construction and testing at time of the workshop; District team thought it was too early to assign implementation value.

Illustration of Reservoir Review

As background and information for the next breakout session, a national review of environmental flow potential for reservoirs was presented in plenary. The review involved three questions, with each culminating in rankings of all 465 reservoirs with federally authorized flood space. The three questions were: 1) how influential could the reservoir be, 2) in terms of hydrologic alteration, what is the reservoir actually doing, and 3) what is the reservoir able to do? Each of these questions involved a different assessment. All were designed to sort the whole portfolio of reservoirs according to their relative promise as a candidate for environmental flow operations.

The "potential to influence" investigation involved a GIS exercise based on the storage volume of each reservoir and its corresponding mean annual flow at the dam and at points placed along the stream network below the dam. A value of storage divided by mean annual flow was computed at each point. Computed values decreased with distance from dam because the corresponding watershed area and associated mean annual flows increased. Computed values were multiplied by corresponding river reach lengths and summed for the full flow path, from dam to receiving lentic water body. Summed values were then sorted, ranked, and categorized as high, middle, and lower thirds within the region for display purposes (Figure 16).

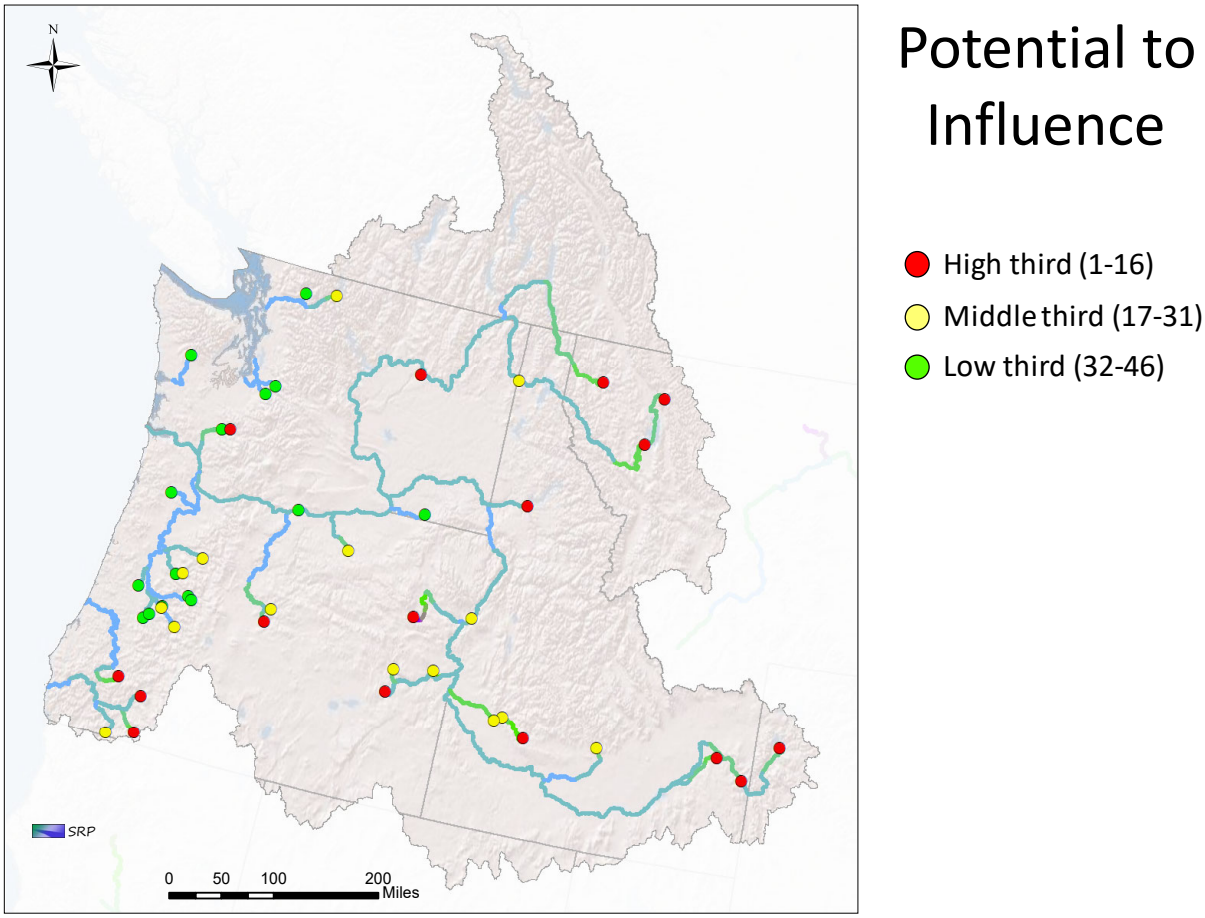


Figure 16 – Results of the potential to influence assessment for the Northwest Region. Categories are based on regional rankings

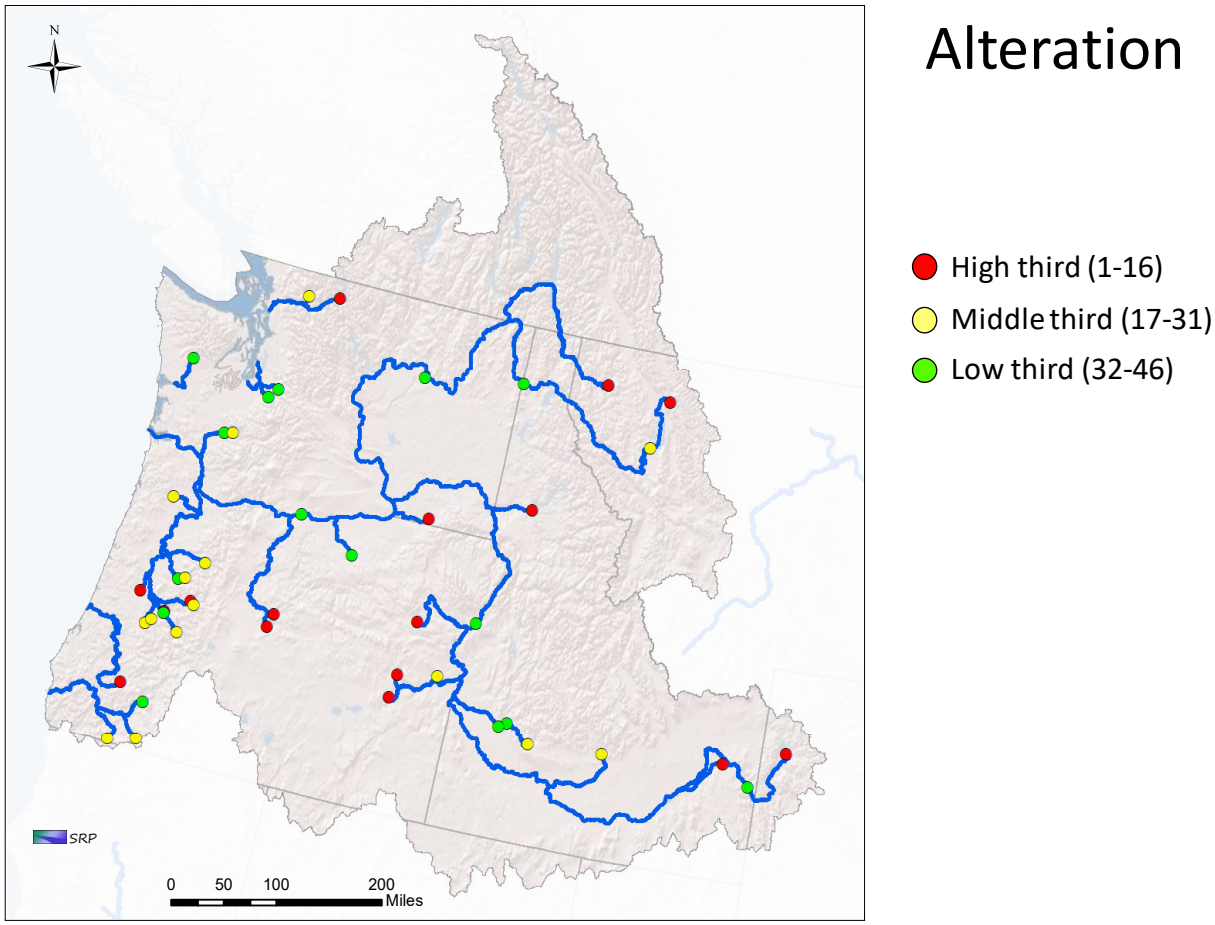


Figure 17 – Results of the hydrologic alteration assessment for the Northwest Region. Categories are based on regional rankings.

The "hydrologic alteration" assessment involved a statistical comparison of reservoir inflows and outflows. Differences in low flows, high flows, monthly volumes, and variability were all computed, expressed as a scale between 0 and 10 and then summed for the four metrics. The resulting sums were sorted, ranked, and categorized as high, middle, and lower thirds for display purposes (Figure 17).

The "characteristics" assessment considered each reservoir's authorities, operational flexibility, temperature management, fish passage, and channel condition. Reservoirs with federally authorized flood space have an average of 4 and as many as 8 authorized purposes per reservoir. Each authority accrued points for the reservoir (fish and wildlife +5, water quality +2.5, recreation +2.5, and all others -2 each). The total of the points was used as the score for the authorities' portion of the assessment. Operational flexibility was estimated by computing the percentage of each reservoirs outflow that occurred between 0 and 20% of flood space encroached and then placing the percentage for each reservoir on a 0 to 10 scale. A reservoirs ability to manage outflow temperatures was scored on a scale from 0 to 10 with 0 being no ability, 5 being limited ability, and 10 being able to operate for water temperature with no expressed limitations. A reservoir's ability to pass fish was scored on a scale from 0 to 10 based on reported effectiveness, with 10 being free passage. Channel condition involved a

comparison of a reservoir's objective flow (high flow limit) and its maximum non-damaging flow. When objective flow was equal to the maximum non-damaging flow a score of 0 was assigned. When objective flow was less than the maximum non-damaging flow the percent difference between the two values increased to a maximum of 10 when maximum non-damaging flow doubled the objective flow (differences greater than double were capped at a score of 10). When objective flow was greater than the maximum non-damaging flow the percent difference between the two values decreased to 0 as the maximum non-damaging flow decreased to 0. Scores for each of the five metrics were summed. Scores for the authorities and operational flexibility metrics were judged to be more important than the other metrics and given two shares each (added twice). The resulting sums were sorted, ranked, and categorized as high, middle, and lower thirds for display purposes (Figure 18).

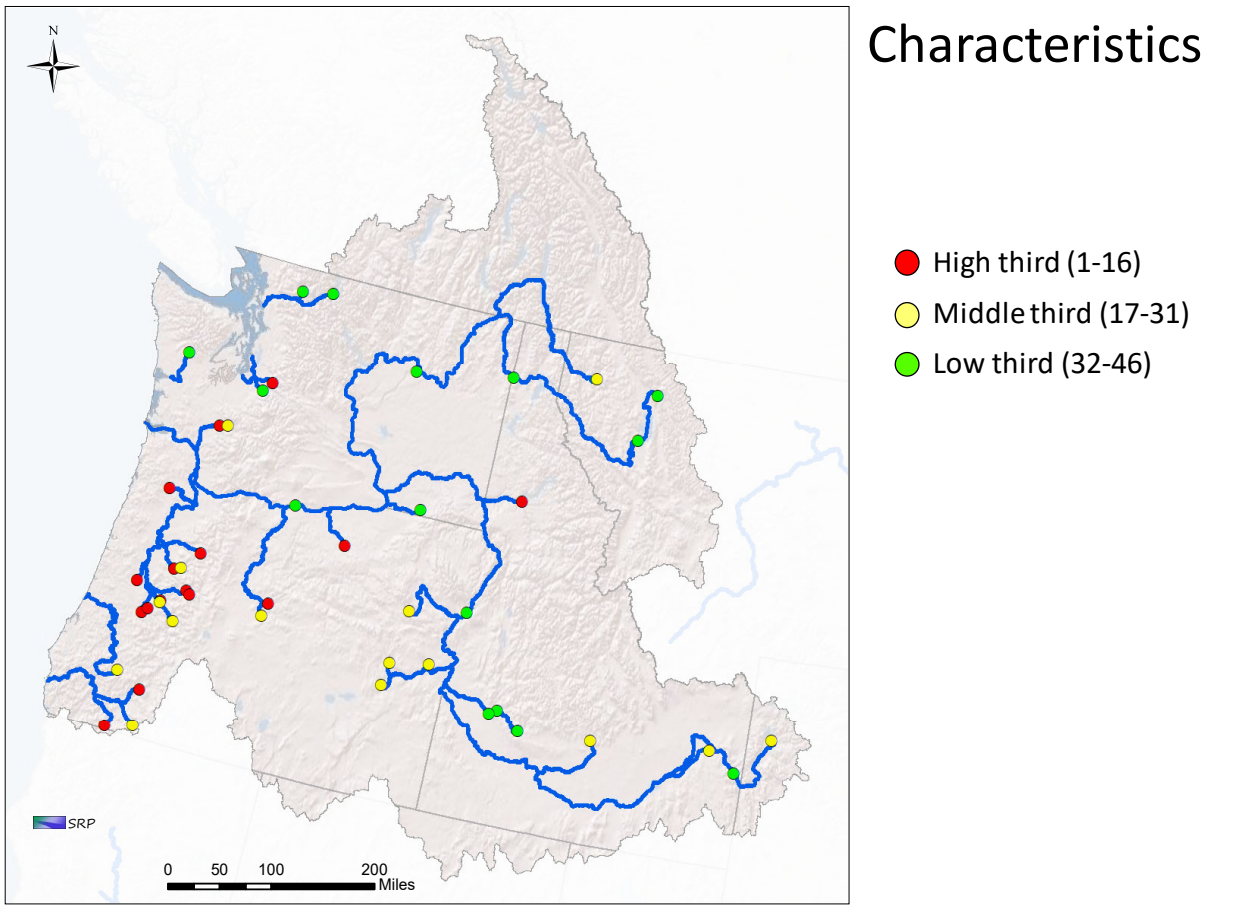


Figure 18 – Results of the characteristics assessment for the Northwest Region. Categories are based on regional rankings.

Prioritization of Reservoirs by District

In the 3rd Breakout Session, location-based teams reviewed their evaluations in the Environmental Opportunity Matrix, selected 4 to 5 environmental actions of interest including "General (Reservoirs) – Downstream – Ecological flows" (select actions in bold, Tables 6a and 6b) and then prioritized reservoirs as candidates for each selected action. Selections were based on actions having both potential environmental benefits and unrealized implementation. Note some actions identified as high interest (actions shaded green, Tables 6a and 6b) were not selected and are therefore not shown on Tables 7, 8, and 9. Location-based teams may wish to go back and reevaluate those opportunities in the future.

The portfolios of dams affiliated with all three of the dams in Northwestern Division include Section 7 dams – projects owned by other agencies and entities but for which the Corps has responsibility for flood risk management operations under Section 7 authority. The location-based teams evaluated the Section 7 dams for potential actionable environmental opportunity along with the Corps-owned dams. In the end, all three location-based teams determined that the Corps did currently have the authority and/or level of interest from the other managing agencies or entities to rank the Section 7 dams as priority projects for environmental opportunity. That does not mean that the potential may not exist for future actions developed in collaboration with those dam managers.

Portland District

The following environmental actions were selected for prioritization:

1. Ecological Flows
2. Management HABs (Algal blooms)
3. Level Management for Vegetation
4. Floodplain Connectivity and Wetland Opportunities
5. Fish Passage related operations

Table 7 presents a summary of the results of analysis conducted by the Portland District team (a more detailed version of the table with additional notes is contained in Exhibit C). Projects were grouped by watershed. The ranking by project and grouping (e.g., subbasin) provided NWP a spatial perspective for decision making and opportunity identification. Cells highlighted in green identify the priority actionable measures identified by the team.

Seattle District

Table 8 presents a summary of the prioritization conducted by the NWS team (a more detailed version of the table with additional notes is contained in Appendix D). The following environmental actions were selected for prioritization by the NWS team:

1. Water Quality (including temperature, nutrients, salinity and HABs)
2. Debris Management
3. Cottonwood Replacement
4. Invasive Species Management

Table 7 – Portland District Reservoir Prioritization

NWP Project		Selected "Actionable" Environmental Opportunities				
		Ecological Flows	Management HABs (Algal blooms)	Level Management for Vegetation	Floodplain Connectivity and Wetland Opportunities	Fish Passage related operations
		Ranking	Ranking	Ranking	Ranking	Ranking
Willamette R. Basin	Big Cliff Dam and Lake				**1**	**1**
	Detroit Dam and Lake	**1**	**1**			
	Foster Dam and Lake	**1**	4			
	Green Peter Dam and Lake	**1**	4			
	Dexter Dam and Lake		4			
	Lookout Point Dam and Lake	**1**	4			
	Hills Creek Dam and Lake	**1**	4			
	Cougar Dam and Lake	**1**	**2**			
	Blue River Dam and Lake	**1**	4			
	Dorena Dam and Lake	4	4			
	Cottage Grove Dam and Lake	5	4			
	Fern Ridge Dam and Lake	6	4			
Rogue River Basin	Lost Creek Dam and Lake	2	5			3
	Applegate Dam and Lake	3	6			3
	Elk Creek Dam (not completed)					
Columbia R. Mainstem and Tributaries	Bonneville Lock & Dam and Lake Bonneville	8	7		2	2
	The Dalles Lock & Dam and Lake Celilo					2
	John Day Lock & Dam and Lake Umatilla			**1**		2
	Toutle River Sediment Retention Struction					
	Willow Creek Dam and Lake	7	3			
Section 7 Projects	Emigrant Dam and Lake					
	Galesville Dam and Lake					
	Mayfield Dam and Lake					
	Mossyrock Dam and Lake					
	Ochoco Dam and Lake					
	Scoggins Dam and Henry Hagg Lake					

	Prioritized "actionable" measures or objectives
	Lower priority "actionable" measures or objectives
	Measures and objectives either not actionable or not a priority

Table 8 – Seattle District Reservoir Prioritization

NWS Project		Selected "Actionable" Environmental Opportunities				
		Ecological Flows	Water Quality	Debris management	Cottonwood Recruitment	Invasive species management
		Ranking	Ranking	Ranking	Ranking	Ranking
Westside Corps Projects	Howard Hanson Dam and Eagle Gorge Reservoir		4		3	
	Mud Mountain Dam and Lake			3		
	Hiram M. Chittenden Locks, Lake Washington Ship Canal		3			
Eastside Corps Projects	Libby Dam and Lake Koocanusa		1	1	1	
	Albeni Falls Dam and Lake Pend Oreille		5	2	2	2
	Chief Joseph Dam and Lake Rufus Woods		2			1
Section 7 Projects	Ross Dam and Lake					
	Upper Baker Dam and Baker Lake					
	Wynoochee Dam and Lake					
			Top priority "actionable" measures or objectives			
			Second priority "actionable" measures or objectives			
			Lower priority "actionable" measures or objectives			
			Measures and objectives either not actionable or not a priority			

Walla Walla District

Table 9 presents a summary of the results of analysis conducted by the NWW team. A more detailed version of the table is in Appendix E. The following environmental actions were selected for prioritization by the NWW Team:

1. Ecological Flows
2. Pool elevation management
3. Temperature Management
4. Debris Management

For Debris Management, the NWW District team did not prioritize individual projects but did note that across multiple projects there is possibility to manage debris more effectively (e.g. Large Woody Debris (LWD) and sediment – see additional information under the section “Actionable Ideas and Discussion”).

Table 9 – Walla Walla District Reservoir Prioritization

	Project name	Select "Actionable" Environmental Opportunities			
		Ecological Flows	Pool Elevation Management	Temperature Management	Debris Management
		Ranking	Ranking	Ranking	Ranking
General Reservoirs	Mill Creek Flood Control Project	2	1	1	
	Lucky Peak Dam and Lake	1	2		
	Dworshak Dam and Lake	3	3	2	
Columbia / Snake River Lock and Dam Projects	McNary Lock and Dam		1	5	
	Ice Harbor Lock and Dam		2	4	
	Little Goose Lock and Dam		4	2	
	Lower Granite Lock and Dam		3	1	
	Lower Monumental Lock and Dam		5	3	
Section 7 Projects	Agency Valley Dam				
	Anderson Ranch				
	Arrowrock				
	Bully Creek Dam				
	Jackson Lake Dam				
	Little Wood				
	Mason Dam				
	Palisades Dam				
	Ririe Dam				
	Warm Springs Dam				
	Hells Canyon Dam				
	Brownlee Dam				

	Prioritized "actionable" measures or objectives
	Lower priority "actionable" measures or objectives
	Measures and objectives either not actionable or not a priority

Parallel Sessions

Plenary Session #4 was originally scheduled to include a series of parallel sessions in which participants would break out into small groups to discuss nominated topics about environmental opportunities related to water infrastructure. The participants did not break out into multiple parallel sessions, agreeing to stay in the full group to engage a discussion regarding partnerships, policy, and outreach considerations related to e-flows. One of the important conclusions that came out of the discussion is

that Endangered Species Act Compliance is an important driver for environmental actions for all three Northwest districts.

The Portland District team discussed experiences with implementation of e-flows through SRP on three sub-basins in the Willamette River Basin. When asked to describe "how are we doing in implementing e-flows in the basin" the team responded that it is difficult to know for sure. Many of the e-flow targets are being met. The flood risk management operations in the basin have mostly eliminated the large damaging floods that historically caused the hydrogeomorphic processes that created and maintained habitat. However, the reservoirs in the system are operated to provide frequent non-damaging high flows that are within e-flow target ranges. It is difficult to know how successful those flows have been in providing ecological benefits. Understanding the outcomes of the three separate tributary e-flow efforts is a focal area currently under study in the ongoing Willamette River Basin SRP "Science" studies. USGS is an important regional partner in the Willamette Basin. ESA is the most important driver for Willamette Basin project operations; Portland District is working to ensure that SRP e-flows efforts are integrated with ESA compliance.

Walla Walla District has been making heavy investment in funding infrastructure improvements at their operating projects, again driven by ESA compliance. NWW is very interested in the potential for SRP funding to help leverage other authorities, including Section 206 or 1135. From their experience, competing through the O&M business line for Environmental Stewardship funding is difficult.

Actionable Ideas and Discussion

In the final breakout session, teams reconvened to further refine their prioritization of reservoirs. Each location-based team identified actionable ideas. An actionable idea is the pairing of a selected **environmental action** and **reservoir(s)** deemed to be compelling in accordance with potential environmental benefits and feasible to implement. This section details actionable ideas for each team.

Portland District

The NWP team identified the following priority environmental opportunities (Table 7): (1) Ecological Flows; (2) Management of HABs (Algal blooms); (3) Level Management for Vegetation; (4) Floodplain Connectivity and Wetland Opportunities; and (5) Fish Passage related operations.

ESA issues implicitly if not directly drove the ranking of the majority of "Environmental Action/Objectives" for NWP. For example, under existing operating criteria, the storage projects in NWP are operated to provide optimal flows for downstream passage as well as temperature optimization. Actions (e.g. ecosystem restoration) that aim to increase floodplain connection facilitate habitat creation for differing life stages of fish, etc.; and rated highest. Ecosystem restoration type projects supporting geomorphic and floodplain improvements, also ranked higher. These habitat creation/restoration centric projects often benefit ESA listed species. By contrast, recreation related projects were not rated high.

Ecological Flows. The Willamette Basin projects ranked highest for e-flows, reflecting the priority placed by NWP on continuing existing e-flows efforts for the Middle Fork Willamette (**Hills Creek** and **Lookout**

Point dams), McKenzie (**Cougar** and **Blue River** dams), and Santiam (**Green Peter**, **Foster**, **Hills Creek** and **Detroit** dams) Rivers. Although the 13 Corps dams in the basin are operated as a system, e-flow targets were established individually for the three major tributaries. The nine general reservoirs on those three tributaries projects are collectively rated number 1. Current Willamette SRP efforts are continuing with a focus on performing field science and monitoring needed to quantify ecosystem responses to effects of USACE reservoir operations on the individual tributaries and on the Willamette mainstem. The remaining dams on the other tributaries (Coast Fork and Long Tom rivers) were judged to have lower opportunity for e-flow actions and were ranked lower priority (3 through 6).

The next highest priority for e-flows in Portland District is the Rogue River basin with **Lost Creek** and **Applegate** dams rated 2 and 3, respectively. The Rogue Projects are currently operated in close coordination with Oregon Departments of Fish and Wildlife to optimize fish benefits.

Willow Creek Dam ranked 7th as most water is reserved for irrigation. Mainstem Columbia River reservoirs are collectively ranked 8th; as run-of-river dams they have little storage available for achieving e-flow targets.

Harmful Algal Blooms (HABs). HABs are a recent (past 2-5 years) issue of concern in Portland District, yet drove some of the higher scores for environmental opportunity. For example, "Water Quality - Management of harmful algal blooms" was directly identified as having a high potential (i.e., concern) by Portland District and opportunity for expansion of current mitigation. HABs urgency reflects recent experiences in **Willow Creek**, Willamette Valley Projects, and in the Rogue River Basin. Some HAB issues have urgency because they are a hazard to recreators at Corps managed sites.

HABs was prioritized at **Detroit** and **Cougar** Reservoirs (1 and 2) and then at **Willow Creek** (3). **Detroit** and Cougar dams were ranked the highest because they directly affected the water supply for the City of Salem and use by Eugene Water and Electric Board (EWEB).

Willow Creek has known issues with HAB. The University of Idaho has been monitoring and researching ways to reduce the outbreaks.

The other 11 Willamette projects were ranked as a collective 4th, followed by Lost Creek (5) and Applegate (6) in the Rogue Basin. Columbia River projects were ranked collectively as a 7th.

Level Management for Vegetation. **John Day Lock and Dam** was the only location deemed actionable for level management for vegetation. The project has worked with partners at the Klickitat County Conservation District to improve salmon passage up Rock Creek. This has entailed vegetation management for Eurasian milfoil in the 1-mile long reservoir to Lake Umatilla.

Floodplain connectivity. Opportunities to enhance floodplain connectivity for environmental benefits were identified primarily in the **Willamette Valley** dams (collectively ranked 1). The other area of opportunity for floodplain (re)connectivity was deemed to be in the **Lower Columbia River Estuary** (LCRE), where ecosystem restoration projects had already been built. Many of these restoration projects directly benefit ESA listed fish species. However, it was felt there may be more opportunities in the LCRE.

Fish Passage. Operational opportunities related to fish passage were identified for the **Willamette Valley projects** (collectively ranked 1st), the **Columbia River Projects** (ranked 2nd), and the **Rogue projects** (ranked 3rd)

Additionally, NWP's Sediment Retention Structure, SRS, was briefly considered. It is located on the North Fork Toutle River and was built as way to control sediment movement generated from the Mount St Helen's eruption of 1980. The SRS also adjusts river flow patterns, in its vicinity. There was thought to use the SRS to shift sediment and build "beneficial" sandy habitat in the vicinity of the structure. In due course, this was deemed as a feasible environmental opportunity, and it was agreed this item should be kept in mind for future consideration.

Seattle District

The NWS team identified the following priority environmental opportunities (Table 8): (1) Water Quality (including temperature, nutrients, salinity and HABs); (2) Debris Management; (3) Cottonwood Replacement; and (4) Invasive Species Management.

The NWS team determined that given the high degree of operational requirements for all of their projects under the recently completed Columbia Rivers Systems Operation (CRSO) Environmental Impact Statement (EIS), as well as individual project BiOps for ESA listed species, limited remaining potential exists for implementation of additional environmental flow management. However, they determined that there are significant opportunities for improvements via other environmental activities, including water quality and debris management.

Water Quality Improvements. NWS identified temperature, nutrients, and harmful algae blooms (HABs) as priority water quality concerns for their reservoirs. **Libby Dam** was identified as the top candidate for water quality improvements with multiple needs including: 1) Temperature and nutrient modelling for Kootenai River DS of Libby Dam, 2) In-Reservoir nitrate study, 3) Sediment analysis, and 4) CE-QUAL-W2 model of the reservoir upstream of Libby Dam. **Chief Joseph Dam** was identified as the 2nd priority with concerns for benthic HABs, needing to learn more about the cyanobacteria which bloom seasonally. This is one of three sites in Washington where this is occurring and impacting human health and wildlife.

The 3rd priority for water quality concerns is at Lake Washington Ship Canal where there is a need for modelling to learn more about temperature impacts related to the project. High water temperatures in the Lake Washington Ship Canal, together with low dissolved oxygen concentrations, have been identified as an impediment to ESA listed salmonid species migration. Modeling operational changes at the Ballard Locks and discharges of cool hypolimnetic waters into the system, via a CE-QUAL-W2 model, will provide potential solutions to address current and future needs for managing water temperature in this important salmonid corridor.

Debris Management. The development of Columbia River System Operations Environmental Impact Statement alternatives has shown that sediment movement downstream from changing flows may impact the overall water and sediment quality of the Columbia River system. Historical sediment contamination exists in the Clark Fork, the main inflow to Lake Pend Oreille and the Pend Oreille River. Several superfund sites have been listed on the Clark Fork, and impoundments downstream of these superfund sites and upstream of Lake Pend Oreille have trapped contaminated sediments. A limited amount of sediment quality samples collected on the Pend Oreille River just upstream of **Albeni Falls Dam** were elevated in cadmium, copper, lead and zinc. These results suggest that contaminants have

been transported down the Clark Fork and through Lake Pend Oreille. Because Lake Pend Oreille traps most Clark Fork sediments it is likely that lake sediments, especially near the Clark Fork delta are elevated in trace element contaminants.

Both **Libby** and **Albeni Falls** dams were identified as needing studies of the relationships between reservoir operations and woody debris nourishment downstream. Dams disrupt both the hydrologic cycle and transport of constituents from the upper watershed to the river below the dam. Along alluvial river channels, the truncation of flood peaks along with the cessation of transport of coarse sediment and large wood (LW) often have negative ecological implications for habitat below dams because river conditions tend to become unnaturally static, reducing floodplain turnover rates, slowly restricting opportunities for pioneering species to establish and simplifying available habitats for aquatic species. Dam operations (changes in flow regulation for ecological purposes) are more difficult to modify than routine maintenance procedures such as how the fate of LW entering reservoirs is handled. The Corps has been successfully addressing this issue at Howard Hanson Dam (HHD) since the mid-2000s and to a limited extent at Mud Mountain Dam (MMD). Several thousand pieces of LW have been transported past HHD and placed in the river below the dam, forming complex habitat and improving existing habitat over at least 30 miles of river. At MMD LW is decked for others to use for fish habitat projects but is not placed in the river to be transported away by the flow. While the work is routine and simple it required a BiOp to implement and several years of study and dedicated funding streams. The benefits of the work at HHD are the cost of creating new habitat is far lower than what it takes to purposely place LW for purposes of habitat creation, new habitat can be created in otherwise inaccessible locations, and a LW nourishment program is arguably more sustainable than construction of mitigation or restoration projects that emulate natural forms but are limited in restoring natural processes. The lessons learned from this work can be applied to the other Seattle District projects. The primary risk factor for this work is concerns by the public which can be allayed by good planning and incremental implementation guided by monitoring and adaptive management. While the number of new logjams along the Green River has increased several-fold (improving habitat), no problems have been reported on a river that has high recreational use. A pilot study is proposed to investigate the feasibility, cost, benefits, and risks of transporting accumulated woody material and placing it in the river below the MMD, Albeni Falls Dam (AFD), and Libby Dam. At AFD all large wood is chipped and burned at considerable effort. At MMD wood that is not used for fish habitat is chipped. Libby is investigating transport of some wood around the dam and placement along the shoreline; a more detailed description of a Libby proposal is provided separately, below. All reaches below the dams have challenges but potentially large opportunities to improve habitat through a wood nourishment program.

Cottonwood Recruitment. Enhanced riparian vegetation recruitment, cottonwoods in particular, is an environmental objective below several dams in NWS. Operational considerations to recruit riparian vegetation downstream of **Libby Dam** are already being implemented via seasonal ramping rates and flow shaping. These actions are addressed under the existing BiOp and EIS guiding operation of the project. Several operational considerations regarding riparian recruitment and survival are currently implemented at Libby Dam via seasonal ramping rates and flow shaping through existing EIS and BiOp requirements. However, the effects of these actions are dependent upon Libby Dam discharge, Kootenay Lake backwater stage, and downstream tributary discharge. In addition to these programmatic/operational actions, there are mitigation requirements within the new EIS and BiOp on

the Kootenai specific to cottonwood planting and survival. At present there is no mechanism to assess success or failure of these actions.

Although the need exists for cottonwood regeneration and recruitment along the Pend Oreille River below the **Albeni Falls Dam**, operational requirements for flood risk management and other authorized purposes of the dam may make it infeasible to implement changes to benefit the species. Below Howard Hanson Dam some opportunity for cottonwood recruitment may be feasible. The river downstream of the dam is characterized by a lack of bare substrate. Investigating the potential to create conditions for sediment movement to recreate lost habitat is needed.

Invasive Species Management. Invasive aquatic plant species, including milfoil and crispus, are issues at **Lake Rufous Woods (Chief Joseph Dam)** and **Lake Pend Oreille (Albeni Falls Dam)**.

There are three known aquatic invasive species in Lake Rufus Woods behind Chief Joseph Dam: Watermilfoil (Myriophyllum sp.), Yellow flag-iris (Iris pseudacorus) and Purple loosestrife (Lythrum salicaria). These species affect water quality and the ecosystem within the water body. Although these species are known to be present in the reservoir staffing issues have prevented treatments for control.

There are three species of interest that are currently not in Rufus Woods Lake; however, they are monitored for early detection: Quagga mussel (Dreissena bugensis), Zebra mussel (Dreissena polymorpha) and Flowering rush (Butomus umbellatus). Visual surveys, artificial substrates, and water samplings are conducted in various locations along the lake. These monitoring efforts are implemented in hopes of detecting populations while they are small and may be more easily contained. Quagga and Zebra mussel in a water system can cause lowered water quality conditions and damage to irrigation and hydropower operations resulting in extensive maintenance costs.

In 2019 Flowering rush was discovered in small pockets on Lake Roosevelt behind Grand Coulee Dam. The Washington Department of Ecology, Colville Tribe and Okanogan County Weed Board are currently planning treatment options to control the Flowering rush found in Lake Roosevelt. Since this finding, Chief Joseph Dam NRM personnel have unofficially monitored Lake Rufus Woods for possible flowering rush. Currently, due to budget and time constraints, visual surveys are only conducted as secondary actions while crews are upriver completing other work. Flowering rush causes displacement of native vegetation and reduction in overall biological diversity of the ecosystem.

Special Dam operations to lower water level during winter might be used for invasive species management. However, because of hydropower operations Lake Rufus Woods operates within a strict 6ft pool range. Planting sedges in the reservoir may help efforts to control invasive plant species. Canada geese nest and occupy shoreline areas along the reservoir, but they would not be affected by lowering the pool level if work was completed by mid-March.

Walla Walla District

The NWW team identified the following priority environmental opportunities (Table 9): (1) Ecological Flows; (2) Pool elevation management; (3) Temperature Management; and (4) Debris Management

Ecological Flows. The NWW Team noted that, similarly to the other districts, existing environmental flow and spill targets are largely stipulated by existing BiOps and EIS. Some operational alternatives for ecological benefit were considered under the 2020 CRSO EIS study.

Otherwise, **Lucky Peak Dam and Reservoir** on the Boise River is viewed as having the greatest potential for e-flows. Minimum winter flows are currently in place. Changes to e-flows would require coordination with upstream dams/irrigators/power productors. There is a need to study the possibility to shape flood releases in pulses to benefit cottonwood regeneration and provide bald eagle habitat. There is uncertainty on potential water releases due to irrigation needs at different times of the year times of year and low water years are problematic. Releases increase litigation risk if they appear to reduce water for irrigation. They could require formal reallocation to reduce risk of litigation which may be addressed via BiOp renewals. The primary action item for e-flows at Lucky Peak would be a study to ensure that releases are optimally shaped (magnitude, duration, and timing) to benefit ecosystems while still providing potential for recreation benefits (floating river).

Mill Creek Project was identified as the second priority project for e-flows. The BiOp for the project currently restricts flows, but potential exists to study opportunities to shape releases for targeting key elevations and seasonal elevation bands with ecologic benefits. The flood action levels for diverting water to Bennington Lake are currently being evaluated. Also flow ramping (in late summer) could be studied to ensure it is being operated to maximize ecological benefits. The key e-flows action item for Mill Creek is to review low level flow control (Flow Ramping).

Dworshak Dam and Lake was identified as the third priority NWW project for e-flows potential. As for the mainstem projects, existing targets for Dworshak Dam are stipulated by BiOp and EIS and they do operate to meet current ecologic flows for fisheries. But additional opportunities do exist to flush flows for fish. NWW also manages flows for water temperatures for lower Snake and monitors dissolved gas during spills. Dworshak does have the ability to add large flows downstream without flooding, but potential ecologic benefits are not clear and would need to be studied further. It may be better to keep the Dworshak pool high if upstream benefits could alternatively be achieved.

Pool Level Management for Environmental Benefits. **Mill Creek** and **McNary** Lock and Dam were identified as having the highest potential.

At **McNary Lock and Dam** (Lake Wallula) there is potential to evaluate pool level effects on fish habitat or effects on wetlands seasonally and to analyze potential elevation ranges to optimize benefit. The Yakima and Walla Walla Rivers join the Columbia within McNary pool. Both deposit sediment at their confluences as flows slow due to backwater effects. The shallow water habitat this dynamic creates has started to grow invasive aquatic plant species, including Flowering Rush and Stargrass, which grow in shallower and warmer water. Figure 19 shows sediment accumulation and impaired water quality (green inundation toward bottom of image due to higher concentrations of algae) in the Yakima River delta.

The project currently has a 3'-5' range of pool operations. This is mostly for hydropower management but is also influenced by fish operations. Lowering the pool at certain times of the year could allow for management of underwater invasive plants and sediment conditions in the Yakima River Delta. These actions would require coordination with upstream Priest Rapids Dam (PRD) since the Public Utility Districts of the mid-Columbia manage for hydropower and are frequently load following. Implementation of e-flows could have ESA compliance challenges, but it would be possible to add e-flows ideas to future BiOp updates.

Operation of **McNary** reservoir at a lower level during high spring runoff flows could help to move more of the sediment out into the deeper areas of the reservoir and downriver. It may also be possible to coordinate this stage adjustment with various flex spill operations that occur between April and September. The reservoir would also be operated at various levels to help the USFWS McNary Wildlife Refuge, which is located in the reservoir) meet wetland goals of flooding certain areas or lowering the reservoir to allow certain areas to dry out/grow. Current operations allow for some variance from standard pool of +/- 5', but all of the potential impacts of raising or lowering the pool would need to be evaluated before any operational change is implemented. Including additional considerations for McNary operations will require regional coordination with local Public Utility Districts. Figure 20 shows pool fluctuations, 2020-2021.

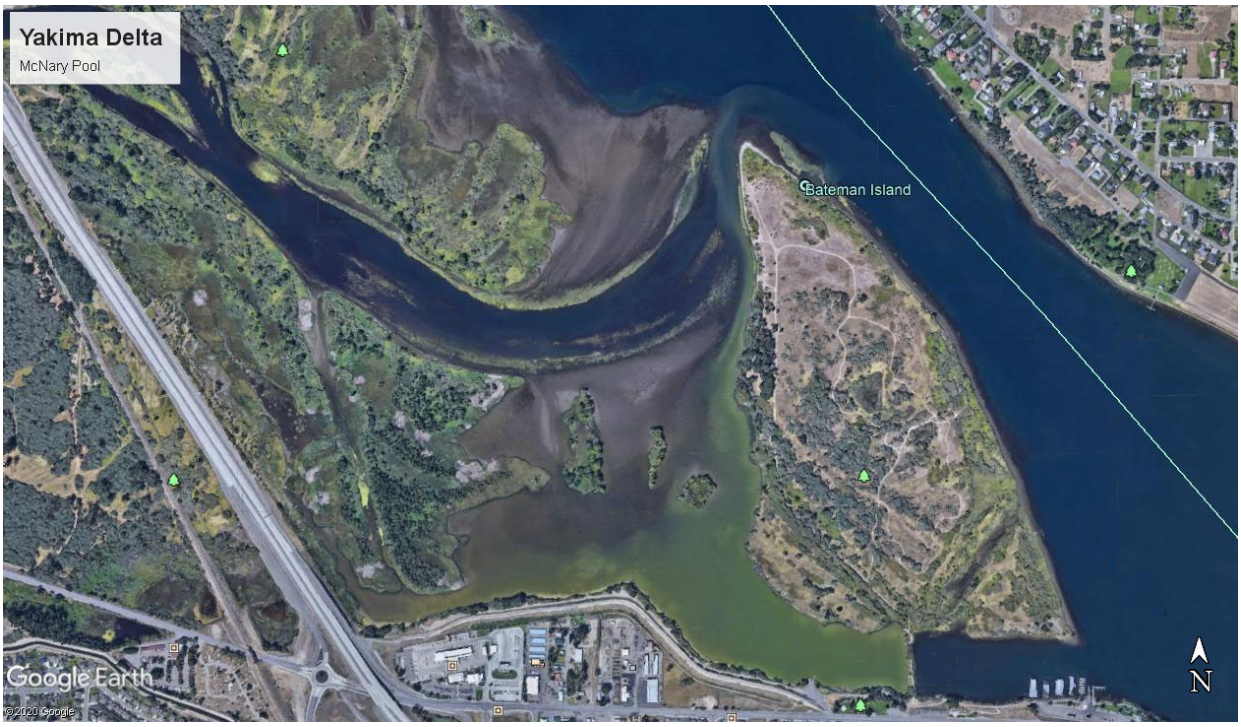


Figure 19 – Aerial view of the Yakima River delta and Bateman Island in the McNary reservoir pool.

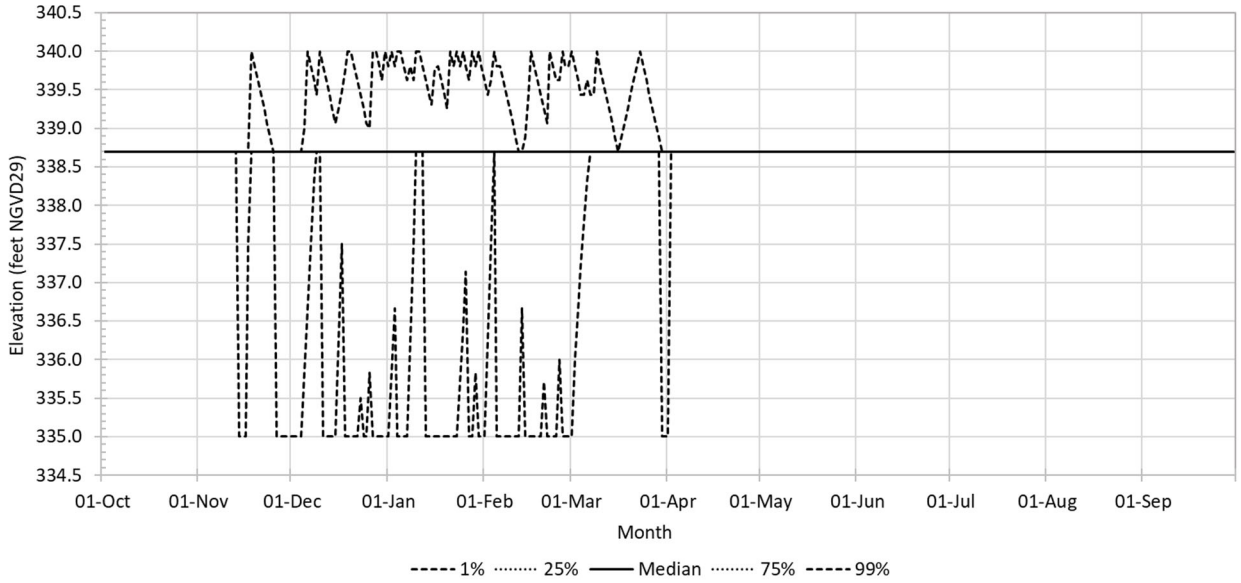


Figure 20 – McNary reservoir pool summary elevation hydrograph, 2020-2021.

The **Mill Creek Project** has two dams – the Diversion Dam (Figure 21) which impounds water into a forebay for fish passage requirements or flood operations, and an Embankment Dam which impounds the flood water that come from the Diversion Dam during floods. Two ideas rose to the top of high impact and feasibility. The potential changes are to impound more water in the forebay to inundate the invasive reed canary grass and to impound more water in the forebay to increase flood plain connectivity.

Figure 21 – Plan view of the Mill Creek diversion dam.

Temperature Management. **Mill Creek Dam** was rated as having the highest potential. Mill Creek currently operates under a total maximum daily load (TMDL) for temperature. A possible action item would be to study the project forebay effects on temperatures (holding water back, higher pool, vegetation to cool water). NWW and others could investigate off-project efforts related to water temperatures such as stream conditions through the City of Walla Walla or Jones Ditch. Other potential measures could be considered to improve instream habitat:

- Retain cooler water somewhere and flush (likely upstream of the diversion dam)
- Plant trees and areas/means for reducing reed canary grass.
- Realign Mill Creek upstream of forebay to the south side of the floodway.
- discuss options with City of WW about releasing cooler water at certain times of the year
- Hold water back to improve ground water recharge and improve late season hyporheic flow.

Debris Management. The NWW District team did not prioritize individual projects but did note that across multiple projects there is possibility to manage debris more effectively (e.g. Large Woody Debris (LWD) and sediment). The District could evaluate potential to promote the storage/deposition further up in various systems as well as actively capturing and removing LWD from the system and then installing elsewhere for environmental benefits (e.g., shallow water habitat construction via dredged

material or LWD use in stream/river restoration projects). If removing debris from projects/sites, there is potential to partner with other organizations to identify potential secondary uses and locations and treat as a mitigation bank of sorts as material may have some economic value.

Non-USACE Dams within NWW Region. These dams include Agency Valley, Anderson Ranch, Arrowrock, Bully Creek, Jackson Lake, Little Wood, Mason, Palisades, Ririe, Warm Springs, Hells Canyon, and Brownlee Dams. All have competing needs for water outflows that include irrigation and flood control. Also, some of these dams interact as a system influencing each other or USACE managed dams. There may be potential to affect local fisheries or recreation at Ririe Dam, but this would need to be studied closer as information was not available during the SRP workshop.

Screening. Many ideas were screened out due to various factors. For example, LPA release flows could have a great influence on downstream habitat. Altering these flows was screened out due to the water already being used for irrigation. Some states have programs to claim unused water rights and use them for fish /environmental projects, but this would be out of the scope of the Corps. Also screened out were changed to DWO flows. These are tied up with flow augmentation for fish and temp affects downstream. Also, hydropower claims much of the outflow levels. The main Snake River dams have potential to what was discussed above regarding MNC Reservoir, but the team didn't see a huge benefit, based on the topography, incoming streams, and level of water. There is potential to do something at the LGR Pool, but the city there does has much of their infrastructure set to work with certain elevations.

Conclusion

The Northwest Operations and Water Management Meeting was held virtually November 18-19, 2020. The Northwest Region is defined as the geographic areas of 3 Corps Districts: Portland (NWP), Seattle (NWP), and Walla Walla (NWW). Teams for each area collaborated to determine environmental opportunities at reservoirs that are feasible to implement with compelling potential benefits. There were 30 participants (Appendix A). More than 50 reservoirs, affecting flows for over 4,629 river miles within the region, were considered.

In formulating and evaluating environmental opportunities, location-based teams followed these steps:

1. list possible environmental actions associated with reservoirs;
2. rate environmental potential of each action;
3. rate degree to which each action has been implemented;
4. select environmental actions with potential and unrealized implementation; and,
5. rank reservoirs according to which are most promising for operational changes related to selected actions.

One characteristic of the Corps projects in the Northwest that distinguishes the region from other parts of the country is the high degree of existing and ongoing consultation under the Endangered Species Act. Virtually all the projects are operating under BiOps negotiated with NMFS and /or USFWS that include conservation actions for flow management and related actions that are already integrated into project operations. Regardless, the District teams were able to identify combinations of environmental action that could be implemented at candidate reservoir.

A key outcome of the meeting is the list of “actionable ideas”, each of which is a pairing of an environmental action with unrealized implementation and a reservoir with potential for related operational changes. There were 35 actionable ideas identified during the workshop involving 13 environmental actions and more than 20 Corps reservoirs (Table 1).

This tally is worthy of reflection. In a day and a half, 30 participants identified 35 actionable ideas. In other words, table 1 includes 35 ways to get more environmental benefits from already built, public, water resources infrastructure - just do more of this (action) at this location (reservoir). It does not mean making the changes would be easy or always generate the anticipated benefits. However, it does clearly connect water resources management to ecosystem management and illustrate the unrealized potential of reservoirs to be used as tools in the restoration and management of ecosystems.

It is hoped that the meeting outcomes can be used by District and Northwest regional partners to initiate implementation of as many of the identified measures as possible using the suite of environmental restoration and management tools and authorities at their disposal, including the Sustainable Rivers Program.

This was the third regional meeting supported by Sustainable Rivers. From a Program perspective, the meeting was done to 1) identify environmental opportunities at reservoirs in the Northwest and 2) cultivate a forum about environmental considerations at reservoirs. The Corps has several recurring meetings that focus on water management and involve multiple Districts. To the knowledge of SRP, none are specific to environment considerations. Sustainable Rivers will continue to advance these regional meetings and help implement the resulting ideas with the overall goal of incorporating environmental strategies into the operations of Corps reservoirs.

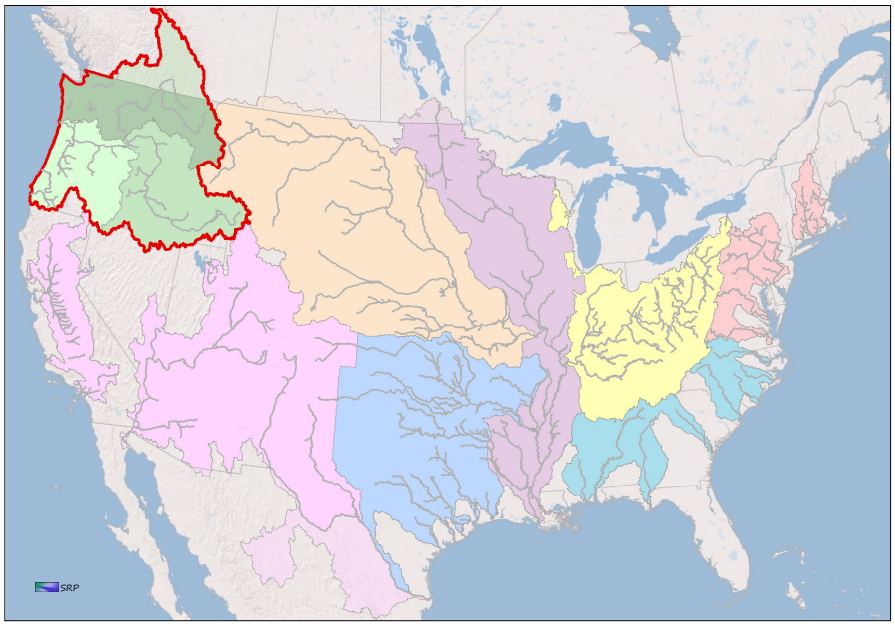
Appendix A: Participants -- Northwest Regional Operations and Water Management Meeting, November 18 and 19, 2020

Last Name	First Name	Office	Area of Expertise	Location-Based Team
Budai	Chris	CENWP-PM-F	Geologist, NWP POC	Portland District
Taylor	Greg	CENWP-OD-V	Operations, Fisheries Biloogist	Portland District
Nuckols	Jason	The Nature Conservany - Oregon	Water Program Manager	Portland District
Tackley	Kathryn	CENWP-ENC-HR	Reservoir Regulatiopn, Physical Scientist	Portland District
Duffy	Keith	CENWP-EC-HY	Hydrology Section, Engineer	Portland District
Rea	Matthew	CENWD-PDD	Planning, SRP Project Manager	Portland District
Darland	Tim	CENWP-ODJ	Operations, Natural Resource Management	Portland District
Ray	Collin	CENWS-PMP	Biologist	Seattle District
Brengle	Craig	CENWS-ODA	Albeni Falls Dam - Natural Resources Management	Seattle District
Baughman	Crystal	CENWS-ODC	Chief Joseph Dam - Natural Resources Management	Seattle District
Zimdars	Eric	CENWS-ENH-Y	Hydrology Section - Water Qulaity	Seattle District
Benjamin	Gretchen	The Nature Conservancy - Wisconsin	Big River Specialist, SRP Program Manager	Seattle District
Moen	Jonathan	CENWS-ENH-W	Water Management, NWS POC	Seattle District
Mattson	Michelle	CEIWR-GC	Ecologist, SRP Support Team	Seattle District
Gleason	Nancy	CENWD-PDD	Fisheries Biologist / Environmental Coordinator	Seattle District
Michelsen	Sonja	CENWS-ENH-Y	Hydrology Section - Reservoir Regulation	Seattle District
Corum	Zac	CENWS-ENH-H	Hydraulic Engineering - Environmentla Restoration	Seattle District
Trumbo	Brad	CENWW-PPL-C	Planning, Biologist	Walla Walla District
Alford	Chris	CENWW-ODT	Operations, Natural Resources Mgmt., NWW POC	Walla Walla District
Boen	Cindy	CENWW-PPL-P	Planning, Landscape Architect	Walla Walla District
Kendy	Eloise	The Nature Conservancy	Freshwater Scientist	Walla Walla District
Nguyen	Jeremy	CENWW-ODC	Mill Creek Dam - Natural Resources Mgmt.	Walla Walla District
Weber	Jeremy	CENWD-PDD	District Support Planner	Walla Walla District
Hickey	John	CEIWR	Hydraulic Engineering, SRP Program Manager	Walla Walla District
Heitstuman	John	CENWW-ECH	Ch., Hydrology Section	Walla Walla District
Price	Mitch	CENWW-ECH	Hydraulics	Walla Walla District
Proctor	Bill	CENWD-PDW-HD	Chief, Hydrologic Engineering and Power Branch	
Bird	Brad	CENWD-RBT	Hydraulic Engineering	
Granet	Jesse	CENWD-PDD	Environmental Specialist	
Amman	Julie	CENWD-PDR	Chief, Reservoir Control Center	

Appendix B

AGENDA

NORTHWEST REGION - OPERATIONS AND WATER MANAGEMENT MEETING



18 AND 19 NOVEMBER, 2020

NORTHWEST REGION - OPERATIONS AND WATER MANAGEMENT MEETING

Meeting goal is to identify environmental opportunities at water infrastructure that are feasible to implement with compelling potential benefits. Participants provide expertise in reservoir operations, water management, water quality, natural resources management, environmental planning, and ecology. Meeting provides a venue for consideration of environmental actions at rivers and water infrastructure of the Northwest Region.

US Army Corps of Engineers
Rock Island District

Sustainable Rivers Program

The Nature Conservancy
Protecting nature. Preserving life.

KEY EVENT DATES

OCT. 30 TH
COORDINATION WITH PARTICIPANTS

NOV. 13TH
DISTRIBUTION OF MATERIALS

NOV. 18TH AND 19TH
OPERATIONS AND WATER MANAGEMENT MEETING

MEETING LOCATION:

Virtual / Webex

https//usace1.webex.com/meet/matthew.t.rea

Northwest Region

Operations and Water Management Meeting

hosted by

Sustainable Rivers Program (SRP)

Agenda

Day 1 – Wednesday, November 18

8:00 am - 8:30 am: Plenary Sessions

Introductions and Meeting Objectives. Session includes welcome, introductions, meeting overview, and meeting objectives – Matt Rea and John Hickey

8:30 am - 9:00 am

SRP Brief. History and status of the Sustainable Rivers Program (SRP). Since its inception in 2002, SRP has engaged 16 river systems and 66 Corps reservoirs. SRP focuses on environmental flows (e-flows), including a process for advancing, implementing, and incorporating e-flows into reservoir operations, while exploring a broader set of strategies about environmental opportunities at reservoirs – Gretchen Benjamin

9:00 am - 9:30 am

Regional Rivers and Reservoirs. Results from ongoing GIS analyses are used to summarize rivers and reservoir systems of the Pacific Northwest. Details include number, volume, purposes, and potential influence of Corps reservoirs in region – John Hickey

9:30 am - 9:45 am: Break

9:45 am - 11:30 am

Overview of Ongoing SRP efforts in NWD (10 minutes each)

1) Willamette River Basin – Greg Taylor and Chris Budai
2) Kansas River Basin – Laura Totten

Reservoir-centric Environmental Efforts within Region. Presentations about their portfolio of multiple purpose reservoirs and related Civil Works infrastructure. Should cover existing ongoing environmental stewardship and ecosystem restoration projects within region. If known, identify environmental gaps or needs in the region (perspectives from NWP, NWW and NWS – 15 minutes each district).

11:30 am - 12:00 pm

Environmental Opportunity Matrix. Review matrix, incorporate any revisions and provide instructions/goals for breakout session – Michelle Mattson

12:00 pm – 12:30 pm: Lunch

12:30 pm - 2:00 pm: Breakout session #1

Focus Session: Ongoing Environmental Work at Reservoirs within Region. Interactive location-based team exercise (with reporting to conclude session) related to current environmental activities at reservoirs. Three topics or questions will be explored:

- Identify environmental opportunities at reservoirs. Define potential and implementation per office.
- What opportunities are underrepresented and feasible?
- What are limitations to implementation?

2:00 pm - 2:30 pm: Plenary session

National Reservoir Review. Review of project authorizations and basic capabilities of Corps reservoirs to operate for environmental purposes, including which reservoirs have fish and wildlife, water quality, and/or recreation as an authorized purpose – John Hickey

2:30 pm - 4:00 pm: Breakout session #2

Focus Session: Prioritization of Reservoirs within Region. Location-based teams will be provided with information from a national reservoir review and tasked with prioritizing reservoirs within their area of interest/expertise. Prioritizations will be done for environmental flow potential and two or three of the most promising environmental activities identified in the morning session. Teams will also develop ideas about how data provided might be applied differently in support of environmental activities.

4:00 pm - 4:15 pm: Plenary Session

Wrap for day and details about tomorrow.

Day 2 – Thursday, November 19

9:00 am - 9:15 am: Plenary Session

10:00 am – 12:00 pm: Breakout Session #3

Strategy Session to Integrate Information. Location-based teams reconvene to finalize thoughts and materials for report out.

12:00 pm - 1:00 pm Lunch

1:00 pm - 2:00 am: Plenary Session

Reports from Location-based Teams. Teams will report to group on identified environmental opportunities and candidate reservoirs. Actionable ideas will be highlighted.

2:00 pm - 3:00 pm

Group discussion. Open discussion about meeting products and actionable ideas. Follow-up tasks. Concluding thoughts.

3:00 pm - 3:30 pm

Review Regional Meeting Concept. Review overall agenda and revisit key components to discuss effectiveness and generate ideas for future meetings. Ideas about meeting goals, construct, and potential would be welcome.

3:30 pm - Meeting Adjourned

Appendix C

SEATTLE DISTRICT

DETAILS OF ENVIRONMENTAL "ACTIONABLE IDEAS"

The NWS team identified the following priority environmental opportunities (Table 8): (1) Water Quality (including temperature, nutrients, salinity and HABs); (2) Debris Management; (3) Cottonwood Replacement; and (4) Invasive Species Management. The NWS Team identified 12 specific actions related to these priority areas.

Kootenai River Modeling (#1) – Category: General; Structure: Libby Dam. There is an ongoing need to more fully understand temperature and nutrient dynamics downstream of Libby Dam in the Upper Kootenai River. The model would inform multi-agency efforts in the US and Canada, including the fate and transport of increased nitrate through the system (current and future), river nutrient additions (current and proposed), river habitat improvement projects (current and future), river water quality monitoring, primary and secondary productivity monitoring, and temperature management at Libby Dam. All ongoing projects are related to recovery of endangered Kootenai River white sturgeon, threatened bull trout, and resident burbot and trout, and are associated with BiOp-required or recommended measures, operational and structural, among other environmental stewardship authorities.

Lake Koocanusa Nitrate Study (#2) – Category: General; Structure: Libby Dam. Coal mining in British Columbia, upstream of Lake Koocanusa, has resulted in 5-fold increase in nitrate (N) loading over the past 20 years, and future increases are expected. A targeted and intensive sampling study will provide insight into nitrate loading of the food web, any spatio-temporal changes in algal composition, and if the reservoir's trophic structure is influenced by N loading increases. Understanding N uptake in the algal community would inform any need for increased HAB and cyanobacteria monitoring. Studying N dynamics through the system may also have implications on established downstream nuisance proliferations of Didymosphenia geminata.

Lake Koocanusa Sediment Analysis (#3) – Category: General; Structure: Libby Dam. A sediment quality study of Lake Koocanusa upstream of Libby dam is needed to determine the extent and level of sediment contamination in the reservoir. Limited monitoring efforts in the Kootenai River ecosystem in Idaho and British Columbia have detected metals, PCBs and organochlorine pesticides in White Sturgeon indicating that contaminants persist in the sediments. Partner agencies such as the USGS and MDEQ would benefit from the outcomes of this project in their own ongoing endeavors. By characterizing the sediments through intensive sampling and conducting a loading analysis, an assessment of reservoir aging will also be possible. This information is vital to the long-term health and safety of the operating project. Without the study, the Corps will not know the extent of sediment contamination in Lake Koocanusa upstream of Libby Dam, or the effects of dam operations on downstream Kootenai River sediment quality

Lake Koocanusa Modeling (#4) – Category: General; Structure: Libby Dam. There has been a longstanding need for a CE-QUAL-W2 model of the reservoir upstream Libby Dam. This tool will help analyze how FRM and hydropower operations, along with operation of the selective withdrawal system, impact the system's spatio-temporal temperature and nutrient distribution dynamics. The goal of this study is to develop a model to support the decisions regarding both operational and structural alternatives to support both Lake Koocanusa productivity and water quality impacts as well as downstream Kootenai River temperature management objectives. Better understanding of the ecological impacts from operations is crucial to further understanding and protecting the short and long-term health of the aquatic ecology in and downstream of the reservoir.

Chief Joseph HAB Study (#5) – Category: General; Structure: Chief Joseph Dam. Harmful Algae Blooms (HABs) form in Lake Rufus Woods at Chief Joseph Dam during the summer months. Public access and recreation occur on Rufus Woods Lake and a better understanding of the source(s) and cause(s) of

known HABs is of critical importance to minimize any harmful impacts on animals or humans. These blooms are unique in the state of Washington because they contain the toxin Anatoxin-a (most blooms contain the toxin Microcystin) making Rufus Woods one of only 3 lakes in the state known to have Anatoxin-a. An investigation is proposed to study the source(s) and cause(s) of the HABs, and to determine why Rufus Woods Lake supports such a unique assemblage of phytoplankton resulting in an Anatoxin-a HAB. Further study of their spatial-temporal abundance, habitat selectivity, and taxonomy will help determine management options and pinpoint the driver(s) behind their origin. Operations will significantly change at Chief Joseph Dam because of the new Columbia River System Operation EIS ROD. These changes may increase the amount of HABs in Rufus Woods Lake which could impact recreation and potentially result in harm to pets, wildlife, and humans

Lake Pend Oreille Sediment Study (#6) – Category: General; Structure: Albeni Falls Dam. Sediment quality sampling in Lake Pend Oreille and the Pend Oreille River upstream of Albeni Falls Dam is proposed. The development of Columbia River System Operations Environmental Impact Statement alternatives has shown that sediment movement downstream from changing flows may impact the overall water and sediment quality of the Columbia River system. Historical sediment contamination exists in the Clark Fork, the main inflow to Lake Pend Oreille and the Pend Oreille River. Several superfund sites have been listed on the Clark Fork, and impoundments downstream of these superfund sites and upstream of Lake Pend Oreille have trapped contaminated sediments. A limited amount of sediment quality samples collected on the Pend Oreille River just upstream of Albeni Falls Dam were elevated in cadmium, copper, lead and zinc. These results suggest that contaminants have been transported down the Clark Fork and through Lake Pend Oreille. Because Lake Pend Oreille traps most Clark Fork sediments it is likely that lake sediments, especially near the Clark Fork delta are elevated in trace element contaminants.

Lake Washington Ship Canal Modeling (#7) – Category: Lock and Dam; Structure: Ballard Locks. As global climate change progresses, there are concerns that water temperatures in lakes and rivers will become unsuitable to support salmonid populations in the PNW. High water temperatures in the Lake Washington Ship Canal, together with low dissolved oxygen concentrations, have been identified as an impediment to ESA listed salmonid species migration. Modeling operational changes at the Ballard Locks and discharges of cool hypolimnetic waters into the system, via a CE-QUAL-W2 model, will provide potential solutions to address current and future needs for managing water temperature in this important salmonid corridor.

Howard Hanson Sediment Transport Study (#8) – Category: General; Structure: Howard Hanson Dam. Howard Hanson Dam completely restricts the passage of gravel and coarser sized sediment from the upper watershed to the Green River, impacting over 30 miles of river below the dam. The truncation of supply has resulted in armoring of 20 miles of the river below the dam and loss and degradation of spawning habitat. Dam operations staff annually place 5,000 to 15,000 tons of quarried, glacially deposited gravel and cobble below the dam as a BiOp requirement for improving degraded spawning habitat of threatened and endangered salmonids. At the same time, Howard Hanson dam has accumulated over 50-years of sediment load within the reservoir. Fine sediment accumulation is resulting in a gradual increase in the elevation of the water quality pool, which can restrict flood operations. There is no imminent risk of problematic loss of flood storage but there is also no program for sediment sluicing or sediment removal to address this future issue. Because there is ample sediment of suitable size and quality depositing in the upper reaches of the reservoir and there is road access to

these locations, a study is envisioned to investigate the feasibility of the Corps contracting gravel and cobble removal and transport from the reservoir to the nourishment site to achieve three benefits: Increase reservoir sustainability, improve spawning conditions (gravel particles in the river are significantly different shape and chemical composition than quarried glacial sediment), potentially reduce cost due to shorter hauling distance to gravel nourishment site.

Large Wood Nourishment Studies (#9) – Category: General; Structure: Libby Dam, Albeni Falls Dam, and/or Mud Mountain Dam. Dams disrupt both the hydrologic cycle and transport of constituents from the upper watershed to the river below the dam. Along alluvial river channels, the truncation of flood peaks along with the cessation of transport of coarse sediment and large wood (LW) often have negative ecological implications for habitat below dams because river conditions tend to become unnaturally static, reducing floodplain turnover rates, slowly restricting opportunities for pioneering species to establish and simplifying available habitats for aquatic species. Dam operations (changes in flow regulation for ecological purposes) are more difficult to modify than routine maintenance procedures such as how the fate of LW entering reservoirs is handled. The Corps has been successfully addressing this issue at Howard Hanson Dam (HHD) since the mid-2000s and to a limited extent at Mud Mountain Dam (MMD). Several thousand pieces of LW have been transported past HHD and placed in the river below the dam, forming complex habitat and improving existing habitat over at least 30 miles of river. At MMD LW is decked for others to use for fish habitat projects but is not placed in the river to be transported away by the flow. While the work is routine and simple it required a BiOp to implement and several years of study and dedicated funding streams. The benefits of the work at HHD are the cost of creating new habitat is far lower than what it takes to purposely place LW for purposes of habitat creation, new habitat can be created in otherwise inaccessible locations, and a LW nourishment program is arguably more sustainable than construction of mitigation or restoration projects that emulate natural forms but are limited in restoring natural processes. The lessons learned from this work can be applied to the other Seattle District projects. The primary risk factor for this work is concerns by the public which can be allayed by good planning and incremental implementation guided by monitoring and adaptive management. While the number of new logjams along the Green River has increased several-fold (improving habitat), no problems have been reported on a river that has high recreational use. A pilot study is proposed to investigate the feasibility, cost, benefits, and risks of transporting accumulated woody material and placing it in the river below the MMD, Albeni Falls Dam (AFD), and Libby Dam. At AFD all large wood is chipped and burned at considerable effort. At MMD wood that is not used for fish habitat is chipped. Libby is investigating transport of some wood around the dam and placement along the shoreline; a more detailed description of a Libby proposal is provided separately, below. All reaches below the dams have challenges but potentially large opportunities to improve habitat through a wood nourishment program.

Large Wood Nourishment Plan at Libby Dam (#10) – Category: General; Structure: Libby Dam. Creation and inundation of Koocanusa Reservoir has effectively eliminated distribution of large wood and nutrients (phosphorus and nitrogen) downstream of Libby Dam, creating a riverine environment void of critical components of normative ecological function. Translocating available large wood materials from upstream of the dam to downstream would restore (in combination with ongoing temperature management via selective withdrawal, ecological flow shaping, tributary delta modification, and proposed nutrient addition immediately downstream of the dam), in part, some of the lost ecological function in the Kootenai River downstream of Libby Dam. A comprehensive plan for wood nourishment

that considers and assesses availability, placement, distribution, mobility, navigational safety, and ecological benefit is needed.

Cottonwood Recruitment Modeling at Libby Dam (#11) – Category: General; Structure: Libby Dam. Several operational considerations regarding riparian recruitment and survival are currently implemented at Libby Dam via seasonal ramping rates and flow shaping through existing EIS and BiOp requirements. However, the effects of these actions are dependent upon Libby Dam discharge, Kootenay Lake backwater stage, and downstream tributary discharge. In addition to these programmatic/operational actions, there are mitigation requirements within the new EIS and BiOp on the Kootenai specific to cottonwood planting and survival. At present there is no mechanism to assess success or failure of these actions. A detailed modeling effort to assess and predict river stage effects on riparian recruitment throughout the river corridor, including both mainstem and off-channel habitats (existing and proposed) between Libby Dam and Kootenay Lake, is needed to allow river managers and biologists to maximize spatial and temporal effectiveness of ecological discharge on riparian recruitment and survival, particularly when considered in conjunction with continuing and ongoing habitat and ecological function restoration projects and operations.

Invasive Species Management at Chief Joseph Dam (#12) – Category: General; Structure: Chief Joseph Dam. There are three known aquatic invasive species in Lake Rufus Woods behind Chief Joseph Dam: Watermilfoil (Myriophyllum sp.), Yellow flag-iris (Iris pseudacorus) and Purple loosestrife (Lythrum salicaria). These species affect water quality and the ecosystem within the water body. Although these species are known to be present in the reservoir staffing issues have prevented treatments for control.

There are three species of interest that are currently not in Rufus Woods Lake; however, they are monitored for early detection: Quagga mussel (Dreissena bugensis), Zebra mussel (Dreissena polymorpha) and Flowering rush (Butomus umbellatus). Visual surveys, artificial substrates, and water samplings are conducted in various locations along the lake. These monitoring efforts are implemented in hopes of detecting populations while they are small and may be more easily contained. Quagga and Zebra mussel in a water system can cause lowered water quality conditions and damage to irrigation and hydropower operations resulting in extensive maintenance costs. In 2019 Flowering rush was discovered in small pockets on Lake Roosevelt behind Grand Coulee Dam. The Washington Department of Ecology, Colville Tribe and Okanogan County Weed Board are currently planning treatment options to control the Flowering rush found in Lake Roosevelt. Since this finding, Chief Joseph Dam NRM personnel have unofficially monitored Lake Rufus Woods for possible flowering rush. Currently, due to budget and time constraints, visual surveys are only conducted as secondary actions while crews are upriver completing other work. Flowering rush causes displacement of native vegetation and reduction in overall biological diversity of the ecosystem.

Special Dam operations to lower water level during winter might be used for invasive species management. However, because of hydropower operations Lake Rufus Woods operates within a strict 6ft pool range. Planting sedges in the reservoir may help efforts to control invasive plant species. Canada geese nest and occupy shoreline areas along the reservoir, but they would not be affected by lowering the pool level if work was completed by mid-March.