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

Refer to NMFS No.:
WCR-2014-997

February 15, 2019

Laura Boerner
U.S. Army Corps of Engineers
Seattle District Environmental and Cultural Resources Branch
P.O. Box 3755
Seattle, Washington 98124-3755

Re: Biological Opinion on Howard Hanson Dam, Operations, and Maintenance, Green River (HUC 17110013) King County, Washington

Dear Ms. Boerner:

Thank you for your February 14, 2018, letter and biological assessment (BA) (Corps 2014) requesting to reinitiate consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Howard Hanson Dam (HAHD) Project in King County, Washington.

NMFS' final biological opinion pursuant to ESA section 7(a)(2) on the effects of the HAHD is enclosed with this letter. We shared a draft opinion with the Corps on October 27, 2015. In our final opinion we conclude that the proposed action is likely to jeopardize the continued existence of ESA-listed Puget Sound (PS) Chinook salmon, PS steelhead, and Southern Resident killer whales (SRKW), and that the proposed action is likely to result in the adverse modification of these three species' critical habitat designated under the ESA. Our opinion includes a Reasonable and Prudent Alternative to the proposed action that, if implemented by the Corps, will offset the effects of the proposed action such that the effects are not likely to jeopardize these species or adversely modify their designated critical habitat.

We also evaluated potential impacts of the action on essential fish habitat (EFH) in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600. We conclude that the proposed action would adversely affect EFH designated for Pacific Coast Salmon.

Please send comments to Ben Mann, NMFS' West Coast Region in Lacey, Washington, at ben.mann@noaa.gov. He is also available at 360-753-7761 if you have any questions or would like additional information regarding this ESA consultation and our EFH recommendations.

Sincerely,

Barry A. Thom
Regional Administrator

cc: Scott Pozarycki, Project Manager, Corps of Engineers
Frederick Goetz, Biologist, Corps of Engineers

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Conference Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation for the

Howard Hanson Dam, Operations, and Maintenance
Green River (HUC 17110013) King County, Washington

NMFS Consultation Number: WCR-2014-997

Action Agency: U.S. Army Corps of Engineers

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	Yes	Yes	Yes
Puget Sound steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	Yes	Yes	Yes
Southern Resident killer whale (*Orcinus orca*)	Endangered	Yes	Yes	Yes	Yes

Fishery Management Plan That Includes Stocks With EFH	Does Action Cause Adverse Effects to EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Groundfish	No	No
Coastal Pelagic Species	No	No
Pacific Coast Salmon	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

Barry A. Thom
Regional Administrator

Date: February 15, 2019

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ACRONYMS AND ABBREVIATIONS

ADP	Adaptive Management Plan
af	Acre-feet (43,560 cubic feet)
AWSP	Additional Water Supply Project
BA	Biological Assessment
BMI	Benthic Macroinvertebrates
BRT	Biological Review Team
BMP	Best Management Practice
Corps	US Army Corps of Engineers
DBH	Diameter at breast height
DIP	Demographically Independent Population
DOE	Department of Ecology
DPS	Distinct Population Segment
DQA	Data Quality Act
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
GRFMCC	Green River Flow Management Coordination Committee
HAHD	Howard A. Hanson Dam
HMP	Harvest Management Plan
HSRG	Hatchery Scientific Review Group
HUC	Hydrologic Unit Code
ITS	Incidental Take Statement
LWD	Large Woody Debris
MIT	Muckleshoot Indian Tribe
MMD	Mud Mountain Dam
MPG	Major Population Group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	Maximum Sustainable Yield
NOR	Natural Origin Recruits
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Unit
Opinion	Biological Opinion
PBF	Physical or Biological Features (characteristics of critical habitat)
PCE	Primary Constituent Element
PDFPS	Permanent Downstream Fish Passage System
PFMC	Pacific Fishery Management Council
PIT	Passive Integrated Transponder
PS	Puget Sound

PSE	Puget Sound Energy
PSTRT	Pacific Sound Technical Recovery Team
RM	River Mile
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measures
Southern Resident	Southern Resident Killer Whale
SSPS	Shared Strategy for Puget Sound
TPU	Tacoma Public Utilities
TRT	Technical Recovery Team
TMDL	Total Maximum Daily Load
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geologic Survey
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
VSP	Viable Salmonid Population
WRIA	Water Resource Inventory Area
WWTIT	Western Washington Treaty Indian Tribes

1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

The biological opinion (Opinion) and incidental take statement (ITS) portions of this document were prepared by National Marine Fisheries Service (NMFS) in accordance with the Endangered Species Act (ESA) of 1973, (16 U.S.C. 1531 et seq.), and implementing regulations at 50 CFR 402. Included in this Opinion is an analysis of the proposed action's likely effects on recently designated critical habitat for Puget Sound steelhead.

NMFS also completed an Essential Fish Habitat (EFH) consultation in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 1855(b)) and implementing regulations at 50 CFR 600.

This Opinion and EFH conservation recommendations are both in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act" (DQA)) and underwent pre-dissemination review.

This Opinion analyzes the U.S. Army Corps of Engineers' (Corps') proposed action to continue to operate and maintain its existing Howard A. Hanson Dam (HAHD). Understanding HAHD requires knowledge of other activities and facilities. Three and a half miles downstream from HAHD is Tacoma Water's (Tacoma's) Headworks Dam, built in 1913 (obstructing fish passage to the upper watershed) to divert water to supply the City of Tacoma, WA. The Corps subsequently developed HAHD in 1962 for the primary authorized purposes of flood control (now termed flood risk management) and the secondary purpose of fish conservation.

In April 1997, under Section 1135 of the 1986 Water Resources Development Act (WRDA), as amended, the U.S. Congress approved an ecosystem restoration project to augment summer low flows in the Green River to improve downstream fish habitat and fish survival by capturing more water during the spring at HAHD for release during the summer low flow period. The City of Tacoma was the local sponsor. The ecosystem restoration project included additional water storage of up to 5,000 acre-feet to augment low streamflows and a collection of habitat restoration projects around the reservoir. Rates of water capture and release were to be adaptively managed, depending on real-time ecosystem restoration needs.

In 1999, Congress authorized the HAHD Additional Water Storage Project (AWSP) which added water storage for Tacoma's municipal water supply and ecosystem restoration as project purposes. The AWSP was adopted by Congress under the 1999 Federal Water Resources Development Act (WRDA, 1999; PL 106-53), which authorized the Corps to store an additional 20,000 acre-feet (af) of water behind HAHD to be subsequently released for Tacoma's municipal and industrial (M&I) water use during the summer when natural flows are low and demand high. The 1999 WRDA also authorized several ecosystem restoration projects, including construction of facilities to improve downstream fish passage at HAHD. The AWSP was designed to operate as a Federal project in which Tacoma was the local sponsor and shared a portion of the project costs.

The AWSP is a major component of Tacoma's efforts to expand its water supply through its Second Supply Project. Tacoma has addressed the effects of its Green River operations, including the effects of its Second Supply Project (Tacoma's interest that is served by the AWSP) in its July 2001 ESA Section 10(a)(1)(B) Habitat Conservation Plan (HCP) (Tacoma 2001). [1] The HCP includes: a commitment to maintaining minimum instream flows downstream from Headworks Dam, installing and operating an adult fish trap and haul system at Headworks Dam, screening to protect juvenile fish at Tacoma's diversion, and numerous fish and wildlife habitat improvement measures upstream of HAHD where Tacoma owns about 11% of the upper Green River watershed. Most of the fish and wildlife habitat improvement projects are components of the AWSP and include a majority federal cost-share. The AWSP governs the operation, management, and long-term maintenance of these improvements. Tacoma has completed most fish protection elements of the HCP, including the upstream passage trap and haul system, but the facility has not yet been operated due to concerns that poor downstream passage survival through HAHD of the progeny produced would negate any potential benefits.

The background to this consultation is complex. The AWSP is a joint project between the Corps and Tacoma. However, as the Federal lead for the project, the Corps is responsible for conforming the project with the ESA. Federal entities are obligated to consult under section 7 of the ESA to ensure that their actions do not jeopardize the continued existence of ESA-listed species, or destroy or adversely modify their critical habitats. Non-federal entities may obtain an incidental take permit (ITP) to avoid potential take liability under the ESA for their activities, as has Tacoma. To be clear, the Second Supply Project is entirely a Tacoma project, while the AWSP is a Federal project for which Tacoma is the local sponsor.

In 2000, the Corps also consulted with NMFS on its proposed actions at HAHD, including the AWSP and a new downstream passage facility and temperature control structure at HAHD, and we concluded that the Corps' proposed action in its 2000 BA (Corps 2000) would avoid jeopardy and destruction and adverse modification of critical habitat (NMFS 2000). In the current consultation, the Corps changed the suite of actions it proposed in 2000 by eliminating its proposal to install and operate a new downstream fish passage and temperature control facility at HAHD.

Tacoma's ITP and conservation measures adopted under the HCP are part of the environmental baseline, and the Corps' actions, proposed in 2000 that have been completed are also part of the environmental baseline for this consultation.

This context is vital to understanding the overall effects of the continued operation and maintenance of HAHD. HAHD's originally authorized purposes of flood risk management and

[1] Tacoma's HCP covers all aspects of Tacoma's water supply project in the Green River basin. Reintroducing anadromous fish to the upper Green River watershed is a part of the HCP and the AWSP (Corps 1998), including an upstream fish passage system at Headworks dam, a system for collecting and safely passing outmigrating fish at HAHD, and screening to exclude juvenile fish from Tacoma's diversion. Tacoma has completed the adult fish trap and haul system and the juvenile exclusion screening at its Headworks facility.

fish conservation (via water storage and release) have been supplemented to provide water storage for Tacoma's municipal supply and use (AWSP). As mentioned above, the capture and subsequent release of an additional 5,000 af of water for ecosystem restoration was authorized in 1997. Developing new facilities to provide downstream fish passage at HAHD and several fish habitat improvement measures were also authorized under the AWSP. The proposed action for this consultation does not include construction and operation of a juvenile fish collection and passage system at HAHD.

1.2 Consultation History

This Opinion is the result of the Corps reinitiating consultation on its Howard Hanson Dam (HAHD) Project in King County, Washington; and the proposed action includes project operation and maintenance, as described in the Corps' biological assessment (BA) (Corps 2014). This Opinion supersedes the biological opinion issued for the continued operation and maintenance of Howard Hanson Dam NMFS issued October 20, 2000 (NMFS 2000).

The Corps' initial consultation with NMFS on operation and maintenance of HAHD (NMFS 2000) followed the Corps' Final Environmental Impact Statement (EIS) for the Additional Water Storage Project (AWSP) (Corps 1998). NMFS' ESA Section 7(a)(2) consultation on issuance of an Incidental Take Permit (ITP) to Tacoma to implement its HCP (NMFS 2001) occurred after the 2000 HAHD biological opinion (NMFS 2000). Tacoma's ITP application included measures aimed at mitigating the effects of its Second Supply Project.

In its initial consultation with NMFS on the operation and maintenance of its HAHD project in 2000, the Corps proposed to design, construct, and operate a juvenile downstream passage fishway and multi-level intake structure to control discharge water temperatures, along with a number of other fish habitat conservation measures. NMFS relied on the Corps' commitment to construct and operate this new fishway and temperature control tower by a reasonable, but unspecified, date, along with the other aspects of the action proposed in 2000, and concluded that the proposed action would not jeopardize the continued existence of the species, or destroy or adversely modify their critical habitats (NMFS 2000). As of 2012, the Corps had not completed design of the downstream passage facility and multi-level intake system, and abandoned its commitment to construct them. As explained by Colonel Estok (Corps retired) in a September 2012 meeting with NMFS, that decision led the Corps to request re-initiation of consultation.

NMFS met with the Corps on October 9, December 10, 2012, and February 13, 2013 to discuss re-initiation of the HAHD consultation. NMFS held government to government meetings with the Muckleshoot Indian Tribe on June 20, 2013, and December 13 and 20, 2013, to discuss this consultation. NMFS and the Corps have met several more times since.

The Corps formally requested to reinitiate consultation on February 14, 2014 (Corps 2014). NMFS received the supplemental BA at the same time.

The Corps' proposed action for this consultation (Corps 2014) does not include developing a new passage system for downstream migrating juvenile salmon and steelhead or a multi-level intake system to control discharge water temperatures, and several other actions proposed in its 2000 BA (Corps 2014, Appendix A).

This biological opinion is based on information provided in NMFS' 2000 biological opinion (NMFS 2000), the Corps' new BA (2014), field investigations, and other sources of information listed in the references cited section of the opinion. A complete record of this consultation is on file at NMFS' West Coast Regional Office in Portland, Oregon.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). Interrelated actions are those that are part of a larger action and depend on that action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). Under the proposed action, there are no proposed changes to any of the actions interrelated and interdependent to the proposed action. Additionally, the interrelated and interdependent actions to the proposed action have received prior ESA consultation (WSB-00-198) and are included in the Tacoma Water Habitat Conservation Plan (HCP) (WSB-00-522). Therefore, we consider interrelated and interdependent actions as part of the environmental baseline (Section 2.3) and not as part of the proposed action.

Interrelated/Interdependent actions include:

1. Withdrawal of the full 20,000 af of water at the Tacoma Headworks Dam for M&I use under the AWSP (WSB-00-198, WSB-00-522).
2. Upstream fish collection and transport facility at the Headworks Dam (WSB-00-198, WSB-00-522)
3. Downstream fish bypass facility at the Headworks Dam (WSB-00-198, WSB-00-522).
4. Integrated conservation measures (WSB-00-198, WSB-00-522).

Howard Hanson Dam is a rock and earthfill dam, authorized by the Rivers and Harbors Act (RHA) of 1950 and completed in 1962 for the purposes of flood risk management and providing fish conservation. Located at river-mile (RM) 64.5, the dam is 450 feet wide and 235 feet high from bedrock to crest. The project occupies 627 acres, with an additional 1,500 acres of easements for the reservoir, road access, and monitoring locations. Figure 1 shows the location of the dam. Figure 2 illustrates the vertical side profile of HAHD, noting key structural elements including the outlet tunnel, 48" bypass pipe, the spillway, and the dam crest. The elevations of various pool storage elevations are also shown.

Details of the proposed action are presented in the BA (Corps 2014) and we incorporate that description here by reference, and provide it below.

The Corps proposes to operate the project in perpetuity to provide: (1) flood-risk management of the Green River, (2) low-flow augmentation for fish conservation during the summer and fall, (3) ecosystem restoration, and (4) water supply for municipal and industrial (M&I) purposes. The Corps has operated the project to reduce flood risk and augment low-flows since the project was completed in 1962. Since 1998, the Corps has been implementing the Section 1135 ecosystem restoration project which added 5,000 acre-feet of water stored in HAHD to augment stream flows to protect steelhead redds from dewatering, improve juvenile salmonid summer rearing habitat conditions, and to improve spawning conditions for Chinook salmon. Ecosystem restoration projects of gravel and large wood nourishment downstream from the dam have been conducted by the Corps since 2003 and 2004 respectively.

Since 2007, the Corps has been storing water to 1,167 feet elevation during the spring annually to provide water fish conservation, flow augmentation, and M&I water for Tacoma. The Corps is currently capturing and storing 20,000 ac ft of water in the reservoir for later use during the spring, summer, and fall. The project is currently managed at the discretion of the Corps to ensure a net benefit to natural resources from storage of the AWSP water. The Corps considers that the water stored for M&I purposes to be relegated to a subordinate level of priority as compared to requirements imposed by natural resource concerns, in the event that conflict arises between these two considerations. Natural resource benefits are accrued under current operations by using at least 10,000 ac-ft (or 50%) of the stored M&I water for the benefit of natural resources in the form of flow augmentation to protect steelhead redds from dewatering, improve juvenile salmonid summer rearing habitat conditions, and to improve spawning conditions for Chinook salmon. Following implementation of Phase 1 of the AWSP, up to 20,000 af annually would be discharged from HAHD and it is anticipated that this entire volume would be diverted for M&I use at Tacoma’s Headworks Dam, although actual use of this Phase 1 water would be used at the discretion of Tacoma, consistent with the HCP.

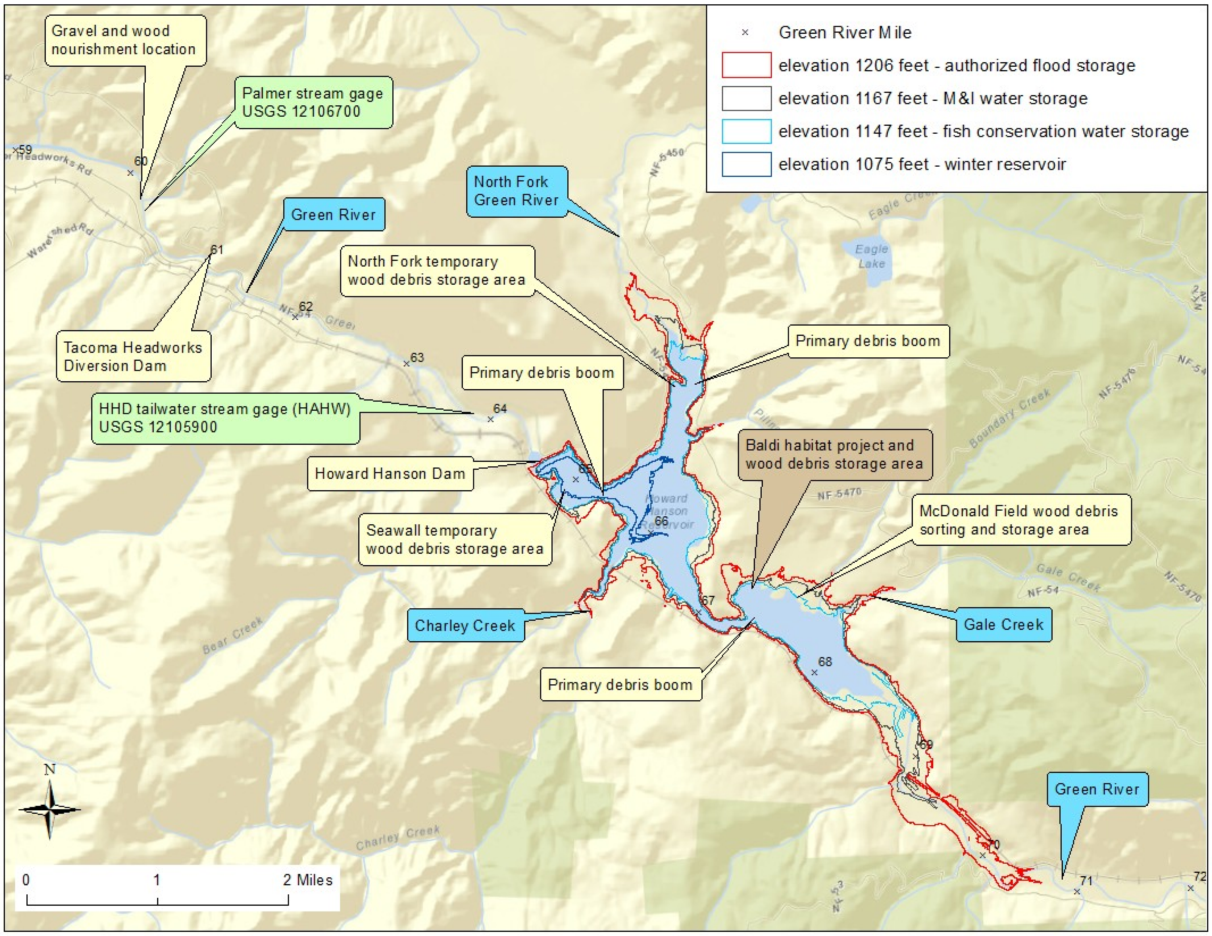

Figure 1. Howard Hanson Dam, reservoir, and vicinity. Source: Corps 2014.

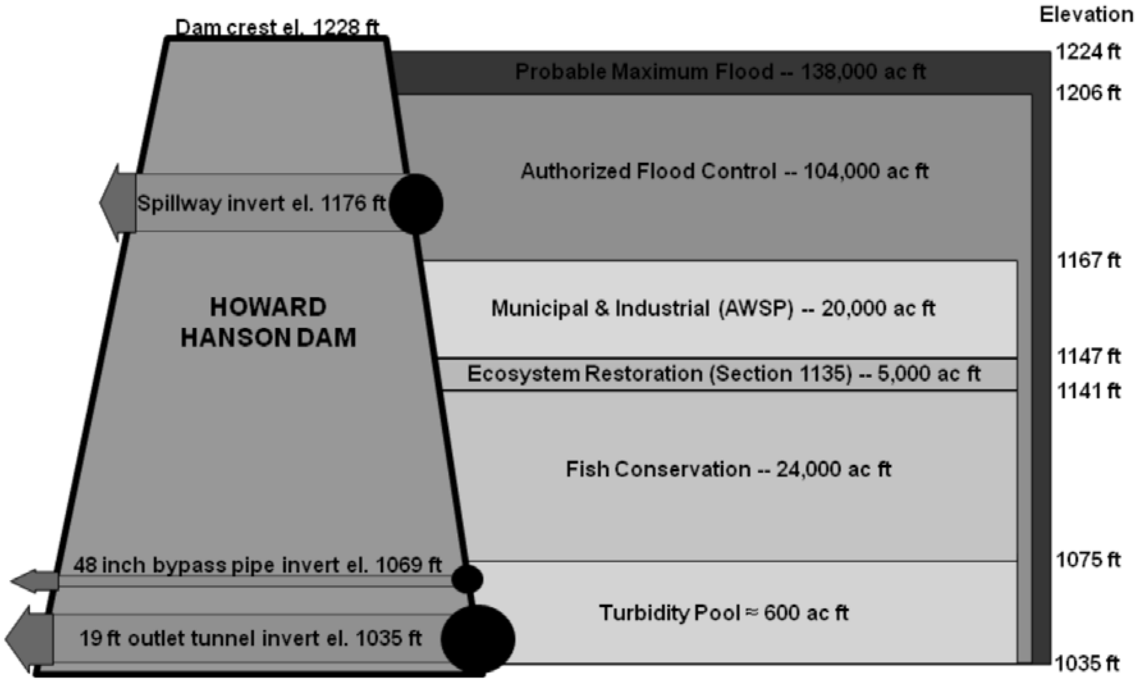

Figure 2. HAHD reservoir storage volumes and allocation. Source: Corps 2014.

1.3.1 Flow Management Operations

1.3.1.1 Winter Flood Risk Management

The project is authorized to provide maximum flood storage up to 106,000 acre-feet from November through February. However, the storage capacity has been reduced to about 104,000 acre-feet due to the accumulation of sediment in the reservoir since its construction in 1962 (Corps 2014). Figure 3 illustrates the minimum flood storage capacity that would be reserved in the reservoir throughout the year. The project regulates runoff from 46 percent of the total drainage area of the Green River. Flood events that require regulation are expected to have a 50 percent chance of occurrence each year (Corps 2011). Releases from the dam during a flood are made to avoid flow in excess of 12,000 cfs as measured at the U.S. Geological Survey (USGS) stream gage (USGS Station No. 12113000) at Auburn, WA (RM 32), which is the leveed channel capacity of the lower Green River. To provide a margin of safety against errors in forecasted local inflow (i.e., inflow downstream of HAHD), the project outflow would be regulated to a flow objective of 10,000 cfs at Auburn on the rising limb of a flood hydrograph. The target flow at Auburn could be increased to 12,000 cfs during a flood recession (once the peak of uncontrolled inflows downstream of HAHD have passed) to evacuate stored flood water as rapidly as practicable.

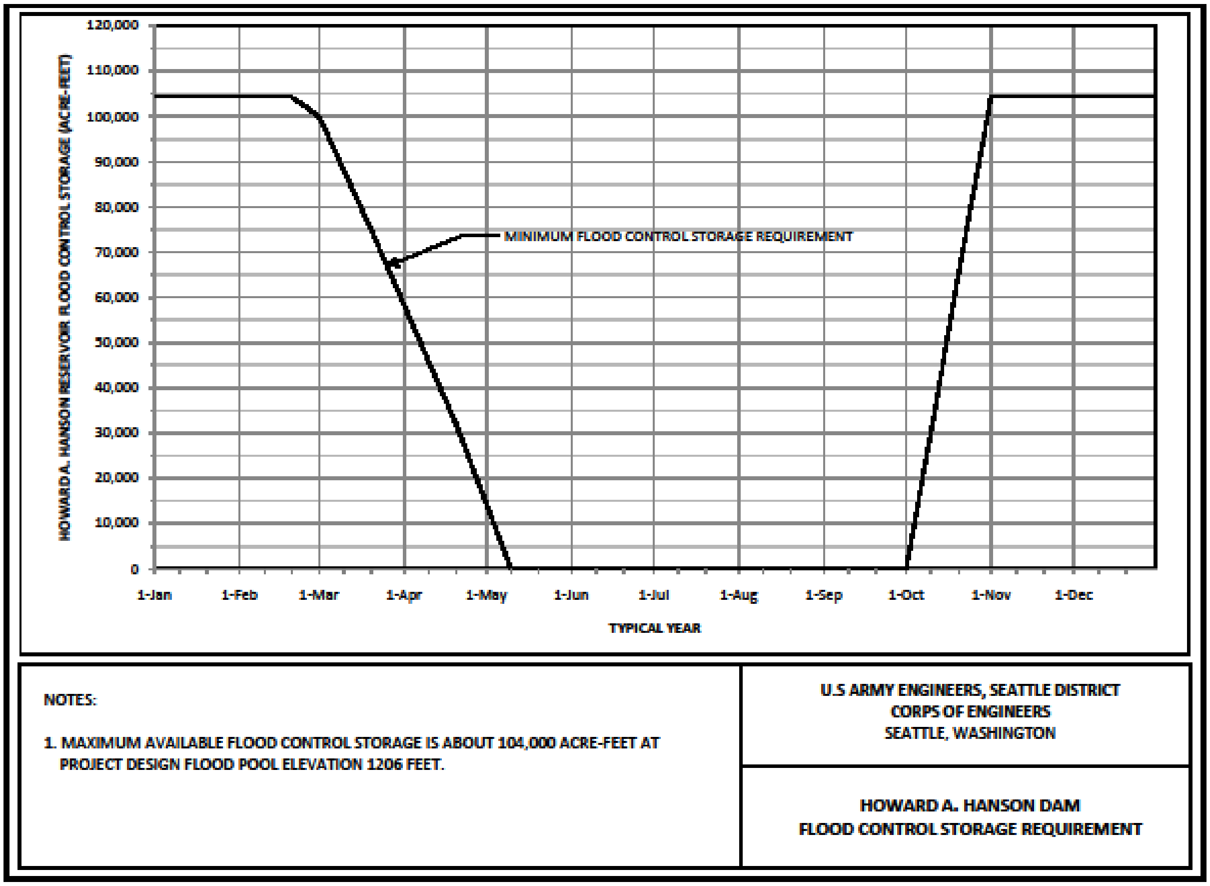

Figure 3. Minimum reservoir storage allocated for HAHD flood risk management. Source, Corps 2014

During a flood event, floodwaters would be stored in the reservoir and the maximum outlet tunnel discharge would generally be limited to 10,000 cfs**.** During extreme inflow events the spillway would be used to discharge water from the project in order to maintain adequate reservoir storage as needed to prevent overtopping of the dam. Under this scenario, it is likely that flows downstream from the dam would exceed 12,000 cfs at Auburn**.** The frequency of floods that would exceed this 12,000 cfs threshold is predicted to be 0.7 percent (about a one in 140-year annual chance flood) (Corps 2011)**.** To date, the spillway has not been used**.** On rare occasions, it is possible that no flow would be discharged from the dam in order to maintain flows below 12,000 cfs at the Auburn stream gage. This would occur if the local inflow below the dam was forecasted to exceed 12,000 cfs**.** This situation has occurred once (in 2009) since HAHD operations were initiated in 1962.

The Corps would generally discharge any remaining pool of summer augmentation water in early to mid-November to facilitate winter flood storage unless drought conditions require holding storage longer to meet instream flow and/or M&I water requirements**.** Outside of flood events, the project would be held with no pool storage all winter so that the maximum potential storage volume would be available to store water from severe storm events**.**

1.3.1.2 Winter Non-Flood Reservoir Operations

The pool would be held to a minimum level all winter (el 1,074 to 1,076) to accommodate flood events, or as may be needed to avoid discharging water with excessive turbidity**.** The low winter pool, referred to as the turbidity pool, is the lowest reservoir elevation that can be held without releasing fine sediments that have been deposited in the reservoir**.** To avoid excessive sediment accumulation that would reduce available flood storage capacity in the reservoir, the Corps would annually draft the reservoir to: (1) locate, to the extent possible, the precise elevation range of the turbidity pool, and (2) remove the veneer of fine sediment that has accumulated in the reservoir over the prior year particularly at the lower elevations (but above 1,074 ft.)**.** During this sediment clearing operation the Corps would gradually lower the reservoir until a noticeable increase in discharge turbidity was observed (the Corps would attempt to keep outflow turbidity below about 30 nephelometric turbidity units (NTUs) throughout this operation, although short-term exceedances may occur).

The Corps also proposes to operate the project to maintain a 1,075-foot pool elevation for one to two weeks during the winter to conduct maintenance and inspections at the dam**.** The Corps would attempt to schedule this maintenance and inspection to coincide with relatively low and constant project inflows to facilitate maintaining a constant pool elevation.

1.3.1.3 Spring Reservoir Refill

Spring refill would begin after the major flood risk season, beginning no earlier than February 20 (Figure 3). A portion of incoming water would be stored for the originally authorized fish conservation purpose, Section 1135 ecosystem restoration, and M&I water for Tacoma. The flow capture and storage rate would range from 0 to more than 50% of inflow. The target date for reaching full storage is June 1, although it can extend into July, depending on hydrologic conditions. The timeframe for the start and end of the water capture period could also be modified. Storage would be adaptively managed by the Corps in consideration of the viewpoints expressed by the members of the Green River Flow Management Coordination Committee (GRFMCC), a stakeholder group consisting of resource agencies, tribes, and other interested parties that meets biweekly via conference call. Spring water storage would provide about 24,200 af for fish conservation, 5,000 af for ecosystem restoration, and 20,000 af for use by Tacoma for its municipal water supply and to meet the instream flow schedule established by its agreement with the Muckleshoot Indian Tribe (MIT) and included in its HCP.[2] By storing a portion of inflowing water, project discharge would be less than inflow by an average of 266 cfs during this period (166 cfs for ecosystem restoration and 100 cfs for the AWSP). These are described in more detail in the environmental baseline because the Corps has been storing water for these purposes since 2007.

In the event the reservoir is not filled to 1,167 feet for a given year, stored water would be allocated based on the historical implementation dates for the various storage purposes with the earlier implemented project purposes receiving priority. The order of priority would therefore be

[2] Tacoma’s commitments to maintaining the minimum instream flows adopted through settlement with the MIT, or through its HCP are not the responsibility of the Corps.

flow augmentation for purposes of downstream fish conservation, flow augmentation in support of the Section 1135 ecosystem restoration project, and then M&I water supply.

1.3.1.4 Summer Conservation Flows

After reservoir refill is complete in the late spring, the Corps would generally pass inflow and maintain the full reservoir until water is needed from storage. Releasing stored water for flow augmentation to provide fish conservation would follow a reservoir guide curve that ensures sufficient water is reserved in the reservoir to achieve a minimum discharge of at least 110 cfs with a reliability of 98 percent as measured at the USGS stream gage at Palmer about 4 miles downstream of the dam. The 110 cfs flow target was developed in the 1950s as the minimum needed to meet the fish conservation purpose of the original project authorization. Minimum discharge from the dam would be based on the 110 cfs flow target plus 113 cfs or reservoir inflow (unless Tacoma requests less to augment storage for later use), whichever is least, for Tacoma's first diversion water right claim (Corps 2011).

The purpose of the flow augmentation is to provide 'for the preservation of fish life" as defined in the project authorization documents. Conservation water would be used to augment river flow to meet specific conservation objectives coordinated between the Corps and the GRFMCC via a biweekly conference call. Based on past operation of this program, flow augmentation water would typically be used to augment steelhead incubation in the early summer and adult Chinook salmon upstream migration and spawning in the late summer and early fall according to the decisions of the committee. The Corps, in agreement with Tacoma, releases sufficient water to meet Tacoma's potable water needs and its commitment to minimum flows at Auburn (Tacoma 2001). If the full volume of intended storage is not achieved during the spring, then available water would be allocated by priority purpose, from highest to lowest, where the highest priority is fish conservation from the original RHA 1950 project authorization (24,200 af), then Sec. 1135 flow augmentation (5,000 af), and then M&I water supply for Tacoma (up to 20,000 af).

Under the proposed action, the Corps would release the water stored under the AWSP (above el 1147) at rates and times requested by Tacoma.

<u>1.3.2 Section 1135 Ecosystem Restoration Project</u>

Under the Section 1135 ecosystem restoration project, 5,000 acre feet of water would be stored during the spring refill as described above in section 1.3.1.3. Water stored during the spring refill between elevation 1,141 and 1,147 feet would be allocated to the ecosystem restoration program. The 5,000 af of ecosystem restoration project water would be adaptively managed in accordance with the needs of a given year and in consideration of the opinions of the GRFMCC.

The GRFMCC has been dividing the Section 1135 water roughly equally between flow augmentation for steelhead incubation in June and July and Chinook salmon upstream migration and water temperature moderation in August and September. The committee has the discretion to allocate the water otherwise and could choose to do so in the future. It should be understood that 5,000 af is not a substantial amount of water for stream augmentation (1 af is about equal to one-half sfd [second foot day, i.e., 1 cfs for 24 hours]).

The ecosystem restoration project also includes four habitat restoration projects.

1.3.3 Municipal and Industrial Water Storage

The Corps relies on Tacoma to track their own storage/capture requirements as the Corps is not a party to the Tacoma surface water permit. In the event sufficient time (100 days) has not elapsed and not all 20 kaf of water can be allocated to Tacoma M&I because it would violate Tacoma permit conditions, then this stored water would be allocated to fish conservation and used to augment flows for instream resources in consideration of the opinions of the GRFMCC.

The Corps would discharge M&I water at rates and times as requested by Tacoma to serve its water needs (typically between June and November 1) consistent with Tacoma's HCP (Corps, 2014). All stored water would be released prior to the onset of the flood risk season, beginning around November 1 (see Section 1.3.1.1).

The purpose of the AWSP is to store water for Tacoma for M&I use. Water stored between reservoir elevation 1147' and 1167' is tied to the AWSP increment of total storage. Storage of this water is managed by agreement between the Corps and Tacoma. The reduction in spring flows downstream from HAHD caused by increasing spring storage was addressed by the Corps in its AWSP EIS (Corps 1998) by closely mimicking the natural hydrograph and engaging in adaptive management to spread out water capture over a longer timeframe and take advantage of storm events to least impact aquatic resources.

Currently, the Corps considers water stored under the AWSP for M&I purposes to be relegated to a subordinate level of priority as compared to requirements imposed by natural resource concerns (see Section 1.3.1.3 above), in the event that conflict arises between these two considerations. Natural resource benefits are accrued under current operations by using at least 10,000 af annually (or 50%) of the stored AWSP water for the benefit of natural resources in the form of flow augmentation to protect steelhead redds from dewatering, improve juvenile salmonid summer rearing habitat conditions, and to improve spawning conditions for Chinook salmon. [3] Currently, the release of this water is managed at the discretion of the Corps. It is NMFS understanding, per the Corps' supplemental BA (COE, 2014) , that following completion of this consultation and construction of the fish passage at HAHD, the Corps will release the entire volume of water stored under Phase 1 of the AWSP (up to 20,000 af annually) available to Tacoma. For purposes of this consultation, NMFS assumes that the entire volume of AWSP water would be discharged from HAHD and diverted for M&I use at Tacoma's Headworks Dam, although actual use of this Phase 1 water would be made at Tacoma's discretion, and Tacoma will adhere to flow regimes consistent with the HCP.

As part of Phase 1 of the AWSP and our original consultation (NMFS 2000), the Corps has constructed a suite of habitat mitigation and restoration projects within the Green River watershed. Since these habitat projects have already been constructed, they are not part of the proposed action presented in this opinion (see Section 2.3, Environmental Baseline). However, the Corps proposes to develop an O&M manual for these habitat projects to ensure that the projects are sufficiently maintained to serve their purpose for the duration of the AWSP (which

[3] See Corps 2014, pages 17-18.

is 50 years) and consistent with the Project Cooperation Agreement between the Corps and Tacoma, the project Feasibility Report (Corps 1998), and other official project documents. Because this manual does not now exist, it cannot be reviewed as part of this consultation. All habitat improvement measures that have been constructed are part of the environmental baseline and are expected to remain in good functioning condition throughout the life of the action. At AWSP project completion, maintenance of project features (offsite habitat improvements) would be turned over to Tacoma as described in the Project Cooperation Agreement and the O&M manual. The Corps would retain an oversight role to ensure the O&M manual is implemented. We thus rely on the Corps' commitment to maintain them in good functioning condition throughout the life of the action.

Another component of the AWSP includes management of the spring reservoir refill to maximize benefits to aquatic habitat and downstream fish. This management has generally been implemented with some modifications. A final component that is still on-going includes monitoring side channel and lateral habitat areas in the downstream river and potentially developing a set of guidelines to apply knowledge gained from the monitoring.

While the Corps' supplemental BA contemplates providing additional storage for Tacoma under Phase 2 of the AWSP around 30 years from now, Phase 2 is not part of the proposed action for this consultation (Corps 2014).

1.3.4 General Reservoir and Flow Management

Normal reservoir operations

HAHD would normally maintain a small reservoir year around (see the above mention of the turbidity pool). Discharge to the Green River would always be via gates, either the large radial gate that controls the 19' outlet tunnel or the smaller gate that controls the 48" bypass pipe. The 48" pipe would be used during the lower flow summer period because it allows finer control. Management of storage and discharge would be done manually by project staff during normal working hours, Monday through Friday, between 7:30 AM and 4:00 PM. The project would not be staffed outside these times except during flood conditions or when inflow and or reservoir conditions require a change to the gate setting.

Upramping

The Corps proposes to manage the project so that the tailwater gage height does not rise any faster than 1 ft/hr, except during flood events. The reason for the upramp limit is to avoid creation of hazardous conditions to downstream river users. Upramping at this rate is not known to cause adverse effects to fish.

Downramping
The Corps proposes to avoid reducing project discharge (termed downramping) at rates that could strand fish downstream of HAHD by following WDFW's downramping guidelines (Hunter 1992) to the extent practicable (Table 1). Rapid downramping rates dewater the river margins more rapidly than small fish, which use these shallow habitats, are able to follow the receding shoreline, causing stranding. The Washington downramping guidelines were developed to prevent stranding of fish on river banks of gravel and sand bars. However the downramping guidelines do not prevent fish from being stranded in potholes, which may later drain or warm up and cause fish mortality. The critical flow below which downramping guidelines would apply is 1,500 cfs. Above this flow level the river channel cross section is steep enough that gravel bar stranding does not usually occur.

Table 1. HAHD downramping guidelines. The guidelines apply to discharges less than 1,500 cfs as measured at USGS Station No. 12105900 immediately downstream from the dam. Source: Corps 2014.

Time Period	Daylight Hours	Night Time Hours
February 16 - May 31	0 in/hr	2 in/hr
June 1 – October 31	1 in/hr	1 in/hr
November 1 – February 15	2 in/hr	2 in/hr

Deviation from normal operation
Operations may deviate from normal for maintenance activities, inspections, and during monitoring or testing for fishery resources that might be performed by the Corps or other agencies. The Corps is occasionally requested to reduce river flow by law enforcement jurisdictions to aid in the search for river drowning victims. Deviations would be considered on a case-by-case basis, and any flow modifications would be coordinated with resource agencies.

1.3.5 Gravel Nourishment

HAHD greatly reduces downstream sediment movement. The Corps proposes to place up to 14,000 tons of spawning gravels, based on monitoring data and hydrologic conditions to ensure the project benefits salmonids. There are two designated deposition sites near RM 60, a short distance downstream of Tacoma's Headworks Dam. The amount would be adaptively managed according to hydraulic conditions. The quantity, size gradation, and timing have been adjusted since 2003 to maximize spawning benefits and minimize adverse effects. The gravel would be placed on the site(s), typically in August but could also be placed during the winter months, and naturally occurring high winter stream flows would erode and distribute it downstream. The process would be managed to reduce the likelihood of creating waves of unstable gravel migrating downstream which could affect fish migration.

1.3.6 Wood Debris Management

The accumulation of wood behind HAHD is episodic and can range from hundreds of trees in large flood years to almost nothing in mild winters. Large woody debris (LWD) is defined as being greater than 12" in diameter and at least 20' long, or any piece of wood containing a root ball greater than 4’ in diameter. Disposition of wood would be governed in part by an agreement between the Corps and Tacoma. In practice, the Corps would place as much large wood in the lower river as practical while avoiding creating a channel spanning logjam downstream of the nourishment site. Any remaining wood would be used for habitat purposes around the reservoir or for defined habitat restoration projects conducted by the Corps, Tacoma, or others. Tacoma’s HCP mirrors the Corps and Tacoma agreements regarding transport of 50% of large wood downstream, but also allocated the remaining reservoir wood among various habitat priorities and cultural uses by the Muckleshoot Indian Tribe (MIT). Because woody debris would be jointly managed by the Corps and Tacoma, wood could be used for all of the above described purposes depending on needs and wood availability.

LWD that is not immediately useful for habitat enhancement projects would be stored on site, or burned in accordance with the requirements of Puget Sound Clean Air Agency regulations if the accumulated debris posed a dam-safety threat (unlikely).

1.3.7 Reservoir Habitat Stewardship Activities

The Corps would conduct two habitat stewardship activities on the reservoir, the Baldi habitat boom to provide overhead cover in the reservoir and a loon nesting platform.

1.3.8 Other Activities

The Corps would continue to monitor project and environmental conditions at established monitoring sites in the basin and maintain project facilities. These include two meteorological stations, stream gages, water quality stations, and monitoring wells and piezometers for the purpose of monitoring water levels across the dam, and especially the right abutment. The Corps would perform regular facilities inspections and maintenance as needed, including mechanical equipment, debris and vegetation control, and maintenance of five miles of road at the project. It would also inspect and periodically repair the stilling basin, clean the trashrack, maintain tower gates, and rehab or replace stop logs. Specific action would be taken to stabilize the left bank slope downstream of HAHD by improving drainage and keeping the access road safe. The Corps proposes to employ best management practices (BMPs) as described in their BA for all maintenance activities.

1.4 Action Area

“Action area” means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The HAHD Project action area is the Green and Duwamish Rivers and their tributaries from the natural upstream limit of anadromous fish access (upstream of HAHD) downstream to Elliot Bay in Puget Sound, all project works, and all of Puget Sound (Figure 4). The proposed action would affect PS Chinook salmon and PS steelhead throughout the Green River watershed. The proposed action would affect Southern Residents in Puget Sound, the portion of their range that overlaps with substantial concentrations of PS Chinook, their preferred prey. The action area is also essential fish habitat (EFH) for Pacific salmon and groundfish.

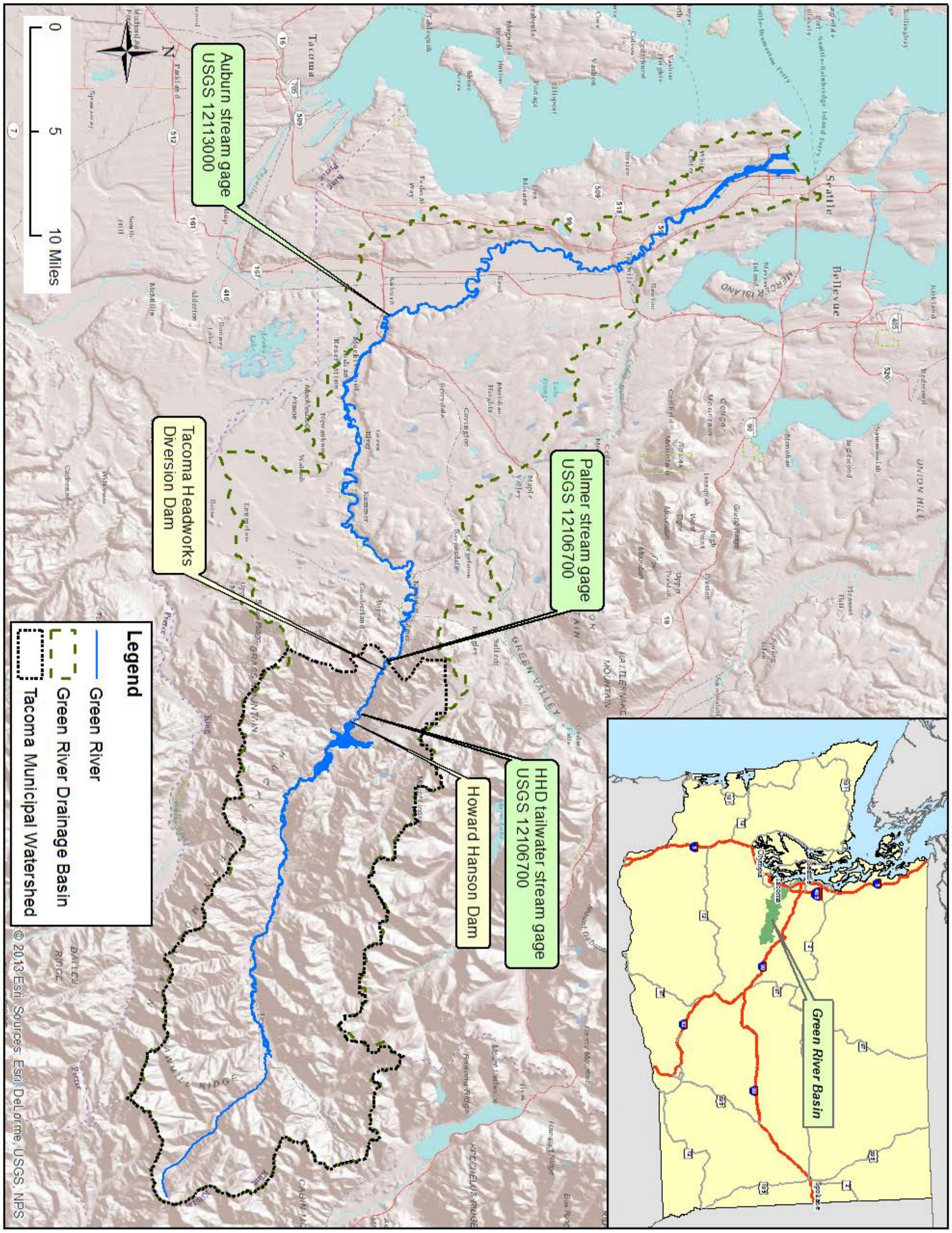

Figure 4. Green/Duwamish River basin and Puget Sound vicinity map.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, Federal agencies must ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This biological opinion relies on the definition of "destruction or adverse modification", which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214).

The designation(s) of critical habitat for PS Chinook salmon used the term 'primary constituent elements' (PCEs) or 'essential features'. The new critical habitat regulations (81 FR 7214) replace this term with 'physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a 'destruction or adverse modification' analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this biological opinion, we use the term physical or biological features (PBFs) in lieu of PCEs or essential features, as appropriate for the specific critical habitat.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.

- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach jeopardy and adverse modification conclusions.
- If necessary, define a reasonable and prudent alternative to the proposed action.

2.2 Range-Wide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that conservation value.

One factor affecting the status of ESA-listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2014, Mote 2016). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Tague et al. 2013, Mote et al. 2014).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4°F as an annual average, and up to 2°F in some seasons (based on average linear increase per decade; Abatzoglou et al. 2014; Kunkel et al. 2013). Recent temperatures in all but two years since 1998 ranked above the 20th century average (Mote et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014).

Decreases in summer precipitation of as much as 30% by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007; Mote et al. 2013; Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007; Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

The combined effects of increasing air temperatures and decreasing spring through fall flows are expected to cause increasing stream temperatures; in 2015 this resulted in 3.5-5.3°C increases in Columbia Basin streams and a peak temperature of 26°C in the Willamette (NWFSC 2015). Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al. 2009).

Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (ISAB 2007). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Mantua et al. 2010; Isaak et al. 2012). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic foodwebs (Crozier et al. 2011; Tillmann and Siemann 2011; Winder and Schindler 2004). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer et al. 1999; Winder and Schindler 2004, Raymondi et al. 2013). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Wainwright & Weitkamp 2013; Raymondi et al. 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts, and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (McMahon and Hartman 1989; Lawson et al. 2004).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7°C by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011, Reeder et al. 2013).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. A 38% to 109% increase in acidity is projected by the end of this century in all but the most stringent CO_2 mitigation scenarios, and is essentially irreversible over a time scale of centuries (IPCC 2014). Regional factors appear to be amplifying acidification in Northwest ocean waters, which is occurring earlier and more acutely than in other regions and is already impacting important local marine species (Barton et al. 2012, Feely et al. 2012). Acidification also affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012, Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011, Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011, Reeder et al. 2013).

The adaptive ability of these threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in many of these ESUs (NWFSC 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

2.2.1 Status of Species

The action area is within the geographic range of one evolutionarily significant unit (ESU)[4] and one distinct population segment (DPS)[4] of listed salmonid. Because the proposed action affects these fish which are a prey species of Southern Resident Killer Whales, we anticipate indirect effects of the proposed action on this endangered species, and thus they are also likely to be affected by the proposed action, and we include them in our review. (Table 2). The biological requirements, life histories, migration timing, historical abundance, and factors for the decline of these species have been well-documented (Busby et al. 1996; Myers et al. 1998; West Coast Biological Review Team (WCBRT) 2003). The following sections summarize the relevant biological information for PS Chinook salmon, PS steelhead, and Southern Residents,

For Pacific salmon, steelhead, and certain other species, we commonly use the four "viable salmonid population" (VSP) criteria (McElhany *et al.* 2000) to assess the viability of the

[4] An ESU, or evolutionarily significant unit, is a Pacific salmon population or group of populations that is substantially reproductively isolated from other nonspecific populations and that represents an important component of the evolutionary legacy of the species. NMFS' ESU policy (56 FR 58612) for Pacific salmon defines the criteria

populations that, together, constitute the species. These four criteria (spatial structure, diversity, abundance, and productivity) encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment.

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends on habitat quality and spatial configuration, and the dynamics and dispersal characteristics of individuals in the population.

"Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation in single genes to complex life history traits (McElhany *et al.* 2000).

"Abundance" generally refers to the number of naturally-produced adults (*i.e.*, the progeny of naturally-spawning parents) in the natural environment (*e.g.*, on spawning grounds).

"Productivity," as applied to viability factors, refers to the entire life cycle (*i.e.*, the number of naturally-spawning adults produced per parent). When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany *et al*. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species' populations has been determined, we assess the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany *et al.* 2000).

for identifying a Pacific salmon population as a distinct population segment (DPS), which can be listed under the ESA. A distinct population segment (DPS) is the smallest division of a taxonomic species permitted to be protected under the Endangered Species Act. Species, as defined in the Act for listing purposes, is a taxonomic species or subspecies of plant or animal, or in the case of vertebrate species, a distinct population segment (DPS).

Table 2. Status of Puget Sound Chinook salmon, Puget Sound steelhead, and Southern Residents and pertinent Federal Register notices.

Species/ESU/ DPS	Status/Review Date/ Federal Register Notice	Critical Habitat Designation Date/ Federal Register Notice	Protective Regulations Date/ Federal Register Notice
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened 8/15/11 70 FR 37160	9/02/05 70 FR 52630	6/28/05 70 FR 37160
Puget Sound steelhead (*Oncorhynchus mykiss*)	Threatened 8/15/11 76 FR 50448	2/24/16 81 FR 9252	Not applicable
Southern resident killer whale (*Orcinus orca*)	Endangered 4/14/2014 79 FR 20802	11/29/06 71 FR 69054	4/14/2011 76 FR 20870

2.2.1.1 Puget Sound Chinook Salmon

The Puget Sound Chinook salmon evolutionarily significant unit (ESU) was listed as threatened on June 28, 2005 (70 FR 37160). We adopted the recovery plan for this ESU in January 2007. The recovery plan consists of two documents: the Puget Sound salmon recovery plan (Shared Strategy for Puget Sound 2007) and a supplement by NMFS (2006). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus *et al.* 2002). The PSTRT's biological recovery criteria will be met when all of the following conditions are achieved:

- The viability status of all populations in the ESU is improved from current conditions, and when considered in the aggregate, persistence of the ESU is assured;
- Two to four Chinook salmon populations in each of the five biogeographical regions of the ESU (Table 6) achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region;
- At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable;
- Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario; Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery; and
- Populations that do not meet the viability criteria for all VSP parameters are sustained to provide ecological functions and preserve options for ESU recovery.

Spatial Structure and Diversity. The Puget Sound Chinook salmon ESU includes all naturally spawning populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in

Washington. The ESU also includes the progeny of numerous artificial propagation programs (NWFSC 2015). The PSTRT identified 22 extant populations, grouped into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity. The PSTRT distributed the 22 populations among five major biogeographical regions, or major population groups (MPG), that are based on similarities in hydrographic, biogeographic, and geologic characteristics (Table 3).

Between 1990 and 2014, the proportion of natural-origin spawners has trended downward across the ESU, with the Whidbey Basin the only MPG with consistently high fractions of natural-origin spawner abundance. All other MPG have either variable or declining spawning populations with high proportions of hatchery-origin spawners (NWFSC 2015).

Table 3 Extant PS Chinook salmon populations in each biogeographic region (PSTRT 2002, NWFSC 2015)

Biogeographic Region	Population (Watershed)
Strait of Georgia	North Fork Nooksack River
	South Fork Nooksack River
Strait of Juan de Fuca	Elwha River
	Dungeness River
Hood Canal	Skokomish River
	Mid Hood Canal River
Whidbey Basin	Skykomish River
	Snoqualmie River
	North Fork Stillaguamish River
	South Fork Stillaguamish River
	Upper Skagit River
	Lower Skagit River
	Upper Sauk River
	Lower Sauk River
	Suiattle River
	Upper Cascade River
Central/South Puget Sound Basin	Cedar River
	North Lake Washington/ Sammamish River
	Green/Duwamish River
	Puyallup River
	White River
	Nisqually River

Abundance and Productivity. Available data on total abundance since 1980 indicate that although abundance trends have fluctuated between positive and negative for individual populations, there are widespread negative trends in natural-origin Chinook salmon spawner abundance across the ESU (NWFSC 2015). Productivity remains low in most populations, and hatchery-origin spawners are present in high fractions in most populations outside of the Skagit watershed. Available data now shows that most populations have declined in abundance over the past 7 to 10 years. Further, escapement levels for all populations remain well below the TRT planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery (NWFSC 2015).

Limiting Factors. Limiting factors for this species include:

- Degraded floodplain and in-river channel structure
- Degraded estuarine conditions and loss of estuarine habitat
- Riparian area degradation and loss of in-river large woody debris
- Excessive fine-grained sediment in spawning gravel
- Degraded water quality and temperature
- Degraded nearshore conditions
- Impaired passage for migrating fish
- Altered flow regime

The Puget Sound Technical Recovery Team (PSTRT) identified Duwamish/Green River Chinook salmon as an independent population of the PS Chinook salmon ESU (Ruckelshaus et al. 2006). The Green River population of PS Chinook salmon exhibits the basic characteristics and biological requirements of PS Chinook salmon described in Meyers et al. (1998), and summarized below in this section.

Life History

Chinook salmon juvenile life history patterns are typically grouped into “ocean-type” and “stream-type” (Healey 1991). Ocean-type juveniles outmigrate to marine waters as sub-yearlings, while stream-type juveniles rear in freshwater for at least a year. The vast majority of Green River PS Chinook salmon smolts outmigrate as sub-yearlings, making the population primarily ocean-type (PSIT and WDFW 2009).

The PSTRT generally adopted the long-term abundance and productivity recovery targets developed by the WDFW and treaty-tribe co-managers (NMFS 2006a, Table 2). The targets are based upon two particular points on a Beverton-Holt stock recruitment curve developed for each population under average marine survival conditions. The high productivity target is the number of spawners needed at the point where the unit replacement line (1.0 recruit per spawner) crosses the curve. No specific planning targets were set for the Green River population.

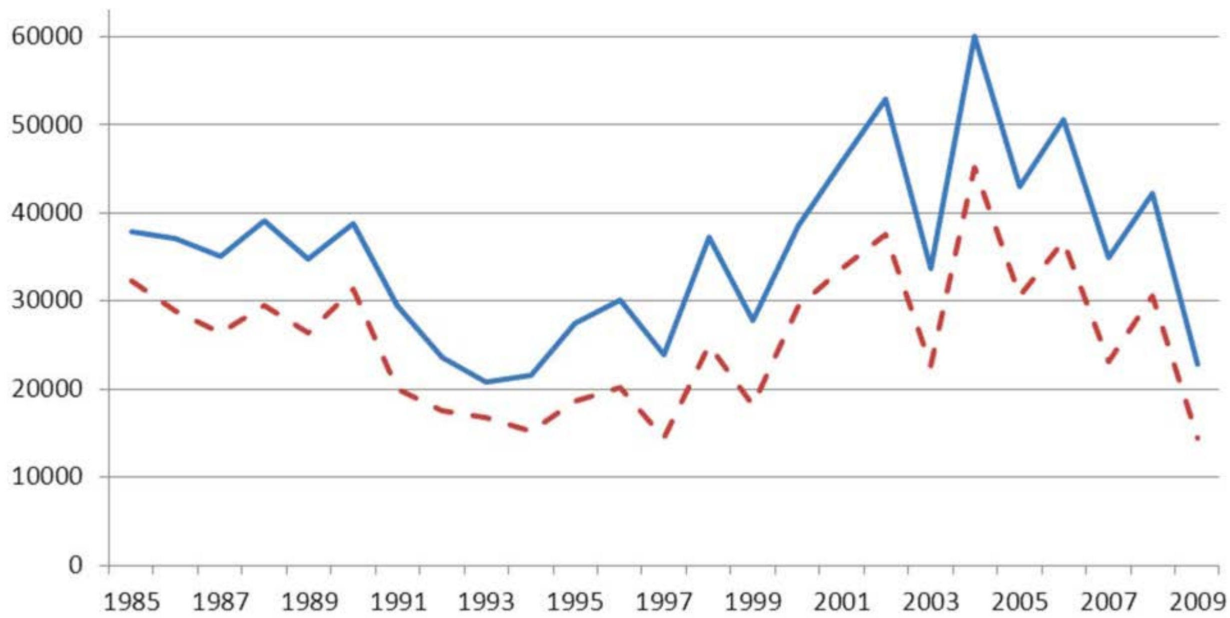

Figure 5. Annual escapement of Puget Sound Chinook salmon from 1984 through 2009. Natural-origin spawners shown in dashed line. Total spawners in solid line. Source: Ford 2011a.

Duwamish/Green River Population of PS Chinook salmon

The PS TRT identified the Duwamish/Green River Chinook salmon population as 1 of 22 independent populations in the ESU (Ruckelshaus et al. 2006). Currently, this population is well below the minimum viability abundance established by the TRT of 17,000 fish (Figure 6). The Green River Chinook salmon natural spawners consist of a high proportion (~60 percent) of hatchery origin fish, with local hatchery sources from the Soos Creek, Icy Creek, and Keta Creek hatchery programs (Ford 2011a). Because the genetic makeup of the hatchery fish is identical with natural origin spawners, there is little risk of adverse introgression effects from the mixture of hatchery and natural-origin spawners.

With multiple factors reducing the survival and spawner to spawner productivity (lack of estuary habitat, contaminant exposure, harvest, and ongoing pollution,) in the Green River/Duwamish drainage, the local population of Chinook salmon experiences a high level of human impacts to habitat and impairment to recovery. With Green River Chinook salmon productivity and abundance trending down, this population faces significant risk to its continued existence.

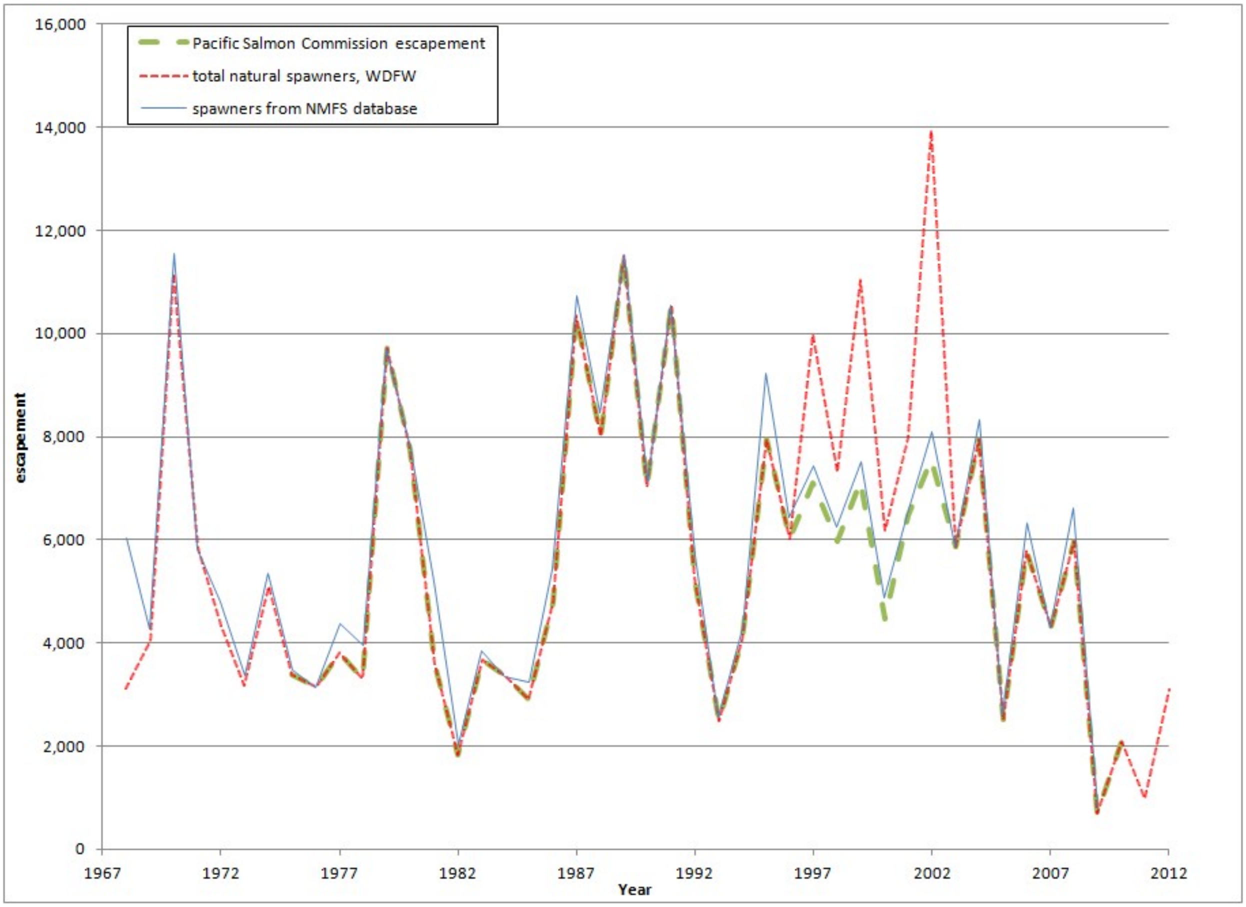

Figure 6. Green River Chinook salmon escapement estimates. Source: Corps 2014.

Recovery Plan

NMFS approved a Puget Sound Chinook salmon Recovery Plan in January 2007 (NMFS 2007b). The PSTRT places the Green River basin in one of five biogeographical regions within Puget Sound that have unique physical and habitat features that have affected the common evolution of groups of Chinook salmon.

The recovery plan adopts ESU and population level viability criteria recommended by the PSTRT (Ruckelshaus et al. 2002, PSTRT 2007). The PSTRT's Biological Recovery Criteria (NMFS 2006a) will be met when the following conditions are achieved:

- All watersheds improve from current conditions, resulting in improved status for the species.
- At least two to four Chinook salmon populations in each of the five biogeographical regions of Puget Sound attain a low risk status over the long-term.
- At least one or more populations from major diversity groups historically present in each of the five Puget Sound regions attain a low risk status.

- Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are function in a manner that is sufficient to support an ESU-wide recovery scenario.
- Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery.

The PSTRT determined that all 22 populations of Chinook salmon currently are at high risk of extinction. The ESU recovery criteria recommend by the PSTRT do not require that all 22 populations reach a low risk status over time, but all of them have to improve from current conditions. Accordingly, most watershed planners in areas with independent populations of Chinook salmon chose to work toward low risk status for their populations to get on a recovery trajectory during the next 10 years and as a precautionary approach to eventually recovery the entire ESU (NMFS 2006a). Table 4 shows the 22 extant populations in each biogeographical region and relates them to the PSTRT's ESU viability criteria.

Table 4. Extant Puget Sound Chinook salmon populations in each geographic region (NMFS 2006)

Geographic Region	Population (Watershed)
Strait of Georgia	**North Fork Nooksack River**
	South Fork Nooksack River
Strait of Juan de Fuca	**Elwha River**
	Dungeness River
Hood Canal	**Skokomish River**
	Mid Hood Canal River
Whidbey Basin	Skykomish River
	Snoqualmie River
	North Fork Stillaguamish River
	South Fork Stillaguamish River
	Upper Skagit River
	Lower Skagit River
	Upper Sauk River
	Lower Sauk River
	Suiattle River
	Upper Cascade River
Central/South Puget Sound Basin	Cedar River
	North Lake Washington/ Sammamish River
	Green/Duwamish River
	Puyallup River
	White River
	Nisqually River (or other late run)

NOTE: NMFS has determined that the bolded populations need to be at low risk for ESU viability. In addition, at least two other populations within the Whidbey Basin region would need to be viable for recovery of the ESU.

NMFS recently completed a review of the ongoing implementation of the recovery plan (Judge 2011) identifying progress through 2010 toward implementing the plan including actions within the action area for this consultation. Recovery actions that have been completed are part of the environmental baseline for this consultation. Our five-year review of progress in implementing the recovery plan, NMFS (Judge 2011) identified the following accomplishments:

- The Co-Managers (the WDFW and Puget Sound Treaty Tribes, collectively) met or exceeded the harvest management performance measures required in the 2004 Harvest Management Plan.
- The WDFW completed its 21st Century Salmon and Steelhead Initiative, which will help them identify, monitor and evaluate long-term, science-based hatchery management strategies.
- Numerous high priority habitat restoration projects have been accomplished across every watershed in Puget Sound.
- The Nisqually watershed completed a major portion of their largest project, the Nisqually Refuge Estuary restoration project, with the support and shared contribution of funds from other South Sound watershed groups.
- The Elwha River Dam removal project is finally funded and demolition was complete in 2014.
- The local commitment to salmon recovery across the ESU remains firm and work is continuing despite a severe recession, significant change in the organizational structure supporting Puget Sound salmon recovery, and a loss of staff and severe funding shortages. Actions within the Green River basin that have benefited Green River Chinook salmon include:
  - Habitat improvement projects in the lower Green River performed by the Corps and Tacoma, including engineered log jams (ELJs), side channel and slough habitat projects, gravel augmentation, and LWD transport.
  - Flow augmentation from HAHD storage.

The Technical Review Team (TRT) and NMFS Science Center describe the equilibrium abundance of a recovered and functional Green River Chinook salmon population at 22,000, with an escapement value of 4,900 (the number of adult salmon needed to reach spawning grounds each year)(Ford 2011a). Returns of natural origin recruits (NORs) (fish that are wild, not hatchery raised) have averaged about 1,288 in recent years. The difference between the total adult population at recovery (22,000) and the level of escapement necessary to support the population (4,900) is the number of returning adults expected to be lost prior to reaching spawning habitat. Achieving recovery of the PS Chinook salmon ESU requires the Green River population to become viable (NMFS 2007b).

Of great significance to both abundance and spatial structure, and thus population viability for the Green River population of Chinook salmon, is safe and effective passage to and from habitats upstream of HAHD (NMFS 2007b). Toward that objective, Tacoma installed an adult fish upstream passage facility and juvenile exclusion screening at Headworks Dam. At the time the recovery plan was adopted, the Corps was developing, and intending to complete and operate, a fish collection system for downstream migrating fish at HAHD, which has not been completed. The Corps is no longer proposing a downstream passage facility as part of the proposed action for this Opinion. Both upstream and downstream facilities were planned as part of a comprehensive effort to restore both upstream and downstream passage between the upper and lower Green River reaches.

Summary

In summary, the status of PS Chinook salmon and Duwamish/Green River Chinook salmon are that their overall numbers are declining and the species is not achieving the recovery plan's targets. In order for this ESU to reach the point where it can be delisted, the Duwamish/Green River population of PS Chinook salmon must achieve a low risk status by increasing abundance, productivity, and diversity. This population is currently at high risk, the abundance of the population is declining and important parts of critical habitat are degraded or inaccessible (NMFS 2006a, NMFS 2007b).

2.2.1.2 Puget Sound Steelhead

The PS Steelhead TRT produced viability criteria, including population viability analyses (PVAs), for 20 of 32 demographically independent populations (DIPs) and three major population groups (MPGs) in the DPS (Hard 2015). It also completed a report identifying historical populations of the DPS (Myers *et al.* 2015). The DIPs are based on genetic, environmental, and life history characteristics. Populations display winter, summer, or summer/winter run timing (Myers *et al.* 2015). The TRT concludes that the DPS is currently at "very low" viability, with most of the 32 DIPs and all three MPGs at "low" viability.

The designation of the DPS as "threatened" is based upon the extinction risk of the component populations. Hard 2015, identify several criteria for the viability of the DPS, including that a minimum of 40 percent of summer-run and 40 percent of winter-run populations historically present within each of the MPGs must be considered viable using the VSP-based criteria. For a DIP to be considered viable, it must have at least an 85 percent probability of meeting the viability criteria, as calculated by Hard (2015).

Recovery planning for this DPS is ongoing. In 2010, NMFS gave PS steelhead a recovery priority of 1 (NMFS 2010a), its highest priority. Population viability analyses have shown that all three of the major population groups (MPGs) are at very low viability (PSSTRT 2013), making the likelihood for extinction moderate to high. Recovery would require highly viable DIPs in all three MPGs. Detailed analysis of population viability has shown that while the viability of the Green River DIP is low (0.982), it is highest among all the DIPs in the Central and Southern Cascades MPG. Given this viability ranking and other factors, we consider it very likely that the final recovery plan for this DPS will identify the Green River DIP as essential to the recovery of the Central and Southern Cascades MPG and the species as a whole. For this reason, we treat recovery of the Green River DIP as essential to the recovery of the species in this Opinion.

<u>Spatial Structure and Diversity</u>**.** The PS steelhead DPS is the anadromous form of O. mykiss that occur in rivers, below natural barriers to migration, in northwestern Washington State that drain to Puget Sound, Hood Canal, and the Strait of Juan de Fuca between the U.S./Canada border and the Elwha River, inclusive. The DPS also includes six hatchery stocks that are considered no more than moderately diverged from their associated natural-origin counterparts: Green River

natural winter-run; Hamma Hamma winter-run; White River winter-run; Dewatto River winter-run; Duckabush River winter-run; and Elwha River native winter-run (USDC 2014). Steelhead are the anadromous form of *Oncorhynchus mykiss* that occur in rivers, below natural barriers to migration, in northwestern Washington State (Ford 2011). Non-anadromous ‘‘resident’’ *O. mykiss* occur within the range of PS steelhead but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (Hard *et al.* 2007).

DIPs can include summer steelhead only, winter steelhead only, or a combination of summer and winter run timing (*e.g.*, winter run, summer run or summer/winter run). Most DIPs have low viability criteria scores for diversity and spatial structure, largely because of extensive hatchery influence, low breeding population sizes, and freshwater habitat fragmentation or loss (Hard *et al.* 2007). In the Central and South Puget Sound and Hood Canal and Strait of Juan de Fuca MPGs, nearly all DIPs are not viable (Hard 2015). More information on PS steelhead spatial structure and diversity can be found in NMFS' technical report (Hard 2015).

<u>Abundance and Productivity</u>. Abundance of adult steelhead returning to nearly all Puget Sound rivers has fallen substantially since estimates began for many populations in the late 1970s and early 1980s. Smoothed trends in abundance indicate modest increases since 2009 for 13 of the 22 DIPs. Between the two most recent five-year periods (2005-2009 and 2010-2014), the geometric mean of estimated abundance increased by an average of 5.4%. For seven populations in the Northern Cascades MPG, the increase was 3%; for five populations in the Central & South Puget Sound MPG, the increase was 10%; and for six populations in the Hood Canal & Strait of Juan de Fuca MPG, the increase was 4.5%. However, several of these upward trends are not statistically different from neutral, and most populations remain small. Inspection of geometric means of total spawner abundance from 2010 to 2014 indicates that 9 of 20 populations evaluated had geometric mean abundances fewer than 250 adults and 12 of 20 had fewer than 500 adults. Between the most recent two five-year periods (2005-2009 and 2010-2014), several populations showed increases in abundance between 10 and 100%, but about half have remained in decline. Long-term (15-year) trends in natural spawners are predominantly negative (NWFSC 2015).

There are some signs of modest improvement in steelhead productivity since the 2011 review, at least for some populations, especially in the Hood Canal & Strait of Juan de Fuca MPG. However, these modest changes must be sustained for a longer period (at least two generations) to lend sufficient confidence to any conclusion that productivity is improving over larger scales across the DPS. Moreover, several populations are still showing dismal productivity, especially those in the Central & South Puget Sound MPG (NWFSC 2015).

Little or no data is available on summer-run populations to evaluate extinction risk or abundance trends. Because of their small population size and the complexity of monitoring fish in headwater holding areas, summer steelhead have not been broadly monitored.

<u>Limiting factors.</u> In our 2013 proposed rule designating critical habitat for this species (USDC 2013b), we noted that the following factors for decline for PS steelhead persist as limiting factors:

- The continued destruction and modification of steelhead habitat
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years
- Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania)
- Declining diversity in the DPS, including the uncertain but weak status of summer run fish
- A reduction in spatial structure
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris
- In the lower reaches of many rivers and their tributaries in Puget Sound where urban development has occurred, increased flood frequency and peak flows during storms and reduced groundwater-driven summer flows, with resultant gravel scour, bank erosion, and sediment deposition
- Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, increasing the likelihood of gravel scour and dislocation of rearing juveniles

Green River Population of PS Steelhead

Steelhead are stocked in the Green River annually.

Green River steelhead enter the river beginning in November (NMFS 2005c). Spawning occurs from March through June with peak spawning occurring during May. Fry emergence peaks in early August. About 82% of winter steelhead in the river undergo smoltification and outmigration at age 2 and about 18% outmigrate at age 3 (NMFS 2005c). Outmigration occurs primarily from late April through early June.

Most (about 57%) Green River winter steelhead spend one winter in the ocean before returning to the river the following winter to spawn (Scott and Gill 2008). A substantial proportion of the population (about 42%) returns after two winters in the ocean, with the remainder (about 1%) returning after three winters. In combination with the age at outmigration, the highest proportion (about 44%) of returning adult winter steelhead are age 4 (primarily 2.2 [2 years freshwater, 2 years saltwater]), followed by about 26% age 5 (primarily 2.3). Most Green River winter steelhead die after spawning. However, a small, but significant number of steelhead return to the ocean as kelts and may be repeat spawners. Scott and Gill (2008) reported that up to 14% of the winter steelhead run may be repeat spawners with an average of 6%.

General habitat use during freshwater rearing by steelhead is described in Scott and Gill (2008). Steelhead may use a variety of habitat types, but often use higher velocity water and migrate farther into headwaters than other salmon. As steelhead juveniles grow, they tend to move away from stream edges and towards faster moving water and may move downstream to larger streams if crowding occurs. During winter, many steelhead juveniles will move back into smaller tributaries to avoid high flows and utilize structures such as boulders, large woody debris (LWD) jams, root-wads, and undercut banks as cover.

There is very little information on steelhead egg to fry or fry to smolt survival rates in the Green River. Similar to Chinook salmon described above, it is generally understood that river flows and fine sediment are important factors that may adversely affect these life stages (Bjornn and Reiser 1991). However, the magnitude and frequency of adverse effects of peak flows and scour on steelhead are likely to be less than for Chinook salmon because of the location and timing of spawning and incubation. Considering both fall- and spring-run fish, spawning and incubation of Chinook salmon eggs occurs during mid-July through January (WDFW and WWTIT 1994) and during the latter part of this period floods from rain-on-snow events can be severe. In contrast, steelhead eggs incubation occurs during the spring and early summer when flows are moderately elevated, primarily from annual winter snow pack melt. Consequently, incubating Chinook salmon eggs and alevins are more likely to be severely affected from peak flows than steelhead. On the other hand, steelhead juveniles typically have a longer freshwater residence period than Chinook salmon juveniles, especially those Chinook salmon that outmigrate as sub-yearlings, and thus may have a higher risk of being affected by natural and human-caused disturbances in the freshwater system.

Relative to other populations in the DPS, the Green River supports a small to moderate run of winter steelhead in the Puget Sound DPS (Figure 7). Most Puget Sound steelhead populations, including the Green River, have had severe declines in recent years (Ford 2011a). Recent escapement levels [5] are substantially lower than occurred in the 1980s and continue to show a downward trend. Ford (2011a) estimated an exponential population trend of 0.938 between 1985 and 2009 and 0.933 for the years 1995 through 2009 for Green River steelhead, indicative of declining population abundance. The geometric mean population from 2005 through 2009 was 265 (Ford 2011) and the mean annual population growth rate between 1985 and 2009 was -0.064, indicative of a 90% probability of decline to 10% of the current population within 50 years. However, risk projections beyond the next 20 years are highly uncertain (Ford 2011a).

[5] "Escapement" is the portion of an anadromous fish population that escapes commercial and recreational fisheries to reach the freshwater spawning grounds.

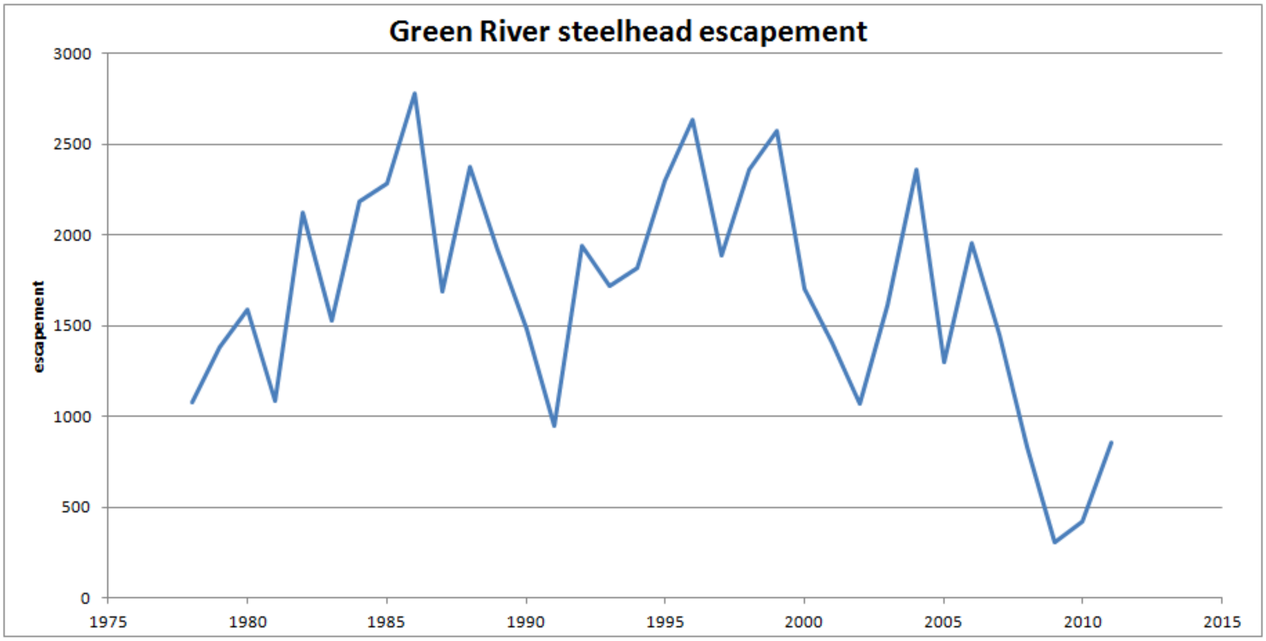

Figure 7. Green River steelhead escapement 1978-2010 (WDFW 2013). Source: Corps 2014.

Summary

The Puget Sound steelhead TRT finalized recovery criteria for this DPS (Hard et al 2014). Due to declines in population abundance and productivity, the DPS continues to exhibit a widespread declining trend, including the Green River population. In summary, the Green River population is essential to recovery of the DPS. The status of PS steelhead DPS is that the number of recruits per spawner is often less than one, meaning that productivity is low and that population abundance is declining, so that it remains at a moderate to high risk of extinction, and access to important upstream critical habitat remains blocked by HAHD. Currently inaccessible critical habitat upstream of HAHD has high conservation value. The PS steelhead DPS and the Green River population remain at a moderate to high risk of extinction.

2.2.2 Status of Designated Critical Habitat

This section examines the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the designated areas. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (*e.g.*, sites with conditions that support spawning, rearing, migration and foraging).

Salmon and Steelhead. For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC_5) in terms of the conservation value they provide to each listed species they support.[6] The conservation

[6] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NOAA Fisheries 2005).

rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS's critical habitat analytical review teams (CHARTs) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area (NOAA Fisheries 2005). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (*e.g*., one of a very few spawning areas), a unique contribution of the population it served (*e.g*., a population at the extreme end of geographic distribution), or if it serves another important role (*e.g*., obligate area for migration to upstream spawning areas).

The physical or biological features of freshwater spawning and incubation sites, include water flow, quality and temperature conditions and suitable substrate for spawning and incubation, as well as migratory access for adults and juveniles (Tables 5 and 6). These features are essential to conservation because without them the species cannot successfully spawn and produce offspring. The physical or biological features of freshwater migration corridors associated with spawning and incubation sites include water flow, quality and temperature conditions supporting larval and adult mobility, abundant prey items supporting larval feeding after yolk sac depletion, and free passage (no obstructions) for adults and juveniles. These features are essential to conservation because they allow adult fish to swim upstream to reach spawning areas and they allow larval fish to proceed downstream and reach the ocean.

Table 5. Primary constituent elements (PCEs) of critical habitats designated for ESA-listed salmon and steelhead species considered in the opinion (except SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, and SONCC coho salmon), and corresponding species life history events.

Primary Constituent Elements		**Species Life History Event**
Site Type	**Site Attribute**	
Freshwater spawning	Substrate Water quality Water quantity	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Floodplain connectivity Forage Natural cover Water quality Water quantity	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	Free of artificial obstruction Natural cover Water quality Water quantity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine areas	Forage Free of artificial obstruction Natural cover Salinity Water quality Water quantity	Adult sexual maturation and "reverse smoltification" Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Nearshore marine areas	Forage Free of artificial obstruction Natural cover Water quantity Water quality	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing

Table 6. Essential features of critical habitats designated for SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, SONCC coho salmon, and corresponding species life history events.

<table>
<tr><th colspan="2">Essential Features</th><th rowspan="2">Species Life History Event</th></tr>
<tr><th>Site</th><th>Site Attribute</th></tr>
<tr><td>Spawning and juvenile rearing areas</td><td>Access (sockeye)
Cover/shelter
Food (juvenile rearing)
Riparian vegetation
Space (Chinook, coho)
Spawning gravel
Water quality
Water temp (sockeye)
Water quantity</td><td>Adult spawning
Embryo incubation
Alevin growth and development
Fry emergence from gravel
Fry/parr/smolt growth and development</td></tr>
<tr><td>Adult and juvenile migration corridors</td><td>Cover/shelter
Food (juvenile)
Riparian vegetation
Safe passage
Space
Substrate
Water quality
Water quantity
Water temperature
Water velocity</td><td>Adult sexual maturation
Adult upstream migration and holding
Kelt (steelhead) seaward migration
Fry/parr/smolt growth, development, and seaward migration</td></tr>
<tr><td>Areas for growth and development to adulthood</td><td>Ocean areas – not identified</td><td>Nearshore juvenile rearing
Subadult rearing
Adult growth and sexual maturation
Adult spawning migration</td></tr>
</table>

CHART Salmon and Steelhead Critical Habitat Assessments

The CHART for each recovery domain assessed biological information pertaining to areas occupied by listed salmon and steelhead, determine whether those areas contained PCEs essential for the conservation of those species and whether unoccupied areas existed within the historical range of the listed salmon and steelhead that are also essential for conservation. The CHARTs assigned a 0 to 3 point score for the PCEs in each HUC_5 watershed for:

Factor 1. Quantity,
Factor 2. Quality – Current Condition,
Factor 3. Quality – Potential Condition,
Factor 4. Support of Rarity Importance,
Factor 5. Support of Abundant Populations, and
Factor 6. Support of Spawning/Rearing.

Thus, the quality of habitat in a given watershed was characterized by the scores for Factor 2 (quality – current condition), which considers the existing condition of the quality of PCEs in the

HUC_5 watershed; and Factor 3 (quality – potential condition), which considers the likelihood of achieving PCE potential in the HUC_5 watershed, either naturally or through active conservation/restoration, given known limiting factors, likely biophysical responses, and feasibility.

2.2.2.1 Rangewide Status of Critical Habitat for Puget Sound Chinook salmon and PS steelhead

Critical habitat has been designated in Puget Sound for PS Chinook salmon, and PS steelhead, among other species. Major tributary river basins in the Puget Sound basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar, Sammamish, Green, Duwamish, Puyallup, White, Carbon, Nisqually, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, and Dungeness rivers and Soos Creek.

Diking, agriculture, revetments, railroads and roads in lower stream reaches have caused significant loss of secondary channels in major valley floodplains in this region. Confined main channels create high-energy peak flows that remove smaller substrate particles and large wood. The loss of side-channels, oxbow lakes, and backwater habitats has resulted in a significant loss of juvenile salmonid rearing and refuge habitat. When the water level of Lake Washington was lowered 9 feet in the 1910s, thousands of acres of wetlands along the shoreline of Lake Washington, Lake Sammamish and the Sammamish River corridor were drained and converted to agricultural and urban uses. Wetlands play an important role in hydrologic processes, as they store water which ameliorates high and low flows. The interchange of surface and groundwater in complex stream and wetland systems helps to moderate stream temperatures. Forest wetlands are estimated to have diminished by one-third in Washington State (FEMAT 1993; Spence *et al.* 1996; Shared Strategy for Puget Sound 2007).

Loss of riparian habitat, elevated water temperatures, elevated levels of nutrients, increased nitrogen and phosphorus, and higher levels of turbidity, presumably from urban and highway runoff, wastewater treatment, failing septic systems, and agriculture or livestock impacts, have been documented in many Puget Sound tributaries (Shared Strategy for Puget Sound 2007).

Peak stream flows have increased over time due to paving (roads and parking areas), reduced percolation through surface soils on residential and agricultural lands, simplified and extended drainage networks, loss of wetlands, and rain-on-snow events in higher elevation clear cuts (Shared Strategy for Puget Sound 2007).

Dams constructed for hydropower generation, irrigation, or flood control have substantially affected PS Chinook salmon populations in a number of river systems. The construction and operation of dams have blocked access to spawning and rearing habitat (*e.g*., Elwha River dams block anadromous fish access to 70 miles of potential habitat) changed flow patterns, resulted in elevated temperatures and stranding of juvenile migrants, and degraded downstream spawning and rearing habitat by reducing recruitment of spawning gravel and large wood to downstream areas (Shared Strategy for Puget Sound 2007). These actions tend to promote downstream channel incision and simplification (Kondolf 1997), limiting fish habitat. Water withdrawals reduce available fish habitat and alter sediment transport. Hydropower projects often change flow rates, stranding and killing fish, and reducing aquatic invertebrate (food source) productivity (Hunter 1992).

Juvenile mortality occurs in unscreened or inadequately screened diversions. Water diversion ditches resemble side channels in which juvenile salmonids normally find refuge. When diversion headgates are shut, access back to the main channel is cut off and the channel goes dry. Mortality can also occur with inadequately screened diversions from impingement on the screen, or mutilation in pumps where gaps or oversized screen openings allow juveniles to get into the system (WDFW 2009). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in many Puget Sound tributary basins (Shared Strategy for Puget Sound 2007).

The nearshore marine habitat has been extensively altered and armored by industrial and residential development near the mouths of many of Puget Sound's tributaries. A railroad runs along large portions of the eastern shoreline of Puget Sound, eliminating natural cover along the shore and natural recruitment of beach sand (Shared Strategy for Puget Sound 2007).

Degradation of the near-shore environment has occurred in the southeastern areas of Hood Canal in recent years, resulting in late summer marine oxygen depletion and significant fish kills. Circulation of marine waters is naturally limited, and partially driven by freshwater runoff, which is often low in the late summer. However, human development has increased nutrient loads from failing septic systems along the shoreline, and from use of nitrate and phosphate fertilizers on lawns and farms. Shoreline residential development is widespread and dense in many places. The combination of highways and dense residential development has degraded certain physical and chemical characteristics of the near-shore environment (Hood Canal Coordinating Council 2005; Shared Strategy for Puget Sound 2007).

In summary, critical habitat throughout the Puget Sound basin has been degraded by numerous management activities, including hydropower development, loss of mature riparian forests, increased sediment inputs, removal of large wood, intense urbanization, agriculture, alteration of floodplain and stream morphology (*i.e*., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, road and railroad construction and maintenance, logging, and mining. Changes in habitat quantity, availability, and diversity, and flow, temperature, sediment load and channel instability are common limiting factors in areas of critical habitat.

The PS recovery domain CHART (NOAA Fisheries 2005) determined that only a few watersheds with PCEs for Chinook salmon in the Whidbey Basin (Skagit River/Gorge Lake, Cascade River, Upper Sauk River, and the Tye and Beckler rivers) are in good-to-excellent condition with no potential for improvement. Most HUC_5 watersheds are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some or a high potential for improvement (Table 7).

Table 7. **Puget Sound Recovery Domain:** Current and potential quality of HUC_5 watersheds identified as supporting historically independent populations of ESA-listed Chinook salmon (CK) and chum salmon (CM) (NOAA Fisheries 2005). Watersheds are ranked primarily by "current quality" and secondly by their "potential for restoration."

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name(s) and HUC_5 Code(s)	Listed Species	Current Quality	Restoration Potential
Strait of Georgia and Whidbey Basin #1711000xxx			
Skagit River/Gorge Lake (504), Cascade (506) & Upper Sauk (601) rivers, Tye & Beckler rivers (901)	CK	3	3
Skykomish River Forks (902)	CK	3	1
Skagit River/Diobsud (505), Illabot (507), & Middle Skagit/Finney Creek (701) creeks; & Sultan River (904)	CK	2	3
Skykomish River/Wallace River (903) & Skykomish River/Woods Creek (905)	CK	2	2
Upper (602) & Lower (603) Suiattle rivers, Lower Sauk (604), & South Fork Stillaguamish (802) rivers	CK	2	1
Samish River (202), Upper North (401), Middle (402), South (403), Lower North (404), Nooksack River; Nooksack River (405), Lower Skagit/Nookachamps Creek (702) & North Fork (801) & Lower (803) Stillaguamish River	CK	1	2
Bellingham (201) & Birch (204) bays & Baker River (508)	CK	1	1
Whidbey Basin and Central/South Basin #1711001xxx			
Lower Snoqualmie River (004), Snohomish (102), Upper White (401) & Carbon (403) rivers	CK	2	2
Middle Fork Snoqualmie (003) & Cedar rivers (201), Lake Sammamish (202), Middle Green River (302) & Lowland Nisqually (503)	CK	2	1
Pilchuck (101), Upper Green (301), Lower White (402), & Upper Puyallup River (404) rivers, & Mashel/Ohop(502)	CK	1	2
Lake Washington (203), Sammamish (204) & Lower Green (303) rivers	CK	1	1
Puyallup River (405)	CK	0	2
Hood Canal #1711001xxx			
Dosewallips River (805)	CK/CM	2	1/2
Kitsap – Kennedy/Goldsborough (900)	CK	2	1
Hamma Hamma River (803)	CK/CM	1/2	1/2
Lower West Hood Canal Frontal (802)	CK/CM	0/2	0/1
Skokomish River (701)	CK/CM	1/0	2/1
Duckabush River (804)	CK/CM	1	2
Upper West Hood Canal Frontal (807)	CM	1	2
Big Quilcene River (806)	CK/CM	1	1/2
Deschutes Prairie-1 (601) & Prairie-2 (602)	CK	1	1
West Kitsap (808)	CK/CM	1	1
Kitsap – Prairie-3 (902)	CK	1	1
Port Ludlow/Chimacum Creek (908)	CM	1	1

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name(s) and HUC5 Code(s)	Listed Species	Current Quality	Restoration Potential
Kitsap – Puget (901)	CK	0	1
Kitsap – Puget Sound/East Passage (904)	CK	0	0
Strait of Juan de Fuca Olympic #1711002xxx			
Dungeness River (003)	CK/CM	2/1	1/2
Discovery Bay (001) & Sequim Bay (002)	CM	1	2
Elwha River (007)	CK	1	2
Port Angeles Harbor (004)	CK	1	1

NMFS designated critical habitat for PS Chinook salmon on September 2, 2005, effective January 2, 2006 (NMFS 2006b). Designated critical habitat for PS Chinook salmon includes PS nearshore marine habitat and all of the mainstem Duwamish and Green Rivers from its confluence with the Elliot Bay on Puget Sound to the natural upstream limit of migration, as well as the accessible reaches of most tributaries to the Green. About 40% of suitable Chinook salmon habitat in the Green River watershed is located upstream of HAHD.

As part of the process to designate critical habitat within the PS Chinook salmon ESU, NMFS assessed the conservation value of habitat within freshwater, estuarine and nearshore areas at the fifth field hydrologic unit code (HUC) scale. That scale corresponds generally to the watershed scale. The ratings were generally devised as “low”, “medium”, or “high” conservation value. The PS Chinook salmon ESU has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 41 are rated high conservation value, 12 with low conservation value, and 8 received a medium rating. Of the marine areas, all 19 are ranked with high conservation value. Rankings were based on a variety of factors and do not necessarily indicate that PBFs are in optimal or good condition (NOAA Fisheries 2005).

The inland action area (Green River watershed) for this consultation serves as spawning and rearing habitat and as a migration corridor for both juvenile and adult PS Chinook salmon. In our 2005 critical habitat designation process, we rated the upper Green River watershed as having medium conservation value and middle and lower Green River watersheds as having ‘high’ conservation value for PS Chinook salmon (NOAA Fisheries 2005). [7] In this opinion the middle Green River is the reach between Tacoma’s Headworks Dam and Auburn, and the lower Green is from Auburn downstream, and includes the reach known as the Duwamish River, which is from the confluence of the Black and Green Rivers to the river’s mouth in Puget Sound.

[7] The upper Green River was scored as of only medium conservation value was because the Critical Habitat Analytical Review Team gave values of zero to spawning/rearing and rearing/migration due to the lack of safe and effective juvenile passage past HAHD.

Critical habitat throughout the Puget Sound recovery domain has been, and continues to be, degraded by numerous management and development activities (Judge 2011). Activities that affect PBFs in Puget Sound include hydropower development (reduced or lost fish passage, disrupting water quantity), loss of mature riparian forests (degrading natural cover), increased sediment inputs (impairing water quality), removal of woody material (eliminating rearing areas), intense urbanization (altering water quality and quantity), agriculture (eliminating riparian vegetation and impairing water quality), alteration of floodplain and stream morphology (e. g. channel modification, dikes and levees, resulting in reduced rearing habitat), wetland draining and conversion, dredging, armoring of shorelines (reducing forage and rearing), marina and port development (impairing migration and forage), road and railroad construction and maintenance, and mining.

The continuing development of the Puget Sound shoreline contributes to a cumulative degradation or loss of near shore and estuarine habitat, reducing the availability of highly productive rearing habitat for Chinook salmon. The sub-estuaries of Puget Sound—the major river deltas—have suffered a collective 80 percent loss of tidal marsh habitats in the past 150 years (Dean et al. 2001). At least 26 percent of Puget Sound shorelines (813 miles) have been modified with bulkheads or other armoring. The degradation of multiple PBFs throughout critical habitat of PS Chinook salmon indicates that the conservation potential of the critical habitat is not being reached, even in areas where the conservation value of habitat is ranked high.

The Muckleshoot Tribe has scaled back its fishing for Green River Chinook salmon and steelhead due to declining abundance caused by habitat degradation and subsequent listing of the species as threatened under the ESA. Salmon fishing in Puget Sound has been restricted to allow Green River Chinook salmon to reach the Green River.

Designated critical habitat for PS steelhead (81 FR 9252, NMFS 2016) is almost identical to that for PS Chinook salmon (78 FR 2726, NMFS 2013), including habitat areas suitable for spawning, rearing, and unobstructed migration corridors to and from spawning and rearing habitats. Critical habitat has been designated in all historically accessible streams in the Green River watershed, including the upper Green River and several tributary streams upstream of HAHD. Steelhead critical habitat in the action area, would benefit from restoring access to high quality spawning and rearing upstream of HAHD. Tacoma has constructed an adult fish trap-and-haul facility which cannot be used due to a lack of safe and effective downstream passage at HAHD.

<u>2.2.3 Southern Resident Killer Whales</u>

The Southern Resident killer whale Distinct Population Segment (DPS), composed of J, K and L pods, was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). A 5-year review under the ESA completed in 2016 concluded that Southern Residents should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016).

The limiting factors described in the final recovery plan included reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008). This section summarizes the status of Southern Resident killer whales throughout their range. This section summarizes information taken largely from the recovery plan (NMFS 2008), recent 5-year review (NMFS 2016), as well as new data that became available more recently.

Abundance, Productivity, and Trends

Southern Resident killer whales are a long-lived species, with late onset of sexual maturity (review in NMFS 2008). Females produce a low number of surviving calves over the course of their reproductive life span (Bain 1990, Olesiuk et al. 1990). Compared to Northern Resident killer whales (a resident killer whale population with a sympatric geographic distribution ranging from coastal waters of Washington State and British Columbia north to Southeast Alaska) Southern Resident females appear to have reduced fecundity (Ward et al. 2013, Vélez-Espino et al. 2014); the average inter-birth interval for reproductive Southern Resident females is 6.1 years, which is longer than the 4.88 years estimated for Northern Resident killer whales (Olesiuk et al. 2005). Recent evidence has indicated pregnancy hormones (progesterone and testosterone) can be detected in Southern Resident killer whale feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017). The authors suggest this reduced fecundity is largely due to nutritional limitation. Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the Southern Resident population (Baird 2000, Bigg et al. 1990, Ford 2000). Groups of related matrilines form pods. Three pods – J, K, and L – make up the Southern Resident community. Clans are composed of pods with similar vocal dialects and all three pods of the Southern Residents are part of J clan.

At present, the Southern Resident population has declined to historically low levels. Since censuses began in 1974, J and K pods have steadily increased their sizes. However, the population suffered an almost 20 percent decline from 1996-2001 (from 97 whales in 1996 to 81 whales in 2001), largely driven by lower survival rates in L pod. The overall population had increased slightly from 2002 to 2010 (from 83 whales to 86 whales). During the international science panel review of the effects of salmon fisheries (Hilborn et al. 2012), the Panel stated that during 1974 to 2011, the population experienced a realized growth rate of 0.71%, from 67 individuals to 87 individuals. Since then, the population has decreased to only 75 whales, a historical low in the last 30 years with a current realized growth rate (from 1974 to 2017) at half of the previous estimate described in the Panel report, 0.29%.

There is representation in all three pods, with 22 whales in J pod, 18 whales in K pod and 35 whales in L pod. There are currently 4 reproductively mature males in J pod, 8 in K pod, and 10 mature males in L pod between the ages of 10 and 42 years. Although the age and sex distribution is generally similar to that of Northern Residents that are a stable and increasing population (Olesiuk et al. 2005), there are several demographic factors of the Southern Resident population that are cause for concern, namely reduced fecundity, sub-adult survivorship in L pod, and the total number of individuals in the population (review in NMFS 2008). Based on an updated pedigree from new genetic data, most of the offspring in recent years were sired by two fathers, meaning that less than 30 individuals make up the effective reproducing portion of the population. Because a small number of males were identified as the fathers of many offspring, a smaller number may be sufficient to support population growth than was previously thought

(Ford et al. 2011, NWFSC unpublished data). Some offspring were the result of matings within the same pod raising questions and concerns about inbreeding effects. Research into the relationship between genetic diversity, effective breeding population size, and health is currently underway to determine how this metric can inform us about extinction risk and inform recovery (NWFSC unpublished data). The historical abundance of Southern Resident killer whales is estimated from 140 to an unknown upper bound. The minimum estimate (~140) is the number of whales killed or removed for public display in the 1960s and 1970s added to the remaining population at the time the captures ended. Several lines of evidence (i.e., known kills and removals [Olesiuk et al. 1990], salmon declines (Krahn et al. 2002) and genetics (Krahn et al. 2002, Ford et al. 2011) all indicate that the population used to be larger than it is now and likely experienced a recent reduction in size, but there is currently no reliable estimate of the upper bound of the historical population size.

Seasonal mortality rates among Southern and Northern Resident whales may be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) identified high neonate mortality that occurred outside of the summer season. At least 12 newborn calves (9 in the southern community and 3 in the northern community) were seen outside the summer field season and disappeared by the next field season. Additionally, stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman et al. 2004). Data collected from three Southern Resident killer whale strandings in the last five years have contributed to our knowledge of the health of the population and the impact of the threats to which they are exposed. Transboundary partnerships have supported thorough necropsies of L112 in 2012, J32 in 2014, and L95 in 2016, which included testing for contaminant load, disease and pathogens, organ condition, and diet composition. A final necropsy report for J34, who was found dead near Sechelt, British Columbia on December 20, 2016 is still pending.

The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses conducted for the 2004 Status Review for Southern Resident Killer Whales and the science panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013). Following from that work, the data now suggests a downward trend in population growth projected over the next 50 years. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates, however, if all of the parameters in the model remain the same the overall trend shows a decline in later years. This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (NMFS 2016f). To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sub-lethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Furthermore, they suggested in order for the population to reach the recovery target of 2.3% growth rate, the acoustic disturbance would need to be reduced in half and the Chinook abundance would need to be increased by 15% (Lacy et al. 2017).

Because of this population's small abundance, it is also susceptible to demographic stochasticity – randomness in the pattern of births and deaths among individuals in a population. Several other sources of stochasticity can affect small populations and contribute to variance in a population's growth and extinction risk. Other sources include environmental stochasticity, or fluctuations in the environment that drive fluctuations in birth and death rates, and demographic heterogeneity, or variation in birth or death rates of individuals because of differences in their individual fitness (including sexual determinations). In combination, these and other sources of random variation combine to amplify the probability of extinction, known as the extinction vortex (Gilpin and Soulé 1986, Fagen and Holmes 2006, Melbourne and Hastings 2008). The larger the population size, the greater the buffer against stochastic events and genetic risks. A delisting criterion for the Southern Resident killer whale DPS is an average growth rate of 2.3% for 28 years (NMFS 2008e). In light of the current average growth rate of 0.29% (from 1974 to present), this recovery criterion reinforces the need to allow the population to grow quickly.

Population growth is also important because of the influence of demographic and individual heterogeneity on a population's long-term viability. Population-wide distribution of lifetime reproductive success can be highly variable, such that some individuals produce more offspring than others to subsequent generations, and male variance in reproductive success can be greater than that of females (i.e., Clutton-Brock 1988, Hochachka 2006). For long-lived vertebrates such as killer whales, some females in the population might contribute less than the number of offspring required to maintain a constant population size (n = 2), while others might produce more offspring. The smaller the population, the more weight an individual's reproductive success has on the population's growth or decline (i.e., Coulson et al. 2006). For example, although there are currently 26 reproductive aged females (ages 11-42) in the Southern Resident killer whale population, only 14 have successfully reproduced in the last 10 years (CWR unpubl. data). This further illustrates the risk of demographic stochasticity for a small population like Southern Resident killer whales – the smaller a population, the greater the chance that random variation will result in too few successful individuals to maintain the population.

Geographic Range and Distribution

Southern Residents occur throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008, Hanson et al. 2013, Carretta et al. 2017). Southern Residents are highly mobile and can travel up to 86 miles (160 km) in a single day (Baird 2000, Erickson 1978), with seasonal movements likely tied to the migration of their primary prey, salmon.

During the spring, summer, and fall months, the whales spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford 2000; Krahn et al. 2002; Hauser et al. 2007). In general, the three pods are increasingly more present in May and June and spend a considerable amount of time in inland waters through September. Late summer and early fall movements of Southern Residents in the Georgia Basin are consistent, with strong site fidelity shown to the region as a whole and high occurrence in the San Juan Island area (Hanson and Emmons 2010, Hauser et al. 2007). All three pods generally remain in the Georgia Basin through October and make frequent trips to the outer coasts of Washington and southern Vancouver Island and are occasionally sighted as far west as Tofino and Barkley Sound (Ford 2000; Hanson and Emmons 2010, Whale Museum unpubl. data). Sightings in late fall decline as the whales shift to the outer coasts of Vancouver Island and Washington.

Although seasonal movements are generally predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (Hanson and Emmons 2010; The Whale Museum unpubl. data). For example, K pod has had variable occurrence in June ranging from 0 days of occurrence in inland waters to over 25 days. Fewer observed days in inland waters likely indicates changes in their prey availability (i.e., abundance, distribution and accessibility). During fall and early winter, Southern Resident pods, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum and Chinook salmon runs (Hanson et al. 2010, Osborne 1999).

In recent years, several sightings and acoustic detections of Southern Residents have been obtained off the Washington and Oregon coasts in the winter and spring (Hanson et al. 2010, Hanson et al. 2013, NWFSC unpubl. data). Satellite-linked tag deployments have also provided more data on the Southern Resident killer whale movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months. Detection rates of K and L pods on the passive acoustic recorders indicate Southern Residents occur with greater frequency off the Columbia River and Westport and are most common in March (Hanson et al. 2013). J pod has also only been detected on one of seven passive acoustic recorders positioned along the outer coast (Hanson et al. 2013). The limited range of the sightings/ acoustic detections of J pod in coastal waters, the lack of coincident occurrence during the K and L pod sightings, and the results from satellite tagging in 2012–2016 (NWFSC unpubl. data) indicate J pod's limited occurrence along the outer coast and extensive occurrence in inland waters, particularly in the northern Georgia Strait.

<u>Limiting Factors and Threats</u>

Several factors identified in the final recovery plan for Southern Residents may be limiting recovery. These are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together to impact the whales. Modeling exercises have attempted to identify which threats are most significant to survival and recovery (Lacy et al. 2017) and available data suggests that all of the threats are potential limiting factors (NMFS 2008).

Quantity and Quality of Prey

Southern Resident killer whales consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016), but salmon are identified as their primary prey. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. The diet data indicate that the whales are consuming mostly larger (i.e., older) Chinook salmon. Chinook salmon is their primary prey despite the much lower abundance in some areas and during certain time periods in comparison to other salmonids, for mechanisms that remain unknown but factors of potential importance include the species' large size, high fat and energy content, and year-round occurrence in the whales' geographic range. Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kcal/kg) (O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one Chinook salmon, they would need to consume approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014). Recent research suggests that killer whales are capable of detecting, localizing and recognizing Chinook salmon through their ability to distinguish Chinook echo structure as different from other salmon (Au et al. 2010).

Scale and tissue sampling from May to September in inland waters of WA and B.C. indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010; Ford et al. 2016). Genetic analysis of the Hanson et al. (2010) samples indicate that when Southern Residents are in inland waters from May to September, they consume Chinook stocks that originate from regions including the Fraser River (including Upper Fraser, Mid Fraser, Lower Fraser, North Thompson, South Thompson and Lower Thompson), Puget Sound (North and South Puget Sound), the Central British Columbia Coast and West and East Vancouver Island.

DNA quantification methods are used to estimate the proportion of different prey species in the diet from fecal samples (Deagle et al. 2005). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40% of the diet in late summer, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). Less than 3% each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples collected in the summer months (May through September). Prey remains and fecal samples collected in inland waters during October through December indicate Chinook and chum salmon are primary contributors of the whale's diet (NWFSC unpubl. data).

Observations of whales overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2009) and collection of prey and fecal samples have also occurred in coastal waters in the winter months. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon, with a smaller number of steelhead, chum salmon, and halibut (NWFSC unpubl. data). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (NWFSC unpubl. data). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon comprise over 90% of the whales' coastal Chinook salmon diet (NWFSC unpubl. data).

Over the past decade, some Chinook salmon stocks within the range of the whales have had relatively high abundance (e.g. WA/OR coastal stocks, some Columbia River stocks), whereas other stocks originating in the more northern and southern ends of the whales' range (e.g. most Fraser stocks, Northern and Central B.C. stocks, Georgia Strait, Puget Sound, and Central Valley) have declined. Changing ocean conditions driven by climate change may influence ocean survival of Chinook and other Pacific salmon, further affecting the prey available to Southern Residents.

Currently, hatchery production is a significant component of the salmon prey base returning to watersheds within the range of Southern Resident killer whales (Barnett-Johnson et al. 2007; NMFS 2008e). Although hatchery production has contributed some offset of the historical declines in the abundance of natural-origin salmon within the range of the whales, hatcheries also pose risks to natural-origin salmon populations (Nickelson et al. 1986; Ford 2002; Levin and Williams 2002; Naish et al. 2007). Healthy natural-origin salmon populations are important to the long-term maintenance of prey populations available to Southern Residents because it is uncertain whether a hatchery dominated mix of stocks is sustainable indefinitely and because hatchery fish can differ, relative to natural-origin Chinook salmon, for example, in size and hence caloric value and in availability/migration location and timing. However, the release of hatchery fish has not been identified as a threat to the survival or persistence of Southern Residents. It is possible that hatchery produced fish may benefit this endangered population of whales by enhancing prey availability as scarcity of prey is a primary threat to Southern Resident killer whale survival and hatchery fish often contribute to the salmon stocks consumed (Hanson et al. 2010).

Nutritional Limitation and Body Condition

When prey is scarce, Southern Residents likely spend more time foraging than when prey is plentiful. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition, can lead to reduced body size of individuals and to lower reproductive and survival rates of a population (Trites and Donnelly 2003). During periods of nutritional stress and poor body condition, cetaceans lose adipose tissue behind the cranium, displaying a condition known as "peanut-head" in extreme cases (Pettis et al. 2004, Bradford et al. 2012, Joblon et al. 2014). Between 1994 and 2008, 13 Southern Resident killer whales were observed from boats to have a pronounced "peanut-head"; and all but two subsequently died (Durban et al. 2009; Center for Whale Research, unpublished data). None of the whales that died were subsequently recovered, and therefore definitive cause of death could not be identified. Both females and males across a range of ages were found in poor body condition.

Since 2008, NOAA's SWFSC has used aerial photogrammetry to assess the body condition and health of Southern Resident killer whales, initially in collaboration with the Center for Whale Research and, more recently, with the Vancouver Aquarium and SR3. Aerial photogrammetry studies have provided finer resolution for detecting poor condition, even before it manifests in "peanut heads" that are observable from boats. Annual aerial surveys of the population from 2013-2017 (with exception of 2014) have detected declines in condition before the death of seven Southern Residents (L52 and J8 as reported in Fearnbach et al. 2018; J14, J2, J28, J54, and J52 as reported in Durban et al. 2017), including five of the six most recent mortalities (Trites and Rosen 2018). These data have provided evidence of a general decline in Southern Resident killer whale body condition since 2008, and documented members of J pod being in poorer body condition in May compared to September (at least in 2016 and 2017) (Trites and Rosen 2018).

Although body condition in whales can be influenced by a number of factors, including prey availability, disease, physiological or life history status, and may vary by season and across years, prey limitation is the most likely cause of observed changes in body condition in wild mammalian populations (Matkin et al. 2017). It is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To demonstrate how this is possible, we reference studies that have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) on adult females and juveniles, which have been studied extensively (e.g., adult females: Gamel et al. 2005, Schaefer et al. 1996, Daan et al. 1996, juveniles: Noren et al. 2009a, Trites and Donnelly 2003). Small, incremental increases in energy demands should have the same effect on an animal's energy budget as small, incremental reductions in available energy, such as one would expect from reductions in prey. Ford and Ellis (2006) report that resident killer whales engage in prey sharing about 76% of the time. Prey sharing presumably would distribute more evenly the effects of prey limitation across individuals of the population than would otherwise be the case (i.e., if the most successful foragers did not share with other individuals). Therefore, although cause of death for most individuals that disappear from the population is unknown, poor nutrition could occur in multiple individuals as opposed to only unsuccessful foragers, contributing to additional mortality in this population.

Toxic Chemicals

Various adverse health effects in humans, laboratory animals, and wildlife have been associated with exposures to persistent pollutants. These pollutants have the ability to cause endocrine disruption, reproductive disruption or failure, immunotoxicity, neurotoxicity, neurobehavioral disruption, and cancer (Reijnders 1986, de Swart et al. 1996, Subramanian et al. 1987, de Boer et al. 2000; Reddy et al. 2001, Schwacke et al. 2002; Darnerud 2003; Legler and Brouwer 2003; Viberg et al. 2003; Ylitalo et al. 2005; Fonnum et al. 2006; Viberg et al. 2006; Darnerud 2008; Legler 2008; Bonefeld-Jørgensen et al. 2011). Southern Residents are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health. High levels of these pollutants have been measured in blubber biopsy samples from Southern Residents (Ross et al. 2000; Krahn et al. 2007; Krahn et al. 2009), and more recently, these pollutants were measured in fecal samples collected from Southern Residents providing another potential opportunity to evaluate exposure to these pollutants (Lundin et al. 2015; Lundin et al. 2016).

Killer whales are exposed to persistent pollutants primarily through their diet. For example, Chinook salmon contain higher levels of some persistent pollutants than other salmon species, but only limited information is available for pollutant levels in Chinook salmon (Krahn et al. 2007; O'Neill and West 2009; Veldhoen et al. 2010; Mongillo et al. 2016). These harmful pollutants, through consumption of prey species that contain these pollutants, are stored in the killer whale's blubber and can later be released; when the pollutants are released, they are redistributed to other tissues when the whales metabolize the blubber in response to food shortages or reduced acquisition of food energy that could occur for a variety of other reasons. The release of pollutants can also occur during gestation or lactation. Once the pollutants mobilize in to circulation, they have the potential to cause a toxic response. Therefore, nutritional stress from reduced Chinook salmon populations may act synergistically with high pollutant levels in Southern Residents and result in adverse health effects.

In April 2015, NMFS hosted a 2-day Southern Resident killer whale health workshop to assess the causes of decreased survival and reproduction in the killer whales. Following the workshop, a list of potential action items to better understand what is causing decreased reproduction and increased mortality in this population was generated and then reviewed and prioritized to produce the Priorities Report (NMFS 2015c). The report also provides prioritized opportunities to establish important baseline information on Southern Resident and reference populations to better assess negative impacts of future health risks, as well as positive impacts of mitigation strategies on Southern Resident killer whale health.

Disturbance from Vessels and Sound

Vessels have the potential to affect killer whales through the physical presence and activity of the vessel, increased underwater sound levels generated by boat engines, or a combination of these factors. Vessel strikes are rare, but do occur and can result in injury or mortality (Gaydos and Raverty 2007). In addition to vessels, underwater sound can be generated by a variety of other human activities, such as dredging, drilling, construction, seismic testing, and sonar (Richardson et al. 1995; Gordon and Moscrop 1996; National Research Council 2003). Impacts from these sources can range from serious injury and mortality to changes in behavior. In other cetaceans, hormonal changes indicative of stress have been recorded in response to intense sound exposure (Romano et al. 2003). Chronic stress is known to induce harmful physiological conditions including lowered immune function, in terrestrial mammals and likely does so in cetaceans (Gordon and Moscrop 1996).

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. While in inland waters of Washington and British Columbia, Southern Resident killer whales are the principal target species for the commercial whale watch industry (Hoyt 2001; O'Connor et al. 2009) and encounter a variety of other vessels in their urban environment (e.g., recreational, fishing, ferries, military, shipping). Several main threats from vessels include direct vessel strikes, the masking of echolocation and communication signals by anthropogenic sound, and behavioral changes (NMFS 2008). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (NMFS 2010c; NMFS 2016f; NMFS in press). Research has shown that the whales spend more time traveling and performing surface active behaviors and less time foraging in the presence of all vessel types, including kayaks, and that noise from motoring vessels up to 400 meters away has the potential to affect the echolocation abilities of foraging whales (Holt 2008; Lusseau et al. 2009; Noren et al. 2009; Williams et al. 2010b). Individual energy balance may be impacted when vessels are present because of the combined increase in energetic costs resulting from changes in whale activity with the decrease in prey consumption resulting from reduced foraging opportunities (Williams et al. 2006; Lusseau et al. 2009; Noren et al. 2009a; Noren et al. 2012).

At the time of the whales' listing under the ESA, NMFS reviewed existing protections for the whales and developed recovery actions, including vessel regulations, to address the threat of vessels to killer whales. NMFS concluded it was necessary and advisable to adopt regulations to protect killer whales from disturbance and sound associated with vessels, to support recovery of Southern Resident killer whales. Federal vessel regulations were established in 2011 to prohibit vessels from approaching killer whales within 200 yards (182.9 m) and from parking in the path of the whales within 400 yards (365.8 m). These regulations apply to all vessels in inland waters of Washington State with exemptions to maintain safe navigation and for government vessels in the course of official duties, ships in the shipping lanes, research vessels under permit, and vessels lawfully engaged in commercial or treaty Indian fishing that are actively setting, retrieving, or closely tending fishing gear (76 FR 20870, April, 14, 2011).

In the final rule, NMFS committed to reviewing the vessel regulations to evaluate effectiveness, and also to study the impact of the regulations on the viability of the local whale watch industry. In March 2013, NMFS held a killer whale protection workshop to review the current vessel regulations, guidelines, and associated analyses; review monitoring, boater education, and enforcement efforts; review available industry and economic information and identify data gaps; and provide a forum for stakeholder input to explore next steps for addressing vessel effects on killer whales.

In December 2017, NOAA Fisheries completed a technical memorandum evaluating the effectiveness of regulations adopted in 2011 to help protect endangered Southern Resident killer whales from the impacts of vessel traffic and noise (Ferrara et al. 2017). In the assessment, Ferrara et al. (2017) used five measures: education and outreach efforts, enforcement, vessel compliance, biological effectiveness, and economic impacts. For each measure, the trends and observations in the 5 years leading up to the regulations (2006-2010) were compared to the trends and observations in the 5 years following the regulations (2011-2015). The memo finds that the regulations have benefited the whales by reducing impacts without causing economic harm to the commercial whale-watching industry or local communities. The authors also find room for improvement in terms of increasing awareness and enforcement of the regulations, which would help improve compliance and further reduce biological impacts to the whales.

Oil Spills

In the Northwest, Southern Resident killer whales are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their small population size, strong site fidelity to areas with high oil spill risk, large group size, late reproductive maturity, low reproductive rate, and specialized diet, among other attributes (Jarvela-Rosenberger et al. 2017). Oil spills have occurred in the range of Southern Residents in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines.

Despite many improvements in spill prevention since the late 1980s, much of the region inhabited by Southern Residents remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers in inland waters. Numerous oil tankers transit through the inland waters range of Southern Residents throughout the year. The magnitude of risk posed by oil discharges in the action area is difficult to precisely quantify. The total volume of oil spills declined from 2007 to 2013, but then increased from 2013 to 2017 (WDOE 2017). The percent of potential high-risk vessels that were boarded and inspected between 2009 and 2017 also declined (from 26% inspected in 2009 to 12.2% by 2017) (WDOE 2017).

Repeated ingestion of petroleum hydrocarbons by killer whales likely causes adverse effects; however, long-term consequences are poorly understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion and disease, pneumonia, liver disorders, neurological damage, adrenal toxicity, reduced reproductive rates, and changes in immune function (Geraci and St. Aubin 1990; Schwacke et al. 2013; Venn-Watson et al. 2015; de Guise et al. 2017; Kellar et al. 2017), potentially death and long-term effects on population viability (Matkin et al. 2008; Ziccardi et al. 2015). For example, 122 cetaceans stranded or were reported dead within 5 months following the Deepwater Horizon spill in the Gulf of Mexico (Ziccardi et al. 2015). An additional 785 cetaceans were found stranded from November 2010 to June 2013, which was declared an Unusual Mortality Event (Ziccardi et al. 2015). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect Southern Residents by reducing food availability.

Rangewide Status of Critical Habitat

The final designation of critical habitat for the Southern Resident killer whale DPS was published on November 29, 2006 (71 FR 69054). Critical habitat consists of three specific marine areas of inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. These areas comprise about 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three physical or biological features (PBFs) essential for the conservation of Southern Residents: (1) Water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

Water Quality

Water quality in Puget Sound, in general, is degraded. Some pollutants in Puget Sound persist and build up in marine organisms including Southern Residents and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. The primary concern for direct effects on whales from water quality is oil spills, although oil spills can also have long-lasting impacts on other habitat features. The Environmental Protection Agency and the U.S. Coast Guard oversee the Oil Pollution Prevention regulations promulgated under the authority of the Federal Water Pollution Control Act. The Northwest Area Contingency Plan, developed by the Northwest Area Committee, serves as the primary guidance document for oil spill response in Washington and Oregon. The Washington State Department of Ecology published a Spill

Prevention, Preparedness and Response Program, 2015-2021 Strategic Plan describing the vision of the Spill Program (WDOE 2015).

Prey Quantity, Quality, and Availability
As discussed above, most wild salmon stocks throughout the Northwest are at fractions of their historic levels. Beginning in the early 1990s, 28 ESUs and DPSs of salmon and steelhead in Washington, Oregon, Idaho, and California have been listed as threatened or endangered under the ESA. Historically, overfishing, habitat losses, and hatchery practices were major causes of decline. Poor ocean conditions over the past two decades have reduced populations already weakened by the degradation and loss of freshwater and estuary habitat, fishing, hydropower system management, and hatchery practices. While wild salmon stocks have declined in many areas, hatchery production has been generally strong.

Contaminants and pollution also affect the quality of Southern Resident killer whale prey in Puget Sound. Contaminants enter marine waters and sediment from numerous sources, but are typically concentrated near areas of high human population and industrialization. Once in the environment these substances proceed up the food chain, accumulating in long-lived top predators like Southern Residents killer whales. Chemical contamination of prey is a potential threat to Southern Resident killer whale critical habitat, despite the enactment of modern pollution controls in recent decades, which were successful in reducing, but not eliminating, the presence of many contaminants in the environment. The size of Chinook salmon is also an important aspect of prey quality (i.e., Southern Residents primarily consume large Chinook salmon, as discussed above), and any reduction in Chinook salmon size is therefore a threat to their critical habitat. In addition, vessels and sound may reduce the effective zone of echolocation and reduce availability of fish for the whales in their critical habitat (Holt 2008).

Passage
Southern Residents are highly mobile and use a variety of areas for foraging and other activities, as well as for traveling between these areas. Human activities can interfere with movements of the whales and impact their passage. In particular, vessels may present obstacles to whales' passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior (review in NMFS 2011b).

2.3 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

In this Opinion, the baseline includes actions that are interrelated and interdependent to the proposed action. Under the proposed action, there are no proposed changes to any of the actions interrelated and interdependent to the proposed action. Additionally, the interrelated and interdependent actions to the proposed action have received prior ESA consultation (WSB-00-198) and are included in the Tacoma Water Habitat Conservation Plan (HCP) (WSB-00-522).

Therefore, we consider interrelated and interdependent actions as part of the environmental baseline and not as part of the proposed action.

Interrelated/Interdependent actions include:

1. Withdrawal of the full 20,000 af of water at the Tacoma Headworks Dam for M&I use under the AWSP (WSB-00-198, WSB-00-522).
2. Upstream fish collection and transport facility at the Headworks Dam (WSB-00-198, WSB-00-522)
3. Downstream fish bypass facility at the Headworks Dam (WSB-00-198, WSB-00-522).
4. Integrated conservation measures (WSB-00-522).

The baseline includes the effects of those elements of the Corps' proposed action from its 2000 BA that it has implemented, including operations to store and release water under the AWSP and several fish habitat improvement projects in the Green River watershed. As part of Phase 1 of the AWSP and our original consultation on the project (NMFS 2000), the Corps has constructed a suite of habitat mitigation and restoration projects within the Green River watershed. The purpose of the habitat mitigation projects was to offset adverse habitat effects resulting from the larger reservoir created by storing the additional 20,000 af of water. The Corps has not completed design and construction of the new downstream fish passage and temperature control facilities included in its 2000 BA proposed action and therefore they are not included in the environmental baseline. The Corps constructed a coffer dam in 2008 to facilitate a downstream fish passage facility at HAHD and is considered part of the environmental baseline. The coffer dam has no effect on fish or habitat downstream of the dam.

The environmental baseline includes the past and present impacts of the dam itself as well as its operation and maintenance to this point in time. The environmental baseline does not include the future effects of the operation and maintenance of the dam. Because the future effects of the dam itself cannot be meaningfully separated out from the effects of future operations and maintenance, all such future effects are analyzed as effects of the proposed action.

Within the action area, there have been numerous consultations with Federal agencies under ESA Section 7 involving the same species considered in this Opinion, ranging in scope from boat docks to licensing hydroelectric projects. Among those involving formal consultations and the issuance of biological opinions are: fish harvesting actions (NMFS 2008b, NMFS 2008d, NMFS 2009), hatchery operations (NMFS 2012a, NMFS 2013), and hydroelectric projects (NMFS 2008e). In 2008, we completed consultation on the Federal Emergency Management Agency's flood insurance program in the state of Washington (NMFS 2008a), and in 2014, we concluded consultation with the Corps on its Mud Mountain Project, located on the White River, the next drainage south of the Green River (NMFS 2014a), a project of similar scope and purpose to HAHD. The actions analyzed in these biological opinions are part of the environmental baseline for this consultation.

Below we describe specific elements of the environmental baseline as they relate to anadromous fish and Southern Resident killer whales, and their habitats within the project action area.

2.3.1 Overview of the Environmental Baseline

The Green-Duwamish River basin is a major drainage flowing into Central Puget Sound. The Green River arises on the western slopes of the Cascade Range and runs about 82 miles to its confluence with the Black River channel (now mostly dry and non-existent), near Renton, Washington to form the Duwamish River. Prior to 1906, the Green River flowed into the White River from the south with its mouth in Elliott Bay in Puget Sound. In 1906, a large flood caused the White River to avulse into the Puyallup and since that time, levies have been constructed to maintain this configuration. The upper Green River is demarcated from the middle and lower Green River basin by HAHD. The lower reach of the Green River, from Auburn downstream, and the Duwamish River, is highly urbanized and industrialized. The middle reach of the Green is rural and forested. The upper Green River is predominately forest land. The upper Green River watershed is in low and mid-elevation hills and mountains, with the hydrograph mainly rain driven, with a moderate amount of winter snow that generally melts in early spring. Tacoma owns about 11% of the upper Green River watershed and manages it to protect water quality. Tacoma has a Habitat Conservation Plan (HCP) with NMFS and USFWS focusing on managing the utility's forest lands for fish, wildlife, and ecosystem function. The other 89% is owned by private, state, tribal, and Federal forest entities. It is managed under the Plum Creek HCP, the Washington Department of Natural Resources HCP covering state trust forest lands, Washington's Forest and Fish rules covering private forest lands, and U.S. Forest Service lands are managed under the Northwest Forest Plan (Interagency SEIS team 1994) to protect fish, wildlife, and forest ecosystems.

Beginning about 8 miles downstream from HAHD, the river runs for 11 miles through the steep, mostly undeveloped, Green River Gorge. From the Auburn city limits downstream, the Green River is increasingly urbanized. Portions of the lower Green River have been channelized and/or diked to facilitate urban development. Further, Green River flows are diminished by Tacoma's water supply Headworks Dam diversion located 3.5 miles downstream from HAHD. Tacoma has water rights and claims for diverting up to 500 cfs at this facility but has formally agreed to limit its diversions to a maximum of 213 cfs (Tacoma 2001). Actual diversions are often less. The adverse effects of flow reduction in the middle and lower Green River caused by Tacoma's diversion are mitigated by Tacoma's adoption of protective minimum instream flows and physical habitat improvements taken as part of its HCP and HAHD discharges during the summer from fish conservation and section 1135 storage. Thus, the productive capacity of the middle and lower Green River has been affected by channel simplification and seasonal flow changes due to operations at HAHD and Tacoma's water diversion. Tacoma holds first and second diversion water rights of 400 (contractually limited to actual diversion of 113 cfs) and 100 cfs, respectively, which are part of the environmental baseline.[8]

In contrast, the upper watershed is primarily forest lands. Tacoma takes steps to protect the quality of its source water, both within lands it owns, and through a series of agreements with large landowners, both public and private, as part of its watershed management plan (Tacoma 2008) developed as part of the HCP. Major landowner agreement measures include:

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[8] By separate agreement, Tacoma has agreed to limit diversions under its first diversion water right to 113 cfs (Tacoma 2001). In this Opinion we assume that the Tacoma could divert up to 213 cfs at its Headworks Dam facility in compliance with its rights and agreements.

discouraging concentrated recreational use (e.g. group gatherings), limits on overnight use, locating any fire camps away from active waterways, access for water quality monitoring, policing and other measures designed to preserve the quality of Green River water for use in Tacoma's unfiltered (pristine) water supply system. In this way, Tacoma's interest in preserving pristine water quality benefits aquatic habitats in the Green River and its tributaries upstream from HAHD. Unlike the lower watershed, the current quality of salmonid habitats in the upper watershed is likely to persist into the future as Tacoma and other landowners have an interest in ensuring their protection.

The average annual flow of the Green River near the project is 999 cfs (USGS station number 12105900, water years 1961 through 2014), with monthly average flows ranging from 268 in August to 1,622 cfs in January. HAHD is located at RM 64.5 blocking upstream and downstream fish passage since it was built in 1962. Operation of HAHD significantly modifies the lower rivers' seasonal, and sometimes its daily, hydrograph. The project stores water during flood events, releasing the water over days to weeks after the event. Under the AWSP, 20,000 af is stored by HAHD during the spring, beginning on or after February 20th each year. Natural resource benefits are accrued under current operations by using 10,000 af of that water for the benefit of natural resources through flow augmentation.

Table 8, 9, and 10 outline commitments that Tacoma has made to protect instream flows. In issuing an ITP to Tacoma that includes implementing its HCP, NMFS determined that these commitments, when combined with other commitments under the HCP, minimized to the maximum extent practicable, the adverse effects of additional water diversion at Headworks dam.

Table 8. Green River minimum flows adopted by Tacoma at USGS Station No. 12113000 (Green River at Auburn, WA) and USGS Station No. 12106700 (Green River at purification plant near Palmer, WA) under Tacoma's 1995 Settlement Agreement with MIT.

Time period	**Auburn MIF in cfs**	**Palmer MIF in cfs**
For Tacoma's First Diversion Water Right Claim		
Wet Years	350	
Wet to Average Years	300	
Average to Dry Years	250	
Drought Years	250-225	
For Tacoma's Second Diversion Water Right		
July 15 – Sept 15	400	200
Sept 16 – Oct 31	NA	300
Nov 1 – July 13	NA	300

Source: Tacoma 1995 (in Tacoma 2001)

Table 9. Minimum instream flow schedule for water withdrawals under Tacoma's first diversion water right claim (during the period 15 July to end of flow augmentation from HAHD) under its HCP, at the Auburn, Washington gage (USGS Station No. 12113000) as defined for different summer weather conditions. Source Tacoma 2001

Summer Weather Condition	Auburn MIF in cfs
Wet	350
Wet to Average	300
Average to Dry	250
Drought years	250 to 225 Depending on the severity of the drought

Table 10. Minimum instream flow schedule for Tacoma's second diversion water right under its HCP at the Palmer, Washington gage (USGS Station No. 12106700) and Auburn, Washington gage (USGS Station No. 12113000). Source Tacoma 2001

Season	Palmer MIF in cfs	Auburn MIF in cfs
July 15 through Sept. 15	200	400
Sept. 16 through July 14	300	Na

A reservoir of varying size is maintained behind HAHD throughout the year. Discharge is managed by the dam's regulating gates. The regulating gates are adjusted as necessary in discrete increments to achieve a target discharge or reservoir elevation. Due to the incremental changes made to the gates, discharge rates from the project present a stair-step pattern as gate changes are made over time. During the low-flow period which roughly occurs from mid-July to mid-September, discharge is switched from the outlet tunnel to the 48-inch bypass pipe which allows for finer control of the discharge (Corps 2014).

About 5.5 miles of riverine fish habitat was lost due to construction of the project and its reservoir. Upstream of the project are private forest lands and U.S. Forest Service managed lands, most of the upper Green River watershed is managed for timber production on Federal, state, public utility, and private lands.

Since 1913, when Tacoma's Headworks Dam was completed, anadromous fish access to the upper watershed has been blocked. Due to that blockage, HAHD was also constructed without fish passage facilities. In 2007, Tacoma completed its juvenile fish screens and adult trap and haul system proposed in its HCP. However, because HAHD does not provide safe and effective passage of downstream migrating juveniles, Tacoma has been unable to place adult fish upstream of HAHD and state, tribal, and Federal fisheries managers will not approve collecting and transporting fish upstream until safe and effective downstream passage is available. Hence, Headworks Dam is currently the upstream limit of anadromous fish access to the Green River. Nearly half of the basin's productive capacity for these fish lies upstream of HAHD. The project has also blocked the flow of sediments, trapping most sediment particles larger than sand, and has interrupted the flow of woody debris.

HAHD has provided flood risk management benefits to the King County cities of Kent, Auburn, Renton, and Tukwila by capturing peak flows from incoming floods and discharging the accumulated water at lower rates. The project has been very effective in reducing downstream flood damage, having prevented an estimated $4 billion in property damage during a single January 2009 flood event (Corps 2009).

In 1997, Congress approved an ecosystem restoration project under Section 1135 of the 1986 Water Resources Development Act to increase the volume of summer conservation storage at the HAHD project. The ecosystem restoration project included additional water storage of up to 5,000 af for low-flow augmentation and several habitat restoration projects around the reservoir (Corps and TPU 1996). These measures have been completed and are a part of the environmental baseline for this consultation.

Ecosystem restoration and water supply were added as project purposes with the AWSP, a dual-purpose project authorized in the Water Resources Development Act of 1999. Tacoma, is the local project sponsor for the AWSP. The AWSP was authorized with two purposes: municipal and industrial (M&I) water supply, and ecosystem restoration (added to the AWSP study in 1994). The AWSP includes changes to project operations to increase non-flood season summer water storage and fish passage. The AWSP includes increased summer water storage in two phases. Phase 1, included in the Corps' proposed action for this Opinion, would provide up to 20,000 ac-ft for Tacoma's use, mostly to provide M&I water, but Tacoma may elect to use a portion to meet minimum flows in the Green River. Fish passage features were also authorized by the Act. Additionally, Phase 2 of the project (to be developed at a later date) includes storage of 2,400 af for M&I and 9,600 af for low-flow augmentation. Phase 2 of the AWSP is not part of the proposed action for this Opinion. It would be consulted upon independently should Phase 2 be implemented.

While Tacoma is the local sponsor for the AWSP, the Corps is the lead federal agency. The two have developed a partnership agreement specifying measures each must take to fulfill the agreement.

A Biological Opinion and Incidental Take Statement for the Corps' O&M, as well as actions under the AWSP was secured by the Corps through the consultation process prescribed in Section 7 of the ESA in 2000. The Corps submitted a Programmatic Biological Assessment to the Services in April 2000. Following consultation, the Services issued an Incidental Take Statement addressing the O&M, and AWSP in a Biological Opinion in October 2000. Those aspects of the Corps' proposed action, and reasonable and prudent measures specified in the ITS issued by NMFS that have been effectively implemented, are part of the environmental baseline for this Opinion.

As required in its HCP, Tacoma has developed intake screens and an adult trap at its Headworks Dam (Tacoma 2001). The HCP also established forest management for fish and wildlife habitat and ecosystem function, including habitat improvement projects located both upstream and downstream of HAHD.

The non M&I water supply components of the AWSP were intended to provide for re-establishment of self-sustaining runs of salmon and steelhead upstream of HAHD (Corps 1998). The M&I water is stored to support the economic development of the Puget Sound area. The full volume of AWSP water (20,000 af) is currently stored annually by HAHD, however, Phase 1 of the AWSP has not been fully implemented. Of the 20,000 af stored for M&I use, natural resource benefits are accrued under current operations through the use of up to 50% (10,000 af) for natural resource benefits in the form of flow augmentation. As a part of the AWSP, Tacoma and the Corps constructed a suite of habitat mitigation (100% funding by Tacoma) and restoration (funded 35% by Tacoma and 65% Corps) projects to offset adverse habitat effects resulting from the larger reservoir created by storing the M&I water.

2.3.2 Status of Fish Habitat in the Action Area

The complex life cycles exhibited by salmon and steelhead give rise to complex habitat needs, particularly during the freshwater phase (Spence et al. 1996). Spawning gravels must be a certain size and free of sediment to allow successful incubation of the eggs. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need places to hide from predators (mostly birds and bigger fish), such as under logs, root wads, and boulders in the stream, as well as beneath overhanging vegetation. They also need places to seek refuge from periodic high flows (side channels and off-channel areas) and from warm summer water temperatures (cold water springs and deep pools). Returning adults generally do not feed in fresh water, but instead rely on limited energy stores to migrate, mature, and spawn. Like juveniles, they also require cool water and places to rest and hide from predators. They also need migratory corridors with adequate passage conditions (safe passage with respect to barriers, water quality, and water quantity) to allow access to the various habitats required to complete their life cycle. Puget Sound is a key part of steelhead habitat as they transition from the river and estuary to the open ocean environment. Acoustic tagging studies in recent years have shown that many steelhead smolts that enter the Sound do not survive to reach the open ocean (Goetz 2015). Reasons for low survival are not known. Puget Sound otherwise satisfies steelhead early marine habitat needs.

To describe the aquatic habitat characteristics of the Green River important to fish survival, we use the physical and biological features (PBFs) identified for PS Chinook salmon critical habitat (70 FR 52630) and steelhead critical habitat (81 FR 9251).

HAHD prevents fish passage and prevents fish access to habitats upstream of the project and affects the following habitat components in the middle and lower 64 miles of the Green River downstream of HAHD:

- Water Quality
- Coarse sediment supply
- Large woody debris (LWD) supply
- Instream flows
- Riparian vegetation
- Floodplain connectivity
- Aquatic productivity

2.3.2.1 Water Quality

Water Temperature

Existing water temperatures are influenced by a leveed lower river with limited riparian vegetation, extensive urbanization of the lower river, numerous water diversions, tributaries, and the operation of HAHD. A temperature Total Maximum Daily Load (TMDL) Water Quality Improvement Report for the Green River was completed in 2011 (WDOE 2011). There have been numerous exceedances of state water quality standards in the Green/Duwamish River watershed, with 17 entries on the current 303(d) list for exceedance of the temperature water quality criterion (WDOE 2012). The majority of the 303(d) listings are in the lower river downstream of RM 35. There are two listings in close proximity to HAHD including just downstream of the Tacoma Headworks Dam at RM 61 and at Kanasket-Palmer State Park at RM 57.

Operation of HAHD has affected downstream water temperatures. Following implementation of the AWSP, discharge water temperatures have tended to be cooler than inflow water temperatures from July 1 through September 15, and up to 3° C warmer than inflow water temperatures from July 15 through early November (Corps, personal communication). The data indicate that in some years there are exceedances of the state water quality standards at all three monitoring locations (inflow, outflow, and USGS Station No. 12113000, near Auburn, WA). HAHD outflow water temperature is influenced by the maintenance of a reservoir and the fact that water is released from the bottom of the reservoir.

Sediment/Turbidity

Upstream of HAHD, existing conditions are affected by forestry, railroad, road, and associated culverts and maintenance activities which may contribute notable amounts of sediment to the river. Turbidity in the upper Green River basin occurs in response to high-flow events and floods. Turbidity downstream of HAHD has historically been influenced by HAHD operations and fine sediment inputs from agricultural and urban runoff. Turbidity in the downstream river has also historically been affected by a large landslide near RM 42. The presence of HAHD and flood management both contribute to a gradual accumulation of sediment behind the dam. There is an estimated 2.6 million cubic yards of sediment that has accumulated in the reservoir since 1962 (Corps 2006a, in Corps 2014). About 70% of the total is located below elevation 1070 feet just upstream of the outlet tunnel. Immediately upstream of the dam the deposits are predominantly sand and silt and are as deep as 40 feet (Corps 2008a, in Corps 2014). Further upstream, the amount of gravel in the accumulated deposits increases. The larger grain size sediment (gravel, cobble, and boulders) tends to deposit in the upper reaches of the reservoir inundation area. A minimum reservoir is maintained year-round behind HAHD to minimize the erosion of this accumulated sediment (known as the turbidity pool). This prevents much of the fine sediment that accumulates behind the dam during floods from subsequently washing downstream as flows recede. Maintenance of a reservoir during the spring and summer plant growing season results in vast unvegetated mudflats throughout the inundation area. Some of this sediment is eroded and transported downstream as a result of rainfall directly on the mudflats or increasing flows through the reservoir. Sediment releases at HAHD tend to be related to high flow events when turbidity increase occurs naturally. However, because flood control and other efforts, such as debris removal to maintain safe conditions, slow the rate at which flood water is released, increased turbidity that would normally return to background levels within 2 to 3 days has taken as long as 60 days. Extended high water release increases fish exposure to increased turbidity downstream.

Monitoring of fine sediment in downstream river spawning gravel indicate some year-to-year variability. For the most part, data indicate less than 17% fine sediment (less than 0.85 mm) and often less than 12% fines depending on the location (Corps 2014). NMFS guidance categorizes 12 to 17% fines in sediment as an at-risk condition, and less than 12% fines as properly functioning (NMFS 1996) indicating that spawning substrate conditions downstream from Headworks Dam are fair to good.

Chemical Contamination/Nutrients
Sediment samples collected from the HAHD reservoir in 2008 indicated that contaminant concentrations were all below freshwater sediment criteria proposed by the State of Washington except for beryllium, the concentration of which was slightly higher than the standard but comparable to other reference sites around Puget Sound (Corps 2008a, in Corps 2014). The downstream water quality is currently affected by contaminants that result from urban and agricultural stormwater runoff. Downstream of RM 11, the river is industrial and is listed as a CERCLA (Comprehensive Environmental Response, Compensation, and Liability) Superfund site for contaminated sediments. Several additional CERCLA and RCRA (Resource Conservation and Recovery Act) Superfund sites in various states of cleanup flank the lower river.

2.3.2.2. Coarse Sediment Supply

Coarse sediment is important to PS Chinook salmon and PS steelhead because it is needed for spawning. The upper Green River watershed is highly productive of coarse sediments, both from natural erosion and erosion associated with roads and timber harvesting. HAHD reservoir retains all but the finest suspended sediment material derived from the upper Green River and its tributaries. The dam precludes bedload transport from areas upstream of the project to areas downstream from the project. Since 2003, the Corps has annually placed up to 14,000 tons of gravel at designated sites downstream from Headworks Dam. Although the project has modified the Green River’s sediment budget, spawning gravels are abundant both upstream and downstream from the project (Judge 2011, Booth et al. 2012).

2.3.2.3 LWD Supply and Riparian Conditions

Large woody debris is broadly important to stream ecology and increases channel complexity. In-channel LWD increases channel complexity by encouraging scour and side channel formation; provides both nutrients and substrate for aquatic insects and other benthic fauna to colonize, increasing a river’s biomass; and, provides hiding and velocity cover to juvenile salmonids. The upper Green River watershed is rich in large woody debris due to the heavily forested nature of the watershed and long-term management for timber harvest. HAHD blocks LWD transport from upstream locations to the lower Green River. The Corps has stockpiled LWD that entered the reservoir during high flow events. The Corps has placed as much of this collected wood as feasible into the river without creating a hazardous log jam at or immediately downstream of the loading site, generally timed to take advantage of high flow events that carried it downstream. Some of the wood collected from the reservoir has been used to create engineered habitat structures throughout the Green River watershed.

The amount of LWD received by the reservoir varies annually and is episodic. Hundreds of trees and large logs enter in a major flood year, down to only a few in years of mild winters. The LWD RPM of the 2000 opinion was modified by mutual agreement in 2004 to better reflect the natural occurrence of LWD and to supply other needs for habitat projects within the Green River basin. For project purposes, LWD is defined as wood greater than 12” diameter at midpoint and at least 20’ long or any piece of wood containing a rootball greater than 4’ diameter. Under the AWSP the Corps transports large wood captured in the reservoir, to the gravel nourishment site downstream from HAHD. Other wood from upstream is allocated to Tacoma’s for its HCP, and some is allocated to various habitat priorities and cultural uses by the MIT.

The upper watershed is primarily forested and the river is rich in LWD. Fallen limbs and trees maintain high levels of LWD in the upper Green River and its tributaries.

The Section 1135 project authorized four now completed habitat restoration projects around the reservoir using LWD. Those projects are in the ongoing operations and maintenance phase, which by agreement between the Corps and Tacoma is the responsibility of Tacoma.

2.3.2.4 Instream Flows

The amount and distribution of streamflows work with the underlying geology and gradient to create channel form and associated fish habitats. Modifying streamflow changes these relationships. Further, reducing flows increases a stream’s rate of response to heat flux, making a river quicker to freeze in the winter and quicker to heat up in the summer. While increasing stream flows can also have substantial morphological and fish habitat effects, flow reductions are the primary modification of streamflows in the lower Green River affecting fish habitats. Instream flows in the lower Green River are modified by the operation of HAHD and Tacoma’s Headworks Dam and diversion.

Tacoma diverts up to 213 cfs from the Green River at its Headworks Diversion while maintaining the agreed-upon minimum streamflows downstream from Headworks Dam (Table 6).

HAHD has modified lower Green River flows in three primary ways: episodic flood control operations; spring water storage; and subsequent summer/fall releases of stored water for fish conservation under the original project authorization, the Section 1135 ecosystem restoration project, and the AWSP.

Below we present a brief synopsis of how HAHD has historically been operated and its associated effects of fish habitats in the lower Green River (operations descriptions are from Corps 2014).

Fall and Winter Operations

HAHD has been operated in the late fall and winter primarily for flood risk management. Any water remaining from the summer conservation season has been released to provide the maximum possible flood storage of about 104,000 acre-feet by November 1 to December 1, depending on the onset of fall rains. The Corps has attempted to manage this operation to avoid discharge turbidity levels in excess of 30 NTUs, although on occasion the discharged water has exceeded this target. The Corps has also conducted routine maintenance during this period (e.g. trashrack cleaning) and has maintained a constant low reservoir level (~1,075 feet) for one to two weeks to do so.

The short-term moderate increase in turbidity caused by the reservoir has been managed to maintain the turbidity pool at an elevation at or below 1,076 feet, depending on the elevation of the sediment delta. Outside of the early fall effort to manage the turbidity pool and active flood damage reduction operations that occur sporadically throughout the fall and winter, the project has operated in a run-of-river manner in which inflow is about equal to outflow during the fall and winter.

Salmonid habitat derives benefits and losses associated with managing peak flows. For example, Kinsel (2008) showed that Chinook salmon survival from egg to fry is inversely related to the magnitude of peak flows during incubation in the Skagit River. This effect is likely associated with bed scour in which high flows mobilize streambed elements, exposing and dislodging eggs. Anderson and Topping (2017) showed that peak incubation flow was negatively related to productivity, and that productivity sharply declined above peak incubation flows of 285 m^3/s. This study also indicated that parr productivity declined as peak flow during the fry migration increased, but increased when flows were >34 m^3/s during parr rearing. During this study which was conducted between 2000 and 2016, the cohort with the highest total productivity (2000) experienced very mild peak flows during incubation (56 m^3/s) and fry (63 m^3/s) periods, as well as an above-average number of days with flows >34 m^3/s during parr rearing (Anderson and Topping, 2017). On the other hand, periodic bedload movement, similarly associated with high stream flows, can improve future spawning habitat conditions by reducing embeddedness and imbrication of the substrate, thereby facilitating future redd construction. Kinsel et al. (2008) showed that Chinook salmon egg to fry survival in the Skagit River is negatively related to flood recurrence interval for flows greater than a 2-year event. During years in which Skagit River peak flows did not exceed the 2-year recurrence interval flood, egg survival ranges from about 10 % to 17 % and appears unrelated to flow. When annual peak flows exceed the 2-year event red scour can depress egg to smolt survival to as little as 2%. With biogeographical similarity to the Skagit watershed, it is likely that the reduction in peak flows greater than the 2-yr recurrence interval flood on the Green River provided by operation of HAHD has had beneficial effects on Chinook salmon egg to fry survival.

Poor egg-to-outmigrant survival because of peak flow events is a major factor limiting Chinook salmon production in Puget Sound rivers (WDFW 2008). The flood control operation of HAHD substantially reduces the magnitude of peak flow events in the Green River downstream. The volume of flood storage reduces peak flows, and the Corps attempts to prevent flows from exceeding 12,000 cfs at Auburn. This has benefitted Chinook salmon eggs incubating in the lower Green River by minimizing redd scour. There is no beneficial flood control effect upstream of HAHD. However, the upper basin benefits from the natural flow and channel processes that also maintain and create high quality spawning and rearing habitats.

Spring Refill Operations

On or after February 20 each year HAHD has begun to store water for later release for fish conservation, ecosystem restoration, and Tacoma's needs. This storage operation, designed to capture 49,200 acre feet, has generally been completed by June 1, but may extend into July during high water years to spread out (lessen) the effect of storage operations on downstream fish and fish habitat. Water captured under the fish conservation and ecosystem restoration program (Section 1135 project) has generally been captured and stored based on a proportional capture strategy whereby a percentage (about 12% on average, or 166 cfs) of the total inflow to the reservoir was stored. Depending on hydrologic and biological conditions, the timeframe and rate of water capture has been modified in response to high flows, snowpack conditions, fish spawning or other factors. This operation has been guided in near real-time by the GRFMCC, a stakeholder group consisting of resource agencies, tribes, and other interested parties that meets biweekly via conference call. Through the adaptive management process, such as reducing the rate of storage to protect spawning PS steelhead, this spring storage program has minimally affected fish habitats in the lower Green River.

Green River steelhead spawn downstream of HAHD primarily from late March into early June, with a peak in May (Scott and Gill 2008). The Green River is more of a rain fed than snow fed river, so seasonal flows usually taper off from winter into spring and summer. A slight uptick in runoff begins in April as snow melts, generally initiating the steelhead smolt out-migration. So steelhead eggs and alevins incubate during a period of steadily declining flows, and complete incubation and emergence occurs as flows recede toward the summer base flow condition. If the difference between spawning flows and incubation flows is large, then the redds where steelhead eggs incubate could become dewatered, causing the loss of eggs or alevins.

Summer Conservation Season Operations

Once the reservoir was refilled, the Corps passed inflow until water was needed from storage to supplement downstream flows. The Corps followed its Water Control Manual (Corps 2011) to achieve a minimum flow of 110 cfs with a reliability of 98% at the USGS Palmer gauge, just downstream of Tacoma's Headworks Dam, located about 3.5 miles downstream of HAHD. The 110 cfs flow target was derived from the original authorizing documents for the project. Discharge from the dam was based on the 110 cfs flow target plus at least 113 cfs or reservoir inflow, whichever was least, to serve Tacoma's first diversion water right claim (FDWRC) of 113 cfs. During the summer peak demand period Tacoma diverted up to 213 cfs (113 cfs FDWRC plus 100 cfs Second Diversion Water Right (SDWR) served by the AWSP), depending on its needs while bypassing established minimum flows (Table 6). The Corps released water from HAHD to supply Tacoma and to meet a 110 minimum instream flow at the Palmer gage.

Under the HAHD authorization, the Corps used conservation water to provide "for the preservation of fish life" (Corps 1948). The Corps convened bi-weekly teleconference meetings with the GRFMCC to allocate specific flows. In addition, Tacoma and the Corps often coordinate flow releases more frequently based on changing M&I water needs. Similar to the adaptive management strategy used for the spring refill, flow augmentation was adaptively managed in consideration of GRFMCC recommendations made to account for extant hydrologic conditions and to time deliveries to provide the greatest benefit to fish resources. This has resulted in deviations above the reservoir storage guide curve (i.e., saving water for later use). Deviations that would pull the reservoir below the guide curve were generally not allowed to ensure sufficient water is retained to compensate for possible late fall drought conditions. The summer conservation or augmentation period typically runs from late June to as late as November, depending on fall hydrologic conditions. The remaining water stored in the reservoir was evacuated down to the winter turbidity pool in the late fall as soon as conditions indicate water storage was no longer needed or in order to prepare for flood operations. The general target date for evacuating the reservoir is November 1, but the actual date of full draft varied depending on hydrologic conditions.

The GRFMCC usually allocated water in the early summer to benefit steelhead egg incubation and alevin survival as spring runoff tapered toward summer base flow conditions. Later in the season, the committee allocated remaining water to augment fall Chinook salmon migration and spawning flows. This increased the likelihood of adult Chinook salmon being able to migrate farther upstream and to seek out the highest quality spawning locations. The lower Green River can experience high water temperatures and very poor migration and spawning conditions in the August-September time period, when Green River Chinook salmon are actively migrating and beginning to spawn.

Water stored between reservoir elevation 1147 and 1167’ is allocated to the AWSP increment of total storage. Storage and release of this water is by agreement between the Corps and Tacoma. It is also part of Tacoma’s HCP. The streamflow reducing effect of storing AWSP water in the spring has been reduced by Tacoma through an instream flow schedule, habitat restoration and improvement projects, and provision of safe upstream and downstream fish passage at its Headworks Dam, as part of its HCP (Tacoma 2000, NMFS 2001). In recent years about half of the water stored under the AWSP (~10,000 af annually) has been released during the summer low flow season and allowed to pass Tacoma’s diversion to benefit fish conservation downstream from Headworks Dam.

Through this complex arrangement of agreements and mandates, the current operation of HAHD stores water from the late winter through spring. This water is released in the summer and fall.

By contrast, the upper Green River is unimpounded and undiverted, exhibiting high quality salmonid habitat throughout the year.

2.3.2.5 Floodplain Connectivity

A watershed’s flow regime is an important component of the channel’s morphometry and riparian conditions. Small and moderate-sized stream discharges (less than or equal to flows with a 2-year recurrence interval) are generally contained within the channel, while larger discharges that occur less frequently exceed the channel capacity and overflow onto the floodplain. During floods, water is stored in sloughs and side channels, or seeps into floodplain soils recharging groundwater storage. This stored groundwater slowly drains back to the channel, providing a source of cool inflow during the summer (Naiman et al. 1992). Because larger floods are stored at HAHD and released later at lower flows, only the sloughs and side channels on the lower river terrace floodplain are recharged.

Side channels to the Green River also provide important habitats to rearing PS Chinook salmon and steelhead. Both Chinook salmon and steelhead typically spawn in the main channel, but rearing juveniles make extensive use of shallower and slower velocity side channels. Side channels occur commonly in the upper and middle Green River. The levee system on the lower river has eliminated most of them.

Under baseline conditions, the Corps' flood control operations at HAHD have affected the formation and quality of off-channel and side-channel habitat within the floodplain. Periodic storage of floodwaters has dramatically reduced the magnitude of once ordinary floods. This flow control has resulted in less and lower quality side- and off-channel habitat in the existing environment. Through the combination of peak flow reduction, channelization, leveeing, and urban development the lower Green River has been substantially simplified, substantially reducing juvenile salmonid rearing habitat.

2.3.2.6 Aquatic Productivity

From samples gathered during 2002, King County found that several tributaries to the Green River and sections of the Green River had among the highest benthic index of biological integrity (B-IBI, a measure of benthic community health) of any King County stream site sampled (EVS Environmental Consultants 2004). However, sites in the Black and Duwamish Rivers had the lowest B-IBI measured. In general, the B-IBI decreased in a downstream direction, indicating that aquatic productivity is higher in the upper Green River than in the lower Green River, an important consideration for rearing juvenile salmon and steelhead.

The recent explosion in the population of pink salmon in the basin has likely affected aquatic productivity. Over the past decade hundreds of thousands of pink salmon (*O. gorbuscha*) have entered the Green River during odd numbered years, with far fewer returning during even numbered years. This explosion in the pink salmon population creates both benefits and detriments to the aquatic productivity of the river. It provides large amounts of marine-derived nutrients to the Green River which feeds the ecosystem, benefiting rearing Chinook salmon. However, recent research suggests that Chinook salmon juveniles that emigrate from freshwater into Puget Sound concurrently with young-of-the-year pink salmon survive to return at lower rates than those that do not outmigrate concurrently with pinks (Ruggerone and Goetz 2004). Thus, while the influx in pink salmon has increased the aquatic productivity of the Green River and other Puget Sound streams as measured in biomass, it has also reduced the year-class strength of Chinook salmon that outmigrated concurrently with pink salmon juveniles. It is not possible at this time to determine whether the influx of pink salmon has increased or decreased Chinook salmon productivity overall.

Since 2000 the Washington Department of Fish and Wildlife (WDFW) has operated a screw trap about 1 mile upstream from the mouth of Big Soos Creek in the middle Green River. From the counts of juvenile wild Chinook salmon collected in the trap WDFW has extrapolated the number of outmigrating juveniles for the entire basin, and using redd counts, estimates egg-to-fry survival each year (Table 11). Since 2008, the total number of outmigrants has ranged from 146,909 (2012) to 1,008,512 (2013) with egg-to-fry survival rates ranging from 2.1% (2009) to 11.4% (2014). These data suggest that egg-to-fry survival, a measure of inland productivity, have improved since 2008, possibly due to habitat improvements that have recently been made. However, as a large fraction of the annual outmigration consists of fry (<45mm fork length) that are captured in March, shortly after emergence, the fish have not had much rearing time and the variation in egg-to-fry survival is likely mostly due to variations in egg survival, rather than variations in rearing productivity. As previously mentioned, egg survival is strongly affected by the frequency, intensity, and duration of flood flows.

Table 11. Estimated annual juvenile wild Chinook salmon production and egg-to-fry survival. Source: WDFW 2009 through 2015.

Outmigration year	Egg-to-fry survival	Chinook salmon fry production
2008	3.4%	546746
2009	2.1%	269277
2010	5.7%	263466
2011	8.0%	445718
2012	6.0%	146909
2013	9.7%	1008512
2014	11.4%	520406

2.3.2.7 Lifestage Specific Habitat Conditions

Spawning Habitat

Spawning habitat quality for PS Chinook salmon and PS steelhead in the Green River sub-basin ranges from poor to good, depending on location. Sufficient quantities of suitably sized substrate are not lacking, but the quality is poor in some areas as a result of fine sediment originating from natural soil sources and from forest land use practices. The most abundant and heavily used spawning areas in the middle river are in the short distance between Tacoma's Headworks Dam and the upper end of the gorge and again from just downstream of the gorge to the vicinity of Auburn. Steelhead spawning areas substantially overlap those of Chinook salmon, but include more extensive use of tributaries. Higher quality spawning habitat is more abundant in the upper Green River upstream of HAHD as a result of improved forest practices over the past two decades and projects implemented under Tacoma's HCP.

Rearing Habitat

Juvenile PS Chinook salmon and PS steelhead rear throughout the lower Green River, extending downstream of the major spawning areas, between RM 25 and 60.8. Rearing juveniles have been observed all the way down to tidewater. Judge (2011) identified a number of limiting factors within the Green/Duwamish River basin that affect the quality and quantity of fry and juvenile rearing habitat: degraded riparian zones, dam operations, sedimentation and mass wasting, high water temperature, hydromodification, and loss and reduced connectivity of estuarine habitat. Anderson and Topping (2017) indicate that the current carrying capacity for Chinook parr is approximately 100,000 parr while fry production was density independent, indicating that the strongest limiting factor is the availability of off-channel and side channel rearing habitat. As a general trend, degradation and loss of rearing habitat is highest in the estuary region and gradually improves in an upstream direction as the number and severity of the limiting factors decline.

The upper watershed provides abundant juvenile rearing habitat owing to higher channel complexity, higher aquatic productivity, and more frequent occurrence of LWD.

Migration Corridors

Chinook salmon and steelhead are limited to only the historical spawning areas available in the lower and middle river sub-basin. Tacoma's Headworks Dam is the upstream limit for anadromous fish use. Headworks Dam is impassible, but in 2007 Tacoma completed facilities for trapping and hauling adult salmon and steelhead around both Headworks Dam and HAHD in anticipation of reintroducing salmon and steelhead to the upper Green River watershed. However, because the Corps has been unable to complete facilities to provide safe and effective downstream passage at HAHD, NMFS and other regional salmon managers have allowed only a few fish to be moved from Tacoma's trap and haul system to habitats upstream of HAHD, to evaluate facility performance and to inform operating plans. [9]

The U.S. Fish and Wildlife Service (USFWS) conducted studies on downstream fish passage at HAHD in the 1990s. Adult and juvenile fish were placed upstream of HAHD to facilitate the studies. Dilley and Wunderlich (1992, 1993) documented poor passage rates and poor survival of juvenile salmonids through the existing outlets at HAHD. Emigration was low. Less than 1% to 14.5% of sub-yearling Chinook salmon that originated from adults planted into the upper Green River were observed to have passed HAHD, and descaling and mortality rates were high (19% mortality and 33% descaling). Too few steelhead smolts were captured to make a passage survival estimate. Given this poor downstream passage survival, NMFS and other regional salmon managers have not allowed ESA-listed fish, and have severely limited the numbers of unlisted fish, to be moved from the trap to habitats upstream of HAHD. Therefore, Chinook salmon and steelhead have no access to their historical spawning and rearing habitat in the upper Green River watershed.

Significant actions affecting the environmental baseline came about following the Water Resource Development Act of 1999. That Act tied Tacoma's interest in M&I water storage to the authorized purpose of HAHD via the AWSP. In addition to the flood water storage and conservation storage originally authorized, 5 kaf more conservation storage was added under ecosystem restoration and 20 kaf of M&I storage for Tacoma. The AWSP also authorized habitat improvement projects to mitigate the impacts of its incremental M&I storage, throughout the basin under ecosystem restoration. The agreement between Tacoma and the Corps requires Tacoma to maintain all the habitat projects (Tacoma and the Corps 2003). Also under the agreement, Tacoma was to provide upstream fish passage at its Headworks Dam, while the Corps would provide safe and effective downstream fish passage at HAHD. All of the

[9] Due to the very poor passage survival at HAHD, Tacoma's trap and haul system cannot be used to move ESA-listed fish. Small numbers of unlisted fish have been placed upstream and more will likely occur for scientific investigation. Few of the progeny of these fish would survive downstream passage

conservation measures in Tacoma's HCP and the Corps' AWSP (Corps 1998) have been completed, except safe and effective downstream fish passage and temperature control at HAHD.

Adult Trap and Haul System

Tacoma, under its HCP, completed construction of an adult trap-and-haul fishway at its Headworks Dam in 2007. The fishway is operable, and Tacoma awaits instruction from NMFS, USFWS, and the state and tribal co-managers to begin passing ESA-listed fish upstream. This facility was developed as part of Tacoma's commitment under the AWSP and its HCP, with the expectation that the Corps would provide safe and effective passage for downstream migrating fish at HAHD. Because the Corps has not developed safe and effective downstream fish passage, Tacoma's adult trap and haul system has not yet been operated (see Juvenile Passage below).

Juvenile Passage

Also in accordance with its HCP, Tacoma installed modern fish screens at its Headworks Dam diversion in anticipation of protecting the influx of downstream migrating juvenile salmon and steelhead that would occur under the partially-completed reintroduction program. Beginning in 2004, the Corps conducted extensive design work on a juvenile fish downstream fishway at HAHD, and began construction. Construction and planning was discontinued in 2012, in part because the project could not be completed with the remaining authorized funds.

Without a functional juvenile downstream fishway, passing adult fish upstream has not been a practical fish management action because the resulting juvenile production would have had to pass through HAHD, which has been shown to provide very poor passage survival (Dilley and Wunderlich 1992, 1993). Until safe and effective downstream fish passage at HAHD becomes available, it would be inappropriate to place ESA-listed fish collected at Tacoma's adult fish passage facility upstream of HAHD.

Summary

Baseline conditions in the action area range from highly functional above HAHD and the middle part of the Green River and in parts of Puget Sound, to severely degraded in the lower river and Duwamish River, mainly due to land use factors as well as the HAHD project existence, operations, and maintenance. The baseline is impaired in the action area by the following:

1) Upstream adult migration is prevented by the dam;
2) High quality upstream habitat is cut-off, or blocked; although adult passage could be provided by Tacoma, but lack of safe downstream passage has prevented use of upstream habitat.
3) Downstream habitat quality is variable:
    a) Locally excessive fine sediment;
    b) Reduced or altered flows have both beneficial (reduced scour), and adverse (reduced channel migration, complexity, and flood-plain function, low summer flows limit the amount of suitable habitat and exacerbate water quality issues;
    c) Reduced riparian vegetation (quantity and quality); and
    d) Elevated late summer and fall temperatures.

2.3.3 Status of Southern Resident Killer Whale Habitat in the Action Area

In our listing decision for Southern Residents we identified three main threats to their survival: (1) quality and quantity of prey, (2) high levels of contaminants from pollution, and (3) disturbance from vessels and sound. As of September 15, 2018 there were only 74 whales in this small population. Their small population size and social structure also put them at risk for a catastrophic event, such as an oil spill, that could impact the entire population.

2.3.3.1 Prey Availability

When prey is scarce, whales likely spend more time foraging than when it is plentiful. Prey limitation causes increased energy expenditure to capture prey and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition can lead to reduced body size and condition of individuals and lower birth and survival rates of a population. Ford *et al.* reported correlated declines in both the Southern Resident killer whales and Chinook salmon and suggested the potential for nutritional stress in the whales (Ford *et al.* 2005, Ford *et al.* 2010a). Food scarcity could also cause whales to draw on fat stores, mobilizing contaminants stored in their fat and potentially have the ability to alter thyroid homeostasis, reduce immune function, cause neurotoxicity, reproductive failure, and restrict the development and growth of the individual (see Table 9 in NMFS 2008 for a review of physiological effects resulting from exposure to toxic chemicals in marine mammals). Thus, nutritional stress may act synergistically with high contaminant burdens in the whales and result in contaminant-induced adverse health effects, higher mortality rates, or lower birth rates.

The availability of Chinook salmon to Southern Residents is affected by a number of natural and human actions. The most notable human activities that cause adverse effects include land use activities that result in habitat loss and degradation, hatchery practices, harvest, and hydropower systems. Details regarding baseline conditions of Puget Sound Chinook salmon in inland waters that are listed under the Endangered Species Act are described above.

Here we provide a review of Southern Resident killer whale determinations in previous ESA Section 7(a)(2) consultations where effects occurred in the action area, and where effects resulted in a significant reduction in available prey (i.e., where prey reduction was likely to adversely affect or jeopardize the continued existence of the whales). We also consider activities that have impacts in the action area, and are out of our jurisdiction for Section 7(a)(2) consultation, but nonetheless significantly reduce available prey (e.g., salmon harvest in Canada). We then assess the remaining prey available to Southern Resident killer whales in light of this environmental baseline.

Habitat-altering activities such as agriculture, forestry, marine construction, levy maintenance, shoreline armoring, dredging, hydropower operations and new development can reduce prey available to Southern Residents. Since the Southern Residents were listed, federal agencies have also consulted on the likely impacts of their actions on Southern Residents, including impacts to available prey. In addition, the environmental baseline is influenced by many actions that pre-date the salmonid listings and that have substantially degraded salmon habitat and lowered natural production of Puget Sound Chinook salmon.

There are also hatchery programs that create prey available to Southern Resident killer whales and can affect their long-term viability of salmon populations. ESA consultations on these programs in the action area have not been completed to date, but a process for doing so is currently under development. The magnitude of change in prey available because of these habitat, hydropower and hatchery activities in the action area are not explicitly summarized here; however, our estimates of prey available to Southern Residents in light of the environmental baseline are based on a fishery harvest management model (described further below). The model is used to estimate abundance of fish in the ocean, and is based on catch and escapement data. These data should reflect all baseline and natural mortality sources, because fish lost to other activities would not be accounted for in escapement or catch data, and thus would not be represented in the abundance estimates.

We have previously consulted on the effects of salmon harvest on Southern Residents. NMFS conducted annual consultations to evaluate effects on Southern Residents of Pacific Coast Salmon Plan fisheries managed by the PFMC (2006-2007, 2007-2008 and 2008-2009, i.e., NMFS 2008b, NMFS 2009) and the U.S. Fraser Panel fisheries (2007, 2008, and 2009, i.e., NMFS 2008e). In 2009, NMFS consulted on a range of Pacific Coast Salmon Plan harvest scenarios based on past-authorized harvest levels and salmon stock abundances. While past consultation on these fisheries had been for a single year, the 2009 consultation was for an undefined duration (NMFS 2009). In 2008 we consulted on the effects on Southern Residents of northern U.S. and Canadian fisheries, and general obligations of southern U.S. fisheries (further constrained by other harvest actions and subject to separate section 7 consultations) under the Pacific Salmon Treaty agreement (new fishing regimes, i.e., amended Chapters 1, 2, 3, 5, and 6 of Annex IV of the Treaty, 2009-2018, NMFS 2008d). In 2010, we consulted on effects of programs administered by the Bureau of Indian Affairs that support Puget Sound tribal salmon fisheries and salmon fishing activities authorized by the U.S. Fish and Wildlife Service in Puget Sound as well as fisheries authorized by the U.S. Fraser Panel in Puget Sound (from May1, 2010 to April 30, 2011, NMFS 2010b and c). We also previously consulted on the effects of the Puget Sound Chinook salmon Resource Management Plan (RMP) pursuant to section 4(d) of the ESA and analyzed effects to Southern Resident killer whales for fisheries from 2010 through April 2014 (NMFS 2011a), from April 2014 to April 2015 (NMFS 2014b), and from May 1, 2015 through April 30, 2016 (NMFS 2015). In these most recent biological opinions on the Puget Sound Chinook salmon RMP, we concluded that the proposed fisheries were likely to adversely affect, but not likely to jeopardize the continued existence of PS Chinook salmon, PS steelhead, Puget Sound/GB (PS/GB) bocaccio (*Sebastes paucispinis*), PS/GB canary rockfish (*S. pinniger*), PS/GB yelloweye rockfish (*S. ruberrimus*), and Southern Resident killer whales.

In these harvest opinions, we characterized the short-term and long-term effects on Southern Residents from prey reduction caused by the project. We considered the short-term direct effects to whales resulting from reductions in Chinook salmon abundance that occur during a specified year, and the long-term indirect effects to whales that could result if harvest affected viability of the salmon stock over time by decreasing the number of fish that escape to spawn. These past analyses suggested that in the short term prey reductions were small relative to remaining prey available to the whales. In the long term, we determined that harvest actions that have met the conservation objectives of harvested stocks were not likely to appreciably reduce the survival or recovery of listed Chinook salmon, and were therefore not likely to jeopardize the continued existence of listed Chinook salmon. The harvest biological opinions referenced above concluded that the harvest actions cause prey reductions in a given year, but were not likely to jeopardize the continued existence of ESA- listed Chinook salmon or Southern Residents.

We have previously consulted on the effects of flood insurance on Southern Residents. NMFS' biological opinion on the National Flood Insurance Program in Washington State-Puget Sound region concluded that the action was likely to jeopardize the continued existence of the Puget Sound Chinook salmon ESU, and that the potential extinction of this ESU as a long-term consequence of the action was also likely to jeopardize the continued existence of Southern Residents (NMFS 2008a).We have also recently consulted on the continued operation and maintenance of the Mud Mountain Dam project, on the White River near Buckley, Washington (NMFS 2014a). In that consultation, we concluded that the proposed action would jeopardize the continued existence of Puget Sound Chinook salmon, Puget Sound steelhead, and Southern Resident killer whales and would adversely modify or destroy their designated critical habitats. Over the long term, the proposed action for the Mud Mountain Dam project would decrease the abundance and productivity of PS Chinook salmon and increase the risk of their extinction. Reducing the numbers of PS Chinook salmon would reduce their availability as prey and increase the likelihood for local depletions of prey during times when Southern Resident foraging focuses on Chinook salmon. In response, Southern Residents would increase foraging effort or abandon areas in search of more abundant prey. By reducing the abundance of PS Chinook salmon, an essential prey species, the proposed operation and maintenance of Mud Mountain Dam would reduce the availability of food, thereby reducing the likelihood that Southern Residents would recover and the conservation value of their critical habitat. Appreciably reducing the potential for survival and recovery of PS Chinook salmon would reduce the potential for Southern Residents to survive and recover. We developed an RPA to reduce the losses of ESA-listed salmon and steelhead that would occur under the proposed action, thereby avoiding jeopardy on PS Chinook salmon, PS steelhead, and Southern Residents.

2.3.3.2 Contaminants

Because Southern Resident killer whales live a long time, are at the top of the food chain, and feed in close proximity to industrial and agricultural areas where exposure to contaminants can be relatively high, they are a relatively highly contaminated population of whales. Recent studies have documented high concentrations of PCBs, DDTs, and PBDEs in killer whales (Krahn et al. 2004, Reijnders and Aguilar 2002, Ross et al. 2000; Ylitalo et al. 2001, Krahn et al. 2007, Krahn et al. 2009, Mongillo et al. in press). Harmful contaminants are stored in blubber, and can later be released and become redistributed to other tissues when the whales metabolize the blubber in response to food shortages or reduced acquisition of food energy that could occur for a variety of other reasons (i.e., disease or reduced foraging efficiency from vessel disturbance). Once these pollutants enter into a whale's circulation they have the potential to affect the whale's immune system and reproductive fitness (Krahn et al. 2002). Although it is currently unknown what role contaminants play in the status of the Southern Resident killer whales, and caution must be used when extrapolating risks across species (Schwacke et al. 2002), Southern Resident killer whales have body burdens that are above health effects thresholds found in other marine mammals (e.g., Hall et al. 2003, Krahn et al. 2007, Krahn et al. 2009), suggesting the whales may already have contaminant levels that can cause deleterious biological health effects.

Puget Sound is a deep-water, multi-branched fjord with several sills that restrict mixing and inhibit ocean inflow and the outflow of toxic chemicals. Toxic chemicals that enter the basin have longer residence times within the basin resulting in food webs being exposed to higher levels of persistent pollutants. Additionally, many species are known to exhibit a high degree of residency within Puget Sound (e.g., there are several resident populations of fish including Pacific herring and Chinook salmon) resulting in more fish being exposed to more contaminants. Thus, the Puget Sound ecosystem and food webs are more susceptible to toxic input because of the proximity to urban areas, and the combination of hydrological isolation of the Puget Sound and the biological isolation of resident species (Collier et al. 2006; West et al. 2008; O'Neill and West 2009). For example, Chinook salmon that remain as residents and mature in Puget Sound experience a three-to five-fold exposure to some contaminants compared to others that migrate and grow to adulthood in the Pacific Ocean (O'Neill and West 2009). Chinook salmon contain higher levels of some contaminants than other salmon species, but only limited information is available for contaminant levels of Chinook salmon in Puget Sound (i.e., Krahn et al. 2007, O'Neill and West 2009, Veldhoen et al. 2010).

2.3.3.3 Vessel Activities and Sound

Vessels used for a variety of purposes (commercial shipping, military, recreation, fishing, whale watching and public transportation) occur in inland waters of the Southern Residents' range. Several studies in inland waters of Washington State and British Columbia have linked interactions of vessels and Northern and Southern Resident killer whales with short-term behavioral changes (Kruse 1991; Williams et al. 2002a, 2002b; Foote et al. 2004; Bain et al.2006; Noren et al. 2009a; Noren et al. 2009b, Holt 2008, Holt et al. 2009, Noren et al. 2010). These vessel activities may affect foraging efficiency, communication, and/or energy expenditure through the physical presence of the vessels, underwater sound created by the vessels, or both. Collisions of killer whales with vessels are rare, but remain a potential source of serious injury and mortality.

Commercial sonar systems designed for fish finding, depth sounding, and sub-bottom profiling are widely used on recreational and commercial vessels and are often characterized by high operating frequencies, low power, narrow beam patterns, and short pulse length (NRC 2003). Frequencies fall between 1 and 500 kHz, which is within the hearing range of some marine mammals including killer whales and may have masking effects (i.e., sound that precludes the ability to detect and transmit biological signals used for communication and foraging).

In inland waters, the majority of vessels in close proximity to the whales are commercial and recreational whale watching vessels and the average number of boats accompanying whales can be great during the summer months (i.e., from 2010 to 2014 an average of 12 to 18 boats were within ½ mile in inland waters from May to September; Eisenhardt and Koski 2015). Sound generated from whale watch vessels varies by vessel size, engine type, and operating speed (Holt 2008). A few studies have evaluated the consequences of short-term behavioral responses on the health of the cetacean populations (i.e., Williams et al. 2006, Noren et al. 2009b, Holt et al. 2009, and Lusseau et al. 2009). Likely effects of vessel interaction and noise include increased energy expenditure from behavioral responses and decreased foraging efficiency due to masking. Both of these effects, particularly in combination, may reduce killer whale fitness. In 2011 NMFS issued vessel management regulations to protect Southern Residents from vessel effects (76 FR 20870; April 14, 2011, and discussed below).

2.3.3.4 Non-Vessel Sound

In-water construction activities are permitted by the Army Corps of Engineers (Corps) under section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act of 1899 and by the State of Washington under its Hydraulic Project Approval (HPA) program. NMFS conducts consultations on these permits and helps project applicants incorporate conservation measures to minimize or eliminate potential effects of in-water activities, such as pile driving, to marine mammals. Sound, such as sonar generated by military vessels also has the potential to disturb killer whales.

2.3.4 Summary of Baseline Conditions for Southern Resident Killer Whales

Southern Resident killer whales are exposed to a wide array of impacts in the action area from past and present state, federal or private actions and other human activities, as well as federal projects that have already undergone formal ESA Section 7 consultation, and state or private actions that are contemporaneous with this consultation. All of the activities discussed in the above section are likely to have some level of impact on Southern Residents when they are in inland waters of their range.

No single threat has been identified as the cause of the recent decline of the Southern Resident killer whales, although the three primary threats are identified as prey availability and quality, environmental contaminants, and vessel effects and sound. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats identified are important to address. It is likely that multiple threats are acting together. For example, disturbance from vessels may make it harder for the whales to locate and capture prey, which may cause them to expend more energy to catch less food, resulting in use of their blubber stores and mobilization of harmful contaminants. The small size of the population increases the level of concern about all of these risks (NMFS 2008).

2.4 Effects of the Action on the Species and its Designated Critical Habitat

"Effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Under the proposed action, there are no proposed changes to any of the actions interrelated and interdependent to the proposed action. Additionally, the interrelated and interdependent actions to the proposed action have received prior ESA consultation (WSB-00-198) and are included in the Tacoma Water Habitat Conservation Plan (HCP) biological opinion (WSB-00-522). Therefore, we consider interrelated and interdependent actions as part of the environmental baseline (Section 2.3) and not as part of the proposed action.

HAHD is an existing dam, and the Corps does not have authority to remove the dam structure. However, in the present context, because it is not possible to segregate the effects of the dam's existence from the effects of the proposed operation of the dam, we have attributed all of those effects to the proposed action. In its BA, the Corps proposes to operate the facility to meet its authorized purposes for flood control, fish conservation, and municipal and industrial water supply. The Corps proposes to take many specific actions to meet these purposes, and all would rely on the existence of the dam structure as part of the proposed action. For example, there would be no way for the Corps to store water for flood control without the dam to hold the water back. Thus, the effects of the dam are intertwined with those of the measures to operate the dam. It would be difficult, if not impossible to segregate out the effects of the existence of the dam from the effects of the operations of the dam.

2.4.1 Method of Analysis

In this step of our analysis, we evaluate the effects of the proposed action on the environment, including the geographic distribution, nature, intensity, timing, frequency, and or duration of the effect. We then look at effects on individual fish and on the affected population(s). Finally, we consider effects on the essential features (PBFs) of any designated critical habitat within the action area.

2.4.2 Analysis of Effects

In the sections below, we first identify the anticipated effects of each element of the proposed action and then we detail how the entire proposed action would affect the survival and recovery of the affected species, and their critical habitats.

HAHD was constructed in 1962 without any upstream or downstream fish passage facilities. HAHD is located 3.5 miles upstream of Tacoma's Headworks Dam which has blocked fish passage since its construction in 1913. These actions rendered about 40% of the basin's Chinook salmon and 50% of its steelhead habitat unavailable. However, as a product of Tacoma's HCP, Tacoma constructed upstream fish passage facilities in 2005 and renovated its water diversion to comply with juvenile fish screening requirements in anticipation of providing trap and haul passage to habitats upstream of HAHD and protecting downstream migrating juveniles from impingement and entrainment at its diversion. The AWSP authorized the Corps to provide downstream passage by constructing and operating a juvenile fish collection and passage system at HAHD. In fact, the Corps actively worked on the design and construction of a downstream fish passage facility for several years before officially stopping in 2012 due to a lack of funds. As described above, the Corps' proposed action for this reinitiation of consultation does not include a juvenile fish collection and passage system. Without safe and effective downstream passage through HAHD, it would be inappropriate to place adult PS Chinook salmon and PS steelhead upstream of the dam because the offspring of those adults could not safely migrate downstream to the ocean, an essential part of their life cycle. For this reason, regional salmon managers, including NMFS, have not allowed ESA-listed fish collected at the trap to be placed upstream of HAHD and would continue to do so under the proposed action.

Therefore, the lack of passage at the dam would mean that the lower Green River watershed would continue to be the only habitat in the Green River watershed that would be available for spawning and rearing PS Chinook salmon and PS steelhead.

2.4.2.1 Water Management Operations

The Corps proposes to continue to manage water as it has over the past several years, including releasing all of the originally authorized 24,200 af of fish conservation water and the additional 5,000 acre-feet of water stored under the Section 1135 program for flow augmentation during June through October when low flows limit downstream salmon and steelhead habitats. Separate from fish conservation and augmentation water, the 20,000 acre-feet of water stored under the AWSP between late February and early June would be released annually under a schedule provided by Tacoma to serve M&I demand in its and its partner's service areas (COE, 2014). Stored M&I water released at HAHD would go 3.5 miles downstream to Tacoma's Headworks Dam where it would available to be diverted into Tacoma's pipeline. For purposes of this consultation, NMFS assumes that the full volume of AWSP water would be discharged from HAHD and diverted for M&I use, although actual use of this stored M&I water would be at Tacoma's discretion, consistent with the HCP.

Storing water in the spring would have two physical effects. It would continue to increase the portion of the upper Green River occupied by Eagle Gorge reservoir, and reduce HAHD discharge rates. The streamflow diminishing effects of storing the additional AWSP water during the spring are included in the environmental baseline (see Section 2.3.2.1 – 2.4.2.3). To minimize downstream effects, Tacoma adopted a minimum instream flow schedule as shown in Tables 6a, 6b, and 6c. The seasonal reduction in riverine fish habitat due to inundation upstream of HAHD was addressed by fish habitat improvements that were part of Tacoma's HCP and the Corps' proposed action for our 2000 consultation (Corps 2000). All of these habitat improvement projects have been completed and are part of the Environmental Baseline for this consultation. AWSP water released at HAHD has no effect on fish or fish habitat downstream of Tacoma's Headworks Dam except as described below.

As discussed in the environmental baseline, current operations accrue natural resource benefits by using up to 10,000 af of AWSP water annually at HAHD to augment flows for the benefit of aquatic species and their habitat in the middle and lower Green River, including PS Chinook salmon and PS steelhead. Following implementation of Phase 1 of the AWSP, 20,000 af annually would be discharged from HAHD and it is anticipated that this entire volume would be diverted for M&I use at Tacoma's Headworks Damn, although actual use of this Phase 1 water would be at the discretion of Tacoma, consistent with the HCP. The anticipated effects of making the entire volume of water stored under the AWSP available for diversion by Tacoma (i.e. 20,000 af annually) would be an increase in the frequency of low river flows in the Green River downstream from Headwaters Dam and the effects associated with reduced flow. All of the effects of water management operations at HAHD accrue to the middle and lower Green River and only affect the upper Green River through effects on the reservoir footprint associated with water storage. The increase of the reservoir's footprint was considered during development of the AWSP, and these effects were addressed in Tacoma's HCP and habitat improvement projects that have been completed. Under the proposed action, effects on the reservoir footprint would have no effect on PS Chinook salmon or PS steelhead because these fish would have no access to this habitat.

Once reservoir refill is complete, the Corps would pass inflow until water is needed from storage to supplement downstream flows. The Corps follows its Water Control Manual (Corps 2011) to achieve a minimum flow of 110 cfs with a reliability of 98% at the USGS Palmer gauge, immediately downstream of Tacoma's Headworks Dam. The 110 cfs minimum flow target plus 113 cfs or reservoir inflow, whichever is least, is based on Tacoma's first diversion water right which is acknowledged in the HAHD project authorization (Corps 2011).

We have identified both beneficial and adverse effects of the Corps' proposed water management operations (see Section 2.3.2). Downstream sedimentation and channel simplification, and increased travel time and higher predation rates on outmigrating Chinook salmon and steelhead smolts would be likely adverse effects of downstream flow reductions caused by spring storage operations. Incubating PS Chinook salmon eggs would benefit from reduced peak flows provided by flood storage. Spawning and rearing Chinook salmon and steelhead would benefit from improved habitat conditions from June through October provided by flow augmentation.

2.4.2.2 Section 1135 Ecosystem Restoration Project

The Corps would store an additional 5,000 af of water during spring refill for the purpose of ecosystem restoration, releasing this water during the summer conservation season (June through October) to promote fish conservation in accordance with the GRFMCC. This project includes a number of completed habitat improvement projects upstream and downstream from the project. In combination with the 24,200 af of water originally allocated to flow augmentation, the proposed action would provide a total of 29,200 af of storage dedicated to flow augmentation. In addition to the 5,000 acre-feet of water storage, there were a total of four habitat restoration projects constructed around the reservoir under the Section 1135 project. The habitat projects have been completed (part of environmental baseline) and they are now in the O&M phase (Corps 2014).

All 5,000 acre-feet of water made available by the Section 1135 project would be used to enhance juvenile rearing habitat and adult fish migration and spawning in the lower Green River. Though this is a substantial benefit to PS Chinook salmon and PS steelhead in the lower river, the lack of safe and effective fish passage renders habitat improvements located upstream of HAHD, made under the program, useless to PS Chinook salmon and PS steelhead.

2.4.2.3 Municipal and Industrial Water Supply

There would be adverse effects in the middle and lower Green River caused by reducing HAHD discharge during the spring due to storing AWSP water at HAHD. Although effects of storing AWSP water has been considered, current operations allow 10,000 af of this water to remain in the river to benefit natural resources through flow augmentation. NMFS anticipates these benefits will diminish after full implementation of Phase 1. Reduced downstream flows contribute to channelization, reduce stream-margin and off-channel habitat that would otherwise be available for rearing juveniles, causes slower outmigration which in turn increases predation and exposure to poor water quality, and increases the rate at which water temperature is influenced by air and solar effects. Tacoma adopted a minimum instream flow schedule, developed a trap and haul adult salmonid passage system, and participated in habitat improvement projects throughout the Green River basin in partnership with the Corps, as mitigation for effects on upstream habitat caused by the additional water storage under the AWSP as per the terms of the HCP. [10]

Under the proposed action, up to 20,000 af of AWSP storage would be discharged from HAHD and it is anticipated that this volume would be diverted for use at Tacoma's Headworks Dam, although actual use of this Phase 1 water would be at Tacoma's discretion, consistent with the HCP. For purposes of this consultation, NMFS assumes all 20,000 af of water would be diverted for M&I use. However, through its HCP, Tacoma has committed to implementing an instream flow schedule and other measures (Tacoma 2001) that NMFS has determined will protect PS Chinook salmon, PS steelhead, and their critical habitats downstream from Headworks Dam (NMFS 2001). Hence, while the proposed action would allow Tacoma discretion in the diversion of the total volume of AWSP water (up to 20,000 af annually), thereby reducing the water available to augment river flow during adult migration and spawning during the spring and fall, sufficient water would remain instream to meet Tacoma's established instream flow schedule under the HCP. It is likely that demand for M&I water would increase through time as the regional population increases (Tacoma 2014), meaning that less of the AWSP water would remain instream over time. However, both Tacoma's HCP and the ITP relied on release of the entire volume of water stored under the AWSP at Tacoma's discretion and included measures designed to minimize those effects to the maximum extent practicable. Under the Corps' proposed action for this consultation, which does not include fish passage to habitats upstream of HAHD, some actions taken by Tacoma to mitigate the effects of its Second Supply Project (fish passage improvements and habitat improvements made upstream of HAHD) would not be useful to ESA-listed fish because they would not have access to that habitat.

2.4.2.4 General Reservoir and Flow Management

Variations in reservoir storage through the year would affect the extent of inundated riverine habitat. The reservoir extends for about 5 miles from the dam at full pool. Under the proposed operations, inundation would reduce the habitat value of about 5 miles of the Green River upstream of HAHD to PS Chinook salmon and PS steelhead. As there is about 25 miles of the mainstem Green River and many more miles of tributary habitat upstream of HAHD that would be available if safe and effective fish passage was available, the loss of lotic (riverine) fish habitat that would be caused by reservoir inundation would be a small adverse effect of the action. Under the proposed action, project-caused effects on PS Chinook salmon and PS steelhead habitats located upstream of HAHD would be inconsequential because the fish would be denied access to those habitats due to a lack of safe and effective fish passage.

Ramping Rates

The proposed action's effects on lower Green River flows are discussed above in Sections 2.4.2.1 through 2.4.2.3, except as regards ramping rates (the rate of discharge change) which are explained in Section 1.3.4.

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[10] We note that Tacoma has constructed several stream habitat improvements throughout the basin. Only a subset of those habitat improvements were developed as part of Tacoma's sponsorship of the AWSP.

The Corps proposes to operate the project such that the water surface elevation immediately downstream from the dam would not rise faster than 1 foot per hour except during floods. This causes a rapid change in water level, and such rapid increases in discharge would have the potential to displace juvenile fish downstream, particularly young-of-year fish. Such high up-ramping is most likely to occur during the flood season when the Corps discharges stored floodwaters in preparation for the next event. Winter is a period of naturally rapid flow increases throughout the Puget Sound region and rapid increases in river stage are not uncommon. Hence, even though rapid upramping during active flood management operations at HAHD would result in adverse effects on fish rearing in the middle and lower Green River, those effects are likely to be similar to conditions that would exist absent the project. As high up ramping rates would be seasonal, infrequent, and similar to natural conditions, the effects on rearing juvenile salmonids in the middle and lower Green River would be small.

The Corps proposes to manage reductions in discharge in accordance with the highly protective ramping rates as developed by Hunter (1992) and recommended by WDFW (2002) (Table 1). By operating the project within these guidelines, the Corps would minimize the potential for entrapment and stranding of juvenile salmonids in the lower Green River.

2.4.2.5 Water Quality

Temperature

The proposed action would affect water temperature in the Green River as a result of maintaining a reservoir, providing flow augmentation, and gravel nourishment. During the winter and in response to flood operations, there would be a negligible effect on water temperature. During the spring, summer, and fall, the reservoir would alter discharge water temperature relative to the reservoir inflow temperature. (Inflow water temperature would be the same under the proposed action and the environmental baseline condition). The typical pattern would be lower outflow water temperature (compared to inflow temperature) in the spring to midsummer, and then relatively warmer outflow water temperature in the late summer and early fall (Figure 8). These effects are due to the fact that flow is discharged from the bottom of the reservoir which contains a supply of cool water that is eventually depleted as summer progresses.[11] The precise time frame for when these effects would occur is variable depending on weather conditions. Cool spring weather would delay the onset of any temperature deviation between inflow and outflow water temperature. In 2007, cooler outflow (compared to inflow) temperatures began in July (Figure 8). The transition from releasing water colder than dam inflow to releasing water warmer than dam inflow typically occurs sometime in August or September depending on weather and hydrologic conditions. HAHD operations, specifically the maintenance of a reservoir and the low elevation outlet, tend to smooth out the natural intraday and day to day variability in water temperature (Figure 10). This results in relatively constant within-day water temperature released from the dam compared to inflow temperatures, which vary diurnally.

The gravel nourishment project may also affect downstream water temperature by increasing the amount of hyporheic flow in the river.[12] Hyporheic flow has been demonstrated to buffer stream

[11] Cold water is denser than warm water and the coldest water is typically found at the bottom of a reservoir.
[12] The hyporheic zone is defined as a subsurface volume of sediment and porous space adjacent to a stream through which stream water readily exchanges.

temperatures from atmospheric warming (or cooling) and thus decrease the daily maximum and minimums (Burkholder et al 2008, Johnson 2004). Flow augmentation during the summer and fall would also buffer stream temperatures from atmospheric warming by increasing the mass of water subject to heat flux and thus limit daily water temperature variations and decrease daily maximum temperatures during the critical low-flow period.

The proposed action would result in cooler water immediately downstream of HAHD during the early summer. In the late summer and early fall, the proposed action would generally result in warmer water temperature immediately downstream of the dam. However, as the water travels further downstream, it is subject to atmospheric warming (or cooling) and the river would thus heat or cool in response to atmospheric conditions, eventually the river water temperature would be dominated by the heat influences of the air and solar radiation. That is, the influence of project operations on the Green River's water temperature under the proposed action would diminish in the downstream direction.

These changes in water temperature would have both beneficial and adverse effects downstream from HAHD. In particular, the reduction in water temperatures during the early summer would be beneficial to the survival of rearing juveniles of both species, and migrating adult Chinook salmon. The occasional extension of summer warm water conditions into the fall (Corps 2014) could slightly increase pre-spawning mortality and reduces reproductive success. We consider the benefit provided to early summer temperatures to be the larger effect because it occurs during a period of high temperature stress to the fish, and would occur in most years.

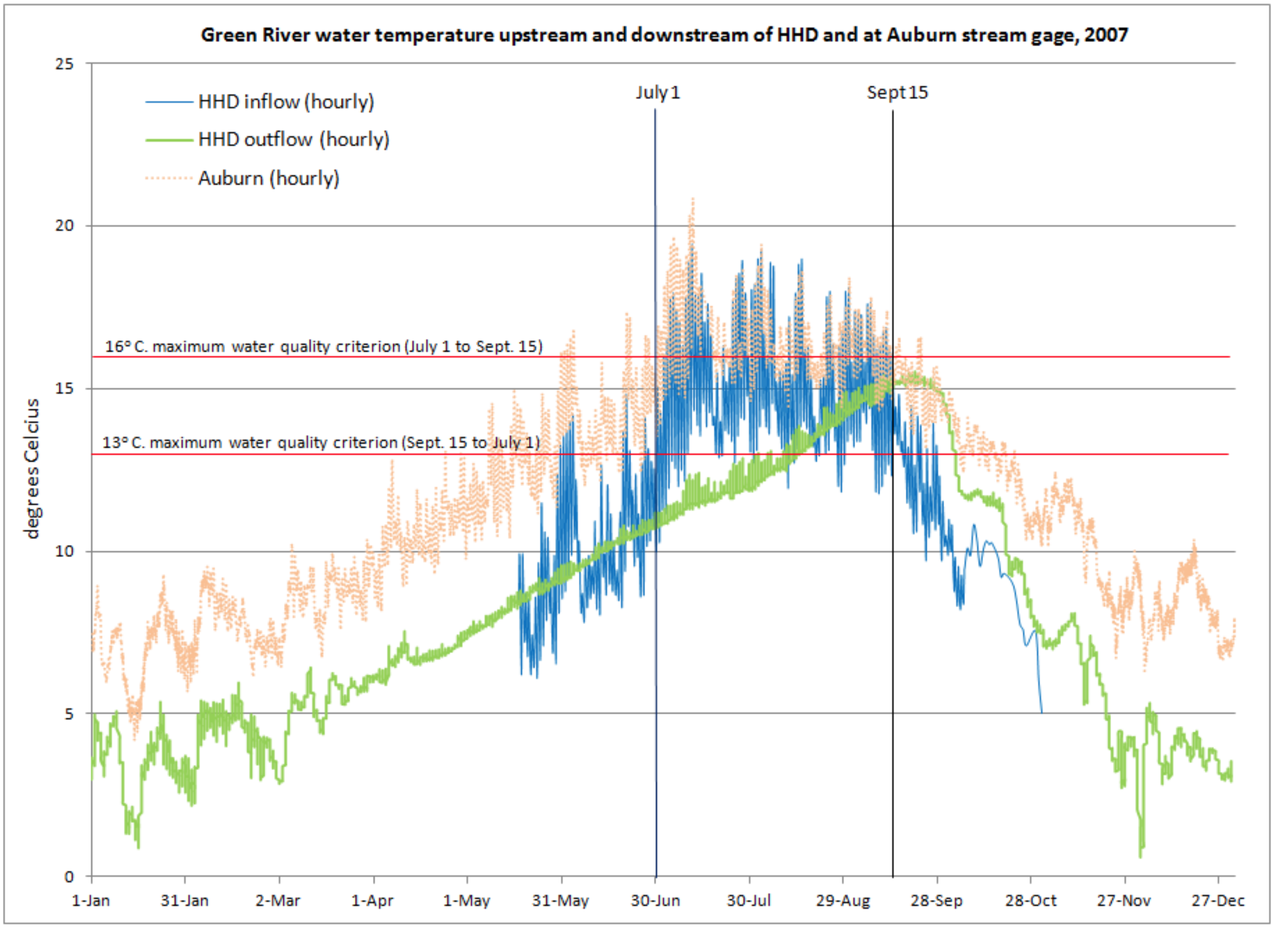

Figure 8. Water temperature measured in 2007 immediately upstream of the HAHD reservoir (HAHD inflow), downstream of HAHD at the tailwater gage (HAHD outflow), and at the Auburn stream gage. Source: Corps 2014Appendix D.

Sediment/Turbidity

The proposed action would affect both the transport of fine sediment and the amount of turbidity in the Green River downstream from HAHD. The transport of fine sediment is predominantly driven by floods. During high flow events, including floods events, HAHD would store turbid inflow waters to reduce the risk of downstream flooding. This would result in some portion of the fine sediment present in the flood waters settling out and remaining behind the dam.

Flood operations would extend the period of time the downstream river is affected by a flood both in terms of flow and turbidity. A theoretical one percent annual chance flood operation would result in a pool behind the dam that would persist for about two weeks. Turbid water would be discharged from the dam for the duration of this two week period. The Corps estimates based on historical data and professional judgement that extreme high water events and operations including debris removal, and maintaining safe conditions could prolong water release up to 60 days (Corps, personal communication). Once floodwaters have been discharged and the reservoir turbidity removed, the continued maintenance of the 'turbidity pool' would generally limit subsequent erosion of flood deposited sediments from behind the reservoir.

The reservoir bed consists predominantly of mud and sand flats that become exposed when the reservoir is low during the late fall and winter to provide flood storage. During this time, rain on the mudflats and moderate to high inflows would re-suspend or erode these sediments, increasing the turbidity in the reservoir. This turbid water would then be released to the river downstream. Historically, the discharge turbidity values this time of year have been relatively low (usually less than 5 NTU, Corps 2014). Releases of substantial quantities of sediment could occur and would harm rearing juveniles of both PS Chinook salmon and PS steelhead and smother incubating Chinook salmon eggs. Such events would be rare and not likely to occur at a greater frequency than caused by natural high flow events. The quantity of sediment that would be transported as a result of the reservoir drawdown in the fall would be negligible relative to that transported/stored in response to flood events, when increased turbidity occurs naturally anyway.

The Corps attempts to maintain the reservoir elevation range of the turbidity pool over time by conducting operations during the early part of the winter season to 1) locate to the extent possible the precise elevation of the turbidity pool, and 2) remove the veneer of fine sediment that has accumulated in the reservoir over the prior year particularly at the lower levels. This is accomplished by lowering the reservoir until a noticeable increase in discharge turbidity occurs.

> "*A review of the most recent five years of data indicated as many as five events that could be directly attributable to reservoir operations occurred in a single year when HAHD discharge turbidity increased when the background turbidity was noticeably lower. The elevated turbidity was due to certain dam safety and maintenance activities described in the BA such as lowering the reservoir in the fall to locate the turbidity pool, low-reservoir dependent inspections and maintenance at the project, and forecasting/human error. Based on this limited review of the historical record, knowledge of dam operations, and best professional judgment, it is predicted that as many as eight such episodes could occur in any one year over the 20 year period of the Biop. Each episode could extend up to 5-days*" (Corps, personal communication).

The Corps conducts a few reservoir maintenance events annually which results in elevated turbidity levels. During those events, turbidity levels generally return to background levels within hours, although it is possible to take a few days to return to background levels. Effects of suspended sediment on ESA-listed fishes could range from behavioral modifications in spawning adults, to lethality for eggs, alevin, fry, or juveniles depending on exposure, intensity, and duration, from smothering, gill damage, and reduced forage capability.

Contaminants

Tacoma evaluates water quality in the Green River at the Tacoma Headworks Dam 3.5 miles downstream from the HAHD reservoir. Recent analysis (12 October 2010) indicates high water quality that meets State and Federal drinking water criteria (TPU 2010, *in* Corps 2014). These data indicate that current HAHD operations do not increase contaminants in the river and because proposed operations would be identical to current operations, negligible levels of contaminants are expected under the proposed action.

2.4.2.6 Deviation from Normal Operations

From time to time, the Corps proposes to deviate from normal project operations for maintenance and inspections of project works, system testing, scientific studies, and search and rescue operations. These operations are undefined at present and their effects unknown. However, to the extent practical, the Corps proposes to coordinate any flow reducing operations with resource agencies. Such operations would be rare and would be coordinated with affected resource agencies. NMFS would agree only to deviations that would be small to negligible over the life of the action.

2.4.2.7 Gravel Nourishment

By annually adding up to 14,000 tons of gravel to the lower Green River, the Corps aims to mitigate the loss of coarse sediment flow through the reservoir. This action would largely, if not entirely mitigate for the reduction in spawning-sized gravels available to spawning PS Chinook salmon and PS steelhead caused by entrapment in the reservoir.

2.4.2.8 Woody Debris Management

Howard Hanson Dam interrupts the flow of LWD from forested areas in the upper watershed to the lower Green River. The substantial benefits to aquatic ecosystems provided by LWD are briefly described in the Environmental Baseline, Section 2.3.2. The disposition of wood received into the reservoir is at least in part governed by agreements between the Corps and Tacoma. A debris salvage plan stipulates that any wood the Corps transports to dry land be made available for a period of 30 days for use by Tacoma. After 30 days, if salvaged wood is not removed it becomes property of the Federal government. Under the AWSP, the Corps and Tacoma agreed that the Corps would be responsible for transporting 50% of large wood received in the reservoir to the downstream river (Tacoma and the Corps 2003, Corps 2001 *in* Corps 2014). By stockpiling collected woody debris in the reservoir and distributing LWD to the middle Green River and making it available for habitat improvement projects in the Green River, the proposed action would minimize the project's adverse effect of trapping incoming LWD. Adding LWD to the Green River downstream from HAHD would increase habitat complexity, benefitting both juvenile and adult Chinook salmon and steelhead.

2.4.2.9 Reservoir Habitat Stewardship Activities

The Baldi floating boom, located in Eagle Gorge reservoir, is a log boom/log storage facility along the reservoir margin that provides shade and hiding cover to aquatic species in the reservoir. This habitat stewardship project would provide modest habitat benefit to rearing juvenile salmon and steelhead if it were accessible. Under the proposed action, the Corps would not provide safe and effective fish passage, precluding anadromous fish use of habitats located upstream of HAHD. For this reason, this facility would be of no value to PS Chinook salmon or PS steelhead. Other reservoir habitat stewardship projects that would be maintained under the proposed action are designed for terrestrial or avian species. Improving habitats for fish-eating birds like bald eagles and ospreys is expected to increase their numbers in the watershed, thereby increasing foraging on juvenile anadromous salmonids. Given the small size of these improvements in bird habitat and the correspondingly small increases in fish-eating bird abundance they are likely to provide, the likely effect of this action on PS Chinook salmon and PS steelhead would be negligible.

2.4.3 Effects on Puget Sound Chinook salmon

Green River Chinook salmon is the largest of the Central/South Puget Sound Major Population Group of Chinook salmon, making its survival and recovery essential to the survival and recovery of the ESU.

2.4.3.1 Adult Migration Spawning and Incubation

Blocked Access to Upstream Habitat
Under the proposed action, there would be no downstream passage facility at HAHD and thus, as in the past, no upstream passage would occur either, regional fish managers would not allow adult PS Chinook salmon trapped at the Headworks Dam to be transported to release sites upstream of the dam. About 40% of the suitable and historical Chinook salmon spawning and rearing habitat in the Green River basin is located upstream of HAHD and would remain unused. The Chinook salmon habitat upstream of HAHD has been degraded by past forest practices. However, that habitat is now covered by several HCPs, the Northwest Forest Plan, Washington's Forests and Fish Law and several agreements between Tacoma and landowners aimed at protecting water quality, meaning that this habitat is improving, while the habitat downstream of HAHD is likely to continue degrading. Under the proposed action, fish access would be limited to habitat downstream of Headworks Dam for spawning and rearing. This habitat would be affected by the proposed action, including decreased seasonal flows from mid-February to June, and reduced recruitment of spawning-sized gravels and woody debris. Thus, the proposed action would substantially limit the abundance of Green River Chinook salmon by preventing egress from high quality habitat upstream of HAHD, thereby effectively preventing use of the upstream spawning and rearing habitat.

HAHD prevents bedload gravel from being passed downstream. Bedload settles out in the upper end of the reservoir where the velocity drops and tractive force declines. The Corps has been augmenting the gravel supply downstream of HAHD and Tacoma's Headworks Dam since 2003 and proposes to continue doing so. There are two designated gravel augmentation sites near RM 60. Up to 14,000 tons of gravel would be added annually, depending on hydrologic and spawning habitat conditions to provide gravel for spawning each year. The quantity, size gradation, and timing have been adjusted since 2003 to maximize spawning benefits and minimize adverse effects. The gravel would be placed on the site, and naturally occurring high winter stream flows, to the extent allowed by the Corps, would mobilize and move it downstream. This process has been managed to reduce the likelihood of creating waves of unstable gravel migrating downstream, which appeared to occur when gravel nourishment initially began.

This action would increase the supply of suitable spawning gravel in the reach between the gravel nourishment site at RM 60 (downstream from Headworks Dam) and the upstream end of the Green River Gorge, an area that is heavily used by spawning Chinook salmon. Gravel that would move downstream into the gorge would become dispersed by river flow, and it is not possible to estimate the extent that it would contribute to spawning habitat therein or further downstream.

Flood control operations would have positive impacts on incubation, but some associated negative effects to habitat. The Corps would attempt to limit high flows to 10,000 cfs (at Auburn) on the ascending limb of a flood and 12,000 cfs once the flood is in recession. These peak flow reducing actions would benefit PS Chinook salmon by reducing flood scour of incubating redds, but would also deny the flows necessary to channel forming and maintenance processes (Swanston 1991) that are characteristic of good salmon habitat.

2.4.3.2 Juvenile Rearing and Outmigration

During winter flood risk management actions, HAHD would store water and a portion of incoming sediments. The reduction in peak flows downstream from the dam would benefit rearing juvenile Chinook salmon and steelhead by reducing displacement and the potential for injury. Reducing peak flows may slightly increase the travel time for outmigrating smolts, but given the fairly short distance traveled, that effect is likely to be negligible.

Upstream of HAHD, the largest effect of the proposed action for juvenile rearing and outmigration would be the unsafe and ineffective downstream passage. Without effective smolt passage at HAHD, fisheries managers including NMFS, would continue to not allow adult Chinook salmon and steelhead, trapped at Headworks Dam to be transported upstream of HAHD. That would prevent use of about 40% of the suitable Chinook salmon spawning and rearing habitat. Salmon habitat has a finite carrying capacity, and by not providing safe and effective downstream passage, the proposed action would effectively reduce potential Green River Chinook population abundance by about 40%. This would be a major impact to the potential abundance and productivity of the Green River population of PS Chinook salmon. The additional habitat is essential to producing more Chinook salmon and increasing their abundance. Increasing the abundance of the Green River population of PS Chinook salmon is necessary to improve the viability of the population and increasing the viability of the PS Chinook salmon ESU. The lesser quantity of habitat downstream of HAHD would necessarily produce many fewer Chinook salmon than would be produced if the entire Green River basin was accessible.

Spring refill at HAHD would cause a reduction in spring river flow and adversely affect juvenile Chinook salmon rearing habitat and smolt out-migration rates downstream from HAHD. Under natural river conditions, higher spring flows would inundate more stream margin and off-channel habitat, increasing the quantity and quality of rearing areas for juvenile Chinook salmon. Higher flows during the spring out-migration and their typically associated greater turbidity (Gregory 1993) would reduce smolt travel time and predation rates, thereby increasing smolt survival and subsequent adult abundance.

The Corps regulates upramping rates (increases in discharge) flows to allow no more than 1 ft/hr increase in river stage except during flood conditions. The reason is for safety to downstream river users. Upramping generally has negligible adverse effects on fish.

While rapidly reducing discharge can cause entrapment (trapped in pools and side channels) and stranding (left high and dry) of fish, particularly juveniles, HAHD discharge reductions would follow Washington's downramping guidelines (Hunter 1992) at discharge rates less than 1,500 cfs (see downramping explanation at Section 1.3.4) to minimize the entrapment and stranding of juvenile salmon and steelhead downstream. This would minimize the adverse effects of downramping-caused entrapment and stranding on juvenile Chinook survival.

2.4.3.3 Summary of effects on PS Chinook salmon

By providing only ineffective and unsafe downstream passage, the proposed action would prevent PS Chinook salmon access to 40% of their historic spawning and rearing habitats upstream of HAHD, and would thereby greatly reduce the potential abundance, productivity, and spatial diversity of the Green River population of PS Chinook salmon. Production would be limited to habitats downstream from HAHD, much of which are degraded and likely to degrade further in the future.

We estimate the action's effects on the number of adult Chinook salmon returning to Puget Sound annually. Based on the recent average escapement, the number of returning adult Chinook salmon that reach the Green River could grow to 2,147 natural origin spawners, an increase of 859 NOR spawners over the recent 5-year average abundance. [13] However, not all outmigrating juveniles would survive. Experience has shown that a well-designed and properly functioning juvenile collection and passage system in storage reservoirs similar to Eagle Gorge reservoir can safely collect and pass about 75% of the fish entering the reservoir. Assuming 75% of the annual production upstream from HAHD would survive passage and be recruited into the adult population were safe and effective downstream passage provided, we estimate that an additional 644 natural origin spawners would return to the Green River from production areas upstream of HAHD. Adding the potential production from the upper Green River to the 1,288 spawners returning from production downstream from HAHD gives a total Green River escapement of 1,932 natural origin spawners returning to the Green River. About 36% of the Chinook salmon returning to the Green River are harvested.

Spring refill would decrease flows in the middle and lower Green River, adversely affecting juvenile outmigrant survival. Summer flow augmentation would benefit rearing juveniles by increasing the amount of suitable habitat. The proposed action would also benefit rearing juveniles by slightly reducing summer water temperatures downstream from HAHD. However, the vast majority of Chinook salmon juveniles in the Green River outmigrate as fry, prior to July 1 and would not benefit from summer flow augmentation, or reduced water temperatures. Flood control operations would reduce redd scour, improving the survival of incubating eggs and pre-emergent fry.

Turbidity plumes from reservoir maintenance, as described in 2.4.2.5 could adversely impact incubating eggs, alevin, or rearing juvenile fish. Sediment deposition in redds could smother

[13] This estimate is based on the most recent 5-years of adult escapement. The Green River population of PS Chinook is severely depressed in abundance and productivity and were we to consider the population to be at its carrying capacity of 22,000 returning adults, our estimate of the effect of lost access to the upper watershed would be around 9,000 adults.

incubating eggs and alevin, and emerged fry or juveniles could suffer suffocation, gill damage, and/or reduced foraging capabilities.

2.4.3.4 Puget Sound Chinook Salmon Designated Critical Habitat

The PBFs of critical habitat for PS Chinook salmon that occurs within the action area for this consultation are "freshwater spawning sites, incubation, and larval development, rearing sites, and migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival" (McElhany et al. 2000). Project effects on freshwater juvenile and adult migration corridors including obstructions, predation, and water quality and quantity are summarized in Table 12. Although Puget Sound is within the action area, PS Chinook salmon critical habitat within Puget Sound is unaffected by the proposed action because project effects are attenuated before reaching the confluence of the Duwamish River with Puget Sound.

Storing flood water would decrease peak flow events downstream of HAHD from mid-October through April improving spawning and egg incubation habitat by reducing redd scour. Redd scour is a major factor limiting Chinook salmon egg to smolt survival (Zimmerman 2010). Reducing redd scour would significantly benefit incubating eggs and alevins because much of the Chinook salmon spawning habitat occurs in areas of incised channels, or between the downstream streambank levee system that, by design, does not allow much over-bank distribution of high flows. By trapping bedload sediments, winter non-flood operations would reduce spawning-sized sediments downstream from HAHD, reducing the extent of spawning habitat. By augmenting gravel downstream from the project, the Corps would partially mitigate this effect.

Table 12. Project effects on PS Chinook salmon critical habitat

PBF	Project effect
Support spawning, incubation, and larval development.	Flow supplementation would improve spawning, and winter peak flow reduction would increase incubation survival by reducing redd scour.
Freshwater rearing sites with: (i)Water quantity and floodplain connectivity; (ii)Water quality and forage (iii)Natural cover, shade, submerged and overhanging wood, log jams, etc.	The action area contains a mix of connected and mostly unconnected floodplain. The proposed action would continue existing conditions and effects, including blocking passage to 40% of suitable Chinook salmon habitat. The proposed action would have the potential to release suspended sediment to the downstream river channel and cause a temporary increase in turbidity, negatively affecting Chinook salmon survival. This impact is primarily limited to longer exposure to high turbidity resulting from delayed release of flood waters. Water quality and quantity would be positively affected by flow augmentation and reduced temperatures. Wood and log jams below HAHD would be improved by the project,
Freshwater migration corridors free of obstruction and excessive predation.	HAHD would block upstream and downstream fish passage. Juvenile downstream migration downstream of HAHD would be compromised by reduced spring flows while water is being stored for later use.
Estuarine, nearshore marine & offshore marine areas.	Would be unaffected by the proposed action.

Spring refill would adversely affect the downstream migration route of juvenile Chinook salmon smolts by reducing project discharge. Lower water is usually clearer and of slower velocity. Clearer and slower water facilitates higher predation, lowering the number of smolts that survive to reach the estuary (Gregory 1993, Gregory and Levings 1998, Smith et al. 2003), however, redd scour reduction is expected increase egg to fry survival that will ensure migrant juvenile numbers do not decline as a result of this effect.

The 24,200 af of fish conservation water provided under the original HAHD authorization and the additional 5,000 af stored under the Section 1135 program would be used to augment low summer flows. This would increase rearing habitat for the small proportion of Green River Chinook salmon that are stream-type and rear in freshwater for an extended period of time, up to one year. The vast majority of Green River Chinook salmon are ocean-type and rear in the river for a short time, three to six months. The summer conservation flow primarily benefits adult Chinook salmon in their upstream migration by increasing the water flow and slightly decreasing the water temperature. The summer conservation flow enhances the upstream migration route of adult Chinook salmon. Although not specifically a part of the Corps' proposed action, Tacoma's agreement to meet specific instream flows downstream from its Headworks Dam was facilitated by the AWSP, which is a partnership project between the Corps and Tacoma. This measure substantially improved the surety that Chinook salmon spawning and rearing habitats in the middle and lower Green River would be protected.

Storing water for Tacoma's use under the AWSP (up to 20,000 af annually) would occur as part of spring refill operations and would contribute to the same effects as described for other aspects of spring storage at HAHD; reducing rearing habitat for PS Chinook salmon. Tacoma mitigates for the impacts of AWSP water storage under its separate HCP through its commitment to an instream flow schedule downstream from Headworks Dam, development of fish passage improvements, and habitat improvements both upstream and downstream of HAHD. However, Tacoma's fish passage system and those habitat enhancement measures located upstream of HAHD would not benefit ESA- listed PS Chinook salmon because under the proposed action unsafe and ineffective fish passage at HAHD would preclude fish passage and access into the upper Green River basin.

As described above in Section 2.4.2.3, under the proposed action, up to 20,000 af of AWSP storage would be discharged from HAHD and it is anticipated that this volume would be diverted for use at Tacoma's Headworks Dam, although actual use of this Phase 1 water would be at Tacoma's discretion, consistent with the HCP. Over time, this would reduce instream flows downstream from Headworks Dam from June through October as Tacoma's demand for potable water increases compared to current operations. The reduction of flows resulting from diversion of 20,000 af of water would reduce Chinook salmon rearing, migration, and spawning habitats downstream from Headworks Dam. While Tacoma developed measures to offset these effects in its HCP (Tacoma 2001) and has since implemented them, under the proposed action those measures associated with fish passage and fish habitat upstream of HAHD would have no value to PS Chinook salmon in the Green River because the lack of safe and effective downstream fish passage at HAHD would preclude their use.

Downramping in compliance with the Washington State guidelines would beneficially stabilize juvenile Chinook salmon fry rearing habitat and reduce the incidence of fry stranding (Refer to fry stranding explanation at Section 1.3.4.). Gravel augmentation would increase the amount of suitable Chinook salmon spawning habitat in the reach between Tacoma's Headworks Dam and the upper end of the Green River Gorge.

2.4.3.5 Summary of Effects on PS Chinook Salmon Critical Habitat

By controlling peak flows, the project would benefit PS Chinook salmon critical habitat in the middle and lower Green River by reducing redd scour. It would also slightly reduce channel complexity. This channel simplification would slightly reduce spawning and juvenile salmon rearing habitats. We consider the benefits of peak flow reduction operations at HAHD (reduced redd scour) to be a substantially larger effect on PS Chinook salmon critical habitat than the adverse effect of channel simplification. Passing woody debris and gravel augmentation would partially mitigate the effects of woody debris and sediment capture in HAHD. Limiting downramping rates would protect PS Chinook salmon fry from stranding mortality. Spring storage would reduce juvenile rearing habitat in the middle and lower Green River. Releasing stored water from HAHD during the summer and fall months would increase habitat for stream-type juvenile Chinook salmon and for migrating adult Chinook salmon. It is unlikely that the proposed action would have any effect on the conservation value of critical habitats in the estuary or nearshore marine environments because project effects are attenuated by the time the river meets the estuary. Most significantly, HAHD would substantially impact PS Chinook salmon critical habitat by precluding access to 40% of their historical habitat located upstream of HAHD.

2.4.4 Effects on Puget Sound Steelhead

The Green River steelhead population is the largest of the Central/South Puget Sound Major Population Group of steelhead, making its survival and recovery essential to the survival and recovery of the DPS.

2.4.4.1 Adult Migration, Spawning and Incubation

Reduced flows downstream from HAHD during spring storage operations would adversely affect adult steelhead migration and spawning. Water storage for the AWSP, Section 1135, and fish conservation water begins in February and continues until June generally. This time period includes most of the adult steelhead migration period and nearly all of the spawning season. Storage would continue to take a percentage of the total incoming flow, leaving instream flow downstream of HAHD sufficient to meet adult steelhead migration and spawning requirements.

HAHD would preclude fish passage to historical habitat upstream of the dam. The habitat downstream of HAHD is not sufficient in size or quality to support the numbers of fish needed to prevent extirpation of the population, the major population group of central and south Puget Sound, and the Puget Sound steelhead DPS. The steelhead habitat upstream of HAHD has been degraded by previous forest practices. However, all of that remaining habitat is now covered by several HCPs, the President's Forest Plan, and the Forests and Fish, Washington's state forest practices act, and Tacoma's agreements with landowners in the upper basin aimed at protecting water quality, meaning that this habitat is improving, while the habitat downstream of HAHD will either stay the same, or continues to be degraded, rendering it unable to achieve the requisite increased steelhead abundance, productivity, and spatial diversity necessary for a viable population.

By providing unsafe and ineffective downstream passage at HAHD, the proposed action would preclude use of the existing upstream passage system, thereby denying access to about 50% of the historical upstream suitable spawning and rearing areas for PS steelhead in the Green River basin. Considering the ongoing incremental degradation of suitable habitat in the lower and middle Green River, lack of access to the upper Green River can be expected to appreciably limit abundance of the population due to the limited quantity and quality of available habitat. This major impact to habitat connectivity would limit the abundance and viability of the Green River DIP because the population is extremely depressed within the confines of currently accessible habitat. Green River steelhead inhabit all of the action area downstream of Headworks dam. Continued operation and maintenance of HAHD would negatively affect PS steelhead by blocking downstream passage, constraining spawning and rearing to just that habitat in the areas located downstream from Tacoma's Headworks Dam. Steelhead spawning habitat in the middle and lower Green River basin is limited, degraded, and is subject to further degradation through urbanization. By contrast, steelhead spawning habitat in the upper Green River watershed is improving and protected from substantial new development. Because habitat quality in the upper Green River watershed is higher and more secure than habitat downstream from HAHD, the proposed action's lack of safe and effective fish passage would reduce the potential abundance of PS steelhead in the Green River by more than half.

Spawning and incubating steelhead would benefit from the Section 1135 flow augmentation program. The Corps, in cooperation with the GRFMCC would allocate water in the early summer to augment flows for steelhead egg incubation and alevin survival as the higher flows of spring runoff taper toward summer base flows. This allocation of water has been shown to be effective in protecting established steelhead redds and would likely continue under the proposed action.

Operating the project would reduce bedload sediment transport, thereby reducing the amount and quality of spawning habitat and steelhead spawning success. The Corps' gravel augmentation program largely mitigates for this effect.

Turbidity plumes from reservoir maintenance, as described in 2.4.2.5 could adversely impact juvenile fish through suffocation, gill damage, and/or reduced foraging capabilities. This operation typically occurs outside of steelhead spawning and egg incubation periods and therefore is limited to rearing juvenile fish.

2.4.4.2 Juvenile Rearing and Outmigration

Because steelhead juveniles rear in the Green River for at least one year, rearing juvenile steelhead in the middle and lower Green River would benefit from reduced peak flows. They would be less likely to be displaced from their over-wintering habitat in the mainstem river channels, so over-winter survival would be higher than it would be without peak flow reduction. They would also benefit from summer and early fall flow augmentation as it would provide additional suitable habitat area, and would also reduce summer water temperatures.

Steelhead smolts outmigrate during the spring, when the Corps would refill the HAHD reservoir. By placing inflowing water into storage, project discharge would be reduced. Reducing flows reduces water velocity which increases travel time for smolts, and is usually correlated with increased water clarity, which leads to higher predation rates (Gregory 1993, Gregory and Levings 1998). Reduced flows would also reduce the rearing habitat available to juvenile steelhead at a time when two year classes of steelhead, young of the year and yearling fish, would be actively foraging, reducing the space and food available to rearing juveniles. The reduced space and food would limit steelhead abundance.

Rapid flow reductions have the potential to entrap and strand rearing juveniles downstream from HAHD. By following Washington's downramping guidelines (Hunter 1992)(see Section 1.3.4) designed to minimize the downstream stranding of newly emergent juvenile salmon and steelhead, the proposed action would minimize such effects.

Under current operations, as described in the environmental baseline, natural resource benefits are accrued through the use of up to half of the water stored under the AWSP (10,000 af annually) in the form offlow augmentation. The Corps' SBA (COE, 2014) states, and the NMFS assumes that, as part of the proposed action, up to the entire volume of water stored under the AWSP and discharged from HAHD, would be diverted by Tacoma (up to 20,000 af annually), thereby reducing streamflows downstream from Headworks Dam, meaning that over time, the benefits of the AWSP to juvenile PS Chinook salmon and PS steelhead rearing downstream from HAHD would decline. Effects of this diversion was considered in Tacoma's HCP.

Later in the season, the Corps, in cooperation with the GRFMCC, would allocate remaining water to augment fall Chinook salmon migration and spawning flows, which also increases rearing habitat for juvenile steelhead at a season when habitat is limiting to the population. The lower Green River can experience high water temperatures during August-September. High water temperatures can cause low growth rates, increase the virulence and infectivity of fish diseases, and cause death. Water temperatures tend to be lower at higher flows, so increasing late summer streamflow improves habitat quality and the capacity of the lower river to support steelhead.

Operating the project would reduce the transport of LWD from the upper watershed to the middle and lower Green River. Woody debris creates velocity and hiding cover for juvenile steelhead and by reducing the amount of LWD in the middle and lower Green River the project reduces juvenile steelhead survival. However, by collecting and moving LWD that enters Eagle Gorge reservoir to release sites downstream from Headworks Dam, the proposed action would minimize this effect.

The lack of safe and effective downstream juvenile fish passage at HAHD would prevent the placing of steelhead into habitats upstream from HAHD. As 50% of the suitable steelhead habitat in the Green River basin lies upstream of HAHD, poor juvenile passage would substantially reduce the potential abundance, productivity and spatial distribution of the Green River steelhead population.

2.4.4.3 Summary of Effects on PS Steelhead

The proposed action would preclude passage at HAHD. Considering the ongoing incremental degradation of suitable habitat in the lower and middle Green River reaches, lack of access can be expected to appreciably limit the viability of the population. This gradual attrition of habitat and habitat productivity in the lower and middle Green River would result in decreased abundance of Green River steelhead, and the Central/South Puget Sound major population group.

Other effects are:

- Spring refill reduces spring river flow, juvenile steelhead rearing habitat, and outmigration survival.
- Summer conservation, Section 1135, and water stored per the AWSP augments low flows and increases juvenile survival.
- Gravel augmentation partially mitigates for the loss of sediment migration due to HAHD, providing an increase of suitable spawning habitat thereby increasing spawning success.
- LWD supplementation downstream of HAHD partially mitigates the loss of natural LWD migration caused by HAHD, and helps increase river channel complexity, slightly increasing juvenile rearing habitat and adult holding habitat, thereby reducing the project's effects on juvenile and adult survival.

- Turbidity plumes resulting from reservoir maintenance could cause suffocation, gill damage, and/or reduced foraging for eggs and young fish.

2.4.4.4 Puget Sound Steelhead Critical Habitat

NMFS designated critical habitat for PS steelhead on February 24, 2016 (NMFS 2016). The designated critical habitat includes all occupied habitat in the Green River basin, including the habitat upstream of HAHD that would be accessible if safe and effective passage were provided.

The PBFs that must be protected within the action area for this consultation are "freshwater spawning sites, incubation, and larval development, rearing sites, and migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival" (70 FR 52630 – 52858, September 2, 2005). None of the critical habitat for PS steelhead located upstream of HAHD is currently accessible to steelhead. Project effects on the PBF's of steelhead critical habitat are summarized in Table 13.

Table 13. Project effects on PS steelhead critical habitat in Green River basin.

PBF	Project effect
Support spawning, incubation, & larval development.	Spring storage would reduce streamflows downstream from HAHD during the steelhead spawning season, reducing spawning success. Adaptive management of refill operations and subsequent flow augmentation, incorporating salmon interests, would reduce this effect. Episodic releases of fine sediment accumulated in Eagle Gorge reservoir would increase the embeddedness of downstream spawning gravels, reducing available spawning habitat but primarily during flood events when turbidity levels increase naturally. Turbidity levels remain high however, for a longer period due to flood control efforts releasing flood waters over a longer period of time and increasing the duration of exposure. Overall the proposed action would modestly reduce the conservation value of PS steelhead spawning habitat downstream from HAHD. By preventing access to and use of spawning and incubation habitat located upstream of HAHD, the proposed action would eliminates the conservation value of that habitat.
Freshwater rearing sites with: (i)Water quantity and floodplain connectivity; (ii)Water quality and forage (iii)Natural cover, shade, submerged & overhanging wood, log jams, etc.	Peak flow reduction would reduce channel complexity downstream from HAHD thereby reducing the amount and quality of juvenile rearing habitat downstream from HAHD. By augmenting flows from June through October, the proposed action would improve summer water quantity and quality, and water temperature. By capturing LWD in Eagle Gorge reservoir the proposed action would reduce LWD-based habitats downstream from HAHD.
Freshwater migration corridors free of obstruction and excessive predation.	HAHD would block passage, thereby preventing use of the habitat as a migration corridor. This lack of access eliminates the conservation value of all critical habitat located upstream of HAHD.
Estuarine, nearshore marine & offshore marine areas.	No project effect on these has been identified.

Steelhead habitats downstream from HAHD would be both beneficially and adversely affected by the proposed action. Peak flow reduction would limit channel complexity, reducing juvenile rearing habitat. The capture of coarse sediment and woody debris that enter Eagle Gorge reservoir would be adverse to spawning and rearing habitats, but these effects would be reduced by the proposed gravel augmentation and woody debris management programs. The reduction in spring flows associated with project refill would adversely affect adult migration corridor and spawning habitat, but these effects would be reduced through adaptive management of refill operations.

By storing water during steelhead spawning and incubation the proposed action would have the potential to cause redd dewatering, killing eggs and alevins, thereby reducing spawning success. This adverse effect on steelhead spawning habitat and spawning success would be largely offset by adaptive management of refill operations in cooperation with the GRFMCC and subsequent flow augmentation. By reducing channel complexity, continued flood flow reduction would slightly reduce downstream spawning habitat.

HAHD and Eagle Gorge reservoir would trap coarse sediments, depriving the middle and lower Green River of spawning gravels. The Corps has been augmenting the gravel supply since 2003 and would continue to do so under the proposed action, largely mitigating this adverse effect. This action would largely but not wholly offset the effects of sediment capture in Eagle Gorge reservoir on steelhead spawning habitat downstream from HAHD. The proposed action would slightly reduce steelhead spawning habitat value downstream from HAHD.

HAHD would interrupt the flow of large woody debris down the Green River. The Corps would collect LWD from the reservoir. Under the proposed action the Corps would transport some of the large wood captured in the reservoir, to the gravel nourishment site downstream from HAHD where it would be moved by the river during high flows. Other wood from upstream would be allocated to Tacoma's for its HCP, and some would be allocated to various habitat priorities and cultural uses by the MIT.

A number of habitat restoration projects using LWD have been constructed by Tacoma upstream of HAHD, which would not be useful to anadromous fish, including Green River steelhead because the proposed action would prevent their access to this habitat. Under the proposed action, only the LWD that is transported downstream of HAHD would benefit Green River steelhead. Habitats and habitat improvements made upstream of HAHD would provide no benefit to ESA-listed fish because the proposed action would block passage to these habitats.

One of the primary effects of the proposed action on steelhead critical habitat would be the obstruction of migration corridors. The very ineffective and unsafe downstream passage would effectively preclude adult passage to upstream and headwater areas where 50% of the suitable steelhead spawning and rearing habitat would otherwise be available.

Additionally, the proposed action would result in reduced spring rearing and smolt migration flows (adverse) and mitigated by increased summer rearing flows (beneficial).

2.4.4.5 Summary of Effects on PS Steelhead Critical Habitat

PS steelhead critical habitat would benefit more from peak flow reduction than it would lose because the flooding effect of juvenile displacement is worsened by downstream levees through increased water depth and velocity. While peak flow reduction would reduce channel complexity and associated spawning and rearing habitats, those effects would primarily affect channel morphometry in the middle Green River. The lower Green River is heavily armored with levees, severely limiting channel complexity. Due to the limited areal extent of the effect and the tendency for steelhead to spawn in tributaries as well as the Green River proper, the channel simplifying effects of the proposed action are expected to have small effects on spawning and rearing habitats in the middle Green River. Passing woody debris and gravel augmentation would partially mitigate the effects of their capture in Eagle Gorge reservoir on juvenile and spawning habitat downstream from HAHD, respectively. Limiting downramping rates would protect PS steelhead fry from stranding mortality, minimizing the proposed action's effects on rearing habitat from downramping. Spring storage would reduce juvenile rearing habitat in the middle and lower Green River. It is unlikely that the proposed action would have any effect on the conservation value of critical habitats in the estuary or nearshore marine environments because project effects are attenuated by the time the river meets the estuary. And most significantly, HAHD adversely modifies PS steelhead critical habitat by precluding access to 50% of the historical steelhead habitat in the basin.

2.4.5 Southern Resident Killer Whales

The best available information indicates that salmon are the primary prey of Southern Residents throughout the year and that the whales predominantly consume Chinook salmon, including PS Chinook salmon. PS steelhead likely make up only a small part of their diet, therefore this section focuses on the effects of the proposed action on the availability of their primary prey, Chinook salmon, in the action area. Based on coded wire tag recoveries, PS Chinook salmon stocks are available to Southern Residents in the whales' designated critical habitat and in a portion of their coastal range, from the mouth of the Strait of Juan de Fuca to the southern west coast of Vancouver Island (Weitkamp 2010). The proposed action has the potential to affect Southern Residents indirectly by reducing availability and inhibiting recovery of Chinook salmon. A decrease in the availability of salmon, and Chinook salmon in particular, may adversely affect the entire DPS of Southern Resident killer whales. In this analysis, NMFS considers effects of the proposed action on the Southern Residents by qualitatively evaluating the reduction of prey availability caused by the action.

We rely on the salmon determinations (as described in the subsequent sections: Integration and Synthesis Section 2.6.1 and Conclusions Section 2.7.1) to evaluate if the proposed action will appreciably reduce the likelihood of survival and recovery of the Southern Residents in the long term. Our analysis focuses on the short, and long-term reductions in Chinook salmon available to the whales as a result of the proposed action described in the opinion. Below we discuss the effects from (1) the short-term reduction in the abundance of Green River Chinook salmon during completion of downstream passage, (described above in Section 2.4.3 Effects on Puget Sound Chinook), and (2) the long-term appreciable reduction in the likelihood of survival and recovery of PS Chinook salmon.

Short-Term Effects on Southern Residents

As described above, the lack of safe and effective downstream passage at HAHD would prevent adult Chinook salmon from use of 40% of the basin's habitat suitable for spawning and rearing upstream of HAHD, substantially limiting the potential size of the population. Similarly, juvenile dam passage survival potential would be very low because there would be no downstream passage facility. Puget Sound Chinook salmon generally, and Green River Chinook salmon in particular, have suffered substantial population declines in recent years. By blocking migration for Chinook salmon, the proposed action would hold production to numbers that are low and likely to get lower since habitat and water quality downstream of HAHD is reasonably certain to continue to degrade. This was based on 2003 data of 1,288 natural origin spawners (in 2017, there were 2,011 natural origin spawners), however, the Green River population and the entire PS Chinook salmon ESU has been declining in abundance and the potential abundance of Chinook salmon in the Green River is substantially larger. This means that our estimate of effects of the action on the prey available to Southern Residents is low and the effect is likely larger than our estimate. For example, if we used larger abundance data from prior to 2005 (e.g. 1967 - 2005), the estimated effect of the action would be substantially larger (about 3 times as large).

Given the total quantity of prey available to Southern Resident killer whales throughout their range numbers in the millions, the annual reduction in prey from the proposed action is extremely small. Therefore, NMFS anticipates that the short-term reduction of Chinook salmon would have little effect on Southern Resident killer whales.

Long-Term Effects of the Action on Southern Residents
NMFS qualitatively evaluated long-term effects on the Southern Residents from the anticipated reduction in PS Chinook salmon (as described in the subsequent sections: Integration and Synthesis Section 2.6.1 and Conclusions Section 2.7.1). We assessed the likelihood for localized depletions, and long-term implications for Southern Residents' survival and recovery, resulting from the proposed action presenting risks to the continued existence of PS Chinook salmon and reducing the ability for the population to expand and increase in abundance. In this way, NMFS can determine whether the reduced likelihood for survival and recovery of prey species is also likely to appreciably reduce the likelihood of survival and recovery of Southern Residents.

To determine the effect on SRKW and SRKW critical habitat, we rely on the estimate of the action's effects on the number of adult Chinook salmon returning to Puget Sound annually where they would be available as prey to Southern Residents (presented above). Based on the recent average escapement, the number of returning adult Chinook salmon that reach the Green River could grow to 2,147 natural origin spawners, an increase of 859 NOR spawners over the recent 5-year average abundance. [14] However, not all outmigrating juveniles would survive. Experience has shown that a well-designed and properly functioning juvenile collection and passage system in storage reservoirs similar to Eagle Gorge reservoir can safely collect and pass about 75% of the fish entering the reservoir. Assuming 75% of the annual production upstream from HAHD would survive passage and be recruited into the adult population were safe and effective downstream passage provided, we estimate that an additional 644 natural origin spawners would return to the Green River from production areas upstream of HAHD. Adding the potential production from the upper Green River to the 1,288 spawners returning from production downstream from HAHD gives a total Green River escapement of 1,932 natural origin spawners returning to the Green River. About 36% of the Chinook salmon returning to the Green River are harvested, meaning that a total of about 3,019 fish originating in the Green River watershed, on average over the past 3 years have been available in Puget Sound as prey for Southern Residents.

As described above, Green River Chinook salmon is the largest of the Central/South Puget Sound Major Population Group of Chinook salmon, making its survival and recovery essential to the survival and recovery of the PS Chinook salmon ESU. The lack of access to the upper Green River due to the proposed action can be expected to appreciably reduce the likelihood that the Green River population would achieve viability. This threatens the survival and recovery of the

[14] This estimate is based on the most recent 5-years of adult escapement. The Green River population of PS Chinook is severely depressed in abundance and productivity and were we to consider the population to be at its carrying capacity of 22,000 returning adults, our estimate of the effect of lost access to the upper watershed would be around 9,000 adults.

Central/South Puget Sound Major Population Group, and ultimately the PS Chinook salmon ESU (see Section 2.6.1).

Based on the best available data, the PS Chinook salmon are an important part of the whales' diet. A reduction in prey in their designated critical habitat from the proposed project would occur over time as abundance declines for PS Chinook salmon. Hatchery programs, which account for a large portion of the production of this ESU, may provide a short-term buffer, but it is uncertain whether hatchery-only stocks could be sustained indefinitely. The effect of blocking adult migration to the upstream habitat is that the potential natural origin population size is limited. As described above in the section on effects on PS Chinook salmon, 60% of the historical spawning habitat below HAHD is not sufficient to produce the numbers of fish needed to achieve a highly viable population. Viability at the population level is a foundational necessity for PS Chinook salmon persistence and recovery.

The loss of this Chinook salmon population would also preclude the potential for the ESU level future recovery to healthy, more substantial numbers. The weakened ESU demographic structure, with declines in abundance, spatial structure, and diversity, will result in a long-term suppression, if not decline, in the total prey available to Southern Residents. In this consultation, the long-term effects are specifically: fewer populations contributing to Southern Residents' prey base, reduced diversity in life histories, spatial structure, resiliency of prey base, greater ESU-level risk relative to stochastic events, and diminished redundancy that is otherwise necessary to ensure there a margin of safety for the salmon and Southern Residents to withstand catastrophic events.

Differences in adult salmon life histories and locations of their natal streams likely affect the distribution of salmon across the Southern Residents' geographic range. The continued decline and reduced potential for recovery of the PS Chinook salmon, and consequent interruption in the geographic continuity of salmon-bearing watersheds in the Southern Residents' critical habitat, is likely to alter the distribution of migrating salmon and increase the likelihood of localized depletions in prey, with adverse effects on the Southern Residents' ability to meet their energy needs. A fundamental change in the prey base within critical habitat originating from the Green River is likely to result in Southern Residents abandoning areas in search of more abundant prey or expending substantial effort to find depleted prey resources. This potential increase in energy demands should have the same effect on an animal's energy budget as reductions in available energy, such as one would expect from reductions in prey.

Lastly, the long-term reduction of PS Chinook salmon is likely to lead to nutritional stress in the whales. Nutritional stress can lead to reduced body size and condition of individuals and can also lower reproductive and survival rates. Prey sharing would distribute more evenly the effects of prey limitation across individuals of the population that would otherwise be the case. Therefore, poor nutrition from the reduction of prey could contribute to additional mortality in this population. Food scarcity could also cause whales to draw on fat stores, mobilizing contaminants stored in their fat and affecting reproduction and immune function.

In summary, the proposed action, in the long term, would appreciably reduce the likelihood of survival and recovery of PS Chinook (see Section 2.6.1), which would have the adverse effect of reducing prey available for Southern Residents in Puget Sound. Prey reduction stresses and weakens the whales, causing their numbers to potentially decrease through starvation, disease or lack of reproduction.

Southern Resident Killer Whale Critical Habitat

NMFS published the final rule designating critical habitat for Southern Residents on November 29, 2006 (71 FR 69054). Critical habitat includes about 2,560 square miles of inland waters including Puget Sound, but does not include areas with water less than 20 feet deep relative to extreme high water. The PBFs of Southern Residents critical habitat are: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

Sufficient quantity, quality and availability of prey are an essential feature of the critical habitat designated for Southern Residents. Increasing the risk of a permanent reduction in the quantity and availability of prey and the likelihood for local depletions in prey in particular locations and times reduces the conservation value of critical habitat for Southern Residents.

The proposed action would reduce the quantity of prey available in critical habitat. The proposed action would not have any effect on marine water quality or passage of Southern Residents. The previous discussion of the effects on Southern Residents as a result of decreased prey availability is also relevant to effects on the prey feature of critical habitat. As described previously, project operations would reduce the amount of Southern Resident's primary prey.

In summary, the proposed action would reduce the quantity of prey available in Southern Resident critical habitat. The loss of Chinook salmon, the whales' primary prey species, would reduce the conservation value of critical habitat for Southern Residents.

2.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

In this section, we highlight numerous actions that have multiple components, portions of which have already occurred, and others which are planned to occur in the future. For ease of understanding the complete picture, we are providing descriptions of each program and state which components have already occurred, and which are anticipated future actions. The components of the actions that have already occurred have effects that contributed to conditions in the environmental baseline, thus while not separating out those components here; we included their effects in the baseline section.

2.5.1 Puget Sound Chinook Salmon and Puget Sound Steelhead

Activities that we include here as cumulative effects are; human population growth and associated land use changes, future climate change, state, tribal or local agency actions such as the Washington State legislation to enhance salmon recovery through tributary enhancement programs, Washington's efforts to reduce greenhouse gas emissions and respond to climate change, and ongoing efforts to recover PS Chinook salmon and steelhead.

2.5.1.1 Human Population Growth, Land Use, and Climate Change

Some characteristics of the environmental baseline in the action area described above are expected to change over time due to the effects of increased human population in the Puget Sound region, attendant changes in land use, and climate change. (Climate change is discussed in Section 2.2.4). The Puget Sound Regional Council anticipates that the Puget Sound region's population will grow from about 3.7 million in 2014 to almost 5 million by 2040 (PSRC 2013). This growth will likely occur mostly within existing urban areas and their peripheries located in valley bottoms and the coastal plain. This implies that undeveloped lands from Seattle to Auburn will become increasingly urbanized. With such urbanization would come increased water pollution, more channel simplification and bank hardening to protect developed property, and reduced instream flows due to diversion to serve municipal and industrial water demands. The overwhelming majority of this change will occur within the lower Duwamish/Green River watershed as the upper watershed is primarily undeveloped forestlands and future development is restricted to protect Tacoma's water supply.

By contrast, within the upper watershed, timber harvesting would likely continue to be the primary economic activity. Much of the forested area is covered by existing Habitat Conservation Plans, including that with Tacoma, with Weyerhaeuser (formerly Plum Creek Timber), and the Washington Department of Natural Resources. Federal forest land is protected by the President's Forest Plan of 1994. These plans are designed to minimize the adverse effects of land management activities on PS Chinook salmon and PS steelhead.

As described in Section 2.2.4, recent projections of the likely physical changes in fish habitats in the Puget Sound ecoregion from the changing climate are increased summer water temperatures and increased winter peak flows (floods). Both of these changes are expected to adversely affect PS Chinook salmon and PS steelhead throughout the action area. However, because HAHD acts to limit downstream peak flows, we anticipate that redd scour, the primary adverse effect of high peak flows on fish survival, would be only slightly increased in the middle and lower Green River. PS steelhead spawn and incubate during the spring and their reproduction would not be affected by increased winter peak flows. Increasing water temperatures would affect all reaches of the Green River. However, due to the fact that air temperatures and thus stream temperatures decrease with increasing elevation, the upper Green River is and will remain cooler than the lowermost Duwamish/Green River which today is only marginally suitable for rearing salmonids during the summer. Hence, warming water temperatures associated with climate change will have larger adverse effects on fish habitats in the lower Duwamish/Green River than on fish habitats in the upper Green River while increasing winter peak flows will have greater effect upstream from HAHD.

2.5.1.2 Washington State

Several legislative measures have been passed in the State of Washington to facilitate the recovery of listed species and their habitats, as well as the overall health of watersheds and ecosystems. The 1998 Salmon Recovery Planning Act provides the basis for developing watershed restoration projects and establishes a funding mechanism for local habitat restoration projects. The Salmon Recovery Planning Act also created the Governor's Salmon Recovery Office, to coordinate and assist in the development of salmon recovery plans. Although this Act is already in effect, it directs future actions to support salmon recovery.

The Statewide Strategy to Recover Salmon is also designed to improve watersheds, while the 1998 Watershed Planning Act encourages voluntary water resource planning by local governments, citizens, and Tribes in regards to water supply, water use, water quality, and habitat at the water resource inventory area (WRIA) level. The Salmon Recovery Funding Act established a board to approve localized salmon recovery funding activities.

Recovery efforts are ongoing. King County, in conjunction with other local governments, businesses, Indian Tribes, environmental groups, and state agencies is working to develop a science-based salmon conservation plan for Water Resource Inventory Area (WRIA) 9, which includes the Green River. There is considerable momentum toward implementing recovery actions, but funding is likely to limit the scale and scope of such efforts into the future.

Entities including NMFS, the Corps, USFWS, tribes, WDFW, DOE, and local stakeholders have partnered to identify and restore functional estuarine and freshwater habitats in the lower Duwamish Waterway, a water body that has been highly modified. Much of the funding has come via the Natural Resource Damage Assessment (NRDA) and federal grants. Completed projects include the following:

- Herring's House, where inter-tidal off channel habitat has been restored with marsh and riparian vegetation.
- Hamm Creek, which has restored estuarine and freshwater marsh habitat and fish passage.
- North Winds Weir, has had marsh and riparian vegetation restored in an off-channel basin habitat.
- Kenco Marine (Turning Basin No. 3), where a dock, dolphins, grounded barges, a building, and fill were removed; and a marsh bench and riparian slope were created and planted.

These projects have common attributes of improving water quality and restoring functional habitat for fish and upland wildlife.

The WDFW and Tribal co-managers implemented the Wild Stock Recovery Initiative in 1992 and completed comprehensive management plans that identify limiting factors and habitat restoration activities. These plans also include actions in the harvest and hatchery components.

The Washington legislature amended the Shoreline Management Act to increase protection of shoreline fish habitat. Washington's Forest and Fish Policy is designed to establish criteria for non-Federal and private forest activities that will improve environmental conditions for listed species, primarily to minimize impacts to fish habitat through protection of riparian zones and instream flows. These actions are likely to gradually improve habitat productivity and capacity and result in long-term benefits, although little may be seen in the near term.

The State of Washington has also undertaken several initiatives to reduce emissions of greenhouse gases (primarily carbon dioxide). This involves efforts to reduce emissions from transportation by reducing motor vehicle miles driven, adopting low emissions standards (California standards), implementing fuel quality standards, provisions for electric vehicles, and others. To reduce emissions from electrical generating stations, the state has set building efficiency standards, including retrofits of existing public buildings, and efforts to encourage greater use of renewable energy. The state's overall goal is to achieve 1990 levels of greenhouse gas emissions by 2020, to be 25% below 1990 levels by 2035, and to be 50% below 1990 levels by 2050 (RCW 70.235.020 – Washington Legislature 2008). Washington has also conducted a comprehensive assessment of the likely impacts of climate change on the state and has developed climate change mitigation and adaptation programs. Based on the state legislative initiatives, there will likely be many follow-up actions aimed at reducing greenhouse gases. While these programs and regulations are likely to be beneficial, climate change and emission of greenhouse gases are global issues and climate projections continue to show adverse climate effects throughout the action area for decades to come.

The Muckleshoot Indian Tribe is a treaty tribe[15] and co-manager with Washington State of salmon harvest under a draft Harvest Management Plan (PSIT and WDFW 2009). While harvest affects the abundance of salmon and steelhead in the basin, and consequently the number of fish potentially affected by project operations, the plan notes that recovery to substantially higher abundance is primarily dependent on *restoration of habitat function*. The Harvest Management Plan is designed intentionally to ensure that the expected abundance reductions will avoid reducing the likelihood of survival and recovery of the ESU (PSIT and WDFW 2009).

2.5.1.3 Tacoma's Water Supply

The City of Tacoma owns 11 percent of the upper Green River watershed, and has intentionally concentrated its holdings in lands adjacent to the Green River and the HAHD reservoir. Tacoma also has agreements with other land holders in the upper watershed aimed at limiting development and protecting water quality. The two other primary landowners in the upper basin are the Washington Department of Natural Resources and the U.S. Forest Service. Timber production is very likely to continue and has adverse effects on water quality and fish habitat. However, private timber operations are governed by Washington's Practices Rules and HCPs, and timber harvesting on U.S. Forest Service lands is guided by the Northwest Forest Plan and is subject to ESA Section 7, requiring consultation with NMFS. Hence, future land disturbance in the upper Green River watershed would be managed to limit adverse effects on water quality and fish habitats. Given the high rate of regional growth and the importance of protecting water

[15] Washington State treaty tribes are successors in right to the Steven's treaties of 1854 and 1855, with the Muckleshoot being party to the Treaty of Point Elliot and Medicine Creek.

quality, Tacoma's policy of acquiring and protecting lands adjacent to the river and Eagle Gorge reservoir are very likely to continue throughout the life of the action.

2.5.1.4 Puget Sound Chinook Salmon Recovery Plan & the Shared Strategy for Puget Sound

The Shared Strategy for Puget Sound, a regional collaborative effort of state and local governments, tribes, interested citizens, technical experts, and policy makers in the Puget Sound region, developed a proposed recovery plan for PS Chinook salmon and other ESA-listed species and submitted it to NMFS in 2002 (Shared Strategy 2002). NMFS (2006a) supplemented the Shared Strategy plan and, after the Shared Strategy participants agreed to the NMFS supplement, adopted the two documents as the species' recovery plan in January 2007. The plan focuses on regional actions and regulations to improve watershed health, thereby improving the status of the species. The State of Washington then enacted The Puget Sound Partnership Act (Section 49(3), RCW 77.85.090(3)) on January 1, 2008 to coordinate plan implementation. This broad, regional support for PS Chinook salmon recovery planning strongly suggests that over time, the plan will be implemented and measurable improvements in the status of the species will ensue. However, plan participants estimate it will take between 50 and 100 years to fully implement the plan.

In 2011, NMFS evaluated progress, to date, in implementing the recovery plan (Judge 2011) and identified the following accomplishments by numerous parties:

- The Co-Managers (the WDFW and Puget Sound Treaty Tribes, collectively) met or exceeded the harvest management performance measures required in the 2004 Harvest Management Plan.
- The WDFW completed its 21st Century Salmon and Steelhead Initiative, which will help them identify, monitor and evaluate long-term, science-based hatchery management strategies.
- Numerous high priority habitat restoration projects have been accomplished across every watershed in Puget Sound, funded by local government and private parties.
- The Nisqually watershed completed a major portion of their largest project, the Nisqually Refuge Estuary restoration project, with the support and shared contribution of funds from other South Sound watershed groups.
- The Elwha River Dam removal project, funded by the Federal government, is complete.[16]
- Despite a severe recession, significant change in the organizational structure supporting Puget Sound salmon recovery, a loss of staff and severe funding shortages; the local commitment to salmon recovery across the ESU remains firm and work is continuing.

Given this substantial ongoing effort to recover PS Chinook salmon, it is likely that the Puget Sound Partnership will continue to provide increasing benefits to salmon and steelhead recovery into the future.

[16] Elwha Dam was removed in 2012 and Glines Canyon Dam has been breached, allowing fish unencumbered access to over 70 miles of spawning and rearing habitat. All Elwha Project works were removed by September 2014.

2.5.2 Southern Resident Killer Whales

A large number of state and private organizations participated in developing the Southern Resident recovery plan and many of these organizations have made commitments to implement portions of that plan (NMFS 2008). Some recovery plan actions identified as necessary for recovery of the species involve normal state agency regulatory functions (e.g. minimizing contaminant discharges). These actions that have been ongoing since listing are part of the environmental baseline that is expected to continue into the future. Other recovery plan actions engage private groups in efforts to educate the public to reduce injuries associated with boat collisions and other effects of whale watching. Several of these actions have been implemented and are increasing protections for Southern Residents. In 2014, NOAA reviewed a decade of research and conservation actions that have been implemented (NOAA Fisheries 2014). However, because funds to implement state and private actions identified in the recovery plan may not become available, we cannot rely on all actions in the recovery plan to be implemented.

Summary of Cumulative Effects

State, tribal and private entities have adopted programs (e.g. Puget Sound Partnership) designed to improve the statuses of PS Chinook salmon, PS steelhead, and Southern Residents. Some actions under these programs have already been implemented and their effects to date are reflected in the current status of the species and the environmental baseline, and may make further contributions to the species' survival and recovery in the future. It is likely that as these programs mature, additional actions will be taken, as described in this section, and that future benefits would accrue to Southern Residents, PS Chinook salmon, and PS steelhead. However, it is impossible to know the scale, scope, and location of such improvements, so at this time we cannot be reasonably certain what benefit might accrue to species in the action area. The likely future adverse effects of regional population growth, land use change, and climate change are reasonably certain to occur and would be partially mitigated by ongoing recovery efforts and Washington's efforts to reduce greenhouse gas emissions. In aggregate, we expect for habitat conditions throughout the basin to be adversely affected by climate change throughout the 30-year life of the action, with the adverse effects of population growth and land use change to mostly occur in the lower and middle Green River watershed, and these cumulative effects will make restoration and recovery objectives both more important, and more difficult to achieve.

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of carrying out the proposed action. In this section, we add the effects of the action (Section 2.4)[17] to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species

[17] Under the proposed action, there are no proposed changes to any of the actions interrelated and interdependent to the proposed action. Additionally, the interrelated and interdependent actions to the proposed action have received prior ESA consultations and are included in the Tacoma Water Habitat Conservation Plan (HCP). Therefore, we are considering interrelated and interdependent actions as part of the environmental baseline and not as part of the proposed action.

in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species.

In the status of the species section (Section 2.2), we showed how the populations of PS Chinook salmon, PS steelhead, and Southern Residents are declining throughout their ranges, and showed that the Green River populations of both fish species are also declining. In the environmental baseline section (Section 2.3) we described how impassible dams, including HAHD, have extirpated both PS Chinook salmon and PS steelhead from about half of their suitable habitat in the Green River basin, how channelization and levees have reduced habitat quality in the lower and middle Green River, and how the past operations of HAHD have adversely affected sediment and large wood transport, and how water quality in the middle and lower Green River is degraded. We also showed how reductions in Southern Resident's preferred prey, waterborne contaminants, disturbance caused by vessels, and sound have adversely affected Southern Residents. In the effects of the action section (Section 2.4), we showed how the proposed action would prevent anadromous fish from using the upper Green River habitat for spawning and rearing and how proposed mitigation measures largely mitigate for the effects of sediment and large wood capture in Eagle Gorge reservoir. We also showed how reductions in the abundance of Green River PS Chinook salmon within the inland range of Southern Residents caused by the project would negligibly affect the number of Chinook salmon available to them over the short-term but, by appreciably reducing the likelihood of survival and recovery of the PS Chinook ESU salmon (see Section 2.7.1), the proposed action would have the adverse effect of substantially reducing prey available for Southern Residents in Puget Sound over the long term, which would stress and weaken the whales, potentially causing their numbers to decrease through starvation, disease or lack of reproduction. In the cumulative effects section (Section 2.5), we showed how future population growth, land use change, and climate change are likely to adversely affect fish habitat into the future, particularly in the middle and lower Green River.

The abundance trend lines for Green River Chinook salmon and steelhead over time have negative slopes (Ford et al. 2011), meaning that their numbers are decreasing over time. If allowed to continue, this negative abundance trend would eventually lead to the populations' extirpation. Considering the ongoing incremental degradation of suitable habitat in the lower and middle Green River reaches, lack of access to and from the upper river basin can be expected to severely limit both abundance and productivity of PS Chinook salmon and steelhead. The trend lines for the entire Puget Sound Chinook salmon ESU and that of the Puget Sound steelhead DPS are similarly negatively sloped, indicating a moderate to high risk of species extinction. The Green River's Chinook salmon and steelhead populations are important parts of their larger ESU and DPS, and are needed to support the species abundance, productivity, and spatial diversity necessary to achieve long-term viability. Maintaining and increasing the number of viable populations (spatial diversity) is important to minimize the potential for a single catastrophic event to wipe out an entire species. Hence, the Green River populations of PS Chinook salmon and PS steelhead are essential to the long-term survival and potential for recovery of both species.

Green River steelhead returns presently average about 986 adults, and have an average annual growth rate of 0.953 from 1995 through 2009 (Ford et al 2011). A value less than 1.0 means they are declining in abundance. This negative abundance trend indicates that the likelihood of long-term population survival is low. The population growth trend line for the Puget Sound steelhead DPS is also less than 1.0. Thus, both the Green River steelhead population, and the overall DPS' numbers are declining. Reversing this trend is imperative for their long-term survival.

HAHD and Tacoma's Headworks Dam block access to upstream spawning and rearing habitat. However, Tacoma installed upstream fish passage facilities at its Headworks Dam in 2006 so that anadromous fish access could be restored to the upper Green River basin, according to terms of its HCP and the Corps' AWSP (authorizing development of a downstream passage system at HAHD). The Corps' HAHD remains as the only obstacle to fish passage to the upper Green River. The lack of effective fish passage is among the primary causes of the declines in the abundance of both PS Chinook salmon and PS steelhead in the Green River (Meyers et al. 1998, Hard 2007) because it substantially reduces Chinook salmon and steelhead spawning and rearing habitat. This causes a reduction in potential population abundance of nearly 40 and 50%, respectively.

Other potential causes of population decline (e.g. overfishing, loss of habitat) are being addressed by NMFS and other parties. The Muckleshoot Tribe has scaled back its fishing for Green River Chinook salmon and steelhead due to declining abundance caused by habitat degradation and subsequent listing of the species as threatened under the ESA. Salmon fishing in Puget Sound has been restricted to allow Green River Chinook salmon to reach the Green River. Forest practices have been improving in Washington since legislated changes in 1973, 1990, and 1998. Land development in rural and urban areas of the Green River basin has been further restricted since 1989 in large part to protect fish habitat. Road and transportation projects and waterway projects have been developed in consultation with NMFS (since 1998) to avoid degradation of fish habitat. Tacoma's HCP and the Corps' AWSP at HAHD were developed with the protection and improvement of access to upstream fish habitat in mind.

The proposed action would result in unsafe and ineffective downstream passage past HAHD, and it would therefore effectively prevent all passage because without safe and effective downstream passage, fish trapped at Tacoma's Headworks Dam could not be transported upstream of HAHD. The lack of safe and effective fish passage would render spawning and rearing habitats upstream of HAHD useless to improving abundance, productivity, and spatial diversity of PS Chinook salmon and PS steelhead. Habitat improvements recently completed in accordance with Tacoma's HCP and its agreement with the Corps that are located upstream of HAHD would also be of no value to the species. The loss of access to and from these habitats would destroy the conservation value of designated (PS Chinook salmon) and proposed (PS steelhead) critical habitat in the upper watershed.

Effects of the action downstream from HAHD would be both beneficial and adverse. Beneficial effects are primarily associated with summer flow augmentation which largely offsets the adverse effects of Tacoma's water withdrawals and winter peak flow reduction which would increase the survival of incubating PS Chinook salmon eggs and fry. The gravel augmentation program largely offsets the reduction in bedload transport caused by the existence of the dam. Adverse effects would be caused by flow reductions during the spring refill period which would slightly delay juvenile outmigration, thereby slightly reducing outmigrant survival. In aggregate, the proposed action would beneficially affect abundance, and productivity of the species in the lower Green River and would support the conservation value of designated (PS Chinook salmon) and proposed (PS steelhead) in the lower Green River. We note that habitat conditions in the lower Green River watershed are likely to decline over time, despite numerous habitat restoration and improvement projects, due to cumulative effects including increased urbanization associated with human population growth. Increased human population invariably results in more degraded habitat conditions due to more impervious surface on the landscape, less instead of more intact riparian areas, and reduced watershed function and aquatic productivity.

Effects of the proposed action on Southern Residents would be due to the project's adverse effects on Chinook salmon, the whales preferred prey. Given the status of the species (endangered with low abundance and productivity), and their strong preference for Chinook salmon prey, the continued existence and potential for recovery of the species is highly dependent on healthy numbers of Chinook salmon throughout its range.

The proposed action would preclude upstream and downstream passage at HAHD. This means that fish cannot use the significant amount of high quality upstream habitat for spawning and rearing. Considering the ongoing incremental degradation of suitable habitat in the middle and lower Green River reaches, preventing access to the upper Green River can be expected to preclude the Green River populations of PS Chinook salmon and steelhead from achieving viability.

In summary, the numbers of PS Chinook salmon in the ESU and PS steelhead in the DPS are declining, leading to a moderate to high risks of extinction. The Green River populations of both species are essential to their survival and recovery. Spawning and rearing habitat downstream from the project is already being utilized by both species, but with 40% of the Chinook salmon critical habitat and 50% of the proposed steelhead critical habitat in the Duwamish/Green River basin located upstream of HAHD, available habitat downstream from HAHD is not adequate to increase the abundance, productivity and spatial diversity of the populations sufficiently to achieve viability. Habitats upstream of the project, when combined with habitats in the middle and lower Green River, would be sufficient in both size and quality to help achieve viability. By blocking downstream juvenile passage, the proposed action effectively prevents access to the upstream habitat, and thereby greatly reduces the river's productive potential and the likelihood that the Green River populations of both species would become viable. By reducing the potential for the Green River population of PS Chinook salmon to achieve viability, thereby reducing the likelihood of survival and recovery of the PS Chinook salmon ESU, the proposed action would reduce the likelihood of survival and recovery of Southern Residents.

2.6.1 Puget Sound Chinook Salmon

The PS Chinook salmon ESU is listed as threatened and rangewide abundance and productivity have decreased in recent years. All extant populations are considered to be at high risk. The Green River population of PS Chinook salmon is currently at high risk and must reach a low risk status to support the potential for recovery of the ESU. The population remains well below recovery targets. Therefore, the proposed action would present risks to the continued existence of the species by excluding this population of the Central/South Sound Major Population Group from the upper Green River basin, and delay or otherwise obstruct their recovery by preventing access to 40% of the suitable Chinook salmon habitat. Without access to and from the upper Green River watershed the population's abundance, productivity, and spatial diversity would not achieve viability, increasing the risk of extirpating the population.

To date, various regional actions have implemented numerous measures identified in the recovery plan (Judge 2011). Continued progress in implementing the plan would, over time, improve the status of the species and its critical habitat. However, plan participants estimate it will take between 50 and 100 years to fully implement the plan.

Chinook salmon critical habitat in the Green River basin has high conservation value. Critical habitat for spawning and incubating PS Chinook salmon would be both adversely and beneficially affected by the proposed action. Precluding flood flow events would prevent the maintenance and formation of salmonid habitat. However, by reducing peak flows, the proposed action would also reduce the potential for redd scour. Given the strong negative correlation between annual peak flows and salmon year-class strength observed in the Skagit River (Zimmerman et al. 2010), we believe the beneficial effect of reducing redd scour would exceed the adverse effects of reduced channel complexity downstream from HAHD on PS Chinook salmon spawning habitat and spawning success. The reduction in channel complexity would reduce the amount of juvenile rearing habitat. Because the reductions in redd scour attributable to high peak flows would be an effect of the action that is certain to occur while the reduction in channel complexity would only be partly attributable to the proposed action, the proposed action would likely benefit PS Chinook salmon spawning and incubation, and may benefit early juvenile rearing in the Green River downstream from HAHD.

Migration corridor critical habitats would continue to be poor for migrating juveniles at HAHD due to lack of passage. It is unlikely that the proposed action would have any effect on the conservation value of critical habitats in the estuary or near shore marine environments.

In summary, numbers of PS Chinook salmon are decreasing, and numbers of Green River Chinook salmon (a population essential for survival and recovery of the ESU) are also decreasing. Under the proposed action, these fish would be denied access to and from about 40% of the suitable Chinook salmon upstream spawning and rearing habitat in the Green River watershed. Production would be limited to spawning and rearing habitat downstream from HAHD, most of which is degraded and is likely to further degrade into the future. This habitat is not suitable to support increased abundance, productivity, or spatial diversity of fish needed for a viable population.

The effects of the proposed action (adverse), when added to the status of the PS Chinook salmon ESU (high risk), the environmental baseline (degraded), and cumulative effects (mostly adverse), would appreciably reduce the likelihood of survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution. Our determination is based on the following considerations:

- All 22 populations of this ESU are considered at high risk and no populations are currently viable. The status of this ESU is far from the delisting criteria described in our recovery plan.

- The Green River population must be at low risk for the ESU to recover.
- The effects of the action would reduce or further depress Green River population abundance, productivity, and spatial diversity.
- Cumulative effects and climate change are likely to reduce the quality of habitat in the lower Green River basin where all the Chinook salmon would be forced to spawn and rear due to lack of passage at HAHD. Due to its areal extent, high quality, and much higher likelihood of remaining as it currently is, or improving into the future, the habitat in the upper basin is the most capable of contributing to a viable population in the long term.

Additionally, the effects of the proposed action, when added to the environmental baseline, cumulative effects, and the status of critical habitat, would appreciably reduce the function of critical habitat in the upper Green River 5th field watershed. Our determination is based on the following considerations:

- All three watersheds have high conservation value, but only the middle and lower watersheds would be available to support a population that is critical to the survival and recovery of the PS Chinook salmon ESU.
- The quality of critical habitat in the lower and middle Green River is fair due to human development and subject to future decline, but the quality of critical habitat in the upper basin, upstream of HAHD, is high and likely to remain high. The lack of access to habitats upstream of HAHD appreciably reduces the potential for the critical habitat to serve its intended conservation role for the species.
- Cumulative effects and climate change are likely to further reduce the quality of critical habitat in the lower Green River basin over time. The habitat in the upper basin is currently in better condition than the habitat in the lower basin and is likely to remain high quality into the foreseeable future.

The proposed action would impair the ability of critical habitat in the Green River watershed to serve its intended conservation role. Because the Green River population of PS Chinook salmon is essential to the recovery of the ESU, this impairment is significant in the context of critical habitat at the ESU scale.

2.6.2 Puget Sound Steelhead

NMFS has listed PS steelhead DPS as threatened and the Green River population is at moderate to high risk of quasi-extinction within 25 to 30 years (Ford 2011) due to a declining population trend. At such low levels of abundance (numbers) and productivity (population growth rate), significantly increasing abundance is extremely unlikely without creating conditions that substantially increase productivity. In this situation, increasing productivity requires significant increases in habitat availability and accessibility, as well as improvements in habitat quality. Rangewide abundance and productivity have decreased in recent years, increasing the risk of species extinction. There is no final recovery plan for this DPS, but considering the established biological recovery criteria, the Green River DIP is very likely to be essential to the recovery of the Central and Southern Cascades MPG, and the species as a whole.

Population viability analyses have shown that all three of the major population groups (MPGs) of the PS steelhead DPS are at very low viability (PSSTRT 2013), making the likelihood for extinction moderate to high. Recovery would require highly viable DIPs in all three MPGs. Continued operation and maintenance of the HAHD project as proposed would have small beneficial effects on the Green River population and larger adverse effects. By reducing peak flows, the project would continue to reduce channel complexity and juvenile rearing habitat downstream from HAHD. Overall, proposed operations would slightly reduce the quality of steelhead spawning and incubation habitat in the Green River downstream from HAHD because it would negatively affect the natural hydrologic cycle and habitat maintaining and forming processes (see Sections 2.4.2 – 2.4.5). The proposed action would result in unsafe and ineffective passage for downstream migrating fish, precluding use of the upper Green River watershed, and thereby appreciably reducing the likelihood that the Green River population of PS steelhead would achieve viability.

Critical habitat for spawning and incubating PS steelhead in the river reach downstream from HAHD would be adversely affected by the proposed action. Safe passage to and from spawning and rearing habitats upstream of HAHD would be blocked by lack of passage facilities. Spawning habitat is abundant in the Green River, but flood control operations would prevent bedload sediment transport, adding to substrate coarsening downstream from HAHD, potentially reducing spawning success. This effect is partially mitigated by the Corps augmenting the gravel supply since 2007, an action the Corps would continue. The proposed action would modestly reduce spawning and rearing habitats downstream from HAHD by reducing gravel recruitment and channel maintaining and forming peak flows.

The effects of the proposed action (adverse), when added to the status of the PS steelhead DPS (high risk), the environmental baseline (degraded), and cumulative effects (adverse), would appreciably reduce the likelihood of survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution. Our determination is based on the following considerations:

- This DPS is at moderate to high risk of extinction and none of the MPGs are considered to be viable.
- The Green River DIP (varies between largest and second largest in the group) is very likely to be essential to the recovery of the Central and Southern Cascades MPG and the species as a whole.
- The effects of the action would reduce or further depress Green River DIP abundance, productivity, and spatial diversity.
- Cumulative effects and climate change are likely to reduce the quality of habitat in the lower Green River basin. The habitat in the upper basin is the most capable of contributing to a viable population.

Additionally, the effects of the proposed action, when added to the environmental baseline, cumulative effects, and the status of critical habitat, would appreciably reduce the function of critical habitat in the upper Green River 5th field watershed and thereby appreciably reduce the potential for the critical habitat to serve its intended conservation role for the species. Our determination is based on the following considerations:

- All three watersheds have high conservation value, but only the middle and lower watersheds would be available to support a population that is critical to the survival and recovery of the PS steelhead ESU.
- All three watersheds in the action area have high conservation value ratings and support a population that is likely to be critical to the survival and recovery of the PS steelhead DPS.
- The quality of critical habitat in the lower basin is fair due to human development, but the quality of critical habitat in the upper basin, upstream of HAHD, is good and improving, and this habitat has the best chance of supporting a viable DIP. Because the proposed action would result in unsafe and ineffective passage, the proposed action effectively eliminates the productive potential of this habitat.
- Cumulative effects and climate change area likely to reduce the quality of critical habitat in the lower Green River basin. The habitat in the upper basin is the most capable of contributing to a viable population.
- The proposed action would impair the ability of the critical habitat to play its intended conservation role, in this case, supporting a viable population of PS steelhead.

The proposed action impairs the ability of critical habitat in the upper and lower Green River watersheds to play its intended conservation role. Given the importance of the Green River population of PS steelhead to the recovery of the DPS, this impairment is significant in the context of critical habitat at the proposed designation scale.

2.6.3 Southern Resident Killer Whales

Based on the analysis of the predicted long-term effects on PS Chinook salmon, the proposed action is likely to adversely affect the productivity and abundance, spatial distribution, and the long-term viability of Southern Resident killer whales.

Several factors identified in the final recovery plan for Southern Resident killer whales may be limiting recovery. These are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats are important to address.

The Southern Resident killer whale DPS is composed of one small population (74 whales) which is currently at most half of its likely previous size (140 to as many as 400 whales). The effective population size (based on the number of breeders under ideal genetic conditions) of 26 whales is very small, and this, in combination with the absence of gene flow from other populations, may elevate the risk from inbreeding and other issues associated with genetic deterioration. This population has a variable growth rate (32-year mean=0.1% ± 3.2% s.d), and risk of quasi extinction that ranges from 1% to as high as 66% over a 100-year horizon, depending on the population's survival rate and the probability and magnitude of catastrophic events. Because of this population's small size, it is susceptible to rapid decline due to demographic stochasticity,[18] and genetic deterioration, as described in the Status of the Species. The influences of demographic stochasticity and potential genetic issues in combination with other sources of random variation combine to amplify the probability of extinction, known as the extinction vortex.

The larger the population size, the greater the buffer against stochastic events. It also follows that the longer the population stays at a small size, the greater its exposure to demographic stochastic risks and genetic risks. In addition, as described in the Status of the Species section, small populations are inherently at risk because of the unequal reproductive success of individuals within the population. The more individuals added to a population in any generation, the more chances of adding a reproductively successful individual. Random chance can also affect the sex ratio and genetic diversity of a small population, leading to lowered reproductive success of the population as a whole. For these reasons, the failure to add even a few individuals to a small population in the near term can have long-term consequences for that population's ability to survive and recover into the future. A delisting criterion for the Southern Resident killer whale DPS is an average growth rate of 2.3% for 28 years (NMFS 2008). In light of the current average annual growth rate of 0.1%, this recovery criterion and the risk of stochastic events and genetic issues described above underscore the importance for the population to grow quickly.

The effects of the proposed action on Southern Residents would be indirect - the reduction of available prey. We have shown that the anticipated short-term reduction of Chinook salmon abundance associated with the proposed action would result in an insignificant annual reduction in adult equivalent prey resources for Southern Residents. Over the long-term, however, the proposed action would appreciably limit survival and impede the recovery of the PS Chinook salmon ESU. Further reductions in Southern Resident prey quantity, or spatial or temporal depletions would reduce the representation of diversity in life histories, resiliency in withstanding stochastic events, and redundancy to ensure there is a margin of safety for the salmon and Southern Residents to withstand catastrophic events. Long-term prey reductions affect the fitness of individual whales and their ability to both survive and reproduce. Reduced fitness of individuals increases the mortality and extinction risk of Southern Residents and reduces the likelihood of recovery of the DPS. Therefore, the effects of the action would reduce appreciably the likelihood of both survival and recovery of the Southern Residents.

Reducing the likelihood of survival and recovery of PS Chinook salmon would reduce prey availability and increase the likelihood for local depletions of prey in particular locations and times. This is also true for PS steelhead, to a lesser extent, as they make up a small portion of the whales' diet. In response, the Southern Residents would increase foraging effort or abandon areas in search of more abundant prey. Reductions in prey or a resulting requirement of increased foraging efficiency would increase the likelihood of physiological effects. The Southern Residents would likely experience nutritional, reproductive, or other health effects (*e.g.*, reduced immune function from drawing on fat stores and mobilizing contaminants in the blubber) from this reduced prey availability. These effects would lead to reduced body size and condition of

[18] Demographic stochasticity refers to the variability in population growth rates arising from random differences among individuals in survival and reproduction.

individuals and can also lower reproductive and survival rates, and diminish the potential for Southern Residents to recover.

Sufficient quantity, quality and availability of prey are an essential feature of the critical habitat designated for Southern Residents. Increasing the risk of a permanent reduction in the quantity and availability of prey and the likelihood for local depletions in prey in particular locations and times reduces the conservation value of critical habitat for Southern Residents.

In summary: (1) Short-term reduction in prey availability associated with the proposed action would result in an insignificant annual reduction in adult equivalent prey resources for Southern Resident killer whales. (2) Reducing the likelihood of survival of PS Chinook salmon as a long-term consequence of the proposed action increases the risk of a permanent reduction in prey available to Southern Residents, and increases the likelihood for local depletions of prey in particular locations and times within designated critical habitat. (3) Appreciable reductions in the potential for future recovery of PS Chinook salmon diminishes the likelihood for Southern Resident killer whale survival and the potential for the whales to recover by diminishing opportunity for the recovery of the PS Chinook ESU.

2.7 Conclusions

2.7.1 Puget Sound Chinook Salmon and Puget Sound Steelhead

After reviewing the current status of the listed species (moderate to high risk for PS Chinook salmon and PS steelhead, respectively), the environmental baseline within the action area (degraded), the anticipated effects of the proposed action (small beneficial effects on spawning and incubating fish downstream of HAHD, with much larger adverse effects of habitat blockage with no passage to or from high quality habitat upstream of HAHD), and cumulative effects (adverse), it is NMFS' biological opinion that the proposed action would jeopardize the continued existence of PS Chinook salmon and PS steelhead and would destroy or adversely modify PS Chinook salmon designated critical habitat and PS steelhead critical habitat.

2.7.2 Southern Resident Killer Whales

After reviewing the current status of the listed species (endangered with no evidence of increased abundance), the environmental baseline within the action area (degraded), the anticipated effects of the proposed action (in the long term, reduced survival and recovery of their primary prey in their designated critical habitat), and cumulative effects, it is NMFS' biological opinion that the proposed action would jeopardize the continued existence of Southern Resident killer whales and would destroy or adversely modify their designated critical habitat.

2.8 Reasonable and Prudent Alternative

When an agency action is determined to jeopardize species, or to destroy or adversely modify designated critical habitat, the Service must provide if possible a Reasonable and Prudent Alternative (RPA) that meets the purpose and need for which the action is being taken, which is both feasible and within the action agency's authority, and which avoids the jeopardy or adverse modification/destruction of habitat. We provide such a RPA here.

2.8.1 RPA Action Item 1 – Permanent Downstream Fish Passage System

Because downstream fish passage is functionally impaired by the operations of the HAHD, and because Tacoma's trap-and-haul facility is not being operated to transport spawners above the dam, approximately 40 percent of the Green River's PS Chinook, and 50 percent of the Green River's PS steelhead spawning and juvenile rearing habitat is not accessible for salmonid reproduction. The NMFS has determined that the following RPA Action Item 1 would avoid jeopardy for naturally spawning PS Chinook salmon and PS steelhead, and SRKW, and would substantially reverse the current adverse modification (blocked downstream fish passage) to their designated critical habitat.

To avoid long term jeopardy and restore adversely modified critical habitat, the Corps must:

- Design and build a permanent downstream fish passage system for HAHD according to the project development milestones described in Appendix A and BMPs described in Appendix B. The system should provide safe downstream fish passage for chinook and steelhead according to the performance measures described in Appendix C.

2.8.2 RPA Action Item 2 – Interim Actions

During the interim period between the issuance of this Opinion and the completion of the downstream fish passage system, the effects described in Section 2.4, Effects of the Action, will continue. The NMFS has determined the interim measure, RPA Action Item 2, will provide new benefit in the form of increased egg survival during the winter. This benefit will reduce impact associated with the amount of time required to implement RPA Action Item 1.

During the interim period, the Corps must:

- Modify operations to minimize redd scour in the Green River by decreasing the frequency of redd scouring flows between October 15 and February 28 (described in Appendix D). Once fish passage is available at HAHD, additional spawning habitat above the dam may reduce the necessity for redd scour reduction downstream of the dam.

2.8.3 The Corps' Implementation Decision

Because this biological opinion has found jeopardy to PS Chinook salmon, PS steelhead, and Southern Residents, and destruction or adverse modification of PS Chinook salmon and Southern Resident designated critical habitat, and PS steelhead critical habitat, and offers a reasonable and prudent alternative to avoid jeopardy and adverse modification of critical habitat, the U.S. Army Corps of Engineers (Corps) is required to notify NMFS of its final decision on implementing the RPA (50 CFR 402.15(b)) within 60 days of the issuance date of this biological opinion. NMFS is aware that the Corps would need to seek and receive Congressional funding. Failure to obtain Congressional authorization and funding to implement this RPA in a timely manner would be cause for re-initiation of consultation.

2.8.4 Analysis of the Effects of the Proposed Action As Modified by the RPAs

In this section we explain how implementing these RPAs, would ensure that the continued operation and maintenance of HAHD would avoid the likelihood of jeopardizing the continued existence of PS Chinook, salmon PS steelhead, and Southern Residents, as well as avoid the likelihood of destruction or adverse modification of their critical habitats.

Salmonid Species and Their Critical Habitats

As an initial matter, the beneficial effects of the proposed action on spawning and incubating fish downstream from the diversion dam, as described in Section 2.4, would continue under the proposed action as modified by the RPA. The RPA would directly address the primary adverse effect of the proposed action. The primary adverse effect of the proposed action on PS Chinook salmon and PS steelhead survival and potential for recovery is the obstruction of the migratory corridor leading from, and effectively to, a major portion of the best quality habitat in the Green River basin. About 40% of the PS Chinook salmon spawning and rearing habitat and 50% of the steelhead spawning and rearing habitat in the Green River lies upstream of HAHD. This habitat is of higher quality (higher productive potential) than habitats downstream from HAHD and is likely to remain high quality into the future while the habitats downstream from HAHD are more likely to further degrade due to urbanization and climate change.

2.8.4.1 Effects of Permanent Downstream Fish Passage System

Achieving the RPA's performance standards in Action Item 1 (found in Appendix A) for a permanent downstream passage system (i.e. fish collection efficiency of 95% and 98% fish facility survival, and safe passage for at least 75% of the juveniles that enter Eagle Gorge reservoir) would allow sufficient smolts to reach salt water to mature and return enough adult fish to improve the abundance and productivity of both PS Chinook salmon and PS steelhead (see details and accompanying explanation below). We also anticipate that the permanent downstream fish passage facility would improve the survival of outmigrating PS steelhead kelts because they outmigrate during the period that the juvenile passage systems would operate and would be safely passed.

Meeting the RPA performance standards would likely lead to self-sustaining populations of Puget Sound Chinook salmon and Puget Sound steelhead in the upper Green River basin. The following list illustrates potential production if performance standards are met:

- Adults: 644
- Redds: 322
- Eggs/female: 5,500
- Calculated egg production: 1,610,000
- Egg to fry survival: 38%
- Fry to smolt survival: 10%
- Reservoir survival: 80%
- Capture efficiency: 95%

- Facility survival: 98%
- In-river survival: 90%
- Estuary survival: 70%
- Calculated estuary survival: 28,707
- Smolt to adult survival: 10%
- Harvest (survival) rate: 38%
- Natural adult survival: 90%
- Returning adults: 982

Meeting the performance standards specified in the RPA would likely lead to abundant, self-sustaining populations of PS Chinook salmon and PS steelhead (644 spawners produce 982 returning adults) in the upper Green River basin. This table is a simple, one-generation, life-cycle model based on typical life-stage ratios (Groot and Margolis 1991), specified performance standards for the PDFPS, and best professional judgment. It is intended to be representative of the likely benefits of RPA implementation in a particular generation, rather than definitive, due to natural variation in life stage survival and declines in the population growth rate as density increases.

We further anticipate that as downstream passage improves, more adult salmon and steelhead, imprinted on the upper Green River watershed, would return. Tacoma and the Corps have provided upstream habitat restoration, and Tacoma has completed construction of an upstream fish passage trap and haul system at Headworks dam and is committed to its operation by its HCP (Tacoma 2001). However, NMFS and the GRFMCC have postponed operation of Tacoma's trap and haul system to avoid smolt losses that would be caused by ineffective downstream passage at HAHD. Safe and effective downstream passage provided under the RPA would change that fundamental circumstance and thus remove the barrier to operation of Tacoma's adult trap and haul system.

As set out in Tacoma's HCP (Tacoma 2001), Tacoma would trap upstream migrating adult salmon and steelhead at Tacoma's Headworks Dam and transport them for release in or upstream of the HAHD reservoir once requested by NMFS and the co-managers. We will request that Tacoma operate its trap and haul system in advance of the Corps installing the PDFPS so that outmigrating juveniles would be available for collection once the system is in operation. In sum, implementing this action would begin the process of repopulating the upper watershed, which is an essential part of achieving population viability and is consistent with our recovery goals (Shared Strategy 2002, NMFS 2006a). Once the permanent passage system is operational, we anticipate that the abundance of Chinook salmon and steelhead in the basin would increase substantially, dramatically improving the likelihood that the population would achieve a highly viable status, a requisite for recovery of PS Chinook salmon (NMFS 2006a) and very likely required for recovery of PS steelhead.

Combined with the increase in spatial diversity afforded by safe passage, this measure would markedly improve the viability of the Green River populations of both species.

There are likely to be some adverse effects associated with implementation of the RPA, but those are expected to be minor and offset by the positive effects. Refilling the reservoir during the spring outmigration is likely to slow smolt migration from the upper watershed through the reservoir as smolts are known to move faster through free flowing streams than slack-water reservoirs. Passage delay can reduce survival as it increases their exposure to mortality vectors in the reservoir, including any water quality issues and predatory species. Water quality in Eagle Gorge reservoir is generally good except for adverse summer water temperatures. The seasonal adverse water temperature condition is unlikely to substantially affect fish survival because the principal period of emigration is during the spring, when water temperatures are not adverse. The species assemblage known to occur in HAHD (Corps 2000) contains low numbers of fish likely to prey on juvenile Chinook salmon and steelhead, suggesting that passage delay would have only a small effect on survival. Further, due to the very strong need for summer flow augmentation in the lower river to protect rearing juveniles of both species, we estimate that the downstream habitat benefit provided by augmenting summer flows outweigh the negative effects of reduced spring flows and increased reservoir storage.

Because a coffer dam is already in place that the NMFS assumes will be utilized during construction of a PDFPS, and work will be conducted on the reservoir side of the dam (upstream) rather than in-stream, construction of the PDFPS is not anticipated to cause adverse effects downstream of the dam where ESA-listed are present. The Tacoma diversion dam is located 3.5 miles downstream of the HAHD blocking all access to the upstream migration of spawning adult fish. Hydrologic input from numerous small streams, including Bear Creek, between the HAHD discharge and Tacoma's diversion dam would also contribute to dilution of any sediment releases that may occur during construction. Further, Tacoma's diversion dam creates a small reservoir that would also contribute to a decrease in turbidity by allowing some settling of suspended sediments. For these reasons, the NMFS does not expect construction related turbidity downstream of the Tacoma diversion dam (the most upstream point that ESA-listed fish will occur) to reach levels causing harm to fish. No ESA-listed fish will be present upstream of the dam before construction of a PDFPS is completed.

It is not uncommon for well-designed fish collection and passage systems to fail to meet the intended performance standards when first made operational. During testing of the fish passage system, fish may experience adverse effects from prolonged migration times, impingement, entrainment, handling and/or tagging efforts and mortality associated with passing through the downstream passage facility. We have developed an adaptive management and performance testing protocol (Appendix C) to minimize any delay in meeting the performance standards, or to demonstrate sufficient performance to support fish population trajectories to meet recovery goals. Even if achieving conformance with the performance standards takes the entire 10 years allowed for system tuning and adaptive management, we anticipate that the viability of both species would be improving as abundance, spatial diversity, and productivity would be increasing, albeit not as fast as they would if the performance criteria were met.

Overall, these adverse effects are likely to result in some harm and mortality of the listed species. However, the extent of the adverse effects is evaluated in the context of the demographic benefits of the RPA. Here, any adverse effects associated with the RPA are far outweighed by the benefits in spatial structure, diversity, abundance, and productivity that are expected as a result of safe and effective passage. Because viable Green River populations of PS Chinook salmon and PS steelhead are essential to the survival and recovery of their respective ESU and DPS, avoiding jeopardy requires addressing the effects of the proposed action that would appreciably reduce the potential abundance, productivity, and spatial diversity of the Green River populations of PS Chinook salmon and PS steelhead – as the passage required by the RPA does.

Safe and effective passage would also support the conservation value of the designated critical habitats of both species by restoring the Green River's migratory corridor. Both HAHD and Tacoma's Headworks Dam are within the migratory corridor for both species. By providing a permanent downstream fish passage system at HAHD, this RPA would directly address the proposed action's adverse effect on the migratory corridor. To avoid adverse modification of critical habitat it is necessary to make changes to the proposed action such that it does not preclude or significantly delay development of the migration corridor to serve its conservation role for the species. This RPA would return the migratory corridor critical habitat PBF to a properly functioning status. Safe and effective passage would also provide proper function to existing high quality upstream spawning and rearing habitats by providing fish access to them.

2.8.4.2 Effects During the Interim Period and Redd Scour Reduction Proposed in RPA Action Item 2

It will take the Corps at least 12 years from the date of this biological opinion to complete the permanent downstream fish passage system and the existing effects are expected to continue for the most part during that interim period. During that period implementing RPA Action Item 2, to reduce redd scour (Appendix D), is anticipated to increase egg to fry survival downstream of the dam, helping to offset the effects of the HAHD and reduce the likelihood of jeopardy or adverse modification of critical habitat.

The Corps will conduct flow management operations that will reduce outflow rates at the dam to a maximum of 5,000 cfs during moderately high inflow events. Based on modeling of the recent historical data (1992-2017), the proposed operations would largely eliminate redd scouring flows in about 35% of all years. This combined with naturally low flows in 25% of years means greater than 50% of all years would have only limited redd scour. In 35% of the modeled years, more limited benefits would occur because only a percentage of the inflow peaks would be regulated under the proposed redd scour reduction operation. In years when all scouring flows can be capped at 5,000 cfs, egg to migrant survival should increase with a corresponding increase in adult returns. The potential benefits of scour reduction was estimated by evaluating historical Chinook salmon production from the Green River (COE technical memo, 2016). Analysis showed that from 2000 through 2016, redd scour reduction would have potentially added an additional 88 to 727 returning adult spawners. The benefits during mixed years are more difficult to estimate but would still occur depending on factors such as the timing of high flows. Even if only a 1% increase in egg to migrant survival were achieved, this potentially translates to hundreds of additional returning spawners.

As described above in the cumulative effects analysis, conditions affecting salmon survival in the Green River during their freshwater life-stages (spawning, incubating, rearing) are expected to decline slowly, due to ongoing urbanization and climate change, but the degree of these effects over the 12 year interim period is not expected to be so significant that it will not be reduced by the anticipated improvement in spawning and incubation success that the redd scour reduction

measures are intended to provide.
For these reasons, we do not anticipate an appreciable reduction in the abundances of the two fish species covered by this biological opinion during the interim and other factors affecting population viability (productivity, spatial diversity, and genetic health) are likely to change very slowly, if at all.

2.8.4.3 Effects of the RPA on Salmonid Critical Habitat Conservation Value

Finally, the interim period does not amount to a significant delay in of the enhancement of the migration corridor to better serve its conservation role for the species. There is a 12 year delay in re-establishing habitat connectivity, migration values, and occupation of habitat that has been blocked for decades. The delay itself is not a further detriment to the conservation value of the critical habitat, but retains the current conservation impairment for several additional years, with co-incidental retention to reclaim the improved habitat value (in other words, the critical habitat had been adversely modified but not destroyed, and retained its potential conservation value). The positive change in spawning and egg survival that will occur as a result of the RPA is a contemporaneous improvement to spawning/rearing critical habitat value in the basin during the interim period. Because the 12-year interim period represents a proportionally small addition to the antecedent 90+ year exclusion of anadromous fish from the upper Green River, and because of the redd scour reduction measures providing interim improvement, we conclude that the RPA will ensure that proper functioning conditions will return to the spawning, rearing and migration components of critical habitat, representing very significant benefits for the conservation role for the species.

2.8.4.3 Effects of the RPA on Southern Residents and Their Critical Habitat

Because PS Chinook salmon are an essential prey base for Southern Residents (prey of sufficient quantity, quality, and availability to support individual growth, reproduction and development is a designated PBF of Southern Resident critical habitat [71 FR 69054]), the higher PS Chinook salmon abundance provided by access to the upper watershed would also contribute to the survival and recovery of killer whales. The higher abundances of PS Chinook salmon and PS steelhead that would be achieved under the RPA ensures that there would be no appreciable reduction in the likelihood of survival and recovery of Southern Residents; or adverse modification of their designated critical habitat as a result of the continued operation of HAHD. As outlined above, we have determined that the interim period does not cause jeopardy or adverse modification for the salmonid species and, since the Opinion's Southern Resident conclusions turn on the effects on Chinook salmon, our determination about PS Chinook salmon during the interim period also applies to Southern Residents.

2.8.4.4 Conclusions

While the proposed action as modified by the RPA will still result in some take of listed species, the RPA avoids Jeopardy and Adverse Modification of Designated Critical Habitat of:

1) *Puget Sound Chinook Salmon and Puget Sound Steelhead*

After reviewing the current status of the listed PS Chinook salmon and PS steelhead (moderate to high risk of extinction for PS Chinook salmon and PS steelhead, respectively), the environmental baseline within the action area (degraded and likely to degrade further), the anticipated effects of the proposed action as modified by the RPA (beneficial effects on spawning and incubating fish downstream from the diversion dam, some minor adverse effects associated with RPA implementation but with very large beneficial effects by providing safe and effective fish passage and access to and from high quality habitat upstream of HAHD), and cumulative effects, it is NMFS biological opinion that implementing the proposed action as modified by the RPA is not likely to jeopardize the continued existence of PS Chinook salmon or PS steelhead, nor destroy or adversely modify PS Chinook salmon critical habitat or PS steelhead critical habitat.

2) Southern Resident Killer Whales

By avoiding appreciably reducing the likelihood of survival and recovery of the PS Chinook salmon ESU, the RPA would avoid jeopardizing the continued existence of Southern Residents and the adverse modification of their critical habitat. This RPA would increase the population numbers of PS Chinook salmon, thereby improving the prey PBF of Southern Resident designated critical habitat. Consequently, the proposed action as modified by the RPA is not likely to result in depletions of killer whale prey that could appreciably reduce the whales' likelihood of survival and recovery.

After reviewing the current status of Southern Residents (endangered with declining abundance), the environmental baseline within the action area (degraded), the anticipated effects of the proposed action as modified by the RPA (and cumulative effects), it is NMFS' biological opinion that that the proposed action as modified by the RPA is not likely to jeopardize the continued existence of Southern Residents, and would not destroy or adversely modify their critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

2.9.1 Amount or Extent of Take

In this biological opinion, the NMFS determined that incidental take is reasonably certain to occur. The following forms of incidental take cannot be accurately quantified as a number of fish. Neither can NMFS predict the range of the sub-lethal responses among the fish that will experience adverse habitat modifications caused by the proposed action. When NMFS cannot quantify take in numbers of affected fish, we instead consider likely extent of changes in habitat quantity and quality to indicate the extent of take as surrogates. Sections 2.1.9.1 through 2.1.9.4 describe take pathways and surrogates identified by the NMFS. These take surrogates are causally linked to the expected level and type of incidental take of PS Chinook salmon and PS steelhead in the Green/Duwamish River.

Individual PS Chinook salmon and PS steelhead, including all life stages (adult, egg, larvae, fry, parr) would co-occur with the effects of the action. For the reasons described in this biological opinion, incidental take of each species is reasonably certain to occur as follows:

2.9.1.1 Incidental take caused by continued operation of the HAHD

1) Take is reasonably certain to occur in the form of harm, injury, harassment, or death from continued operations of HAHD water storage by increasing downstream water temperatures (related to reservoir heating) to those above background inflow temperatures and to temperatures that exceed state maximum criterion between July 15 and November 15. Temperatures higher than tolerance capabilities for salmon and steelhead may cause avoidance which could disrupt spawning, increase vulnerability to other environmental stressors such as disease, or be lethal. The exact physical extent of the river affected by increased water temperatures from the operation of the HAHD is unknown. For take associated with increased water temperatures, the best available take surrogate is the amount of time that water temperatures are elevated above temperatures known to be harmful to fish because the extent of take is directly correlated with the duration of exposure above those temperatures (the longer that fish are exposed to water temperatures harmful to salmon and steelhead, the greater the likelihood that fish will experience adverse effects from elevated water temperature). We estimate that water temperatures will be elevated above background levels and to temperatures that exceed state maximum criterion as a result of continued operations of HAHD between July 15 and November 15, thus this time period is the surrogate for incidental take through this pathway. Take will be exceeded if discharge waters below the HAHD are increased above background inflow temperatures and exceed state maximum criterion before July 15, or after November 15 in any year. Temperature will be monitored at the existing tailwater monitoring station located approximately 0.5 miles below HAHD.

2) Prolonged exposure to increased turbidity related to high flow water release is reasonably certain to cause take in the form of harm, injury, harassment or death for up to 60 days after high flow events (including flood events). High flow from HAHD is released over a prolonged period, thus causing the water instream below HAHD to take longer to reach normal turbidity levels than would happen naturally. Increased turbidity can cause smothering of eggs and alevin, gill abrasion, decreased forage efficiency in juveniles, and behavioral modifications in juvenile and adult salmonids. The physical extent of take is assumed by NMFS to occur from the HAHD discharge to Elliot Bay, approximately 64 river miles, during the most extreme flood events. However, turbidity levels likely become indistinguishable from other inputs of turbid water, scour, and erosion before reaching Elliot Bay. Because it is not practicable to quantify take related to prolonged high flow water release, and because other sources of turbidity likely affect water quality throughout the lower extent of the Green/Duwamish River system during high flow events, the NFMFS considers the duration of high flow water release as the best available take surrogate. The duration of high flow release is causally linked to the expected take from increased instream turbidity (the longer turbidity is elevated, the longer fish will be exposed to the adverse effects from that turbidity). We estimate that turbidity will be elevated for up to 60 days after high flow events. Take would be exceeded if high flow discharge below the HAHD exceeds inflow for more than 60 days after any high flow event for flood control purposes. Turbidity will be monitored at the existing tailwater monitoring station located approximately 0.5 miles below HAHD.

3) Continued HAHD reservoir maintenance activities are reasonably certain to harass, harm, injure or kill small numbers of juvenile and/or adults during brief but intense sediment releases downstream of the dam. As described in section 2.4.2.5, increased turbidity can cause suffocation to incubating eggs, alevin, and juveniles. Juvenile and adult fish may also suffer gill damage and/or decreased forage efficiency when turbidity levels increase above background. For this consultation, the NMFS and the Corps assume take will occur for any increase in turbidity above background levels related to reservoir maintenance. As determined by the Corp using historical data and professional judgement, up to eight events related to reservoir maintenance as described in section 2.4.2.5 (Sediment/Turbidity) could occur in any one year period raising discharge turbidity to levels above background for a duration of up to five days (though actual turbidity levels may return to background within hours). Because actual take caused by reservoir maintenance is not practical to quantify, the NMFS considers the number of reservoir maintenance events causing increased turbidity above background, for a maximum of five days per event, to be the best available take surrogate. The number and duration of events causing exposure to increased turbidity has been shown to correlate with effects to fish described above. The NMFS anticipates take to occur as a result of reservoir maintenance up to a maximum of eight events per year and a maximum of five days per event. Take will be exceeded if reservoir maintenance causes turbidity levels to increase above background levels more than eight times per year and/or more than five days per event.

4) Though providing some benefit during egg incubation and summer low flows, spring refill and storage behind HAHD of approximately 49,200 af (24,200 af for fish

conservation, 5,000 af Section 1135 water for ecosystem restoration, and 20,000 af of AWSP water stored for M&I purposes and discharged so that it is available for downstream diversion by Tacoma) is expected to cause take in the form of harassment, harm, injury or death, by increasing discharge water temperatures in the summer, reducing downstream flows causing sedimentation and channel simplification, reduction in stream-margin and off-channel habitat and increased travel times (causing higher predation and exposure to poor water quality) throughout the full 64.5 mile extent of the river downstream of HAHD to the confluence with Elliot Bay. Spring refill typically occurs from February 20 through the end of May, but may extend into July depending on hydrologic conditions. Because the number of fish that would be killed due to the combined effects of spring storage cannot be predicted, the NMFS considers the volume of water stored as the best available take surrogate, as the volume of water stored is directly correlated to the extent of effects on fish that spring storage imposes downstream of HAHD. Take will be exceeded if spring storage (February –July, depending on hydrologic conditions) exceeds 50,000 af of water in any year.

2.9.1.2 Incidental take during testing of the PDFPS and collection efficiency

Take in the form of harm, injury, harassment or death is reasonably certain to occur during the testing of the PDFPS. Take could occur from prolonged migration times through the reservoir increasing predation, inability to locate the fish collection facility, impingement, entrainment, handling and/or tagging efforts and mortalities associated with passing through the downstream passage. Performance criteria in Appendix C specify rates at which performance is considered successful or when conditions require "minor adjustments", "adjustments", or "modifications" to the passage system. During the testing period, incidental take above the minimum performance requirements (75% survival from entry into the reservoir to downstream passage) could occur while tuning or adjustments are being made. The PDFPS must meet performance standards for any two consecutive years, after which the PDFPS is considered successfully functional within a 10 year period or the Corps must request reinitiation. During the testing period, it is impossible to determine the extent of incidental take that could occur, however NMFS assumes that it is likely to be higher than the full performance requirement of 75% survival from entry into the reservoir to discharge below HAHD, especially during early testing. Per the Corps adaptive management protocol in Appendix C, collection efficiency could be less than 70% during initial testing requiring adaptive management strategies to meet performance requirements. Therefore, the NMFS imposes a maximum incidental take limit of 65% mortality (minimum of 35% survival) of fish attempting to migrate downstream through the PDFPS and a maximum of 10 years to meet full performance requirements. Take will be exceeded if mortality exceeds 65% of the test fish attempting to migrate downstream, or if performance requirements are not met within 10 years.

2.9.1.3 Incidental take during the operation, and monitoring of the permanent downstream fish passage system.

Operation and monitoring of a PDFPS is reasonably certain to cause take through handling of fish (for monitoring purposes), inability to locate the collection facility, slow migration through the reservoir increasing predation, and mortalities caused by passage through the PDFPS. Once the downstream fish passage facility has been tested and determined to meet performance standards and is operating (February 2031), it would collect the majority of outmigrating Chinook salmon and steelhead, including adult fallbacks, kelts, and smolts. Take would be minimized through the adherence to performance standards specified in RPA Action 1 and described in Appendix C (combined reservoir survival, collection efficiency, and collection survival of 75%). Take would be exceeded if less than 75% of the juvenile migrants entering the reservoir survive passage through the PDFPS (including incidental take associated with monitoring), and/or less than 2% of the adult fallbacks and kelts survive downstream passage through the PDFPS after initial testing of the passage facility is complete and the system is fully operational.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action as modified by the RPA, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures, and Terms and Conditions

"Reasonable and prudent measures" (RPMs) are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02). Because take is still expected to occur at Howard A. Hanson Dam despite the range of habitat and survival benefits intended by the RPA, we provide the following reasonable and prudent measures to minimize the expected take.

The terms and conditions described below are non-discretionary, and the Corps must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Corps has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the following terms and conditions are not complied with, the protective coverage of section 7(o)(2) will likely lapse.

RPM #1 – The COE shall minimize take associated with the design and construction of downstream passage - (RPA Action Item 1) by avoiding delay.

> Term and Condition #1 Implementing the proposed action and RPA will take many years before the permanent downstream fish passage system is complete. The Corps must meet the design and construction schedule milestones provided in Appendix A in order to avoid delays in meeting the completion date of 2030.

RPM #2 - Monitor take during operation of the PDFPS (RPA Action Item 1).

> Term and Condition # 2 The Corps must evaluate passage survival at HAHD of juvenile PS Chinook and PS steelhead to demonstrate compliance with performance standards. If the downstream passage is not meeting the performance criteria then the Corps must develop, in consultation with NMFS, remedial measures (e.g. changes in facility configuration, project operations, or both). Measures to ensure that the PDFPS meets

performance criteria (safely passes at least 75% of the fish entering Eagle Gorge reservoir) are provided in Appendix C.

RPM #3 – Minimize take associated with construction of the downstream passage (RPA Action Item 1) by Documenting use of Best Management Practices.

Term and Condition #3 Implementing the proposed action and RPA will require in-water work. To minimize take caused by in-water construction work, the Corps must coordinate with NMFS, the Washington Department of Fish and Wildlife, and the Muckleshoot Indian Tribe to identify in-river work windows, and employ the best management practices. The specific protective measures the Corps must employ during in-water/over-water work are provided in Appendix B. The Corps must coordinate with the NMFS before construction begins to determine monitoring requirements.

RPM #4 – Implement and monitor operations to reduce redd scour below HAHD according to the following criteria (RPA Action Item 2).

Term and Condition # 4 Over a running 3 year period, from October 15 through February 28, the Corps will reduce a minimum of 75 percent of all HAHD inflow events between 5,000 and 12,000 cfs to a maximum outflow of 5,000 cfs. Operations will be monitored against these performance criteria and reported to NOAA after the first three years of operation and annually thereafter until the PDFPS is complete and performance requirements have been met.

RPM #5 – Convene meetings with co-managers, NMFS, and Tacoma to discuss flow management to increase fish protection, fish passage design and monitoring, and establish protocols to reintroduce fish upstream of HAHD.

Term and Condition # 5 During the interim period, the Corps must:

- On or before February 2020 with NMFS, convene a meeting with co-managers and the City of Tacoma, to discuss the use of storage releases to supplement streamflows for Chinook and steelhead spawning, rearing, incubation, and migration; for water temperature improvement; and to discuss the efficacy of operation modifications that would maintain flows between February and June in order to increase off-channel habitat connectivity for juvenile Chinook and steelhead rearing opportunity. If such discussions identify feasible and potential conservation benefits, introduce this as a future topic in the adaptive management strategy for fish conservation.
- Participate in meeting(s) with NMFS, co-managers, and the City of Tacoma to collectively identify strategies for facility performance testing (i.e. using hatchery fish versus natural origin) and performance testing/monitoring design.
- Participate in meeting(s) with NMFS, co-managers, and the City of Tacoma to collectively identify cooperative strategies for trap and haul operations to reintroduce fish upstream of HAHD during the development of Items 1 and 2 Implementing the proposed action.

2.10 Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.11 Section 7(a)(1) Conservation Recommendations

Conservation recommendations offered under section 7(a)(1) of the ESA are discretionary advisory actions that NMFS encourages the Action Agency to conduct for the purpose of enhancing the conservation of species, rather than merely minimizing the risk of jeopardy.

No conservation recommendation is offered at this time.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

The consultation requirement of Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions, or proposed actions that may adversely affect EFH. The MSA (Section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effects include the direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that may be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the Corps and descriptions of EFH for Pacific coast salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Department of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The project action area includes EFH for Chinook salmon, coho salmon, and Puget Sound pink salmon (PFMC 1999). Although the action area (Sections 1.4) includes portions of Puget Sound that provide EFH for an array of rockfish, we have determined that the proposed action would have no physical or biological effect on that habitat. We therefore focus on the action's effects on areas designated as EFH for adult, fry, juvenile, and smolt life history stages of Chinook salmon *(Oncorhynchus tshawytscha)*, coho salmon *(Oncorhynchus kisutch)*, and pink salmon

(Oncorhynchus gorbushca). No Habitat Areas of Particular Concern for these species have been identified in the action area.

3.2 Adverse Effects to Essential Fish Habitat

Based on information provided in the Biological Assessment (BA) (Corps 2013a) and the analysis of effects presented in the biological opinion, NMFS concludes that the proposed action would adversely affect EFH designated for Pacific Salmon by obstructing effective fish passage, and diminishing the value of spawning and rearing habitats. The proposed action also provides beneficial effects on Chinook salmon and pink salmon EFH by reducing peak flow-induced scour downstream of HAHD, which improves the survival of incubating eggs and alevins.

3.3 Essential Fish Habitat Conservation Recommendations

NMFS expects that the RPA (Section 2.8) and the reasonable and prudent measures required in our ITS (Section 2.9), in addition to the measures in the proposed action, will conserve EFH. Consequently, NMFS adopts those measures as our EFH conservation recommendations.

NMFS expects that full implementation of these EFH conservation recommendations, combined with the mitigative measures included in the proposed action, would protect, by avoiding or minimizing the adverse effects described in Section 3.2 above, in the Green River EFH used by PS Chinook salmon and pink salmon.

3.4 Statutory Response Requirement

As required by Section 305(b)(4)(B) of the MSA, the Federal agency (in this case the Corps) must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH conservation recommendations, unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigation, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS' Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(l)].

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The Corps must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENT & PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (the Data Quality Act) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the Opinion addresses these Data Quality Act (DQA) components, documents compliance with the DQA, and certifies that this Opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this opinion is the U.S. Army Corps of Engineers (Corps). Other interested users could include local Native American tribes, agencies of the State of Washington, King and Pierce Counties, conservation organizations, and citizens in affected areas. Individual copies of this opinion were provided to the Corps. This opinion will be posted on the NMFS West Coast Region web site (http://www.westcoast.fisheries.noaa.gov/). The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan.

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this biological opinion/EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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APPENDIX A: Design Process and Criteria for the Green River Permanent Downstream Fish Passage System

Overarching Guidance

The permanent downstream fish passage system must be designed consistent with (NMFS 2011c) guidelines (Anadromous Salmonid Passage Facility Design, National Marine Fisheries Service, 2011, Portland OR) or any update of these guidelines prior to initiation of the pre-construction engineering and design (PED). The primary purpose for the new fish passage system is to provide safe, timely and effective downstream fish passage throughout the range of conditions likely to occur during the annual smolt migration. The new system must meet the passage performance criteria provided in the RPA:

- 95% collection of fish attracted to the fishway (from the fish collection efficiency line shown in Figure 1C into the trap),
- 98% survival of fish through the facility to their release downstream of HAHD, and
- An overall juvenile fish project passage survival rate of 75%, from entry into Eagle Gorge reservoir to release points downstream.

Project Development Milestones

These milestones serve a planning function to measure progress in achieving the overall objective of 1) completing construction by the end of calendar year 2030, and 2) providing operational juvenile downstream passage of juvenile Chinook outmigration no later than February, 2031.

Failure to meet any one of these milestones' target dates is not intended in itself to be cause to require reinitiation of consultation so long as the "complete construction" target date remains achievable. If at any time the project schedule falls 18 months behind the target dates listed below, the Corps and NMFS would meet to discuss the project status and any potential need for reinitiation of consultation.

By January 31 each year until project completion, the Corps must provide a progress report to NMFS documenting progress toward or achievement of the following target milestones:

- Complete a post-authorization decision document (PADD), consistent with Corps processes, with approval by the appropriate Department of Army official by 2024. This begins the process of seeking additional Congressional authorization and appropriations.
- If Congressional authorization and appropriation are enacted, immediately initiate PED (target date 2025).
- Complete PED not later than three years (target date end of FY 2027) after enactment of any Congressional authorization and appropriation, and initiate construction contracting.

- Complete construction no longer than 6 years after enactment of any Congressional authorization and appropriation (completion date calendar year 2030).

- Begin downstream fish passage system operations by the February 2031 juvenile outmigration season following completion of construction.

APPENDIX B: Best Management Practices for In-Water Work

The COE will provide NMFS copies of "environmental submittals" from its contractor/s for contemporaneous review and opportunity for input.

1. <u>Pollution and erosion control</u>. Any action that will require earthwork and may increase soil erosion and cause runoff with visible sediment into surface water, or that will require the use of materials that are hazardous or toxic to aquatic life (such as motor fuel, oil, or drilling fluid), must have a pollution and erosion control plan that is developed and carried out by the applicant, and commensurate with the scale of the action.

a. The plan must include practices to minimize erosion and sedimentation associated with all aspects of the project (*e.g.*, staging areas, stockpiles, grading); to prevent construction debris from dropping or otherwise entering any stream or waterbody; and to prevent and control hazardous material spills.

b. During construction, erosion controls and streams must be monitored and maintained daily during the rainy season and weekly during the dry season as necessary to ensure controls are properly functioning.

c. If monitoring shows that the erosion controls are ineffective at preventing visible sediment discharge, the project must stop to evaluate erosion control measures. Repairs, replacements or the installation of additional erosion control measures must be completed before the project resumes.

d. Proper maintenance includes removal of sediment and debris from erosion controls like silt fences or hay bales once it has reached on-third of the exposed height of the control.

2. <u>Stormwater management.</u> Any action that will expand, recondition, reconstruct, or replace pavement, replace a stream crossing, otherwise increase the contributing impervious surface within the project area, or create a new stormwater conveyance or discharge facility, must have a stormwater management plan that is developed and carried out by the applicant, commensurate with the scale of the action.

3. <u>Site restoration.</u> Any action that results in significant disturbance of riparian vegetation, soils, streambanks, or stream channel must have a site restoration plan that is developed and carried out by the permittee (or Corps), that is commensurate with the scale of the action. The goal of the plan is to ensure that riparian vegetation, soils, streambanks, and stream channel are cleaned up and restored after the action is complete. No single criterion is sufficient to measure restoration success, but the intent is that the following features should be present in the upland parts of the project area, within reasonable limits of natural and management variation:

a. Human and livestock disturbance, if any, are confined to small areas necessary for access or other special management situations.

b. Areas within the project footprint showing signs of apparent erosion associated with the work are completely stabilized and healed, bare soil spaces are small and well-dispersed.

c. Soil movement, such as active rills and soil deposition around plants or in small basins, is absent or slight and local.

d. Native woody and herbaceous vegetation, and germination microsites, are present and well distributed across the site.

e. Plants are native species and have normal, vigorous growth form, and a high probability of remaining vigorous, healthy and dominant over undesired competing vegetation.

f. Vegetation structure is resulting in rooting throughout the available soil profile.

g. Plant litter is well distributed and effective in protecting the soil with little or no litter accumulated against vegetation as a result of active sheet erosion ("litter dams").

h. In disturbed areas, a corridor of continuous shrubs and trees appropriate to the site are planted immediately post construction to provide shade and other habitat functions for the streambank.

i. Streambanks are stable, well vegetated, and protected at margins by roots that extend below baseflow elevation, or by coarse-grained alluvial debris.

4. <u>Compensatory mitigation[19].</u> Any action that will permanently displace riparian or aquatic habitats or otherwise prevent development of properly functioning condition of natural habitat processes will require compensatory mitigation within the defined action area to fully offset those impacts.

a. Examples of actions requiring compensatory mitigation include construction of a new or enlarged boat ramp or float, the addition of scour protection to a boat ramp, or construction of new impervious surfaces without adequate stormwater treatment.

b. For displaced riparian and aquatic habitat, the primary habitat functions of concern are related to the physical and biological features essential to the long- term conservation of listed species. Those are water quality, water quantity, channel substrate, floodplain connectivity, forage, natural cover, space, and free passage. Examples of acceptable mitigation for riparian losses includes planting trees or other

[19] The compensatory mitigation proposed here minimizes the impacts related specifically to construction activities associated with PDFPF; the conclusion of this Opinion is not reliant on the benefits accrued by this specific mitigation.

woody vegetation in the riparian area, removal of existing overwater structures or restoration of shallow-water, off-channel, or beach habitat by adding features such as submerged or overhanging large wood, aquatic vegetation, large rocks and boulders, side channels and undercut banks.

c. For new impervious surfaces with inadequate stormwater treatment, the primary habitat functions of concern are water quality and water quantity. Examples of acceptable mitigation for inadequate stormwater management includes providing adequate stormwater treatment at an alternate site where it did not exist before or retrofitting an existing but substandard stormwater facility to provide capacity necessary to infiltrate and retain the proper volume of stormwater.

d. As part of NMFS's review under clause 3 above, NMFS will determine if the proposed compensatory mitigation fully offsets permanent displacement of riparian or aquatic habitats and/or impacts that prevent development of properly functioning processes.

5. Preconstruction activity. Before alteration of the action area, flag the boundaries of clearing limits associated with site access and construction to minimize soil and vegetation disturbance, and ensure that all temporary erosion controls are in place and functional.

6. Site preparation. During site preparation, conserve native materials for restoration, including large wood, vegetation, topsoil and channel materials (gravel, cobble and boulders) displaced by construction. Whenever practical, leave native materials where they are found and in areas to be cleared, clip vegetation at ground level to retain root mass and encourage reestablishment of native vegetation. Building and related structures may not be constructed inside the riparian management area.

7. Heavy equipment. Heavy equipment will be selected and operated as necessary to minimize adverse effects on the environment (*e.g.*, minimally-sized, low pressure tires, minimal hard turn paths for tracked vehicles, temporary mats or plates within wet areas or sensitive soils); and all vehicles and other heavy equipment will be used as follows:

a. Stored, fueled and maintained in a vehicle staging area placed 150 feet or more from any waterbody, or in an isolated hard zone such as a paved parking lot.

b. Inspected daily for fluid leaks before leaving the vehicle staging area for operation within 50 feet of any waterbody.

c. Steam-cleaned before operation below ordinary high water, and as often as necessary during operation to remain free of all external oil, grease, mud, seeds, organisms and other visible contaminants.

d. Generators, cranes and any other stationary equipment operated within 150 feet of any waterbody will be maintained and protected as necessary to prevent leaks and spills from entering the water.

8. <u>Actions that require work area isolation.</u> Any action that involves excavation (other than access management), backfilling, embankment construction, or similar work below ordinary high water where adult or juvenile fish are reasonably certain to be present, or 300 feet or less upstream from spawning habitats, must be effectively isolated from the active stream.

9. <u>Fish capture and removal.</u> Whenever work isolation is required and ESA-listed fish are likely to be present, the applicant must attempt to capture and remove the fish as follows:

a. A fishery biologist experienced with work area isolation and competent to ensure the safe capture, handling and release of all fish will supervise this part of the action, and complete the fish salvage form from Appendix C that will be submitted with the action completion report.

b. Any fish trapped within the isolated work area must be captured and released using a trap, seine, electrofishing, or other methods as prudent to minimize the risk of injury, then released at a safe release site.

c. If electrofishing is used to capture fish, that work must be consistent with NMFS' electrofishing guidelines (NMFS 2000).

10. <u>Piling installation.</u> Pilings may be concrete, steel round pile 24 inches in diameter or smaller, steel H-pile designated as HP24 or smaller, or wood that has not been treated with preservatives or pesticides. Any proposal to use wood pilings treated with preservatives or pesticides is not covered by this consultation and will require individual consultation.

a. When practical, use a vibratory hammer for piling installation. For pile driving in the Green River in the month of October, only a vibratory hammer may be used.

b. Jetting may be used for piling installation in areas with coarse, uncontaminated sediments.

11. <u>Pile driving with an impact hammer.</u> When using an impact hammer to drive or proof steel piles, one of the following sound attenuation methods must be used:

a. Completely isolate the pile from flowing water by dewatering the area around the pile.

b. If water velocity is 1.6 feet per second or less, surround the piling being driven by a confined or unconfined bubble curtain (*see,* Wursig *et al*. 2000, and Longmuir and Lively 2001) that will distribute small air bubbles around 100% of the piling perimeter for the full depth of the water column.

c. If water velocity is greater than 1.6 feet per second, surround the piling being driven by a confined bubble curtain (*e.g.,* a bubble ring surrounded by a fabric or non-metallic sleeve) that will distribute air bubbles around 100% of the piling perimeter for the full depth of the water column.

12. <u>Pile removal.</u> Use the following steps to minimize creosote release, sediment disturbance and sediment resuspension:

a. Install a floating surface boom to capture floating surface debris.

b. Keep all equipment (*e.g.*, bucket, steel cable, vibratory hammer) out of the water, grip piles above the waterline, and complete all work during low water and low current conditions.

c. Dislodge the piling with a vibratory hammer, when possible; never intentionally break a pile by twisting or bending.

d. Slowly lift the pile from the sediment and through the water column.

e. Place the pile in a containment basin on a barge deck, pier, or shoreline without attempting to clean or remove any adhering sediment – a containment basin for the removed piles and any adhering sediment may be constructed of durable plastic sheeting with sidewalls supported by hay bales or another support structure to contain all sediment and return flow which may otherwise be directed back to the waterway.

f. Fill the holes left by each piling with clean, native sediments immediately upon removal.

g. Dispose of all removed piles, floating surface debris, any sediment spilled on work surfaces, and all containment supplies at a permitted upland disposal site.

13. <u>Broken or intractable piling.</u> When a pile breaks or is intractable during removal, continue removal as follows:

a. Make every attempt short of excavation to remove each piling, if a pile in uncontaminated sediment is intractable, breaks above the surface, or breaks below the surface, cut the pile or stump off at least 3 feet below the surface of the sediment.

b. If dredging is likely where broken piles are buried, use a global positioning system (GPS) device to note the location of all broken piles for future use in site debris characterization.

14. <u>Pesticide-treated wood installation.</u> Use of lumber, pilings, or other wood products treated or preserved with pesticidal compounds may not be used below ordinary high water, or as part of an in-water or overwater structure

15. <u>Pesticide-treated wood removal.</u> When it is necessary to remove pesticide-treated wood, the following conditions apply.

a. Ensure that, to the extent possible, no wood debris falls into the water. If wood debris does fall into the water, remove it immediately.

b. After removal, place wood debris in an appropriate dry storage site until it can be removed from the project area.

c. Do not leave wood construction debris in the water or stacked on the streambank at or below the ordinary high water.

d. Evaluate wood construction debris removed during a project, including pesticide- treated wood pilings, to ensure proper disposal of debris.

16. Required monitoring/reporting. The Corps will coordinate with the NMFS prior to initiation of any construction related activities to determine reporting requirements.

References:

Würsig, B., C.R. Greene Jr., and T.A. Jefferson. 2000. Development of an air bubble curtain to reduce underwater noise from percussive piling. Marine Environmental Research 49: 19-93.

Longmuir, C., and T. Lively. 2001. Bubble curtain systems for use during marine pile driving. Report by Fraser River Pile & Dredge Ltd., New Westminster, British Columbia. 9 p.

APPENDIX C: Performance Criteria for Howard Hanson Dam Permanent Downstream Fish Passage System (PDFPS)

This appendix details the process for evaluating the performance of the permanent downstream fish passage system. The Corps will design in consultation with the NMFS, and fund post-construction performance evaluations to ensure the performance criteria are met.

There are two categories of evaluation. First is the primary evaluation of the system to ensure it meets all the performance criteria and whether troubleshooting will be necessary. Primary evaluation will begin one year post construction to allow one year for facility tuning once operational.

The Corps and NMFS anticipate facility tuning will be needed at project start-up, including to operations, debris management practices, and fish handling/holding protocols. Facility changes may be warranted to address a wide range of fish responses. The COE will seek funding as necessary to perform both performance testing, and implementation of adjustments and modifications.

Once the performance criteria have been satisfactorily met, this evaluation will be considered complete.

The second category of evaluation is long term and intended to ensure the system maintains performance over time – specifically 98% survival through the fish passage facility.

The requisite fish passage performance criteria are:

- An overall juvenile fish project passage survival rate of 75%, from entry into Eagle Gorge reservoir to release points downstream.
- 95% collection of fish attracted to the PDFPS, and
- 98% survival of all fish through the facility to their release downstream of HAHD.

I. Primary Evaluation of the (PDFPS) (to determine passage survival rate)

a. *Performance testing* will be conducted beginning in year two to allow for one year of facility tuning once operational.

b. *Tiered test sequence*: Performance testing may initially examine passage survival from the head of the reservoir to release downstream of the HAHD. Further testing of FCE or other project elements would only be conducted if the initial testing does not meet the overall juvenile passage performance criterion of 75%. If the performance metric for juvenile fish project passage survival rate of 75% is met, it will be assumed the 95% FCE and 98% facility survival criteria have also been met.

c. *Test fish*: Test fish will not consist of natural origin recruits. The Corps will coordinate with the NMFS, MIT, and Tacoma to determine origin of fish to be used for testing purposes.

d. *Test periods*: Studies will require testing at times of the year when most juvenile Chinook and steelhead migrants are actively moving downstream (February through June). If hydrologic conditions are unusual, the Corps and NMFS will discuss results to determine if any aspect of the testing should be redone. The Corps must obtain NMFS' concurrence regarding test validity and the need for further testing.

e. *Primary evaluation*: Evaluation is to occur over the entire migration period. When two successive years of performance meeting the criteria occurs, then primary evaluation is considered complete. If after 10 years of primary evaluation the facility has not provided two successive years of meeting criteria then, the COE shall request re-initiation.

II. Evaluation of the Fish collection efficiency (FCE)

Timeframes for completing Adjustments and Modifications as described below under Adaptive Management (no design needed):

a. FCE will be measured as the proportion of fish that are collected by the fish passage facility divided by the total number of fish in the *FCE measurement zone* (line shown on Figure C-1) over the test period. Study design will include sufficient test fish such that point estimates of FCE can be made within a precision level, standard error of ±2.5%.

b. If FCE of 95% or greater is achieved for two study years, then no further evaluation is required.

c. If FCE ≥ 85%, but < 95%, NMFS and the Corps would identify, and carry out Minor Changes. Continued actions to improve FCE may not be necessary if the Corps and the NMFS agree that performance is sufficient based on population abundance trajectories or other appropriate metrics.

d. If FCE ≥70% but < 85%, after two study years, the Corps would carry out Operational or Facility Adjustment(s) to improve FCE.

    i. Timeframes for completing Adjustments (no design needed) to ensure that the facility will physically operate as intended. The action is expected to be completed in 1-2 years (however, timeframes will be updated and defined during the design phase).
    ii. If, after two years of testing, FCE remains <85%, and all feasible Adjustments have been tried, then the Corps will carry out Modifications, unless NMFS concurs that further modifications are not warranted.

If FCE < 70%, the Corps will complete Adjustments first (if not already completed) and then Modification(s), with NMFS concurrence on the measures.

    i. Timeframes for completing Modifications (new design required) depend on design needs. If additional funding is needed, the timeline to complete a Modification will be determined by the design schedule (1-2 years) and receiving funds through the federal appropriations process (1 or more years); total up to 5 years.

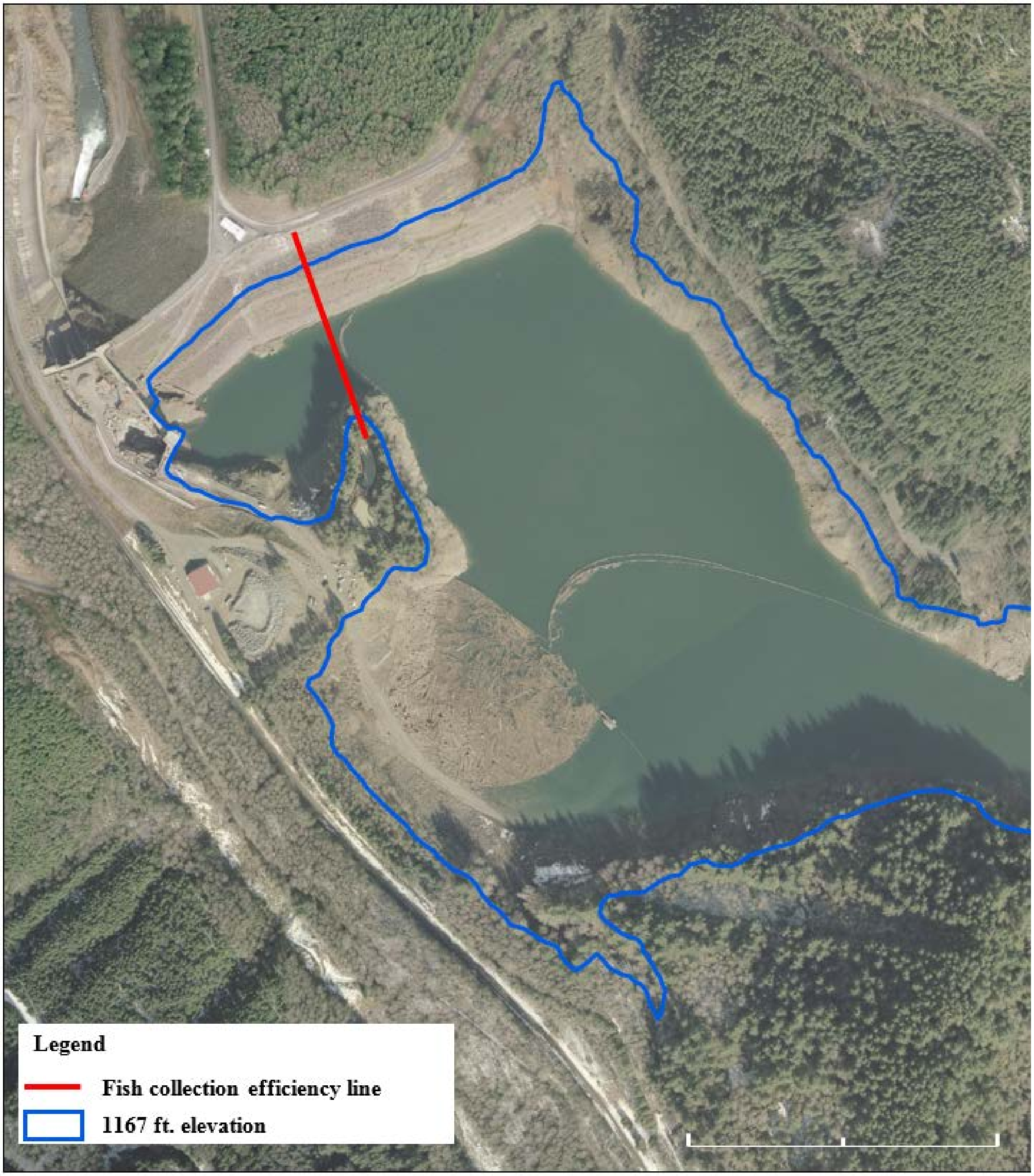

Figure 1C-1 Location of fish collection efficiency measurement point.

III. Facility performance

a. Facility performance criterion is 98% survival through the facility to release downstream of HAHD.

b. Injury definition and metrics: visible trauma (including hemorrhaging, open wounds without fungus growth, gill damage, bruising greater than 0.5 cm in diameter, etc.), loss of equilibrium, or greater than 20% descaling. Descaling is defined as the sum of the area on one side of the fish that shows recent scale loss. This does not include the area where scales have regenerated or fungus has grown.

c. If mortality or injury is $\leq$ 2%, no further action is required.

d. If mortality or injury is >2% but $\leq$4% then minor changes are required.

e. If mortality or injury is >4%, then operation or structural changes are required.

IV. Adaptive management:

If initial evaluations fail to demonstrate compliance with the performance standards adaptive management actions and follow-up evaluations will be required. Adaptive management actions may include evaluation of future changed operational, structural, or environmental conditions to ensure they have not negatively affected performance. NMFS will review and comment on study concepts, objectives, and plans. The Corps and the NMFS will work collaboratively towards consensus on these concepts, objectives, and plans. The Corps will ensure evaluations are carried out and reports produced for NMFS' review within timelines necessary to inform adaptive management decisions outlined in this document.

1. "Minor changes" **–** are intended to occur within existing budgets; examples include but are not limited to the following:

   - Structural: rotating entrance, adjusting baffles, and other tuning of the existing facility; changes in debris management practices, changes in fish handling/holding/transport using existing facilities

   - Operational PDFPS: longer or shorter operational periods of PDFPS, pulsing operations; increasing or decreasing entrance flows, bypass flows, etc.

   - Operating the dam with flow pulses, operating at a lower pool level during conservation season, and changing the rate of reservoir drawdown through summer and fall.

2. “Adjustments” – are intended to occur within a program revision or within a two year budget cycle; examples include but are not limited to the following:

    - Operational (PDFPS): changing debris management practices, fish handling/holding practices, or other operational changes as deemed necessary.

    - Operational (Flow Management): changes in refill pattern, operating at lower pool level during conservation season, operating dam with pulses, changing rate of reservoir drawdown through summer and fall.

3. “Modifications” – are major changes that may require additional authorization of funds or trigger specific decision analyses: examples include but are not limited to the following:

    - Structural: Major new design components.

    - Operational: starting refill earlier in the year than under current rule curve, not drawing reservoir down as low in winter, modifying downstream minimum flows or exceeding ramping rates

4. After modifications or adjustments are made, the Corps will fund and conduct one or more years of tests to assess changes. Study concepts, objectives, and plans will be developed in collaboration with NMFS in the same manner described above.

5. Application of new information: As new relevant information becomes available, NMFS and the Corps will apply this information within the adaptive management context described above and with a view also to the regulatory reinitiation criteria. If significant operational, structural, or environmental changes occur in the future, the Corps will consult with NMFS to determine whether additional performance testing is warranted.

V. Long term monitoring of ongoing operations

a. Long-term monitoring consists of routine inspections of facility operations, and fish condition subsampling to ensure the facility is operating as designed and is safely passing fish.

b. Operation monitoring will identify factors such as debris accumulations or equipment breakdown that may develop over time and harm fish. An Operation and Maintenance Plan will be completed after design and prior to the completion of the permanent downstream fish passage facility.

c. Facility performance will be measured as the survival rate and condition of fish transiting the fish passage facility.

d. If this evaluation detects mortality >2%, it would trigger an investigation to remedy the problem.

References:

NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Ore

APPENDIX D: HAHD Interim RPA: Water Management Operations to Reduce Redd Scour – Monitoring and Adaptive Management

Over a running 3 year period, between October 15 through February 28, the Corps will reduce 75% of all HAHD inflow events between 5,000 and 12,000 cfs to a maximum outflow of 5,000 cfs until the PDFPS is operational and meeting performance criteria.

Evaluation:

The Corps will annually review available data on Chinook salmon egg to migrant survival rates in relation to HAHD outflows and the operations conducted to reduce redd scour to assess whether the survival rates are consistent with expectations. The review will assess the survival rate against the rate predicted from the regression model produced in support of the interim RPA and in consideration of the many other factors that could influence the survival rate. This review is intended to be a check over time to generally verify the relationship between egg survival and reductions in redd scouring flows.

The primary data to be reviewed are the egg to migrant survival rate estimated from adult spawning surveys and juvenile migration estimated from the juvenile smolt trap operation. Spawning surveys have historically been conducted by the Washington Department of Fish and Wildlife (WDFW) and Muckleshoot Indian Tribe. These surveys are expected to continue in the future. WDFW has operated and maintained the juvenile smolt trap since 2000 with funding from the Corps, City of Tacoma, King County, and WDFW. In recent years these parties have agreed to cost share the annual operation of the trap. This cost share relationship is expected to continue in the future. This review of egg to migrant survival rates is contingent on all parties continuing these monitoring activities.

Reporting and adaptive management:

The Corps will report evaluation results to NMFS annually. If after the first 3-year period and each year after using 3-year averages, operational or biological results are not meeting expectations, the Corps will work with NMFS to assess the reasons expectations have not been met and determine if operational adjustments are warranted. This assessment will include consideration of the precision of egg-to-migrant survival rate estimates and most recent population status information.