BUREAU OF RECLAMATION

Final Biological Assessment

The Effects of the Proposed Action to Operate the Klamath Project from October 1, 2024, through September 30, 2029 on Federally-Listed Threatened and Endangered Species

Klamath Project, Oregon/California

Interior Region 10 – California – Great Basin

U.S. Department of Interior

June 2024

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Prepared by

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Acronyms and Abbreviations

2020 Biological Assessment	Final Biological Assessment on the Effects of the Proposed Action to Operation the Klamath Project from April 1, 2020 through March 31, 2024 on Federally Listed, Threatened, and Endangered Species
2023 FONSI	April 2023 'Finding of No Significant Impacts'
ACFFOD	Amended and Corrected Findings of Fact and Order of Determination
Action Area	areas affected by the federal action
AF	acre-feet
AFA	Aphanizomenon flos- aquae
BIA	U.S. Bureau of Indian Affairs
BiOp	biological opinion
BOD	biochemical oxygen demand
CBOD	carbonaceous biochemical oxygen demand

CDFW	California Department of Fish and Wildlife
CFR	code of federal regulations
cfs	cubic feet per second
CI	confidence interval
CNRFC	California Nevada River Forecast Center
CJS	Cormac-Jolly-Seber
Delta	Williamson River Delta
DO	dissolved oxygen
DPS	Distinct Population Segment
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FASTA	Flow Account Scheduling Technical Advisory
FERC	Federal Energy Regulatory Commission
FFA	Flexible Flow Account
FW	fall-winter
HGMP	Hatchery and Genetic Management Plan
HID	Horsefly Irrigation District
IGD	former Iron Gate Dam site
Interior	U.S. Department of Interior
InterMAT	Inter-Seasonal Management Advisory Team
IntraMAT	Intra-Seasonal Management Advisory Team
IOP	Interim Operations Plan
KBAO	Klamath Basin Area Office
KBPM	Klamath Basin Planning Model
kcal/kg	kilocalorie/kilogram
KDD	Klamath Drainage District
KHSA	Klamath Hydroelectric Settlement Agreement
KID	Klamath Irrigation District
KPFA	Klamath Power and Facilities Agreement
KPO	Klamath Project Operations
KRM	Keno Release Model
KSD	Klamath Straits Drain
LiDAR	Light Detection and Ranging
LR Diversion	Lost River water diverted into the Lost River Diversion Channel
LRD	Link River Dam
LRDC	Lost River Diversion Channel
LRS	Lost River Sucker
LVID	Langell Valley Irrigation District
MAE	mean absolute error
MS	maximum storage operation
NAA	no action alternative
NEPA	National Environmental Policy Act
NFWF	National Fish and Wildlife Foundation

NMFS	National Marine Fisheries Service
NMFS 2019 BiOp	Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for Klamath Project Operations from April 1, 2019 through March 31, 2024
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NRKW	Northern Resident Killer Whale
NWFSC	Northwest Fisheries Science Center
NWI	Normalized Wetness Index
NWR	national wildlife refuge
O&M	operation and maintenance
OAR	Oregon Administrative Rule
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
PAH	polycyclic aromatic hydrocarbon
ppb	parts per billion
PDF	Probability Density Function
pHOS	proportion of hatchery-origin spawners
PIT	passive integrated transponder
pNOB	proportion of natural origin broodstock
POI	prevalence of infection
Project	Klamath Project
RBF	River Base Flow
RBM10	River Basin Model-10
Reclamation	U.S. Bureau of Reclamation
Renewal Corporation	Klamath River Renewal Corporation
rkm	river kilometer
RM	river mile
ROR	run-of-river scenario
S3	Stream Salmonid Simulator
SAR	Smolt-to-adult return
Services	USFWS and NMFS
SNS	Shortnose Sucker
SONCC Coho Salmon	Southern Oregon Northern California Coast Coho Salmon
SRKW	Southern Resident Killer Whale
SS	spring-summer
SSC	suspended sediment concentration
SSO	site-specific objective
TAF	thousand acre feet
TID	Tulelake Irrigation District
TMDL	Total Maximum Daily Load
TN	total nitrogen

TOP	Temporary Operations Plan
TP	total phosphorus
UKL	Upper Klamath Lake
U.S.C.	United States Code
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USFWS 2019 BiOp	Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker
USGS	U.S. Geological Survey
VBDC	Van Brimmer Ditch Company
VSP	Viable Salmonid Population
WOA	Without Action
WRIMS	Water Resources Integrated Modeling System
WUA	weighted usable area
YOY	young of the year

1 Introduction

1.1 Purpose of the Biological Assessment

The U.S. Bureau of Reclamation (Reclamation) currently meets its obligations under Section 7(a)(2) of the Endangered Species Act (ESA) by operating the Klamath Project (Project) in accordance with two biological opinions (BiOps): the September 30, 2023 U.S. Fish and Wildlife Service (USFWS) *Biological Opinion on the Effects of Proposed Interim Klamath Project Operations Plan, effective October 1, 2023, through October 31, 2024, on the Lost River Sucker and the Shortnose Sucker*[1] (USFWS, 2023a) and the March 29, 2019 National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) *Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for Klamath Project Operations from April 1, 2019 through March 31, 2024* (NMFS, 2019), extended by letter through October 31, 2024 (NMFS, 2024).

On March 29, 2019, Reclamation completed reinitiated consultation with NMFS and USFWS (collectively the Services) pursuant to Section 7(a)(2) of the ESA on the effects of a 5-year plan of operations for the Project (2019-2024) on federally-listed species and their designated critical habitats, including the listed Southern Oregon/Northern California Coast (SONCC) evolutionarily significant unit (ESU) of Coho Salmon, Southern Resident Killer Whales (SRKW), Lost River Suckers (LRS), and Shortnose Suckers (SNS). As a result, the Services provided Reclamation with written BiOps (NMFS 2019 BiOp and USFWS 2019 BiOp) concluding the proposed 2018 Operations Plan was not likely to jeopardize the continued existence of SONCC Coho Salmon, SRKW, LRS, and SNS nor destroy or adversely modify SONCC Coho Salmon, LRS, and SNS designated critical habitat. SRKW critical habitat was determined to be outside the action area.

Based on information related to weighted usable area (WUA) curves provided by a third party, which were confirmed in October 2019 and revealed effects of the 2018 Operations Plan on listed species or designated critical habitat (specifically to SONCC Coho Salmon) in a manner or to an extent not previously considered, Reclamation requested reinitiation of formal consultation with both Services on November 13, 2019, under Section 7 of the ESA (50 Code Federal

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[1] As related to Reclamation's 2017 Section 7 reinitiated consultation effort, prior to October 1, 2023, Reclamation operated the Project consistent with three previous successive USFWS BiOps including 1) the March 29, 2019 *Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker* (USFWS, 2019a); 2) the April 10, 2020 *Biological Opinion on the Effects of the Proposed Interim Klamath Project Operations Plan, effective April 1, 2020, through September 30, 2022, on the Lost River Sucker and the Shortnose Sucker* (USFWS, 2020a); and 3) the January 13, 2023 *Biological Opinion on the Effects of the Proposed Interim Klamath Project Operations Plan, effective January 13, 2023, through September 30, 2023, on the Lost River Sucker and the Shortnose Sucker* (USFWS, 2023b).

Regulations [CFR] § 402.16 (a)(2)). In written letters dated November 14, 2019, and December 9, 2019, NMFS and USFWS, respectively, accepted Reclamation's request to reinitiate consultation.

As part of the reinitiated consultations, on February 7, 2020, Reclamation transmitted a *Final Biological Assessment on the Effects of the Proposed Action to Operate the Klamath Project from April 1, 2020 through March 31, 2024 on Federally Listed, Threatened, and Endangered Species* (2020 Biological Assessment; Reclamation, 2020a) to the Services on Project operations during the period of April 1, 2020 through March 31, 2024. However, Reclamation and the Services agreed that it was in the public interest that additional time be provided to complete the consultations on Project operations, and as such, Reclamation would develop and submit to the Services a modified or new proposed operations plan, informed by a collaborative process, in lieu of the one set forth in the 2020 Biological Assessment.

Upon completion, the ongoing reinitiated consultation will supersede the current 2020 BiOp. In this 2024 Biological Assessment, Reclamation's current Proposed Action was developed in coordination with USFWS and NMFS and addresses the effects of Project operations on listed and candidate species and/or their designated critical habitat.

Furthermore, within this consultation there is a need to address the changing environmental conditions from removal of four dams on the mainstem Klamath River downstream of the Project (Renewal Corporation, 2021), as well as the reconnection of Agency Lake and Barnes units of the Upper Klamath National Wildlife Refuge (NWR) to Upper Klamath Lake (UKL). In particular, Reclamation proposes to continue to store waters of the Klamath and Lost rivers and operate the Project for the delivery of water to meet authorized Project purposes and contractual obligations inclusive of deliveries to historical wetland habitat in compliance with applicable state and federal law. Reclamation also proposes to conduct routine operation and maintenance (O&M) activities on Project facilities to ensure the proper long-term viability, functioning, and operation of the Project. Additionally, Reclamation proposes to carry out various conservation measures to meet its obligations under the ESA regarding the effects of its Proposed Action on ESA-listed species and/or their designated critical habitat.

Reclamation has prepared this Biological Assessment pursuant to Section 7(a)(2) of the ESA of 1973, as amended (1973, 16 United States Code [U.S.C.] 1531 et seq.) to evaluate the potential effects on ESA-listed and candidate species that could result from the continued operation of the Klamath Project as well as O&M of the Project.

This Biological Assessment provides information on the anticipated effects of the Proposed Action from October 1, 2024, through September 30, 2029[2], on federally-listed and candidate species for use by the Services in preparation of their respective 2024 BiOps. Reclamation has collaborated extensively with each of the Services, as well as co-managers, constituents, and

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[2] Reclamation's Proposed Action has a term of 5 years (2024 to 2029), or until such time that reinitiation of formal consultation is required as outlined in Section 50 CFR § 402.16. Reclamation determined that the term of the 2024 Proposed Action is consistent with the intent of the previous Proposed Action (e.g., 2018) and is appropriate due to uncertainties that may occur within the Klamath River Basin (e.g., changes to the Klamath River following dam removal) and the inability to describe the Proposed Action over a period longer than 5 years.

Tribes, in the development of the Proposed Action and Biological Assessment. As a result, Reclamation has prepared a single Biological Assessment for the purposes of its Section 7(a)(2) consultation with the Services.

1.2 Klamath Project Description

Authorized in 1905, the purpose of the Project is to provide water for irrigation and related purposes (e.g., stock watering) to up to approximately 230,000 acres of farmland in southern Oregon and northern California. The Project's service area encompasses lands in Klamath County, Oregon, and Siskiyou and Modoc counties, California. Communities within the Project include Klamath Falls, Bonanza, Merrill, and Malin in Oregon, and Tulelake and Newell in California.

The Project consists of a complex network of storage and conveyance features including reservoirs, lakes, dams, diversion dams, canals, and drains. Major Project facilities in Oregon include the A, B, C, D, E, F, and G canals; Link River Dam (LRD); Gerber Dam; Malone Diversion Dam; Miller Creek Diversion Dam; the Lost River Diversion Dam; Lost River Diversion Channel (LRDC); Anderson-Rose Diversion Dam; and the Klamath Straits Drain (KSD). Major Project facilities in California include the D, J, M, N, P, Q, and R canals; Clear Lake Dam; and the P Canal Tunnel (Figure 1-1). Water made available through these facilities is delivered to Project lands through approximately 675 miles of canals and laterals. Irrigation return flows and local runoff is collected from irrigated lands through approximately 545 miles of drains. Approximately 50 separate pumps are used to convey irrigation and drainage water to different portions of the Project.

In addition to Project facilities, in which title is vested in the United States, locally and privately-owned irrigation works are also used to divert and convey Project water to its place of use. In certain cases, Reclamation has agreements with the owners of these facilities concerning their construction and continued operation.

Waters of the Upper Klamath and Lost River watersheds that are used for irrigation and related purposes within the Project are considered "Project water," including water stored in UKL, Clear Lake Reservoir, or Gerber Reservoir, or diverted from natural flow in both the Klamath and Lost rivers. Total active storage capacity of the Project's three reservoirs is approximately 1,066,000 acre-feet (AF).

Stored water in Clear Lake and Gerber reservoirs is generally used for irrigation purposes in the Langell and Yonna valleys, although it can be and occasionally has been used for irrigation in the portion of the Project between Klamath Falls, Oregon, and Tulelake, California. Project water stored in UKL is used for irrigation on lands between Klamath Falls and Tulelake, Poe Valley, the Lower Klamath Lake area, and along the Klamath River between Lake Ewauna and the town of Keno, Oregon. Natural flow in the Lost River above Harpold Dam is primarily used in Langell and Yonna valleys, although all water in the Lost River below Harpold Dam is generally diverted and used within the Project during the irrigation season. Natural flow in the Klamath River, resulting from natural runoff and other discharges into the river below LRD, is primarily used in the Lower Klamath Lake area. Details on points of diversion are provided in Table 1-1 and Table 1-2.

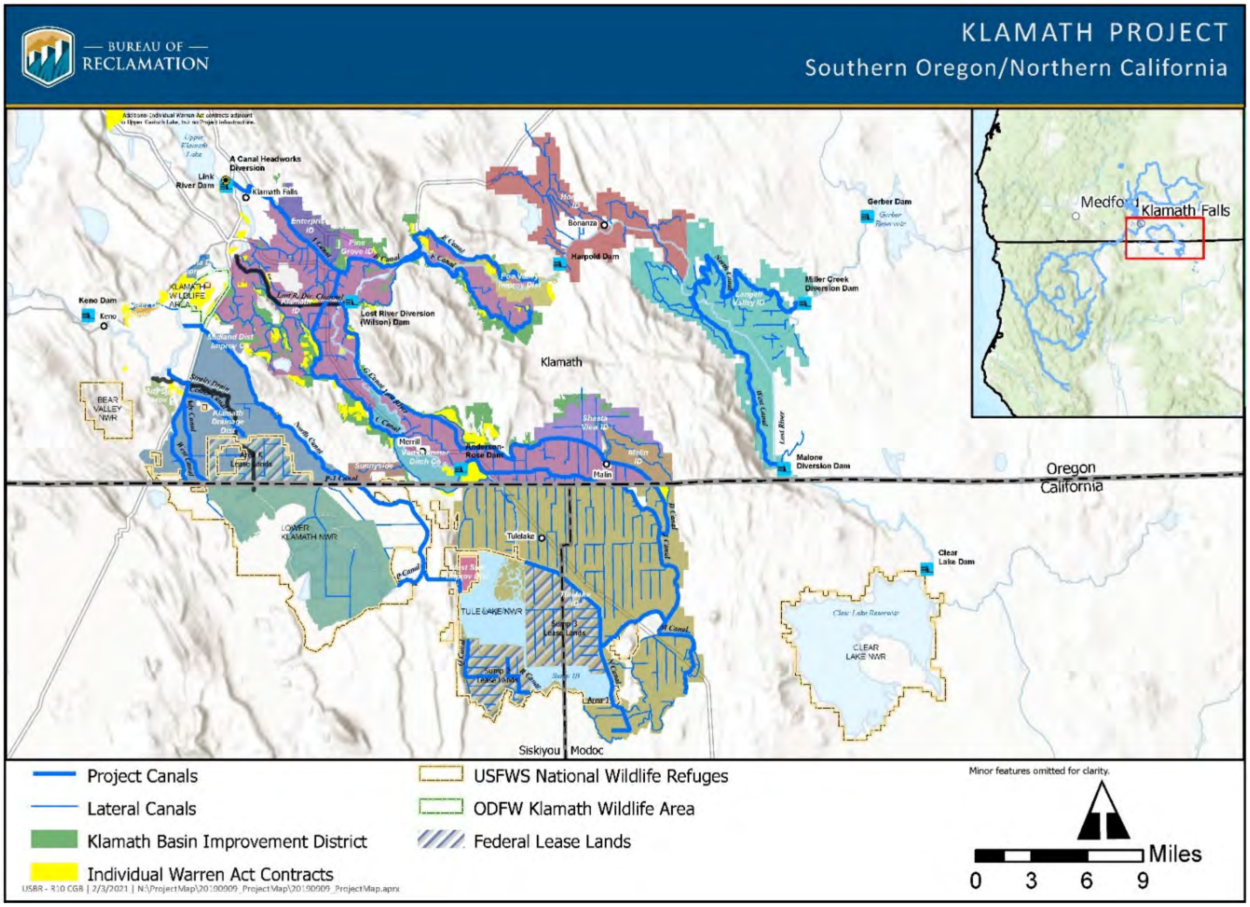


Figure 1-1. Klamath Project map

Table 1-1. List of project points of diversion during summer season duty (March 1 – October 31 or February 28 – November 15)

Operator	Source	Point of Diversion Name	Max CFS	Duty (AF)	Screened?
Combined KID/TID	UKL	"A" Canal	1,150	420,370[a]	Yes
Combined KID/TID	Klamath River	Station 48	650	-	No
Combined KID/TID	Klamath River	No. 1 Drain	100	-	No
Combined KID/TID	Klamath River	Miller Hill Pumping Plant	105	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #1	10[b]	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #2	-	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #3	-	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #4	-	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #5	-	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #6	-	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #7	-	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #8	-	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #9	-	-	No
Combined KID/TID	Klamath River	KID Pumping Plant #10	-	-	No

Operator	Source	Point of Diversion Name	Max CFS	Duty (AF)	Screened?
KDD	Klamath River	North Canal	200	80,446[a]	No
KDD	Klamath River	Ady Canal	400	-	No
Ady District Improvement Company	Klamath River	ADIC Culvert #1	14.51[c]	2,031[a]	No
Ady District Improvement Company	Klamath River	ADIC Culvert #2	-	-	No
Ady District Improvement Company	Klamath River	ADIC Culvert #3	-	-	No
Ady District Improvement Company	Klamath River	ADIC Culvert #4	-	-	No
Ady District Improvement Company	Klamath River	ADIC Culvert #5	-	-	No
Ady District Improvement Company	Klamath River	ADIC Siphon #6	-	-	No
Ady District Improvement Company	Klamath River	ADIC Siphon #7	-	-	No
Johnston & Son	Klamath River	Johnson Intake Channel	4.84	678	No
Modoc Lumber	Klamath River	Modoc Culvert	1.55	217	No
Pioneer District Improvement Company	Klamath River	Pioneer POD	2	1,495[a]	No
Pioneer District Improvement Company	Klamath River	Pioneer Pumping Facility	10.68	-	No
Reames	Klamath River	Reames Pumping Plant	1.33	417	No
Plevna District	Klamath River	Plevna/Collins #1	7	3,315[a]	No
Plevna District	Klamath River	Plevna/Collins #2	8	-	No
Plevna District	Klamath River	Plevna/Collins #3	8	-	No
Plevna District	Klamath River	Plevna POD	9	-	No
Individual Warren Act	UKL	Cove Point	1	114	No
Individual Warren Act	UKL	Memorial Park	1.5	334	No
Individual Warren Act	UKL	Moore Park	1.1	70	No
Individual Warren Act	UKL	Cell Tech	12	1,747	No
Individual Warren Act	UKL	Geary Bros #1	5	3,056[d]	No
Individual Warren Act	UKL	Geary Bros #2	10	-	No
Individual Warren Act	UKL	Running Y #1	70	20,407[e]	No
Individual Warren Act	UKL	Running Y #2	20	-	No
Individual Warren Act	UKL	Running Y #3	60	-	No
Individual Warren Act	UKL	Horton	2	257	No
Individual Warren Act	UKL	Schildmeyer #1	3	1,313[f]	No
Individual Warren Act	UKL	Schildmeyer #2	2	-	No
Individual Warren Act	UKL	Schildmeyer #3	2	-	No
Individual Warren Act	Klamath River	Miller Island Refuge #1	29[g]	4,010[h]	No
Individual Warren Act	Klamath River	Miller Island Refuge #2	-	-	No
Individual Warren Act	Klamath River	Miller Island Refuge #3	-	-	No
Individual Warren Act	Klamath River	Miller Island Refuge #4	-	-	No

Operator	Source	Point of Diversion Name	Max CFS	Duty (AF)	Screened?
Individual Warren Act	Klamath River	Miller Island Refuge #5	-	-	No
Individual Warren Act	Klamath River	Miller Island Refuge #6	-	-	No
Individual Warren Act	Klamath River	Miller Island Refuge #7	-	-	No
Individual Warren Act	Klamath River	Miller Island Refuge #8	-	-	No
Individual Warren Act	Klamath River	Griffith HG	0.5	132	No
Individual Warren Act	Klamath River	Kerns	4	549	No

Notes:
a. Where noted, total AF shared for all operator points of diversion
b. Total cfs for all KID Pumping Plant points of diversion
c. Total cfs for all Ady District Improvement Company points of diversion
d. Total AF for both Geary Bros points of diversion
e. Total AF for Running Y points of diversion
f. Total AF for Schildmeyer points of diversion
g. Total cfs for all Miller Island Refuge points of diversion
h. Total AF for all Miller Island Refuge points of diversion

Table 1-2. List of project points of diversion during winter season duty (November 1 – February 28)

Operator	Source	Point of Diversion Name	Max CFS	Duty (AF)	Screened?
KDD	Klamath River	North Canal	200	28,910[a]	No
KDD	Klamath River	Ady Canal	400	-	No
Ady District Improvement Company	Klamath River	ADIC Culvert #1	14.51[b]	412[a]	No
Ady District Improvement Company	Klamath River	ADIC Culvert #2	-	-	No
Ady District Improvement Company	Klamath River	ADIC Culvert #3	-	-	No
Ady District Improvement Company	Klamath River	ADIC Culvert #4	-	-	No
Ady District Improvement Company	Klamath River	ADIC Culvert #5	-	-	No
Ady District Improvement Company	Klamath River	ADIC Siphon #6	-	-	No
Ady District Improvement Company	Klamath River	ADIC Siphon #7	-	-	No

Notes:
a. Where noted, total AF shared for all operator points of diversion
b. Total cfs for all Ady District Improvement Company points of diversion

Reclamation directs the operation of the Project, and the Project holds water rights in connection with those operations for irrigation and other purposes perfected under state law.

The Project also hosts a single hydroelectric power generation facility located where the A Canal drops water into the C Canal (hence, "C-Drop"), owned by Klamath Irrigation District and averaging 1,600 megawatt hours per year.

Reclamation has responsibilities to protect tribal trust resources of seven federally recognized Tribes in the Klamath Basin. Some of these tribes hold reserved water rights to support the purposes of their respective reservations. These include instream water rights to support tribal fishing rights that are prior ("senior") to the water rights associated with the Project and which prohibit subsequent ("junior") appropriators from depleting certain waters, including UKL, its tributaries, and the Klamath River, below a protected level.

Reclamation maintains over 160 perpetual contracts on the Project, serving 204,239 acres, with district entities and individual landowners to provide water from the Project for irrigation and related purposes in exchange for payment of Project costs and other conditions. In addition, 2,906 acres are served by annual contracts for water surplus to the needs of the perpetual contractors. Project water is also delivered from various sources to two USFWS NWRs.

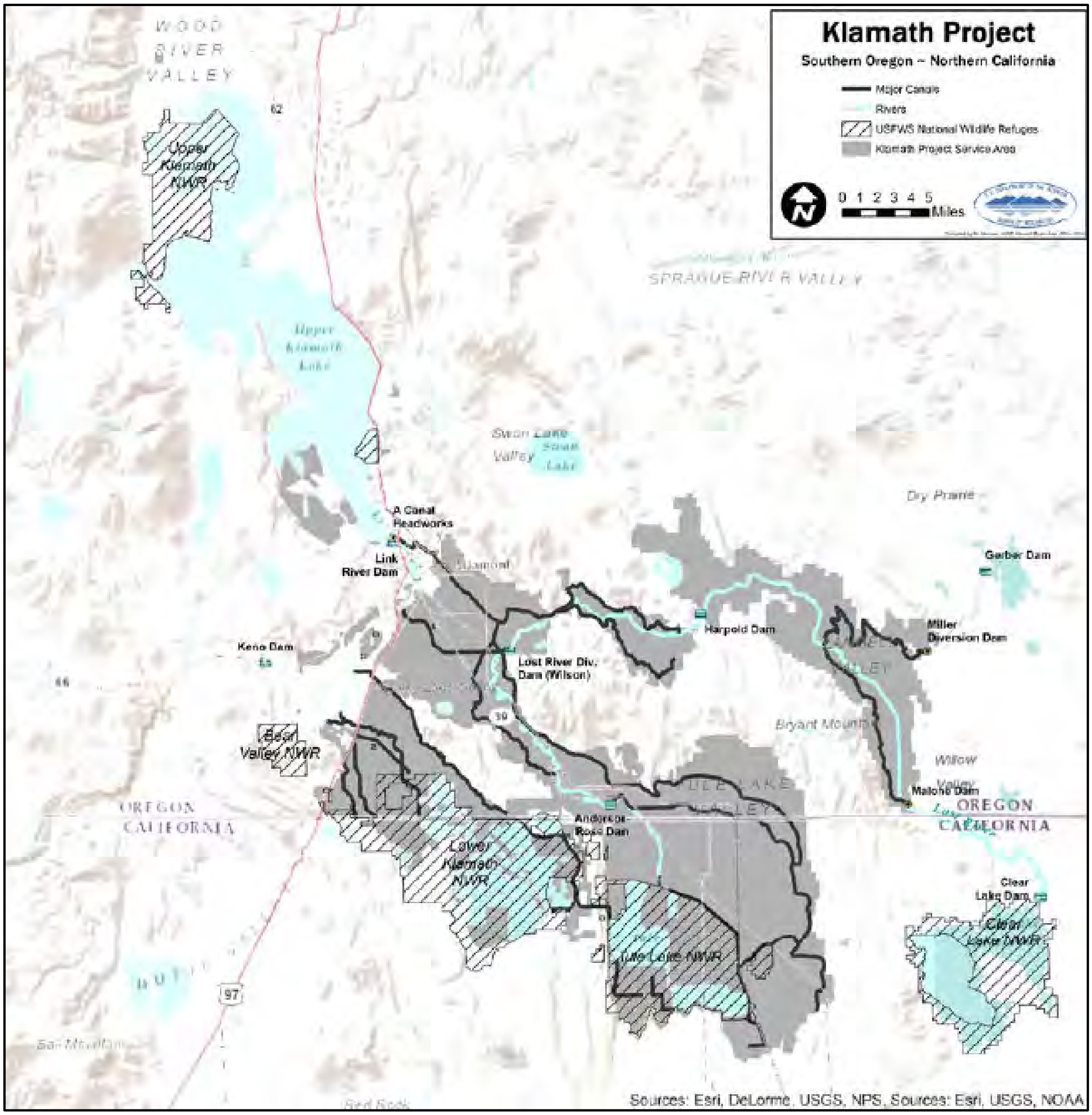
The Upper Klamath, Lower Klamath, Tule Lake, and Clear Lake NWRs are adjacent to or within the Project service area and are affected by Project operations. Land within the Lower Klamath and Tule Lake NWRs is also used for agricultural purposes administered through either Reclamation's agricultural leasing program (conducted under the authority of the Kuchel Act, 1964) or the USFWS cooperative farming program. Project operations make water available for use in the NWRs, and water within the NWRs is commonly used for both irrigation and historical wetland habitat purposes.

1.3 Action Area

The Action Area includes "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). Project lands are identified in Figure 1-2.

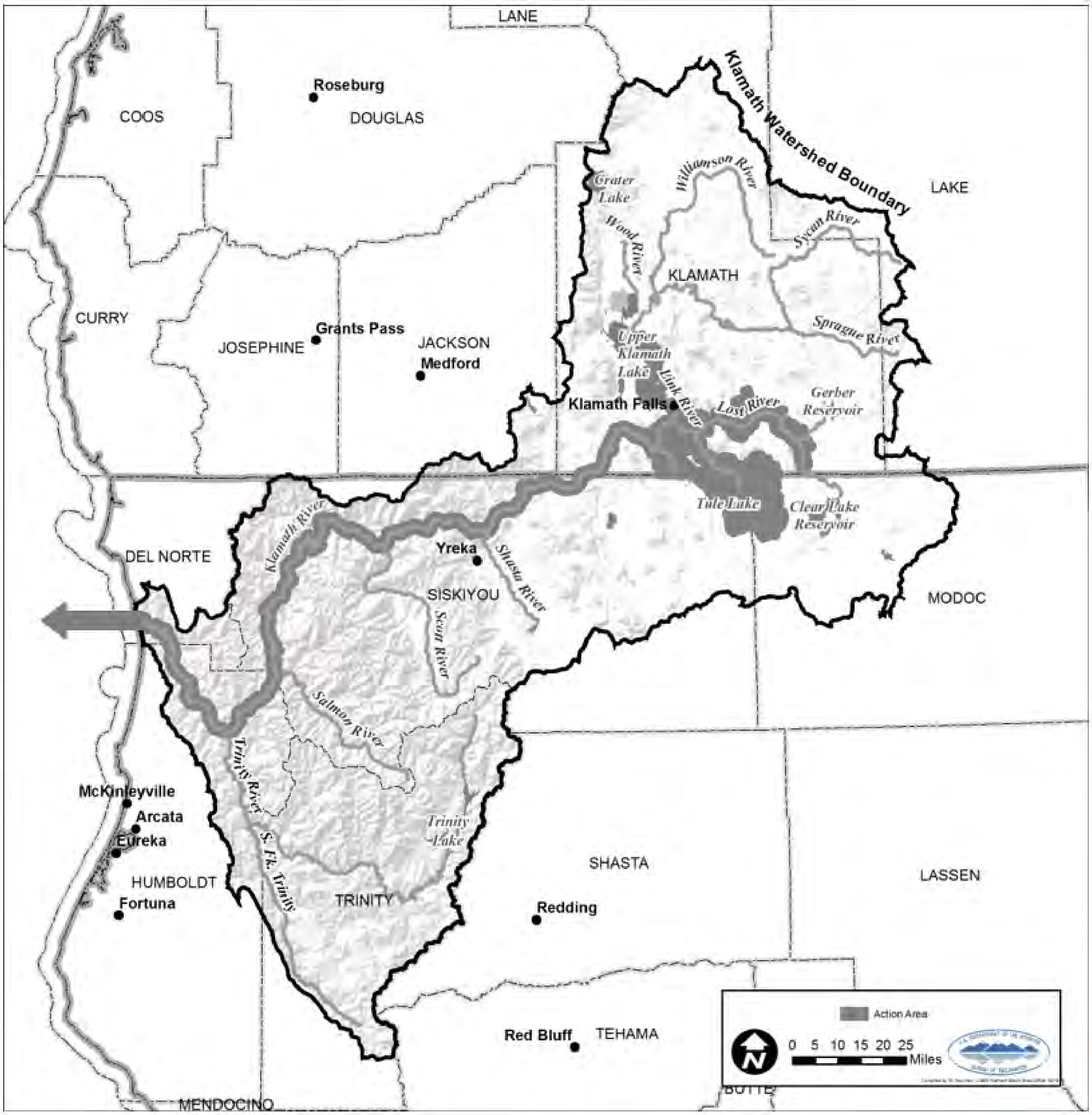
The Action Area extends from UKL, in south central Oregon, and Gerber Reservoir and Clear Lake Reservoir in the Lost River drainage in southern Oregon and northern California, to approximately 254 miles downstream to the mouth of the Klamath River at the Pacific Ocean, near Klamath, California (Figure 1-3).

Altogether, the Project provides water for irrigation purposes to up to approximately 230,000 acres of land, including federally owned lands within Lower Klamath and Tule Lake NWRs (see Section 2.4.4, regarding NWRs and associated acreages within the Project). Approximately 200,000 acres are primarily served from UKL and the Klamath River. Approximately 20,000 acres are served from Clear Lake and Gerber reservoirs, although as noted elsewhere, stored water from these reservoirs can be used under certain circumstances to meet irrigation demands in portions of the area served from UKL and the Klamath River.



Notes: Project lands are shown as shaded area on the map. Source: Reclamation (2018)

Figure 1-2. Upper Klamath Basin of Oregon and California



Note: Source Reclamation (2018)

Figure 1-3. Map of the Action Area

In addition to the above acreages, live flow from the Lost River is used for irrigating approximately 10,000 acres, mostly located immediately upstream and downstream of Harpold Dam (i.e., Yonna and Poe valleys). Live flow from the Lost River is also used seasonally in lieu of stored water from UKL for later irrigation use on the area of the Project served from UKL and the Klamath River.

Within the Upper Klamath Basin, the Action Area includes Agency Lake, UKL, Keno Impoundment (Lake Ewauna), Lost River including Miller Creek, and all Reclamation-administered facilities including reservoirs, diversion channels and dams, canals, laterals, and drains, including those within Tule Lake and Lower Klamath NWRs, as well as all land, water, and facilities in or providing irrigation or drainage for the service area of the Project.

The Action Area of Project operations extends downstream from UKL to Keno Dam, which will be the new compliance point for Klamath River flows pursuant to the anticipated BiOp from NMFS following the removal of Iron Gate Dam (the previous compliance point for Klamath River flows was at Iron Gate Dam, which was removed in 2024). There is a potential for direct effects on listed suckers to occur throughout the Action Area above Keno Dam, although measures such as fish screens at the A Canal and Clear Lake Dam, and a fish ladder at the LRD reduce these effects. Salmon may be affected at Keno Dam or its releases, as well as through potential entrainment at unscreened (Table 1-1 and Table 1-2) Project facilities within the Keno Impoundment as salmon return to the Upper Basin following the removal of impassable dams in the Klamath River.

The Action Area specific to the SRKW extends out into the Pacific Ocean where SRKW feed on concentrations of adult Chinook Salmon (Section 7.1.6). This Action Area extends to that section of the ocean where there is species overlap between Chinook Salmon and SRKW. The exact boundaries of this area cannot be defined based upon current information.

1.4 Federally Proposed and Listed Species and Designated Critical Habitat

The federally-listed species that may be affected by the Proposed Action and therefore are considered in this document were identified and confirmed through coordination and correspondence with the Services in February 2024. As shown in APPENDIX A , Reclamation sent and received concurrence on specific species within the Action Area and designated critical habitat under the jurisdiction of either the USFWS or NMFS.

Table 1-3 lists the species considered in this document, which are endangered, threatened, and proposed species that are known or suspected to occur within the Action Area and that may be affected by the Proposed Action. Table 1-4 lists the endangered, threatened and proposed species that are known to or suspected to occur within the Action Area for which Reclamation has determined the Project has no effect. As such, the species identified in Table 1-4 will not be discussed further in this document.

Table 1-3. Endangered, threatened, and proposed species that are known or suspected to occur within the Action Area that may be affected by the Proposed Action and which are considered in this document

Phylum	Species Common Name	Species Scientific Name	ESA Status	Critical Habitat Designation
Fish	Lost River Sucker^	*Deltistes luxatus*	Endangered	Designated
Fish	Shortnose Sucker^	*Chasmistes brevirostris*	Endangered	Designated
Fish	SONCC Coho Salmon^	*Oncorhynchus kisutch*	Threatened	Designated
Fish	North American Green Sturgeon (Southern DPS)*	*Acipenser medirostris*	Threatened	Designated
Fish	Pacific Eulachon (Southern DPS)*	*Thaleichthys pacificus*	Threatened	Designated
Mammal	Southern Resident Killer Whale (DPS)^	*Orcinus orca*	Endangered	Designated
Plant	Applegate's milk-vetch*	*Astragalus applegatei*	Endangered	None
Fish	Bull Trout*	*Salvelinus confluentus*	Threatened	Designated
Amphibian	Oregon spotted frog*	*Rana pretiosa*	Threatened	Designated
Reptile	Northwestern Pond Turtle*	*Actinemys marmorata*	Proposed	None
Insect	Monarch Butterfly*	*Danaus plexippus*	Candidate	Proposed

Notes:
The species denoted with a carat (^) are considered in a species-specific chapter (i.e., Chapters 5 through 7).
The species denoted with an asterisk (*) will be considered in Chapter 8.
Source: USFWS (2024)

Table 1-4. Endangered, threatened, and proposed species that are known or suspected to occur within the Action Area for which the U.S. Bureau of Reclamation has determined the Klamath Project has no effect

Phylum	Species Common Name	Species Scientific Name	ESA Status	Critical Habitat Designation
Amphibian	California red-legged frog	*Rana aurora draytonii*	Threatened	Designated
Bird	Northern spotted owl	*Strix occidentalis caurina*	Threatened	Designated
Bird	Yellow-billed cuckoo (Western DPS)	*Coccyzus americanus occidentalis*	Threatened	Proposed
Invertebrate	Shasta crayfish	*Pacifastacus fortis*	Endangered	None
Mammal	Fisher	*Pekania pennanti*	Proposed	n/a
Mammal	Gray wolf	*Canis lupus*	Endangered	None

Phylum	Species Common Name	Species Scientific Name	ESA Status	Critical Habitat Designation
Mammal	North American wolverine	*Gulo gulo luscus*	Proposed	n/a
Plant	Gentner's fritillary	*Fritillaria gentneri*	Endangered	Designated
Plant	Greene's tuctoria	*Tuctoria greenei*	Endangered	Designated
Plant	Slender Orcutt grass	*Orcuttia tenuis*	Threatened	Designated
Plant	Yreka phlox	*Phlox hirsuta*	Endangered	None

Source: USFWS (2024)

1.5 Consultation History

Reclamation has consulted with the Services on Project operations as species were listed and critical habitat designated since the late 1980s. Table 1-5 summarizes the entire history of ESA consultations undertaken by Reclamation since 1988. The most recent completed consultations for SONCC Coho Salmon and SRKW occurred in 2019 and for LRS and SNS in 2023.

Table 1-5. History of Endangered Species Act consultations undertaken by the U.S. Bureau of Reclamation since 1988

Date	Service	Subject of Consultation	Determination
7/18/1988	USFWS	Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Lost River Sucker and Shortnose Sucker	Endangered status was determined for the LRS and SNS. This rule implemented listing and protection provided by the ESA.
6/14/1989 (superseded by 1995 BiOp)	USFWS	Formal Endangered Species Consultation on the Use of Acrolein (Magnicide H) in Canals and Drainage Ditches within the Project Service Area in Klamath County, Oregon, and Siskiyou County, California	The continued use of acrolein in Project canals and drainage ditches, as traditionally applied, is likely to jeopardize the continued existence of the SNS and LRS.
8/14/1991 (superseded by 2008 BiOp)	USFWS	Formal Consultation on the Effects of the 1991 Operation of the Project on the Lost River Sucker and Shortnose Sucker, Bald Eagle, and American Peregrine Falcon	The proposed 1991 drought operation of the Project was likely to jeopardize the continued existence of LRS and SNS but would not jeopardize the continued existence of the Bald Eagle. The American Peregrine Falcon was not likely to be affected and was not addressed in the consultation.

Date	Service	Subject of Consultation	Determination
1/6/1992 (superseded by 2008 BiOp)	USFWS	Formal Consultation on the Effects of the 1992 Operation of the Klamath Project on the Lost River Sucker and Shortnose Sucker, Bald Eagle, and American Peregrine Falcon	The operation of the Project was not likely to jeopardize the continued existence of the LRS and SNS or the Bald Eagle. The American Peregrine Falcon was not likely to be affected and was not addressed in the consultation.
3/27/1992 (superseded by 2008 BiOp)	USFWS	Reinitiation of Formal Consultation on the Effects of the 1992 Operation of the Klamath Project on the Lost River Sucker and Shortnose Sucker, Bald Eagle, and American Peregrine Falcon	The proposed 1992 operation of the Project was likely to jeopardize the continued existence of the LRS and SNS, but not likely to jeopardize the continued existence of the Bald Eagles. The American Peregrine Falcon was not likely to be affected and was not addressed in the consultation.
5/1/1992 (superseded by 2008 BiOp)	USFWS	Reinitiation of Formal Consultation on the Effects of the 1992 Operation of the Klamath Project at Clear Lake Reservoir on the Lost River Sucker and Shortnose Sucker, Bald Eagle, and American Peregrine Falcon	The proposed 1992 operation of the Project at Clear Lake Reservoir was likely to jeopardize the continued existence of the LRS and SNS, but not likely to jeopardize Bald Eagles. The American Peregrine Falcon was not likely to be affected and was not addressed in the consultation.
7/22/1992 (superseded by 2008 BiOp)	USFWS	Formal Consultation on the Effects of the Long-Term Operation of the Klamath Project on the Lost River Sucker and Shortnose Sucker, Bald Eagle, and American Peregrine Falcon	The long-term operation of the Project was likely to jeopardize the continued existence of the LRS and SNS, but not likely to jeopardize the continued existence of the Bald Eagle. The American Peregrine Falcon was not likely to be affected and was not addressed in the consultation.
2/22/1993 (superseded by 2008 BiOp)	USFWS	Reinitiation of Formal Consultation on the BiOp for the Long-Term Operation of the Project – Upper Klamath Lake Operations	One-year modification of lake elevation. Reclamation was released from the March 1, 1993 requirement of maintaining a 4,141-foot surface elevation for 1993 only.

Date	Service	Subject of Consultation	Determination
8/11/1994 (superseded by 2008 BiOp)	USFWS	Reinitiation of Formal Consultation on the Long-Term Operation of the Project, with Special Reference to Operations at Clear Lake Reservoir on the Lost River Sucker and Shortnose Sucker, Bald Eagle, and American Peregrine Falcon	The proposed long-term operation of the Project was likely to jeopardize the continued existence of the LRS and SNS, but not likely to jeopardize the continued existence of the Bald Eagle. The American Peregrine Falcon was not likely to be affected and was not addressed in the consultation. Reasonable and Prudent Alternatives were specified in the BiOp for Clear Lake and a new minimum elevation for Clear Lake Reservoir was established.
2/9/1995	USFWS	Final Biological Opinion on the Use of Pesticides and Fertilizers on Federal Lease Lands and Acrolein and Herbicide Use on the Klamath Project Rights-of-Way (Reinitiation of Consultation on the Use of Acrolein for Aquatic Weed Control in Reclamation Canals and Drains)	The use of pesticides and fertilizers on federal lease lands and acrolein and herbicide use on Project rights-of-way was not likely to jeopardize the continued existence of the LRS and SNS and may affect, but not likely to adversely affect the Bald Eagle, or Applegate's milk-vetch, and not likely to affect the American Peregrine Falcon.
2/2/1996 (not superseded by 2008 BiOp)	USFWS	Reinitiation of Formal Consultation on the Use of Pesticides and Fertilizers on Federal Lease Lands and Acrolein and Herbicide Use on the Klamath Project Rights-of-Way Located on the Klamath Project	Use of Metam-Sodium, Lorsban, Pounce, and Disyston on Project lands as described under the description of the Proposed Action was not likely to jeopardize the continued existence of the Bald Eagle, American Peregrine Falcon, LRS, and SNS or adversely modify the LRS and SNS proposed critical habitat.
7/15/1996 (superseded by 2008 BiOp)	USFWS	Formal Consultation on PacifiCorp and The New Earth Corporation Operations, as Permitted by Reclamation, for the Lost River Sucker and Shortnose Sucker	The Proposed Action was not likely to jeopardize the continued existence of the LRS and SNS and was not likely to adversely modify or destroy proposed critical habitat.
5/6/1997	NMFS	Endangered and Threatened Species; Threatened Status for Southern Oregon Northern California Coast Evolutionarily Significant Unit of Coho Salmon	The SONCC Coho Salmon ESU was determined to be a “species” under the ESA of 1973, as amended, and was listed as threatened. Critical habitat was not designated.

Date	Service	Subject of Consultation	Determination
4/2/1998 (superseded by 2008 BiOp)	USFWS	Amendment to the 1992 Biological Opinion Dealing with A-Canal Sucker Entrainment Reduction	Reclamation was granted a 5-year extension (to 2002) to implement entrainment reduction measures for all life stages of LRS and SNS into A Canal. The date for completion of A Canal screen was extended until 2002. Not likely to jeopardize species.
4/20/1998	USFWS	Amendment to the 1992 Biological Opinion to Cover Operation of Agency Lake Ranch Impoundment	The action was not likely to jeopardize the continued existence of Lost Ricer Sucker and SNS.
4/21/1998 (superseded by 2008 BiOp)	USFWS	Amendments to the August 27, 1996, Biological Opinion on PacifiCorp and New Earth Operations, as Permitted by Reclamation, for the Lost River Sucker and Shortnose Sucker	Five amendments regarding sampling dates, report consolidation, and due date extension, extension of incidental take coverage, and monitoring fulfillment. Not likely to jeopardize species.
6/2/1998	NMFS	Reclamation transmitted a Biological Assessment to NMFS on 1998 Project operations and requested formal consultation.	NMFS deferred consultation until the following year (1999).
7/13/1998 (superseded by 2008 BiOp)	USFWS	An Amendment to the Revised July 22, 1992 Project Long-Term Operations Biological Opinion, Dealing with Anderson-Rose Releases. The purpose of this amendment is to adjust requirements for release of spawning flows from Anderson-Rose Dam on the Lost River.	The USFWS concurred with Reclamation’s recommended Reasonable and Prudent Alternative changes. Not likely to jeopardize species.
3/9/1999	NMFS	Project operations 1999 Biological Opinion. Reclamation provided the Draft Project 1999 Annual Operations Plan Environmental Assessment and requested NMFS use the 1998 Biological Assessment as the basis for preparing the 1999 Biological Assessment.	Reclamation requested formal consultation with NMFS regarding the 1999 Annual Operations Plan.

Date	Service	Subject of Consultation	Determination
4/15/1999	USFWS	Amendment to the 1996 Biological Opinion. Incidental Take of Lost River Sucker and Shortnose Sucker Owing to Lowered Water Levels in Upper Klamath Lake by a Change in Operation of Link River Dam to Reduce Risk of Flooding During the Spring 1999 Runoff Period	The Services concurred with Reclamation's determinations of "may affect, likely to adversely affect," and it was determined that the action was not likely to jeopardize the continued existence of the LRS and SNS.
5/5/1999	NMFS	Designated Critical Habitat; Central California Coast and Southern Oregon Northern California Coast Coho Salmon	Critical habitat was designated for two ESUs of Coho Salmon pursuant to the ESA.
6/18/1999	NMFS	Reclamation letter regarding Draft BiOp for Project operations 1999 (Dated April 22,1999)	Reclamation reviewed draft BiOp and proposed to modify Project operations described in the March 9, 1999 draft Environmental Assessment.
7/12/1999	NMFS	NMFS BiOp on Project operations through March 2000	Not likely to jeopardize SONCC Coho Salmon or adversely modify designated critical habitat.
8/18/1999	USFWS	One-year, Emergency Amendment to the 1995 BiOp, Use of Pesticides and Fertilizers on Leased Lands and Use of Acrolein in Project Canals and Drains	The LVID-operated canal system was exempt from the prohibitions of Section 9 of the ESA. Incidental take covered by amendment for SNSs in LVID-operated irrigation canal system. The amendment included Reasonable and Prudent Measures to be implemented by LVID to minimize take.
9/10/1999 (superseded by 2008 BiOp)	USFWS	Revised Amendment to the 1992 BiOp to Cover Operations and Maintenance of Agency Lake Ranch Impoundment	The Services concurred with Reclamation's determination of "may affect, likely to adversely affect" and determined the action was not likely to jeopardize the continued existence of the LRSs and SNS.
4/4/2000	NMFS	NMFS letter advised Reclamation to request initiation of consultation pursuant to Section 7(a)(2) of the ESA on Project operations.	1999 BiOp and associated Incidental Take Statement expired on March 31, 2000.
4/26/2000	NMFS	Klamath River Flows Below Iron Gate Dam-2000 Operation Plan-Project	Proposed flows were both sufficient and necessary to avoid possible 7(d) foreclosures and fulfill obligation to protect Tribal trust resources.

Date	Service	Subject of Consultation	Determination
1/22/2001	NMFS	Reclamation's Biological Assessment of the Project's Continuing Operations on SONCC ESU of Coho Salmon and Their Critical Habitat	Requested initiation of formal ESA Section 7 consultation. The Biological Assessment provided description of the effects on federally-listed species and their designated critical habitat from ongoing operation of the Project based on historical operations.
4/5/2001	USFWS	Biological Opinion Regarding the Effects of Operation of the Bureau of Reclamation's Klamath Project on the Endangered Lost River Sucker and Shortnose Sucker, Threatened Bald Eagle, and Proposed Critical Habitat for the Lost River Sucker and Shortnose Sucker	Likely to jeopardize the LRS and SNS and adversely modify proposed critical habitat. Not likely to jeopardize the continued existence of the Bald Eagle.
4/6/2001	NMFS	2001 Biological Opinion on ongoing Klamath Project operations	Likely to jeopardize SONCC Coho Salmon and likely to adversely modify designated critical habitat.
4/13/2001 (superseded by 2008 BiOp)	USFWS	Concurrence Memorandum Responding to Reclamation's Request to Postpone Spawning Releases at Anderson Rose Dam for 2001	Not likely to jeopardize sucker species; USFWS concurred with drought year assessment.
8/22/2001 (superseded by 2008 BiOp)	USFWS	Amendment to the April 5, 2001 Biological Opinion on Klamath Project Operations to Cover Safety of Dams Modification of the Clear Lake Dam	Not likely to jeopardize the continued existence of the LRS and SNS and will not likely adversely modify proposed critical habitat.
9/12/2001 (superseded by 2008 BiOp)	USFWS	Amendment to the April 5, 2001 Biological Opinion on Klamath Project Operations to Cover Link River Topographic Survey Fish Passage Assessment	Not likely to jeopardize the continued existence of the LRS and SNS and will not likely adversely modify their proposed critical habitat.
9/19/2001	USFWS	Amendment to the November 27, 2000 Biological Opinion for the Airport Runway Extension Project and the April 5, 2001 Biological Opinion on Klamath Project Operations to Cover Salvage in the Lost River Diversion Channel and for the Station 48 Maintenance Project	Not likely to jeopardize the continued existence of the LRS and SNS and will not likely adversely modify their proposed critical habitat.

Date	Service	Subject of Consultation	Determination
9/28/2001	NMFS	Amendment to the April 6, 2001 Biological Opinion and Reasonable and Prudent Alternatives for Reclamation's Project Operations	Provided minimum IGD flows for October to December 2001.
12/28/2001	NMFS	Amendment to the April 6, 2001 Biological Opinion and Reasonable and Prudent Alternatives for the Bureau of Reclamation's Klamath Project Operations	Provided minimum IGD flows for January to February 2002.
2/27/2002	USFWS and NMFS	Reclamation's Final Biological Assessment on Effects of PAs Related to Project Operations (April 1, 2002-March 31, 2012)	Requested initiation of formal ESA Section 7 consultation.
3/28/2002 (superseded by 2008 BiOp)	USFWS	Biological/Conference Opinion Regarding the Effects of Operation of Reclamation's Project During the Period April 1, 2002, Through May 31, 2002 on the Endangered Lost River Sucker and Shortnose Sucker, Threatened Bald Eagle, and Proposed Critical Habitat for the Lost River Sucker and Shortnose Sucker.	Not likely to jeopardize the continued existence of the LRS and SNS or Bald Eagle.
5/16/2002	NMFS	NMFS Draft Biological Opinion on Klamath Project operations between April 1, 2002, and March 31, 2012	Likely to jeopardize the continued existence of SONCC Coho Salmon and adversely modify critical habitat.
5/31/2002	NMFS	Biological Opinion on Klamath Project operations and the Klamath Project's effects on the Southern Oregon Northern California Coast Coho Salmon	Likely to jeopardize the continued existence of SONCC Coho Salmon and likely to adversely modify critical habitat.
5/31/2002 (superseded by 2008 BiOp)	USFWS	Biological Opinion on the 10-year (June 1, 2002, through March 31, 2012) Operation Plan for the Klamath Project	Likely to jeopardize the continued existence of the LRS and SNS, and in part, the adverse modification of their proposed critical habitat. Not likely to jeopardize the continued existence of the Bald Eagle.

Date	Service	Subject of Consultation	Determination
7/24/2002 (not superseded by 2008 BiOp)	USFWS	Biological/Conference Opinion Regarding the Effects of Construction of the A-Canal Fish Screen and Link River Fish Ladder, Reclamation – Project and its Effect on the Endangered Lost River Sucker and Shortnose Sucker and Proposed Critical Habitat for Lost River Sucker and Shortnose Sucker	Not likely to jeopardize the continued existence of the LRS and SNS.
3/4/2003 (superseded by 2008 BiOp)	USFWS	Amendment to the 2002 Biological Opinion on the Effects of the 10-Year Operations Plan for the Klamath Project as it Relates to Operation of Clear Lake and Gerber Reservoir	No effects to the LRS and SNS different from those analyzed in the 2002 BiOp.
5/31/2007 (not superseded by 2008 BiOp)	USFWS	Biological Opinion Regarding the Effects on Listed Species from Implementation of the Pesticide Use Program on Federal Leased lands, Tule Lake and Lower Klamath National Wildlife Refuges, Klamath County, Oregon, and Siskiyou and Modoc Counties, California	Not likely to adversely affect the Bald Eagle, LRS, or SNS, and therefore will not likely jeopardize their continued existence.
10/1/2007	USFWS	Reclamation's Biological Assessment on the Effects of the Proposed Action to Operate the Klamath Project from April 1, 2008 to March 31, 2018	May affect, and is likely to adversely affect Coho Salmon, LRS, and SNS, and may adversely modify critical habitat for Coho Salmon, LRS, and SNS. No effect on Applegate's milk-vetch.
4/2/2008	USFWS	Biological/Conference Opinion Regarding the Effects of the Bureau of Reclamation's Proposed 10-Year Operation Plan (April 1, 2008- March 21, 2018) for the Project and its Effects on Lost River Sucker and Shortnose Sucker	Not likely to jeopardize the continued existence of the LRS and SNS and is not likely to destroy or adversely modify proposed critical habitat for these species.
3/15/2010	NMFS	NMFS Biological Opinion on Operation of the Klamath Project Between 2010 and 2018.	Likely to jeopardize the continued existence of SONCC Coho Salmon and is likely to destroy or adversely modify SONCC Coho Salmon designated critical habitat.
12/11/2012	USFWS	Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Lost River Sucker and Shortnose Sucker	Two units of critical habitat for the LRS and SNS were designated under the ESA.

Date	Service	Subject of Consultation	Determination
5/31/2013	USFWS and NMFS	Joint Biological Opinion on the Effects of Proposed Klamath Project Operations from May 31, 2013, through March 31, 2023, on Five Federally Listed Threatened and Endangered Species	May affect but is not likely to adversely affect the southern DPS of Green Sturgeon, the Southern DPS of Pacific Eulachon, or both their critical habitat. Not likely to jeopardize the continued existence of the SONCC Coho Salmon ESU, LRS, and SNS nor likely to result in the destruction or adverse modification of their critical habitat.
3/29/2019	NMFS	Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson- Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for Klamath Project Operations from April 1, 2019 through March 31, 2024	Not likely to jeopardize the continued existence of the SONCC Coho Salmon ESU, or the SRKW DPS, or destroy or adversely modify designated critical habitat for the SONCC Coho Salmon ESU. Not likely to adversely affect Green Sturgeon, Eulachon, or designated critical habitat for Eulachon. Regarding Magnussen Stevens Act, NMFS concluded the Proposed Action would adversely affect Coho Salmon and Chinook Salmon EFH and provided conservation recommendations that would protect, by avoiding or minimizing the adverse effects described above, the mainstem Klamath River and tributaries designated as EFH for Pacific Coast salmon.
3/29/2019	USFWS	Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker	Not likely to jeopardize the continued existence of the LRS and SNS and is not likely to result in the destruction or adverse modification of their critical habitat.
4/10/2020	USFWS	Biological Opinion on the Effects of the Proposed Interim Klamath Project Operations Plan, effective April 1, 2020, through September 30, 2022, on the Lost River Sucker and the Shortnose Sucker	Not likely to jeopardize the continued existence of the LRS and SNS and is not likely to result in the destruction or adverse modification of critical habitat for LRS and SNS. However, USFWS does anticipate incidental take of LRS and SNS as well as adverse effects to their designated critical habitat as a result of implementation of the modified Proposed Action.

Date	Service	Subject of Consultation	Determination
01/13/2023	USFWS	Biological Opinion on the Effects of the Proposed Interim Klamath Project Operations Plan, effective January 13, 2023, through September 30, 2023, on the Lost River Sucker and the Shortnose Sucker	Not likely to jeopardize the continued existence of the LRS and SNS and is not likely to result in the destruction or adverse modification of critical habitat for LRS and SNS. However, USFWS does anticipate incidental take of LRS and SNS as well as adverse effects to their designated critical habitat as a result of implementation of the Proposed Action.
09/30/2023	USFWS	Biological Opinion on the Effects of Proposed Interim Klamath Project Operations Plan, effective October 1, 2023, through October 31, 2024, on the Lost River Sucker and the Shortnose Sucker	Not likely to jeopardize the continued existence of the LRS and SNS and is not likely to result in the destruction or adverse modification of critical habitat for LRS and SNS. However, USFWS does anticipate incidental take of LRS and SNS as well as adverse effects to their designated critical habitat as a result of implementation of the Proposed Action.
3/26/2024	NMFS	NMFS Letter response to Reclamation request to extend the 2019 BiOp through October 31, 2024	Granted.

As part of the January 2017 reinitiation of formal consultation, in December 2018, Reclamation transmitted to the Services a Biological Assessment for Project operations from 2019 to 2029 (later amended to cover water years 2019 through 2024). On March 29, 2019, the Services provided separate but coordinated 2019 BiOps. The NMFS 2019 BiOp concluded that the 2018 Proposed Action was not likely to jeopardize the continued existence of the SONCC Coho Salmon ESU or the SRKW Distinct Population Segment (DPS) or destroy or adversely modify the designated critical habitat for the SONCC Coho Salmon ESU or SRKW DPS. In their 2019 BiOp, NMFS also concluded that the 2018 Proposed Action would not likely adversely affect North American Green Sturgeon Southern DPS, Pacific Eulachon, or the designated critical habitat for Pacific Eulachon.

Additionally, as part of the 2018 Biological Assessment, Reclamation conducted an Essential Fish Habitat (EFH) assessment in compliance with Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act, analyzing Chinook Salmon and SONCC Coho Salmon habitat. NMFS’s 2019 BiOp concluded that Reclamation's 2018 Proposed Action would adversely affect SONCC Coho and Chinook salmon EFH. NMFS provided conservation measures in the 2019 BiOp to protect the mainstem Klamath River and tributaries designated as EFH for Pacific Coast salmon, by avoiding or minimizing the adverse effects described above. Reclamation reviewed NMFS's EFH assessment response document and associated conservation recommendations, providing a written response to NMFS on April 25, 2019, as required by 50 CFR § 600.920(k)(l).

In January 2023, Reclamation released an updated Temporary Operations Plan (TOP) and associated Drought Plan to make certain adjustments to the IOP that would enable it to comply with UKL elevation requirements following 3 years of exceptional drought.

The USFWS developed a 2023 BiOp issued for the period October 1, 2023 through October 31, 2024 (USFWS, 2023a). This BiOp concluded that extending IOP operations during the above period is not likely to jeopardize the continued existence of suckers or to result in the destruction or adverse modification of their designated critical habitat. However, the USFWS anticipated incidental take of suckers and adverse effects to their designated critical habitat. NMFS responded to the 2023 TOP with a letter affirming that extending IOP operations is expected to result in effects consistent with the anticipated effects of the proposed action analyzed in NMFS' 2019 NMFS BiOp through March 31, 2024 (NMFS, 2022). On March 26, 2024, NMFS extended this BiOp through October 31, 2024 (NMFS, 2024).

The focus of the current consultation and this Biological Assessment is to update previous analyses to incorporate a Proposed Action that accounts for the operational implications of removal of the four Klamath River dams previously operated by PacifiCorp as well as the dynamic and not entirely predictable environmental conditions anticipated to occur during and immediately after said removal, as well as the reconnection of Agency Lake and Barnes units of Upper Klamath NWR to UKL.

1.6 Organization

The following chapters provide the Biological Assessment for the Project:

- *Chapter 2 - Environmental Baseline* identifies the existing structures and operations of the Project. This chapter describes the environmental conditions and climate in the Action Area, the past and present operations of the Project, and the federal, state, and private actions that have occurred within the Action Area and have influenced the current status of listed species. Additionally, this chapter references related but independent activities that are occurring in the Action Area that have ongoing effects to federally-listed species in the Action Area (e.g., dam removal).
- *Chapter 3 - Proposed Action* represents coordination and consensus between the Services and Reclamation on the discretionary operation of the Project. [More detail as the content is developed]
- *Chapter 4 - Seasonal Operations* presents seasonal and interannual changes associated with the Proposed Action. It incorporates the "Without Action Analysis" as well.

- *Chapter 5 - Lost River and Shortnose Suckers* analyzes the effects of the Proposed Action on LRS and SNS and their designated critical habitat. It also provides species-specific status and conditions of designated critical habitat within the environmental baseline to facilitate an aggregate analysis of the Proposed Action effects in conjunction with the species response to current and future stressors not associated with the Proposed Action.
- *Chapter 6 - Southern Oregon Northern California Coast Coho Salmon* analyzes the effects of the Proposed Action on SONCC Coho Salmon and their designated critical habitat. It also provides species-specific status and conditions of designated critical habitat within the environmental baseline to facilitate an aggregate analysis of the Proposed Action effects in conjunction with the species response to current and future stressors not associated with the Proposed Action.
- *Chapter 7 - Southern Resident Killer Whale* analyzes the effects of the Proposed Action on SRKWs and their designated critical habitat. It also provides species-specific status and conditions of designated critical habitat within the environmental baseline to facilitate an aggregate analysis of the Proposed Action effects in conjunction with the species response to current and future stressors not associated with the Proposed Action.
- *Chapter 8 - Other Species* discusses the effects of implementing the Proposed Action on other species
- *Chapter 9 - Cumulative Effects* encompasses only the effects of future state or private activities reasonably certain to occur on federally-listed species and designated critical habitats within the Action Area. These activities include activities such as [content included later based on effects analysis].
- *Chapter 10 - Conclusions* is a summary of findings regarding potential effects to listed species individuals as a direct or indirect result of the Proposed Action, interaction among effects of the Proposed Action (adverse, insignificant, discountable, or beneficial), and an estimate of anticipated incidental take.

Findings are further supported by technical appendixes providing analyses on the following topics:

- *APPENDIX A - Species List* for USFWS and NMFS Consultation
- *APPENDIX B - Species Spatial and Temporal Domains:* The timing and location of species and their current status range-wide and within the Project area
- *APPENDIX C - Description of the Klamath Basin Planning Model, Keno Release Version*
- *APPENDIX D - Essential Fish Habitat*: An analysis of EFH and impacts of the Proposed Action on EFH

Appendices include attachments with detailed technical analyses.

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2 Environmental Baseline

“Environmental baseline” refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. 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. The impacts to listed species or designated critical habitat from Federal agency activities or existing Federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR § 402.02).

However, ESA only subjects *discretionary* actions to analysis with respect to listed species and their designated critical habitat; impacts from Federal agency activities or existing Federal agency facilities that *are not within the agency's discretion* to modify are instead part of the environmental baseline (50 CFR § 402.02; 89 FR 24268, 24297, April 05, 2024 [publishing a new final rule for implementing Section 7 of the ESA and revising the definition of Environmental Baseline]). Courts have identified that “discretionary actions” concerning Baseline involve scenarios where “Congress has imposed broad mandates” with respect to “directing agencies to achieve particular goals.” *San Luis & Delta-Mendota Water Auth. v. Jewell*, 747 F.3d 581, 640 (9th Cir. 2014)(citing to National Wildlife Federation v. NMFS, 524 F.3d 917, 928-29 (9th Cir. 2008). Notably, “while the goals themselves may be mandatory, the agencies retain considerable discretion in choosing what specific actions to take in order to implement them.” *Id*.

Generally, “with respect to existing Federal facilities, such as a dam, courts have recognized that effects from the existence of the dam can properly be considered a past and present impact included in the ‘environmental baseline’ when the Federal agency lacks discretion to modify the dam. *See, e.g., Friends of River v. NMFS,* 293 F. Supp. 3d 1151, 1166 (E.D. Cal. 2018).” (89 FR 24275). Further, the environmental baseline includes “the original construction of facilities and past operations and maintenance that have occurred.” (89 FR 24276). Therefore, the environmental baseline for this consultation includes any effects caused by the existence of dams and other facilities within the Project if Reclamation lacks the authority to modify or remove the facilities. It also includes the effects of all past and present operations of the Project, as opposed to proposed future operations described in the Proposed Action.

The Endangered Species Consultation Handbook (USFWS and NMFS, 1998) identifies the ongoing discretionary operations of water supply projects as a new commitment of resources subject to the same approach as for other types of Section 7 analyses (page 4-30).

In operating the Project, Reclamation has the discretion to store inflow into Project reservoirs, release water subject to channel capacities, divert water at Project facilities, and route water through Project control structures.

The environmental baseline does not include effects of the Proposed Action, which are the consequences of the proposed discretionary action to be analyzed in this consultation. In 2020, Reclamation included a Without Action (WOA) scenario in the environmental baseline of the 2020 Biological Assessment for the long-term operation of the Project. In the WOA scenario, all Project facilities exist, but they were not actively operated. There was no discretionary regulation of flows through the system, including, for example, storing and releasing water from reservoirs and delivering water otherwise required by contract. The intent of the WOA scenario was to help separate impacts attributable to the effects of existing structures, such as dams, from the effects of the proposed action.

In determining which scenarios would be appropriate to characterize the environmental baseline, Reclamation also considered the 2020 proposed action adopted in the April 2023 'Finding of No Significant Impacts' (2023 FONSI), which is currently being implemented, as modified by the IOP Plan. Reclamation determined that the 2019 Proposed Action adopted in the FONSI includes various components also included in this current Proposed Action. Thus, the 2020 Proposed Action adopted in the 2023 FONSI would encompass some of the effects of this Proposed Action and would not be appropriate to inform the environmental baseline condition. The 2020 Proposed Action adopted in the 2023 FONSI, however, is used in representing the No Action Alternative in the Environmental Assessment associated with this Biological Assessment. The No Action Alternative represents the current management direction of Reclamation, as required by the National Environmental Policy Act (NEPA).

Pursuant to this Biological Assessment, Reclamation provides two additional tools (discussed below) to help support the Services' understanding of Baseline in performing their Section 7 analyses. Through this effort, Reclamation attempts to analyze the Proposed Action within a space defined by analytical boundaries and illustrated by the following scenarios. The purpose of this modeling is to help illustrate and distinguish the effects of the Proposed Action from effects of the Project's inherent and variable capability to store, release, divert, and route water.

1. The first model scenario reflects a run-of-river scenario (ROR) that eliminates all operations, except those needed to provide flood control and to protect existing facilities. This scenario depicts conditions without Reclamation storing, diverting, or routing water. The ROR scenario, when examined in the context of the Proposed Action, is intended to help analyze how the storage, release, diversion, and routing of water in the Proposed Action could affect river flows.

2. The second model scenario reflects a maximum storage operation (MS) that uses stored water only to meet flood control, minimum downstream flows for fish, and minimal deliveries to Reclamation's settlement contractor. The MS operation is intended to help analyze how minimal operations may affect flows below dams and storage in reservoirs where releases are made to meet certain basic requirements. This scenario, when examined in the context of the Proposed

Action, is intended to help analyze how the release and diversion of water for irrigation in the Proposed Action could affect downstream flows and storage in reservoirs.

These additional modeling scenarios are intended to provide information that helps separate the environmental baseline from the effects of the Proposed Action for irrigation water deliveries. Reclamation understands that neither of the scenarios constitutes the Environmental Baseline itself, as defined above. They are analytical tools to help understand the effects of the Proposed Action. The Proposed Action, subtracting ROR and MS scenarios, informs understanding of the magnitude of hydrologic alterations caused by operation of the Project to store, release, divert, and route water for irrigation purposes alone. As such, ROR and MS scenarios are informative in considering effects of the Proposed Action relative to the baseline conditions, as these scenarios do not include the effects of the Proposed Action for irrigation.

The effects of the Proposed Action are added to the environmental baseline, as shown in Figure 2-1 to evaluate the overall effects on species.

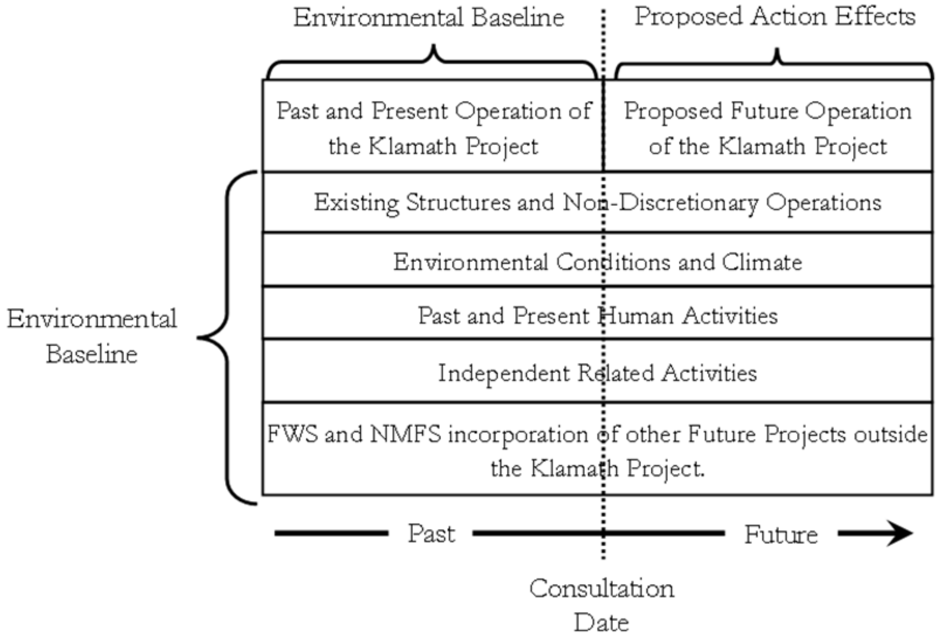


Figure 2-1. Conceptual model of the environmental baseline role in a reinitiation of consultation

Components of the environmental baseline include: (1) existing structures and modeling approach; (2) environmental conditions and climate, which provides a landscape level description of Oregon’s and California’s hydrology, anticipated climate change, and past periods of drought; (3) past and present operations of the Project under prior ESA consultations, which become part of the environmental baseline each time Reclamation consults on operations; (4) past and present human activities, which describe other federal, state, and private actions that have occurred within the Action Area; (5) independent related activities, which describe activities consulted upon where necessary and implemented separately from the operation of the Project.

2.1 Existing Structures and Modeling Approach

In operating the Project, Reclamation must comply with statutory and regulatory requirements, including Oregon and California water law. Applicable federal law includes the Reclamation Act of 1902 and the Endangered Species Act, as amended.

Reclamation has used two modeling approaches to explore scenarios as explained below that depict Reclamation's limited ability to adjust operations.

The ROR scenario identifies hydrologic conditions in the absence of the operation of the Project and provides a basis to measure hydrologic impairment by factors other than the operation of the Project. Under ROR, the Project releases reservoir inflow, subject only to downstream channel capacities. The Project does not store water. There are no Project or senior water right holder diversions. ROR eliminates any operation of the Project, except as needed to bypass inflow, thereby providing a basis to help assess the effects of the Proposed Action.

The ROR is similar to the previous WOA operation approach in the prior consultation in that both scenarios assume that the Project will not be operated for authorized purposes, except to protect facilities and downstream channels. However, the ROR operation scenario assumes free flow of water, instead of operating consistent with a particular high-flow date. Reclamation chose ROR because it more closely reflects natural conditions in the river, given the continued existence of Klamath Project and previous landscape alteration (i.e., reef notching). It is also more useful in determining the effects of operations on river flows, as flows under ROR can be compared to flows under MS and the Proposed Action. The ROR eliminates the effects of possible discretionary operations from the environmental baseline.

The MS scenario attempts to model how much water is needed to meet routine obligations apart from most irrigation water deliveries. The MS scenario identifies those ongoing operations that may be within the agency's discretion to modify but would be generally expected as initial operation. In the MS scenario, Reclamation stores and releases inflow only for flood control, minimum downstream flows, and deliveries to settlement contracts that predates the Project. It includes some reasonable assumptions to depict how the Klamath Project would operate aside from irrigation deliveries.

For both ROR and MS, Reclamation is not operating the Project to deliver water under repayment contracts, Warren Act contracts, and annual water rental agreements. Generally, these contracts indemnify Reclamation from liability for shortages of Project water due to drought and other physical or natural causes beyond the control of the Contracting Officer. Reclamation recognizes that the capacity of the Project to deliver water has been constrained in recent years for various reasons, so the likelihood of contractors receiving full deliveries of Project water in any given year is uncertain. Any contract shortage would be allocated in accordance with the priority of each contract type and, after higher priority contract classes have been fully served, apportioned among contractors in the lowest priority contract class for which water is available.

2.1.1 Upper Klamath Lake

The LRD is located at the head of the Link River, the natural outlet of UKL. The dam was constructed by Copco between 1919 and 1921. In connection with construction of LRD, Copco excavated channels through the two natural reefs upstream of the dam. The purpose of these channels was to facilitate outflow from UKL, allowing the lake to be drawn lower than occurred naturally. Additionally, immediately upstream from LRD, Copco dredged two 40-foot-wide channels on both sides of the river, as well as a section across the river at the upstream face of the dam.

Effects associated with the continued existence of those facilities are attributed to the environmental baseline. Operational assumptions for facilities within the UKL are as follows:

The Link River originates at the downstream face of LRD and flows approximately two kilometers before emptying into Lake Ewauna and forming the head of the Klamath River. Flows from LRD are regulated by Reclamation for storage of water in UKL, delivery of water for irrigation and historic wetland use, and maintenance of downstream Klamath River flows.

The Klamath Project regulates Upper Klamath Lake levels through a combination of releases at Link River Dam and diversions at the A Canal Headworks. Additional diversions from UKL include Project diversions by holders of two settlement contracts and several Warren Act contractors, as well as numerous non-Project diversions.

Water Rights Settlement Contracts: Reclamation administers one contract that provides for the diversion of project water by contractors that hold water rights that are senior to those of the United States, the 1909 Settlement Contract between the United States and the Van Brimmer Ditch Company (VBDC). This contract provides for the delivery of up to 50 cubic feet per second (cfs) of water from April 15 to October 1 of each year through KID's operation of the C Canal, in satisfaction of the water rights VBDC original claim to waters from Lower Klamath Lake and the Klamath River. Reclamation must satisfy this settlement contract prior to servicing any other contracts. Prior to the development of the Klamath Project, the VBDC point of diversion was from the Keno Impoundment.

In ROR,

- There are no diversions at A Canal. The headworks on the A Canal would be closed, and the fish screening system would be deactivated, preventing any water diversions through the A Canal to irrigated lands within the Klamath Project. Project contractors who customarily divert water from UKL would not do so. Other direct diversions from UKL for irrigation and other purposes by non-Project interests would continue consistent with historical practices, as Reclamation has no discretionary control over non-federal diversions.
- The gates at Link River Dam are all completely opened, and the release is regulated by Reclamation's Link River Dam maximum release vs. water surface elevation curve. The gates and spillway bays on LRD would be fully open to allow flood flows while

maintaining dam integrity. The gate discharging water into the fish ladder on LRD would be closed, rendering the ladder inaccessible for fish. There would be no active diversions into the Eastside (Ankeny) and Westside (Keno) power canals.

- No water is delivered to the VBDC.

In MS,

- There are no Project-related diversions at A Canal or from UKL, similar to the Run of River.
- Link River Dam is operated to meet one of three objectives (whichever requires the largest release on any given day)
- Link River minimum flow levels, as implemented in the current Interim Operations Plan, to ensure water for the environment.
- Upper Klamath Lake flood pool elevations, as implemented in the current Interim Operations Plan, to protect life and property.
- Demands of the Keno Impoundment (defined in the Maximum Storage description in Section 2.1.2)
- VBDC diverts 50 CFS continuously from March to October. There are no VBDC diversions from November to February.

2.1.2 Keno Impoundment

Keno Dam was constructed between 1965 and 1966 to replace the function of the former Needle Dam and, before it, the Keno Reef. Keno Dam is operated to regulate releases out of UKL and the LRDC while maintaining upstream water surface elevations in the Keno Impoundment. In connection with construction of Keno Dam, the Pacific Power and Light Company made channel improvements for approximately 17 miles upstream of the dam. These improvements were intended to increase channel capacity to approximately 15,000 cfs. Ownership and operation of Keno Dam was transferred to Reclamation in early 2024 (PacifiCorp and Reclamation, 2022). Gaged Klamath Project diversions out of the Keno Impoundment, and the hydrologically connected LRDC, include Station 48, Miller Hill, North Canal, and Ady Canal. In addition, water is diverted from the Keno Impoundment by several private entities as well as several entities possessing Warren Act contracts with Reclamation.

In ROR,

- All Klamath Project diversions are turned off.
- There is no diversion of Lost River water into the LRDC.
- No Klamath Straits Drain water is discharged to the Keno Impoundment through the F/FF Pump Station.

- The Keno Impoundment closure term is implemented (for ungaged accretions and diversions as determined through a mass balance analysis of the historical data)
- Keno Dam releases are not operated to a minimum required flow. Releases are a result of the sum of the Link River Dam release and the Keno Impoundment closure term.

In MS,

- All Klamath Project diversions are turned off.
- There is no diversion of Lost River water into the LRDC.
- No Klamath Straits Drain water is discharged to the Keno Impoundment through the F/FF Pump Station.
- The Keno Impoundment closure term is implemented (for ungauged accretions and diversions as determined through a mass balance analysis of the historical data)
- A minimum flow of 350 CFS is implemented at Keno Dam. (Link River Dam will release to meet this minimum flow if necessary.)

2.1.3 Clear Lake Dam (not modeled but qualitative description)

Clear Lake Reservoir is located at the head of the Lost River, in Modoc County, California, approximately 5 miles south of the state border with Oregon. Clear Lake Reservoir has an active storage capacity of approximately 513,000 AF, although outflow from the lake is significantly impaired below 4,522 feet.

In ROR,

- The gates on Clear Lake Dam would be set to the fully open position, to pass flood flows while maintaining the integrity of the dam. The maximum release capacity through the gates on Clear Lake Dam is 780 cfs. Particularly in the spring months, inflows to Clear Lake would periodically exceed release capacity at the gates, resulting in water being temporarily impounded. However, no appreciable interannual storage would accrue within the reservoir (i.e., above the "dead pool" elevation), given the combined effect of outflow and evaporation.
- The channel between Clear Lake Reservoir and the Clear Lake Dam has historically been dredged periodically. However, dredging has not occurred since the 1980s, and inflows of silt and other sediment have aggraded the bed of this channel. Consequently, when the water surface level in Clear Lake Reservoir drops below 4,522.0 feet, this channel is constrained to the point of ceasing all outflow.
- When Clear Lake Reservoir drops below 4,522.0 feet, the channel between Willow Creek and the east lobe of Clear Lake Reservoir also becomes hydrologically disconnected. When this channel becomes disconnected, Willow Creek instead flows entirely towards the Clear Lake Dam forebay.

- It is assumed no Lost River water leaves the Lost River basin (i.e., no Lost River water is diverted into the Lost River Diversion Channel)

In MS,

- Under maximum storage, water is stored in Clear Lake reservoir to its maximum capacity. Clear Lake reservoir has a capacity of 410,000 AF. The current reservoir, constructed in 1922, has never filled completely, even during the wettest years.
- No agricultural diversions are made directly from the reservoir.
- No flows are released from the Lost River system originating from Clear Lake Reservoir. It is assumed no Lost River water leaves the Lost River basin (i.e., no Lost River water is diverted into the Lost River Diversion Channel)

2.1.4 Gerber Dam (not modeled but qualitative description)

Gerber Dam is located approximately 14 miles east of the town of Bonanza on Miller Creek, a tributary to the Lost River.

In ROR,

- The Gerber Dam release gates would be set to the fully open position, to pass flood flows while maintaining the integrity of the dam. The maximum outlet capacity of the gates on Gerber Dam is 900 cfs.
- Although inflow to Gerber reservoir would occasionally exceed outlet capacity leading to impoundment, this storage would be temporary and occur primarily in spring. Even with this impoundment, the reservoir would completely drain each year to the point where its surface area would be less than 100 acres.
- The volume, duration, and frequency of temporary storage of water behind Gerber Dam would vary based on the rate and timing of snowmelt and associated runoff upstream, plus additional hydrologic conditions.

In MS,

- Under maximum storage, water is stored in Gerber Reservoir to its maximum capacity. That capacity is 94,270 AF. Gerber Reservoir does fill and spill occasionally as it has within the last 10 years.
- The volume of spill from Gerber would
- No agricultural diversions are made directly from the reservoir.

2.1.5 Effects on Upper Klamath Lake Storage

Modeling scenarios, using the period of record (water year 1991 to 2022), can be used to show the effects of the ROR and MS scenarios on UKL storage.

- End of April Storage
    - In the ROR scenario, the average end of April Upper Klamath Lake water surface elevation is 4,138.97 feet. The minimum surface elevation would be 4,137.32 feet and the highest surface elevation that could be reached is 4,140.81 feet. End of April storage could vary by 3.49 feet in elevation.
    - In the MS scenario, the average end of April Upper Klamath Lake water surface elevation is 4,143.28 feet. The minimum surface elevation would be 4,143.17 feet and the highest surface elevation that could be reached is 4,143.29 feet. End of April storage could vary by 0.12 feet in elevation.
- End of September Storage
    - In the ROR scenario, the average end of September Upper Klamath Lake water surface elevation is 4,136.74 feet. The minimum surface elevation would be 4,136.09 feet and the highest surface elevation that could be reached is 4,137.77 feet. End of September storage could vary by 1.68 feet in elevation.
    - In the MS scenario, the average end of September Upper Klamath Lake water surface elevation is 4,142.94 feet. The minimum surface elevation would be 4142.38 feet and the highest surface elevation that could be reached is 4,143.30 feet. End of September storage could vary by 0.92 feet in elevation.

2.1.6 Effects on Klamath River Flows

Modeling scenarios can be used to show the effects of the ROR and MS scenarios on Klamath River flows.

In the ROR simulation, average monthly flows at Keno are higher than the MS simulation in all months except October and November. The reason the MS average flow at Keno is higher in these two months is that UKL storage must be released to increase flood pool capacity for the winter. In the ROR study, the UKL surface elevation never reaches flood pool.

The MS simulation maximum daily flow at Keno during the period of record was 7,147 CFS, and the minimum daily flow at Keno was 350 CFS. The ROR maximum daily flow at Keno during the period of record was 5,029 CFS, and the minimum daily flow was 88 CFS. In the ROR simulation, the maximum flow was dampened by the available storage capacity whereas in the MS simulation the elevated water surface allowed for larger releases when needed for flood control.

2.2 Environmental Conditions and Climate

2.2.1 Hydrology

Runoff in the Klamath River Basin varies considerably on a seasonal and year-to-year basis, as well as from place to place. A review of historical information in the Klamath River Basin shows that some runoff trends within the basin may be apparent depending on the location and historical period that is assessed. For example, while Reclamation has observed a multi-decadal decline in UKL inflows, climatological studies such as the Secure Reservoir Operations suggests a shift towards warmer precipitation (more rain, less snow) in the future (Reclamation, 2021). Additionally, the western United States and Klamath River Basin have experienced a general decline in spring snowpack, reduction in the amount of precipitation falling as snow in the winter, and earlier snowmelt runoff between the mid- and late-twentieth century (Knowles et al., 2006; Regonda et al., 2005).

Annual peak discharge records indicate that, due to a number of factors, an assessment of whether observed changes are due to natural climate variability or climate change is not possible (Villarini et al., 2009). For the entire western United States, observed trends of temperature, precipitation, snowpack, and streamflow might be partially explained by anthropogenic influences on climate (e.g., Barnett et al., 2008; Pierce et al., 2008; Bonfils et al., 2008; Hidalgo et al., 2009; Das et al., 2009). However, it remains difficult to attribute observed changes in hydroclimate to historical human influences or anthropogenic forcings. This is particularly the case for trends in precipitation (Hoerling et al., 2010) and for trends in basin-scale conditions rather than at the larger western United States scale (Hidalgo et al., 2009).

2.2.2 Climate Change

Climate change has long-term implications for the Klamath River Basin, including warming of air and water temperatures, changes in precipitation (i.e., amount of rain versus snow, and frequency of rain on snow events), the amount of snowpack, water quantity (e.g., more frequent, high intensity storms, and lower summer flows), and overall seasonal streamflow patterns (NRC, 2004). General climate trends identified in the western United States suggest that historical twentieth century warming is projected to continue with estimates varying from roughly 2.8 to 3.9°C (5 to 7°F) during the 21st century, depending on location (Reclamation, 2011).

Over the course of the twentieth century, Klamath River Basin average mean-annual temperature has increased by approximately 1°C (2°F) in Jackson and Klamath counties in south-central Oregon and Siskiyou County in north-central California (though large variations in annual temperature has been observed and the warming has not been steady; Reclamation, 2011). The warming rate of air temperatures for the Pacific Northwest over the next century is projected to be approximately 0.1 to 0.6°C per decade (0.18 to 1.08°F; ISAB, 2007). Model results suggest that water temperatures in the Klamath River above Klamath, California, are projected to increase by approximately 2.8 to 3.3°C (5 to 6°F) during the 21st century (ISAB, 2007). Temperatures averaged over just the upper portion of the basin (Klamath River above the former Iron Gate Dam site [IGD]) are projected to have a similar trend (Reclamation, 2011). Flint and Flint (2012) found indications that warming conditions have already occurred in many areas of the Klamath River Basin and that the stream temperature projections for the 21st century may be an underestimate.

Projections suggest that some western river basins may gradually become wetter (e.g., Columbia) while others gradually become drier (e.g., San Joaquin and Truckee). The Klamath and Sacramento basins have roughly equal chances of becoming wetter or drier (Reclamation, 2011).

The Klamath River Basin annual precipitation has fluctuated considerably during the past century, varying between 20 to 45 inches (Reclamation, 2011).

Projection of climate change is geographically complex and varies considerably within the Klamath River Basin, particularly for precipitation. Precipitation conditions are generally wetter towards the coast and on the windward side of coastal mountain ranges, precipitation tends to decrease towards the east, and relatively arid conditions exist over the northern reaches of the basin. Mean annual temperature in the lower basin is warmer than the upper basin, and the lower basin experiences less variation in seasonal temperatures. Annual average temperatures are generally cooler in the interior plateau areas of the upper basin, while warmer temperatures are observed in lower lying areas of the lower basin and near the California coast (Reclamation, 2011). The overall precipitation change projection suggests a slight increase over the entire basin during the early 21st century, transitioning to a northern increase and southern decrease by the 2070s (Reclamation, 2011).

Increased warming is expected to diminish the accumulation of snow during the cool season (i.e., late autumn through early spring), the availability of snowmelt to sustain runoff during the warm season (i.e., late spring through the summer), and reduce snow-water equivalents (NMFS, 2010a; Reclamation, 2011). Generally, snowpack decrease is projected to be more substantial over the portions of the basin where cool season temperatures are generally closer to freezing thresholds (e.g., lower lying valley areas and lower altitude mountain ranges) and more sensitive to projected warming. This could possibly lead to increases in December-March runoff and decreases in April-July runoff, though the degree to which these results occur in the Klamath River Basin appears to vary by subbasin (Reclamation, 2011).

For example, the Wood and Shasta rivers both have headwater areas at sufficiently high elevation (2,500-4,000 feet) and groundwater recharge areas more resilient than most stream reaches in the event of temperature increases and associated changes in precipitation (NRC, 2004). In a study of the Klamath River Basin, Mayer and Naman (2011) suggest that streamflow characteristics and response to climate vary with stream type between surface (rain basins and snowmelt basins) versus groundwater dominated basins. They posit that in the groundwater basins that sustain UKL inflows and mainstem river flows during the typically dry summers, the streamflow response to changes in snowpack are dampened and delayed, and the effects are extended longer in the summer. Changes in snowpack, annual runoff, and runoff seasonality within the Klamath River Basin could change the availability of natural water supplies (NMFS, 2010a; Reclamation, 2011), increase the demand for water by humans (Döll, 2002; Hayhoe et al., 2004), and decrease water availability for salmonids (Battin et al., 2007).

While most of the predicted effects of climate change cannot be precisely forecasted, there are general known impacts such as increased mean seasonal runoff volume for December through March (Reclamation, 2011, Table 3), and some studies suggest that the stream flows of the Upper Klamath Basin may already be experiencing the effects of climate change (e.g., Mayer and Naman, 2011). It is important to acknowledge that the ongoing effects of climate change do and will continue to influence the environmental baseline of the Project now and into the future.

However, the full magnitude and timing of the future effects due to climate change are currently unknown.

2.2.3 Drought

Drought trends in the Klamath River Basin are inextricably linked with climate change. The full magnitude and timing for future effects are similarly difficult to predict. However, recent evidence suggests that climate and weather is expected to become more extreme, with an increased frequency of drought (IPCC, 2019). Extended droughts occurred in the late 1980s and early 1990s and were established as likely causes of decreased abundance of SONCC Coho Salmon (Good et al., 2005). Another drought from 2014 through 2016 reduced stream flows and increased temperatures, further exacerbating salmonid stress and disease issues. Drought conditions returned to the Klamath Basin in 2020 and have persisted through the present day (Reclamation, 2020b). The state of Oregon declared a state of drought emergency in the Upper Klamath River Basin in 3 of the past 5 years due to unusually low snowpack and lack of precipitation. During the recent drought, unusually warm temperatures intensified the effects of very low precipitation and snowpack.

Climate change is expected to alter the flow patterns controlling the seasonality and magnitude of droughts. Average winter precipitation is anticipated to increase over the long term, but year-to-year variation in precipitation is expected to increase. Additionally, extended droughts punctuated by extreme events such as heavy rainfall associated with atmospheric rivers and rain-on-snow events are likely to increase stressors on aquatic habitats and species (May et al., 2018).

2.2.4 Flooding

Flooding in the Klamath River Basin is, like drought, inextricably linked with climate change, and the full magnitude and timing for future effects are similarly difficult to predict. However, recent evidence suggests that more extreme climate and weather is expected to increase the frequency of flooding (IPCC, 2019).

Climate change is expected to alter the flow patterns controlling the seasonality and magnitude of floods, similar to droughts. Average winter precipitation is anticipated to increase over the long term with year-to-year variation in precipitation leading to increased frequency of extreme rain events. Heavier winter rainstorms from warming may lead to increased flooding and high-flow events that result in scouring of riverbeds and increasing suspended sediment in systems.

2.3 Past and Present Operation of Klamath Project

The Project historically operates to store, release, route, and divert water to irrigation contractors within the Klamath River Basin under requirements from the Oregon Water Resources Department (OWRD), the Services (endangered species), and Congress (Reclamation Act of 1902). This section describes the evolving nature of regulatory efforts imposed on the Project to benefit species that are now protected under the federal ESA. The effects from past and present operation of the Project under these regulatory requirements, including any resulting take of listed species, are included in the environmental baseline.

2.3.1 Endangered Species Act Consultations Pursuant to Section 7

Congress enacted the ESA in 1973. Section 4 of the ESA authorizes the Services to classify species as threatened or endangered and to designate critical habitat for listed species (16 U.S.C. 1533). Between 1988 and 1997, several aquatic species found in Klamath River Basin and/or the Pacific Ocean (within the Action Area for purposes of SRKWs) were listed under the federal ESA as endangered or threatened.

Section 7 of the ESA requires federal agencies to consult with the Services to ensure that actions they fund, authorize, permit, or otherwise carry out will not jeopardize the continued existence of any listed species or adversely modify designated critical habitats (16 U.S.C. 1536). The operation of the Project is a federal action that requires consultation under Section 7 of the ESA. Reclamation has consulted with USFWS and/or NMFS on the operation of the Project several times since 1988. Those consultations have resulted in Biological Opinions, both jeopardy and non-jeopardy, that have been the subject of litigation in federal courts.

Each of these prior consultations help inform the current environmental baseline for federally-listed species and designated critical habitats within the action area and provide data upon which subsequent consultations are based (USFWS and NMFS, 1998). These prior consultations document the status of each of the federally-listed species and designated critical habitats at the time of consultation and describe the anticipated effects of the prior proposed actions and the resulting incidental take that was reasonably certain to occur at the time. Refer to the species-specific chapters (Chapters 5 through 8) for incorporation of past data and current status of the federally-listed species and designated critical habitats within the action area.

2.3.1.1 U.S. Fish and Wildlife Service Consultations 1988 - 1992

On July 18, 1988, the USFWS designated LRS (*Deltistes luxatus*) and SNS (*Chasmistes brevirostris*) as endangered species under the ESA (53 FR 27130). The following year, Reclamation began consultations on the effects of aquatic herbicide use within the Project on these species.

On August 14, 1991, Reclamation completed the first consultation on Project operations' effects on all federally-listed species, including LRS and SNS (Reclamation, 1992). The USFWS issued a BiOp (USFWS, 1991) concluding that the 1991 proposed drought operations of the Klamath Project were likely to jeopardize the continued existence of the LRS and SNS. As part of its RPA, the USFWS required Reclamation to provide a minimum reservoir elevation of 4,522.0 ft at Clear Lake and specified minimum reservoir elevations at Upper Klamath Lake during parts of the year.

On January 6, 1992, the USFWS issued an interim BiOp (USFWS, 1992a) for Klamath Project operations from January 1, 1992, until the USFWS issued a new BiOp later in 1992. In this interim BiOp, the USFWS concluded that the interim operations were not likely to jeopardize the continued existence of the LRS or SNS (or bald eagle).

In July 1992, the USFWS issued a BiOp (USFWS, 1992b) on the long-term operation of the Project, concluding that the proposed operation was likely to jeopardize the continued existence of LRS and SNS. The USFWS developed a Reasonable and Prudent Alternative that required Reclamation to operate to specified lake elevations during parts of the year at UKL, Clear Lake Reservoir, Gerber Reservoir, and Tule Lake.

2.3.1.2 National Marine Fisheries Service Consultations 1999 - 2002

On May 6, 1997, NMFS listed the SONCC Coho Salmon ESU as threatened (62 FR 24588), and 2 years later, on May 5, 1999, NMFS designated SONCC Coho Salmon critical habitat (64 FR 24029). Since 1999, NMFS and Reclamation have conducted six Section 7 consultations regarding the potential effects of Reclamation’s proposed Project operations on SONCC Coho Salmon and its designated critical habitat (1999, 2001, 2002, 2010, 2013, and 2019). Consultations in 2001 and early 2002 resulted in the curtailment of Project deliveries those years.

On March 9, 1999, Reclamation requested formal Section 7 consultation under the ESA on the effects of Project operations on SONCC Coho Salmon. On July 12, 1999, NMFS issued a final BiOp concluding that the proposed 1-year operation (April 1999 through March 2000) of the Project was not likely to jeopardize the continued existence of SONCC Coho Salmon or adversely modify designated critical habitat. Following expiration of that BiOp, Reclamation operated the Project as proposed in an April 26, 2000 letter to NMFS, ensuring that operations were consistent with Section 7(d) of the ESA.

On April 6, 2001, NMFS issued a BiOp for Project operations, concluding that the proposed operation was likely to jeopardize the continued existence of SONCC Coho Salmon and adversely modify or destroy its critical habitat. The 2001 BiOp addressed Project operations for the April through September 2001 period and included a Reasonable and Prudent Alternative that mandated instantaneous minimum releases from IGD and ramping rates below IGD to prevent Coho Salmon stranding. NMFS amended the 2001 BiOp to address operations through February 2002 and concurred that proposed operations through May 2002 were not likely to adversely affect Coho Salmon.

In May 2002, NMFS issued a BiOp on the effects of proposed Project operations between April 1, 2002, and March 31, 2012, on SONCC Coho Salmon. In that BiOp, NMFS concluded that the proposed operations were likely to jeopardize the continued existence of Coho Salmon and adversely modify its critical habitat. NMFS developed a comprehensive Reasonable and Prudent Alternative that included: (1) specific water management measures over the next 10 years (2002 - 2012); (2) a water bank and water supply enhancement program to provide flows to the Klamath River below IGD to improve Coho Salmon habitat; (3) an agreed upon long-term flow target to be achieved by 2010; (4) an inter-governmental task force to develop, procure, and manage water resources in the Klamath River Basin; and (5) an inter-governmental science panel to develop and implement a research program.

2.3.1.3 2008 U.S. Fish and Wildlife Service and 2010 National Marine Fisheries Service Biological Opinions

In October 2007, Reclamation initiated consultations with the Services regarding the effects of Project operations on federally-listed threatened and endangered species for an effective period from 2008 to 2018 (10-year duration). On April 2, 2008, USFWS issued a final BiOp (Reference No. 8-10-08-F-070070) covering Project operations until 2018, concluding that the proposed action would not likely jeopardize the continued existence of the endangered suckers or adversely modify their critical habitat. The proposed action included, among other measures, end-of-month minimum surface elevations for UKL, Clear Lake, and Gerber Reservoir.

On March 15, 2010, NMFS issued a final BiOp covering 2010 to 2018 (NMFS, 2010a), concluding that Reclamation's proposed action would likely jeopardize the continued existence of SONCC Coho Salmon and likely result in the destruction or adverse modification of its critical habitat. NMFS developed a Reasonable and Prudent Alternative that addressed: (1) increased fall and winter flow variability; and (2) increased spring discharges in select average and wetter exceedances.

2.3.1.4 2013 Joint Biological Opinion (U.S. Fish and Wildlife Service and National Marine Fisheries Service)

In December 2012, Reclamation formally reinitiated consultation with the Services under Section 7(a)(2) of the ESA, focusing on the potential effects of proposed Project operations from April 1, 2013, to March 31, 2023, on federally-listed threatened and endangered species. Reclamation’s biological assessment concluded that the proposed action would likely adversely affect LRS, SNS, and SONCC Coho Salmon and their critical habitat. The Services issued a joint BiOp in May 2013, concluding that operating the Project for a 10-year term (from May 31, 2013, through March 31, 2023) would not likely jeopardize the continued existence of the suckers or the SONCC Coho Salmon ESU, nor result in the destruction or adverse modification of their critical habitat (NMFS File No. SWR-2012-9372; FWS File No. 08EKLA00-2013-F-001).

2.3.1.5 2019 U.S. Fish and Wildlife Service and National Marine Fisheries Biological Opinions

In late 2016, in connection with two related cases in the U.S. District Court for the Northern District of California, Yurok Tribe v. Bureau of Reclamation, No. 16-cv-6863, and Hoopa Valley Tribe v. Bureau of Reclamation, No. 16-cv-4294, Reclamation was required to provide certain flows in the Klamath River for the stated purpose of disease mitigation for Coho Salmon in the Klamath River until such time that the Klamath reconsultation is complete (Court Order; March 24, 2017; Case Nos. 3:16-cv-06863-WHO and C16-cv-04294-WHO). The court required Reclamation to implement three types of flows intended to reduce and mitigate the effects of *Ceratonova shasta* on Coho Salmon in the Klamath River: (1) surface flushing flows; (2) deep flushing flows; and (3) reservation of 50,000 AF by April 1 of each year for potential implementation of emergency dilution flows. The court ordered that these flows be implemented until consultation was completed.

In 2017, Reclamation reinitiated consultation with the Services and delivered a final biological assessment to both in December 2018. That biological assessment initially covered Project operations from 2019 to 2029 but was later amended to cover water years 2019 through 2024. On March 29, 2019, the Services provided separate but coordinated 2019 Biological Opinions. The USFWS 2019 BiOp (TAILS No. 08EKLA00-2019-0068) concluded that Reclamation's 2018 proposed action was not likely to jeopardize the continued existence of LRS and SNS or result in the destruction or adverse modification of their critical habitat.

The NMFS 2019 BiOp (NMFS File Nos. WCR-2019-11512, WCRO-2019-00113) concluded that the 2018 proposed action was not likely to jeopardize the continued existence of the SONCC Coho Salmon ESU or the SRKW DPS or destroy or adversely modify the designated critical habitat for the SONCC Coho Salmon ESU. In their 2019 BiOp, NMFS also concluded that the 2018 proposed action would not likely adversely affect Green Sturgeon, Eulachon, or the designated critical habitat for Eulachon. Additionally, as part of the 2018 biological assessment, Reclamation conducted an EFH assessment in compliance with Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act, analyzing Chinook Salmon and SONCC Coho Salmon habitat. NMFS's 2019 BiOp concluded that Reclamation's 2018 proposed action would adversely affect SONCC Coho and Chinook salmon EFH. NMFS provided conservation recommendations in the 2019 BiOp to protect the mainstem Klamath River and tributaries designated as EFH for Pacific Coast salmon by avoiding or minimizing the adverse effects described above. Reclamation reviewed NMFS's EFH assessment response document and associated conservation recommendations, providing a written response to NMFS on April 25, 2019, as required by 50 CFR § 600.920(k)(l).

The NMFS 2019 BiOp was written to expire on March 31, 2024. Reclamation requested, and on March 26, 2024, NMFS granted, an extension of the BiOp until October 31, 2024.

2.3.1.6 Consultations from 2020 to 2022

Reclamation reinitiated consultation with the Services on November 13, 2019, due to new information in fall 2019 revealing effects on SONCC Coho Salmon that had not been considered in Reclamation's modified biological assessment or the 2019 NMFS BiOp (per 50 CFR § 402.16(a)(2)). Reclamation then developed an updated biological assessment of the effects of Project operations on federally-listed threatened and endangered species, which was published and delivered to the Services in February 2020. Reclamation's 2020 Biological Assessment analyzed a proposed modification to the approach for managing water related to Project operations, in response to the new information concerning the effects on listed species and their designated critical habitat.

Since Reclamation released the 2020 Biological Assessment, a series of regional, national, and global events stalled the consultation process. As a result, from 2020 through 2022, Reclamation operated the Project according to a series of Drought Plans, an Interim Operations Plan (IOP), and Temporary Operating Plans (TOPs). These plans are described in a series of transmittals to the Services, beginning with the 2020 IOP and Drought Plan.

In April 2020, the USFWS responded to Reclamation's IOP with a BiOp on proposed operation of the Project from April 1, 2020, to September 30, 2022 (TAILS No. 08EKLA00-2020-F-0059), concluding that the modified proposed action was not likely to jeopardize the continued existence of suckers or to result in the destruction or adverse modification of their critical habitat. This BiOp revised and replaced the USFWS' 2019 BiOp for Project operations. However, the USFWS anticipated the proposed action would result in incidental take of suckers and adverse effects to their designated critical habitat, and the BiOp included terms and conditions designed to minimize the effects of the incidental take, which required that certain UKL elevations be met. Also in April 2020, NMFS released a letter stating the IOP is consistent with their 2019 BiOp findings (NMFS, 2020).

In April 2021, Reclamation implemented a TOP due to drought conditions that made it impossible to fully, and simultaneously, implement operations under the 2019 Biological Assessment and IOP. This TOP was then adjusted and re-transmitted to the Services in June 2021. The Service's internal analysis confirmed Reclamation's conclusion that current and projected hydrologic conditions this year would preclude attainment of the 4142.0 ft. of elevation in UKL necessary to provide adequate habitat for shoreline spawning LRSs, regardless of any proactive water conservation measures that Reclamation might take at that point in time. Success of river spawning suckers, including the majority of LRSs and all SNSs in UKL, was determined to be unlikely to be greatly impacted by UKL elevation that year, as UKL tributary access is not elevation dependent.

In 2022, Reclamation transmitted a new TOP to the Services due to continued drought conditions. NMFS responded to the TOP with a letter stating that the modified actions proposed in the TOP are not likely to result in adverse effects to listed species or critical habitat beyond those considered in NMFS' 2019 BiOp. The USFWS responded to the TOP with a letter stating that their own analysis aligned with Reclamation's conclusion that hydrologic conditions precluded managing water levels in UKL to provide adequate habitat for shoreline spawning LRS.

2.3.1.7 2023 U.S. Fish and Wildlife Service Biological Opinion

In January 2023, Reclamation released a new TOP and associated Drought Plan. In response, on January 13, 2023, the USFWS issued a BiOp on the proposed continued operation of the Project under the 2019 BA and 2020 IOP from January 13, 2023, to September 30, 2023 (Project Code 2022-0020519-S7), concluding that the proposed action is not likely to jeopardize the continued existence of suckers or to result in the destruction or adverse modification of their critical habitat. This 2023 BiOp superseded the BiOp provided by the USFWS on April 1, 2020. However, USFWS anticipated incidental take of suckers and adverse effects to their designated critical habitat, and the BiOp included terms and conditions to minimize the incidental take, including UKL elevations (USFWS, 2023b). No response was needed from NMFS because NMFS had already concluded in its prior letter that the IOP was consistent with its 2019 BiOp, which was still in effect.

Additional information on consultation history can be found in Section 1.5 – Consultation History.

2.3.2 Klamath Basin Adjudication and Water Rights Regulation

In 1975 the State of Oregon began a basin-wide adjudication of pre-1909 state-based water rights and all federal reserved rights to water from the Klamath River and its tributaries in the State of Oregon. The Klamath Basin Adjudication includes hundreds of separate water right claims, including those made by the United States on behalf of the Project, Lower Klamath and Tule Lake NWRs, and the Klamath Tribes.

In 2013 OWRD issued a Findings of Fact and Order of Determination, which has since been amended and corrected (ACFFOD). Under Oregon law, the ACFFOD is subject to judicial review, but is enforceable unless stayed by the court. These proceedings are ongoing in Klamath County Circuit Court and may result in changes to the ACFFOD and the nature of the water rights determined therein.

Enforcement of water rights identified in the ACFFOD since 2013, particularly the instream flow water rights claimed on behalf of the Klamath Tribes, has significantly changed water usage patterns in the Upper Klamath Basin. These water rights vary by stream segment, but have a priority of "time immemorial," making them prior to (i.e., "senior") to all other water rights to water from those sources. The level of enforcement has varied over the course of the year and by stream segment, but frequently, the call on behalf of the Klamath Tribes has curtailed surface water diversions throughout much of the Upper Klamath Basin.

USFWS' temporary water right transfer from the Agency Lake and Barnes Ranch properties is not part of Reclamation's Proposed Action but is instead within the environmental baseline. Collectively, the transferred water right from the Agency Lake and Barnes Ranch properties allows for diversions at the Ady Canal of up to approximately 31 cfs and 11,200 AF in total annually. This transferred water right has a priority date of September 13, 1920, and is potentially subject to water rights regulation in the Upper Klamath Basin based on calls by senior water rights holders, including potentially a call made on behalf of the water rights for the Project.

2.4 Past and Present Human Activity

The environmental baseline includes the past and present impacts of all federal, state, and private actions and other human activities in the Action Area. In addition, the environmental baseline includes 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 that are contemporaneous with the consultation in process, including the past and present impacts of Project operations. These past and present impacts comprised within the environmental baseline are summarized in the sections below.

2.4.1 Water Resource Development

2.4.1.1 Hydrologic Alterations

Water diversion for agriculture began in the Upper Klamath Basin in the 1870s, with small dams along the Lost River and its tributaries. More conventional dams and reservoirs began to be constructed around 1900. There are more than 40 constructed impoundments upstream of Clear Lake Reservoir (USFWS, 2021) and more than a dozen impoundments upstream of Gerber Reservoir. Similar small reservoirs and ponds were constructed on tributaries to UKL, primarily in the Sprague River Basin, beginning around 1910. There are currently 186 water rights of record for use of stored water in the Williamson River watershed, including the Sprague and Sycan rivers and their tributary streams. This section summarizes key hydrologic alterations within the Action Area that affect the environmental baseline.

Dams Dams and dikes have been built throughout the Upper Klamath Basin and have converted hundreds of thousands of acres of marsh and lake habitat for agricultural purposes (including Tule Lake), blocking migration corridors, isolating population segments, and limiting spawning areas.

Diversions Project facilities that divert water from UKL (either stored by LRD or from live flow) and the Klamath River for irrigation purposes are limited to the A Canal and the LRDC. Federal diversion works on the Lost River include Malone, Miller Creek, Lost River, and Anderson-Rose diversion dams and the North and South Poe Valley, Stukel, and Adams pumps. Particularly important to the operation of the Project are diversions of the Lost River to the Klamath River through the LRDC. Private facilities also divert water from UKL and the Lost and Klamath rivers under both Project contracts and state water rights.

Outside the Project, diversions for irrigated agriculture are the most common form of diversions of surface water in the Klamath River Basin. There are approximately 160,000 acres of irrigated land above and around UKL, most in the Williamson and Sprague River basins. Estimated average consumptive use of these diversions in the Upper Klamath Basin is approximately 350,000 AF per year (NRC, 2004). There are approximately 51,600 acres irrigated in the Shasta River watershed. There are an additional 33,000 acres irrigated in the Scott River watershed. The combined estimated consumptive use associated with this agriculture is approximately 170,000 AF per year (Chesney et al., 2009).

There are four trans-basin storage reservoirs in the Klamath River Basin that divert water to the Rogue River Basin: Fourmile Lake, Howard Prairie Lake, Hyatt Reservoir, and Keene Creek Reservoir (this information is summarized from Reclamation, 2012a). Four Mile Dam stores and diverts water that would otherwise flow into UKL, all others provided flows to the Klamath River via Jenny Creek. Keene Creek Reservoir is primarily a regulating reservoir for water from Howard Prairie Lake and Hyatt Reservoir for power generation and irrigation. Reclamation (2012a) estimated that approximately 37,000 AF of water is diverted per year from the Klamath River Basin: Fourmile Lake, 5,000 AF per year; Howard Prairie Lake, 24,000 AF per year; and Hyatt Reservoir, 8,000 AF per year. Howard Prairie Lake and Hyatt Reservoir water historically flowed to

Jenny Creek and entered the Klamath River in the historic Iron Gate impoundment, and a total of 32,000 AF per year is diverted from these sources.

Throughout the year, Reclamation operates the LRDC to divert flow in the Lost River, up to the channel's capacity, to the Klamath River, when needed to avoid flooding in the Tule Lake Primary Sump. The diversion of water from the Lost River to the Klamath River via the LRDC is considered part of the baseline condition, as to operate otherwise would threaten the structural integrity of federal Reclamation facilities. During part of the irrigation season, flows from the Lost River into the LRDC may be rediverted for agricultural use before reaching the Klamath River. During the spring/summer months, some stored UKL water released into the Link and Klamath River is diverted via the LRDC at Station 48 into the Lost River system to meet irrigation needs.

Reservoir and Lake Water Surface Elevation Modification Water levels in UKL, Clear Lake Reservoir, and Gerber Reservoir are managed to meet downstream water needs. When water is released from the reservoirs or evaporates, the water level drops, reducing fish habitat (Buchanan et al., 2011). But when tributary inflow and precipitation exceed water releases and other outflow, lake water levels rise. For suckers, habitat needs vary by life stage. The best available information suggests suckers in Clear Lake exclusively spawn in tributaries. LRS and SNS in UKL spawn in the Williamson River, and one spawning population of LRS spawns at shoreline springs in UKL. Until 2022 when suckers were observed spawning in gravels at boat ramps, suckers in Gerber Reservoir were only known to spawn in tributaries (Reclamation, 2023).

Before Clear Lake Dam was built, the area where its reservoir now stands included both open water and ephemeral wet meadow. Clear Lake Reservoir was created to control the flow of the Lost River to help reclaim Tule Lake, and subsequently to store water for irrigation. Subpopulations of suckers inhabited the Lost River watershed from historical Tule Lake to the location of present-day Clear Lake, including the Lost River. After completion of Clear Lake Dam, some of these suckers may have been confined to Clear Lake. Since the dam was built, water levels within the Clear Lake Reservoir are higher than what historically occurred within the historical footprint. When water levels in the reservoir are above 4,524 feet (Reclamation datum), suckers can access spawning grounds in Willow Creek and other streams. These higher water levels give suckers more habitat in Clear Lake Reservoir and provide better protection from predators. The dam’s outlet structures have fish screens to keep adult and young suckers from being carried downstream, but not larvae.

Gerber Reservoir does not have screens to keep suckers in, so some suckers move downstream into Miller Creek; volitional upstream movement is not possible. Higher water levels in Gerber Reservoir allow SNS to access tributary spawning grounds in Barnes Valley Creek and Ben Hall Creek. At low surface elevations, suckers have been observed spawning at gravels adjacent to boat ramps. It remains unknown if eggs spawned at gravels adjacent to boat ramps develop into larvae or not (Reclamation, 2018).

Groundwater Withdrawals Groundwater is important for fish, wildlife, irrigators, and residents throughout the watershed, but particularly in the Upper Klamath River Basin and in the Scott and Shasta River valleys. Through natural discharges and the addition of pumped water to streams, groundwater provides cool, late summer stream flows to sustain fish at a critical time for spawning and rearing.

Since 2001, the upper basin has experienced greatly increased groundwater pumping, particularly within and near the Project (Gannett et al., 2010, 2012; Gannett and Breen, 2015). This is due, in part, to changes in surface water management and a series of consecutive dryer-than average years (Gannett et al., 2010). These increases in pumping have resulted in groundwater-level (water table) declines of 10 to 15 feet over much of the Project area (Gannett et al., 2010, 2012; Gannett and Breen, 2015). These reductions in water table elevation have likely contributed to reduced groundwater discharge in streams and as springs (Gannett et al., 2010, 2012).

The use of groundwater is under state jurisdiction and subject to state law. While Reclamation has no direct control over these activities, it has funded OWRD to monitor groundwater levels.

Water Quality

Upper Klamath Lake While UKL was historically eutrophic (Sanville et al., 1974; Johnson et al., 1985), large-scale watershed development from the late-1800s through the 1900s has likely contributed to the current hypereutrophic condition in UKL (Bortleson and Fretwell, 1993). This legacy, combined with current nutrient loading from the watershed and lake sediment, facilitates extensive cyanobacteria blooms (Boyd et al., 2002) that typically result in large diel fluctuations in dissolved oxygen (DO) and pH, high concentrations of the hepatotoxin microcystin, and toxic levels of un-ionized ammonia during bloom decomposition (Boyd et al., 2002; Walker et al., 2012). Together, these conditions create a suboptimal environment for native aquatic biota.

Phosphorus, which naturally occurs in relatively high levels in the Upper Klamath Basin, is the key driver of water quality issues in UKL (Boyd et al., 2002; Walker et al., 2012). Anthropogenic sources of phosphorous from past and current land use activities in the watershed have contributed to additional UKL loading that is approximately 40% higher than the natural background (Walker et al., 2012, 2015). Plus, the intact riparian areas and lake-fringe wetlands that historically filtered and retained phosphorus have been diminished, exacerbating phosphorus loading. These factors result in summer water phosphorus concentrations up to six times higher than the natural background (reviewed in NRC, 2004).

Understanding phosphorus loading and concentrations is critical to disrupt the processes linked to large cyanobacteria blooms during the growing season (Boyd et al., 2002). Of specific concern is the cyanobacteria species *Aphanizomenon flos-aquae* (AFA, a nitrogen-fixing cyanobacteria that dominates the UKL phytoplankton community during the growing season and exhibits large bloom cycles [Nielsen et al., 2018]). During bloom development and proliferation, AFA photosynthesis facilitates an increase in pH (Jassby and Kann, 2010; Nielsen et al., 2018). Later in the summer, these AFA blooms "crash", and their decomposition reduces DO and may increase ammonia concentrations. In addition to changes in these water quality parameters, AFA bloomcrashes increase the amount of available nitrogen for uptake by other phytoplankton, primarily the toxin-producing cyanobacteria *Microcystis aeruginosa* (Jassby and Kann, 2010).

The best available science regarding water quality for the purposes of ESA Section 7 consultations has not demonstrated a direct, consistent, and discernible relationship between UKL elevation and water quality (e.g., Wood et al., 1996; NRC, 2002; Krause et al., 2022). Specifically, NRC (2002) did not find a relationship between UKL elevation and AFA density (represented by chlorophyll-a concentrations) and found no support for the hypothesis that maintaining higher UKL elevations would effectively dilute internal phosphorus loading and reduce algal density.

Keno Impoundment UKL is considered the greatest source of nutrients and generates the highest biochemical oxygen demand (BOD) in the Klamath River during the irrigation season via export of substantial AFA biomass (NRC, 2004; ODEQ, 2017; Schenk et al., 2018). Decomposition of senescing AFA in the Keno Impoundment regularly leads to suboptimal DO concentrations and pH, which persist through the growing season (ODEQ, 2017). Additionally, the shallow channel morphology in this reach facilitates water temperatures that typically exceed 25°C during summer months (ODEQ, 2017). While AFA blooms are often observed in the Keno Impoundment, algae concentration rapidly decreases within this reach (ODEQ, 2017), suggesting that these blooms are typically less intense and more spatially and temporally variable than those observed in UKL (Reclamation, 2007).

During the irrigation season, evidence suggests that discharge from the LRDC can have a substantial negative impact on DO concentrations at Miller Island in the Keno Impoundment, though the magnitude and duration of the effect is less than that resulting from releases from UKL (ODEQ, 2017) and is highly dependent on Project operations. Also during this period, very little water from the Project and Lost River watershed flows to the Klamath River. The Project has been characterized as a nutrient sink, rather than source (ODEQ, 2017; Schenk et al., 2018), given that only 30% of the flow entering the Project is returned to the Klamath River (ODEQ, 2017).

Outside of the irrigation season, water quality in the Keno Impoundment improves, in part due to reduced biomass exported from UKL, lower water temperatures, and increased DO concentrations (ODEQ, 2017). During this period, the LRDC, which drains the Lost River watershed when needed for flood control purposes and the Project, flows towards the Klamath River. This contributes some nutrient and BOD load to the Klamath River (Schenk et al., 2018). However, this additional load tends to be relatively small compared to the total load from UKL (Schenk et al., 2018).

Clear Lake Reservoir Clear Lake Dam stores water from Willow Creek and a series of smaller, seasonal tributaries within Clear Lake Reservoir, reducing flow into the reclaimed portion of Tule Lake (Gannett et al., 2010; Reclamation, 2020a; Stene, 1994). Outflow from Clear Lake Reservoir forms the origin of the Lost River (Gannett et al., 2010). There are more than 30 constructed impoundments upstream of Clear Lake Reservoir. The amount of water impounded by these diversions in the upper Clear Lake watershed is unclear, and the extent that these impoundments are impacting flows in tributaries and lake elevations is not understood. The extent that these diversions reduce tributary flows and lake elevations has not been directly studied.

When Clear Lake Reservoir water levels are lowered, water quality may become degraded, as temperatures increase and DO concentrations are reduced. DO concentrations under ice cover remain above 8 mg/L (Reclamation unpublished), which is a level that will support fish growth and reproduction (Geist et al., 2006; Morace, 2007; Cross et al., 2017). There are few large-scale impacts outside of cattle grazing and road infrastructure in the Clear Lake Reservoir drainage that also likely influence water quality.

Gerber Reservoir Generally, water quality is better in Gerber Reservoir than in other large reservoirs in the Upper Klamath Basin (Phillips and Ross, 2012). During summer and early fall, weak stratification of the water column develops occasionally in Gerber Reservoir particularly at sites near the outlet where depth is greatest (Piaskowski and Buettner, 2003). When the reservoir is stratified, DO concentrations of less than 4 mg/L were observed at depths generally greater than 4 meters. This stratified condition and associated hypoxia typically persist for less than a month, over a small portion of the reservoir near the dam (Piaskowski and Buettner, 2003).

Tule Lake Tule Lake is classified as highly eutrophic because of high nutrient concentrations and resultant elevated biological productivity (ODEQ, 2017). Tule Lake water quality is affected primarily by the import of UKL surface water through the LRDC and A Canal during the irrigation season and, secondarily, by Lost River runoff during winter and spring months. Shallow bathymetry and internal nutrient cycling from lake sediment also contribute to Tule Lake's eutrophic status. Water quality in Tule Lake can vary seasonally and diurnally, especially in summer. Water quality in the sumps is similar to UKL with large diurnal fluctuations in DO concentrations and pH (Buettner, 2000; Hicks et al., 2000; Beckstrand et al., 2001), largely due to high levels of aquatic macrophyte and green algal biomass during the growing season.

Drought conditions in water years 2020-2022 resulted in Tule Lake going dry (USFWS, 2023b). When poor hydrology in water year 2021 resulted in no surface water deliveries from UKL for irrigation, Reclamation announced that surface elevations in Tule Lake Sump 1A would fall below 4034.0 ft, the minimum surface elevation described in USFWS's 2020 BiOp (USFWS, 2020a). Following Reclamation's announcement, the USFWS NWR requested to drain Tule Lake Sump 1A to conduct beneficial restoration activities that could only occur during extreme drought conditions. Sump 1A was completely dry by fall in 2021. Drought continued in water year 2022 and Tule Lake Sump 1B went dry. Tule Lake Sump 1B was largely refilled during the winter of 2022-2023, and Sump 1A was largely refilled during the winter of 2023-2024, and water level management has returned to historical practices. While important as a water conveyance facility for Project use, it is also possible that USFWS may wish to re-establish redundant sucker populations in this water body (USFWS, 2023b).

Lost River Local geology suggests that the Lost River was historically eutrophic (ODEQ, 2017). However, as with the basin above UKL, largescale changes in land use in the early 1900s and manipulations of the river channel and associated waterbodies throughout the twentieth century have contributed to hypereutrophic conditions in the Lost River. Nutrient loading, which is greatest in the middle and lower portions of the Lost River watershed (Schenk et al., 2018), contributes to algal growth. Subsequent senescence of these algal populations facilitates a cycle of high pH and suboptimal or lethal DO and toxic ammonia concentrations (ODEQ, 2017).

Extremely low DO concentrations have been measured in Wilson Reservoir, Harpold Reservoir, and at Anderson Rose Dam in the Lost River (Reclamation, 2009). While DO concentrations can periodically reach stressful conditions throughout the Lost River, its middle reach appears to be the most impaired (Reclamation, 2012b). ODEQ (2017) notes that a reduction in nitrogen loading may improve water quality. The Oregon portion of the Lost River (including KSD) is listed as water quality impaired by Oregon under Section 303(d) of the Clean Water Act due to DO and chlorophyll-a concentrations and pH and ammonia toxicity (Kirk et al., 2010).

Klamath River Klamath River water quality is influenced by Upper Klamath Basin water quality conditions in the upper reaches, past and present land use practices, variations in hydrologic conditions (including tributaries to the Klamath River), and Project operations and changes downstream as tributaries enter the river. The Klamath River originates in shallow, naturally eutrophic UKL, which delivers substantial biomass, nutrients, and thermal load to the Klamath River (NCRWQCB, 2010). As the river nears the Pacific Ocean, it becomes generally less eutrophic due to increased stream gradient and tributary inputs of cooler, less eutrophic water (NCRWQCB, 2010). Due to tributary accretions, by the time it reaches the Pacific Ocean, only a small portion of the Klamath River's volume originates in the Upper Klamath Basin. The effects of the interaction of these water quality parameters (e.g., confounding effects) on Coho Salmon are not well documented in the lower Klamath Basin.

Portions of the Klamath River are listed as impaired under Section 303(d) of the Clean Water Act due to microcystin, elevated nutrients, organic enrichment/low DO concentration, sedimentation/siltation, and/or elevated water temperature (NCRWQCB, 2010). Given the water quality dynamics in the Upper Klamath Basin above the California/Oregon state line, the two states have coordinated Klamath River and UKL Drainage Total Maximum Daily Loads (TMDLs) to ensure they are complimentary (NCRWQCB, 2010). The sources of these pollutants primarily originate within Oregon but also enter the Klamath River from tributaries (NCRWQCB, 2010), while historically pollutants also came from the PacifiCorp hydropower facilities and the Iron Gate Hatchery both of which will have been removed by the time of implementation of this Proposed Action. The water quality parameters (or pollutants) of concern in the Klamath River in California include water temperature, DO, carbonaceous biological oxygen demand, total phosphorus, total nitrogen, and microcystin (NCRWQCB, 2010).

The Klamath River Renewal Corporation (Renewal Corporation) is in the process of removing facilities at Iron Gate Hatchery and transferring hatchery operations to the Fall Creek Hatchery (NMFS, 2021a). Production targets at the renovated Fall Creek Hatchery will be similar to previous targets developed for Coho Salmon at Iron Gate Hatchery but reduced for Chinook Salmon and eliminated for steelhead (NMFS, 2021a). Consequently, this hatchery-associated pollutant input will change locations and be reduced in load.

In the following sections, anticipated water quality conditions within the Klamath River following removal of the Lower Klamath Project developments are presented. In accordance with the approach presented in the Renewal Corporation's Biological Assessment (Renewal Corporation, 2021) and NMFS's associated BiOp (NMFS, 2021a), short-term effects that are anticipated during the 2 years following dam removal are distinguished from long-term effects that are expected to last more than 2 years.

Fine Sediment In the 2 years during and after dam removal, suspended sediment concentration (SSC) will be elevated in the reach below the former site of IGD (Renewal Corporation, 2021; NMFS, 2021a). Lower Klamath Project dam removal is anticipated to release 1.2 to 2.9 million metric tons of fine sediment that was previously stored in the reservoirs into the Klamath River downstream of IGD, resulting in higher SSCs than normally occur under background conditions (Renewal Corporation, 2021).

From the beginning of drawdown through October 2025, SSCs will begin to increase during reservoir drawdown, prior to the deconstruction of the dams, and continue to rise through the spring runoff period as material behind the dams is mobilized downstream (Renewal Corporation, 2021). The Renewal Corporation expects SSCs to exceed 1,000 mg/L for approximately 8 weeks in early 2024, with the potential for peak concentrations exceeding 5,000 mg/L for several days to up to 2 weeks (Renewal Corporation, 2021). This is expected to result in lethal and sublethal effects on Coho and Chinook salmon and other native fish species inhabiting the Klamath River in the hydroelectric reach and downstream of IGD (Renewal Corporation, 2021).

Coarse Sediment and Bedload Deposition Modeling conducted by the Renewal Corporation predicts that reservoir sediments will coarsen over the 2 years following dam removal, as flows transport and sort fine sediments, and the Klamath River channel erodes to its historical pre-dam elevation (Renewal Corporation, 2021). Two sediment "wedges" are anticipated to aggrade the Klamath River channel near the IGD footprint, potentially affecting channel morphology, including inducing braiding and filling pools (Renewal Corporation, 2021). This pulse of coarse sediment may also scour or bury existing salmon redds and impact upstream passage, including by temporarily blocking tributary access, particularly to Bogus Creek (Renewal Corporation, 2021). Over the long-term (5 to 50 years), this wedge of coarse sediment is expected to disperse, resulting in re-equilibration of the bed elevation as large-scale aggradation occurs (Renewal Corporation, 2021).

Temperature Water temperature can be affected by a variety of factors. Historically, water temperatures immediately downstream of the former IGD site have been the lowest, with a steep upward trend downstream to Seiad Valley and Happy Camp, and then a gradual decreasing trend downstream to the mouth (Asarian and Kann, 2013). The highest annual maximum daily water temperatures were recorded between 2001 and 2011, 28 to 29°C, at Happy Camp, CA (Asarian and Kann, 2013). Temperatures in the mainstem Klamath River are also substantially affected by the Scott River and minimally by the Shasta River (NRC, 2004). While air temperature generally drives water temperature in the Klamath River, the large thermal mass associated with water stored in Project reservoirs (including UKL) seasonally affects

Klamath River water temperatures. The magnitude of the temperature effect of stored water releases depends on three principal factors: (1) the temperature of the water as it is released from the impoundments; (2) the volume of the release; and (3) the meteorological conditions (e.g., ambient air temperature).

Over the next coming years, Lower Klamath Project dam removal is predicted to result in a 2 to 10°C decrease in water temperatures during the late summer and fall months (Renewal Corporation, 2021), a small increase in water temperatures during spring and early summer months, and greater diel variation in temperature overall (NMFS, 2021a). Dam removal effects on flow and sediments may result in the creation of pockets of cooler water in summer and warmer water in winter that could be used as temperature refugia by Coho Salmon in both seasons (Renewal Corporation, 2021).

Nutrients Elevated nutrient levels can stimulate excess primary productivity, which alters pH, depresses DO concentrations, and can lead to harmful concentrations of cyanotoxins, all of which can adversely affect aquatic organisms. Each of these factors indirectly affect fish, including Coho Salmon and Chinook Salmon. Generally, nutrient concentrations are highest at Keno Dam and decrease longitudinally with increasing distance downstream (Asarian et al., 2010). Due to tributary dilution and nutrient sequestration in the river and reservoirs, the Klamath River is considered a nutrient sink from June to October. More specifically, Asarian and Kann (2011) found that phosphorus and nitrogen concentrations and loads decreased substantially between Keno Dam and Turwar (near the mouth of the river) annually during this period.

Dissolved Oxygen Historically, the lowest DO levels in the Klamath Basin have been observed in summer and early fall in the reaches above the former Copco Reservoir #1 (Reclamation, 2012a; PacifiCorp, 2018). These conditions are largely influenced by algal blooms in UKL that provide an influx of organic matter (PacifiCorp, 2018) and the effect of UKL algal dynamics appears to attenuate further downstream. Historically, DO concentrations in the Klamath River below the former site of IGD exceeded minimum DO requirements for salmonids and other coldwater species (Asarian and Kann, 2013; PacifiCorp, 2018).

Increased SSC resulting from Lower Klamath Project dam removal are predicted to acutely reduce DO concentrations downstream of IGD over the short-term: during reservoir drawdown (mid-January 2024) and during the breach of the Copco No. 1 historical cofferdam (mid-June 2024) (Renewal Corporation, 2021). Under the median impact year modeled by the Renewal Corporation (2021), the two peak SSC events in mid-January and mid-June 2024 would result in DO levels less than 5 mg/L.

Over the long-term, DO downstream of the former site of IGD is predicted to increase as a result of dam removal, due to reduced algal blooms in the vicinity of the former Lower Klamath Project reservoirs (NMFS, 2021a).

pH Generally, pH in the Klamath River below the former IGD site has historically been lower (more acidic) than that observed in UKL, the Keno Impoundment, and the former Lower

Klamath Project reservoirs (Asarian and Kann, 2013). The highest pH levels have historically been observed from July to September, between the former site of IGD and river mile (RM) 90, which is between Orleans and Seiad Valley (Asarian and Kann, 2013). Ammonia toxicity can also be a concern in the Klamath River, where and when high nutrient concentrations coincide with elevated pH and water temperature.

Improved water quality is predicted to occur as a result of the removal of the four Lower Klamath Project dams, including more neutral pH as a result of reduced algal blooms in the area of the former Lower Klamath Project reservoirs (NMFS, 2021a).

Aquatic Plants and Algae Daily cycles of DO and pH within the Klamath River are largely driven by photosynthesis and respiration by periphyton and macrophytes, in response diel cycles of light and water temperature (NCRWQCB, 2010; Renewal Corporation, 2021). High flows appear to limit periphyton and macrophyte biomass by dislodging or disrupting this aquatic vegetation (Asarian and Kann, 2013; Asarian et al., 2015). Also, as flow increases, these organisms have less effect on DO concentrations because their oxygen production (photosynthesis) and consumption (respiration) are "diluted" by the increased water volume. Conversely, when flow is low, the ratio between the bed surface area and the water volume is higher, and periphyton effects on DO concentrations are greater.

In addition to periphyton and macrophytes in the mainstem Klamath River, the cyanobacteria *Microcystis aeruginosa* and AFA influence water quality in the Klamath system; historically, this has been particularly true within in the Lower Klamath Project reservoirs and immediately downstream of IGD (Asarian and Kann, 2011, 2013; PacifiCorp, 2018). *M. aeruginosa* produces the hepatotoxin microcystin, which can sometimes reach substantial concentrations in the reservoirs and the Klamath River (NCRWQCB, 2010). Historically, biomass of both cyanobacteria species increased through Lower Klamath Project reservoirs, peaking below IGD (Asarian and Kann, 2011). Removal of these Lower Klamath Project dams is predicted to reduce habitat for these algae, resulting in fewer and less substantial algal blooms (NMFS, 2021a).

Contaminants Reclamation, in coordination with various partners, is responsible for the identification and management of pests and invasive species on Reclamation lands and waters at Reclamation-owned facilities (reserved works and transferred works canals, laterals, drains, pumps, and office/shop areas within the boundaries of the Project) in accordance with applicable laws and regulations, and oversees the development and implementation of Integrated Pest Management Plans outlining various tools and methodologies, including pesticide use, to accomplish this. Pesticide use for agricultural purposes, as analyzed by the USFWS in the February 9, 1995 BiOp (USFWS, 1995) related to pesticide and fertilizer use on federal lease lands and Project rights-of-way, is estimated to occur on up to 60% of lands within the Project. Pesticide use is also common in urban areas (e.g., Klamath Falls, Merrill, Malin, Tulelake), and Klamath County operates a vector control program that involves pesticide application to waterbodies, including drains within the Project. These pesticides volatilize, degrade, settle to the bottom with sediment, or remain in the water column where they are diluted (USFWS, 2007c). Pesticide residues in drainage water may also be discharged into the

Keno Impoundment via discharges the KSD. This reach also receives drainage from neighboring non-project areas such as Keno Irrigation District and private lands.

Since the late 1980s, pesticides consistently have been detected in the Tule Lake Sumps, but generally at low levels not known to be acutely toxic to aquatic life (Sorenson and Schwarzbach, 1991; Dileanis et al., 1996; Eagles-Smith and Johnson, 2012). In 2011, however, Reclamation detected bifenthrin and prodiamine (Reclamation, unpublished data). The concentration of bifenthrin measured in 2011 could adversely impact aquatic life (APVMA, 2010; Syngenta Crop Production Inc., 2015). Studies on pesticide use on the leased lands within the Tule Lake NWR concluded that pesticide use does not likely pose a threat to LRS and SNS in the Tule Lake Sumps when label directions are followed and when appropriate buffers are in place (USFWS, 2007c).

DaSilva (2016) monitored for 34 active pesticide ingredients at multiple sites around Tule Lake, including within Tule Lake NWR. Two herbicides (2,4-D and dicamba) were detected in multiple locations, but neither exceeded the aquatic life benchmark values for fish (DaSilva, 2016).

Between 1998 and 2000, several wildlife mortalities and fish die-offs were documented and investigated on Tule Lake NWR, but with the exception of one incident in which off-refuge use of acrolein caused a fish die-off, there was little supporting evidence that implicated pesticides as causative agents in any of the mortality events (Snyder-Conn & Hawkes, 2004). However, the results of the study did reveal some evidence of trace wildlife exposure to the herbicides dicamba and 2,4-D and a few cases of limited acetylcholinesterase inhibition in birds, suggesting potential low-level exposure to organophosphate or carbamate insecticides (Eagles-Smith & Johnson, 2012; Snyder-Conn & Hawkes, 2004). Additionally, some pesticides and herbicides in use within the Klamath Basin can be toxic at low concentrations (Eagles-Smith & Johnson, 2012). While some products are listed as toxic, the actual risk of these products is a function of exposure or the amount released into the environment.

While most of the sampling to date in Tule Lake suggests pesticides may not be present in concentrations that would adversely affect suckers, a lack of detection of toxic pesticides does not necessarily mean they do not exist in the environment (Eagles-Smith & Johnson, 2012; USFWS, 2007c). Highly toxic pesticides, like metam-sodium (Vapam), can harm fish at low concentrations and may escape detection during surveys. Many newer pesticides are difficult to monitor due breaking down in the environment rapidly (USFWS, 2007c). Reclamation (2011, Unpublished Data) collected bimonthly water samples from the Tule Lake Sumps during Vapam application period and did not detect this pesticide.

Within the hydroelectric reach and downstream of the former site of IGD in the Klamath River, reservoir drawdown and Lower Klamath Project dam removal will mobilize contaminants previously trapped behind the four dam facilities, resulting in low level exposure to contaminated sediments over both the short-term and long-term (NMFS, 2021a). Effects of contaminants in sediments released during dam removal activities are anticipated to be negligible due to the very low levels of contaminants in the reservoir sediments, low bioaccumulation potential, and the dilution effects of the river and ocean (NMFS, 2021a).

2.4.1.2 Morphological Processes

Historical land use practices, including timber harvesting, mining, and agriculture, have altered sediment transport in the Klamath River Basin. Currently, both natural and anthropogenic processes limit transportation of fine sediment to the Klamath River above Keno Dam. Historically, UKL acted as a sink, trapping fine sediment from tributary inflows before entering the Klamath River. Downstream on the Klamath River, Keno Dam (and, historically, the four Lower Klamath Project dams that were removed in 2023 to 2024) interrupts the movement of fine sediment from the upper basin. Additionally, dam-induced changes to the hydrograph historically have altered riparian vegetation and reduced instream mobilization of coarse sediment downstream, leading to armoring and colmation of the riverbed and decreasing the quality of habitats, including spawning habitats. Much of this is expected to change as the lower river equilibrates following removal of the Lower Klamath Project dams (Renewal Corporation, 2021).

During and immediately after the process of Lower Klamath Project dam removal (Section 2.5.2), as the Klamath River returns to riverine conditions within the formerly impounded hydroelectric reach (between the former site of IGD and Keno Dam), an estimated 5.3 to 8.6 million cubic yards of reservoir sediment would be eroded downstream (Interior et al., 2016). Most of this erosion would occur during reservoir drawdown and would be dominated by processes of scouring a new river channel and slumping of the fine sediment into this newly formed channel (Interior et al., 2016).

Effects of dam removal on SSC within the Klamath River are predicted to be relatively short-lived and to decrease with distance downstream (Interior et al., 2016; Renewal Corporation, 2021). Nonetheless, the short-term impact of dam removal is predicted to include two or more months during which SSC within the reach immediately downstream of the former IGD site may increase by more than 1,000-fold over the background conditions (Interior et al., 2016; Renewal Corporation, 2021).

The mobilization of previously impounded sediment may also create fish passage barriers along some Klamath River tributaries in the vicinity of the former Lower Klamath Project reservoirs (Renewal Corporation, 2021). In such cases, the Renewal Corporation plans to restore passage using light equipment and manual labor to move materials within impacted tributaries (Renewal Corporation, 2021).

Following post-dam removal normalization, the tributaries downstream of Keno Dam will again be the primary sources of sediment for the Klamath River and it is predicted that the river system will return to more natural sediment functions (Renewal Corporation, 2021).

2.4.2 Historical Habitat Alteration

Historically, the Upper Klamath Basin contained approximately 185,000 acres of shallow lakes and fringe wetland areas (USFWS, 2016). Since the 1880s, approximately 75% of the historical wetland habitat in the Upper Klamath Basin has been lost, primarily through levees and draining for agricultural use. Human settlement occurred throughout the 6,805-square-mile region, primarily in the first half of the twentieth century, as lands were reclaimed and converted to agriculture (U.S. Census Bureau, 1950). Levees were built to drain land for agriculture and settlement, streams were dammed and diverted or alternatively, straightened and widened, and lakes and rivers were dredged for navigation purposes.

2.4.2.1 Disconnected Waterbodies, Floodplains, and Drained Wetland

Prior to European settlement, the land along the Klamath and Lost rivers was subject to seasonal flooding. In its pre-settlement state, the Klamath River would seasonally overflow and drain through the Lost River slough and then into Tule Lake by way of the Lost River, as well as through the Klamath Straits and then into Lower Klamath Lake. Tule Lake was approximately 96,000 acres and Lower Klamath Lake was approximately 89,000 acres, which included open water and marshes. UKL's shorelines were also dominated by shallow waters and natural wetlands. As floodwaters receded in the spring, the land would be exposed and would produce natural hay and wild grasses suitable for cattle feed.

European settlers arrived in the 1850s and began settling lands and grazing cattle in the area shortly thereafter. The construction of levees along the river likely started at this time to control seasonal flooding of the land. After 1870, individuals began to claim and settle these lands under Oregon's various Swamp Land Acts. The reclaimed lands were generally seasonally flooded marshes bordering the lake. The historical setting and project construction history are described in detail in numerous Reclamation documents (e.g., Stene, 1994) and summarized here.

Following flooding that occurred in the spring of 1890, people from the Klamath Basin and Tule Lake built a mile-long dike along the east bank of the Klamath River, to stop the flow of the Klamath River into Tule Lake via the Lost River Slough. This act marked the beginning of efforts to drain and reclaim Tule Lake. Tule Lake had historically fluctuated in size (±96,000 acres) and was 25 feet at its deepest when Congress authorized the Klamath Project in 1905. Today, only approximately 14,000 acres of Tule Lake remain, in the form of a diked sump (Tule Lake Primary Sump). The remainder of the original lakebed has been reclaimed over the past century, including approximately 43,000 acres of homesteaded farms. The Tule Lake NWR has approximately 17,000 acres of the reclaimed area within refuge boundaries that is managed by USFWS for the primary purpose of waterfowl conservation.

Diking around UKL and Agency Lake began around 1890, and shortly thereafter diking efforts around the mouth of the Wood River and elsewhere led to the draining of approximately 27,000 acres of former marshes. On the northeast end of UKL, along the Williamson River delta, approximately 23 miles of dikes were constructed to protect the Klamath Indian Reservation from the effects of storage operations in UKL. In the late 1880s, a dike was constructed across what was called Little Wocus Marsh, isolating approximately 500 acres of historical wetlands. A crude dike was constructed to prevent the 4,150-acre Wocus Marsh from flooding, and drainage channels were also constructed as part of what was called the Wocus Reclamation and Irrigation Project. Dikes were constructed from the Skillet Handle to the head of Howard Bay, to reclaim Caledonia Marsh. Other areas around UKL were also diked for timber purposes, to create log holding ponds and protect mills (e.g., Lamm Lumber Company at Modoc Point). Between 1909 and 1913, the Southern Pacific Railroad also built an embankment north of Klamath Falls, along the eastern shore of UKL, which allowed reclamation of additional areas at Algoma and Shady Pine.

Lower Klamath Lake and its wetlands were impacted by diking, drainage ditches, and land conversion for agricultural uses. In its natural condition before being altered, Lower Klamath Lake was approximately 29,000 acres in size, surrounded by an additional 59,000 acres of marshes, and connected to the Klamath River via a narrow channel called the Klamath Straits. Water would flow from the Klamath River through the Klamath Straits into Lower Klamath Lake. Today, Lower Klamath Lake no longer exists due to the numerous alterations to the landscape.

Alterations to the natural flow began on the east side of the Klamath River, 5 miles east of Keno, when the Southern Pacific Railroad and California Northeastern Railway Company began constructing an embankment across the Klamath Straits. Southern Pacific Railroad constructed the embankment between 1907 and 1909, but initially a trestle bridge spanned the Klamath Straits, allowing water to continue to flow between the Klamath River and Lower Klamath Lake. In 1912, Reclamation authorized the railroad to fill in the channel and complete the embankment. At that point, all flow from the Klamath River to Lower Klamath Lake went through a concrete structure the railroad had built in the embankment at Reclamation’s instruction. What was previously Lower Klamath Lake’s bed now comprises an array of croplands fed by a system of canals, accessed via a network of roads. USFWS has constructed diked units on the former lakebed, which are permanently or seasonally flooded and, in some cases, farmed for waterfowl conservation purposes.

2.4.2.2 Fish Access

Anadromous salmonids have been prevented from accessing historical habitat in UKL tributaries, particularly in the Wood and Williamson and Sprague River basins (Figure 2-2). Volitional reintroduction of these species following lower Klamath River dam removals may allow anadromous salmonids to re-populate their historical habitats. The current baseline status of these habitats is discussed in detail in Section 4.8.1 of the Lower Klamath Project Biological Assessment (Renewal Corporation, 2021).

Source: Figure 3 in CDFW (2021)

Figure 2-2. Upper Klamath River Basin streams opened to anadromy following removal of the four mainstem Klamath River Hydroelectric dams

2.4.2.3 Land Use: Timber Production, Fire Suppression, and Livestock Grazing

Terrestrial habitat conditions within the Klamath River Basin have been affected by timber harvesting, fire suppression, mining, and associated road development since 1900. Timber harvesting in the Klamath Basin began in the early 1900s, increased during the 1950s, and peaked in the late 1970s and early 1980s (USFS, 1994). Historical fire suppression has also resulted in the accumulation of downed woody material and other organic debris in forested stands (USFS, 1994). These factors, along with livestock grazing, have contributed to a substantial change in vegetation patterns in the watershed (Hessburg et al., 1999).

Log storage still occurs in the Klamath River near Klamath Falls. These mills are point sources for discharges into the Klamath River, and in-water log storing operations further contribute to poor water quality. Soluble organic matter leaches from logs floating in water, and the bark that falls off the logs forms benthic deposits that can reduce oxygen levels in the water.

Mining activities within the Klamath River began prior to 1900. Most of the river and creek bottoms downstream of Hornbrook were placer mined from valley wall to valley wall. This activity, and its scale, altered channel morphology by piling gravel into tailing deposits. The negative impacts of stream sedimentation on fish abundance were documented in the 1930s. Mining operations adversely affect spawning grounds through increased recruit of fine sediment, decreased mobilizing of coarse substrates, reduced prey abundance, and impacts to river channels. Stricter environmental regulations since the 1970s have eliminated large-scale mining operations in the river. In 2009, California suspended all instream suction dredge mining in the rivers (NMFS, 2019).

2.4.3 Biological Alterations

2.4.3.1 Harvest

The following excerpt from USFWS' 2023 BiOp (USFWS, 2023b) succinctly describes the past and present harvest of LRS and SNS:

Migrating suckers were a historically important food source for the Klamath Tribes and were harvested in large numbers during the spring months (Bendire 1889 p. 444, Evermann and Meek 1897 p. 60). Settlers of European descent also utilized sucker migrations as a source of food and fish oil, including some commercial harvest. Historical accounts of sucker harvest from the late 19th century describe a large fishery on the Lost River for fish migrating upstream from Tule Lake (Bendire 1889 p. 444, Gilbert 1897 p. 6). The construction of dams on the Lost River and the draining of Tule Lake for agricultural purposes eliminated this fishery. However, a large recreational fishery for suckers developed in the Williamson and Sprague Rivers. In 1967, the Klamath Falls fisheries agent for the Oregon Fish and Game Commission was quoted in the newspaper as stating, "we've estimated that about 100,000 pounds-that's 50 tons-of mullet [suckers] were snagged out of the two rivers in a three-week period" (Cornacchia 1967, entire). This snag fishery, which targeted primarily LRS but included SNS (Bienz and Ziller 1987 p. X), existed in the Williamson and Sprague Rivers up to 1987 when the Oregon Fish and Game Commission outlawed harvest of both species. Until 1987, fishing pressure during the spawning migration likely contributed to population declines in Lost River and SNS in the Williamson and Sprague Rivers, but the magnitude of the effect is difficult to discern due to a lack of data on population sizes and harvest quantities during most of the 20th century. At present, some Lost River and SNS are inadvertently captured while anglers target other species in UKL; however, the numbers are likely small, and anglers are required by law to immediately release the fish.

The following excerpt from NMFS' 2019 BiOp (NMFS, 2019) succinctly describes the past and present harvest of Coho Salmon:

Coho salmon have been harvested in the past in both coho- and Chinook-directed ocean fisheries off the coasts of California and Oregon. However, stringent management measures, which began to be introduced in the late 1980s, reduced coho salmon harvest substantially. The prohibition of coho salmon retention in commercial and sport fisheries in all California waters began in 1994 (NMFS 2014a). With the exception of some tribal harvest by the Yurok and Hoopa Valley for subsistence and ceremonial purposes, the retention of coho salmon is prohibited in all California river fisheries. Tribal fishing for coho salmon within the Yurok tribe's reservation on the lower Klamath River has been monitored since 1992. The median Yurok harvest from the entire area from 1994 to 2012 was 345 coho salmon, which approximates an average annual maximum harvest of 3.1 percent of the total run (NMFS 2014a). The recent Yurok Tribe Fall Harvest Management Plan (Yurok Tribe 2018b) includes weekly fishing closures intended to protect coho *salmon from harvest. The majority of coho salmon captured by Hoopa Valley tribal fisheries are Trinity River Hatchery origin fish (Orcutt 2015). With regards to ocean fisheries, in 1995, ocean recreational fishing for coho salmon was closed from Cape Falcon in Oregon to the United States/Mexico border. ln order to comply with the SONCC coho salmon ESU conservation objective, projected incidental mortality rates on Rogue/Klamath River hatchery coho salmon stocks are calculated during the preseason planning process using the coho salmon Fishery Regulation Assessment Model (Kope 2005). Specifically, the Pacific Fishery Management Council applies a SONCC coho salmon ESU consultation standard requirement of no greater than a 13.0 percent marine exploitation rate on Rogue/Klamath hatchery coho salmon, which applies to incidental mortality in the Chinook salmon ocean fisheries from Cape Falcon in Canada to the United States/Mexico border (PFMC 2018). ln summary, while major steps have been taken to limit effects of harvest on SONCC coho salmon, the population is still impacted by incidental mortality associated with various Chinook salmon fisheries, and by subsistence and ceremonial tribal fisheries.*

A recent summary of SONCC Coho harvest in the Klamath, provided by the California Department of Fish and Wildlife (CDFW) at the June 2020 SONCC Ad Hoc Workgroup meeting, included the following summary of SONCC Coho harvest (CDFW, 2020):

Based on full sport fishing closures on Coho salmon in 1996, contemporary fisheries harvest monitoring and management is focused primarily on collecting data on Coho harvest that occurs mistakenly by unknowledgeable anglers (due to mis-identification of species or lack of regulatory knowledge).

2.4.3.2 Predation

Several species of native and non-native fishes prey upon larval and juvenile SNS and LRS, including the following (Koch et al., 1975; Logan and Markle, 1993):

- Native fish predators
    - Redband Trout (*Oncorhynchus mykiss newberrii*)
    - Blue Chub (*Gila coerulea*)
    - Tui Chub (*Gila bicolor*)
- Non-native fish predators
    - Fathead Minnow (*Pimephales promelas*)
    - Yellow Perch (*Perca flavescens*)
    - Bullheads (*Ameiurus species*)
    - Largemouth Bass (*Micropterus salmoides*)
    - Crappie (*Pomoxis species*)
    - Green Sunfish (*Lepomis cyanellus*)

- Pumpkinseed (*Lepomis gibbosus*)
- Sacramento Perch (*Archoplites interruptus*)

In addition to preying upon suckers, some of these species may also compete with them for food or space (Markle and Dunsmoor, 2007).

Birds also prey on endangered suckers in the Upper Klamath Basin including:

- American White pelicans (*Pelecanus erythrorhynchos*)
- Double-Crested Cormorants (*Phalacrocorax auritus*)
- Gulls (*Larus sp.*)
- Herons (*Ardea sp.*)
- Caspian Terns (*Hydroprogne caspia*)

Adult and juvenile Coho and Chinook salmon are preyed upon by piscivorous fish, avian predators, pinnipeds (seals, sea lions), and other mammals. A study estimated that 223 adult Coho Salmon were eaten by pinnipeds in the Klamath River estuary between August and November 1997. One study (Nickelson, 2003) surmised that concentrated hatchery releases from Iron Gate Hatchery may increase predation rates of juvenile Coho Salmon by piscivorous fish (e.g., steelhead). The extent to which predation has a measurable effect on Coho or Chinook salmon in the Action Area is unknown.

2.4.3.3 Fish Parasites and Disease

Suckers Degraded water quality conditions may compromise fish health and increase their susceptibility to disease and parasites (Holt et al., 1997; Perkins et al., 2000a; ISRP, 2005). Several parasites are common in the Upper Klamath Basin and when combined with other environmental stressors, can have synergistic effects on the health and survival of suckers. The extent that pathogens affect suckers is not fully understood but some parasites likely contribute to sucker mortality. Disease and parasites are most prevalent in suckers found in UKL, Lake Ewauna, and the Keno Impoundment. Suckers in Clear Lake, Gerber, the Lost River, and Tule Lake have had fewer instances of fishes affected by these diseases and parasites.

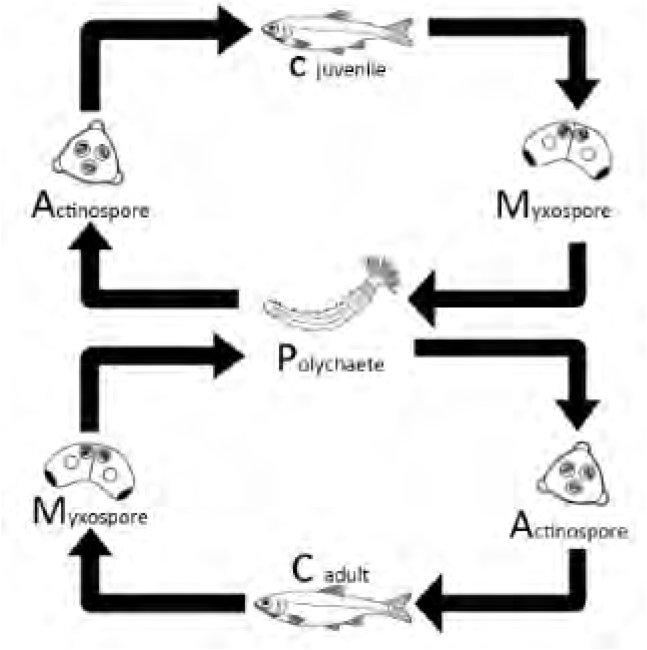
Parasites and disease that are commonly observed adversely affecting suckers include:

- *Lernaea sp.*
- *Bolbophorus sp.* (black spot)
- F*lavobacterium columnare* (gram-negative bacterial infection)
- *Contracaecum sp.* (nematode)
- Eye flukes
- *Ichthyobodo* (gill and skin parasite)

Pathogens Klamath River salmonids are exposed to various pathogens that cause infection and mortality. Prevalent pathogens include, but are not limited to, *Flavobacterium columnare* (columnaris), *Ichthyopthirius multifilis* (ich), *Nanophyetes salmincola*, and the myxozoan parasites *Parvicapsula minibicornis* and *Ceratonova shasta* (Foott et al., 2002). Infection and disease proliferation are primarily dependent on water temperature and annelid density (Warren, 1991; Stocking and Bartholomew, 2007). However, stream flow can be a contributing factor, especially as it relates to habitat suitability (Som et al., 2016a; Shea et al., 2016; Hillemeier et al., 2017) and dilution effects (Som and Hetrick, 2016; Hillemeier et al., 2017) for *P. minibicornis* and *C. shasta*. More specifically, low, stable flows are thought to increase disease virulence (Som et al., 2016a). However, there remains considerable debate about the nature of the relationship between flow management and disease conditions (Reclamation, 2018). Some evidence alludes to a possible link between flow management and disease proliferation (Shea et al., 2016; Som et al., 2016a,b). Still, other studies conclude no apparent association between flow and other factors, such as annelid density, that influence disease conditions (Malakauskas et al., 2013).

Ceratonova Shasta *Ceratonova shasta* (*C. shasta*) are a part and present conditions in the Action Area and are thus part of the environmental baseline. The life-cycle of *C. shasta* involves two hosts: salmonids and the annelid worm, *Manayunkia speciosa* (*M. speciosa*) (Bartholomew et al., 1997) (Figure 2-3). Annelid hosts release *C. shasta* actinospores (infectious to fish) and salmonid hosts release *C. shasta* myxospores (infectious to annelids) (Hallett and Bartholomew, 2011). Actinospores are released from infected *M. speciosa* into the water column as temperatures warm, typically in late March or early April (Som et al., 2016a). Actinospores released from *M. speciosa* infect fish through the gills (Bjork and Bartholomew, 2010), traveling through the bloodstream to the intestine, where myxospore replication and maturation of *C. shasta* occurs. Parasite replication in the fish can cause extensive tissue damage resulting in the diseased state, enteronecrosis (previously termed ceratomyxosis) (Hallett and Bartholomew, 2011). Upon maturation, myxospores are released from infected adult or juvenile carcasses and are available for uptake via suspension feeding by *M. speciosa*.

Given the critical role of *M. speciosa* in the lifecycle of *C. shasta*, it is important to understand its lifecycle and habitat requirements. *M. speciosa* prefers depositional areas with low water velocity such as lake and reservoir in- and outflows, pools, eddies, riffles, and runs (Som et al., 2016a). Runs and eddy-pools tend to have the highest relative *M. speciosa* densities and frequency of occurrence (Stocking and Bartholomew, 2007). *M. speciosa* construct flexible tubes, which allow them to suspension-feed (Som et al., 2016a). *M. speciosa* reproduction typically peaks in the spring to early summer as temperatures increase (Som et al., 2016a), and the reproductive cycle includes a stage in which non-feeding larva are brooded in the maternal tube until they reach suitable size for release (Som et al., 2016a).



Notes: Actinospores released into fresh water from infected Manayunkia speciosa annelids develop into myxospores in the intestine of salmonids. Both juvenile and adult salmonids may become infected with actinospores and contribute myxospores to the system. Source Foott et al. (2011)

Figure 2-3. The life cycle of *Ceratonova shasta*

M. speciosa are thought to be infected with *C. shasta* myxospores through suspension feeding (Hallett and Bartholomew, 2011), though infection in adult *M. speciosa* is relatively low (i.e., less than 6% prevalence of infection (POI) in the Klamath River from 2013-2018) (Bartholomew et al., 2018). Neither horizontal (between *M. speciosa* individuals) nor vertical (adult to egg or larvae) *C. shasta* infection has been observed in *M. speciosa* (Hallett and Bartholomew, 2011). POI is directly correlated with the number of adult salmon returning to spawn but is also influenced by other factors contributing to myxospore production, survival, and availability (Som et al., 2018). Som et al. (2018) indicated that infected *M. speciosa* may occur in areas exhibiting a smaller range in water depth and velocity at peak flows, relative to areas with uninfected *M. speciosa* populations. Similarly, Som et al. (2018) noted that the highest *M. speciosa* POI was observed during drought years with relatively homogenous Klamath River flow regimes. Finally, it appears that *M. speciosa* infection may be more likely if maturing *M. speciosa* leave maternal tubes during periods when myxospores are present in the water column and available for uptake (Alexander, 2018).

Once myxospores have infected *M. speciosa*, the myxospores develop into actinospores (Hallett and Bartholomew, 2011), a process that takes approximately 700 degree-days (Alexander, 2018), or 7 weeks at 17°C (as cited in Hallett and Bartholomew, 2011). Several hundred actinospores can be released each day from a single infected *M. speciosa* (Hallett and Bartholomew, 2011). Actinospore concentrations (and presumably the rate at which actinospores are released from *M. speciosa* individuals) increase to measurable concentrations when water temperatures reach approximately 10°C, continuing to increase with increasing water temperatures up to 17°C and then decline as temperatures exceed 17°C (Foott et al., 2011). Actinospores are viable for up to 13 days at 11°C, but only 3 to 7 days at 18°C (Hallett and Bartholomew, 2011). In the Klamath River system, actinospore concentrations typically peak in the late spring or early summer (Bartholomew et al., 2018, 2019), depending on water temperatures and degree-days within a given year. Annual maximum actinospore concentrations vary substantially between years (Bartholomew et al., 2018) due to factors related to salmonid and *M. speciosa* life stage timing and densities as well as hydrologic and meteorological conditions (Som and Hetrick, 2016; Shea et al., 2016; Som et al., 2019). Similarly, actinospore concentrations tend to vary intra-annually between sampling sites, though the highest spore concentrations typically occur near the confluence of Beaver Creek (Bartholomew et al., 2018), where spawner carcass densities are typically highest.

Actinospores attach to salmonid gills, migrate to the gill blood vessels where replication occurs, and then migrate via the circulatory system to the intestine and other internal organs (Hallett and Bartholomew, 2011). Once in the intestines, actinospores develop into myxospores, typically taking 2 weeks at 18°C (Hallett and Bartholomew, 2011). The progression of myxospore development is often fatal to the salmonid host; clinical signs of the disease state include necrosis of intestinal tissues, often accompanied by a severe inflammatory reaction (Hallett and Bartholomew, 2011). Myxospores are released when the salmonid host dies (Hallett and Bartholomew, 2011). As such, years with greater adult salmon returns and areas with concentrated spawning and associated mortality may contribute substantially to the Klamath River myxospore load (Som and Hetrick, 2016). Finally, neither horizontal (fish to fish) nor vertical (adult to egg) *C. shasta* infection has been observed in salmonids (Som et al., 2016b).

The severity of *C. shasta* infection and related mortality in salmonids is affected by a variety of factors including dose (a mechanism of velocity and spore concentration), exposure duration, exposure temperature, fish rearing temperature, and the inherent resistance of the fish strain (Hallett et al., 2012; Som et al., 2019). For example, Som et al. (2019) estimated that the probability of survival in juvenile Coho exposed to *C. shasta* spores dramatically declines with exposure time. Hallett et al. (2012) found that five genotype II actinospores per liter led to greater than or equal to 40% mortality in Coho at water temperatures greater than 15°C. Further, the authors found that time from exposure to mortality was influenced by water temperature and spore concentration, and water temperature explained a substantial part of this variation. Ray et al. (2012) also found that water temperature was negatively correlated with "mean days to death" after exposure to *C. shasta* in Chinook and Coho salmon. Finally, it is also important to acknowledge that *C. shasta* infection does not always result in mortality. Indeed, infection at low doses does not necessarily lead to a diseased state and subsequent mortality unless the fish is overwhelmed by spores (Hallett et al., 2012).

Concentrations of specific genotypes of *C. shasta* spore may influence infection rate and severity and associated mortality in specific salmonid species (Atkinson and Bartholomew, 2010). There are three genotypes of *C. shasta*, each correlating to specific salmonid hosts (Atkinson et al., 2018): genotype O - Steelhead and Redband Trout, genotype I – Chinook Salmon, and genotype

II – Coho Salmon. Although salmonids can be infected by all *C. shasta* genotypes, the response of hosts varies by genotype. Accordingly, genotype II is of particular interest in this Biological Assessment since it causes mortality for Coho Salmon (Atkinson and Bartholomew, 2010) and can successfully replicate in other host species. Hurst et al. (2019) found that Chinook Salmon exposed to genotype I and genotype II had a more virulent response to genotype I, primarily early mortality of hosts, and that genotype II replicated more slowly but produced more myxospores. Furthermore, coinfection of genotypes versus sequential infection of different genotypes is also likely to influence the relative success of myxospore production. For example, coinfection inhibited maximum myxospore production in genotype II because genotype I caused host mortality too rapidly (Hurst et al., 2019). While the response of Coho to mixed infections is unclear, the ability of *C. shasta* strains to coinfect and to replicate among different hosts warrants further attention in Coho. It should also be noted that in natural systems, susceptibility to *C. shasta* varies among salmonid life stages and strains, which may influence the response of the host to mixed infections (Hurst et al., 2019).

The timing of spore release relative to the life stage and strain of the salmonid host also influences the susceptibility of fish to *C. shasta* infection. Juvenile salmon, including re-distributing young of year individuals, are particularly susceptible to infections by *C. shasta* during migration from April through July (NMFS, 2012). Consequently, there is extensive monitoring of *C. shasta* POI and associated mortality during this period each year. Between 2009 and 2019, *C. shasta* maximum observed POI at the Kinsman trap on the Klamath River (prior to the date at which 80% of outmigrating salmon juveniles passed the trap) ranged from 0% in 2010 and 2013 to 100% in 2015 (Voss et al., 2018). In some years (e.g., 2010, 2013, 2014, 2016, 2017, and 2018), annual maximum POI occurred after the 80% outmigration date (True et al., 2017; Voss et al., 2018), suggesting that in some years the timing of juvenile salmon outmigration may influence exposure risk.

Since 2007, Oregon State University scientists have monitored mortality related to *C. shasta* exposure and infection through "sentinel studies" in which Klamath River (Iron Gate Hatchery and/or Trinity River Hatchery) Chinook, Rainbow Trout, and Coho are held in live cages in the river (and thereby exposed to *C. shasta*) at various sites in April, May, June, and September (Bartholomew et al., 2018, 2019). From 2009 to 2018, April mortality was generally less than 15% for Chinook and close to 0% for Coho; however, Coho have not been monitored in all years (Bartholomew et al., 2019). In May during the same period, Chinook mortality ranged from 90% (2015, Seiad Valley) to 0%, with the highest observed percent mortality in 2014 and 2015 (Bartholomew et al., 2018). In June during the same period, Chinook mortality ranged from 80% (2016, Orleans) to 0%, with the highest percent mortality in 2009, 2014, 2015, and 2016 (Bartholomew et al., 2018). Similarly, for Coho in June 2009 through 2017, mortality ranged from approximately 70% (2014, Seiad Valley) to 0%, with the highest percent mortality in 2009, 2011, and 2014 (Bartholomew et al., 2018). The relative impact of high mortality during these sentinel studies should be considered in the context of juvenile outmigration timing since the highest percent mortality often occurred after the 80% outmigration date.

Given the complex lifecycle of *C. shasta*, opportunities exist to disrupt *C. shasta* dynamics in the Klamath River. Increased flow is the primary mechanism known to facilitate mechanical disruption of potential and occupied *M. speciosa* habitat, dilute pathogen concentrations, and decrease in-stream temperatures. Thus, the disturbance created by high flow addresses the assertion that for an infectious zone to exist, there must be adequate *M. speciosa* habitat, stable flow, proximity to salmon spawning areas where release of myxospores occurs, and temperatures above 15°C (Som et al., 2016a,b). Accordingly, management actions to disrupt *C. shasta* have largely been focused on flow disturbance.

Sediment maintenance flows, or flushing flows, are a type of flow disturbance known to displace *M. speciosa*. Historically, sediment maintenance flows are defined as any flow event that exceeds 6,030 cfs for at least 72 hours. The flushing flows mobilize the fine sediment surface layer and occur naturally in wet water years. Sediment mobilization can cause dislodgement and redistribution or reduction of benthos (e.g., Giller et al., 1991; Mosisch and Bunn, 1997), such as *M. speciosa* and their preferred substrate. Indeed, monitoring of *M. speciosa* densities in 2017, a high flow year, revealed low densities relative to previous years (Bartholomew et al., 2018). However, the behavioral plasticity of *M. speciosa* allows the species to tolerate a wide range of velocities and can persist, disperse, and redistribute to more suitable habitat following dislodgment (Malakauskas et al., 2013; Alexander et al., 2014). In particular, microhabitat associated with Cladophora buffers against sediment disturbances from high flow events, and *M. speciosa* densities have been shown to be unaffected within those microhabitats in flow events greater than 5,000 cfs (Stocking and Bartholomew, 2007).

It is also possible that increased discharge can dilute spore concentrations (Hallett et al., 2012). Hillemeier et al. (2017) recommended implementation of spring dilution flows when spore concentrations exceed five spores per liter or POI exceeds 20%. While these thresholds were based on mortality observations by Hallett et al. (2012), they do not account for the effect of water temperature Hallett et al. (2012). Although spore concentrations decreased following high flows in 2005, POI remained steady at approximately 40% (Hillemeier et al., 2017), emphasizing the importance of other factors, such as temperature, that influence *C. shasta* infection in Chinook.

In 2018, Reclamation implemented two flows intended to disrupt *C. shasta* dynamics largely based on the Klamath River Disease Guidance Document (Hillemeier et al., 2017). A surface flushing flow (6,030 cfs for 72 hours) was released from IGD in early April to scour preferred *M. speciosa* fine sediment habitat. Additionally, a dilution flow (3,000 cfs until 50,000 AF is expended) was implemented in May with the intention of diluting *C. shasta* actinospore and myxospore concentrations within the water column (and to reduce salmon POI). *M. speciosa* density was substantially reduced after the surface flushing flow in April 2018, relative to what was observed earlier in the spring (Alexander, 2018). However, *M. speciosa* density rebounded by the time the dilution flow was implemented in May 2018 (Alexander, 2018). This information suggests that a surface flushing flow prior to February would likely allow for rebound of *M. speciosa* populations during the outmigration period (Alexander, 2018), which would likely have implications for disease dynamics. Despite this rebound in *M. speciosa* in 2018, the POI in

Chinook Salmon juveniles during the outmigration period was low relative to the 2009-2018 period of record.

In 2019, a surface flushing flow again occurred in April and dilution flow in June. Despite this, the majority of juvenile Klamath River Chinook Salmon were infected with *C. shasta* (Voss et al., 2019). In fact, POI in the first detection of 2019 was the highest value of the past 11 years of monitoring (Voss et al., 2019). The authors surmise that changes in environmental conditions and other factors that influence disease severity in salmonids (i.e., river temperatures, flows, and myxozoan exposure dose) may explain this unexpected POI. Indeed, 2019 was unique in the period of record, having severe spring spore concentrations (up to 160 spores per liter) despite wet water year conditions and an early season sediment flushing event (Bartholomew, 2019).

In 2020 and 2021—two hydrologically dry years—POI for Klamath River Chinook Salmon was among the highest since monitoring began in 2009 (Table 2-1) (Voss et al., 2024). However, in 2022, the third dry year in a row, POI was closer to the historical mean, much lower than in 2020 and 2021.

Table 2-1. Historical and recent annual *Ceratonova shasta* prevalence of infection in juvenile Chinook Salmon collected between the former site of Iron Gate Dam and Trinity River confluence

Year	Histology (% Positive)	Quantitative Polymerase Chain Reaction (% Positive)
2009	54% (50/93)	47% (264/561)
2010	15% (22/146)	17% (128/774)
2011	3%1 (3/118)	17% (62/374)
2012	9% (9/98)	30% (160/526)
2013	16% (6/37)	46% (234/508)
2014	42% (20/48)	81% (467/576)
2015	62% (37/60)	91% (437/482)
2016	14% (8/58)	48% (243/504)
2017	8% (3/40)	26% (153/600)
2018	4% (1/27)	20% (114/570)
2019	40% (16/40)	68% (395/581)
2020	60% (18/30)	73% (433/593)
2021	75% (24/32)	82% (368/447)
2022	32% (16/50)	53% (472/896)
Mean	27% (233/877)	49% (3,930/7,992)

Source: Voss et al. (2024)

Understanding the factors that influence *C. shasta* parasite abundance and their interactions is a critical need given the unexpected spore concentrations observed in 2019. In Hillemeier et al. (2017) it is hypothesized that spore concentrations are influenced by flow, water temperature, annelid density, and salmonid carcass density. Reclamation frequently implements two types of flow releases to reduce spore concentrations: surface flushing flows and dilution flows. Surface flushing flows mobilize fine sediment substrate, which displaces annelids and reduces available annelid habitat to areas with lower velocity and stable substrate (Malakauskas et al., 2013). Annelid displacement is supported by the Som et al. (2016a) conceptual model for *C. shasta* spore concentration, which suggests that annelid densities are reduced following late winter and early spring flushing events and the reestablishment of annelids to approximately pre-flush event densities occur the following fall (Reclamation, 2018). While no clear relationship between dilution flows and spore concentration has been quantified to date, this may be the result of having an insufficient number of dilution flow events occurring during periods of high spore concentrations (Som and Hetrick, 2018). A comprehensive review of the relevant literature suggested that deep flushing flows are expected to have the greatest influence on reducing *C shasta* infections (Atkins, 2018).

However, the effectiveness of management measures varies depending on water temperature (Atkins, 2018), which has been shown to be closely related to spore concentration and infection prevalence. For example, water temperature increases up to 17°C have been found to cause higher rates of actinospore release by *M. speciosa* (Foott et al., 2011). Water temperature is also associated with risk of fish mortality from *C. shasta* (Foott et al., 2011; Som et al., 2019). Therefore, increased water temperature may have a two-fold effect increasing spore concentrations, as well as infection potential and fish mortality.

Salmonid carcasses are an intermediate host for *C. shasta* ,and a single carcass can produce large amounts of actinospores (Foott et al., 2013), thus contributing to the likelihood of infection and mortality. However, Foott et al. (2016) found carcass removal did not measurably decrease spore concentrations, indicating that the relationship between carcasses and disease prevalence requires further investigation. In addition, annelid infection rates and density are also hypothesized to be associated with *C. shasta* prevalence (Foott et al., 2011). Relatively high rates of annelid infection (greater than 1%) coincided with high spore concentrations observed in 2015 (Bartholomew et al., 2018), although further observations and analysis would be needed to quantify the relationship between annelid infection and *C. shasta* proliferation.

While these empirical examples provide the basis for a theoretical model for *C. shasta* prevalence in the Klamath Basin, clear relationships to predict the influence of these factors on spore concentrations and salmonid mortality have not been quantified. Moreover, given the severity of disease conditions in 2019, increased sampling frequency of spore concentration and consistent monitoring of environmental conditions are essential for improving the understanding of disease dynamics in the Klamath Basin. This highlights the need for quantification of flow, temperature, annelid density, and salmonid carcass density effects on spore concentrations and infection rates and subsequent mortality.

2.4.3.4 Scientific Research

Excerpt directly from the USFWS 2019 BiOp (USFWS, 2019a Page 89):

In 2018, the USFWS consulted (08EKLA00-2018-F-0065) on the effects to LRS and SNS of issuing scientific permits for the purpose of promoting recovery of the species under section 10(a)(1)(A) of *the ESA. The consultation addressed purposeful take of the species using a variety of scientific collection techniques, marking, transport and relocation, and biological sampling. Take authorized as part of scientific research includes purposeful lethal take of 15 adults, 30 juveniles, 1,000 larvae, and 2,000 eggs. Additionally, non-lethal harm of 20 adults, 40 juveniles, 500 larvae, and 1,000 eggs was authorized. The Service considered the effects of the issuance of scientific permits (as currently proposed) on the reproduction, abundance, and distribution of the species, as well as how the aggregation of these effects will affect the overall survival and recovery of the species. The Service determined that the action was not likely to jeopardize the continued existence of the LRS and SNS, nor adversely modify the designated critical habitat of the species.*

2.4.4 National Wildlife Refuges

The Upper Klamath, Lower Klamath, Tule Lake, and Clear Lake NWRs are adjacent to or within the Project service area and are affected by Project operations. These refuges were established by various executive orders starting in 1908. The USFWS manages the refuges, as part of the Klamath Basin Refuge Complex, under the Migratory Bird Treaty Act (codified as 16 U.S.C. 703-712, 1918), NWR System Administration Act of 1966 (16 U.S.C. 668dd-668ee, 1966), NWR System Improvement Act (Pub. L. 105-57, 111 Stat. 1252-1260), the 1964 Kuchel Act (Pub. L. 88-567) (Kuchel Act; described below), and other laws pertaining to the NWR System.

These NWRs support numerous fish and wildlife species and provide habitat and resources for migratory birds of the Pacific Flyway. Approximately 80 percent of the migrating waterfowl on the Pacific Flyway come through the Klamath Basin on both spring and fall migrations. During the peak of the migration, there are up to one million birds in the Klamath Basin Refuge Complex, primarily in Lower Klamath and Tule Lake NWRs.

Project operations make water available for use in the refuges, and water within the NWRs is commonly used for both irrigation and wetland purposes. See Section 2.3.2., Project Water Rights, regarding the various water rights appurtenant to lands in Lower Klamath and Tule Lake NWRs.

Operationally, Lower Klamath NWR can receive Project water from UKL and the Klamath River, as well as water from the Tule Lake sumps, which is conveyed through Sheepy Ridge via the P-Canal Tunnel. Tule Lake NWR can receive Project water from irrigation return flows, which are stored in the Tule Lake sumps; however, when irrigation demand is high, stored water from UKL (diverted at the Lost River Diversion Channel [LRDC] and released through Station 48) may be used to meet associated demands for historical wetland habitat. Tule Lake NWR can also use water from natural flow in the Lost River. In some instances, stored water from Clear Lake Reservoir has been released to support irrigation operations within TID, including Tule Lake NWR.

Note that all of Tule Lake NWR is served under Reclamation’s water supply contract with TID (Contract No. 14-06-200-5954, dated September 10, 1956), which allows for the district to provide delivery and drainage services to these lands through Project facilities for which the O&M is transferred to TID. The portion of Lower Klamath NWR in Oregon, comprising approximately 5,600 acres, is served under the water supply contract between Reclamation and

Klamath Drainage District (KDD) (Contract No. Ilr-402c, dated April 28, 1943). In addition, the USFWS has a separate agreement with KDD, dated May 25, 1940, for use of the Ady Canal to deliver water to the portion of Lower Klamath NWR in California.

In connection with Upper Klamath NWR, the USFWS manages two federally-acquired parcels adjacent to Upper Klamath NWR (Agency Lake and Barnes Ranch) with associated water rights. In 2017, USFWS applied to OWRD to temporarily transfer the water rights from the Agency Lake and Barnes Ranch properties to Lower Klamath NWR through the 2021 irrigation season. OWRD approved this application, designated as number T-12642, by order dated August 2, 2017. Following 2021, the temporary transfer was extended. In 2024, USFWS is planning to breach the dikes separating these properties from UKL. While the reconnection will alter the hydrology of the UKL system in ways that will affect Project operations, it is not part of Reclamation’s Proposed Action, is considered reasonably likely to occur, and is therefore considered within the environmental baseline and accounted for in anticipated operations as described in the Proposed Action.

2.4.5 Hatcheries and Conservation Rearing Programs

2.4.5.1 Hatcheries

Two fish hatcheries historically operated within the Klamath River Basin: the Trinity River Hatchery (near the town of Lewiston, California), and the Iron Gate Hatchery on the mainstem Klamath River near Hornbrook, California. Both hatcheries historically focused on the production of Chinook Salmon, Coho Salmon, and Steelhead. As part of the Lower Klamath Project dam removal effort, hatchery production at Iron Gate Hatchery is being transferred to a renovated Fall Creek Hatchery, near the community of Copco, California, after which the facilities at Iron Gate Hatchery will be removed (Renewal Corporation, 2021). This operational change will maintain production targets for Coho yearlings but eliminate Steelhead production and reduce Chinook production from 6M juveniles to 3.25M juveniles overall.

Iron Gate Hatchery Iron Gate Hatchery Coho Salmon production focused on the conservation of the Upper Klamath Population Unit. To conserve the remaining genetic and phenotypic traits of the Upper Klamath Population Unit, the Iron Gate Hatchery Coho program was operated as an “integrated type,” where natural- and hatchery -origin fish are used as broodstock. A Hatchery and Genetic Management Plan (HGMP) for Coho Salmon was developed for Iron Gate Hatchery as part of the CDFW’s application for an ESA Section 10(a)(1)(A) permit for the Iron Gate Hatchery Coho Salmon program (CDFW and PacifiCorp, 2014; 78 FR 6298; 79 FR 69428). The HGMP was intended to guide hatchery practices toward the conservation and recovery of SONCC Coho Salmon; specifically, through protecting and conserving the genetic resources of the upper Klamath River Coho Salmon population.

Fall Creek Hatchery In consultation with NMFS and CDFW, the Renewal Corporation developed new hatchery production goals for Falls Creek Hatchery, prioritizing fish production goals during the 8-year period following dam removal (Renewal Corporation, 2021; NMFS, 2021a). As a state- and federally-listed species in the Klamath River, Coho Salmon production is the highest priority, followed by Chinook Salmon, which are a valuable prey source for listed SRKWs (NMFS, 2021a). Steelhead production is the lowest priority (NMFS, 2021a). Due to limited water availability and rearing capacities and recent low hatchery steelhead returns, Steelhead production will be discontinued (Renewal Corporation, 2021; NMFS, 2021a).

Trinity River Hatchery When a program is well integrated, the proportion of natural-origin fish used in hatchery broodstock (pNOB) is greater than the proportion of hatchery fish on spawning grounds (pHOS) (CDFW and PacifiCorp, 2014). Hatcheries pose risks to natural-origin salmon populations (summarized in NMFS, 2021a), including increased risk of predation of, and competition with, rearing natural origin salmonids (Collis et al., 1995; Nickelson, 2003). Though these effects have not been quantified in the Klamath Basin, average annual releases of 5,766,512 Chinook Salmon, 80,651 Coho Salmon, and 82,528 steelhead from Iron Gate Hatchery (CDFW, 2014) (based upon data available since 2001; CDFW 2013, 2014, 2016) are assumed to have impacted SONCC Coho in the past.

2.4.5.2 Rearing Programs

Klamath Basin Sucker Rearing Program Excerpt directly from the USFWS 2019 BiOp (USFWS, 2019a Page 90):

The Service started an assisted rearing program for Lost River and SNS in 2015 to supplement populations in UKL through augmentation. The primary target of the effort is SNS, but the lack of an effective way to identify live larvae and juveniles means that both species are collected and reared. ln 2013, the Bureau of Reclamation agreed to fund such a program as a way to improve the environmental baseline of the species to minimize impacts to suckers that may result from Klamath Project operations with a 10-year target of releasing a total of 8,000 to 10,000 suckers with lengths of at least 200 mm. The Service funded expansion of the program and aims to collect around 20,000 larval suckers for assisted rearing in spring of 2019.

The program was designed to maximize retention of genetic diversity and maintain natural behaviors post-release as much as possible (Day et al., 2017 pp. 306-307). Larvae are collected as they drift downstream in the Williamson River, so no brood stock are maintained, and the effects of artificial breeding are avoided. Collection efforts are currently spread across the drift season to maximize the genetic variability. Juveniles are stocked into semi-natural ponds and growth depends on a combination of natural and artificial feed.

The first release of reared suckers into UKL occurred in spring 2018, and the proportion of released individuals that will join the spawning population is unknown. Thus, the assisted rearing program is likely to be a source of recruitment for both SNS and LRS in UKL, but the specific impact on population trajectories will be uncertain until information on survival and recruitment probabilities of released individuals is available. Support for the ongoing operation of this program is a component of the current proposed action.

Klamath Tribes Sucker Rearing Excerpt directly from the USFWS 2019 BiOp (USFWS 2019a Page 90):

Included in the programmatic consultation on the issuance of recovery permits for actions involving LRS and SNS (08EKLA00-2018-F-0065) is assisted rearing, which allows for the collection of up to 75,000 wild-hatched larvae from the UKL system. The Klamath Tribes established a rearing program in 2018, and the first collections under the program were performed in spring 2018. A total of 20,000 larvae from the UKL system were brought into captivity. This first cohort is currently in captivity with an anticipated release date in spring 2020. The current permit allows for collection of up to 20,000 larvae per year. Although the scale of releases and the specific of effects of this action are unknown at present, it may result in additional recruitment to populations of LRS and SNS in UKL.

2.4.6 Alterations to Address Effects

Given the collective effect of the basin-wide, physical alterations that have been detrimental to listed species, Reclamation, OWRD, Oregon Department of Fish and Wildlife (ODFW), NMFS, USFWS, and other federal, state, and local agencies, corporations, non-profit entities, and individuals, have all undertaken various activities to address the effects of these past and present impacts. The following sections describe some beneficial physical alterations.

Diversion and Canal Screening and Fish Passage Facilities To reduce entrainment in the many diversions and canals throughout the Klamath River Basin, a series of fish screens have been placed at the entrance to diversions, so that water may pass through but not fish. These include a wide range of types and sizes including pump, cone, rotary drum, traveling belt, and panel screens, key examples of which are provided here.

Reclamation reconstructed the A Canal headworks in 2002 and 2003, with a new fish screening system including an automated trash-rack structure, fine-mesh fish screens, a fish bypass system, and a fish evaluation station. This screening system prevents entrainment of juvenile and adult suckers into the A Canal, but not larvae. The screens are in place any time diversions are made into the A Canal. Moreover, the fish bypass system allows fish to circumvent the headworks and screening entirely. Finally, at the end of irrigation season, the A Canal gates are closed and the forebay between the trash rack and head gates is slowly dewatered. Annual fish salvage occurs within the dewatered forebay during late October or early November. Monitoring during the week following initial salvage is conducted and additional salvage efforts are undertaken when fish are observed.

Oregon's Fish Screening Program has provided cost share incentives and technical assistance to encourage water users to voluntarily install fish-friendly screens at their water diversions. Under Oregon's Fish Screening Program, the Geary Canal, which diverts water directly from UKL for the 4,200-acre reclaimed Wocus Marsh, was screened in 2010. While the Fish Screening Program has made great progress, thousands of water diversions remain unscreened in the Upper Klamath Basin. Additional details regarding screening efforts can be found in Reclamation's 2020 Biological Assessment (Reclamation, 2020a).

Fish passage improvements within the Klamath River Basin include dam removal and fish ladder construction. Keno Dam currently has a fish ladder that will pass anadromous fish (NMFS, 2021a). In 2004, Reclamation constructed a fish ladder on LRD to allow suckers to migrate between the Keno Impoundment and UKL. The ladder was designed to allow sucker passage (Reclamation, 2020a), but will also support anadromous fish passage (NMFS, 2021a). In 2008, the Chiloquin Dam was removed from the Sprague River, restoring connectivity and fish access to potential spawning habitat upstream in the Sprague River watershed.

Additional details about ongoing removal of PacifiCorp's Klamath Hydroelectric Project dams are contained in the Renewal Corporation's 2021 Biological Assessment (Renewal Corporation, 2021).

Habitat Restoration Numerous agencies and organizations have engaged in various restoration projects throughout the Klamath Basin for the benefit of fish and wildlife.

Upper Klamath Lake There have been several large projects to restore littoral wetland habitat and ecological functioning around UKL and within the Klamath River. Examples of these programs are summarized below.

USFWS has led a Sucker Recovery Implementation Team, which Reclamation has funded since 2013. In addition to supporting monitoring and research on LRS and SNS in the Upper Klamath Basin, the Sucker Recovery Implementation Team funds projects intended to improve the amount and quality of sucker habitats, sucker passage issues, and sucker survival. Reclamation has obligated $1.5 million annually between fiscal year 2013 and fiscal year 2018, along with $2.1 million in 2019, towards the Sucker Recovery Implementation Team and associated monitoring. Activities that have and will be undertaken with the funds already obligated are part of the baseline condition and not part of the Proposed Action.

In 1994, the Bureau of Land Management acquired a 3,200-acre parcel (Wood River Wetland) on the north end of Agency Lake and adjacent the Wood River, and subsequently restored the land to a wetland. As part of this project, the channel of the Wood River was restored in 2001.

In 1998, Reclamation, with assistance from The Nature Conservancy and USFWS, acquired approximately 7,100 acres along the northeast shore of Agency Lake, which had previously been diked and drained as part of the private diking efforts that occurred beginning in the early 1900s. USFWS currently administers these lands and is developing plans to remove the levees and restore the area to natural functioning wetlands.

In 2008, The Nature Conservancy and other groups acquired 7,700 acres at the mouth of the Williamson River, which is still being actively restored to a delta wetland.

Trout Unlimited is also undertaking an ambitious restoration plan for endangered Bull Trout (*Salvelinus confluentus)* in the Upper Klamath Basin, including instream and riparian restoration work on Sun, Annie, and Crane creeks (Buktenica et al., 2018). In connection with Trout Unlimited's work to restore Crane Creek, Reclamation has prepared a Resource Management Plan for 1,200-acre tract 2 miles northwest of Agency Lake, which contains a portion of the creek's historical channel.

Klamath River There are several restoration and recovery actions underway in the Klamath Basin aimed at improving habitat and water quality conditions for anadromous salmonids, some of which are supported by Reclamation.

Reclamation-funded restoration and recovery actions in the Klamath Basin are improving habitat and water quality conditions for anadromous salmonids. Since 2015, Reclamation and its partner the National Fish and Wildlife Foundation (NFWF) have administered more than $4 million for the program, including $1.7 million in grants for three projects in 2023 (Table 2-2). This funding has already been obligated, so the work that has and will be accomplished with those funds is part of the baseline condition and not part of the Proposed Action. Restoration activities under this program have and continue to occur. Restoration activities are confined to the mainstem Klamath River below the former IGD site, inclusive of all tributaries (except the Trinity River), with most restoration being conducted on the Shasta, Scott, and Salmon rivers and their tributaries. Restoration projects are typically implemented by state, tribal, local, or private non-governmental organizations.

Table 2-2. Summary of funded projects the U.S. Bureau of Reclamation has supported with assistance, since 2015, from National Fish and Wildlife Foundation as the Grant Administrator

Grant Cycle or Year	Pre-Proposals	Full-Proposals	Projects Funded	Funding
2013*	--	--	--	$500,000
2014*	--	--	--	$500,000
2015*	--	--	--	$500,000
2016	31	12	12	$500,000
2017	20	9	4	$500,000
2018	12	10	5	$500,000
2019	6	4	4	$700,000
2022	11	7	7	$1,700,000
Totals	80	42	32	$5,400,000

Notes: * Contracts administered by NFWF following 2015. Pre- and full-proposals and projects funded are as tracked by NFWF following that time.

NMFS also funds coastal salmonid restoration activities through the Pacific Coastal Salmon Recovery Fund. Since 2000, NMFS has awarded approximately $73 million per year for projects throughout the Pacific West, many of which are in the Klamath River Basin (NMFS, 2023).

The U.S. Department of Agriculture has also completed several salmonid restoration projects in the Klamath National Forest, including habitat restoration and placement of large woody debris.

In addition to these federal efforts, multiple local watershed groups exist in the Klamath Basin, including the Scott River Watershed Council, the Siskiyou Resource Conservation District, the Shasta River Coordinated Resource Management Planning Group, and the Salmon River

Restoration Council. These types of groups have undertaken restoration activities, including construction of off-channel ponds, side channels, and “beaver dam analogue structures.”

2.4.7 Near Shore Pacific Ocean (Southern Resident Killer Whale)

2.4.7.1 Toxic Chemicals

Contaminants of various types, including persistent organic pollutants that are believed to pose significant risks for SRKWs and other marine life, enter marine waters from numerous sources throughout the Action Area but are typically concentrated near populated areas of high human activity and industrialization (Mongillo et al., 2016). High levels of pollutants found within the marine environment have been measured in blubber biopsy samples from SRKWs (Ross et al., 2000; Krahn et al., 2007, 2009), and more recently, these pollutants were measured in fecal samples collected from SRKWs (Lundin et al., 2016b, 2016a). Contaminants can also come from agricultural areas (Krahn et al., 2007). The Action Area is one of many sources of contaminants to the marine environments.

2.4.7.2 Disturbance from Vessels and Sound

Ocean-going vessels (ships and boats) have the potential to affect killer whale behavior and physiology through physical presence and encounters, crowding, and underwater sound, which can mask echolocation and communication signals (NMFS, 2008). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (NMFS, 2016b). Vessel strikes are rare but do occur and can result in injury or mortality (Gaydos and Raverty, 2007).

In December 2017, NMFS completed a technical memorandum evaluating the effectiveness of regulations adopted in 2011 to help protect endangered SRKWs 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 memorandum 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 found 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.

2.4.7.3 Oil Spills

In the northwest, SRKWs are the marine mammal population that is most vulnerable to the risks imposed by an oil spill due in part 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 (Jarvela Rosenberger et al., 2017). Oil spills have occurred in the range of SRKWs, and there is potential for spills in the future. Oil can be discharged into the marine environment in many ways, including shipping and rail accidents, refineries and associated production facilities, and pipelines. Despite improvements in spill prevention since the late 1980s, much of the region inhabited by SRKWs remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers in inland waters. Small spills are also common: over 6.5 million liters of oil from cars and trucks are estimated to reach the Puget Sound each year.

Repeated ingestion of petroleum hydrocarbons by killer whales likely causes adverse effects, including physiological and behavioral changes (Geraci and Aubin, 1990). In marine mammals, acute exposure to petroleum products can damage the lungs and impair adrenal function leading to diseases in both organs (Schwacke et al., 2013; Venn-Watson et al., 2015), impair immune function (de Guise et al., 2017), impair reproductive function (Kellar et al., 2017), and potentially cause death and long-term effects on population viability (Matkin et al., 2008). Oil spills also have the potential to adversely impact habitat and prey populations, and, therefore, may also adversely affect SRKWs by reducing food availability.

2.4.7.4 Quantity and Quality of Prey

Excerpt directly from the NMFS 2019 BiOp (Page 225):

There are many factors that affect the abundance, productivity, spatial structure, and diversity of Chinook Salmon and thus affect prey availability for the whales. For example, Lower Columbia River Chinook salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable, particularly given changing habitat conditions. Human impacts and limiting factors come from multiple sources, including hydropower development, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors that include environmental variability and predation of salmonids by a number of marine mammals and other marine species. Following along these lines, in 2011 NMFS convened an independent science panel to critically evaluate the effects of salmon fisheries on the abundance of Chinook salmon available to SRKWs. Overall, the panel concluded that, at a broad scale, salmon abundance will likely influence the recovery of the whales, but the impact of reduced Chinook salmon harvest on future availability of Chinook salmon to SRKWs is not clear, and the panel cautioned against overreliance on correlative studies or implicating any particular fishery (Hilborn et al., 2012). Following the independent science panel approach on the effects of salmon fisheries on SRKWs (Hilborn et al., 2012), NMFS and partners have actively engaged in research and analyses to fill gaps and reduce uncertainties raised by the panel in their report.

2.4.7.5 Salmon Harvest Actions

Coho and Chinook salmon have been harvested in the past in ocean fisheries off the coasts of California and Oregon. With the exception of some tribal harvest by the Yurok and Hoopa Valley for subsistence and ceremonial purposes, the retention of Coho Salmon is now prohibited in all California river fisheries. While major steps have been taken to limit effects of harvest on SONCC Coho Salmon, the population is still impacted by incidental mortality associated with various Chinook Salmon fisheries and by subsistence and ceremonial tribal fisheries. Most Coho Salmon captured by Hoopa Valley Tribal fisheries are Trinity River Hatchery origin fish (Orcutt, 2015). The 2011 independent science panel convened by NMFS concluded that the impact of Chinook Salmon harvest on future availability of Chinook Salmon to SRKWs is not clear and cautioned against overreliance on correlative studies or implicating any particular fishery (Hilborn et al., 2012).

2.5 Independent Related Activities

The scope and complexity of agency actions on the Klamath River involve multiple activities with ongoing effects on federally-listed species that are consulted upon separately from the Project. These "independent related actions" with their independent Section 7 consultations, where warranted, are part of the baseline conditions experienced by federally-listed species but may not be undertaken by Reclamation and are not part of the operation of the Project to store, release, divert, route, and blend water.

2.5.1 Wetland Restoration on Upper Klamath National Wildlife Refuge Barnes Unit, Agency Lake Units and Adjacent Lands

The Upper Klamath NWR was established in 1928 and is located on the northwest end of UKL. Derived from the mission of the NWR System, Upper Klamath NWR has the following seven defined purposes:

- "…as a refuge and breeding ground for birds and wild animals…subject to the use…for irrigation and other incidental purposes, and to any other existing rights (EO 4851)."
- "…to preserve intact the necessary existing habitat for migratory waterfowl in this vital area of the Pacific flyway… (Kuchel Act, 16 U.S.C. 695k)."
- "…to prevent depredations of migratory waterfowl on the agricultural crops in the Pacific Coast states (Kuchel Act, 16 U.S.C. 695k)."
- "…dedicated to wildlife conservation…for the major purpose of waterfowl management, but with full consideration to optimum agricultural uses that is consistent therewithin (Kuchel Act, 16 U.S.C. 695l)."
- "…for waterfowl purposes, including the growing of agricultural crops by direct plantings and sharecrop agreements with local cooperators where necessary… (Kuchel Act, 16 U.S.C. 695a)."
- "…for use as an inviolate sanctuary, or for any other management purpose, for migratory birds (Migratory Bird Conservation Act, 16 U.S.C. 715d)."
- "…to conserve (A) fish or wildlife which are listed as endangered species or threatened species…or (B) plants… (Endangered Species Act 1973, 16 U.S.C. 1534)."

The purpose of the USFWS project to reconnect the Agency Lake and Barnes Ranch units of the Upper Klamath NWR to UKL, according to the Environmental Assessment, is "to restore a full gradient of wetlands (open water, submergent, emergent and seasonal fringe) across the Upper Klamath NWR Agency Lake, Barnes Units, Eisenberg Unit and USFWS easements" (Stantec, 2023) by reconnecting more than 14,000 acres of full gradient wetlands to Upper Klamath and Agency lakes. Completion of the project would fulfill the purpose of the refuge and contribute to wildlife goals of the Upper Klamath NWR (Section 1.2), as well as larger regional and continental landscape goals to conserve priority bird habitats (IWJV, 2013).

The following documents the effects on federally-listed species.

- USFWS 2023 Intra-service Section 7 Biological Evaluation Forms. Project Name: Barnes-Agency Restoration Project (Phase 1) (IPaC No. 2023-0026819; USFWS, 2023c)
- USFWS 2023 Environmental Assessment - Environmental Assessment of Wetland Restoration on Upper Klamath National Wildlife Refuge Barnes Unit, Agency Lake Units and Adjacent Lands (Stantec, 2023)

The 2023 intra-service Section 7 biological evaluation (USFWS, 2023c) lists nine species that may occur within the Action Area, seven of which are threatened or endangered. Species of concern identified in this document are LRS, SNS, Bull Trout, and Oregon spotted frogs. Findings of this evaluation state no adverse effects to any of the species of concern. The USFWS determined the Project would have no effect on Oregon spotted frog critical habitat and no adverse modification of LRS, SNS, and Bull Trout critical habitat. The USFWS also determined the Project may affect but is not likely to adversely affect LRS, SNSs, Bull Trout, and Oregon spotted frog (Stantec, 2023; USFWS 2023c).

2.5.2 Removal of Lower Klamath Hydroelectric Project Facilities

In 2010, representatives of numerous organizations within the Klamath River Basin negotiated with PacifiCorp to arrive at the 2010 Klamath Hydroelectric Settlement Agreement (KHSA). The KHSA addressed the interim operations of the four PacifiCorp owned dams (i.e., JC Boyle, Copco 1 and 2, and IGD) downstream of the Project and established a framework for facilities removal. The KHSA was amended in 2016 to provide for removal of the dams via the Federal Energy Regulatory Commission (FERC) licensing process rather than through Congressional action. As a precursor to dam removal the Renewal Corporation was established as the designated Dam Removal Entity.

In 2016, PacifiCorp and the Renewal Corporation filed a joint application with FERC to separate PacifiCorp’s Klamath Hydroelectric Project (FERC Project No. 2082) facilities into two separate projects and to transfer ownership of one of the newly created projects—the Lower Klamath Project—to the Renewal Corporation (CWB, 2023).

In March 2018, FERC approved splitting the license for the Klamath Hydroelectric Project into two separate FERC licenses. In that order, PacifiCorp’s East Side, West Side, Keno, and Fall Creek developments remained in the Klamath Hydroelectric Project (FERC No. P-2082). The J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate developments were placed into the Lower Klamath Project (FERC No. P-14803).

On June 17, 2021, the FERC issued an order approving transfer of the license for the Lower Klamath Project (FERC No. 14803-001) from PacifiCorp to the Renewal Corporation and the states of California and Oregon (FERC, 2021a). On the same date, FERC issued a notice of intent to prepare an environmental impact statement for the proposed Lower Klamath Project surrender and removal, which included a list of permits and authorizations that were anticipated to be required for the proposed surrender and removal, including consultation under ESA Section 7 with NMFS (FERC, 2021b).

The Renewal Corporation proposed the removal of the hydroelectric dams and other facilities at four developments (J.C. Boyle, Copco No.1, Copco No. 2, and Iron Gate) on the mainstem Klamath River as described in the Biological Assessment (Renewal Corporation, 2021). Broadly described, the proposed action was comprised of preparing the facilities for dam removal, including road improvements, dam and gate improvements, and general infrastructure modifications. When that work is completed, the reservoir would be drawn down in preparation for the removal of the dams and the restoration of the former reservoir footprints and tributary reconnections commenced. FERC issued a final Environmental Impact Statement for the proposed dam removal on August 26, 2022, and approved the removal on November 17, 2022.

Copco No. 2 Diversion Dam was removed in the summer of 2023. Generation at J.C. Boyle, Copco No. 1, and Iron Gate powerhouses ceased in January 2024. The remaining three dams are expected to be removed in the spring through fall of 2024. As part of this dam removal effort, the Renewal Corporation will remove most of the facilities at Iron Gate Hatchery, improve facilities at the existing Fall Creek Fish Hatchery near the confluence of Fall Creek with the Klamath River, then move hatchery operations upstream to the upgraded Fall Creek Hatchery (NMFS, 2021a). In parallel with this dam removal process, the Renewal Corporation is implementing a large-scale restoration program during 2023-2025 (Renewal Corporation, 2020).

The following documents the effects on federally-listed species.

- NMFS 2021 Biological Opinion (NMFS Consultation No WCRO-2021-01946) - Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Surrender and Decommissioning of the Lower Klamath Hydroelectric Project No. 14803-001, Klamath County, Oregon and Siskiyou County, California.
- USFWS 2021 Biological Opinion (USFWS Consultation No 08EYRE00-2021-F-0127) - Biological Opinion for the Surrender and Decommissioning of the Lower Klamath Hydroelectric Project, Nos. 14803-001, 2082-063.

In the BiOp, NMFS concluded that the proposed action is not likely to jeopardize the continued existence of the SONCC Coho Salmon ESU, SRKW DPS, and Southern DPS Eulachon, or destroy or adversely modify designated critical habitat for the SONCC Coho Salmon ESU, SRKW, or Southern DPS Eulachon. However, NMFS anticipated non-jeopardizing incidental take of SONCC Coho Salmon, SRKW, and Southern DPS Eulachon. An incidental take statement with Reasonable and Prudent Measures and terms and conditions is included with the BiOp. In addition, NMFS concurred with FERC’s determination that the proposed action is not likely to adversely affect Southern DPS Green Sturgeon or its critical habitat. Minor, short-term, and adverse effects of the preferred action are addressed in the BiOp.

2.5.3 Keno Dam Transfer

The 2016 KHSA revision confirmed the 2010 agreement between Reclamation and PacifiCorp to transfer the title to the Keno facility from PacifiCorp to the U.S. Department of the Interior (Interior) (ADIC et al., 2016; Section 2.5.3). More recently, Reclamation Klamath Basin Area Office (KBAO) proposed to acquire Keno Dam and related real property interests, and subsequently operate the dam consistent with historical practices. In addition, for the purpose of operating Link River and Keno dams, Reclamation would also (1) acquire the Weed Bridge Gaging Station, (2) assume all of PacifiCorp's rights and obligations in certain landowner agreements along the Keno Reach of the Klamath River, and (3) acquire certain real property interests necessary for Reclamation's assumption of O&M of LRD. All properties would be acquired by donation from PacifiCorp to the United States.

The following documents the effects of the transfer on federally-listed species.

- U.S. Department of Interior 2023 Environmental Assessment-Keno Dam Transfer, Klamath Project, Oregon/California Interior Region 10 – California Great Basin CGB-EA-2023-037. (Interior, 2023a)
- U.S. Department of Interior 2023 Finding of No Significant Impact – Keno Dam Transfer, Klamath Project, Oregon/California Interior Region 10 – California Great Basin CGB-FONSI-2023-037. (Interior, 2023b)

Reclamation considered potential short-term and long-term effects of the proposed action, both beneficial and adverse. Reclamation found that the proposed action is not a major federal action that will significantly affect the quality of the human environment, and preparation of an environmental impact statement is not required.

The environmental assessment described the existing environmental resources of the proposed action area and evaluated the effects of the no action and proposed action alternatives. Reclamation determined that water and biological resources, recreation, cultural resources, Tribal trust assets and sacred sites, climate change, air quality, noise socioeconomics, public health, and laws will not be significantly impacted by the proposed action.

On December 19, 2023, FERC amended the license for the Klamath Project (P-2082), which removed Keno Dam from the FERC-licensed project. Six months later, in June 2024, title to Keno Dam and responsibility for operations transferred from PacifiCorp to Interior. Reclamation now oversees Keno O&M as per the agreements (PacifiCorp and Reclamation, 2022; CWB, 2023).

2.5.4 Scientific Study and Recovery of Lost River Sucker and Shortnose Sucker

USFWS proposed to issue Section 10(a)(l)(A) permits for scientific purposes and to promote the recovery of the LRS and SNS. Issuance of said permits would enable the public to engage in legitimate wildlife-related activities that promote recovery that would otherwise be prohibited by law. Recovery permits are to promote conservation efforts by authorizing scientific research, wildlife management activities, and to gather data to support the recovery of the species.

The following documents the effects on federally-listed species.

- USFWS 2023 Biological Opinion - Biological Opinion on the Effects of Proposed Interim Klamath Project Operations Plan, effective October 1, 2023, through October 31, 2024, on the Lost River Sucker and the Shortnose Sucker. (USFWS, 2023a)

USFWS used the effects of the proposed action on the reproduction, numbers, and distribution, and their effect on the survival and recovery of LRS and SNS as the basis to assess the overall effect of the proposed action on the species. After reviewing the effects of the proposed action on the designated critical habitat in the action area, USFWS determined that implementation of the action as proposed is not likely to adversely affect designated critical habitat for the LRS and SNS.

2.5.5 Oregon Highway 140 Expansion

The Western Federal Lands Division of the Federal Highway Administration, in cooperation with the Oregon Department of Transportation and Klamath County, proposed to widen the pre-existing roadway prism of OR-140 outside of the city of Klamath Falls, OR, between mile post 57.0 and mile post 62.6. Additionally, the Federal Highway Administration proposed to construct a wetland mitigation located approximately 3 miles east (across the lake) from mile post 62.6. The mitigation property is a 45-acre parcel adjacent to UKL, of which 10.9 acres of wetland enhancements will be constructed.

The following documents the effects on federally-listed species.

- USFWS 2019 Biological Opinion-Biological Opinion for Oregon Highway 140 (OR-140) Klamath County Boat Marina to Lakeshore Drive Project, Klamath Count, Oregon (Project OR DOT 140 (1)) (USFWS, 2019b)

The biological assessment determined that the proposed action “may affect and is likely to adversely affect” LRS and SNS, with potential effects covered in the BiOp. According to the BiOp, the proposed action will likely result in lethal and nonlethal harm to LRS and SNS but is not expected to appreciably reduce the likelihood of survival and recovery of the species in the wild. Harm may result from the potential for embankment material to crush or otherwise alter LRS and SNS behaviors (e.g., fleeing). A total of 780 juvenile suckers may be subjected to lethal harm which is only a small portion of the listed species population in UKL based on the take permit. Other life stages will not be harmed. Project effects will be temporary in nature, spatially and temporally restricted, and affect only a very small portion of the LRS and SNS population. The proposed action is not likely to result in jeopardy for the LRS and SNS.

2.5.6 Livestock Grazing Management on the Modoc National Forest

The U.S. Forest Service (USFS) proposed issuing grazing authorization through grazing permits and allotment management plans. A grazing permit is a document authorizing livestock to use National Forest Service lands or other lands under USFS control for livestock production (USFS, 2020). The grazing permit provides authorization to graze specific number, kind, and class of livestock for a specified time-period on a defined allotment or management area. An allotment management plan is a long-term operating plan for a grazing allotment, prepared and agreed to by the permittee and permitting agency. Requirements from this consultation will be incorporated into term grazing permits and allotment management plans.

The following documents the effects on federally-listed species.

- USFWS 2011 Biological Opinion- Biological Opinion on the Effects of Continued Authorization of Livestock Grazing Management on the Modoc National Forest on Three Federally Listed Threatened and Endangered Species. (USFWS, 2011)

USFS determined that the project “may affect and is likely to adversely affect” LRS and SNS and their designated critical habitat and slender Orcutt grass due to habitat modification and disturbance. However, based on the analysis presented in the biological assessment, meetings with USFS, and existing USFWS information, the USFWS concluded that the survival and recovery of the LRS, SNS, and slender Orcutt grass is not in jeopardy as a result of implementation of the proposed project. Similarly, the project will not result in destruction or adverse modification of critical habitat.

2.5.7 Area S Resource Management Plan

Area S is a roughly 1,200-acre parcel, located approximately 30 miles northwest of the town of Klamath Falls, OR, and about 2 miles from Agency Lake. Neighboring landowners and Trout Unlimited expressed concerns and interest in changes in resource management to improve environmental conditions that have been detrimental to local cultural and economic interests and wildlife, wetland, riparian, and stream health. Most species and critical habitats of concern have been dismissed from further analysis, except Oregon spotted frog and its and Bull Trout critical habitats.

The following documents the effects on federally-listed species.

- Environmental Assessment: Area S Resource Management Plan Klamath County, Oregon 2019-EA-009.
- Biological Evaluation Area S Threemile and Crane Creek Restoration Project Klamath County, Oregon.
- Informal Consultation on the Area S Resource Management Plan, Klamath County, Oregon.
- Resource Management Plan, Area S

The Area S Resource Management Plan provided for reactivation of the abandoned Crane Creek channel located on Area S between Fourmile Creek and the private land boundary to the north, reestablishment of a natural hydrologic connection between Crane Creek and Threemile Creek, and development of wetland habitat from the decommissioning and regrading of Threemile Canal. The management plan is anticipated to have long-term beneficial effects for Oregon Spotted frog and its critical habitat and critical habitat for Bull Trout. The construction work to restore Crane Creek was substantially completed in 2021.

3 Proposed Action

3.1 Background

This Proposed Action has been prepared pursuant to Section 7(a)(2) of the ESA of 1973, as amended, (16 U.S.C. § 1531 et seq.), to evaluate the potential effects of the continued operation of Reclamation's Project on species listed as threatened or endangered under the ESA and on designated critical habitat. The Project is located in south-central Oregon and northeastern California and contains approximately 230,000 acres of irrigable land. Reclamation stores, diverts, and conveys waters of the Klamath and Lost rivers to meet authorized Project purposes and contractual obligations in compliance with state and federal laws and carries out the activities necessary to maintain the Project and ensure its proper long-term functioning and operation. This Proposed Action is intended to last a total of 5 years, both to allow monitoring and analysis of changes due to removal of PacifiCorp's four hydropower facilities on the Klamath River and reconnection of Agency Lake Ranch-Barnes Ranch to UKL as well as to provide adequate time to conduct a new follow-on ESA consultation effort. This Proposed Action, therefore will act as a "bridge" from the existing BiOps and the subsequent IOP to a longer-term BiOp in the future after the effects of dam removal and reconnection of Agency-Barnes are more fully known.

Major sections of the Proposed Action include:

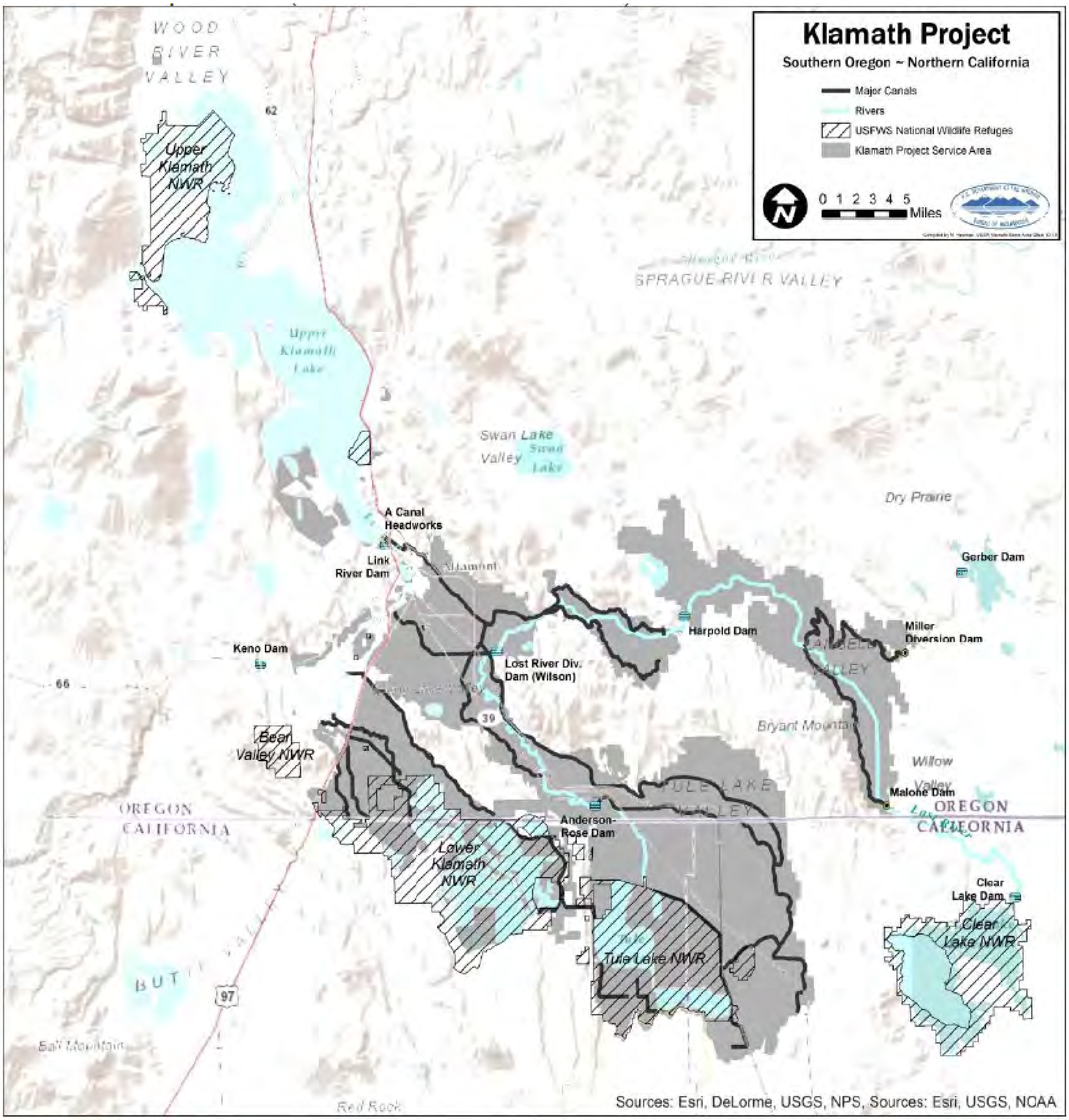
- Modeling of Proposed Action
- Proposed Action vs. Interim Operations Plan
- Operation and Maintenance Activities
- Compliance Monitoring
- Adaptive Management

Significant changes from the 2018 Biological Assessment include:

- Flows based on Normalized Wetness Index, UKL Status, and Operations Index
- Revised UKL bathymetry
- Compliance point for Klamath River flows moved from IGD to Keno Dam
- Implications of Agency-Barnes reconnection to UKL
- Emphasis on adaptive management
- Water supply for Lower Klamath NWR and Tule Lake NWR

3.2 Action Area

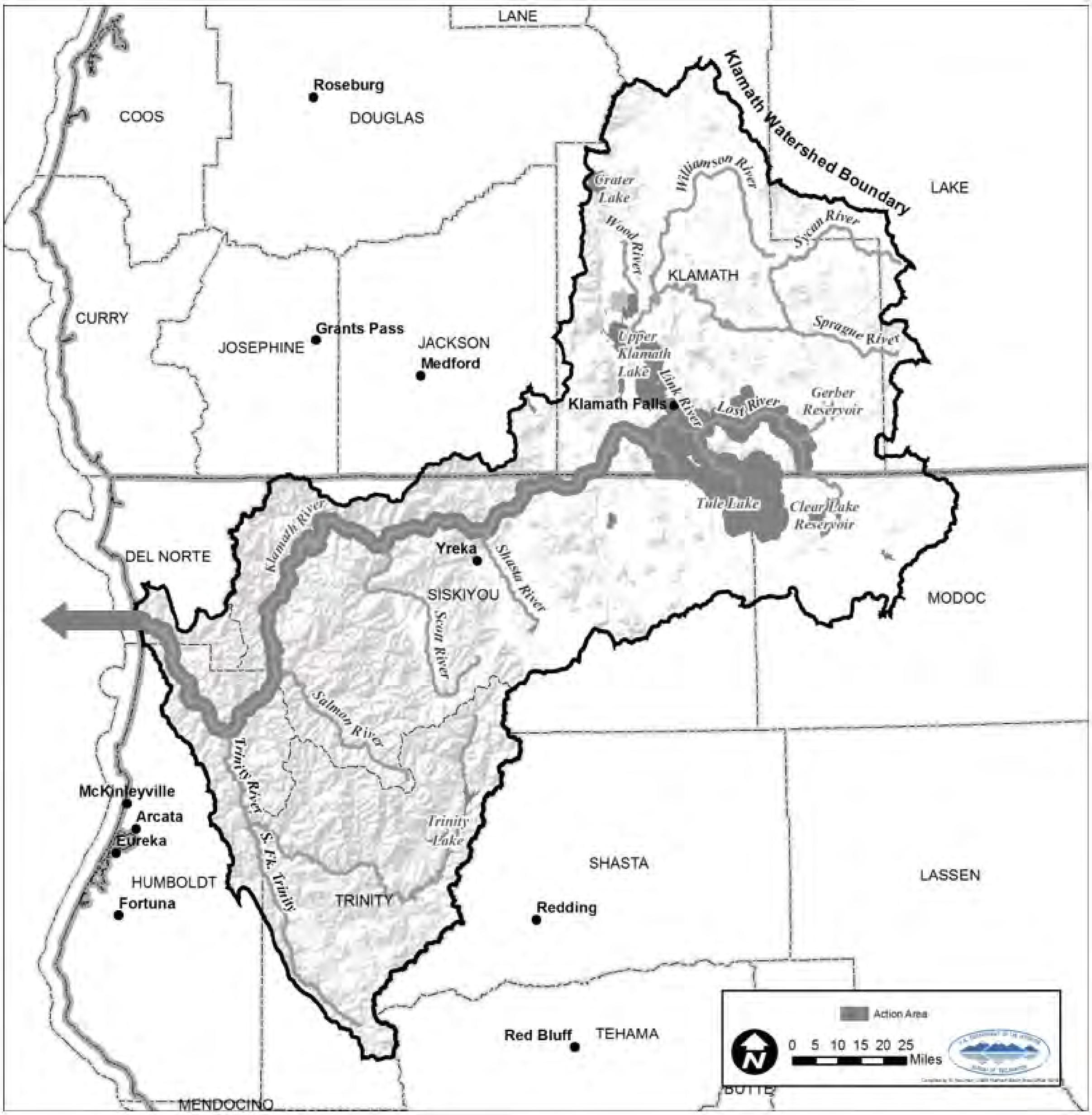
The Action Area includes "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action" (50 CFR § 402.02). Project lands are identified in Figure 3-1.



Notes: Klamath Project lands are shown as shaded area on the map. Source: Reclamation (2018)

Figure 3-1. Upper Klamath Basin of Oregon and California

The Action Area extends from UKL (that includes a reconnected Agency-Barnes wetland complex) in south-central Oregon, and Gerber Reservoir and Clear Lake Reservoir in the Lost River drainage in southern Oregon and northern California, to approximately 254 miles downstream to the mouth of the Klamath River at the Pacific Ocean, near Klamath, California (Figure 3-2). The Action Area specific to the SRKW extends out into the Pacific Ocean where SRKW feed on concentrations of adult Chinook Salmon (Section 7.1.6). This Action Area extends to that section of the ocean where there is species overlap between Chinook Salmon and SRKW. The exact boundaries of this area cannot be defined based upon current information.



Source: Reclamation (2018)

Figure 3-2. Map of the Action Area

Altogether, the Project provides water for irrigation purposes to approximately 230,000 acres of land, including federally owned lands within Lower Klamath and Tule Lake NWRs (see Section 2.4.4, regarding NWRs and associated acreages within the Project). Most of the 230,000 acres are served from UKL and the Klamath River and primarily include KID, Tule Lake Irrigation District (TID), and Klamath Drainage District (KDD). Approximately 20,000 acres are served from Clear Lake and Gerber reservoirs, primarily Langell Valley Irrigation District (LVID) and Horsefly Irrigation District (HID), although stored water from Clear Lake and Gerber reservoirs can be used under certain circumstances to meet irrigation demands in portions of the area served from UKL and the Klamath River.

Within the Upper Klamath Basin, the Action Area includes Agency Lake, UKL, Keno Impoundment (Lake Ewauna), Lost River including Miller Creek, and all Reclamation-administered facilities, including reservoirs, diversion channels and dams, canals, laterals, and drains, including those within Tule Lake and Lower Klamath NWRs, as well as all land, water, and facilities in or providing irrigation or drainage for the service area of the Project.

Effects of the Proposed Action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. (50 CFR § 402.02). This Biological Assessment considers both direct and indirect effects for the purpose of analyzing potential species impacts.

The effects of Project operations extend downstream from UKL to Keno Dam, which will be the new compliance point for Klamath River flows. There are direct effects on listed suckers throughout the Action Area above Keno Dam, although measures such as fish screens at the A Canal and Clear Lake Dam, and a fish ladder at the LRD reduce these effects. Salmon may also be affected downstream of Keno Dam due to flow reductions and at Keno Dam due to fish passage limitations at the ladder and potential entrainment at unscreened Project facilities within the Keno Impoundment, as salmon return to the Upper Klamath Basin following the removal of impassable dams in the Klamath River.

The Action Area specific to the SRKW extends out into the Pacific Ocean where SRKW feed on concentrations of adult Chinook Salmon (Section 7.1.6). This Action Area extends to that section of the ocean where there is species overlap between Chinook Salmon and SRKW. The exact boundaries of this area cannot be defined based upon current information.

3.3 Proposed Action

Reclamation’s proposed Project operations from completion of environmental compliance (currently estimated to be no sooner than November 1, 2024), to October 31, 2029, consists of the following three major elements:

1. Store waters of the Upper Klamath Basin and Lost River
2. Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes, subject to water availability, while maintaining UKL and Klamath River hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat
3. Perform O&M activities necessary to maintain Project facilities to ensure proper long-term function and operation

Each of the elements of the Proposed Action is described in detail in Sections 3.3.1, 3.3.2, and 3.3.3.

Reclamation has managed UKL elevations and Klamath River flows at IGD in accordance with a series of BiOps from the Services. For the 2018 Biological Assessment, Reclamation, in consultation with the Services, used the Klamath Basin Planning Model (KBPM) to simulate operations of the Project for the 1981 through 2016 period of record of historical hydrology for development of the proposed action. For the current consultation effort, Reclamation has incorporated recent hydrologic data to expand the period of record from 2016 through 2022 (i.e., 1981 to 2022). Although the current Biological Assessment simulates conditions since 1981, daily and monthly exceedances are computed using the 1991-2022 period. This 30-year period is more consistent with other climatological data, such as the National Weather Service normal, and acknowledges that decade-by-decade inflows have decreased (Figure 3-3). Extending the data set through 2022 captures the drought period that occurred during water years 2020-2022.

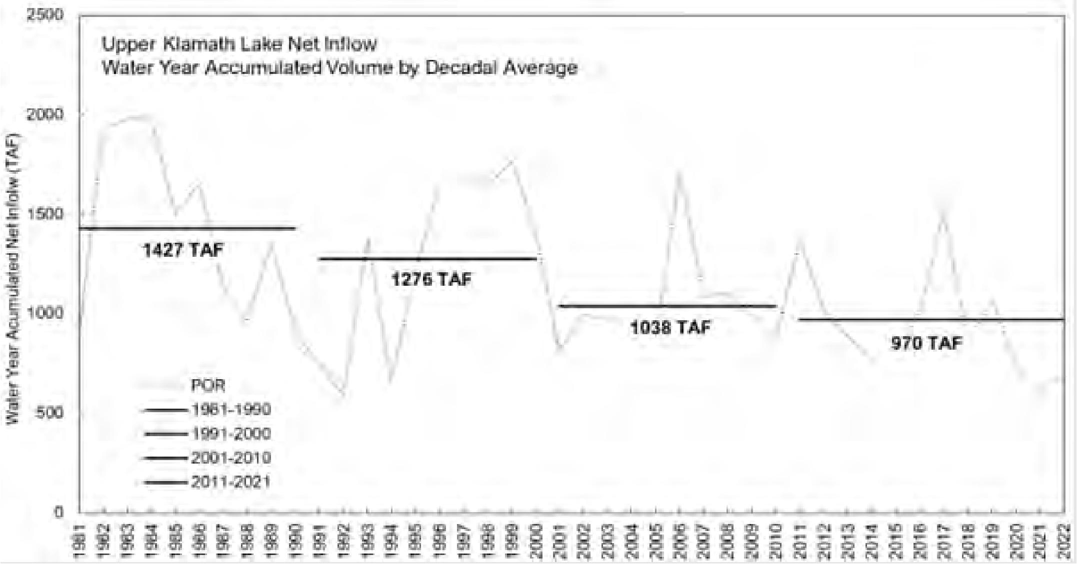


Figure 3-3. Decreasing trend in Upper Klamath Lake total annual net inflow since water year 1981 as indicated by decadal average

Reclamation has made substantial improvements to the KBPM structure and has incorporated data updates and refinements, including: revised accretions and UKL inflow datasets, a new UKL bathymetric layer, updated UKL net inflow estimates for the period of record, and updated daily Project diversion data and return flows for the period of record. Project operations using facilities that store and divert water from UKL, the Klamath River, and the Lost River were simulated in the KBPM over a wide range of hydrologic conditions for the period of October 1, 1980, through November 30, 2022, using daily input data to obtain daily, weekly, monthly, and annual results for river flows, UKL elevations, and Project diversions, including deliveries to the Lower Klamath and Tule Lake NWRs. The resulting simulations produced estimates of the water supply available from the Klamath River system (including UKL) for the period of record. Under implementation of the Proposed Action, Reclamation will develop an operational model (i.e., the IGD calculator) that incorporates KBPM logic from the final Proposed Action model run titled 'Viewer_v11d for MST11b_DraftPA_Jan26' to be used for real-time operations.

It is important to note that the full effects of climate change during the term of this Biological Assessment are not completely understood. However, data suggests that the period of record includes a climate change signal to some extent, as shown by the drying trend in Figure 3-3. That trend is expected to continue as similar trends have been observed in the Pacific Northwest over the past several decades (Mote, 2003).

Elevations used in this section are referenced to Reclamation's datum for UKL, which is 2.01 ft lower than the North American Vertical Datum of 1988. Other Project facilities have their own unique datums as well.

A complete and detailed explanation of the Proposed Action and the updates to the KBPM used in development of the Proposed Action can be found below and in APPENDIX C .

3.3.1 Element One–Store Waters of the Upper Klamath Basin and Lost River

Reclamation operates three reservoirs for the purpose of storing water for delivery to the Project's service area: UKL, Clear Lake Reservoir, and Gerber Reservoir.

Bathymetric data compiled by Reclamation in 2023 for UKL (including nearshore areas such as Upper Klamath NWR, and Tulana and Goose Bay farms), including the reconnected Agency Lake/Barnes Ranch units of Upper Klamath NWR, have a combined "active" storage volume of 645,627 AF between the elevations of 4,136.0 and 4,143.3 feet above sea level (Reclamation datum), which is the historical range of water surface elevations within which UKL has been operated. Clear Lake Reservoir has an active storage capacity of 467,850 AF (between 4,521.0 and 4,543.0 feet above sea level, Reclamation datum). Of this, 139,250 AF is reserved for flood control between 4,537.4 and 4,543.0 ft.

Gerber Reservoir has an active storage capacity of 94,270 AF (between 4,780.0 and 4,835.4 feet above sea level, Reclamation datum). No storage capacity in Gerber Reservoir is reserved for flood control purposes.

Reclamation proposes to store water annually in UKL and Clear Lake and Gerber reservoirs with most inflow occurring from October through April. In some years of high net inflows or atypical inflow patterns (i.e., significant snowfall or other unusual hydrology in late spring/early summer), contributions to the total volume stored can also be significant in May and June. The majority of water deliveries occur during March through September, transitioning from live flow early in the season to storage in the latter months. Storing water through the winter and spring results in peak lake and reservoir storage between March and May. Flood control releases may occur at any time of year as public safety, operational, storage, and inflow conditions warrant.

The Project's primary storage reservoir, UKL, is shallow with approximately 6 ft (1.8 m) of usable storage when at full pool (approximately 645,627 AF). Gerber Reservoir also has limited storage capability. Clear Lake has somewhat more capacity but has never completely filled. Thus, UKL, Clear Lake, and Gerber Reservoir do not have the capacity to carry over significant amounts of stored water from one year to the next. UKL also has limited capacity to store higher than normal inflows during spring and winter months, because the levees surrounding parts of UKL are not adequately constructed or maintained for that purpose. Therefore, the amount of water stored in any given year is highly dependent on volume and timing of inflows in that year and, to a much lesser extent, preceding years. Because of this limited capacity in reservoirs, snowpack plays a large role in water supply within the Klamath Basin.

3.3.2 Element Two–Operation and Delivery of Water from Upper Klamath Lake and the Klamath River

Operate the Project, or direct the operation of the Project, in a manner consistent with state and federal law, for the delivery of water for irrigation purposes, subject to water availability and the terms of the Project contracts, and consistent with flood control requirements while maintaining hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat. The Project has two service areas: the east side and the west side. The east side of the Project includes lands served primarily by water from the Lost River and Clear Lake and Gerber reservoirs. The west side of the Project includes lands that are served primarily by water from UKL and the Klamath River, although Reclamation has made occasional allocations of stored water from the east side of the Project for uses or offsets on the west side of the Project. The west side also may use other sources of water from the east side, such as winter runoff and return flows. Return flows are diverted water that was not entirely consumed by irrigation practices. This excess diversion water drains off agricultural lands into catchments and is recirculated or returned to other points of diversion for reuse. The Project is operated so that flows from the Lost and Klamath rivers are controlled, except during flood operation and control periods. The Project was designed based on use of a given volume of water several times. Therefore, water diverted from UKL and the Klamath River for use within the west side may be reused several times before it discharges back into the Klamath River via the KSD. Return flows from water delivered from the reservoirs on the east side may also be reused several times.

The portion of the Project served by UKL and the Klamath River consists of approximately 230,000 acres of irrigable land, including areas around UKL, along the Klamath River (from Lake Ewauna to Keno), Lower Klamath Lake, and from Klamath Falls to Tulelake. Most irrigation deliveries occur between April and October, although water is diverted year-round for irrigation use within certain areas of the Project.

Stored water and live flow in UKL are directly diverted from UKL via the A Canal and smaller, privately-owned diversions. Consistent with state water law and, as applicable to the Project, the term “live flow” encompasses surface water in natural waterways that has not otherwise been released from storage (i.e., “stored water”). Live flow can consist of tributary runoff, spring discharge, return flows, and water from other sources such as municipal or industrial discharges (Reclamation, 2020a). The A Canal (1,150 cfs capacity) and the connected secondary canals it discharges into (i.e., the B, C, D, E, F, and G canals) serve approximately 71,000 acres within the Project. In addition to the A Canal, there are about 8,000 acres around UKL that are irrigated by direct diversions from UKL under water supply contracts with Reclamation.

In addition to direct diversions from UKL, stored water and live flow is released from UKL through LRD, for re-diversion from the Klamath River between Klamath Falls and the town of Keno. Water released from LRD flows into the Link River, a 1.5-mile river that discharges into Lake Ewauna, which is the upstream extent of the Klamath River. The approximately 16-mile section of the Klamath River between the outlet of Link River and Keno Dam is commonly referred to as the Keno Impoundment. Water elevations within the Keno Impoundment must be maintained within a relatively narrow range due to agreements with property owners whose lands were inundated by the construction of Keno dam.

There are three primary points of diversion along the Keno Impoundment that are used to re-divert stored water and live flow released from UKL via the LRD. Approximately 3 miles below the outlet of Link River, water is diverted into the LRDC where it can then be pumped or released for irrigation use either through the Miller Hill Pumping Plant or Station 48. The Miller Hill Pumping Plant (105 cfs capacity) is used to supplement water in the C-4 Lateral for serving lands within KID that otherwise receive water through the A Canal. KID operates and maintains the Miller Hill Pumping Plant. Water re-diverted into the LRDC can also be released through Station 48 (650 cfs maximum capacity), where it is then discharged into the Lost River below the Lost River Diversion Dam for re-diversion and irrigation use downstream. TID makes gate changes at Station 48 based on irrigation demands in the J Canal system, which serves approximately 62,000 acres within KID and TID. To the extent that live and return flows in the Lost River at Anderson-Rose Dam and the headworks of the J Canal (810 cfs capacity) are insufficient to meet associated irrigation demands and maintain Tule Lake Sump elevations, water is released from Station 48 to augment the available supply. In addition to Miller Hill and Station 48, there are other smaller, privately-owned pumps along the LRDC that serve individual tracts within KID.

The other two primary points of diversion along the Keno Impoundment that re-divert stored water and live flow from UKL are the North and Ady canals (200 cfs and 400 cfs capacity, respectively), which are operated by KDD. In addition to lands within the boundaries of KDD, the Ady Canal also delivers water to the California portion of Lower Klamath NWR. Together, the North and Ady canals deliver water to approximately 45,000 acres of irrigable lands in the Lower Klamath Lake area, including lands in KDD.

In addition to the lands served by the LRDC and Ady and North canals, Reclamation has entered into water supply contracts along the Keno Impoundment, including lands on the west side of the Klamath River and on Miller Island. These diversions require that the Keno Impoundment be operated within a narrow range of elevations. The area covered by Project contracts is approximately 4,340 acres, including lands within Plevna District Improvement Company (523 acres), Pioneer District Improvement Company (424 acres), Midland District Improvement Company (581 acres), and Ady District Improvement Company. Another 1,090 acres are covered under eight separate contracts, for lands currently within the Miller Island Refuge Area, managed by the ODFW. The remaining lands (1,285 acres) irrigated as part of the Project are privately owned. Reclamation estimates annual irrigation diversions associated with these lands under contract (excluding LRDC and North and Ady canals) to be approximately 8,000-15,000 AF, with the maximum duty allowed under Oregon law being 15,185.5 AF.

There are other irrigation diversions not associated with the Project in the Keno Impoundment, most notably Keno Irrigation District, encompassing approximately 3,600 acres. Reclamation estimates these non-Project irrigation diversions to be approximately 9,000-12,000 AF annually.

Reclamation assumes demands for irrigation supply and historical wetland habitat deliveries over the proposed lifetime of this Proposed Action are similar to those that have occurred in the 42-year period of record for water years 1981 through 2022. However, continued improvements in irrigation infrastructure and equipment combined with advances in irrigation practices and technology may help to reduce Project irrigation demand in the future. The irrigation “demand” is the amount of water required to fully satisfy the irrigation needs of the Project. While these historical demands are retained for analysis and comparison purposes, irrigation deliveries to the Project within this Proposed Action were modeled using the Agricultural Water Delivery Sub-model (see Reclamation, 2019, Appendix 4, Section A.4.4.4). The proposed modeled deliveries during this 42-year period of record generally fall within the range of historical Project deliveries. In addition, the period of record exhibits a large range of hydrologic and meteorological conditions, and the various modeled deliveries during this period are reasonably expected to include the range of conditions likely to occur during the proposed term of this Proposed Action.

3.3.3 Element Three–Operation and Maintenance Activities

This section outlines the O&M activities that are performed on Reclamation’s various features within the Project. Most of these activities have been ongoing throughout the history of the Project and have been implicitly included in previous consultations with the USFWS on Project operations (Section 1.5). With the anticipated transfer of ownership of Keno Dam to Reclamation, Keno Dam O&M activities have been added. Additionally, anadromous fish are expected to repopulate upstream of their previous extent at IGD. O&M of Keno Dam, the fish ladder at Keno Dam, fish screens, headgates, and canals owned by Reclamation will now be conducted in a way that minimizes impacts to listed species.

Reclamation has attempted to include all maintenance activities necessary to maintain Project facilities and to continue proper long-term functioning and operation. Reclamation also recognizes that this is not an exhaustive list and that there may be items that were inadvertently omitted. O&M activities are carried out either by Reclamation or through contract by the appropriate irrigation district according to whether the specific facility is a reserved or transferred work, respectively.

3.3.4 Dams and Reservoirs

Generally, Project facilities, including but not limited to Link, Keno, Clear Lake, Gerber, and Lost River Diversion dams, will continue to be operated consistent with all applicable federal laws and regulations. Specific operating characteristics are detailed below.

Keno Dam will become the new reference point for assessing Project compliance with Klamath River flow requirements as the lowest point of control for Project operations controlling flows in the Klamath River, post-removal of the four downstream Klamath Hydroelectric Project dams.

3.3.4.1 Exercising of Dam Gates

The gates at Gerber, Clear Lake, Link River, and Lost River Diversion dams are exercised bi-annually, before and after each irrigation season to be sure they properly operate. The approximate dates the gates are exercised are March to April 15 and October 15 to November 30, and potentially in conjunction with any emergency or unscheduled repairs. The need for unscheduled repairs is identified through site visits. Once identified, the repair need is documented and scheduled.

Exercising gates requires anywhere from 10 to 30 minutes depending on the facility. The gates at Gerber, Link River, and Lost River Diversion dams are opened, and water is discharged during the exercising process. To maintain required downstream flows, as one gate is closed another is opened by a corresponding amount. When exercising the gates at LRD, the Keno Impoundment elevation/storage would be drafted as needed to ensure NMFS' BiOp required flows at Keno Dam are met; once the dam exercise operation was completed, the drafted volume would be replenished by increased releases at LRD. The following information describes facility-specific maintenance activities performed when exercising gates:

- LRD will be operated by Reclamation similar to PacifiCorp operations. The dam is operated continuously due to the daily flows required from UKL to the Klamath River. As such, the gates are considered exercised whenever full travel of the gates and a minimum flow of 250 cfs is achieved; Reclamation will document these occurrences. The stoplog gates at LRD are not exercised annually and are typically only removed under flood control operations and during infrequent stoplog replacement. A review of O&M inspection should be performed every 6 years.
- Clear Lake Dam gate exercise activities include exercising both the emergency gate and the operation gate. Depending on water conditions, some water may be allowed to discharge to allow for sediment flushing. Flushing requires a release of flows that must be near 200 cfs for approximately 30 minutes. This activity occurs once a year generally between March and April and is contingent on Clear Lake Reservoir surface water level elevations.
- The frost valves at Gerber Dam are exercised annually to prevent freezing of dam components. Valves are opened sometime in the fall, when the risk of freezing begins, at

a flow rate of approximately 2 cfs and closed in the spring once persistent freezing temperatures have ceased.

3.3.4.2 Stilling Well Maintenance

Gage maintenance is required at various Project facilities to ensure accurate measurement of flows. Gage maintenance generally includes sediment removal from the stilling well, replacement of faulty equipment, modification and/or relocation of structural components, and/or full replacement of the structure, as necessary. Reclamation estimates that every 5 to 10 years, one structure is replaced. Stilling wells are cleaned once a year during the irrigation season, which typically runs from April 1 through October 15.

3.3.4.3 Other Maintenance

To determine if repair and/or replacement of dam components is necessary, activities may include land-based observation and/or deployment of divers. Divers are deployed at Clear Lake Reservoir, Gerber Reservoir, Lost River Diversion Dam, LRD, and Keno Dam every 6 years prior to the Comprehensive Facilities Review for inspection of the underwater facilities. In addition, at Gerber Dam, the adjacent plunge pool is de-watered approximately every 8 years for inspection of headgates, discharge works, and other components; fish salvage by Reclamation staff would be conducted for this effort. Through these inspections, if replacement is deemed necessary, Reclamation would evaluate the potential effects to federally-listed species and determine if additional ESA consultation would be required.

Design Operation Criteria, which outlines O&M guidelines for facilities maintenance is required at LRD, Keno Dam, Clear Lake Dam, Gerber Dam, and the LRDC gates. The Design Operation Criteria is used to develop Standard Operating Procedures for Reclamation facilities. The Standard Operating Procedures outline the maintenance procedures, requirements, and schedule. The activities address the structural, mechanical, and electrical concerns at each respective facility. Some of the components of facilities that require maintenance are typically reviewed outside of the irrigation season and include, but are not limited to, the following:

- Trash racks - Maintained when necessary and are not on a set schedule. Trash racks are cleaned and debris removed daily, and maintenance is specific to each pump as individual pumps may or may not run year-round. Cleaning can take anywhere from 1 to 8 hours.
- Fish screens (Section 3.6).
- Concrete repair occurs frequently and as needed (not on a set time schedule). The amount of time necessary to complete repairs to concrete depends on the size and type of patch needed.
- Gate removal and repair/replacement are performed when needed (i.e., no set time schedule). Inspections of gates occur during the dive inspection prior to the Comprehensive Facilities Review every 6 years. Gates are continually visually monitored.

Boat ramps and associated access areas at all reservoirs must be maintained, as necessary, to allow all weather boating access to carry out activities associated with O&M of the Project. If the boat ramp is gravel, it should be maintained on a 5-year cycle. If the structure is concrete, it should be maintained on a 10-year cycle. Maintenance can include grading, geotextile fabric placement, and gravel augmentation/concrete placement depending on boat launch type. Reclamation does not perform maintenance of boat ramps on a time schedule, but rather as needed.

3.3.5 Canals, Laterals, and Drains

All canals, laterals, and drains are either dewatered after irrigation season (from approximately October 15 through April 15) or have the water lowered for inspection and maintenance every 6 years as required as part of the review of O&M or on a case-by-case basis. Inspection includes checking the abutments and examining concrete and foundations, mechanical facilities, pipes, and gates. The amount of time necessary for inspection is based on size and specific facility.

As with other typical facilities, the C Siphon, which replaced the C Flume in 2018, would be operated, maintained, and monitored in a similar manner. Along with the external inspection of the facility, maintenance staff would enter the siphon when de-watered to perform an inspection of the siphon’s internal features. Additionally, inspections of the concrete piers that support the siphon above the LRDC would be conducted. As necessary, hardware would be replaced throughout the life of the facility. Historically, dewatering of canals, laterals, and drains has included biological monitoring and (as needed) listed species salvage. This practice would continue under the current Proposed Action (Section 3.12).

The facilities are also cleaned to remove sediment and vegetation on a timeline ranging from annually to every 20 years. Inspections of all facilities take place annually. Inspections occur year-round or as concerns are raised by Project patrons; cleaning and maintenance takes place year-round on an as-needed basis. Cleaning the facilities may include removing sand bars in canals, silt from drains, or material filling the facilities. Animal burrows that may be impeding the facilities are dug up and compacted to repair them. Trees that are deemed to interrupt operations of facilities (and meet criteria outlined in the O&M guidelines) and/or pose a safety threat to the structural integrity of the facilities are removed and the ground returned to as close to previous conditions as practicable.

All gates, valves, and equipment associated with the facilities are to be exercised bi-annually before and after the irrigation season. Any pipes and structures located on dams or in reservoirs that are associated with irrigation facilities are replaced when needed and have an average lifespan of 30 years. Reclamation O&M staff replace approximately 10 sections of pipe per year and attempt to perform this maintenance activity when the canals are dry. The following information describes facility-specific maintenance activities performed when exercising gates:

- A Canal headgates include six gates that need to be checked. The A Canal headgates are only operated and exercised when the fish screens are in place. If the breakaway screens were to fail, the A Canal would still be operating until the screen is put back into place. This allows for uninterrupted operation at A Canal if a screen needs to be replaced to its previous position. Screens typically break once or twice a year (during normal operation). KID is notified through an alarm, and the screens are repaired at the earliest time practicable.

- The A Canal headgates are typically exercised in the spring (February through March timeframe) and fall (October through November timeframe). This activity occurs when the bulkheads are in place and the A Canal is drained and empty.
- The LRDC diagonal gates and banks should be inspected every 6 years. Review of O&M inspections alternate every 6 years and take place anywhere from October 15 through March 31. This inspection would require drawdown of the LRDC (i.e., drawdown at least once every 6 years; however, as maintenance requires, LRDC drawdowns may be more frequent). The drawdown of the LRDC would leave enough water to ensure that fish were not stranded during this activity. The appropriate drawdown level is coordinated by Reclamation O&M and fisheries staff. Biological monitoring would be incorporated, and, if necessary, flows would be increased for fish protection.
- The gates in the concrete structure in the railroad embankment immediately upstream of the Ady Canal are exercised annually. This activity includes closing and opening the gates and typically occurs in the July to September timeframe. All debris is also removed once a year, generally during the June through September timeframe.

3.3.6 Primary Fish Screen Maintenance

The A Canal fish screens have automatic screen cleaners. Cleaning is triggered by timing or head difference. When cleaned on a timer, the timing intervals are set at 12 hours, but intervals can be changed at (KID) operator’s discretion for a period defined by hours or on a continuous basis.

Fish screens at Clear Lake Dam are manually cleaned periodically when 6 to 12 inches of head differential between forebay one and forebay two is encountered. The need for cleaning the fish screen is dictated by water quality and lake elevation and varies from year to year. For instance, in some years, such as 2009, the screen was cleaned every other day beginning approximately the end of June/early July until it was shut off. In contrast, in 2011, no cleaning took place during irrigation season because the head differential never exceeded 0.3 foot. There is an extra set of fish screens that the Reclamation O&M staff uses during the cleaning process. The extra fish screen is lowered in place behind the first set of screens so that no fish can pass. The primary screens are then lifted and cleaned and then placed behind the second pair of screens in the lineup. This process is continued until all screens are cleaned. This process can take up to 10 hours. Upon completion, the remaining set is stored away until the next cleaning which is anytime a head difference of 0.5 foot occurs. During flood releases (when Clear Lake Reservoir elevations are 4,543.0 ft or above), fish screens would not be in place.

3.3.7 Fish Ladder Maintenance

LRD fish ladder gate exercise activities include exercising both the head gate and the attraction flow gate, which includes closing and opening the gates and physical inspection of the ladder. This activity occurs twice annually and generally occurs in the February/March timeframe and again in the November/December timeframe. The amount of time necessary for the gates to be exercised is no longer than 15 minutes. This activity includes biological monitoring by Reclamation staff biologists.

3.3.8 Roads and Dikes

Road and dike maintenance, including gravel application, grading, and mowing, occurs as necessary from April through October. Pesticides and herbicides are also used on Reclamation managed lands, primarily canal rights-of-way to control noxious weeds. This activity typically occurs annually. Pesticide spraying occurs generally from February through October (in compliance with the Pesticide Use Plan) and is applied according to the label. Vegetation control occurs on facilities where necessary throughout the year. Techniques used to control noxious weeds may include cultural, physical, and chemical methodologies for aquatic and terrestrial vegetation. The effects of these activities have been evaluated in previous Section 7 consultations, and incidental take coverage was provided in the USFWS's BiOps (1995) and (2007d) dated February 9, 1995, and May 31, 2007, respectively. In both BiOps, the USFWS determined that the maintenance action of pesticide application would not jeopardize the continued existence of LRS and SNS. The products used for this maintenance activity are still being used to minimize take and are in compliance with current Integrated Pest Management Plans required by the Reclamation Manual's Directive and Standard ENV 01-01. At this time, there have been no changes to the action.

3.3.9 Pumping Facilities

All pumping plants are monitored yearly by visual evaluation. Dive inspections occur every 6 years according to the review of O&M inspection criteria. This activity would include dewatering of the adjacent facility and installation of coffer dams. Dive inspections and dewatering of the facilities typically occurs in the August to December timeframe. Biological monitoring occurs daily during the dewatering of the facility and has historically been, and will continue to be, incorporated into maintenance activities to ensure the protection of fish, as necessary. Aquatic weeds that collect on trash racks and around pump facilities are monitored continuously throughout the irrigation season and removed as needed. Weed removal typically occurs daily for those pumps that are operating continually through the season.

All pumps are greased, oil checked, cleaned, and exercised monthly if they are not in regular use. Pumps used for irrigation are maintained daily during the irrigation season. Drainage pumps would be maintained and operated daily, year-round. Pumps are greased and oiled according to the pump manufacturer's specifications. Excess grease and oil are removed and cleaned. When oil is being changed, oil spill kits are kept on site and used, as necessary.

Should a pump require repair, the pump chamber would be isolated from the water conveyance facility by placement of a gate, bulkhead, or coffer dam. The chamber would then be de-watered to allow for maintenance access. Appropriate staff would be on site to perform fish salvage, as necessary, during the de-watering process.

3.4 Modeling of the Proposed Action

As in the previous Section 7 ESA consultations on Reclamation Project operations, the KBPM was used to simulate operations under the Proposed Action. Various versions of the KBPM have been used for about 15 years, each based in the Water Resources Integrated Modeling System (WRIMS). This highly flexible modeling system enables implementation of operational alternatives in simulations. In the current re-consultation effort, removal of dams in the Klamath Hydroelectric Project required that the downstream-most compliance point be moved from the U.S. Geological Survey (USGS) gage below IGD (USGS Station ID#11516530) to the USGS gage below Keno Dam (USGS Station ID#11509500). As a result, the version of the KBPM developed in support of this re-consultation has been named the Keno Release Model (KRM) and is based on the model viewer entitled "Viewer_v11d for MST11b_DraftPA_Jan26, including two studies: MST11b_DraftPA_Jan26 and MST11b_DraftPA_PFoff_Jan26. The two studies are identical in rules, parameter settings, and results; however, one model study releases the Flexible Flow Account (FFA) in form of a pulse flow, and the other releases the FFA evenly over a longer period of time in the spring/summer.

The operational strategy embodied in the Proposed Action is described below. The description conforms to the operational rules used to simulate the Proposed Action in the KRM except in specific instances which will be highlighted and discussed. A detailed description of the KRM model simulation of the Proposed Action is provided in APPENDIX C .

The KRM includes the following critical assumptions:

- The Upper Klamath River Basin will experience water year types within the range observed in the period of record.
- UKL inflows will be within the range observed in the period of record.
- Normalized Wetness Index (NWI) inflow forecasts will be within the range and accuracy of historical inflow forecasts.
- Accretions below LRD and Keno Dam will be consistent with accretion timing, magnitude, and volume assumed in the KRM.
- Water deliveries to the Project will be consistent with distribution patterns analyzed for the KRM.
- Revised UKL bathymetry in the model is reasonably representative of actual UKL bathymetry and therefore accurately represents UKL storage capacity.
- The Agency Lake/Barnes Ranch units of Upper Klamath NWR will be reconnected to UKL at the outset of operations under this Proposed Action and was therefore modeled as being connected.
- Due to the removal of PacifiCorp's hydropower dams (Boyle, Copco1, Copco2, and IGD), the compliance point for discharges to the Klamath River is Keno Dam.

- Facility operational constraints and limitations, and/or associated maintenance activities, will be within the historical range for the period of record.
- Water deliveries to Project lands will be consistent with the contractual, ESA, and other obligations Reclamation set forth in the development of the Proposed Action.
- Reclamation will implement the Proposed Action as described to the greatest extent practicable. However, implementation of the Proposed Action may not exactly replicate the modeled results and actual Klamath River flows and UKL elevations may differ slightly during real-time operations.

The KRM shows the results of applying proposed operating rules to a broad range of hydrologic conditions over the 42-year period of record. A detailed description of the KRM model can be found in APPENDIX C .

3.4.1 Key Model Structural Variables

The KRM implements a consistent year-round operational strategy for making water management decisions focused on continuous tracking of the hydrologic conditions in the Upper Klamath Basin (NWI) and water storage conditions in UKL (UKL Status). These are then averaged into a single number, the Operations Index.

3.4.1.1 Normalized Wetness Index

Daily Version of the Normalized Wetness Index The NWI is a daily index expressing the hydrologic status (from dry to wet) of the Upper Klamath Basin that is used in two ways in the KRM. The continuous smoothed daily NWI is one component of the Operations Index, the main structural variable governing the movement of water in the KRM. Because the NWI was designed to track with UKL net inflow, with some modification from its daily form, it provides the means to forecast seasonal UKL net inflow volumes that are used in the KRM to allocate water to Project irrigation. This seasonal forecasting application of the NWI is described in APPENDIX C .

The daily NWI incorporates information about recent UKL net inflow volume (30-day trailing sum), longer term (31 to 1,095-day trailing sum) precipitation, current snowpack (snow water equivalent), and various combinations of climate indices for the Pacific Ocean (Pacific Decadal Oscillation index and Niño 3.4 index). Each of these variables is multiplied by a date-specific weight, then summed to compute the daily Wetness Index, which is then normalized. Date-specific weights are developed in a manner that yields NWI values that track with the 91-day forward sum of UKL net inflow. The end result is an index that tracks well with UKL net inflow volumes summarized over time periods different than that to which the daily NWI was optimized (Figure 3-4).

The NWI used for seasonal forecasting differs from the daily NWI in how the date-specific weights are developed. Seasonal forecasts of UKL net inflow used in the KRM include April-September totals forecasted on March 1 and April 1, and forecast date through September totals forecasted on April 15, May 1 and 15, and June 1. For each forecast date, the date-specific weights used in the NWI calculation are derived in a manner that yields forecasts tracking with the seasonal UKL net inflow volumes being forecasted. After the date-specific weights are determined and the NWI calculated, quantile regression is used to compute the 50% and 95% exceedance forecasts of seasonal UKL net inflow that are subsequently used in computing allocations for Project irrigation.

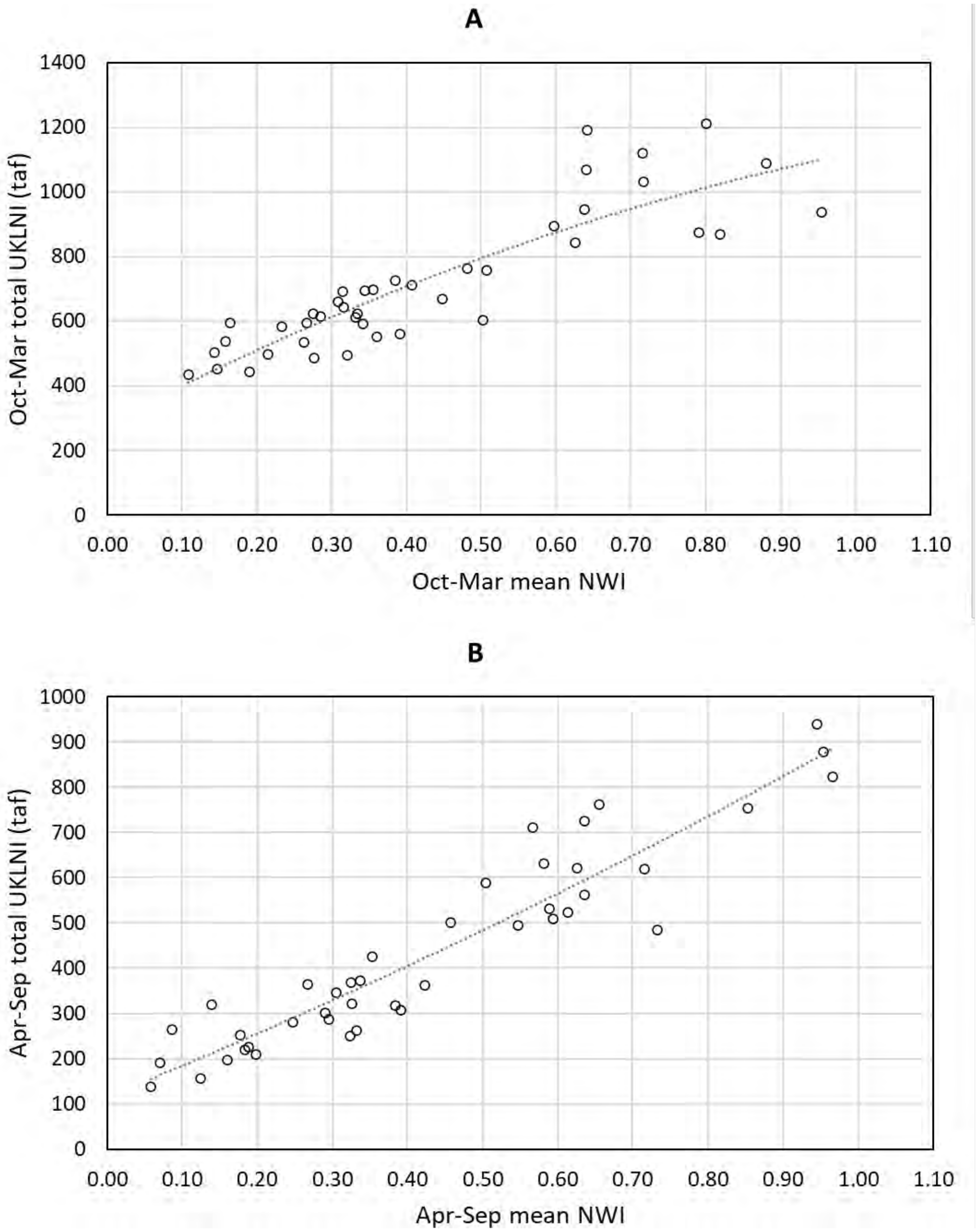


Figure 3-4. Daily Normalized Wetness Index averaged over fall-winter (A) and spring-summer (B) periods relative to the actual Upper Klamath Lake net inflow volumes for the same periods

A description of NWI computation for daily NWI values used in the Operations Index, as well as the NWI values used for seasonal forecasting, is provided in APPENDIX C .

Seasonal Version of the Normalized Wetness Index In past BiOps, spring/summer water allocations to the Klamath River and agriculture relied heavily on seasonal water supply forecasts from the Natural Resources Conservation Service (NRCS). These water supply forecasts were developed using principal components regression analysis based on antecedent streamflow conditions, precipitation, snowpack, temperature, and water levels in a monitoring well (Risley et al., 2005). Forecast error played a large role in how well the overall water management system functioned, since the allocations were made and fixed in the spring. NRCS intends to issue seasonal UKL net inflow forecasts using a machine-learning model beginning in 2024.

The recent revision of the UKL bathymetry (Hollenback et al., 2023) forced recalculation of the UKL net inflow time series. NRCS is working to reconstruct the forecasts that would have been made over the period of record from water years 1981-2023 if their machine-learning model had been used. The California Nevada River Forecast Center (CNRFC) forecasting model should also be recalibrated to the revised net inflow time series before their forecasts are used in Proposed Action operations.

A Hydro Team, consisting of federal agency personnel and stakeholders, was formed to consider potential modifications to the IOP model structure in use since 2020. As a result, a NWI was developed for use in the fall-winter (FW) period. Since then, the NWI has been developed into a year-round daily index that forms half of the Operational Index, from which many decisions are based on in the Proposed Action. Because of the obvious potential to use the NWI in forecasting, a version of the NWI was developed specifically for use in seasonally forecasting UKL net inflow volumes. The seasonal version of the NWI relies upon the same variables as the daily version except for the treatment of climate indices.

In the Proposed Action, seasonal forecasts of net inflow into UKL are used only to determine allocations to Project irrigation. Because of the very recent change in the UKL net inflow time series, the NWI is the only forecast model that has been calibrated using the new net inflow time series. Therefore, the KRM presently uses only the NWI to forecast UKL net inflows and calculate the seasonal progression of water volumes available for irrigation use. However, the KRM is structured to use the NRCS, CNRFC, and NWI models for forecasting either individually or in combination. Combined forecasts consist of an average weighted by the reflection of the mean absolute error (MAE) associated with each forecast model. The reflection is a simple transformation that flips the model-specific MAE relative to the mean of all the models so that the reflected MAE for the best performing model (i.e., the smallest MAE) will be the largest weight when combining the forecasts. Combined forecasts among some or all of the three main forecasting models frequently outperformed the individual models when this KRM component was built prior to the change in the UKL net inflow time series, and this will likely be true using the recalibrated models as well.

Table 3-1 and Table 3-2 compare the absolute values of the errors (actual – forecast) from the three forecast models. This is not yet an apples-to-apples comparison, because the NRCS and

CNRFC forecasts are made for, and errors are computed from, the UKL net inflow time series used before the recent revision, whereas the NWI-based forecasts and errors use the revised UKL net inflow time series. Nonetheless, these comparisons illustrate the kind of evaluation that should be performed before finalizing the selection of forecast model products for use in the Proposed Action. Note that in this imperfect comparison, the NWI outperforms the other two models for the May 1 and June 1 forecasts and is intermediate for the April 1 forecast (Table 3-1 and Table 3-2), but on each date a combination of forecasts performs the best.

Table 3-1. Mean absolute errors of seasonal Upper Klamath Lake net inflow forecasts among the three forecast models and the best performing combination of the three models

Source	Mar 1 Apr-Sep	Apr 1 Apr-Sep	Apr 15 Apr 15-Sep	May 1 May-Sep	May 15 May 15-Sep	Jun 1 Jun-Sep
NRCS	-	47	-	38	-	20
CNRFC	-	54	-	41	-	27
NWI	72	50	40	32	31	16
Best combined	-	39	-	30	-	15

Table 3-2. Mean absolute percentage errors of seasonal Upper Klamath Lake net inflow forecasts among the three forecast models and the best performing combination of the three models

Source	Mar 1 Apr-Sep	Apr 1 Apr-Sep	Apr 15 Apr 15-Sep	May 1 May-Sep	May 15 May 15-Sep	Jun 1 Jun-Sep
NRCS	-	12.0%	-	15.7%	-	15.6%
CNRFC	-	14.1%	-	16.3%	-	19.9%
NWI	21.7%	13.3%	12.4%	14.4%	17.9%	15.7%
Best combined	-	10.6%	-	12.2%	-	12.3%

When the NRCS and CNRFC have finished reconstructing their forecasts, Reclamation and the Services will evaluate the forecast characteristics and the effects on the Proposed Action outcomes of using the best performing model or combination of models in the KRM. Reclamation and the Services will seek agreement on the specific forecast model or combination of models to be used for updating forecasts every 2 weeks from April 1-June 1. Until then the Proposed Action will use the NWI-based forecasts.

Reclamation and the Services will evaluate the performance of the forecast combinations each year and decide whether changes from the previous year should be made.

3.4.1.2 Upper Klamath Lake Status

In addition to tracking the hydrologic condition of the Upper Klamath Basin using the NWI, the storage condition of UKL is another important consideration for water management. Before describing it, however, it is important to understand the use of shadow UKL levels in the KRM. As described in Section 3.4.1.4, the KRM implements a deferred use operation (FFA) for river flow through Keno Dam in which a specified proportion of calculated releases during October 1 through March 1 is stored in UKL for use during March 2 through June. A similar deferred use operation is employed for Project irrigation (Deferred Project Supply [see Section 3.4.2.4 for Deferred Project Supply definition]) in which inflows or return flows from the Lost River and F/FF pumps (located on the Klamath Straits Drain, which drains KDD and Lower Klamath NWR) that are discharged from the Project to the river to contribute to targeted releases from Keno Dam (when neither LRD nor Keno Dam is spilling) that can offset releases from UKL, accruing a volume there that can be used by irrigators, with specific approval by Reclamation, during the irrigation season. Deferred Project Supply can also be accrued when UKL water that is set aside for maintaining Sump 1A in Tule Lake NWR and Unit 2 in Lower Klamath NWR is replaced by inflows or return flows from the Lost River and F/FF pumps when neither dam is spilling.

Each of these deferred use operations is intended to provide flexibility to those using the water and is designed to have no or minimal impact on how water is used by other system components at any point in time. To achieve that end, a water accounting structure keeps daily track of what UKL levels would be if the deferred use operations were not occurring—this is called the UKL shadow level. By using the UKL shadow level to determine the UKL Status, and hence the Operations Index, the deferred use operations can proceed in a flexible manner without affecting the Operations Index which is a key component in the computation of river releases, Project irrigation allocation, etc. For example, if the FFA results in an extra 20,000 AF remaining in UKL, this would normally cause higher releases from UKL due to the greater volume. That would negate the benefit of retaining the extra water for later use. Thus, the shadow level tracking.

In the KRM, lower and upper bounds are set on UKL shadow levels, and daily UKL Status is calculated as the relative position of UKL shadow level (*L*) on day *d* between the specified lower (low) and upper (up) bounds for water years 1991-2022 using Equation 1:

$$UKL\ Status_d = \left(\frac{L_d - L_{low}}{L_{up} - L_{low}}\right) \tag{1}$$

When L_d is at or above the upper bound, UKL Status will be one, and when L_d is at or below the lower bound, UKL Status will be zero. The lower bound is established as the 95% exceedance UKL shadow level on the first day of each month (interpolated for other days) as computed from the output of a particular simulation. Similarly, on the first day of each month (interpolated for other days), the upper bound is the flood release curve (Figure 3-5) minus 0.2 ft during December-March but is otherwise the highest simulated UKL shadow level. The upper and lower bounds are determined iteratively by repeatedly running the KRM and recalculating the lower and upper bounds for each iteration using the results from the prior simulation. After several iterations, the upper and lower bounds stop changing significantly.

UKL bounds do not prevent UKL levels from moving above or below them; they are not lake level requirements. Rather, they specify the UKL shadow level at which and below the UKL Status will be zero, or at which and above the UKL Status will be one. The upper and lower bounds used in the KRM for the Proposed Action are in Figure 3-5. Additional information on flood control curves is found in APPENDIX C – 1.3.

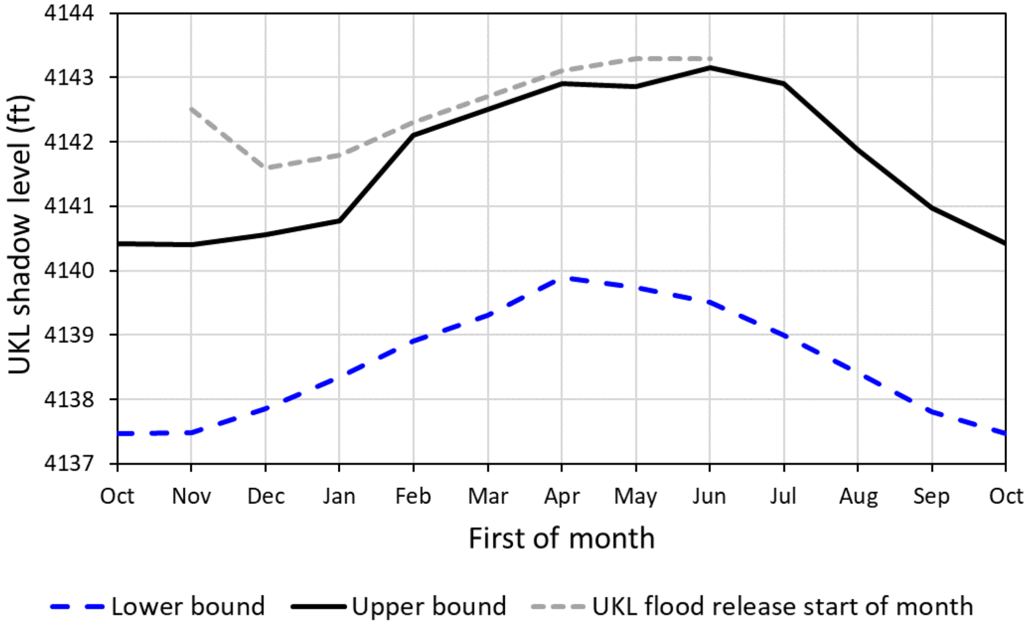


Figure 3-5. Lower and upper bounds used for computing UKL Status, and the winter/spring flood release curve for Upper Klamath Lake

3.4.1.3 Operations Index

The Operations Index is the main structural variable governing the movement of water in the KRM. The KR model calculates the Ops Index on a daily basis as the average of the other two indices tracking hydrologic conditions (NWI) and storage in UKL (UKL Status). The hydrologic status of the Upper Klamath Basin is estimated using a daily NWI that is smoothed using a 14-day trailing average for use in the KRM. UKL storage conditions (elevations) are tracked by the daily UKL Status Index. Operations Index values range from 0 (driest, lowest storage) to 1 (wettest, highest storage) because the average of the NWI and UKL Status is rescaled (normalized).

In the KRM, normalized variables are rescaled to the minimum and maximum values for water years 1991-2022 using Equation 2:

$$Normalized_i = \left(\frac{X_i - X_{min}}{X_{max} - X_{min}}\right) \qquad (2)$$

Where i is day of the water year and min/max are the minima/maxima for day i over water years 1991-2022. This simple rescaling of variables retains the relative patterns within each variable while ensuring that the normalized variable is zero when the raw variable is at the minimum, and one when the raw variable is at the maximum.

In water years 1981-1990, which are also simulated, normalized variables are constrained to be no lower than 0 and no higher than 1, because the raw variable may in these years be lower or higher than the daily minimum or maximum from 1991-2022. The same approach is used for the NWI and UKL Status variables.

The Operations Index tracks consistently with UKL net inflow over seasonal periods. For example, October-March and April-September average Operations Index values show clear relationships to similarly averaged UKL net inflow volumes (Figure 3-6).

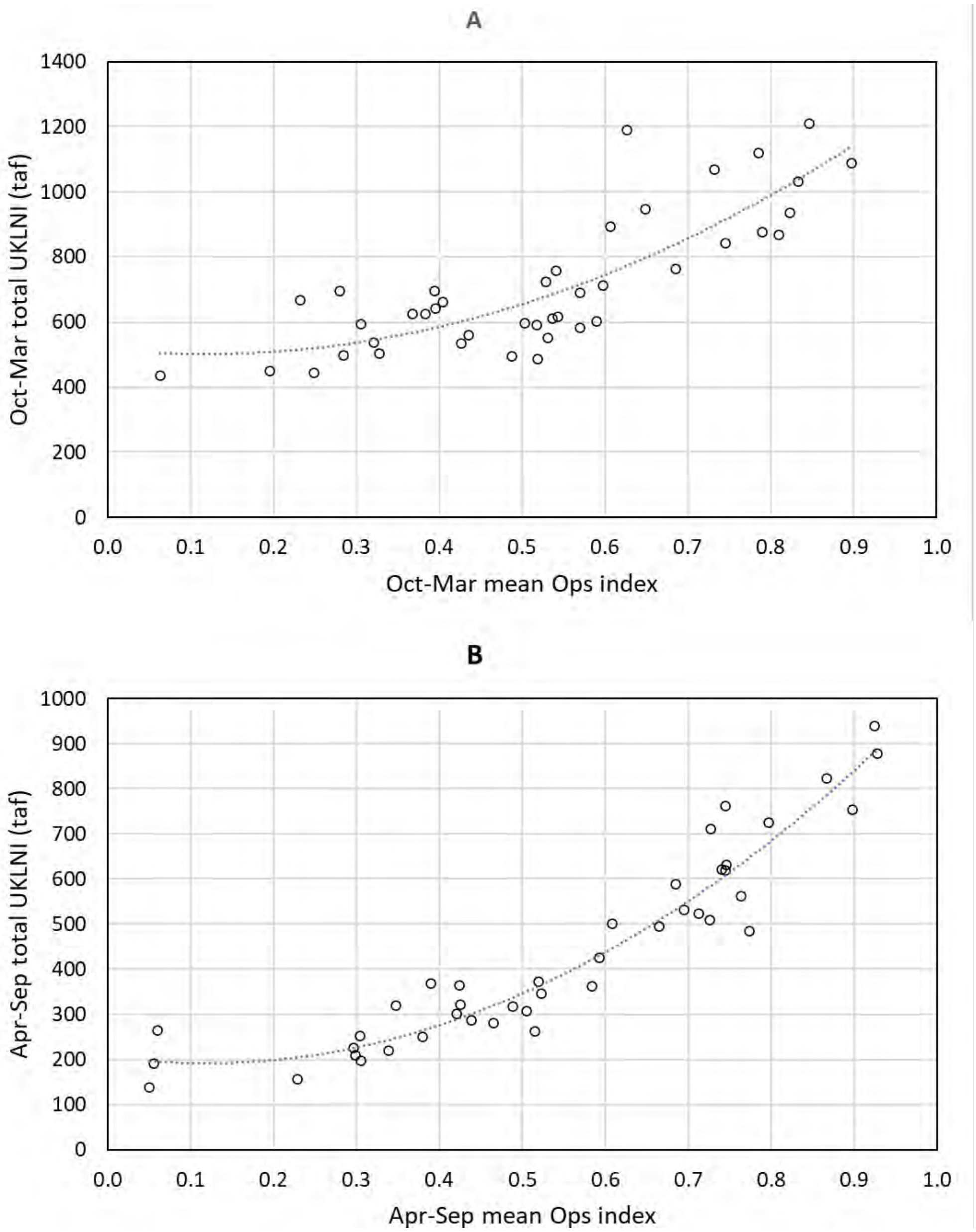


Figure 3-6. Seasonal relationship between the mean Operations Index and Upper Klamath Lake net inflow volume for October-March (A), and April-September (B) in the Proposed Action

3.4.1.4 Releases from Keno Dam to the Klamath River

A daily River Base Flow (RBF) regime for Keno Dam releases was established by specifying base flows for the center 15 days of each month and interpolating flows for the remaining days (Figure 3-7). The RBF is the lowest flow that will ever be targeted for release from Keno Dam on any given day of the year, which would occur only when the Operations Index or the Keno Release Multiplier (KRmult) is 0. On each day (d) a Keno Release Multiplier is selected based on the Operations Index and the current month (Table 3-3), and the Keno Release Target is computed:

$$Keno\ Release\ Target_d = RBF_d + (RBF_d \times KRmult_d) - FFAinc_d + FFAuse_d \qquad (3)$$

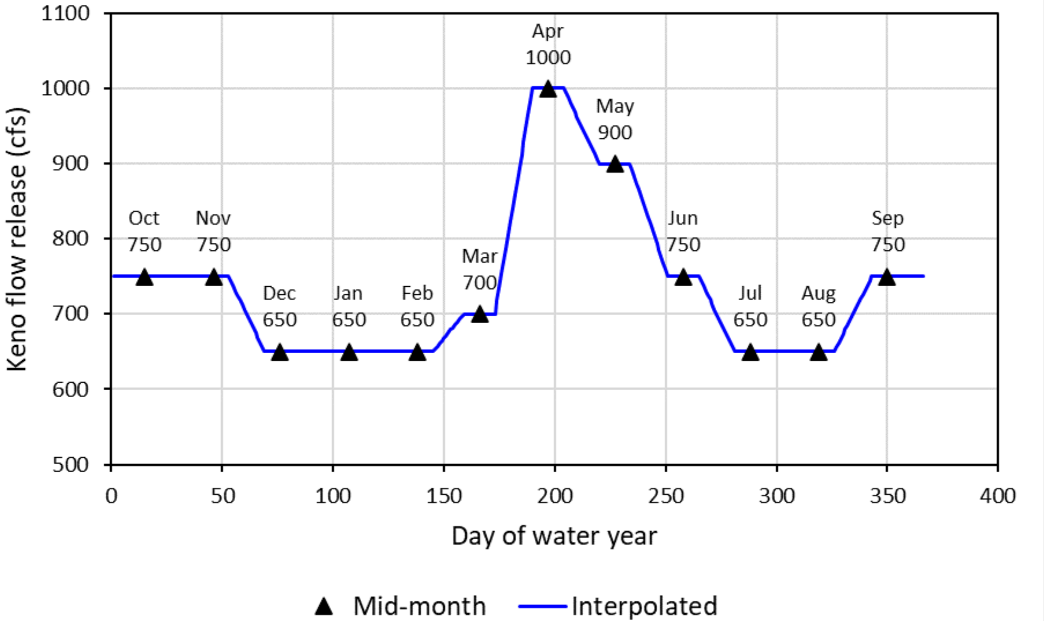


Figure 3-7. River Base Flows specified for 15 days centered on the fifteenth day of each month, with daily flows linearly interpolated between these periods

Table 3-3. Keno Release Multiplier lookup table used by the Keno Release Model

Operations Index	Oct	Nov	Dec-Feb	Mar	Apr	May	Jun	Jul-Sep
0	0	0	0	0	0	0	0	0
0.2	0.06	0.06	0.07	0.17	0.14	0.11	0.14	0
0.4	0.09	0.09	0.16	0.35	0.27	0.4	0.17	0.01
0.6	0.14	0.16	0.6	0.93	0.62	0.74	0.33	0.05
0.8	0.34	0.6	2.05	2.49	2.19	1.73	0.72	0.23
1	1.08	2.43	4.78	6.28	5.3	4.18	2.5	0.68

Note: Each day the Operations Index is computed and used to look up the associated multiplier values (interpolated as necessary).

An FFA operation is used in the KRM that defers use of some water targeted for release to the River during FW ($FFAinc_d$), storing the accumulating volume in UKL during the October 1-March

1 accrual period. Then during March 2-June 30, the stored FFA water ($FFAuse_d$) is used in a manner that can vary each year. Key elements of this operation include the FFA reserve proportion (used to compute $FFAinc_d$) determined by the value of the Operations Index (Table 3-4), and the expectation that the full FFA volume will be released from Keno Dam to the Klamath River each year during the release period of March 2-June 30. When the Operations Index exceeds 0.7, the FFA reserve proportion declines to zero, because with wetter conditions comes less need to augment flows or to shape a discrete event like a pulse flow. However, if the Operations Index drops back down below 0.7, the FFA will resume accrual once again as long as it is still within the accrual period. Also, in years when the Operations Index exceeds 0.7 and FFA ceases to accrue, the accrued volume does not disappear (unless it is spilled) and is designated for release between March 2-June 30.

Table 3-4. Flexible Flow Account reserve proportion lookup table for the Keno Release Model

Operations Index	FFA Reserve Proportion
0	0.9
0.6	0.7
0.7	0
1	0

Note: Reserve proportions are interpolated to correspond with the computed Operations Index.

Use of the FFA volume ($FFAuse_d$) may take different forms year to year. Pulse flows may be implemented from the FFA volume or the volume may be used to augment flows. Two simulations of the Proposed Action (MST11b_DraftPA_Jan26 and MST11b_DraftPA_PFoff_Jan26) have been prepared to illustrate the flexibility intended for the use of the FFA. In one (MST11b_DraftPA_Jan26), a pulse flow operation is implemented annually based upon a set of criteria intended to provide a realistic (but not prescriptive) representation of how pulse flows could be implemented. In the other simulation (MST11b_DraftPA_PFoff_Jan26), no pulse flows are implemented and the FFA volume is added to the Keno Release Targets according to one of many possible distribution shapes.

The conditions governing pulse flow operations in the KRM are not intended to constrain real-time operations. Operationally, sizing the peak release based on ramping rates (which typically govern the declining limb of the pulse flow) and release targets immediately before the pulse flow must be done in a manner that prevents using more volume for the pulse flow event than is available in the FFA. If the entire FFA volume is not consumed during implementation of a pulse flow, the remainder of the FFA volume will be used in a manner agreed upon by Reclamation, NMFS, and USFWS.

Flood control releases from LRD or Keno Dam will stop the accrual of FFA volume. Flood control releases from LRD will spill the stored FFA volume after the Deferred Project Supply volume (another deferred use operation; Section 3.4.2) has been spilled.

3.4.1.5 Keno Operations

Given that Keno Dam is the new compliance point under this Proposed Action, Reclamation will make flow release adjustments as needed at LRD and/or Keno Dam to ensure that average daily Keno release target flows are met or exceeded. This includes periods when the monthly minimum Keno Base (Figure 3-7) is being released, when daily Keno releases above the Keno Base (Keno base x Keno Release Multiplier) are prescribed/required, or when the FFA is being released for pulse flows or augmentation. The latter actions may require multiple adjustments within a day, whereas the former may not require any adjustments for days. Reclamation's Proposed Action assumes the proposed daily average Keno Dam releases are targets that Reclamation will follow to the greatest extent practicable and will only make flow adjustments when daily Keno Release Targets vary by 25 cfs or greater due to operational constraints and streamflow gage precision (i.e., the smallest possible incremental flow adjustment at LRD and Keno Dam is 25-30 cfs).

Reclamation acknowledges that there are many points of diversion as well as return flows in the Keno Impoundment reach (LRD to Keno Dam) that could have considerable negative or positive impacts on Link River releases intended to meet target Keno releases. Accordingly, Reclamation is committed to close coordination with the water users in the Keno Impoundment reach to ensure that those Project operations/diversions do not prevent Reclamation from meeting its ESA obligations in terms of Keno Releases to the Klamath River. Additionally, Reclamation has committed to operating the Keno Impoundment within a one-foot elevation range, itself within the historical 1.5-foot operating range used by PacifiCorp (Reclamation 1967, PacifiCorp and Reclamation, 2022).

Facility control limitations, changing accretions/diversions between LRD and Keno Dam, wind effects on UKL and Lake Ewauna, and stream gage measurement error may limit Reclamation's ability to manage precise releases from Keno Dam. In addition, facility control emergencies and maintenance may arise that warrant a temporary reduction in the proposed Keno releases. Therefore, Reclamation recognizes that minor variations in Keno Dam releases (within 5% of daily average targets) may occur for short durations and that all daily Keno Dam releases proposed above are targets. Reclamation anticipates that there may be unique conditions that may result in deviations from proposed Keno releases greater than 5% due to facility control limitations, stream gage error, maintenance of facilities (including replacement of fish tracking antenna arrays in the river), and/or emergency situations. However, these deviations are expected to occur infrequently, and in coordination with NMFS, will be corrected as quickly as practicable.

For the reasons described above, Reclamation proposes to allow a maximum reduction of 5% below the daily required Keno Dam target releases, not to exceed 48 hours in duration, unless otherwise coordinated with NMFS. Additionally, Reclamation proposes to perform Keno Dam release volumetric evaluations at least biweekly to ensure that the required flow volume released at Keno (based on the formulaic distribution of Keno Dam releases as informed by the KRM's Operations Index) is reconciled so that the total flow volume released at Keno is equal to the required flow volume that should have been released for a given period under the Proposed

Action. Under circumstances where the Keno Dam release flow volume for a given day or week is greater than required under the anticipated BiOp from NMFS, Reclamation may reduce daily Keno flow releases by up to 5% to recover the volume of water that was over-released from Keno, above what was required in NMFS' BiOp. Regardless, flows will not be reduced below Keno base flow minimums. Under circumstances where the Keno Dam release flow volume for a given day or week is less than what was required to be released, there is no limit on the magnitude of the subsequent, corresponding flow increases to reconcile the difference between required, and released flow volumes for a given period.

3.4.1.6 Ramp Rates

Ramp rates limit rapid fluctuations in streamflow downstream of dams. Reclamation proposes to implement the down-ramping rates used in the KRM that includes a ramping rate structure that varies by release rate at Keno Dam. The proposed KRM ramp rates at Keno Dam were designed to approximate ramp rates at the Iron Gate gage similar to those required under previous BiOp, including 2019 (Table 3-5). Keno Dam is anticipated to be owned and operated by Reclamation by the time of implementation of this Proposed Action, and the ramp rates will be implemented by Reclamation as part of Keno operations.

Table 3-5. Ramp rates for releases from Keno Dam under the Proposed Action compared to those for releases from Iron Gate Dam under previous Biological Opinions

Keno Release Threshold (cfs)	**Keno Ramp Rate (cfs/day)**	**IGD Release Threshold from IOP (cfs)**	**IGD Ramp Rate (cfs/day)**
<1,400	150	<1,900	150
<2,800	300	<3,300	300
<3100	600	<3600	600
<3500	$C13_{-1}$ - 2,500	<4000	$C15_{-1}$ - 3,000
<4100	1,000	<4600	1,000
≥4,100	min(2,000, $C13_{-1}$ - 3,100)	≥4,100	min(2,000, $C15_{-1}$ - 3,600)

Note: $C13_{-1}$ and $C15_{-1}$ are the prior day releases from Keno Dan and IGD, respectively.

The target ramp-down rates at Keno, when possible, are as follows:

- When Keno flows are greater than or equal to 4,100 cfs: decreases in flows of 1,000-2,000 cfs per 24-hour period and no more than 500 cfs per 6-hour period
- When Keno flows are less than 4,100 cfs but equal to or greater than 3,500 cfs: decreases in flows of 1,000 cfs or less per 24-hour period and no more than 250 cfs per 6-hour period
- When Keno flows are less than 3,500 cfs but equal to or greater than 3,100 cfs: decreases in flows of 600-1,000 cfs or less per 24-hour period and no more than 200 cfs per 6-hour period

- When Keno flows are less than 3,100 cfs but equal to or greater than 2,800 cfs: decreases in flows of 600 cfs or less per 24-hour period and no more than 150 cfs per 6-hour period
- When Keno flows are less than 2,800 cfs but equal to or greater than 1,400 cfs: decreases in flows of 300 cfs or less per 24-hour period and no more than 75 cfs per 6-hour period
- When Keno flows are 1,400 cfs or less: decreases in flows of 150 cfs or less per 24-hour period and no more than 50 cfs per 2-hour period.
- Upward ramping (ramp-up) is not restricted

Facility control limitations and stream gage measurement error may limit the ability to manage precise changes in releases from Keno. In addition, facility control emergencies may arise that warrant the exceedance of the proposed ramp-down rates. Therefore, Reclamation recognizes that minor variations in ramp rates (within 10% of targets) may occur for short durations and all ramp rates proposed above are targets. Reclamation expects some conditions will result in deviations from proposed ramp rates due to facility control limitations, changing accretions/diversions between LRD and Keno Dam, wind effects on UKL/Lake Ewauna, stream gage error, and/or emergency situations; however, deviations will occur infrequently and in coordination with the Services, they will be corrected as quickly as practicable.

Under some circumstances (based on presence and abundance of ESA-listed species, life cycle stage, hydrologic conditions in the Klamath River and tributaries, and other considerations), the proposed ramp rates may be more stringent than necessary to prevent the stranding of ESA-listed species downstream of Keno. Reclamation, in coordination with the Services, may explore more flexible ramp rates to determine under what conditions those rates would be appropriate to implement.

Simulated Proposed Action outcomes for the river expressed as percent exceedance, maximum and minimum of daily flows computed by month for water years 1991-2022 are in Table 3-6 and Table 3-7 for the Keno gage and Table 3-8 and Table 3-9 for the Iron Gate gage. Note that tables are provided for each of the Proposed Action simulations (pulse flows on and off).

Table 3-6. Simulated Proposed Action outcomes for the Klamath River with pulse flows on, Keno gage

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,418	2,281	3,335	6,705	7,772	6,046	6,878	5,759	4,654	1,658	1,370	1,189
5%	1,161	1,475	2,088	2,164	3,381	3,978	4,612	3,307	1,851	893	1,220	1,072
10%	975	1,104	1,428	1,628	2,510	2,877	3,796	2,549	1,368	839	1,034	897
15%	948	1,041	1,165	1,271	1,787	2,604	3,128	2,264	1,294	797	920	872
20%	937	907	785	992	1,224	2,427	2,855	2,141	1,219	776	846	848
25%	869	860	758	764	1,074	2,233	2,500	2,039	1,176	757	790	831
30%	840	803	746	751	909	1,717	2,237	1,932	1,148	748	768	823
35%	794	784	736	737	758	1,470	2,070	1,714	1,098	737	745	815

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
40%	779	777	726	725	735	1,375	1,947	1,563	1,052	698	727	791
45%	773	773	719	717	713	1,224	1,841	1,484	1,026	681	708	777
50%	771	770	710	708	699	1,182	1,651	1,446	1,001	677	690	771
55%	770	765	701	697	691	1,123	1,545	1,405	990	673	678	766
60%	767	763	689	687	686	1,049	1,472	1,345	978	669	673	757
65%	764	760	679	679	681	982	1,417	1,304	969	665	666	755
70%	762	759	673	674	677	943	1,363	1,235	956	659	662	754
75%	762	758	669	671	673	921	1,300	1,188	930	655	656	753
80%	760	755	665	665	669	904	1,260	1,140	913	654	654	751
85%	758	752	663	660	662	881	1,210	1,107	874	653	653	750
90%	757	742	661	658	658	821	1,138	1,030	831	651	651	745
95%	752	726	656	656	655	756	1,043	948	783	650	650	730
Min	751	706	650	650	650	675	877	840	708	650	650	709

Notes: Values are flow rates (cfs) at the Keno gage. Statistics are computed from daily flows for water years 1991-2022 for the specified months.

Table 3-7. Simulated Proposed Action outcomes for the Klamath River with pulse flows off, Keno gage

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,418	2,281	3,335	6,705	7,772	6,046	6,878	5,759	4,654	1,658	1,370	1,189
5%	1,161	1,475	2,087	2,164	3,381	3,656	4,504	3,307	1,851	893	1,220	1,072
10%	975	1,104	1,429	1,628	2,510	2,712	3,531	2,674	1,366	839	1,034	897
15%	948	1,045	1,165	1,271	1,787	2,474	3,141	2,365	1,298	799	920	872
20%	937	914	785	993	1,231	2,313	2,752	2,250	1,231	776	846	849
25%	869	864	759	764	1,096	1,534	2,385	2,140	1,183	757	791	832
30%	840	808	749	751	912	1,363	2,211	2,039	1,150	748	767	823
35%	802	784	736	737	757	1,283	2,044	1,914	1,111	737	745	816
40%	779	777	726	726	734	1,208	1,900	1,783	1,069	698	727	791
45%	773	773	720	717	712	1,172	1,780	1,698	1,043	681	708	777
50%	772	770	711	708	699	1,119	1,637	1,649	1,009	677	690	771
55%	770	765	701	697	691	1,066	1,570	1,593	985	673	679	766
60%	767	763	689	688	685	997	1,522	1,527	967	669	673	757
65%	764	760	680	679	681	952	1,491	1,463	956	665	666	755
70%	762	759	673	674	677	930	1,434	1,407	943	659	662	754
75%	762	758	669	671	673	914	1,371	1,346	926	655	656	753
80%	760	755	666	665	669	897	1,318	1,288	907	654	654	751
85%	758	752	663	660	662	870	1,237	1,239	879	653	653	750
90%	757	742	661	658	658	821	1,150	1,115	825	651	651	745
95%	752	726	656	656	655	757	1,100	1,016	799	650	650	730
Min	751	706	650	650	650	675	877	885	703	650	650	709

Notes: Values are flow rates (cfs) at the Keno gage. Statistics are computed from daily flows for water years 1991-2022 for the specified months.

Table 3-8. Simulated Proposed Action outcomes for the Klamath River with pulse flows on, Iron Gate gage

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,902	3,231	6,609	12,735	10,344	8,341	7,855	6,251	5,406	2,163	1,768	1,555
5%	1,549	1,887	3,043	3,799	4,721	5,042	5,546	4,235	2,449	1,336	1,568	1,444
10%	1,446	1,553	1,981	2,338	3,329	3,977	4,718	3,330	1,981	1,254	1,363	1,291
15%	1,333	1,450	1,756	1,997	2,692	3,509	4,120	3,000	1,803	1,200	1,306	1,233
20%	1,301	1,339	1,527	1,783	2,243	3,295	3,591	2,762	1,669	1,160	1,230	1,204
25%	1,259	1,281	1,351	1,541	1,797	3,079	3,251	2,642	1,608	1,134	1,166	1,182
30%	1,207	1,227	1,262	1,406	1,557	2,895	3,005	2,527	1,572	1,096	1,115	1,166
35%	1,171	1,191	1,205	1,317	1,472	2,559	2,864	2,306	1,502	1,077	1,080	1,146
40%	1,152	1,167	1,172	1,258	1,374	2,307	2,691	2,141	1,442	1,040	1,062	1,133
45%	1,140	1,147	1,143	1,223	1,292	2,050	2,524	2,027	1,398	1,023	1,041	1,122
50%	1,133	1,134	1,119	1,187	1,230	1,866	2,296	1,932	1,360	1,009	1,019	1,109
55%	1,122	1,125	1,100	1,151	1,195	1,724	2,203	1,877	1,338	999	1,005	1,096
60%	1,110	1,117	1,079	1,121	1,160	1,584	2,090	1,815	1,319	990	988	1,081
65%	1,096	1,109	1,065	1,097	1,131	1,503	1,980	1,754	1,301	980	975	1,069
70%	1,084	1,100	1,052	1,081	1,105	1,424	1,881	1,675	1,275	972	967	1,059
75%	1,072	1,088	1,039	1,061	1,087	1,361	1,741	1,612	1,259	958	955	1,049
80%	1,054	1,078	1,022	1,041	1,069	1,310	1,669	1,532	1,235	948	945	1,038
85%	1,036	1,066	1,003	1,021	1,048	1,276	1,637	1,483	1,207	940	934	1,027
90%	1,024	1,051	984	992	1,019	1,236	1,564	1,369	1,149	927	924	1,010
95%	1,015	1,026	961	969	996	1,129	1,421	1,264	1,070	917	913	998
Min	986	978	918	912	930	1,024	1,250	1,102	1,001	898	883	958

Notes: Values are flow rates (cfs) at the Iron Gate gage. Statistics are computed from daily flows for water years 1991-2022 for the specified months.

Table 3-9. Simulated Proposed Action outcomes for the Klamath River with pulse flows on, Iron Gate gage

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,902	3,231	6,609	12,735	10,344	8,341	7,855	6,251	5,406	2,163	1,768	1,555
5%	1,549	1,887	3,043	3,799	4,721	4,719	5,517	4,235	2,465	1,337	1,570	1,444
10%	1,448	1,553	1,981	2,338	3,329	3,693	4,559	3,423	1,996	1,254	1,363	1,291
15%	1,334	1,455	1,756	2,002	2,692	3,347	4,106	3,173	1,796	1,200	1,306	1,232
20%	1,300	1,344	1,530	1,782	2,243	3,094	3,550	2,852	1,674	1,159	1,230	1,203
25%	1,261	1,280	1,351	1,541	1,801	2,851	3,171	2,757	1,617	1,135	1,166	1,183
30%	1,208	1,230	1,262	1,405	1,565	2,478	3,009	2,634	1,569	1,098	1,115	1,166
35%	1,173	1,197	1,206	1,318	1,488	2,272	2,867	2,499	1,519	1,077	1,080	1,146
40%	1,152	1,168	1,171	1,261	1,380	2,076	2,576	2,332	1,455	1,040	1,062	1,133
45%	1,142	1,148	1,143	1,227	1,303	1,949	2,434	2,216	1,410	1,023	1,041	1,123
50%	1,134	1,134	1,118	1,188	1,234	1,780	2,265	2,133	1,371	1,009	1,019	1,109
55%	1,123	1,125	1,100	1,151	1,198	1,702	2,191	2,058	1,351	999	1,005	1,096
60%	1,111	1,117	1,081	1,121	1,160	1,566	2,123	1,994	1,320	990	988	1,081

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
65%	1,097	1,109	1,066	1,097	1,131	1,495	2,028	1,911	1,291	980	975	1,069
70%	1,084	1,100	1,052	1,081	1,105	1,418	1,855	1,845	1,267	972	967	1,059
75%	1,072	1,088	1,039	1,063	1,087	1,359	1,803	1,771	1,247	958	955	1,049
80%	1,054	1,078	1,022	1,041	1,069	1,312	1,760	1,706	1,223	948	945	1,038
85%	1,036	1,066	1,003	1,022	1,048	1,276	1,667	1,632	1,190	940	934	1,027
90%	1,024	1,051	984	992	1,019	1,235	1,562	1,447	1,139	927	924	1,010
95%	1,015	1,026	961	970	996	1,130	1,476	1,361	1,081	917	913	998
Min	986	978	918	913	931	1,025	1,250	1,159	993	898	883	958

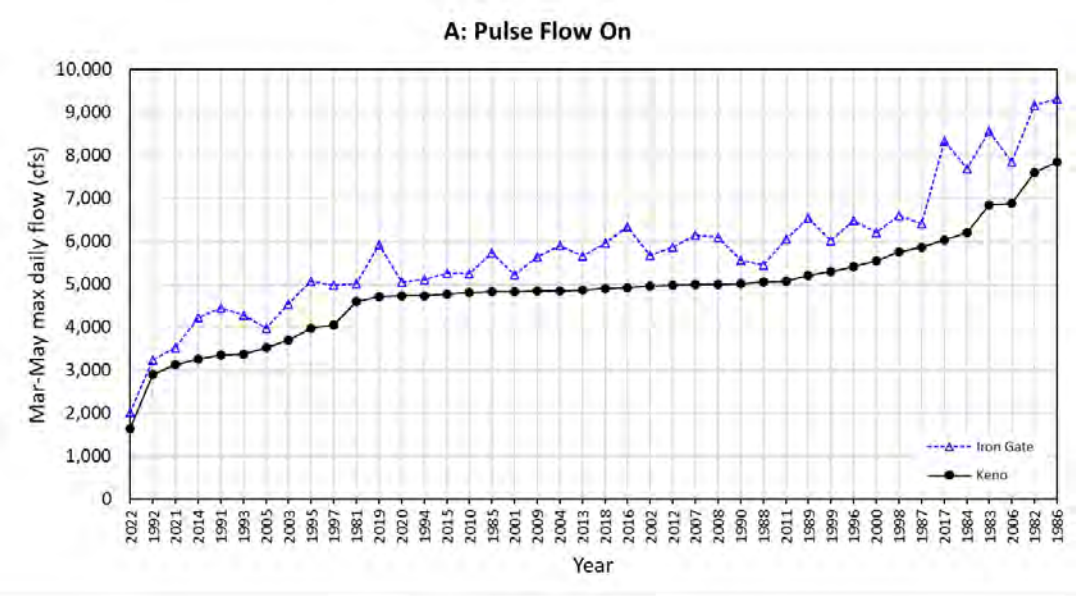
Notes: Values are flow rates (cfs) at the Iron Gate gage. Statistics are computed from daily flows for water years 1991-2022 for the specified months.

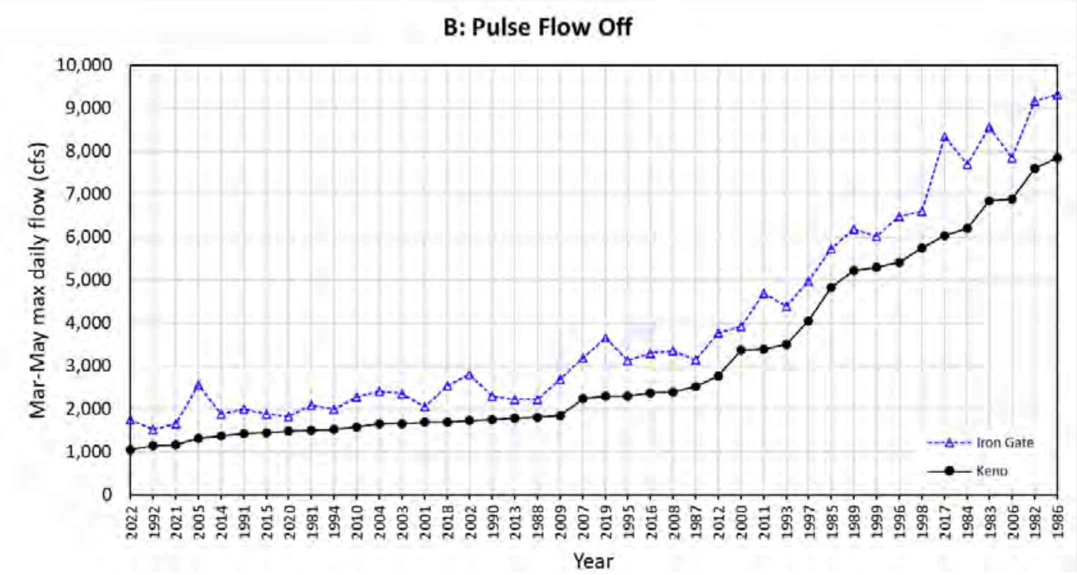
The volume used from the FFA each year for each of the Proposed Action simulations is very similar (Table 3-10). In 1989, less FFA water was used when the pulse flow was off because in that scenario some of the FFA volume spilled (after all the Deferred Project Supply volume spilled).

Table 3-10. Flexible Flow Account volumes used by the Klamath River each year for each of the Proposed Action simulations (pulse flows on and off)

Year	FFA Used with Pulse Flows On (TAF)	FFA Used with Pulse Flows Off (TAF)	Year	FFA Used with Pulse Flows On (TAF)	FFA Used with Pulse Flows Off (TAF)
1981	22	22	2002	34	34
1982	0	0	2003	18	18
1983	0	0	2004	24	25
1984	7	7	2005	16	16
1985	15	15	2006	22	22
1986	0	0	2007	35	35
1987	35	35	2008	36	36
1988	36	36	2009	36	36
1989	36	30	2010	25	25
1990	36	36	2011	36	36
1991	17	17	2012	36	36
1992	12	12	2013	35	35
1993	12	12	2014	16	16
1994	34	34	2015	25	25
1995	20	20	2016	34	34
1996	0	0	2017	11	11
1997	0	0	2018	27	27
1998	8	8	2019	24	24
1999	5	5	2020	34	34
2000	20	20	2021	14	14
2001	35	35	2022	4	4

Maximum daily flows at Keno Dam and IGD with pulse flows on and off are shown in Figure 3-8. IGD flows are higher and show more variability due to accretions downstream of Keno.





Note: Years are sorted based on the magnitude of the Mar-May max daily flow at Keno.

Figure 3-8. Maximum daily flow for March through May in each year for the pulse flow on (A) and pulse flow off (B) scenarios of the Proposed Action

3.4.2 Project Allocations for Irrigation

3.4.2.1 Project Supply from Upper Klamath Lake

Water available for irrigation use from UKL during the spring-summer (SS) period is divided into firm and variable components (defined in this section) from UKL storage and inflow. The Project Share of storage or inflow components is determined by the Operations Index (Table 3-11).

Table 3-11. Project Share of storage and inflow components of Klamath Project allocation

Operations Index	Project Share
0	0.12
0.2	0.17
0.4	0.26
0.6	0.26
0.8	0.25
1	0.24

Note: Project Share values are interpolated based on the value of the Operations Index

Starting on March 1 and repeated on April 1, UKL storage above 4,138.8 ft (Reclamation KB datum) is determined as UKL shadow storage minus UKL storage at 4,138.8 ft. This is multiplied by Project Share to determine on March 1 the provisional Project Supply from Storage, and on April 1 to determine the Firm Project Supply from Storage. (Method for calculating project share is found in APPENDIX C under 3 – Project Irrigation Allocation.)

Estimates of UKL net inflow volume for April through September are used to calculate the Project Supply from Inflow. Such estimates are comprised of the actual UKL net inflow volume since April 1 plus the forecasted UKL net inflow volume from the forecast date through September. The variable Apr95vol is the 95% exceedance forecast on April 1 of April-September UKL net inflow. Then on April 15 Apr95vol is the 95% exceedance forecast of April 15-September UKL net inflow plus the actual UKL net inflow from April 1-14. The April 15 Apr95vol multiplied by the Project Share is the Firm Project Supply from Inflow. Note that this is constrained to not exceed the maximum Project allocation of 350 TAF minus Firm Project Supply from Storage. On April 15, the Firm Project Supply is the Firm Project Supply from Storage plus the Firm Project Supply from Inflow.

Another component of Project Supply computed every 2 weeks after April 1 varies until becoming firm on June 1. On day d this supply is computed as:

$$Variable\ Project\ Supply_d = (Apr50vol_d - Apr95vol_d) \times Project\ Share_d \times PSM_d \tag{4}$$

Apr50vol is computed in the same manner as Apr95vol using the 50% exceedance forecast instead of the 95% exceedance forecast. PSM_d is the Project Supply Multiplier on day *d* that is determined by the exceedance quantile of the cumulative actual UKL net inflow volume since

April 1 (Table 3-12). As actual UKL net inflow increases above the median (the exceedance quantile declines from 0.5), the Project Supply Multiplier increases above 1 and increases the Variable Project Supply. The opposite occurs when the inflows decline below the median (the exceedance quantile increases from 0.5).

Table 3-12. The Project Supply Multiplier is determined by the exceedance quantile for cumulative Upper Klamath Lake net inflow volume since April 1

Inflow Exceedance Since Apr 1	Project Supply Multiplier
0.05	1.5
0.5	1
0.95	0.5

Note: Exceedance is computed for water years 1991-2022 (Details of Period of Record are found in Section 3.3).

The final Project Supply from UKL becomes firm on June 1 and consists of the sum of the Firm Project Supply from Storage, the Firm Project Supply from Inflow, and the June 1 Variable Project Supply. No further adjustments to the final Project Supply are made after June 1.

3.4.2.2 Project Supply from Other Surface Water Sources

There are two additional sources of water to the Project and NWRs. They are Lost River inflow to Wilson Reservoir and F/FF Pump Station returns to the Keno Impoundment. This water can be used directly during the irrigation season or collected as deferred supply in UKL to be used later by the Project or NWRs. Deferred Project Supply in UKL can also be accumulated when NWR use of their allocation from UKL is replaced by irrigation returns or water from the Lost River.

3.4.2.3 Project Direct Use of Lost River and F/FF Pump Station Returns

During the irrigation season, the Project can re-divert F/FF Pump Station returns to Keno Impoundment or Lost River water diverted into the LRDC (Lost River water diverted into the LRDC will be referred to as "LR Diversions"). To be counted as direct use from Lost River, the re-diversion for Project use must occur on the same day the water becomes available in the system as return flow. The points of diversion where this re-diversion is simulated in the KRM are Station 48, Miller Hill, North Canal, and Ady Canal. Irrigation season project diversions at Station 48, Miller Hill, North Canal, and Ady Canal first rely on all available Lost River water and F/FF returns. Irrigation season Project diversions at Station 48, Miller Hill, North Canal, and Ady Canal only count against UKL Project supply (or deferred supply; discussed below) once the Lost River and F/FF sources are exhausted. Note that FW KDD diversions are assumed to be from UKL.

3.4.2.4 Deferred Project Supply

Deferred Project Supply is water that Reclamation has allocated to Project irrigators after meeting all relevant legal obligations, including but not limited to tribal water rights and the Endangered Species Act, but that Project irrigators forego for the potential for future diversion when Reclamation determines that it has available supply. Deferred Project Supply is solely used as a term of art to describe how Reclamation would provide additional flexibility to allocation usage. Deferred Project Supply may be derived from either UKL or from the Lost River. For example, LR Diversions and F/FF pumping into the Keno Impoundment that is not directly re-diverted (Section 3.4.2.3), can accumulate as a Deferred Project Supply in UKL under the following conditions:

- Keno Impoundment is balanced, meaning:
- Releases at LRD are in balance with Project deliveries out of the Keno Impoundment, targeted flow releases from Keno Dam, and operational storage levels within the Keno Impoundment.
- Keno Impoundment is not in flood control operations (see rules in APPENDIX C , 4 – Project Irrigation Diversions).
- UKL is not in flood control operations (see rules in APPENDIX C , 4 – Project Irrigation Diversions).
- The date is on or between November 1 and September 30. No Deferred Project Supply is accumulated in October.
- LR Diversions and F/FF pumping result in a calculable reduction in Link releases (through mass balance) needed to meet targeted flow releases from Keno Dam.

The calculated reduction in releases from LRD is the Deferred Project Supply. Each day Deferred Project Supply is calculated under the above conditions, it is added to the Deferred Project Supply account in UKL.

Deferred Project Supply can also be accumulated in UKL using the 43,000 AF dedicated historical wetland habitat supply from UKL storage that is intended to keep Lower Klamath NWR Unit 2 and Tule Lake NWR Sump 1A water surface elevations at specified environmental thresholds. (see APPENDIX C for additional details). If these environmental thresholds can be maintained through a combination of redistributed drainage from irrigated lands and flow from the Lost River, the 43,000 AF (or remaining portion of the dedicated historical wetland habitat supply) will be credited to the Project on a uniform schedule from April 2 to September 30. Reclamation and the Services will coordinate throughout the irrigation season to ensure that there are sufficient water supplies for Unit 2 and Sump 1A before any of the UKL historical wetland habitat supply is dedicated to Deferred Project Supply.

Use of Deferred Project Supply begins with irrigation season Project diversions from UKL. Each day water is diverted from UKL, Deferred Project Supply is withdrawn in proportion to its contribution to remaining available Project water volume in UKL. Diversions of Deferred Project Supply are deducted from the UKL Deferred Project Supply account daily during the irrigation season. This is necessary to continually update the UKL shadow operation for correct calculation of UKL Status. Any Deferred Project Supply remaining in the UKL Deferred Project Supply account at the end of October is converted to general UKL storage on November 1.

If UKL enters flood control operations, UKL Deferred Project Supply spills first (prior to the FFA for Klamath River flows). The daily quantity of UKL Deferred Project Supply that spills is calculated as the minimum of the flow in excess of required flow at Link River or flow in excess of targeted flow at Keno plus any spill diverted to Tule Lake NWR or Lower Klamath NWR. To prevent or reduce spill of UKL Deferred Project Supply, early withdrawals from the account can be made and distributed to Lower Klamath NWR or Tule Lake NWR in priority with other uses. Where physically practicable, Deferred Project Supply moved to Lower Klamath NWR or Tule Lake NWR to avoid spill may be rediverted for agricultural irrigation use at a later date, in coordination with Reclamation and USFWS. Note that Deferred Project Supply diverted to the NWRs may be subject to evaporative and transmission loss that may reduce the volume available for rediversion at a later date.

3.4.2.5 Project Outcomes Under the Proposed Action

Under the Proposed Action (with pulse flows on), the firm supply on June 1 of water available to the Project irrigators from UKL without considering Deferred Project Supply volumes (Table 3-13) ranges from 32-307 TAF. The firm supply on June 1 sums the firm supply on April 15 and the final calculated variable supply on June 1. By design, the firm supply on June 1 can only increase from the firm supply on April 15, although the increase may be small or nonexistent. The firm and variable Project Supplies are finalized on June 1 and will not be altered after June 1 of each year.

Table 3-13. Project irrigation supply from Upper Klamath Lake under the Proposed Action (with pulse flow on) without consideration of Deferred Project Supply

Year	Firm Storage Apr 1	Firm Inflow Apr 15	Firm Supply Apr 15	Variable Apr 1	Variable Apr 15	Variable May 1	Variable May 15	Firm Variable Jun 1	Firm Supply Jun 1
1981	63	58	121	13	12	6	2	6	127
1982	95	143	238	76	31	10	26	29	267
1983	89	185	274	103	40	37	14	14	288
1984	96	167	263	91	37	37	25	45	307
1985	76	115	191	69	28	51	53	41	232
1986	101	103	204	58	24	19	31	29	232
1987	93	67	160	27	15	3	12	7	167
1988	93	41	134	10	9	17	22	20	155
1989	92	126	218	83	29	32	50	36	255
1990	87	46	133	15	10	16	17	19	152
1991	53	58	111	14	10	9	1	5	116
1992	18	14	32	3	3	7	6	3	35
1993	58	162	220	68	35	26	15	7	227
1994	59	38	97	6	8	3	0	0	97
1995	76	102	177	54	23	29	44	38	216
1996	95	91	186	41	22	41	44	71	257
1997	89	95	183	40	20	37	40	39	222
1998	90	141	231	70	32	0	11	62	293
1999	70	179	248	101	39	43	37	39	287
2000	87	84	171	53	20	57	83	70	241
2001	72	54	126	14	10	9	2	1	127

Year	Firm Storage Apr 1	Firm Inflow Apr 15	Firm Supply Apr 15	Variable Apr 1	Variable Apr 15	Variable May 1	Variable May 15	Firm Variable Jun 1	Firm Supply Jun 1
2002	69	58	127	23	13	24	33	25	152
2003	68	71	139	19	16	24	37	25	164
2004	72	61	133	33	14	19	21	20	153
2005	26	38	63	8	7	7	25	73	136
2006	72	149	221	68	32	45	49	58	279
2007	90	76	165	30	17	21	28	19	185
2008	72	114	186	56	24	15	13	16	202
2009	79	83	161	27	14	0	11	15	177
2010	60	70	130	15	13	12	9	5	135
2011	89	131	220	68	29	30	13	13	233
2012	89	110	199	35	25	4	6	5	203
2013	73	68	141	14	15	9	5	1	143
2014	56	47	104	9	10	3	0	0	104
2015	66	36	102	7	7	2	0	2	104
2016	82	70	152	37	15	9	12	8	161
2017	97	143	240	77	32	24	14	15	255
2018	71	67	138	15	14	14	7	12	150
2019	63	112	175	38	26	29	25	21	196
2020	50	42	92	7	7	0	0	4	96
2021	20	16	36	4	3	2	2	2	39
2022	5	15	20	1	3	10	14	12	32

Notes: Firm supply decisions are finalized for the various components on the specified dates. The variable component varies every two weeks until becoming firm on June 1. All units are TAF.

Annual irrigations from all available surface water sources are summarized in Table 3-14. The inclusion of winter water and other water sources yields higher diversions than in Table 3-13. The SS period consists of A Canal and net Station 48/Miller Hill diversions from March through November 15, and North and Ady to Project diversions from March through September. The totals from UKL are larger than in Table 3-13, because they include Deferred Project Supply. The FW period consists of irrigation diversions under winter water rights from October through February. (Because the Proposed Action simulation ends on November 30, 2022, the FW diversion reported for KDD in 2022 in Table 3-14 is small because includes only October-November diversions.)

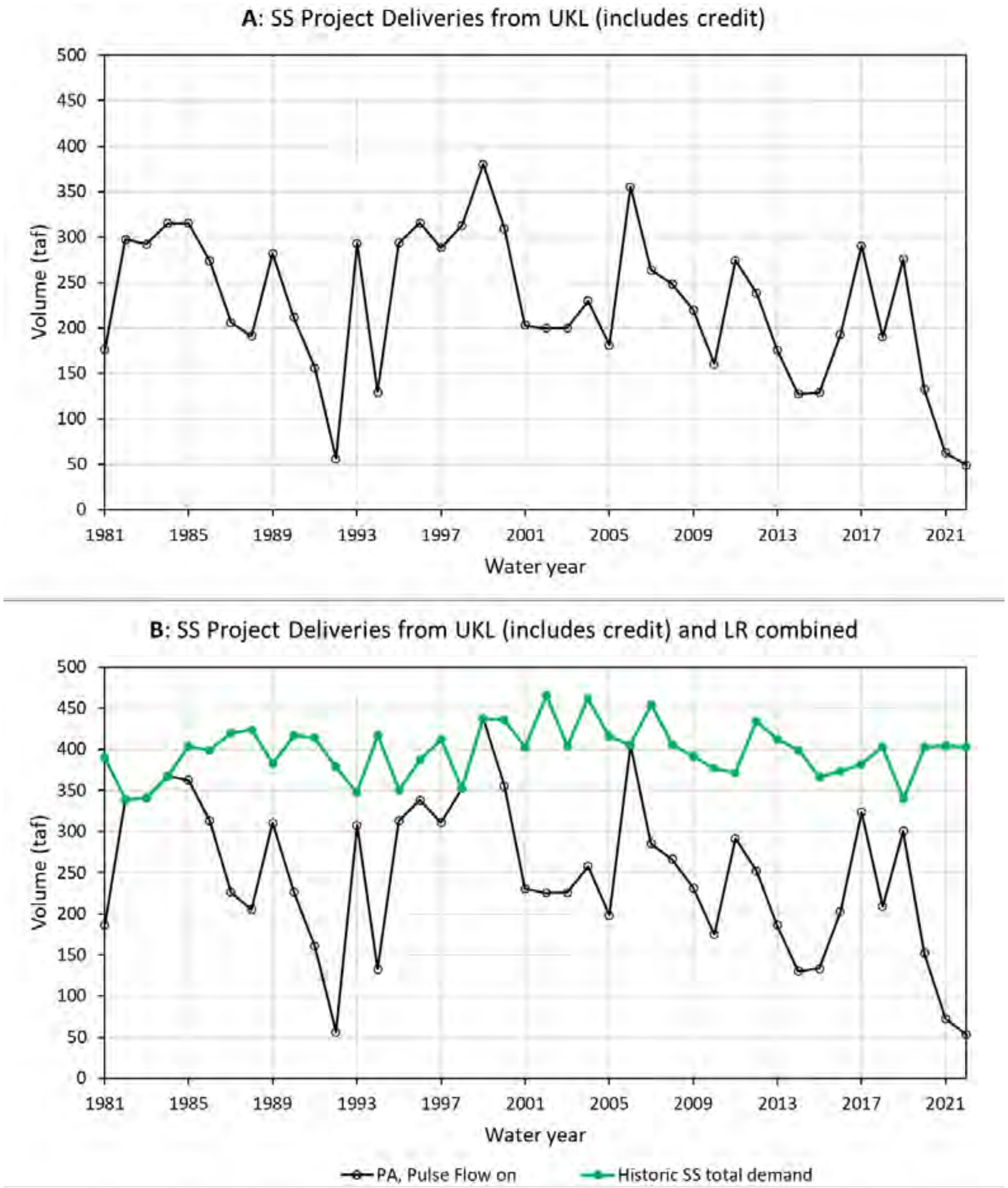
Simulated SS deliveries from UKL including diversion of Deferred Project Supply are shown in Figure 3-9(A), whereas SS diversions from all surface water sources are in Figure 3-9(B). The latter illustrates how the Proposed Action simulation caps Project deliveries at the estimated historical demand.

Table 3-14. Simulated irrigation diversions (TAF) under the Proposed Action (with pulse flows on) from all surface water sources

Year	SS from UKL	SS from Returns	SS Total	FW Ag Diversion	Total Annual Ag Diversion
1981	176	10	187	29	216
1982	297	42	339	29	368
1983	292	49	341	29	370
1984	315	53	368	29	397
1985	315	47	362	29	391
1986	274	39	313	29	342
1987	206	20	226	29	255
1988	191	14	205	29	234
1989	282	29	311	29	340
1990	212	15	227	29	256
1991	156	5	161	27	188
1992	56	0	56	27	83
1993	293	15	308	29	337
1994	129	3	132	29	161
1995	293	19	313	29	342
1996	315	23	338	29	367
1997	288	23	311	29	340
1998	313	40	353	29	382
1999	380	57	437	29	466
2000	309	46	355	29	384
2001	203	27	230	29	259
2002	199	26	226	29	255
2003	200	26	226	29	255
2004	230	28	258	29	287
2005	181	17	198	29	227
2006	355	50	405	29	434
2007	264	21	285	29	314
2008	248	18	266	29	295
2009	220	11	231	29	260
2010	160	15	175	29	204
2011	274	17	291	29	320
2012	238	14	252	29	281
2013	176	10	186	29	215
2014	127	3	130	29	159
2015	129	5	134	29	163
2016	193	10	203	29	232
2017	290	33	323	29	352
2018	190	19	209	29	238
2019	275	25	300	29	329
2020	133	20	152	28	180
2021	63	10	72	25	97

Year	SS from UKL	SS from Returns	SS Total	FW Ag Diversion	Total Annual Ag Diversion
2022	49	4	53	8	61

Notes: 'From UKL' reports all diversions from UKL including the use of Deferred Project Supply. 'From returns' reports use of irrigation returns to the LRDC and returns from pumps F and FF. 'SS total' is the SS diversions from UKL and returns combined. 'FW Ag Diversion' is the FW diversion using winter water rights.



Note: Simulated Project deliveries are capped by historical demand.

Figure 3-9. Simulated spring-summer Klamath Project irrigation deliveries under the Proposed Action (pulse flows on) from Upper Klamath Lake including diversion of Deferred Project Supply (A) and deliveries from all surface water sources (B)

Simulated SS deliveries from all surface water sources can be readily visualized by sorting years from lowest to highest deliveries, as is done in Figure 3-10. SS deliveries range from 53 to 437 TAF.

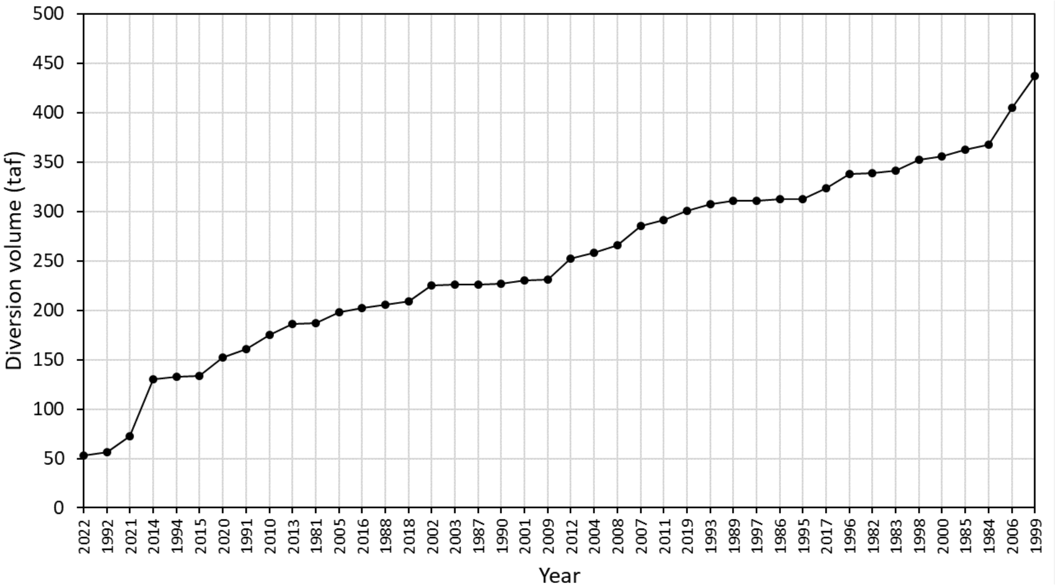


Figure 3-10. Total spring-summer deliveries from all surface water sources sorted by year from lowest to highest diversion

It is important to note that Project Supply formulation in the KRM was reliant upon inclusion of Deferred Project Supply as a key component of the overall supply. The model took an appropriately conservative approach to evaporative loss and return flows to the system to ensure that water available to the Project was not overestimated. However, Reclamation will coordinate closely with the Services to take advantage of opportunities, as they arise in the course of prescribed operations under the Proposed Action, to maximize the availability of Deferred Project Supply in a manner that ensures that modelled outcomes in the Klamath River and UKL are realized for the benefit of the ecosystem and species.

3.4.3 Upper Klamath Lake

UKL flood control elevations are used to provide adequate storage capacity in UKL to capture high runoff events, to avoid potential levee failure due to overfilling UKL, and to mitigate flood conditions that may develop in the Keno plain upstream of Keno Dam. The general process of flood control consists of spilling water from UKL when necessary to prevent elevations from increasing above flood pool elevations, which change throughout the year in response to inflow forecasts and experienced hydrology. Flood pool elevation is calculated each day to create a smooth UKL operation while allowing UKL to fill. The UKL flood control elevations shown in Table 3-15 are intended to be used as guidance, and professional judgment will be utilized in combination with hydrologic conditions, snowpack, forecasted precipitation, public safety, and other factors in the actual operation of UKL during flood control operations. For example, the elevation at which flood control is triggered in December is lower than that in March to allow enough capacity for anticipated large winter inflows, whereas in March there are fewer wet months remaining.

Flood release rules used in the KRM consist of UKL level thresholds inherited from PacifiCorp above which UKL will spill (Table 3-15). In this Proposed Action, operations other than the flood release curve contribute to flood avoidance. The additional storage associated with the wetland restoration and reconnection to UKL in the Upper Klamath NWR increases the active storage capacity of UKL. Targeted releases from Keno to the Klamath River when the Operations Index is very high are intentionally large to retain the integrity of deferred use operations (i.e., FFA and Deferred Project Supply), which also contributes to flood avoidance. Operationally, situations may arise in which flood releases may need to occur at lower elevations than UKL flood level thresholds.

Table 3-15. Flood release threshold levels for Upper Klamath Lake used in the Keno Release Model on the first day of each month

Start of Month	Flood Release Threshold (ft)
Jan	4,141.8
Feb	4,142.3
Mar	4,142.7
Apr	4,143.1
May	4,143.3
Jun	4,143.3
Jul	4,143.3
Aug	4,143.3
Sep	4,143.3
Oct	4,142.5
Nov	4,142.5
Dec	4,141.6

Note: Daily values are interpolated.

Simulated outcomes for UKL levels under the Proposed Action with pulse flows on are presented as daily minimum and maximum levels by month and percent exceedance of daily levels by month for water years 1991-2022 in Table 3-16. When pulse flows are off, UKL levels are occasionally up to 0.2 ft higher for a brief time after the pulse flow would have been released, an effect that rapidly diminishes to zero as the FFA volume is released to the Klamath River in one of many other possible distribution shapes.

Springtime and end-of-season UKL levels are important characteristics of the lake outcomes. Table 3-17 reports these outcomes, which are also plotted in Figure 3-11.

Table 3-16. Simulated Proposed Action outcomes for Upper Klamath Lake with pulse flows on

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	4,140.4	4,140.6	4,141.0	4,142.3	4,142.7	4,143.1	4,143.3	4,143.3	4,143.3	4,143.0	4,142.0	4,141.0
5%	4,140.1	4,140.2	4,140.7	4,141.8	4,142.5	4,142.9	4,143.2	4,143.3	4,143.3	4,142.6	4,141.6	4,140.6
10%	4,139.9	4,140.1	4,140.6	4,141.3	4,142.3	4,142.8	4,143.1	4,143.2	4,143.1	4,142.4	4,141.3	4,140.4
15%	4,139.8	4,140.0	4,140.4	4,141.1	4,142.1	4,142.7	4,143.1	4,143.1	4,142.9	4,142.2	4,141.2	4,140.3
20%	4,139.8	4,139.9	4,140.3	4,141.0	4,141.9	4,142.6	4,142.9	4,143.1	4,142.8	4,142.1	4,141.1	4,140.2
25%	4,139.8	4,139.9	4,140.3	4,140.9	4,141.7	4,142.5	4,142.9	4,143.0	4,142.7	4,141.9	4,140.9	4,140.1
30%	4,139.7	4,139.8	4,140.2	4,140.9	4,141.6	4,142.3	4,142.8	4,142.9	4,142.6	4,141.8	4,140.8	4,140.0
35%	4,139.7	4,139.8	4,140.1	4,140.8	4,141.5	4,142.2	4,142.7	4,142.8	4,142.5	4,141.6	4,140.7	4,139.9
40%	4,139.6	4,139.7	4,140.1	4,140.7	4,141.4	4,142.1	4,142.5	4,142.6	4,142.3	4,141.4	4,140.5	4,139.8
45%	4,139.4	4,139.5	4,140.0	4,140.6	4,141.3	4,142.0	4,142.4	4,142.4	4,142.2	4,141.3	4,140.4	4,139.6
50%	4,139.3	4,139.4	4,139.8	4,140.5	4,141.3	4,141.9	4,142.4	4,142.3	4,141.9	4,141.2	4,140.2	4,139.4
55%	4,139.1	4,139.3	4,139.7	4,140.4	4,141.2	4,141.8	4,142.4	4,142.2	4,141.8	4,141.0	4,140.1	4,139.3
60%	4,139.0	4,139.2	4,139.6	4,140.3	4,141.1	4,141.7	4,142.2	4,142.1	4,141.6	4,140.9	4,140.0	4,139.2
65%	4,138.8	4,139.0	4,139.5	4,140.2	4,141.0	4,141.7	4,142.2	4,142.0	4,141.5	4,140.7	4,139.8	4,139.1
70%	4,138.7	4,138.9	4,139.4	4,140.0	4,140.8	4,141.6	4,141.9	4,141.6	4,141.4	4,140.6	4,139.7	4,139.0
75%	4,138.6	4,138.8	4,139.3	4,139.9	4,140.7	4,141.5	4,141.8	4,141.5	4,141.2	4,140.4	4,139.6	4,138.9
80%	4,138.6	4,138.7	4,139.1	4,139.8	4,140.5	4,141.2	4,141.7	4,141.4	4,141.1	4,140.3	4,139.4	4,138.8
85%	4,138.5	4,138.7	4,139.0	4,139.7	4,140.2	4,141.0	4,141.5	4,141.3	4,140.9	4,140.1	4,139.3	4,138.6
90%	4,138.3	4,138.3	4,138.8	4,139.4	4,140.0	4,140.5	4,140.8	4,140.9	4,140.4	4,139.5	4,138.7	4,138.0
95%	4,137.6	4,137.8	4,138.2	4,138.8	4,139.4	4,140.2	4,140.4	4,140.0	4,139.5	4,138.9	4,138.3	4,137.7
Min	4,137.1	4,137.2	4,137.7	4,138.4	4,138.9	4,139.2	4,139.5	4,139.5	4,138.9	4,138.5	4,137.7	4,137.2

Notes: Values are UKL levels (ft, Reclamation KB datum). Statistics are computed from daily flows for water years 1991-2022 for the specified months.

Table 3-17. Simulated Upper Klamath Lake levels (ft, Reclamation KB datum) under the Proposed Action with pulse flows on during spring and mid-summer, and minimum (Sep-Nov) Upper Klamath Lake levels at the end-of-season

Year	Mar 31	Apr 30	Jul 31	Min.	Year	Mar 31	Apr 30	Jul 31	Min.
1981	4,142.1	4,142.0	4,139.9	4,138.1	2002	4,142.2	4,142.3	4,140.3	4,138.6
1982	4,142.9	4,143.3	4,142.5	4,140.9	2003	4,141.8	4,142.0	4,140.4	4,138.8
1983	4,143.0	4,142.8	4,142.4	4,140.7	2004	4,142.3	4,142.4	4,140.5	4,138.4
1984	4,143.1	4,143.0	4,141.8	4,140.4	2005	4,140.9	4,140.8	4,140.5	4,138.7
1985	4,142.9	4,143.3	4,141.0	4,140.0	2006	4,142.8	4,143.3	4,141.9	4,139.8
1986	4,143.0	4,142.8	4,141.1	4,139.7	2007	4,143.0	4,143.1	4,141.0	4,139.5
1987	4,143.0	4,142.6	4,141.0	4,139.8	2008	4,142.1	4,142.5	4,141.4	4,139.8
1988	4,143.0	4,142.6	4,140.8	4,139.0	2009	4,142.4	4,142.4	4,141.0	4,139.3
1989	4,143.1	4,143.3	4,141.2	4,139.9	2010	4,141.8	4,141.7	4,140.4	4,139.0
1990	4,143.0	4,142.8	4,140.7	4,139.3	2011	4,142.9	4,142.8	4,142.0	4,140.3
1991	4,141.5	4,141.5	4,139.9	4,138.2	2012	4,142.8	4,142.8	4,141.3	4,139.7
1992	4,140.6	4,140.4	4,138.5	4,137.1	2013	4,142.3	4,142.4	4,140.3	4,139.2
1993	4,141.7	4,143.1	4,141.8	4,140.1	2014	4,141.6	4,141.6	4,139.6	4,138.4
1994	4,142.0	4,141.6	4,139.4	4,137.8	2015	4,142.2	4,141.7	4,139.9	4,138.6
1995	4,142.3	4,142.9	4,142.0	4,139.5	2016	4,142.5	4,142.4	4,140.5	4,138.9
1996	4,142.9	4,143.1	4,141.5	4,139.7	2017	4,143.1	4,143.0	4,141.2	4,139.7
1997	4,142.7	4,142.9	4,141.3	4,139.8	2018	4,142.2	4,142.2	4,140.5	4,139.0
1998	4,143.1	4,143.1	4,142.0	4,139.7	2019	4,141.8	4,143.0	4,141.2	4,139.7
1999	4,143.1	4,143.3	4,141.7	4,140.0	2020	4,141.8	4,141.4	4,140.0	4,138.7
2000	4,142.9	4,143.3	4,141.2	4,139.6	2021	4,140.6	4,140.2	4,138.5	4,137.5
2001	4,142.5	4,142.4	4,140.1	4,138.6	2022	4,139.5	4,139.6	4,138.7	4,137.5

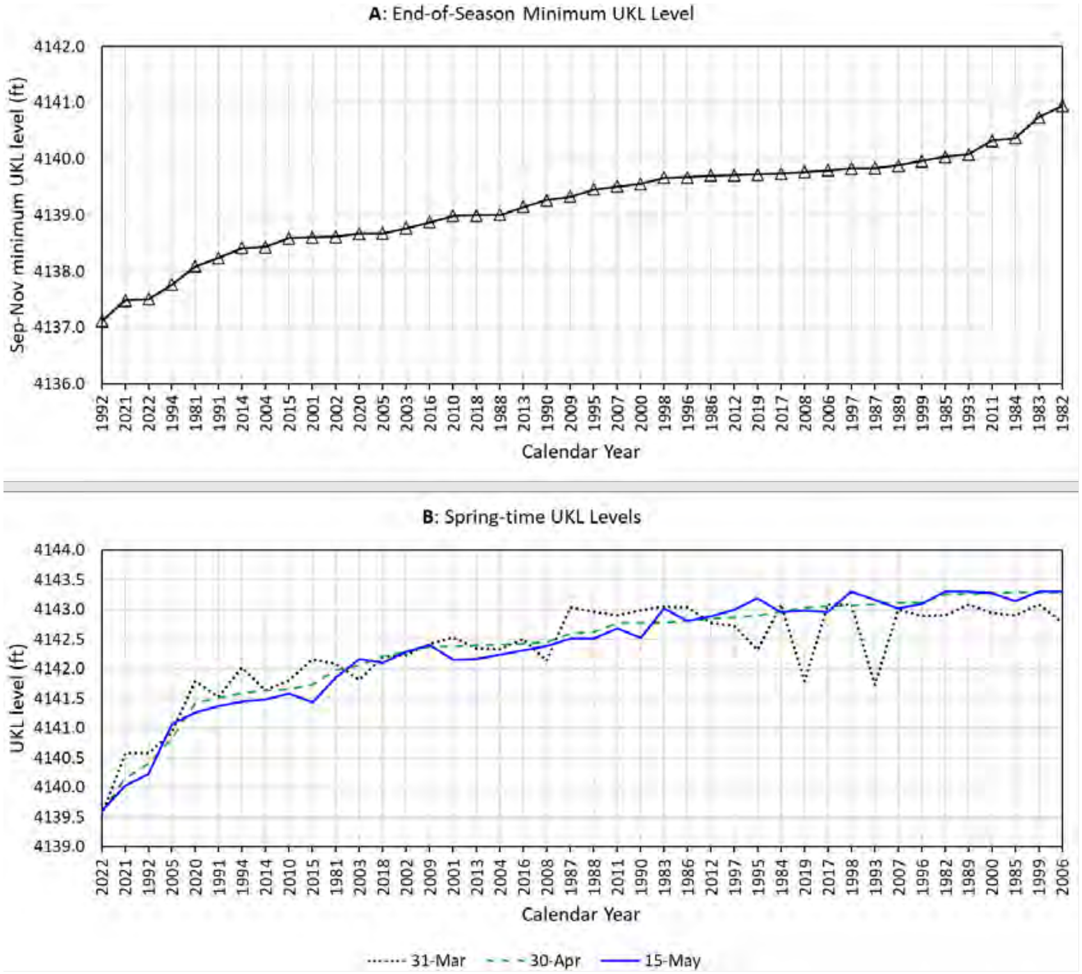


Figure 3-11. Simulated Upper Klamath Lake levels (ft, Reclamation KB datum) under the Proposed Action with pulse flows on for end-of-season (A, sorted by minimum Upper Klamath Lake level) and spring dates (B, sorted by April 30 Upper Klamath Lake level)

The KRM does not include any explicitly modeled UKL minima. Lake elevations in the output tables and graphs above are the result of the interactions of model parameters and inputs and represent the range of elevations that might reasonably be expected to result from operations during the period of this action. However, since there are no seasonal or annual UKL elevation restrictions built into the model, there are instances in which UKL elevations realized in past operations may not be reproduced under the new Proposed Action.

3.4.3.1 Wetland Restoration within Upper Klamath National Wildlife Refuge

The USFWS intends to reconnect a full gradient of wetlands within a diked and drained portion of the Upper Klamath NWR known as Agency Lake/Barnes Ranch by breaching dikes and hydrologically reconnecting the area to the UKL-Agency Lake complex (Stantec, 2023). Providing a wide range of benefits to many species, including migratory water birds and historical wetland habitat, the project is also intended to improve water quality and physical habitat for endangered suckers and salmonids. Potential effects of this project on issues related to water management were analyzed in Stantec (2023) and Dunsmoor (2022).

The KRM includes the code that was incorporated into an earlier version of the KBPM as described in Dunsmoor (2022). The Proposed Action uses this code, assuming the reconnection of this area within the Upper Klamath NWR. Functionally, the code adjusts the measured UKL net inflow for the changes to evapotranspiration that will accompany the transition from pasture and hay back to wetlands and open water, and then simulates UKL dynamics using an elevation-capacity relationship that reflects the addition of the volume of the reconnected area to the volume of UKL.

3.4.3.2 Tule Lake and Lower Klamath National Wildlife Refuges

The Tule Lake and Lower Klamath NWRs are dependent on live flow in UKL and the Klamath River as well as the Lost River for water supply.

3.4.3.3 Dedicated National Wildlife Refuge Supply from Upper Klamath Lake

Each irrigation season, 43,000 AF from UKL is dedicated to the NWRs when consistent with Oregon water rights for the purpose of keeping Lower Klamath NWR Unit 2 and Tule Lake NWR Sump 1A at specified surface water elevations to maintain habitat for endangered suckers at these locations. This volume can be delivered to the NWRs from April-October as required to overcome evaporative or other losses that may impact available habitat. The rate of cumulative delivery should not exceed the rate that would occur with uniform daily delivery of the dedicated supply from April-October.

If delivery of the dedicated supply is below the maximum cumulative rate, the volume of under delivery is transferred to Deferred Project Supply so that it does not affect UKL Status and targeted Klamath River flows. Whether this credit is delivered to the Project or to historical wetland habitat depends on coordination between USFWS and Reclamation regarding other potential replacement water supplies to maintain Unit 2 and Sump 1A.

In the KRM, 21,000 AF of the 43,000 AF dedicated historical wetland habitat supply is reserved for Lower Klamath NWR. The remaining 22,000 AF of supply is reserved for Tule Lake NWR. The division of dedicated supply in real-time operations should be based solely on the immediate needs of the individual NWRs in meeting specified environmental thresholds. Figure 3-12 plots annual deliveries of dedicated UKL supply to the Lower Klamath NWR, and Figure 3-13 shows deliveries to the Tule Lake NWR.

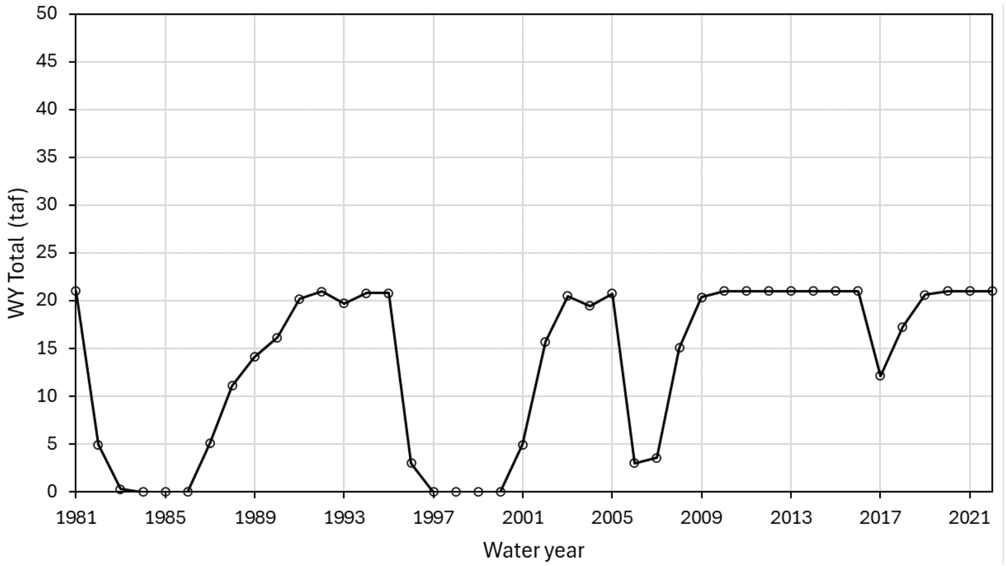


Figure 3-12. Delivery of dedicated Upper Klamath Lake historical wetland habitat supply to Lower Klamath National Wildlife Refuge in the Keno Release Model Proposed Action simulation, April – October through Ady Canal

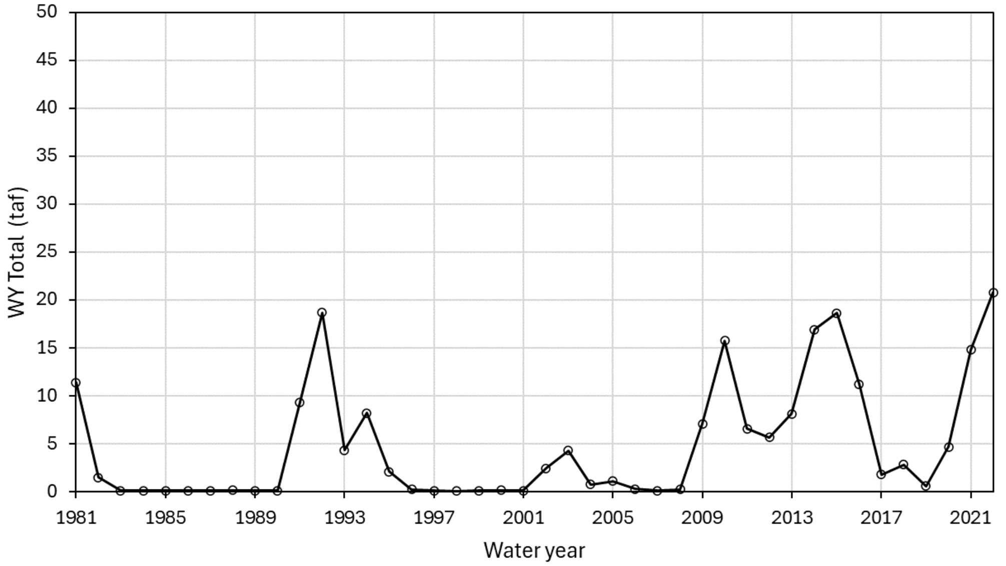


Figure 3-13. Delivery of dedicated Upper Klamath Lake historical wetland habitat supply to Tule Lake National Wildlife Refuge in the Keno Release Model Proposed Action simulation, April – October

Note the years that there is less than 21,000 AF of UKL supply delivered to Lower Klamath NWR or less than 22,000 AF delivered to Tule Lake NWR. These are years where all or a portion of the dedicated supply was credited to the Project because the Lower Klamath NWR Unit 2 and Tule Lake NWR Sump1A environmental thresholds were met using other water sources (i.e., Lost River, Deferred Project Supply, FFA Spill discussed below). Reclamation will coordinate closely with the Services and Project contractors to identify opportunities to use available water supplies in a manner that maximizes water availability for Project irrigation while also optimizing historical wetland habitat on NWR lands and meeting obligations to listed species.

Lost River Refuge Supply Throughout the year, water from the Lost River can be allowed to flow to the Tule Lake NWR. This water may be used to replenish storage in Sump 1A, Sump 1B, and, during the winter, to pre-irrigate agricultural lands (called Sump 3 in the KRM) in the Tule Lake NWR lease lands. Additionally throughout the year, any Lost River water that is diverted into the LRDC, not re-diverted by irrigators, and not needed for UKL Deferred Project Supply can be diverted at Ady Canal and conveyed to the Lower Klamath NWR.

Surplus Lost River water and TID irrigation drainage can be delivered to the Lower Klamath NWR through D Plant. There is no specified schedule for D Plant pumping in the Proposed Action, but it is assumed that D Plant pumping will occur at the discretion of TID and USFWS.

The KRM Proposed Action simulated Lost River water that flowed to the Tule Lake NWR including D Plant is shown in Figure 3-14, and the KRM Proposed Action simulated Lost River water conveyed to the Lower Klamath NWR by way of the LRDC and Ady Canal is shown in Figure 3-15.

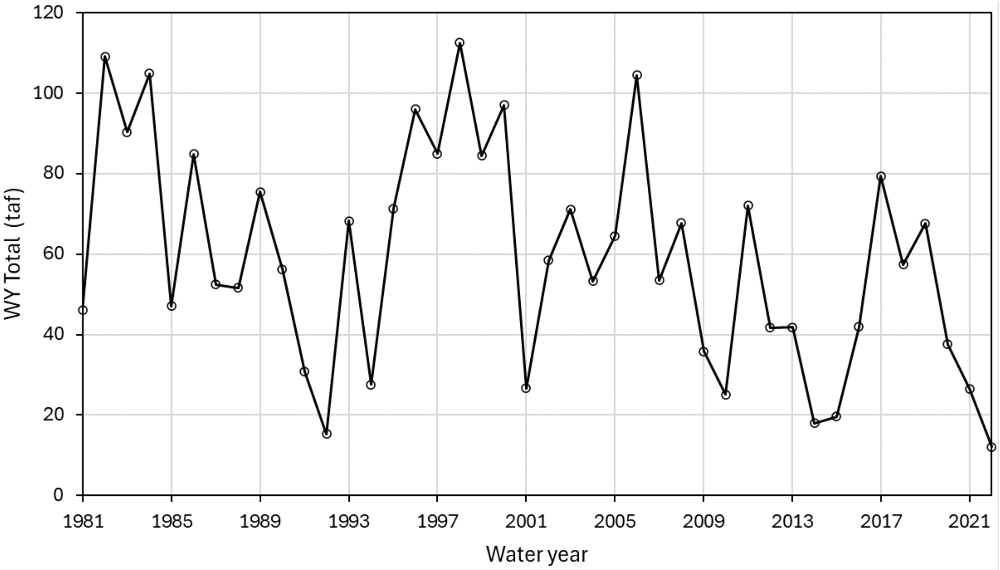


Figure 3-14. Lost River water flowing to Tule Lake sumps and, a fraction of the flow, through D Plant

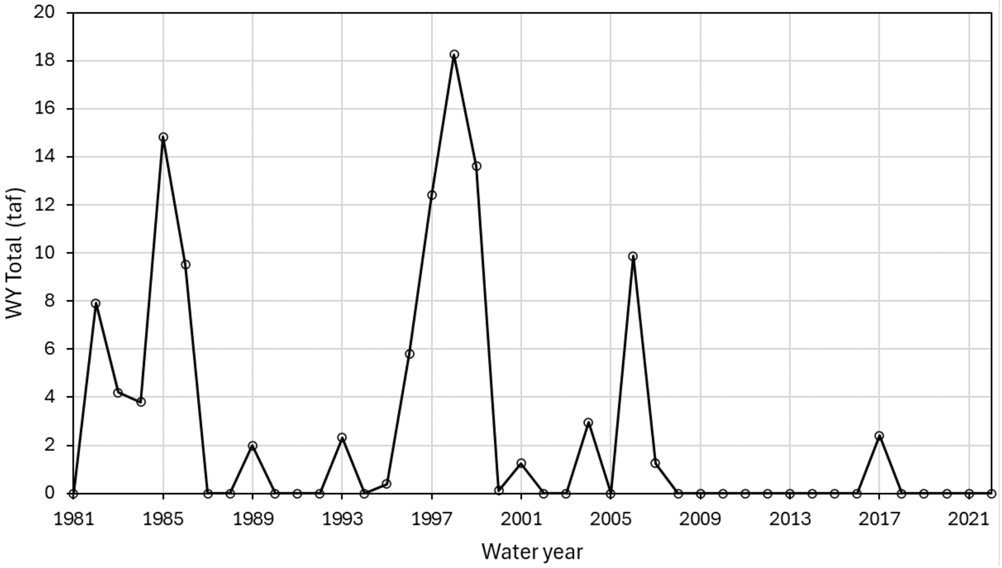


Figure 3-15. Lost River water flowing through the Lost River Diversion Channel and diverted at Ady Canal to the Lower Klamath National Wildlife Refuge

Flood Control Releases of Deferred Project Supply for Historical Wetland Habitat If it is determined by Reclamation in coordination with water users that there is a high likelihood that Deferred Project Supply will have to be released for flood control, early release of Deferred Project Supply can be made from UKL for distribution to the Tule Lake and Lower Klamath NWRs. When UKL is in flood control and Deferred Project Supply is spilling, the spill can be diverted to the Tule Lake and Lower Klamath NWRs. Figure 3-16 shows Deferred Project Supply redistributed to the Tule Lake and Lower Klamath NWRs before and during UKL flood control operations in the KRM Proposed Action simulation.

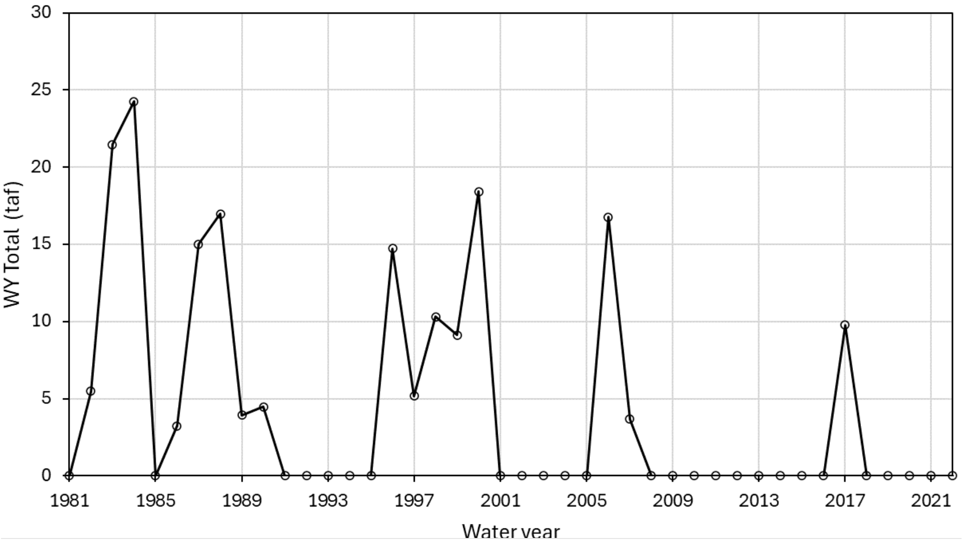


Figure 3-16. Flood control redistribution of Deferred Project Supply for Historical Wetland Habitat

Flexible Flow Account Spill and Lower Klamath National Wildlife Refuge Any spill of FFA due to flood control is not available for diversion by the refuge or irrigators. Spill of FFA must result in flow to the Klamath River at Keno. However, once FFA is exhausted, any UKL spill for flood control can be diverted at Ady Canal to the Lower Klamath NWR in priority with other uses at that time. Figure 3-17 shows water year UKL spills captured at Ady Canal and delivered to the Lower Klamath NWR as simulated in the KRM.

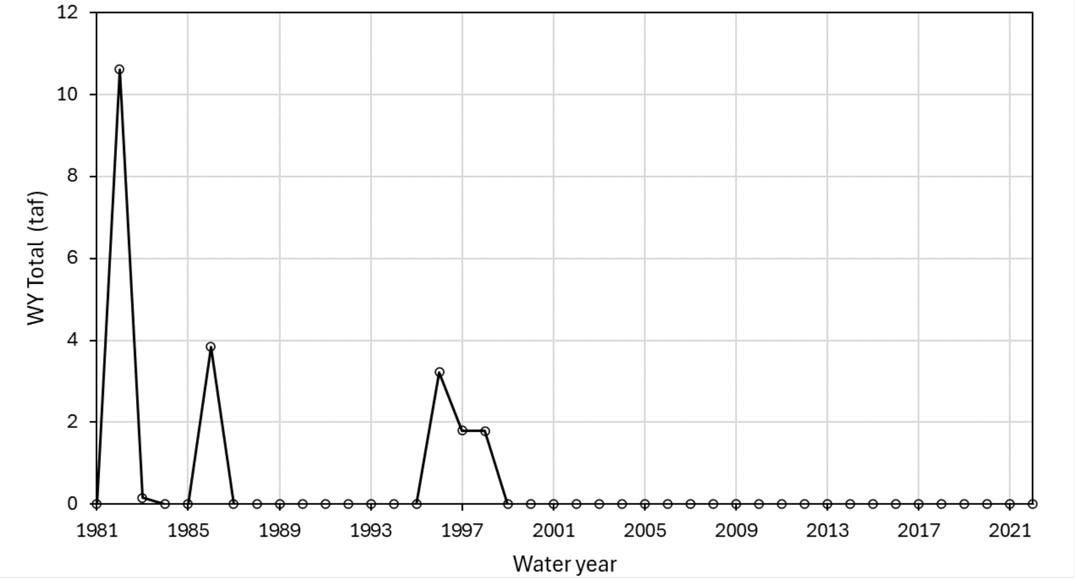


Figure 3-17. Lower Klamath National Wildlife Refuge capture of Upper Klamath Lake flood control releases after all Flexible Flow Account released to the Klamath River

3.5 Proposed Action vs. Interim Operation Plan Mass Balance Analysis

Comparing this Proposed Action to the IOP, both the annual average flow released at Keno and Klamath Project diversions of UKL water were reduced. This section explains, through mass balance over the period of record on an annual average basis, where the water that was available in the IOP is going under the new Proposed Action.

Mass balance dictates that within a specified control volume and time frame:

$$\text{Inflow} - \text{Outflow} = \text{Change in Storage}$$

First, consider a control volume that includes UKL, the Keno Impoundment, and Wilson Reservoir. As in the KRM, assume no change in storage in the Keno Impoundment or Wilson Reservoir.

3.5.1 Inflows

In the Proposed Action and IOP, the modeled inflows into the defined control volume are:

1. UKL net inflow
2. Lost River flow into Wilson Reservoir
3. F/FF Pumping
4. Keno Impoundment accretions (closure term)

Table 3-18 lists the water year change in inflows between the Proposed Action and the IOP. The last row of Table 3-18 lists the water year average change of each inflow over the period of record. UKL net inflow is **reduced** by an average of 9.3 TAF due to the Agency-Barnes reconnection. Lost River flow into Wilson Reservoir is **reduced** by 8.0 TAF due to reduction in irrigation return flow resulting from reduction in A Canal diversions. F/FF Pumping is **reduced** by 37.5 TAF due to new assumptions regarding KDD returns to the KSD, reflecting recently increased capability to reuse water instead of returning it through F/FF pumps. Keno Impoundment accretions are **reduced** by 6.8 TAF because ungaged diversions are now part of the closure term (this means the Project will not have to reduce UKL Project supply by an additional 7 TAF under the Proposed Action as it was under the IOP).

Annual average change in inflow = –9.3 – 8.0 – 37.5 – 6.8 = –61.6 TAF

Table 3-18. Change in control volume inflows (TAF) compared to Interim Operations Plan

Water Year	UKL Net Inflow	Lost River	F/FF Pumps	Keno Impoundment Accretions
1981	-10	-5	-35	-8
1982	-4	-13	-44	-6
1983	-9	-15	-53	-7
1984	-9	-11	-53	-7
1985	-17	-9	-60	-7
1986	-15	-16	-52	-8
1987	-16	-10	-44	-8
1988	-10	-6	-46	-6
1989	-9	-15	-59	-8
1990	-16	-3	-56	-7
1991	-17	1	-39	-8
1992	-4	0	7	-7
1993	-8	-11	-44	-16
1994	-14	-1	-25	-8
1995	-9	-11	-39	10
1996	-17	-8	-42	20
1997	-9	-11	-56	-8

Water Year	UKL Net Inflow	Lost River	F/FF Pumps	Keno Impoundment Accretions
1998	-17	-11	-59	-8
1999	-8	-2	-56	-11
2000	-28	-7	-54	-6
2001	-9	-12	-26	0
2002	-18	-12	-37	-12
2003	-11	-12	-12	-7
2004	-14	-8	-32	-8
2005	-10	-11	-55	-8
2006	-8	-6	-58	-17
2007	-6	-4	-59	-8
2008	-11	-12	-49	-7
2009	-11	-6	-46	-7
2010	-15	-13	-38	-8
2011	-14	-15	-59	-7
2012	-13	-7	-44	-7
2013	-3	-9	-37	-8
2014	-12	1	-2	-7
2015	3	-5	-29	-7
2016	-3	-12	-13	-8
2017	3	-12	-32	-7
2018	4	-8	-16	-7
2019	-1	-6	-48	-7
2020	-3	-3	-3	-8
2021	3	2	17	-7
2022	1	0	15	-8
Average	-9.3	-8.0	-37.5	-6.8

3.5.2 Outflows

In the Proposed Action and IOP, the modeled outflows into the defined control volume are:

1. Diversion to Project (AG)
2. Diversion to Tule Lake NWR (note this diversion was 0 TAF in the IOP)
3. Diversion to Lower Klamath NWR
4. Keno Release

Table 3-19 lists the water year change in outflows between the Proposed Action and the IOP. The last row of Table 3-19 lists the water year average change of each outflow over the period of record. Diversion to the Project is **reduced** by 77.3 TAF on average. Diversion to Tule Lake NWR is **increased** by 64.8 TAF acknowledging that the IOP specified diversions to Tule Lake NWR was 0 TAF. Diversion to Lower Klamath NWR through Ady Canal was **reduced** by 0.5 TAF on average, and flow at Keno was **reduced** by 46.3 TAF.

Annual average change in outflow = –77.3 + 64.8 – 0.5 – 46.3 = –59.3 TAF

Table 3-19. Change in control volume outflows (TAF) compared to Interim Operations Plan

Water Year	Diversion to Project	Diversion to Tule Lake NWR	Diversion to Lower Klamath NWR	Flow at Keno
1981	-99	58	-11	-27
1982	-96	111	4	-135
1983	-110	94	-3	-63
1984	-89	105	2	-9
1985	-79	47	-7	-91
1986	-133	85	-8	-45
1987	-121	62	-11	-38
1988	-98	63	-6	-26
1989	-128	76	-4	-70
1990	-68	59	-4	-4
1991	-24	40	4	-49
1992	38	34	7	-7
1993	-91	73	5	-231
1994	-13	36	-1	42
1995	-87	73	6	-156
1996	-79	98	1	-37
1997	-109	85	-3	-19
1998	-93	113	5	-147
1999	-24	85	-2	-84
2000	-78	99	-5	-120
2001	-66	27	-16	-36
2002	-134	61	-4	-10
2003	-97	75	6	-19
2004	-87	54	6	5
2005	-119	66	4	-49
2006	-51	105	4	-193
2007	-63	55	-15	-59
2008	-123	68	-7	6
2009	-93	43	-2	-11
2010	-106	41	1	0
2011	-126	79	-4	-113
2012	-87	47	-1	-46
2013	-105	50	0	63
2014	4	35	7	7
2015	-83	38	-1	-62
2016	-114	53	8	-14
2017	-108	83	2	-1
2018	-81	60	-5	25

Water Year	Diversion to Project	Diversion to Tule Lake NWR	Diversion to Lower Klamath NWR	Flow at Keno
2019	-62	68	6	-137
2020	-29	42	7	-3
2021	40	41	8	26
2022	27	33	8	-7
Average	-77.3	64.8	-0.5	-46.3

Note that in the IOP, simulated irrigation season surface water diversions were not constrained by historical demand. This was not the case in the Proposed Action where SS diversions were not allowed to exceed demand. Post-processing the IOP surface water diversion results by capping them at historical demand reduces the IOP diversions by 18.6 TAF on an annual average basis. The reductions in diversion occur entirely in wet years and more accurately reflect the actual demand. The difference between the water year total Proposed Action diversion to the Project and the demand-capped IOP diversion to Project is -58.7 TAF, significantly less than the -77.3 TAF reduction reported above. However, the actual historical demand still shows that demand exceeded supply in drier years.

3.5.3 Yurok Tribe Boat Dance Ceremony

The Boat Dance is part of a traditional Yurok religious ceremony held to restore and renew the balance of the world. The ceremony, including the Boat Dance, is held in late summer in even-numbered years and has been practiced on the river since time immemorial. In the Boat Dance, Yurok religious practitioners dance in large hand carved redwood canoes and travel on the Klamath River within the Yurok Reservation. To safely conduct the ceremony, it is necessary to have sufficient flows in the river to provide predictable currents and a water depth that allows for the canoes to pass over a riffle. If the Boat Dance cannot take place, the Tribe’s world renewal ceremony cannot be completed. Reclamation would increase water releases from LRD to the lower Klamath River to support the Boat Dance. In the past, 7 TAF has been used to support this event. The bi-annual Yurok Tribal Boat Dance flows are anticipated to serve as environmental cues for early returning Coho Salmon adults and parr Coho Salmon and enhance passage opportunities. Reclamation will determine the timing and quantity of Boat Dance flows in consultation with the Yurok Tribe.

3.5.4 Change in Storage

UKL starts with the same storage in the Proposed Action as in the IOP. Between October 1, 1990, and September 30, 2022 (the end of water year 2022), the cumulative difference in storage between the Proposed Action and the IOP is -96.5 TAF. Divide -96.5 by 42 years (number of water years in the period of record) to get the annual average change in storage: -2.3 TAF. This accounts for the difference between the water year average change in inflow (-61.6 TAF) and the water year average change in outflow (-59.3 TAF).

3.6 Compliance Monitoring

Reclamation will monitor flows daily at LRD, Keno Dam, Clear Lake Reservoir, Gerber Reservoir, and all major diversion points (A Canal, Station 48, Miller Hill, North Canal, and Ady Canal). Reclamation will also continue monitoring at other locations necessary to effectively manage the Project, such as the LRDC, pumping plants E/EE and F/FF, and Harpold Dam. Reclamation will also continue to fund USGS gages at Sprague River, Williamson River, UKL, LRD, Keno Dam, and other locations within the Project area. Reclamation will also work with USGS, OWRD, NMFS, and USFWS to identify other locations necessary to effectively administer the Project.

In addition, Reclamation will closely coordinate with agricultural or other diverters to anticipate and adjust for any significant changes in diversions that could affect releases from Keno to the Klamath River.

If in the course of monitoring these various hydrologic gaging stations or through coordination with cooperators at the Services, it becomes apparent that flows are not in compliance with the modelled outcomes in the Proposed Action, Reclamation will immediately take steps to adjust operations to bring them back in compliance. Any volumetric difference in prescriptive flows will be assessed and remedied through an equal release as soon as practicable.

3.7 Special Studies

Special studies address areas of scientific uncertainty on the reasonable balance among competing demands for water, including the requirements of fish, wildlife, and agriculture. While special studies do not avoid, minimize, or mitigate adverse effects on federally-listed species, over time they may inform the effectiveness of measures taken to avoid, minimize, or mitigate incidental take. The criteria for identification of a special study in the Proposed Action balances uncertainty and flexibility. Reclamation would not rely on uncertain outcomes from a study but may require direct or incidental take to conduct the study.

Reclamation may from time to time modify and refine the special studies listed below in collaboration with the Services.

3.7.1 Klamath River Basin Natural Flow Study

In the early 2000s, KBAO partnered with the Reclamation’s Technical Service Center located in Denver, Colorado, to produce a study to estimate the natural flow of the Klamath River at the Keno Dam location. Only the effects of agriculture development were accounted for to produce the document titled *Natural Flow of the Upper Klamath River* (Reclamation, 2005).

The 2005 document underwent internal review by Reclamation and external review by the National Research Council (NRC) in 2008. The NRC comments focused on issues with the 2005 study monthly time step, effects of ground water use, and the issue that only agricultural changes to the Upper Klamath Basin were addressed. Other landscape scale changes to the Klamath Basin were not accounted for.

In 2020, KBAO decided to revise and improve the 2005 document by incorporating the NRC recommendations and use the latest available technology/data to produce an updated document. The Technical Service Center in Denver has provided the support and resources to produce the updated document titled *Klamath River Basin Revised Natural Flow Study* (Reclamation, 2020c). The main goals/motivation to produce the revised study are:

- Contribute to the Klamath Basin Science Initiative
- Provide rigorous scientific information to support habitat studies, drought planning, and water supply/allocation planning
- Address deficiencies in the 2005 study outlined by the NRC

The current document takes a comprehensive, unified approach that relies on a partnership with the Desert Research Institute and USGS, collaboration with NMFS, USFWS, and OWRD, and engagement with local stakeholders. The study evaluates natural streamflow within the Klamath River Basin, which includes 11 watersheds and over 10 million acres in southern Oregon and northern California. The Natural Flow Study is relying on best science practices to provide essential information to develop near-term and long-term solutions for the Klamath River Basin. The final publication of the Natural Flow Study is anticipated in 2025.

3.7.2 Updated Bathymetry Inflow/Storage Study

Concerns were raised about bathymetric data availability for UKL—field surveys showed water depths that were significantly different from data generated as part of those bathymetric survey efforts. Due to these concerns and given the importance of accurate elevation-area-volume relationships for UKL planning efforts, Reclamation developed a new bathymetric surface for UKL, including Agency Lake, in early 2023. The new bathymetry was developed by combining Light Detection and Ranging (LiDAR) data, collected in late 2020, for the upland areas around UKL with data collected by boat during a bathymetric (underwater) survey of the wetted UKL area in November 2020, April 2021, and October 2022. Additional details regarding the UKL bathymetric survey can be found in the *Upper Klamath Lake 2020-2022 Sedimentation Survey Report* (Hollenback et al., 2023b).

This new bathymetry was used to develop new area-capacity tables for UKL and to recompute UKL inflows for the period of record. The recomputed UKL inflows were used for the Proposed Action modeling and to reconstruct the historical NRCS inflow forecasts.

3.8 Monitoring Studies

Reclamation will continue to support research and monitoring projects that inform managers on the status of ESA-listed species populations as appropriated funds allow. These studies will inform stakeholder technical working groups such as the Adaptive Management Team (Section

3.11). Each effort will be used to evaluate the impact the Project on listed species including estimating Incidental Take, but also represent research that advances understanding of the species needs.

3.9 Water Shortage Planning

Reclamation generally follows an established process for identifying and responding to the situation where available water supplies are inadequate to meet beneficial irrigation demands within the Project. During the FW period, Reclamation coordinates directly with KDD and USFWS regarding Project water availability and demands (for both NWR and irrigation purposes). Reclamation does not make any public announcement of the volume of water available during the FW period for delivery to the Project, including Lower Klamath NWR.

Near the beginning of the SS irrigation season, Reclamation issues an annual Operations Plan, which identifies the anticipated volume of water available from the various sources used by the Project and the associated operating criteria applicable that year. The Operations Plan is posted on Reclamation’s website, a press release is issued, and copies are sent by letter to Project water users and affected Tribes.

In the event of an anticipated shortage in the volume of water available for irrigation use from Clear Lake and Gerber reservoirs, Reclamation coordinates the allocation and delivery of limited supplies with LVID, HID, and others with a contractual right to receive stored water from these reservoirs.

In the event of an anticipated shortage in the volume of water available for irrigation use from UKL and the Klamath River, Reclamation will coordinate with irrigation districts and water users regarding anticipated irrigation demands within the Project. If the volume of water or the timing when it is available is less than the anticipated demands of the repayment districts (KID and TID), Reclamation may determine it necessary to issue an Annual Drought Plan, which identifies and explains how water from UKL and the Klamath River is to be allocated among various entities with different contractual priorities to Project water. The Annual Drought Plan is posted on Reclamation’s website, a press release is issued, and affected Project water users are provided a copy and notified by letter of the volume of water available under their respective contract.

The Annual Drought Plan will identify an initial allocation from UKL and the Klamath River for entities and individuals by order of contractual priority. Reclamation then updates the allocation (either increasing or decreasing the water available) as the irrigation season progresses and hydrologic conditions change, again notifying affected contractors by letter. Reclamation staff attends district board meetings, calls contractors by telephone, and answers direct inquiries related to the Annual Drought Plan allocation.

In addition to possibly allocating the available water through the Annual Drought Plan, there are other actions that Reclamation can take or directly facilitate in response to a shortage in water available from the Project.

Consistent with Reclamation policy, Reclamation may administratively approve the transfer of water between districts and individual water users within the Project. Such transfers do not increase the amount of water available to the Project or expand the Project's service area but rather simply temporarily change the place of use within the Project. Prior to approval, Reclamation reviews each application on a case-by-case basis to make sure these basic conditions are met.

These internal transfers are generally used by irrigators to address a shortage in the water available under a given contract, based on the contractual priority it provides to Project water. Overall, these types of transfers promote the efficient and economical use of water.

Internal Project transfers are also available for irrigable lands within Lower Klamath and Tule Lake NWRs, subject to the approval of USFWS. Water made available to an NWR through an internal transfer approved by Reclamation is separate from any water that may be available for delivery to the NWR consistent with the terms of this Proposed Action.

Reclamation may also engage in irrigation demand reduction activities within the Project. Similar efforts have occurred periodically over the last two decades, subject to proper legal authority and the availability of federal appropriations. In the past, these activities have included agreements with individual landowners to forgo use of Project water or to pump supplemental groundwater.

3.10 Conservation Measures

The term "conservation measure" is defined as an action to benefit or promote the recovery of listed species that are included by the federal agency as an integral part of the Proposed Action. These actions will be taken by the federal agency or applicant, and serve to minimize or compensate for, project effects on the species under review. These may include actions taken prior to the initiation of consultation, or action which the federal agency or applicant have committed to complete in a Biological Assessment or similar document. The conservation measures proposed assist Reclamation in best meeting the requirements under Section 7 of ESA by (1) "…utilizing our authorities in furtherance of the purpose of this Act by carrying out programs for the conservation of endangered species…" and (2) avoiding actions that jeopardize the continued existence of listed species.

1. Fish salvage at Project canals occurs when canals are: (1) temporarily dewatered for a discrete action related to maintenance and/or repairs at Project facilities inclusive of canals, canal banks, levees, levee roads, water control structures, and drain features (Section 5.4.9), and (2) when canal systems are dewatered at the end of each irrigation season. Under both circumstances fish are salvaged from pools where they are stranded. Reclamation proposes, in coordination with both Services, to continue the salvage of suckers and salmon species both for routine maintenance and repair at Project structures and at conclusion of the irrigation

season when project canals, laterals, and drains are dewatered consistent with past salvage efforts since 2005 as some canals do not seasonally dewater.

2. Reclamation proposes to continue support of a captive rearing effort by the Service for LRS and SNS. The intention is to improve the numbers of suckers reaching maturity in UKL. Ultimately, a captive rearing program's function would be to promote survival and recovery of the sucker populations that suffer losses from entrainment due to the Project or other threats. Captive propagation is already an important part of listed fish recovery efforts nationwide, including at least three sucker species (i.e., June sucker, razorback sucker, and robust redhorse sucker).

3.11 Adaptive Management

Adaptive Management, as defined in Interior’s *Technical Guide on Adaptive Management* (Williams et al., 2009), is a decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a ‘trial and error’ process, but rather emphasizes learning while doing. Adaptive management does not represent an end, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders.

Reclamation is committed to a long-term adaptive management process that is conducted in a transparent, collaborative manner with Klamath Basin stakeholders. To that end, Reclamation has initiated, and will continue to support through the duration of this Proposed Action and beyond, adaptive management that meets the long-term management, research, and monitoring needs of the Klamath Basin. Reclamation envisions continuing stakeholder conversations initiated in 2023 with both a management/policy group and a technical group—collectively, the Adaptive Management Team—that represents the multiple entities and interests in the Klamath Basin, supported by facilitation. Reclamation will continue to support a robust series of conversations in a constructive and collaborative approach, such as Structured Decision-Making, that leads to development of long-term goals, objectives, and work plans, including identification and fulfillment of science needs; discussion of collaborative management approaches; collection, dissemination, storage, and utilization of collected data; and development of models and decision-making tools.

Reclamation understands that, notwithstanding the description of the long-term program described above, a Klamath Basin adaptive management program and Structured Decision-Making structure will be shaped by the participation of member entities. However, Reclamation’s intent for the program is for it to foster transparent and collaborative resource management as it has in the Great Plains (Working Together to Control Invasive Plants and Restore Prairies [U.S. National Park Service nps.gov]), Delaware Bay (Developing objectives with multiple stakeholders: adaptive management of horseshoe crabs and Red Knots in the Delaware Bay [usgs.gov]), the Prairie Pothole Region (of 2013-1279.pdf [archive.org]), and California's Central Valley (CVPIA Science Integration Team). The management and technical group members will help determine topics and identify management needs in a collective format through the structured and joint development of tools such as diagrams and models that may be used to understand outcomes and risks that inform management actions. The groups will also be able to support monitoring and research needs through the joint development of models to help inform medium and long-term management actions.

Adaptive management will represent an important strategy in Reclamation's long-term effort to minimize impacts to ESA-listed species. For example, there is little data to inform how ESA-listed species will repopulate new habitats post dam removal, nor is there data on how the Project might impact that recolonization. The Adaptive Management Team's engagement on such questions could drive establishment of a wide-ranging, multi-year research program that leads to the development of management practices and restoration projects that are focused on program objectives.

Short-term actions and evaluation criteria may be formulated by a subset of the technical stakeholder working group based on technical expertise. Informed recommendations will be made to the Management Team. Environmental responses to actions will be monitored and evaluated to assess the effectiveness of the action.

As new science accumulates, project opportunities arise, and environmental conditions evolve, the adaptive management program provides an opportunity to collaboratively and strategically manage activities to efficiently apply stakeholder resources and to realize tangible benefits to ESA-listed species and their habitats.

3.12 Inter-Seasonal and Intra-Seasonal Management

While the adaptive management program addresses the long-term science and management needs of the Klamath Basin, there remains a need for transparent communication and collaboration with regard to short- and long-term seasonal operation of the Project to ensure consistency with the anticipated outcomes of the Proposed Action. Therefore, Reclamation has created a technical team to speak to specific needs such as the Real-time Operations (RTO) (formerly known as the Flow Account Scheduling Technical Advisory [FASTA] team) and if needed will convene a longer term Water Year Operations team (WYOps) (formerly known as the Klamath Project Operations [KPO] team).

The RTO will support seasonal (with a forward-looking time horizon of roughly 30 days to the end of the Water Year horizon) water management operations through regular engagement with Reclamation on hydrologic conditions and flow management. This team will fill a similar role to the previous FASTA team, meeting as often as weekly during critical time periods to offer technical input to Reclamation staff. This team will attempt balanced representation in the Klamath Basin, consisting of technical representatives from Klamath Basin Tribes, Klamath Water Users Association, federal and state agencies, and other groups with appropriate and relevant expertise. Among other tasks, the RTO will work with Reclamation to support decisions around disposition of the FFA, allocation of historical wetland habitat water to the Deferred Project Supply, and drought-related water shortage planning.

If the RTO is inadequate to address the longer-term planning needs required by the BiOp, Reclamation will convene the WYOps to meet this need. The WYOps will support long term seasonal (with a focus on forward-looking time horizon of roughly 6 months) water management operations, also through regular engagement with Reclamation on hydrologic conditions and flow management. With similar representation as the RTO, the WYOps will work with Reclamation to focus on optimizing the Project’s ability to successfully transition from the current season into the next season and year.

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4 Seasonal Operations

The seasonal operation of the Project moves water from the winter and spring into the summer and from wetter years to drier years. Reclamation takes actions to:

- Store water and reduce flows downstream (i.e., flood control)
- Release water to increase flows downstream (i.e., pulse flows)
- Divert water for fish and wildlife and agricultural purposes
- Route water into different routes (e.g., canals, laterals, diversions)

The purpose of this chapter is to describe the range of environmental conditions from the operation of the Project under the Proposed Action. Modeling of lake surface elevation, flow, water temperature, and physical habitat shows the potential consequence from hydrologic alteration by the Proposed Action and the conditions without the consequences caused by the Proposed Action. APPENDIX C describes the Project model and operational scenarios developed through an iterative process with Project constituents. The magnitude and trends of hydrologic alteration inform the deconstruction of the seasonal operation of the Project. The modeling presented in this chapter supports the effect analyses of the Proposed Action that are provided in subsequent species-specific chapters (5 through 7).

Analyses included the following three scenarios:

1. Flow Through (ROR): This scenario represents conditions without the storage of water. Inflows into Klamath reservoirs are passed downstream subject to the channel capacity of downstream reaches. Physical flow control structures remain in an “open” configuration and are not actively operated. No storage of water would occur; therefore, no water is available for later release. No diversions or flow routing would occur from Project facilities. Non-Project facilities would operate when water is available.
2. Maximum Storage (MS): Shows conditions without the release of water. Klamath reservoirs would maximize storage and make releases only when required for flood control or other settlement contractor obligations. Similar to Flow Through (ROR), no diversion or routing of water would occur. Non-Project facilities would operate when water is available.
3. Proposed Action: The operation of the Project under the Proposed Action is described in Chapter 3 and analyzed in the Effects Analysis chapters (5 through 7). The Proposed Action includes pulse flows.

For detailed discussions of these scenarios see Sections 3.4.2 and 3.5 and APPENDIX C Sections 4, 6, and 7.2. For all three scenarios, all Lost River water remains in the Lost River Basin, and none is diverted to the LRDC. Also, there were no diversions to the refuges for historical wetland habitat and there were no return flows from the refuges. Lost River flow functionally ends at the Tule Lake NWR, but that wasn't specifically modeled.

For the Project, analyses include:

- Water Operations:
    - Upper Klamath Lake Surface Elevations: KBPM monthly median lake elevation. Chapter 3 and APPENDIX C – *Exploratory modeling* provide details. Simulation of the seasonal operation relied on the KRM.
    - Downstream flows: KBPM monthly median downstream flows (cfs) for Keno Dam, the IGD site and LRD. Chapter 3 and APPENDIX C – *Exploratory modeling* provide details. Simulation of the seasonal operation relied on the KRM.
    - A Canal Diversion: KBPM monthly median diversion flows (cfs). Chapter 3 and APPENDIX C – *Exploratory modeling* provide details. Simulation of the seasonal operation relied on the KRM.
    - Clear Lake Surface Elevations: Clear Lake measured end of month lake surface elevations.
    - Gerber Reservoir Surface Elevations: Gerber Reservoir measured end of month lake surface elevations.
- Water Temperatures: River Basin Model-10 (RBM10) monthly median water temperatures for the three scenarios described above and historical temperatures. See Perry et al. (2018) for detailed methods.
- Suitable Habitat: Stream Salmonid Simulator (S3) Model median monthly weighted useable area for Chinook Salmon habitat and Probability Density Function (PDF) median monthly habitat area for Coho. See Perry et al. (2019) for detailed description of the S3 model and its application to Klamath River Chinook Salmon. See Som et al. *in review* for a detailed description of the PDF model and its application to Klamath River Coho Salmon.

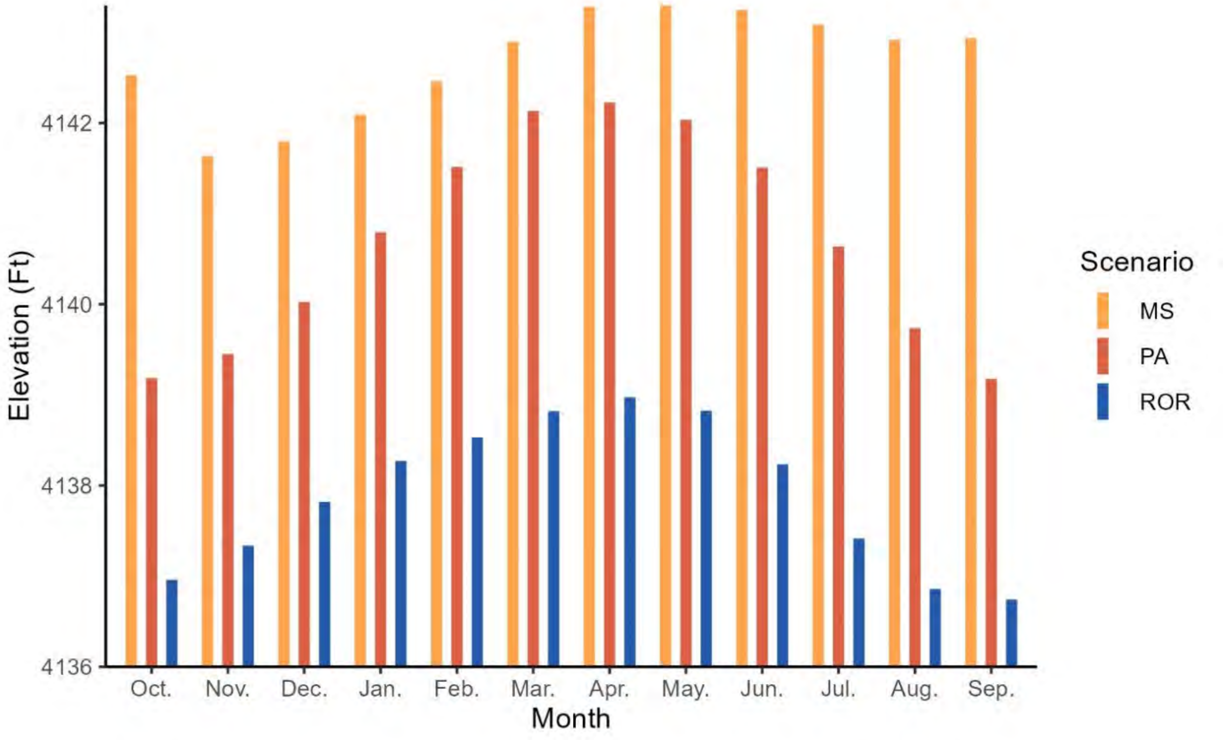
Qualitative analysis of the effects of O&M activities (i.e., non-water operation actions) will be discussed in the effects sections of species-specific chapters (5 through 7). This will include, for example, removal, repair, and replacement of water control infrastructure; road repair; and weed abatement via mowing.

4.1 Klamath Project

4.1.1 Water Operations

4.1.1.1 Upper Klamath Lake Surface Elevations

Figure 4-1 shows the elevation for UKL for the ROR, MS, and Proposed Action scenarios.



Note: See also Table 5-6 and Table 5-7.

Figure 4-1. Upper Klamath Lake monthly median surface elevations, all years 1991–2022

In general, lake levels are higher in the winter, spring, and early summer and lower in late summer and fall. One notable exception is the MS scenario, where lake levels remain higher through spring, summer, and early fall before water is released in October and November to prepare for winter, spring precipitation events, and flood control. Lake levels under the Proposed Action are lower than the MS scenario throughout the entire year.

4.1.1.2 Klamath River Downstream Flow

Keno Dam Figure 4-2 shows the downstream flow for Keno Dam for the Flow Through (ROR), MS, and Proposed Action scenarios.

In general, flows are higher in the spring and lower in the summer, fall, and winter. One notable exception is the MS scenario, where flows increase substantially in October and November in order to release stored water and to prepare for winter and spring precipitation events and flood control. Flows under the Proposed Action are lower than the MS in late-fall (October and November), winter, and early-spring (March); higher in April; lower in May; and higher in summer through early fall (September).

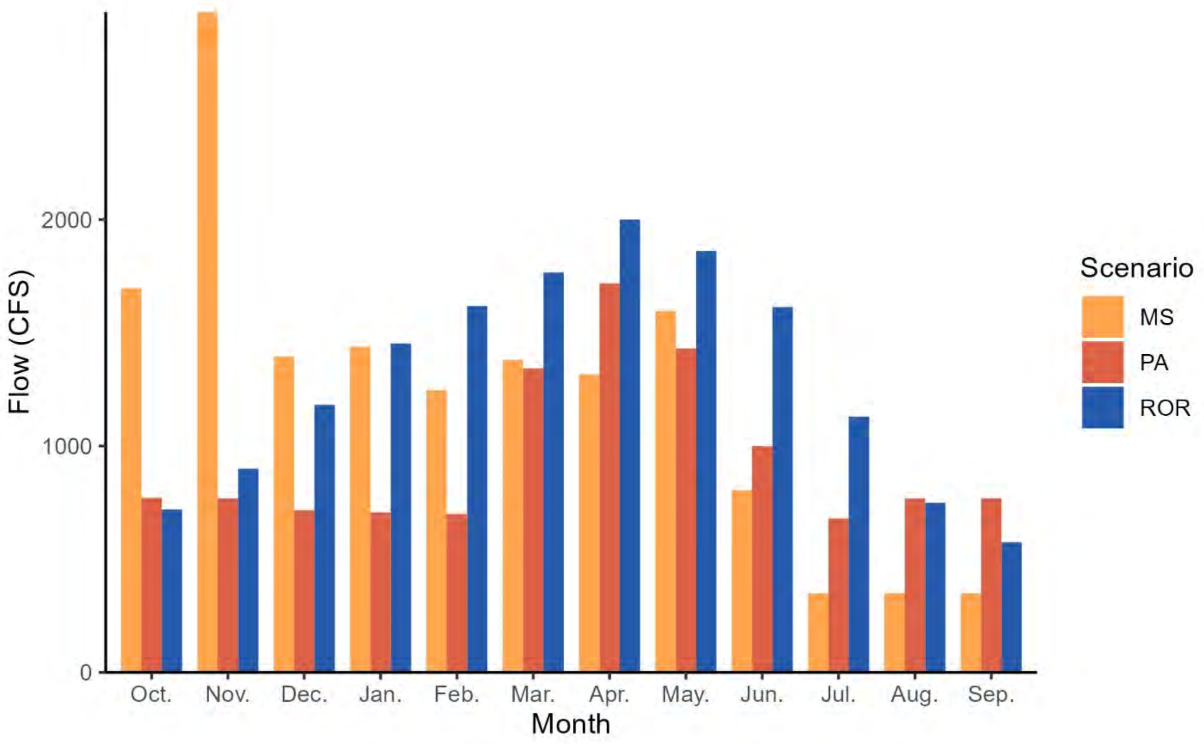


Figure 4-2. Klamath River monthly median downstream flows at Keno Dam, all years 1991–2022

Former Iron Gate Dam Site Figure 4-3 shows the downstream flow at the IGD site for the Flow Through (ROR), MS, NAA (IOP), and Proposed Action scenarios.

In general, flows are higher in the spring and lower in the summer, fall, and winter. One notable exception is the MS scenario, where flows increase substantially in October and November to release stored water and to prepare for winter and spring precipitation events and flood control. Flows under the Proposed Action are lower than the MS scenario in late fall (October and November) and winter, higher in early spring (March and April), lower in late spring (May), and higher in summer and early fall (September).

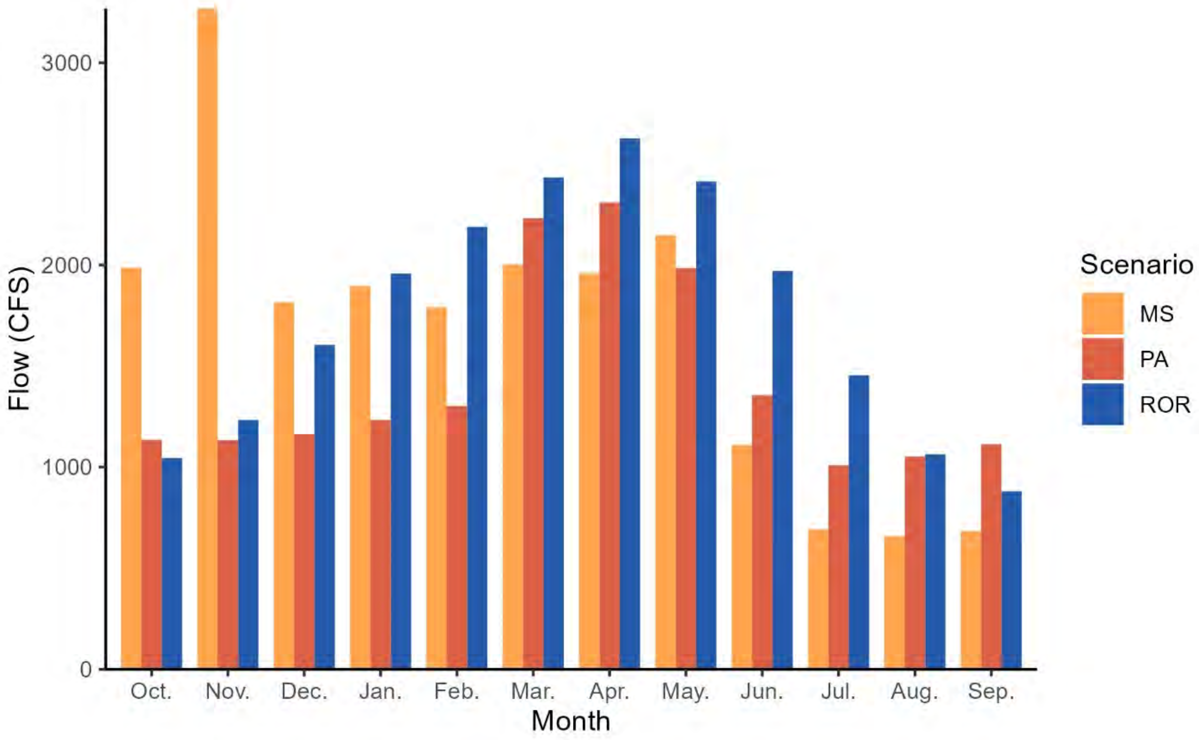


Figure 4-3. Klamath River monthly median downstream flows at former Iron Gate Dam site, all years 1991–2022

4.1.1.3 Link River Downstream Flow

Figure 4-4 shows the downstream flow at the LRD for the Flow Through (ROR), MS, and Proposed Action scenarios.

In general, flows are higher in the spring and lower in the summer, fall, and winter. One notable exception is the MS scenario, where flows increase substantially in October and November to release stored water and to prepare for winter and spring precipitation events and flood control. Flows under the Proposed Action are lower than the MS scenario in late fall (October and November), winter, and early spring (March); higher in April; lower in May; and higher in summer and early fall (September).

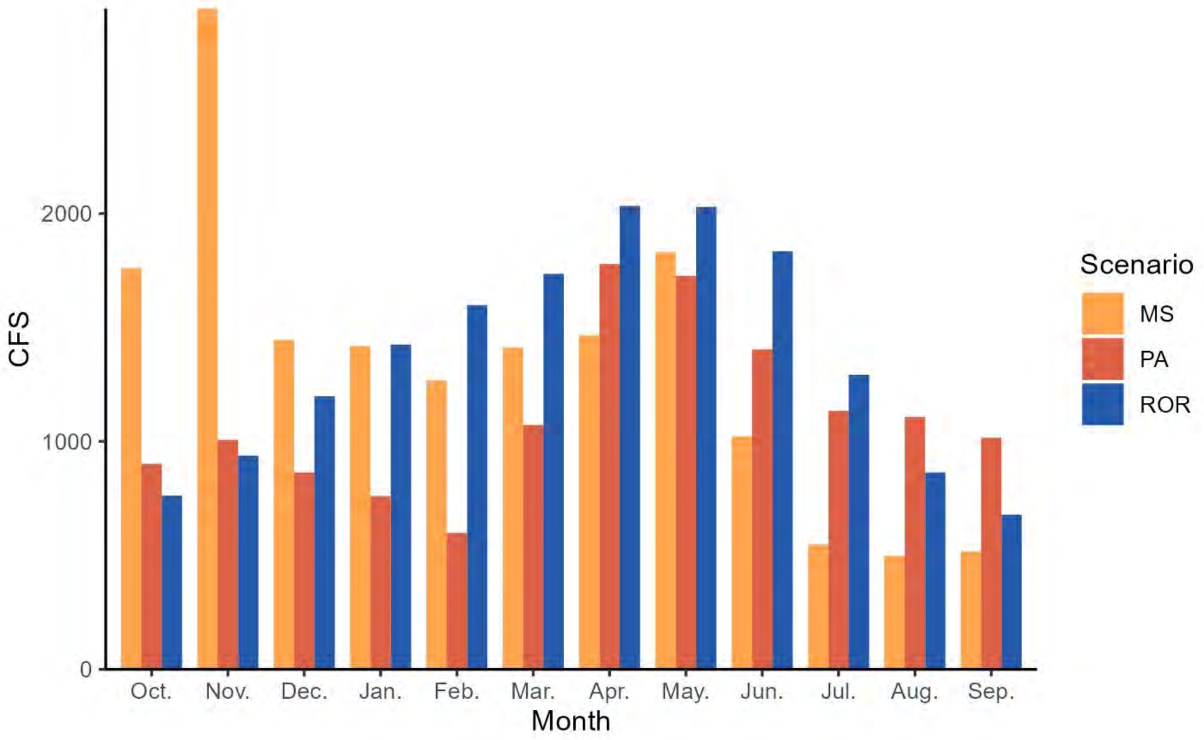


Figure 4-4. Link River monthly median downstream flows at Link River Dam, all years 1991–2022

4.1.1.4 A Canal Diversions

Figure 4-5 shows the diversion flow at A Canal for the Flow Through (ROR), MS, and Proposed Action scenarios.

In general, diversion flows occur in late spring through summer and into early fall. There are no diversions in late fall through winter and extremely low diversions in early spring. Flows under the Proposed Action are always higher than the MS scenario under which there are no diversions at any time (i.e., diversion would not occur without the Proposed Action).

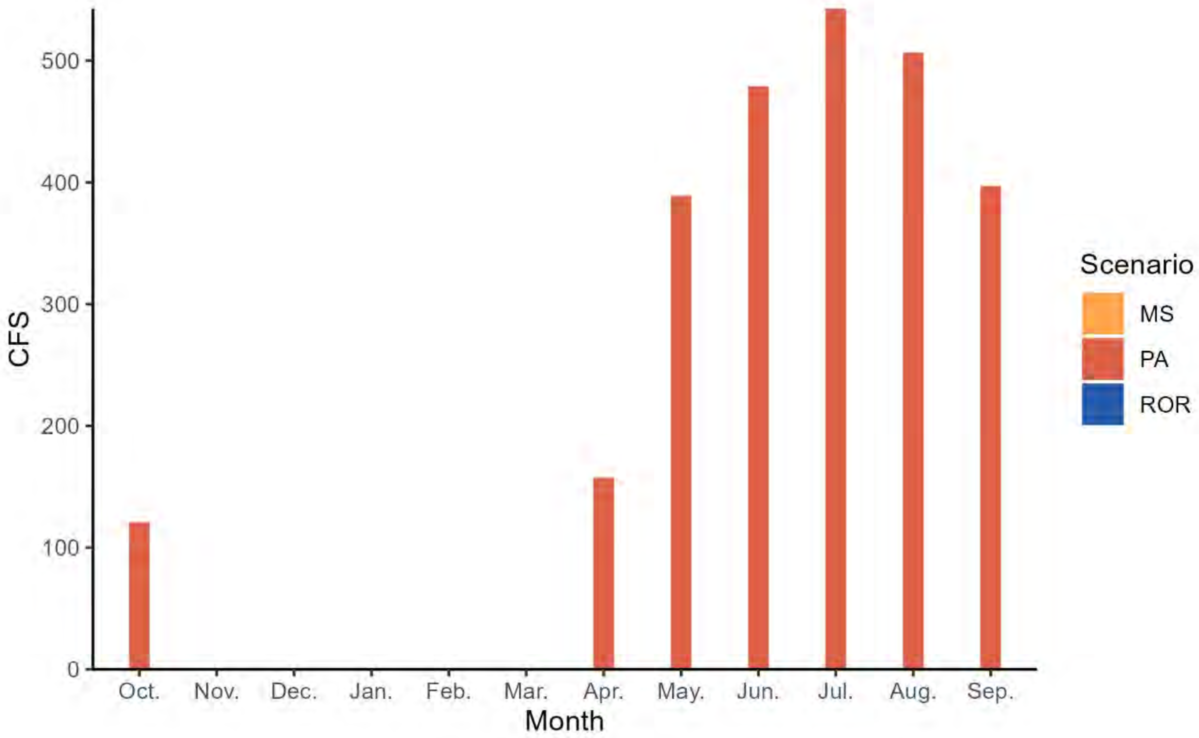
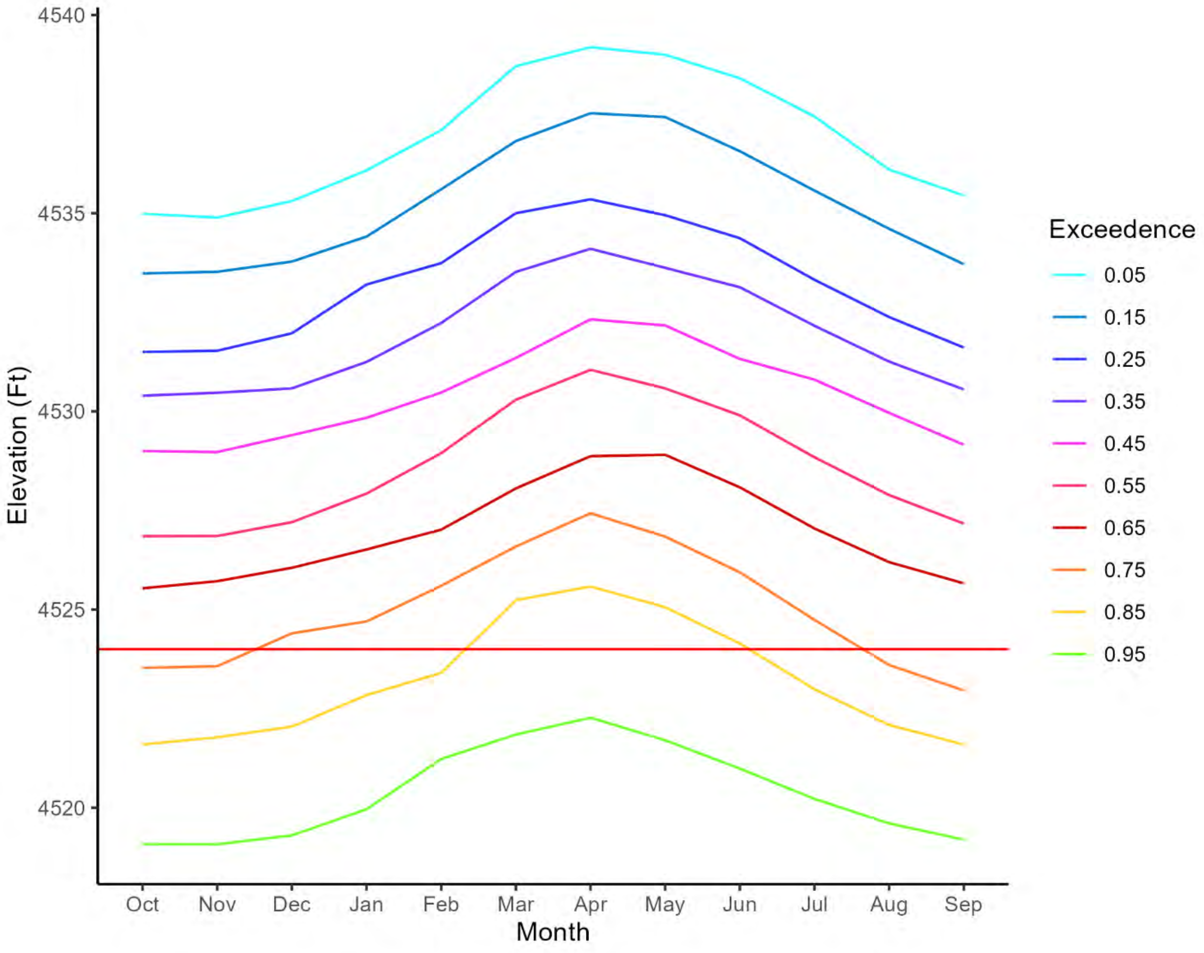


Figure 4-5. Monthly median diversion flows at A Canal, all years 1991–2022

4.1.1.5 Clear Lake Surface Elevations

Figure 4-6 shows the measured end of month elevation for Clear Lake over the period of record (1911-2023). Seasonally, lake levels start out lower and increase throughout winter into spring, reach their annual highs in mid-to-late spring before decreasing throughout summer and fall. Under the Proposed Action, lake levels and exceedances would be expected to remain consistent with those experienced over the period of record. Under the MS scenario, the east lobe of Clear Lake would largely resemble a shallow lake or wet meadow during spring months and would be mostly non-watered in late summer through winter. The wetted area of the lake would be predominantly confined to the west lobe.

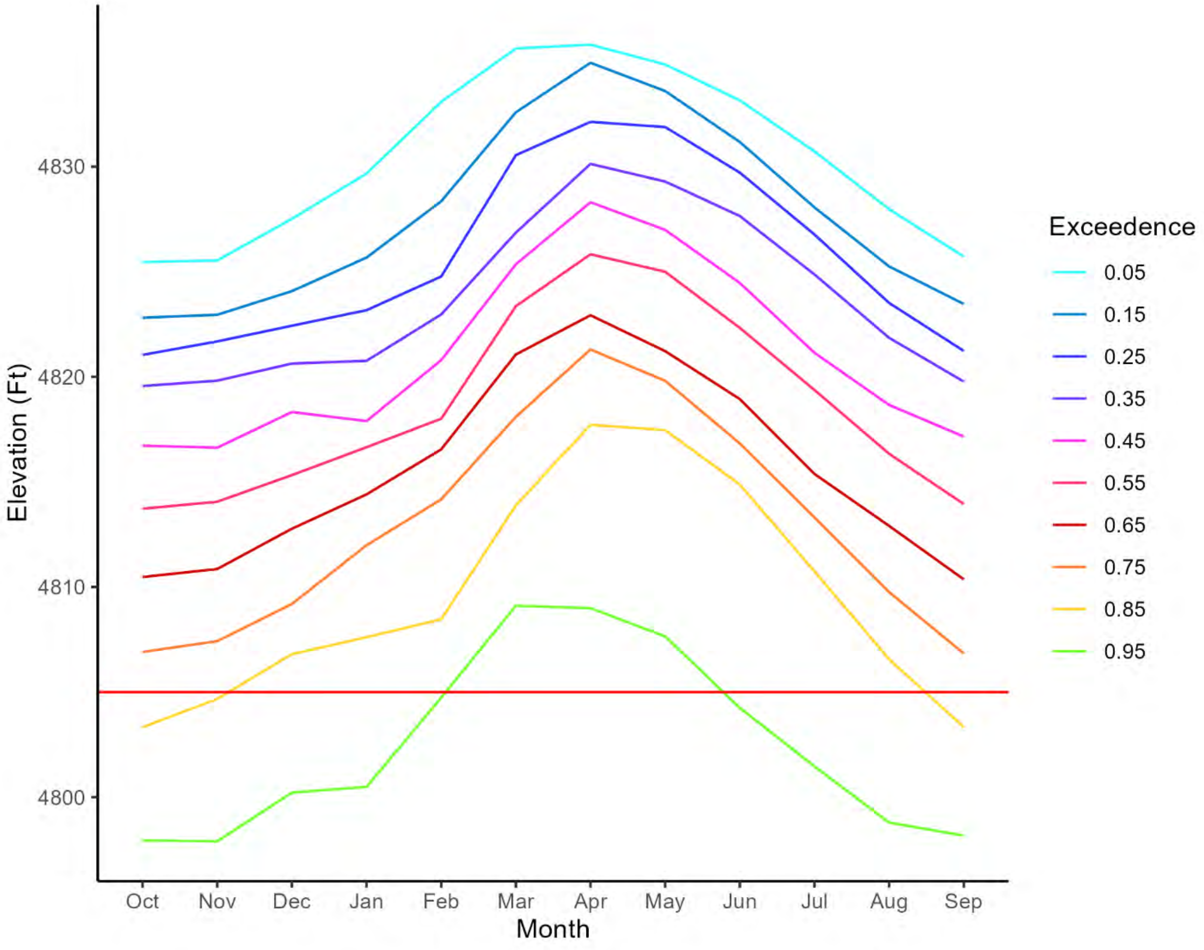


Note: The red line indicates the 4,524-foot threshold required for access to Willow Creek spawning grounds.

Figure 4-6. Probability of exceedance of end of month Clear Lake surface elevations derived from model output for the 113-year period of record (1911-2023) under the Proposed Action

4.1.1.6 Gerber Reservoir Surface Elevations

Figure 4-7 shows the measured end of month elevation for Gerber Reservoir over the period of record (1925-2023). Seasonally, lake levels start out lower and increase throughout winter into spring, reach their annual highs in mid-to-late spring before decreasing throughout summer and fall. Under the Proposed Action, lake levels and exceedances would be expected to remain consistent with those experienced over the period of record. Under the MS scenario, Gerber Reservoir would likely be a small lake for several weeks during mid-February through April when inflows exceed the gate openings on the dam (about 900 cfs). Lake area would be substantially reduced or eliminated throughout the remainder of the year. The remaining creek channels may provide limited wetted area in some years under the MS scenario.



Note: The red line indicates the 4,805-foot threshold required for access to Gerber Reservoir tributary spawning grounds.

Figure 4-7. Probability of exceedance of end of month Gerber Reservoir surface elevations derived from model output for the 99-year period of record (1925-2023) under the Proposed Action

4.1.2 Water Temperatures

Reclamation uses a heat budget model called RBM10 (Yearsley, 2001, 2009; Perry et al., 2011) to analyze the effect of historical IGD flow releases on Klamath River water temperatures. RBM10 allows the user to model the effects of discharge on water temperature at numerous points along a river channel (Perry et al., 2011). Reservoirs behind Iron Gate, J.C. Boyle, and Copco No. 1 and No. 2 dams will no longer exist after the dams are removed but are still included in the model as updates could not be made to the model on time for this consultation. Reclamation analyzed RBM10 output for river miles 174.0 (downstream of the confluence with the Shasta River), 136.8 (downstream of the confluence with the Scott River), and 62.5 (downstream of the confluence of the Salmon River) for 1991 to 2021. Reclamation determined that this combination of sites and years was appropriate to assess the effect of the Proposed Action over the periods and locations relevant for juvenile outmigration, juvenile rearing, and adult migration. The period from 1991–2021 was selected to match the climatological data and acknowledge the decade-over-decade decrease in inflows to the Project (see Chapter 3 and APPENDIX C for further discussion).

Water Temperature modeling includes the following scenarios:

- Flow Through (ROR): Inflows into Klamath reservoirs are passed downstream subject to the channel capacity of downstream reaches. Physical flow control structures remain in the system in an "open" configuration but are not actively operated. No storage of water would occur; therefore, no water is available for later release. No diversions or flow routing would occur from Project facilities. Non-Project facilities would operate when water is available.
- MS: Shows conditions without the release of water. Klamath reservoirs would maximize storage and make releases only when required for flood control or other settlement contractor obligations). Similar to Flow Through (ROR), no diversions and no flow routing would occur. Non-Project facilities would operate when water is available.
- Proposed Action Alternative: The operation of the Project under the Proposed Action is described in Chapter 3 and analyzed in the Effects Analysis chapters (5 through 7). The Proposed Action includes pulse flows.

Figure 4-8 shows the monthly median temperature for the Flow Through (ROR), MS, and Proposed Action scenarios at monitoring points below the Salmon River, Scott River, and Shasta River, on the Klamath River. In general, temperatures at all three representative locations follow the same seasonal pattern with temperatures lowest in winter and highest from summer into early-fall regardless of scenario. The three representative sites have similar monthly median water temperatures. The furthest downstream sites (e.g., Below Salmon River) are slightly warmer than the upstream sites (e.g., Below Shasta River). Within a given month for all three representative locations, the three scenarios do not differ substantially from each other and the variances (25th and 75th quantile bars) substantially or totally overlap.

Figure 4-9 shows the difference in monthly median temperature between the MS scenario and the Proposed Action at monitoring points below the Salmon River, Scott River, and Shasta River on the Klamath River. In general, temperatures under the Proposed Action are slightly warmer in winter and slightly cooler in summer and fall. Below the Scott and Shasta rivers, temperatures under the Proposed Action are also cooler in spring, an effect not seen Below the Salmon River. Also, temperatures under the Proposed Action below the Shasta River are slightly warmer in September only, contrary to the general trend of cooler fall temperatures under the Proposed Action. Temperatures under the Proposed Action never increase by more than 0.1°C nor decrease by more than 0.5°C. Most temperature decreases between the Proposed Action and the MS scenario are between 0.2°C and 0.4°C and all increases are between 0°C and 0.1°C.

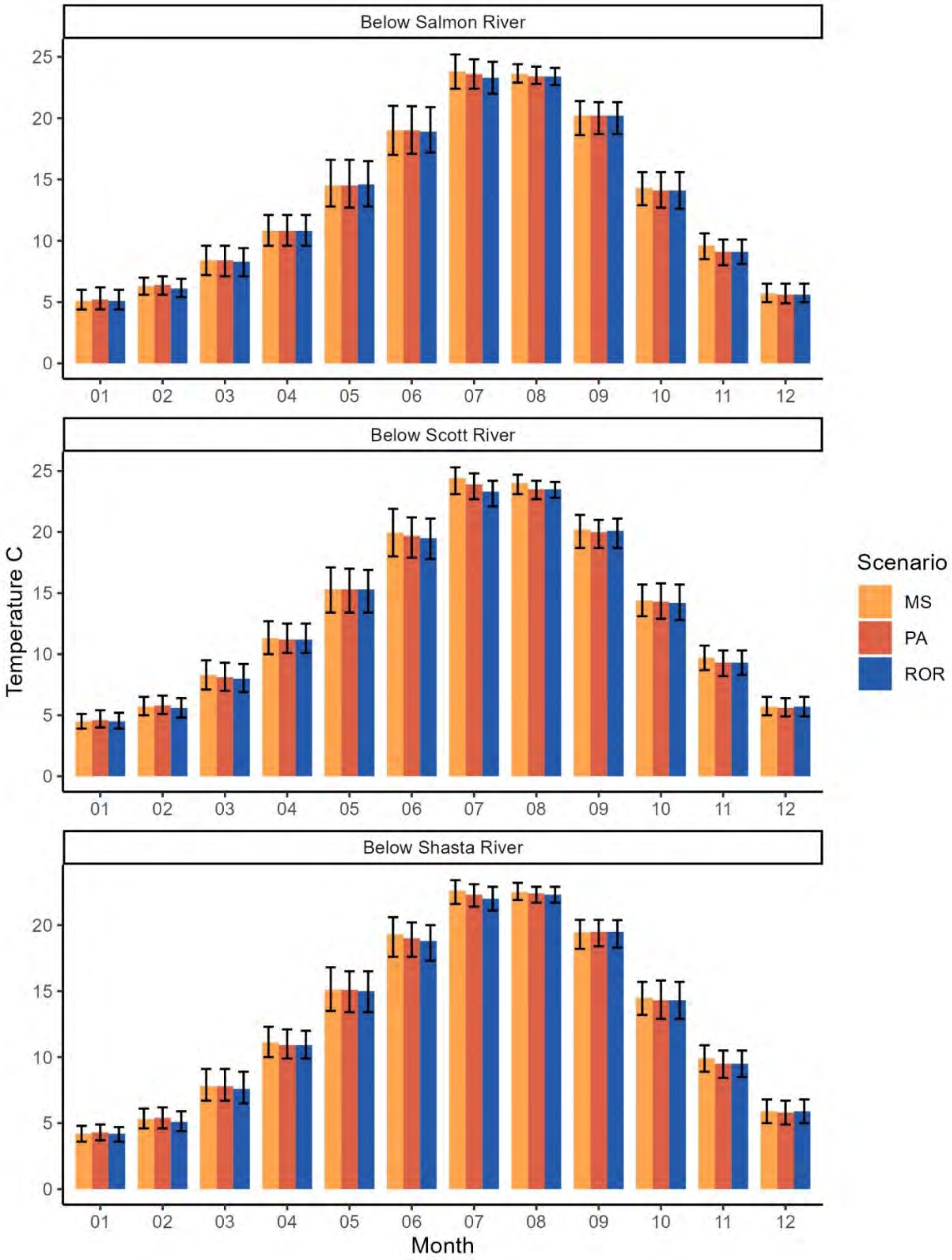


Figure 4-8. Monthly median temperature at three representative locations on the Klamath River, all years 1991–2022

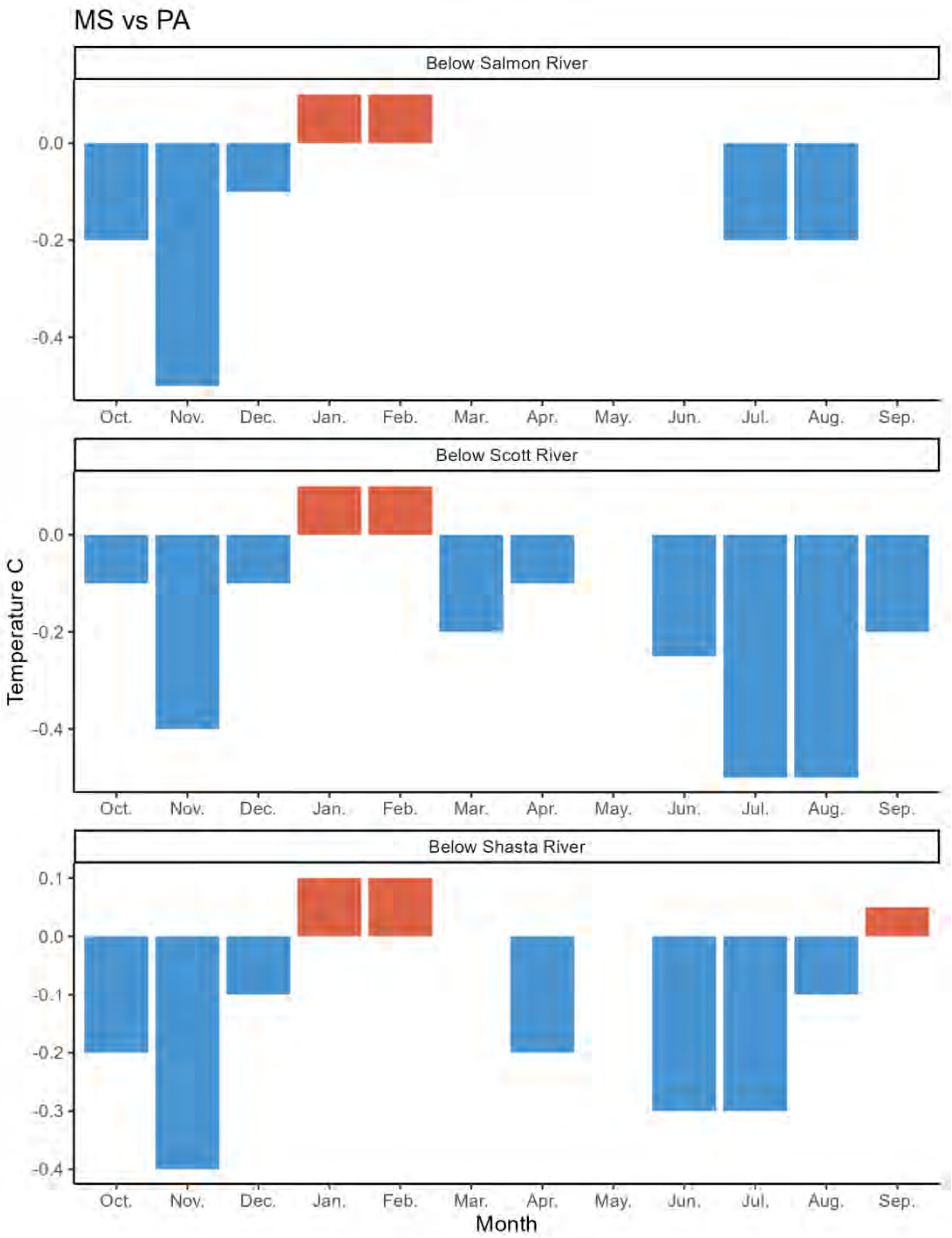


Figure 4-9. Difference in monthly median temperature between the Proposed Action and Maximum Storage scenario at three representative locations on the Klamath River, all years 1991–2022

4.1.3 Suitable Habitat

4.1.3.1 Stream Salmonid Simulator Model

The Habitat module of the S3 model was applied to incubation and rearing habitat for egg to embryo, fry, and parr life stages of Chinook Salmon in the Klamath River below the IGD site. S3 is a life-stage-based population model that tracks daily growth, movement, and survival of juvenile salmon. The model uses river flows as a key driver of habitat availability and capacity, which then drives population dynamics. The Habitat module breaks the river up into discrete habitat units referenced by the upstream and downstream boundaries defined as river kilometers (rkm) from the ocean. This module was used to construct a daily time series of WUAs for each habitat unit between IGD and the ocean. These time series used simulated flows for the Lower Klamath River, which were generated by using simulated flows at IGD and historical tributary inflows and accretions. These flows were applied to habitat suitability curves from the habitat suitability model of Som et al. (2016a) for juvenile Chinook Salmon life stages. The time period from 1991–2021 was selected to match the climatological data and acknowledge the decade-over-decade decrease in inflows to the Project (see Chapter 3 and APPENDIX C for further discussion). Detailed methods for the entire S3 model can be found in Perry et al. (2019).

Habitat modeling includes the following scenarios:

- Flow Through (ROR): Inflows into Klamath reservoirs are passed downstream subject to the channel capacity of downstream reaches. Physical flow control structures remain in the system in an “open” configuration but are not actively operated. No storage of water would occur; therefore, no water is available for later release. No diversions or flow routing would occur from Project facilities. Non-Project facilities would operate when water is available.
- MS: Shows conditions without the release of water. Klamath reservoirs would maximize storage and make releases only when required for flood control or other contract obligations. Similar to Flow Through (ROR), no diversions and no flow routing would occur. Non-Project facilities would operate when water is available.
- Proposed Action Alternative: The operation of the Project under the Proposed Action is described in Chapter 3 and analyzed in the Effects Analysis chapters (5 through 7). The Proposed Action includes pulse flows.

For detailed discussions of these scenarios see Sections 3.4.2 and 3.5 and APPENDIX C Sections 4, 6, and 7.2. For all three scenarios, all Lost River water remains in the Lost River Basin, and none is diverted to the LRDC. Also, there were no diversions to the refuges for historical wetland habitat and there were no return flows from the refuges. Lost River flow functionally ends at the Tule Lake NWR, but that wasn’t specifically modeled.

Figure 4-10 shows the median daily total habitat for egg to embryo, fry, and parr life stages under the Flow Through (ROR), MS, and Proposed Action scenarios for the Klamath River from IGD site to the mouth. In general, habitat area decreases across the incubation period for eggs to embryos, increases across the rearing period for fry before decreasing sharply in June, and then peaking in spring for parr while remaining relatively stable year-round. Monthly variability is highest for fry, more stable for eggs to embryos especially in the early fall, and the most stable for parr in summer through late winter. Variability in habitat for the parr life stage is much higher in spring with the tendency towards extreme high flows under all scenarios.

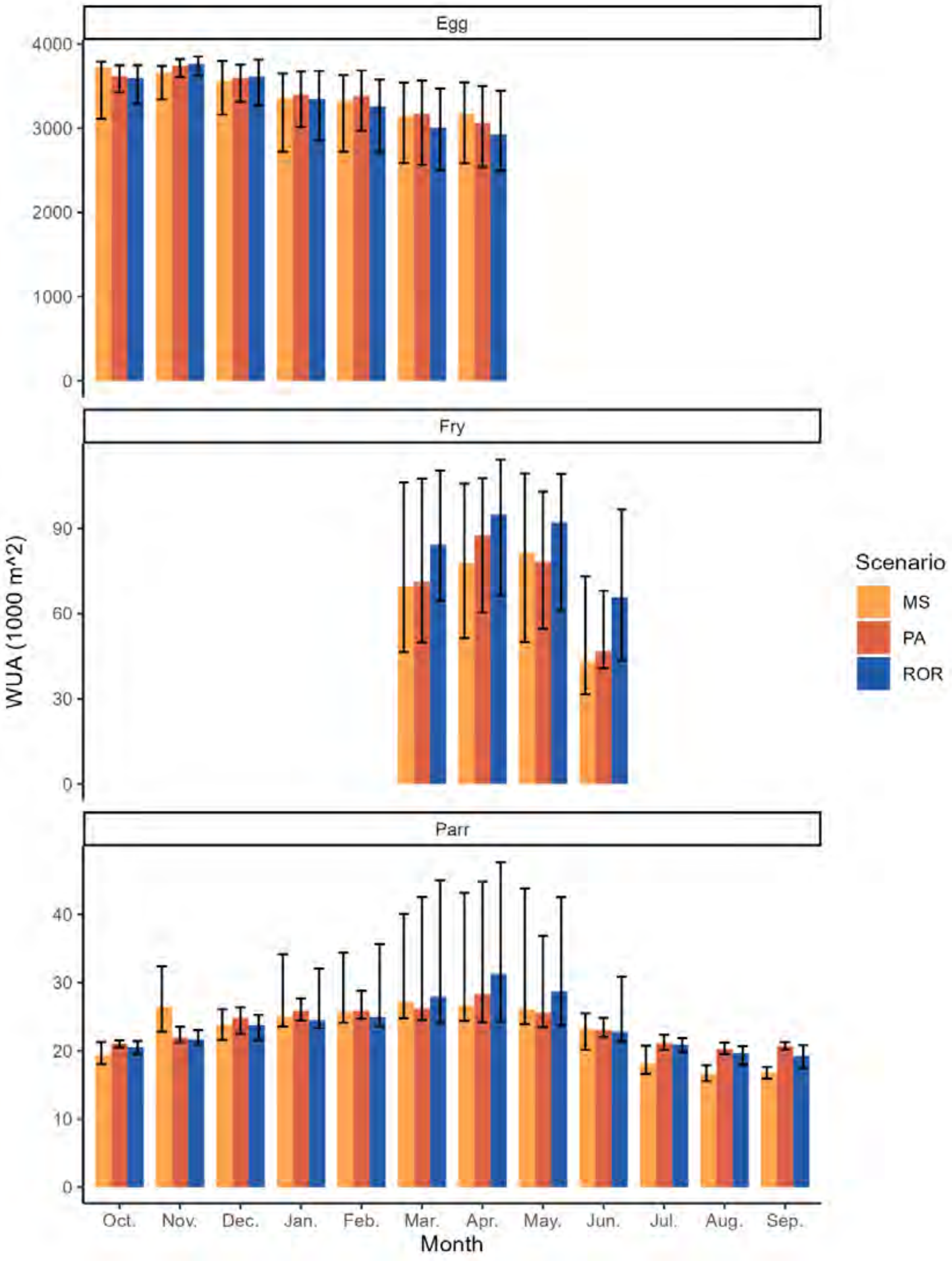


Figure 4-10. Median daily total habitat for Chinook Salmon egg to embryo, fry, and parr in the Klamath River, all years 1991–2022

Figure 4-11 shows the difference in median daily total habitat between the MS scenario and the Proposed Action for egg to embryo, fry, and parr life stages on the Klamath River from the IGD site to the mouth. The magnitude of differences in habitat area under the Proposed Action compared to the MS scenario is larger for eggs to embryos, smaller for parr, and intermediate for fry. Increases in habitat area under the Proposed Action for eggs to embryos range between ~25,000 to ~75,000 m^2 and decreases are both ~100,000 m^2. Increases in habitat area under the Proposed Action for fry range between ~1,000 to ~10,000 m^2 and single decrease is less than 5,000 m^2. Increases in habitat area under the Proposed Action for parr range between ~500 to ~4,000 m^2 and decreases are mostly less than 500 m^2 with one ~4,000 m^2.

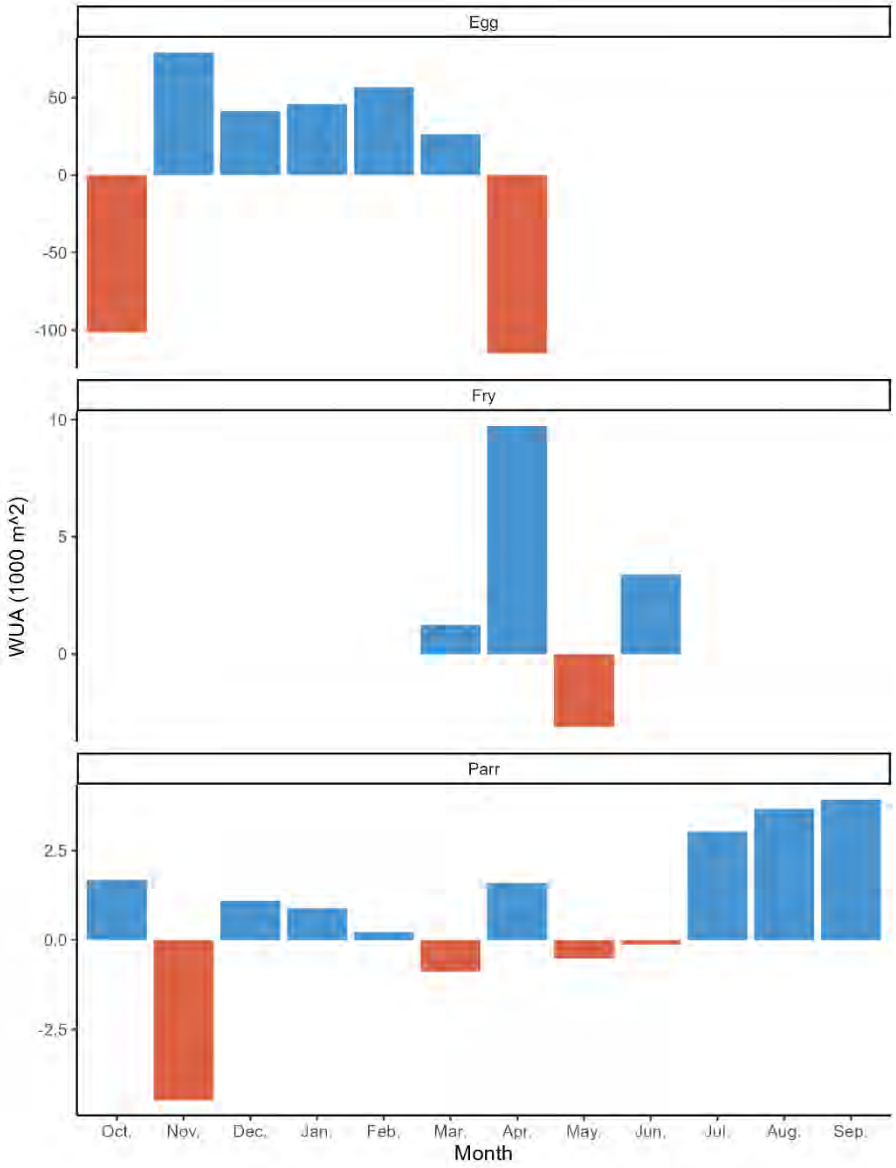


Figure 4-11. Difference in median daily total habitat between the Proposed Action and Maximum Storage scenario for Chinook Salmon egg to embryo, fry, and parr in the Klamath River, all years 1991-2022

Trends in differences in habitat area under the Proposed Action compared to the MS scenario vary for different life stages. Habitat area under the Proposed Action for the egg to embryo life stage is larger from mid-fall to early spring but is smaller at both the beginning (October) and end (April) of the incubation period. Habitat area under the Proposed Action for the fry life stage is larger through most of the rearing period but is smaller in May. Habitat area under the Proposed Action for parr is generally larger but is smaller in November, March, and late spring into early summer.

4.1.3.2 Probability Density Function Model

The Probability Density Function Model takes Coho habitat data from the Klamath and applies it to an occupancy model developed on the Trinity River. This model estimates probabilities of Coho presence/absence which are then scaled and applied to calculate a weighted usable habitat area (WUA). The occupancy model allows simultaneous estimation of both an ecological and detection process. In this case the ecological process is presence/absence of Coho Fry instead of abundance. For the ecological process, a model was fit having depth, velocity, and distance to cover as fixed effects, and for the detection process fixed effects of depth and each specific observer. The habitat model was originally developed and fit using data for Coho Salmon fry from a large-scale effort to assess how physical habitat variables related to the presence and abundance of juvenile salmonids in the restoration reach of the Trinity River (Smit et al., *accepted*). Som et al. (2018) provides extensive detail on the habitat sampling design upon which this model was developed.

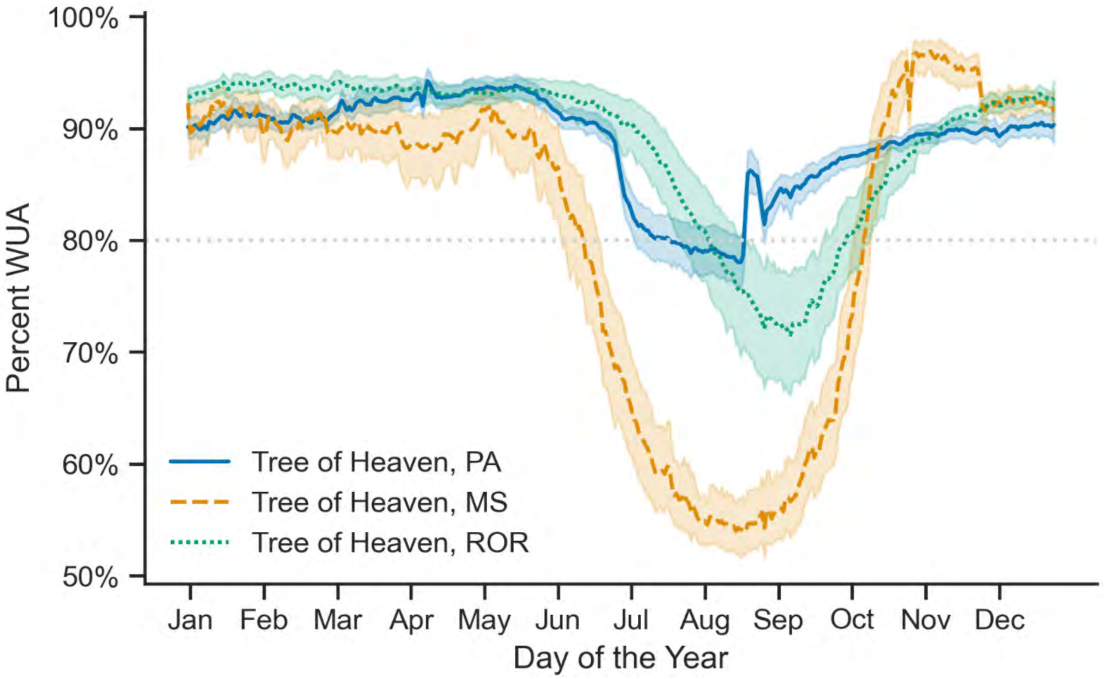
To adapt this model to the Klamath River, data for depth, velocity and distance to cover was taken from Wright et al. 2014. Precise details on data collection and sampling design can be found there. The output of the logistic regression occupancy model was translated into a habitat quality metric having values between 0 and 1 by dividing all predicted presence probabilities by the maximum value calculated over the range of all observed ecological effects. This predicted probability is then multiplied by the area of the habitat units to determine a weighted usable area (WUA) for each of the three locations (Tree of Heaven Campground, Beaver Creek, and Klamath Community Center). The WUA is then used to determine the effects of various scenarios on habitat volume.

Habitat modeling includes the following scenarios:

- Flow Through (ROR): Inflows into Klamath reservoirs are passed downstream subject to the channel capacity of downstream reaches. Physical flow control structures remain in the system in an "open" configuration but are not actively operated. No storage of water would occur; therefore, no water is available for later release. No diversions or flow routing would occur from Project facilities. Non-Project facilities would operate when water is available.
- MS: Shows conditions without the release of water. Klamath reservoirs would maximize storage and make releases only when required for flood control or other settlement contractor obligations . Similar to Flow Through (ROR), no diversions and no flow routing would occur. Non-Project facilities would operate when water is available.

- Proposed Action Alternative: The operation of the Project under the Proposed Action is described in Chapter 3 and analyzed in the Effects Analysis chapters (5 through 7). The Proposed Action includes pulse flows.

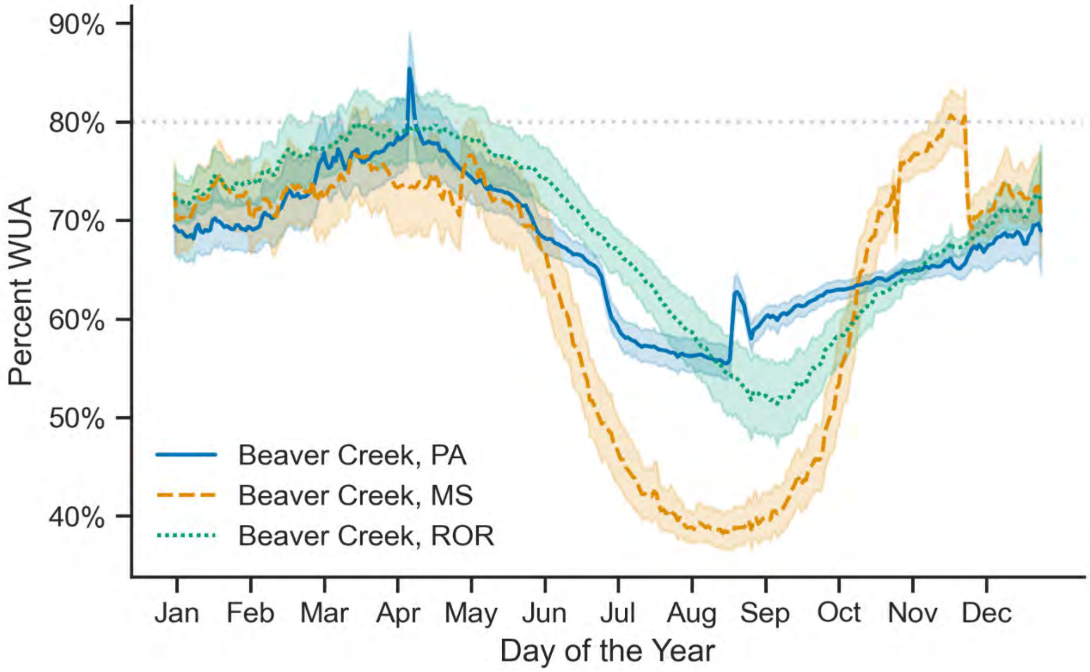
Figure 4-12 shows the mean daily percent of maximum WUA for Coho Salmon under the Flow Through (ROR), MS, and Proposed Action scenarios at the Tree of Heaven Campground on the Klamath River (rkm 281). Seasonally, available Coho Salmon habitat at Tree of Heaven Campground is highest in winter though spring, decreasing throughout summer to a seasonal low in early fall before increasing again through late-fall and early-winter. The average amount of habitat available under the Proposed Action remains above 80% of maximum and is equal to or greater than the MS scenario with the exception of mid-October though late-November. The MS scenario’s substantial increase in habitat in the fall is driven by the need to spill large amounts of water though fall for flood control.



Note: Shaded areas represent 96% confidence intervals.

Figure 4-12. Daily average percent of maximum weighted usable area for Coho Salmon at Tree of Heaven Campground

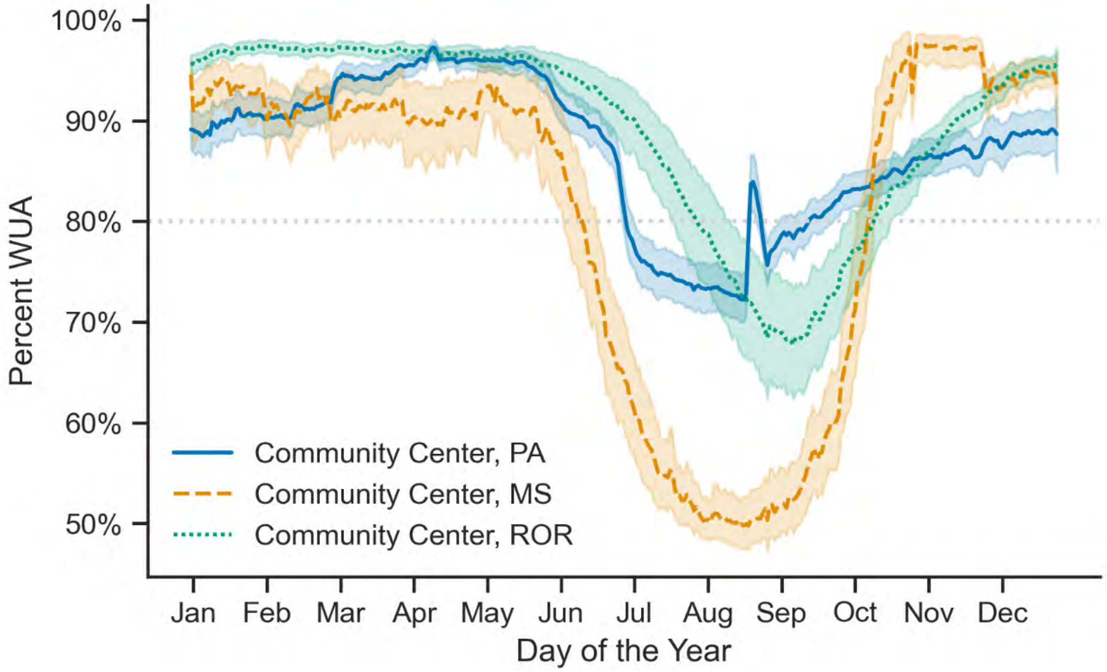
Figure 4-13 shows the mean daily percent of maximum WUA for Coho Salmon under the Flow Through (ROR), MS, and Proposed Action scenarios at Beaver Creek on the Klamath River (rkm 264). Seasonally, available Coho Salmon habitat at Beaver Creek is high through winter and peaks in mid-spring before decreasing throughout summer to a seasonal low in early fall and increasing again through late-fall and early-winter. The average amount of habitat available under all three scenarios remains below 80% of maximum except for one brief spike in spring. However, the Proposed Action consistently provides more habitat than the MS scenario with the exception of mid-October through late-November. The average amount of habitat available under the Proposed Action remains above 80% of maximum and is equal to or greater than the MS scenario with the exception of mid-October though late-November.



Note: Shaded areas represent 96% confidence intervals.

Figure 4-13. Daily average percent of maximum weighted usable area for Coho Salmon at Beaver Creek

Figure 4-14 shows the mean daily percent of maximum WUA for Coho Salmon under the Flow Through (ROR), MS, and Proposed Action scenarios for the Klamath Community Center on the Klamath River (rkm 259). Seasonally, available Coho Salmon habitat at the Klamath Community Center is highest in winter though spring, decreasing throughout summer to a seasonal low in early fall before increasing again though late-fall and early-winter. The average amount of habitat available under the Proposed Action remains above 80% of maximum and is equal to or greater than the MS scenario with the exception of mid-October though late-November. The MS scenario’s substantial increase in habitat in the fall is driven by the need to spill large amounts of water though fall for flood control.



Note: Shaded areas represent 96% confidence intervals.

Figure 4-14. Daily average percent of maximum weighted usable area for Coho Salmon at Klamath Community Center

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5 Lost River and Shortnose Sucker

5.1 Status of Species and Critical Habitat

5.1.1 Endangered Species Act Listing Status

LRS and SNS were federally listed as endangered throughout their entire ranges on July 18, 1988 (53 FR 27130-27134 [1988]). Both species were also listed as endangered under the California Endangered Species Act in 1974 (Fish and Game Code 1.5 § 2050-2115.5) and under the Oregon Endangered Species Act in 1991 (ORS 496.171-496.192). A recovery plan was published for both species in 1993 (USFWS, 1993) and revised in 2013 (USFWS, 2013). Species Status Assessments were published in 2007 (USFWS, 2007a,b) and in 2019 (USFWS, 2019c).

The 2019 Species Status Assessment outlines the current risk to extirpation faced by LRS and SNS in the Klamath Basin. Overall resiliency for both species is generally low, due to low redundancy in LRS populations and a combination of low numbers, lack of access to spawning habitat, and mixed genetics in SNS populations. If conditions in UKL remain unchanged, both species are likely to face precipitous declines, with a projected 78% decline in SNS species over the next 10 years and potential extirpation within the next 40 years (USFWS, 2019c). Both species are likely to realize reduced risk of extinction from implementation of the rearing program, but landscape-scale improvements to nutrient loads in UKL and recovery efforts in Clear Lake Reservoir will be necessary to achieve full recovery (USFWS, 2019c).

5.1.2 Distribution and Abundance

LRS and SNS are endemic to the Upper Klamath River Basin, including the Lost River and Lower Klamath Lake sub-basins (Figure 5-1; Moyle, 2002)[3]. Historically, these species occupied all major lakes within the Upper Klamath River Basin and spawned and reared in all major lake tributaries (USFWS, 2019c). It is estimated that the available habitat has been reduced by approximately 75% (USFWS, 2007a,b), meaning that UKL now comprises approximately 80% of available habitat (USFWS, 2013).

Given differences in population dynamics, life history, and genetics between populations in the Klamath River and Lost River basins, each species is classified into two recovery units, the UKL Unit and the Lost River Basin Unit (USFWS, 2013). Each recovery unit comprises four management units, although both species are not represented within all management units (USFWS, 2013; Table 5-1).

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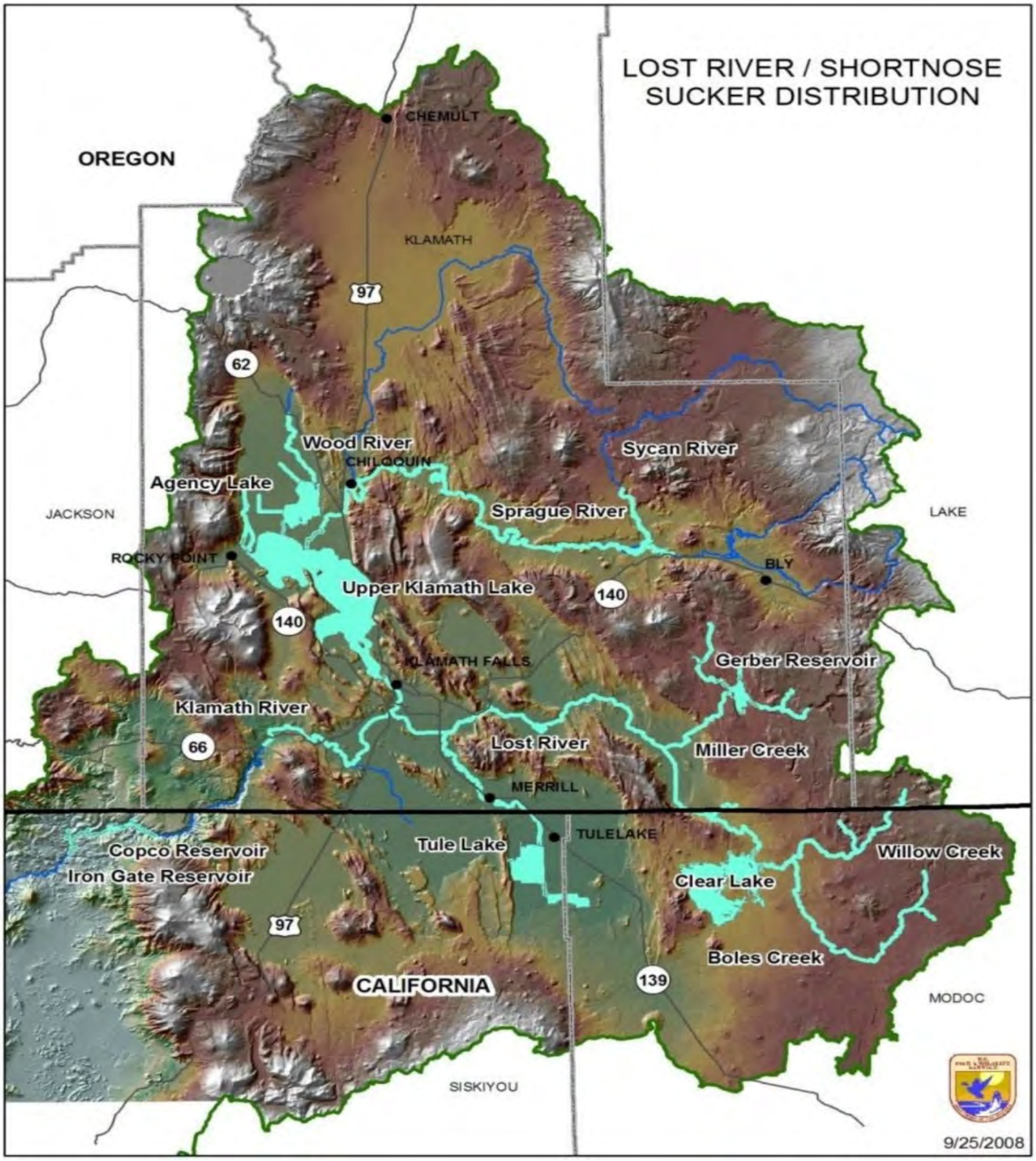
[3] The ranges of LRS and SNS are largely contained within the Action Area; therefore, the range-wide status of the species is generally equivalent to the status of the species in the Action Area (USFWS, 2020a). To limit redundancy this section combines both range-wide and action area status as they are functionally equivalent.



Notes: Lower Klamath Lake and Sheepy Lake are not depicted on the map because populations no longer occur there. Source: Figure 4 in USFWS (2019c).

Figure 5-1. The Lost River and Shortnose Sucker are endemic to the lakes and rivers of the Upper Klamath Basin in south central Oregon and north central California

Table 5-1. Recovery units and management units for Lost River and Shortnose suckers

Recovery Unit	Management Unit	Species
Upper Klamath Lake	UKL and tributaries – river spawning individuals	LRS and SNS
Upper Klamath Lake	UKL and tributaries – shoreline spring spawning individuals	LRS
Upper Klamath Lake	Keno Reservoir	LRS and SNS
Upper Klamath Lake	Populations below Keno Reservoir	LRS and SNS
Lost River Basin	Clear Lake Reservoir and tributaries	LRS and SNS
Lost River Basin	Tule Lake	LRS and SNS
Lost River Basin	Gerber Reservoir and tributaries	SNS
Lost River Basin	Lost River	LRS and SNS

Source: 77 FR 73739-73768 (2012)

The removal of the lower Klamath River dams eliminated LRS and SNS habitat downstream of Keno Dam (Renewal Corporation, 2021). A relocation effort occurred in the spring 2023 and several hundred suckers were translocated from the reservoirs to UKL in 2023 (Josh Gondek, USFWS, pers. comm. 10/4/2023, S. Jane Spangler, USFWS, pers. comm. 12/13/2023). While dam removal will result in increased habitat connectivity, it will also eliminate lake-type habitat (albeit artificial) with riverine (i.e., free-flowing) habitat resulting in the elimination of these isolated populations. Individuals from these populations were translocated to UKL.

The status of Upper Klamath Basin LRS and SNS are presented in this section within the framework of abundance, productivity, population spatial structure, and diversity. This framework corresponds almost exactly with the resilience (i.e., abundance and productivity), redundancy (i.e., population spatial structure) and representation (i.e., genetic diversity) framework presented in the 2019 LRS and SNS Species Status Assessment (USFWS, 2019c). Moreover, this framework also corresponds to the Viable Salmonid Population (VSP) parameters established by McElhany et al. (2000) used for assessing SONCC Coho Salmon. This allows consistency and clarity within this document while also maintaining comparability with past assessments.

5.1.2.1 Abundance and Productivity

In most habitat locations, SNS and LRS population sizes and productivity (i.e., resilience) are low, because of limited reproductive success and poor juvenile survival (Table 5-2; USFWS, 2019c).

Table 5-2. Population attributes for endangered suckers in the Upper Klamath Basin

Species	Location	Population Size	Reproductive Success	Larval/Juvenile Survival	Adult Survival
SNS	UKL	Low	Presumed Adequate	Low/Zero	Moderate
SNS	CLR	Low	Intermittent	Moderate	Moderate
SNS	GBR	Low	Intermittent	Presumed Adequate	Presumed Adequate
LRS	UKL	Moderate	Presumed Adequate	Low/Zero	High

Species	Location	Population Size	Reproductive Success	Larval/Juvenile Survival	Adult Survival
LRS	CLR	Low	Intermittent	Moderate	Moderate
LRS/SNS	Other	Low	Low/Zero	Low/Zero	Presumed Adequate

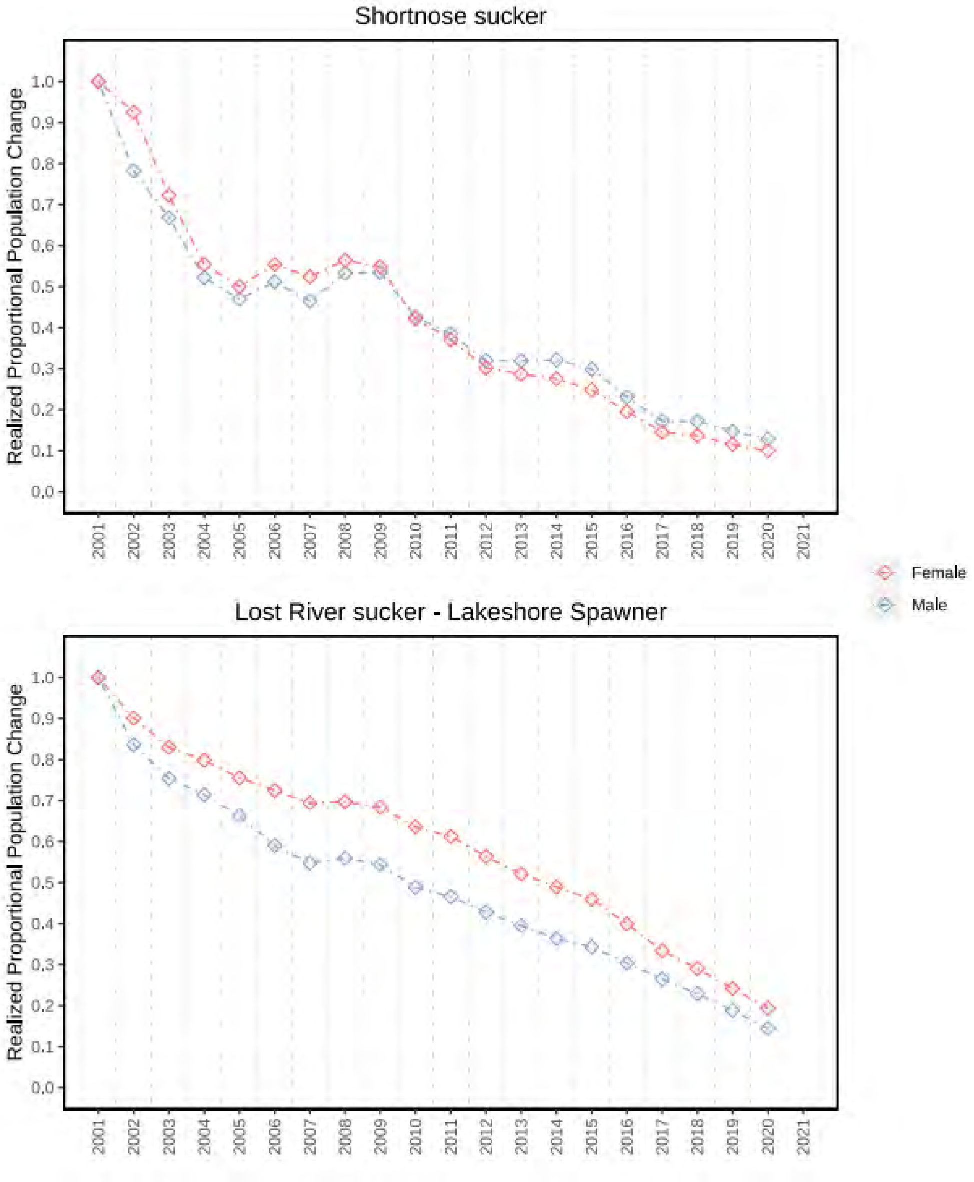
Notes: Locations are UKL – Upper Klamath Lake, CLR – Clear Lake Reservoir, GBR – Gerber Reservoir, and Other, which includes reservoirs on the Klamath River, Lake Ewauna, and Tule Lake Sump 1A. Adapted from USFWS (2019c)

Upper Klamath Lake UKL contains the largest remaining populations of both LRS and SNS. Figure 5-2 illustrates the realized proportional population change for UKL male and female LRS shoreline-spring-spawners (2001-2020), and SNS (2001-2020; Figure 19 in Krause et al., 2023).

Declines in both species of suckers in UKL were first realized in the mid-1960s (Hewitt et al., 2017). The popular sucker fishery was closed in 1987 following a large sucker die-off, which revealed the population was made up of almost exclusively old individuals (Scoppettone, 1988; Hewitt et al., 2017) Suckers were listed as endangered in 1988 (53 FR 27130). Suckers in UKL experienced one significant recruitment event in the early 1990s. Population estimates were first estimated in the early 2000s, and the population has continued to decline each year since. Within the last decade abundances of LRS and SNS have declined by 76% for tributary-spawning LRS (100,000 to 24,000), 50% for shoreline-spawning LRS (8,000 to 4,000), and 68% for SNS (19,000 to 6,000; Hewitt et al., 2018; Krause et al., 2023). The most recent data indicate a continuation and potential acceleration of the decline with spawner abundances estimated at 24,000 LRS river-spawners, 4,000 LRS shoreline-spring-spawners, and 6,000 SNS (Krause et al., 2023; USFWS, 2023c).

Adult LRS in UKL have relatively high survivorship. However, juvenile survival is extremely low. For the last two decades, there has been little to no recruitment of juveniles into adult populations (Hewitt et al., 2018). Consequently, all adult suckers in UKL are thought to originate from cohorts that hatched in the 1990s (Hewitt et al., 2018). Thus, the population is in steady decline as the adults are nearing their maximum age of approximately 30 years for SNS and 50 years for LRS (NRC, 2004; Terwilliger et al., 2010; Scoppettone and Vineyard, 1991).

Mark-recapture analyses of adult LRS from the shoreline-spawning subpopulation in UKL indicate annual survival from 2001 to 2020 ranged from 80% to 96% for females, and 77% to 93% for males (Hewitt et al., 2011, 2012, 2018, Krause et al., 2023). The lowest annual survival rates for shoreline spawning LRS have occurred in the last 5 years, 2016-2020 (females 80-87%, males 77-86%; Krause et al., 2023). Lost River Suckers from the tributary-spawning subpopulation had annual survival ranging from 62% to 96% for females, and 64% to 96% for males during the same period. The lowest annual survival rates for tributary spawning LRS have occurred in the last five years, 2016-2020 (females 62-87%, males 75-89%; Krause et al., 2023).


Shortnose sucker

Lost River sucker - Lakeshore Spawner

Notes: Changes in population size are derived from lambda estimates from Cormack-Jolly-Seber (CJS) likelihoods (annual survival and seniority probabilities) Source: Figure 19 from Krause et al. (2023). Lost River tributary spawners follow a similar trend (Krause et al., 2023) as Lakeshore spawners.

Figure 5-2. The realized proportional change in the size of Shortnose Suckers and Lost River shoreline spawning suckers (Lakeshore spawners) populations from 2000 to 2020

Mark-recapture analyses of adult SNS indicate that, from 2001 to 2020, annual survival ranged 65% to 95% for females, and 61% to 90% for males (Hewitt et al., 2011, 2012, 2018, Krause et al., 2023) . Lowest annual survival for SNS occurred in 2010 (females 74%, males 75%), 2016 (females 75%, males 72%), and 2017 (females 65%, males 61%; Krause et al., 2023). Population dynamics associated with recruitment of new individuals into the SNS spawning population are less clear, but small recruitment events may occur in some years. Individuals in this population have exceeded average life expectancy and are near the maximum known age for the species (33 years; Buettner and Scoppettone, 1991; Terwilliger et al., 2010).

Clear Lake Reservoir Adult suckers in Clear Lake Reservoir experience lower and more variable survival than adults in UKL (Hewitt et al., 2021). Mark-recapture analyses of adult LRS indicate annual survival from 2006 to 2018, excluding 2007, ranged from 62% to 96% for females and 57% to 95% for males (Hewitt et al., 2021). For SNS, including a small number of Klamath Largescale Suckers (*Catostomus snyderi*) and hybrids that could not be differentiated (Smith et al., 2020), mark-recapture analyses indicate annual survival from 2006 to 2018 ranged from 50% to 90% for females and 41% to 93% for males (Hewitt et al., 2021).

Low survival of adult suckers is partially attributed to avian predation by American White Pelicans (*Pelecanus erythrorhynchos*) and Double-Crested Cormorants (*Phalacrocorax auritus*) (Evans et al., 2016, 2022). Avian predation rates have been estimated as ranging from 4.3%-10.5% on juveniles and 0.1% to 7.2% on adult suckers in UKL and Clear Lake Reservoir (Evans et al., 2022). Avian predation is partly mediated by lake elevations and tributary flows, which affects the amount of habitat available for avian predators and the susceptibility of adult suckers to mortality. During years with low lake elevations but sufficient tributary flow to allow sucker spawning, pre- and post-spawn adult suckers inhabiting shallow water may be particularly vulnerable to predation by colonial waterbirds (Hewitt et al., 2021).

Unlike UKL sucker populations, LRS and SNS in Clear Lake Reservoir periodically have successful recruitment events, although the magnitude of recruitment is difficult to estimate (Hewitt et al., 2021) due to juvenile rearing in tributaries (Bart et al., 2021; Martin et al., 2022). SNS, which are more abundant in Clear Lake Reservoir, have had more successful recruitment events than LRS (Hewitt et al., 2021). Recruitment is partly driven by adult access to spawning grounds. When lake elevations, tributary flows, or both are low, access to spawning areas is restricted (Hewitt et al., 2021).

Gerber Reservoir and Other Locations The third spawning population of suckers is found in Gerber Reservoir (USFWS, 2019c). Intermittent monitoring in the Gerber Reservoir watershed since 1992 has documented a substantial SNS population with multiple size classes including many small individuals, which suggests regular recruitment occurs (Barry et al., 2007a). LRS were not observed in Gerber Reservoir during early or recent fisheries investigations (Barry et al., 2007a). Like in Clear Lake Reservoir, lake elevation and tributary flows may restrict access to spawning habitat in tributaries in Gerber Reservoir (USFWS, 2019c). When surface elevations are low, suckers may spawn in shoreline areas (Reclamation, 2023). For example, in 2022 suckers were observed spawning in gravels below two boat ramps (Reclamation, 2023). However, this was the first reported incidence of shoreline spawning in Gerber Reservoir and it is unknown if eggs developed into larvae (Reclamation, 2023). Extreme low water events may also directly cause adult mortality due to reduction in habitat.

Tule Lake has supported hundreds to thousands of adult suckers in two small, diked sumps, Sump 1A and Sump 1B (Hodge and Buettner, 2009). Spawning has not been observed in the sumps, though spawning aggregations of adult suckers from Tule Lake have been observed in the Lost River below Anderson Rose Dam. There is no indication that spawning is successful; poor spawning habitat and inconsistent flows in the Lost River have limited this population.

Three consecutive years (2020-2022) of drought conditions resulted in Sump 1A going dry in 2021, and Sump 1B going dry in 2022. In 2021 suckers from Sump 1A were translocated to Sump 1B (USFWS, 2023a). When drought conditions continued into 2022, suckers from Sump 1B were captured and relocated to temporary holding ponds on Lower Klamath NWR. Sump 1A was completely dry in 2021 and 2022; Sump 1B was completely dry in 2022. Tule Lake Sumps are full as of May 2024. However, it is uncertain how long they will remain so, how frequently they will fill, or if they will remain full in the future.

Data on other populations, including Keno Impoundment and the Lost River proper, are limited but suggest low numbers of individuals (Desjardins and Markle, 2000; Hodge and Buettner, 2009). Lack of suitable habitat for rearing and spawning, presence of predation, extremely poor water quality, and variable water levels may restrict abundance in these locations.

Klamath River Reservoir Between 150 and 400 suckers were salvaged and translocated prior to drawdown and dam removal (Spangler [USFWS], pers. comm. 12/13/23). These populations are no longer present now that the reservoir lake habitat has returned to river. These reservoirs were “sinks” and moving these suckers to UKL was beneficial for the population.

5.1.2.2 Spatial Structure

Spatial structure (i.e., redundancy) for these populations has likely always been relatively low as pre-settlement populations probably numbered no more than four for each species (USFWS, 2019c). However, the destruction of at least two major populations (Lower Klamath and Tule Lake) as well as other sub-populations and spawning locations, has likely further degraded redundancy. Suckers occur in other waterbodies, including Lake Ewauna and the Lost River proper (Shively et al., 2000). However, these populations are small and consist almost entirely of SNS. Within population redundancy is minimal as well with only LRS in UKL currently having more than one substantial spawning population, though SNS in Gerber Reservoir have two distinct spawning tributaries (USFWS, 2019c).

5.1.2.3 Diversity

The diversity (i.e., representation) of sucker populations is influenced by effects from geographic isolation, hybridization, and genetic introgression (USFWS, 2019c). SNS in Gerber Reservoir have endured large fluctuations in habitat size and geographic isolation from other sucker populations in the basin (Piaskowski and Buettner, 2003). This has likely restricted genetic variation and population size in the region. Like Clear Lake Reservoir SNS, Gerber Reservoir SNS morphology also includes characteristics associated with Klamath Largescale Suckers (Markle et al., 2005; Barry et al., 2007a). Despite the apparent hybridization, the USFWS considers the Gerber Reservoir population to be SNS until the status of these fish has been resolved (USFWS, 2020a; Smith et al., 2020).

5.1.3 Overall Status and Significance of Population

The most recent species status assessment for LRS and SNS (USFWS, 2019c) determined that both species have a high degree of threat of extinction and a low recovery possibility. The abundance of LRS and SNS is low across most populations and productivity has remained low to non-existent despite substantial larval recruitment. Also, population spatial structure is limited in both species due to the loss of suitable lake habitats and their associated populations and the loss of connectivity between remaining populations. Genetic diversity has also likely declined given the substantial reductions in population size across all populations for which reliable estimates exist, the loss of populations, and the loss of connectivity between extant populations.

The ranges of LRS and SNS are largely contained within the Action Area and, therefore, are critical to the overall species viability and extinction risk.

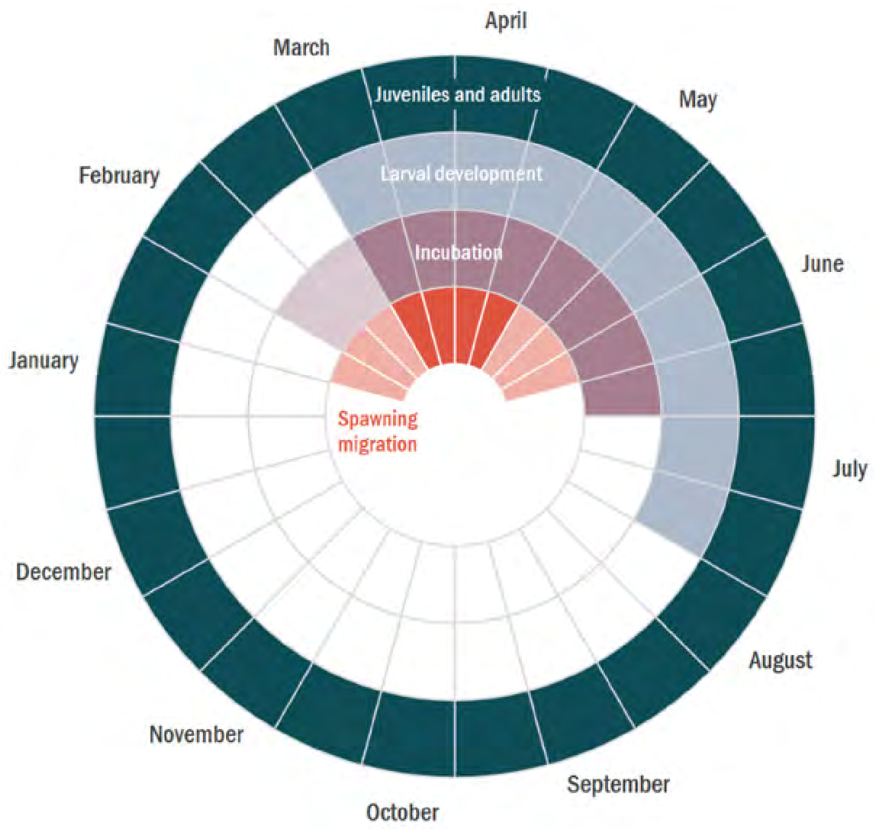
5.1.4 Life History and Habitat Requirements

LRS and SNS are large-bodied, long-lived species of lake suckers from the Catostomidae family. LRS and SNS have complex life histories that use stream, river, lake, wetland, and shoreline habitats. Due to similarities in life history between the two species, the following descriptions apply to both, except where noted. Similarly, most life history studies have been conducted on UKL populations, but Lost River Basin populations are assumed to share similar patterns.

5.1.4.1 Adult Migration

Rising water temperatures are a critical cue for initiation of migration (Hewitt et al., 2017; Hewitt and Hayes, 2013) and hydrologic conditions such as low lake elevations and low tributary flows can restrict access to shoreline (Burdick et al., 2015) and tributary spawning grounds (Hewitt and Hayes, 2013). Suckers also have a high degree of breeding site fidelity (Hewitt et al., 2018).

Adult LRS and SNS in Clear Lake Reservoir begin migrating from open water lake habitats to spawning grounds in tributary streams and rivers as early as February when water temperatures are at least 6°C, reservoir surface elevations are adequate for access to Willow Creek, and when Willow Creek has adequate flows (Hewitt et al., 2021). Adult LRS and SNS in UKL begin spawning migrations as early as March when water temperatures are 10°C for LRS, and 12°C for SNS (Hewitt et al., 2021; Figure 5-3).



Note: Data sources: Reiser et al., 2001; Hewitt and Hayes, 2013; Hewitt et al., 2012, 2021

Figure 5-3. Life stage periodicity diagram for Lost River and Shortnose suckers in Clear Lake Reservoir and Upper Klamath Lake

5.1.4.2 Spawning

Spawning occurs from February through May in Clear Lake and March through May in UKL (Figure 5-3) over gravel substrates in rivers and shoreline spring habitats less than 1.3 m (4.3 ft) deep (Buettner and Scoppettone, 1990). Both species are broadcast spawners (Buettner and Scoppettone, 1990), and fertilized eggs settle within the top few inches of the substrate until hatching (Coleman et al., 1988). In UKL there are two main spawning aggregations of LRS; those that spawn in the Williamson and Sprague rivers (tributary-spawners) and those that spawn at springs along the eastern shoreline of UKL (Barry et al., 2007a). Both populations of LRS show a high degree of site fidelity, returning year after year to the same locations, with little interbreeding (Hewitt et al., 2018). SNS in UKL only spawn in the Williamson and Sprague rivers (Hewitt et al., 2018). Both species of suckers in Clear Lake Reservoir and SNS in Gerber Reservoir spawn primarily in tributary streams and spawn in gravels near boat ramps when surface elevations are low (Barry et al., 2007a; Banet et al., 2021, Reclamation, 2023).

Lake elevation and high tributary inflows are necessary for adult suckers to make annual spawning migrations between the two lobes in Clear Lake Reservoir and access spawning grounds in Willow Creek (Hewitt et al., 2021). Suckers in Clear Lake will spawn at temperatures as cool as 6℃ and will stage to spawn (move from the west lobe to the east lobe) as early as

January (Hewitt et al. 2021). Suckers in Clear Lake opportunistically spawn when lake elevations are 4,524 ft or higher, and inflows are approximately 42 to 45 cfs or higher in Willow Creek; typically, early March through the end of May (Hewitt et al. 2021). Several age classes are represented in population surveys for both species, indicating successful recruitment occurs some years (Hewitt et al. 2021). However, meaningful additions to the population are most apparent after large spawning events, which do not occur every year (Hewitt et al. 2021). Annual survival of LRS is 60 to 89% and 42 to 89% for SNS in Clear Lake (Hewitt et al. 2021); substantially lower than survival of suckers in UKL which is typically 90%, (Hewitt et al., 2017). Unlike UKL, the LRS population in Clear Lake is smaller than the SNS population. Abundance estimates are not yet available for suckers in Clear Lake. Entrainment at Clear Lake was estimated to be 270,000 larval suckers and 3,700 juvenile suckers in 2013 (Sutphin and Tyler, 2016). It is unclear how entrainment varies among years, spawning timing and conditions in tributaries, and lake elevations, though the estimate derived in 2013 is suspected to be high (Sutphin and Tyler, 2016). However, available information indicates that the Clear Lake sucker populations have persisted under recent management of the lake (USFWS, 2019c).

5.1.4.3 Egg Incubation and Larval Emergence

Sucker eggs require flowing water and relatively porous substrate to allow gas exchange, waste removal, and protection from predators (Coleman et al., 1988). Eggs hatch approximately 8 days after fertilization, depending on temperature (Coleman et al., 1988). Larvae emerge from the gravel approximately 10 days after hatching, when about 7 to 10 millimeters (0.2 inches to 0.6 inches) total length and mostly transparent with a small yolk sac (Coleman et al., 1988; Buettner and Scoppettone, 1990).

5.1.4.4 Larvae

After emerging from gravel, larvae transition rapidly from tributaries to lakes (Buettner and Scoppettone, 1990; Cooperman and Markle, 2003; Ellsworth and Martin, 2012). Peak larval drift occurs in mid-May (Scoppettone et al., 1995). Most larvae from tributary populations drift from the river toward the lake during dark hours (Cooperman and Markle, 2003; Ellsworth and Martin, 2012), then exit the river current during daylight hours and move to nearshore shallow habitat (Cooperman and Markle, 2003). Little is known about the drift dynamics of LRS larvae from UKL shoreline springs.

Once in lakes, larvae generally inhabit near-shore areas (Cooperman and Markle, 2004; Erdman et al., 2011), particularly those with emergent vegetation (Cooperman and Markle, 2004). Emergent vegetation provides protection from non-native predators (e.g., Fathead Minnows [*Pimephales promelas*]), currents, and turbulence, while providing access to prey (Cooperman and Markle, 2004; Crandall et al., 2008; Markle and Dunsmoor, 2007) and warmer temperatures, which may promote growth (Crandall et al., 2008; Cooperman et al., 2010). Emergent wetland habitat also provides habitat for piscivorous predators (e.g., Fathead Minnows, Yellow Perch [*Perca flavescens*], and avian predators).

Differences do exist between LRS and SNS larval habitat use. SNS larvae predominantly use nearshore areas adjacent to and within emergent vegetation, and LRS larvae tend to occur more often in open water habitat than near vegetated areas (Burdick and Brown, 2010). Additionally, habitat use differs among locations, based on local habitat availability. For example, compared to UKL, emergent vegetation is generally scarce or absent along the shorelines of Clear Lake and Gerber reservoirs (Reclamation, 2020a).

5.1.4.5 Juveniles

When larvae are approximately 20-30 millimeters (0.8-1.2 inches), they develop into juveniles and transition from predominantly feeding at the surface to feeding near the lake bottom (Markle and Clauson, 2006). Few diet studies have been conducted, but identifiable prey include chironomid larvae and pupae, chydorids, ostracods, and harpacticoid copepods (Markle and Clauson, 2006). In UKL, juveniles are generally found in a wide variety of habitats including deeper, un-vegetated off-shore habitat (Buettner and Scoppettone, 1990; Burdick et al., 2008; Burdick and Brown, 2010), though some juvenile suckers continue to use relatively shallow (less than 1.2 m [3.9 ft]) vegetated areas, and habitat use varies by species. One-year-old juveniles occupy shallow habitats during April and May, then appear to seek deeper waters along the western shore of UKL during early summer (Bottcher and Burdick, 2010; Burdick and Vanderkooi, 2010). As summer progresses and DO levels are reduced in this deeper part of UKL, juveniles appear to move back into shallower areas throughout the rest of the lake (Bottcher and Burdick, 2010).

Catches of age-0 suckers in UKL are typically highest in August and decline through October until very few juveniles are observed (Burdick and Martin, 2017). Some of the reduced abundance may be associated with both emigration and entrainment from UKL (Markle et al., 2009). Age-0 suckers move from UKL into the Link River primarily between July and October, generally peaking in August (Markle et al., 2009).

Little is known about juvenile habitat use in Clear Lake Reservoir. Unlike UKL, Clear Lake Reservoir has no surrounding wetlands and only limited submerged or emergent vegetation. Some juvenile suckers in Clear Lake Reservoir may spend one or more years in the Willow Creek drainage prior to migrating into Clear Lake Reservoir (Bart et al., 2021). Juvenile suckers are found throughout Clear Lake Reservoir; for unknown reasons, juvenile suckers survive better in Clear Lake Reservoir than in UKL (Bart et al., 2021). Less is known about juvenile sucker survival in Gerber Reservoir, but it is assumed to be like Clear Lake Reservoir due to similar physical habitat characteristics.

5.1.4.6 Adults

After spawning, adult LRS and SNS are distributed throughout UKL, including in Pelican Bay, typically at depths greater than 2 m, which provides protection from avian predators and access to food resources (Banish et al., 2007, 2009). Pelican Bay has clear, cool water that was thought to be used by suckers primarily when water quality conditions are poor; however, submersible antennas deployed in May through September of 2023, detected thousands of suckers in Pelican Bay in June, July, and August suggesting some suckers use Pelican Bay throughout the summer (Krause, pers. comm. 12/21/2023). Previous studies have found that when water quality declines in summer, adults congregate in the northern portion of UKL (Reiser et al., 2001; Banish et al., 2009). During periods of extremely poor water quality, adult suckers seek refuge near cool-water springs with higher DO concentrations, and by mid-September, many suckers can be found in the deepest portions of UKL (Banish et al., 2007, 2009). When surface elevations are low in water bodies other than UKL (e.g., Tule Lake, Clear Lake Reservoir, Gerber Reservoir), suckers do not always have access to deeper water refuges.

Relatively little is known about the diets of adult LRS and SNS. Limited data from Clear Lake Reservoir suggest that adult LRS tend to feed directly near the lake bottom, whereas adult SNS primarily consume zooplankton from the water column (Scoppettone et al., 1995).

5.1.5 Limiting Factors, Threats, and Stressors

5.1.5.1 Historical and Current Limiting Factors and Stressors

The factors that have contributed to the decline of LRS and SNS populations were documented at the time the species were listed (53 FR 27130–27134 [1988]) and have been comprehensively evaluated and updated in the most recent species status assessment for LRS and SNS (USFWS, 2019c). This section reviews and summarizes the main contributing factors.

Habitat Alteration Loss and degradation of spawning and rearing habitats were identified as primary drivers of population declines at the time LRS and SNS were listed (53 FR 27130–27134 [1988]). Available habitat has been physically blocked or reduced in quantity by dams, dikes, and diversions. Irrigation and hydropower operations also altered the timing and magnitude of flow patterns and changes in lake elevations and morphology, reducing the suitability and availability of riverine habitats. These alterations have eliminated or disconnected historical lake and river spawning and rearing habitats. In addition, historical littoral and wetland habitats that were used by rearing juveniles and larvae were dredged, drained, or converted to agricultural land. As a result, it is estimated that only 25% of the historically available rearing habitat remains (USFWS, 2019c).

Water Quality Prior to LRS and SNS listings, large die-off events attributed to cyanobacterial blooms occurred during dry, hot years, contributing to mortality and population declines (53 FR 27130–27134 [1988]). Poor water quality persists in the Upper Klamath River Basin, including elevated temperatures, low DO, elevated nutrient levels, elevated pH, and AFA, which contribute to stress and increased mortality rates among LRS and SNS (USFWS, 2019c). The dominance of AFA in the UKL phytoplankton community (NRC, 2004) has likely contributed to the increased frequency of mass die-off events (Burdick et al., 2020a,b; USFWS, 2020a). Degraded water quality may also increase sucker susceptibility to disease, parasites, and predators through increased stress levels and altered behavior (USFWS, 2019c). Adult suckers are less susceptible than juveniles to effects from degraded water quality. The combination of poor water quality, disease, parasites, and predation has resulted in year-class failure for juvenile suckers; failure to recruit into the population; and a population age structure that is heavily weighted towards older individuals (Krause et al., 2022).

Entrainment Entrainment of larval and juvenile suckers into unscreened diversions and water control structures was identified as a source of mortality and a significant threat to LRS and SNS at the time of listing (53 FR 27130–27134 [1988]). Screening projects (e.g., the A Canal fish screen) have reduced entrainment losses (USFWS, 2020a), but entrainment is a still a source of injury and mortality.

Harvest Historically, overharvest of adult LRS and SNS likely contributed to population declines in UKL, especially for LRS, but harvest activities ceased in 1987 (53 FR 27130–27134 [1988]).

Non-Native Fishes Non-native fishes were identified as a potential threat to LRS and SNS at the time of their listing because of potential competition and predation (53 FR 27130–27134 [1988]). Non-native Fathead Minnow and Yellow Perch are predators to LRS and SNS (Hereford et al., 2016; USFWS, 2019c). Numerous other non-native species may also have a negative impact on sucker populations through competition or predation (NRC, 2004).

Hybridization At the time of LRS and SNS listing, hybridization among sucker species was identified as a potential cause of the loss of pure genotypes of listed species. There were additional concerns that dams and other habitat modifications would spatially concentrate multiple species' spawning activity, increasing the likelihood of overlapping spawning distributions that would further promote hybridization opportunities (53 FR 27130–27134 [1988]).

Larval and Age-0 Juvenile Survival At the time of LRS and SNS listing, juvenile recruitment failures were well-documented (53 FR 27130–27134 [1988]) and have continued since. Currently, larval and age-0 survival is the limiting factor for establishing productive, resilient LRS and SNS populations (USFWS, 2019c). Low or zero survival rates among larval and age-0 juvenile cohorts in UKL (Burdick and Martin, 2017) are the cause of the near absence of new adult recruits. Without the recruitment of new year classes and additional spawners, the productivity and abundance of the extant populations are expected to continue to decline (USFWS, 2019c). The 2020 age-0 cohort of SNS and LRS was the lowest since monitoring began (Martin et al., 2022). The poor survival of larval and age-0 is not fully understood, but likely reflects a combination of factors including water quality, disease, parasites, entrainment, and predation (Foott et al., 2014, USFWS, 2019c). An artificial propagation program at the Klamath Falls National Fish Hatchery (the sucker assisted rearing program) has been undertaken to increase juvenile SNS and LRS survival and provide a source of new recruits for the existing populations. The goal of the conservation-focused hatchery is to offset the effect of persistent natural recruitment failures, contribute to population viability, and to help prevent extirpation of SNS and LRS populations (Rasmussen and Childress, 2018).

5.1.5.2 Updated Threats

This section describes new threats to population recovery that were not documented at the time LRS and SNS were federal ESA listed.

Climate Change Climate change is predicted to increase air temperatures, decrease snowpack, and change the type, volume, and timing of basin-wide annual precipitation (Dettinger et al., 2015; McCabe et al., 2018; Reclamation, 2021). Temperatures in the basin are projected to increase by 3˚F by mid-century and by 4.5˚F with a range of 2.5˚F to 10˚F by the end of the century (Reclamation, 2021). Elevated air temperatures will increase the evaporation demand, further impair water quality in the basin, and overall result in altered hydrology (Dettinger et al., 2015). Increases in air temperature have been attributed to the long-term negative trends in snowpack in the western United States (McCabe et al., 2018). The snowpack in the Klamath Basin, as measured by April 1 snow-water equivalent, is projected to decrease by roughly 30-40% by the 2030s and 60% by the 2070s. Additionally, rising temperatures have caused the snowpack to melt earlier and more precipitation to occur as rainfall instead of snow (Reclamation, 2021). Annual precipitation is projected to increase by about 2% by mid-century and about 5.5% by the end of the century (Reclamation, 2021). The timing, spatial extent, and precise level of climate change effects are difficult to forecast, but increases in summer water temperatures coupled with altered hydrology would likely compound existing water quality issues.

At present, lethal temperatures for suckers are uncommon, but stressful temperatures for suckers occur with regularity. Climate change may increase the frequency and duration of these stressful temperature events and is likely to make high stress events more common.

Predation, Parasitism, and Disease Avian predation from species such as American White Pelicans and Double-Crested Cormorants has been a substantial source of sucker morality. Juvenile and adult suckers are vulnerable to predation by these birds at high rates (Evans et al., 2016, 2022).

Native redband trout, tui chub, and other native fishes are known to prey upon sucker eggs, larvae, and juveniles. As anadromous salmonids volitionally move back into the upper Klamath Basin, predation on LRS and SNS eggs, larvae, and juveniles may increase. While abundant quantities of both eggs and larvae (Cooperman and Markle, 2003, Ellsworth and Martin, 2012) are produced, reductions in the number of eggs and drifting sucker larvae could conceivably threaten the overall production.

Lernaea sp., a parasitic copepod or “anchor worm,” which feeds on fish tissues by puncturing the skin of its host (Briggs, 1971), is a common parasite on suckers in the Upper Klamath Basin. *Lernaea* sp. are commonly found on juvenile suckers (both species) in UKL and Clear Lake during summer months (Burdick et al., 2017). Attachment sites can open a pathway for other pathogens or disease, causing secondary infections. Severe inflammation and necrosis (dead tissue) in the skin and muscle occur far and deep beyond the attachment site (Janik et al., 2018). The trematode metacercariae, *Bolbophorus* sp. (Janik et al., 2018), commonly called “black spot,” is a flat worm that infects the skeletal muscle tissue of LRS and SNS in UKL. The number of metacercariae infections in suckers is typically higher for SNS than LRS; as many as 11 raised cysts have been observed on a single young of the year sucker (Burdick et al., 2017; Janik et al., 2018). Host response includes melanization of the skeletal muscle tissue that surrounds the encysted digenean metacercariae; however, the surrounding tissue is typically unaffected (Burdick et al., 2015a, 2017).

A number of pathogens have been identified from moribund (dying) suckers, including gram-negative bacterial infections of apparent *Flavobacterium columnare*, which can damage gills or produce body lesions, which then leads to respiratory problems, an imbalance of internal salt concentrations, and provides an entry route for lethal systemic pathogens (Foott, 1997, 2004; Holt et al., 1997; ISRP, 2005). One parasite that severely impacts young of the year SNS is the nematode larvae *Contracaecum* sp. (Janik et al., 2018). When present, the nematode enlarges and thins the atrium, and prevents normal heart function (Janik et al., 2018). While not terribly common, *Contracaecum* sp. is expected to cause cardiovascular failure and inhibit swimming performance (Janik et al., 2018). Affected suckers are not expected to survive (Janik et al., 2018). While its prevalence in wild suckers is not known (Burdick et al., 2017; Banner and Stocking, 2007), *Ichthyobodo* sp. (formerly *Costia* sp.) is a parasite that attaches to the gills or skin (Callahan et al., 2002). This obligate ectoparasite can cause or contribute to mortality of wild juvenile suckers by impairing normal body functions (Hereford et al., 2016, 2019). For example, *Ichthyobodo* sp. infestations in fish can cause anorexia, surface cell-death, reduced oxygen uptake, reduced ion regulation, and impaired circulation (Lom and Dyková, 1992).

Parasites were not identified as a threat at the time of listing, but recent information indicates they could be (Buchanan et al., 2011). Parasites can lead to direct mortality, provide a route for pathogens to enter fish through wounds, and can make fish more susceptible to predation (Robinson et al., 1998). While many parasites are common, especially in UKL, the role Project operations have on their occurrence is unknown.

The lack of information regarding disease, parasites, and stress affecting juvenile suckers is likely due to the inherit hardiness of the species and the difficulty for researchers to capture compromised and affected suckers using passive gear. Several studies (Saiki et al., 1999; Meyer and Hansen, 2002; Lease et al., 2003; Hereford et al., 2019) have found suckers show little to no sign of distress until immediately before death, despite high parasite loads, compromised water quality conditions, or other factors, which may explain why understanding causes of mortality for juvenile suckers is so difficult. Further, suckers with compromised health may be heavily predated upon. The algal toxin microcystin can be ingested by LRS and SNS when they eat larval insects that have accumulated the toxin (Burdick and Martin, 2017). Exposure to microcystin may increase LRS energy expenditure or stress (Martin et al., 2019). The presence of cyanobacteria may cause adverse effects to water quality conditions or the food web (Martin et al., 2019; Burdick et al., 2020a,b). Definitive links between microcystin and SNS survival have not been established (USFWS, 2020a).

Small Populations The small size of LRS and SNS populations also increases the risks posed by catastrophic events and demographic effects (USFWS, 2019c). For a small population, catastrophic events (e.g., AFA die-off) pose a greater risk because the loss of a relatively small number of individuals represents a larger proportion of the remaining populations. Small populations are vulnerable to demographic effects, such as random swings in sex ratio that may reduce population growth rates and effective population size (Hartl and Clark, 2007). Individuals within a small population may be susceptible to increased predation (Gascoigne and Lipcius, 2004) or otherwise exhibit reduced fitness resulting directly or indirectly from low population size or density. Collectively, such effects are referred to as Allee effects (Drake and Kramer, 2004). Very small populations are also exposed to genetic risks including inbreeding depression, genetic drift, reductions in genotypic and expressed phenotypic diversity that allows populations to adapt to changing habitats or environmental variability (Hartl and Clark, 2007).

5.1.6 Recovery Plan

On March 17, 1993, a recovery plan for LRS and SNS was published, which was later revised in 2013 (USFWS, 2013). For each species, the plan detailed their status, factors limiting their recovery, and a recovery program. The goal of the recovery program is to reverse the decline of LRS and SNS populations, so ESA protection is not necessary. The program aims to restore natural population dynamics within the species range, with an emphasis on populations within UKL and Clear Lake Reservoir. This section summarizes the criteria and actions established to meet recovery goals.

5.1.6.1 Recovery Criteria

USFWS established recovery criteria based on addressing the factors limiting population recovery. These criteria apply to both downlisting and delisting the species (USFWS, 2013). Table 5-3 lists the limiting factors and the respective recovery criteria for downlisting or delisting.

Table 5-3. Factors for decline and respective recovery criteria for down- or delisting Lost River and Shortnose suckers

Factor	Downlisting Criteria	Delisting Criteria
The present destruction, modification, or curtailment of its habitat or range	• Current spawning and rearing habitat are maintained and improved access ensures annual use. • A range-wide Spawning and Rearing Enhancement Plan has been developed and implemented. This plan shall identify and prioritize areas of potential spawning and rearing habitat for enhancement and/or restoration, including areas that are degraded or unavailable due to lack of connectivity or passage. • Connectivity and access are assured to habitats that provide refuge to suckers to avoid poor water quality (particularly Pelican Bay) during the months of July, August, and September – UKL Recovery Unit. • Natural vegetated wetland areas are restored, including in-stream, wetland, and riparian areas around the mouth of Willow Creek where it meets Clear Lake Reservoir and throughout its drainage – Clear Lake Reservoir Management Unit.	n/a

Factor	Downlisting Criteria	Delisting Criteria
Overutilization for commercial, recreation, scientific, or educational purposes	n/a	Although recreational fishing of LRS and SNS has not been permitted since 1987, given the potential recreational use once these species are delisted, Oregon and California states and The Klamath Tribes, collaboratively or separately, should prepare and finalize population management plan(s) for the LRS and SNS.
Disease or predation	Newly identified or clarified effects of predation and disease are minimized through implementation of recommendations from ongoing scientific research that clarifies the interaction of LRS and SNS with predators and pathogens.	n/a
Inadequacy of existing regulatory mechanisms	Because the inadequacy of regulatory mechanisms is not considered to be a threat to either the LRS or SNS, recovery criteria under this factor are not necessary.	n/a
Other natural or manmade factors affecting its continued existence	• An Entrainment Reduction Plan has been developed and implemented. This plan shall identify and prioritize screening of diversions throughout the Upper Klamath Basin, including the Project, and propose strategies for efficient reduction of entrainment. • Establishment of two additional recurring and successful spring-spawning populations in the UKL-Spring Management Unit – LRS specific. • Development and implementation of a plan to assess, monitor, and improve juvenile and sub-adult vital rates and demography, including threats and negative impact reduction. This plan shall also designate specific demographic or vital rate targets, and strategies for achieving these targets, important for downlisting and delisting. • The effects of detrimental water quality have been minimized through implementation of recommendations from ongoing scientific research that clarifies the relationship of these factors with sucker mortality – UKL Recovery Unit.	After 25 years, the average annual rate of population change is greater than one and the number of spawning individuals is greater than what was present in the baseline years for the Upper Klamath Lake River and UKL-Spring Management units.

Source: USFWS (2013)

Recovery in all occupied management units is not required to achieve overall species recovery (USFWS, 2013). This is largely because populations within several of the management units function as “sink populations”[4] due to lack of access to spawning habitats (Moyle, 2002; NRC, 2004).

5.1.6.2 Key Recovery Actions

The following overarching actions (excerpted from USFWS [2013]) are required to meet recovery criteria:

- Action 1: Restore or enhance spawning and nursery habitat
- Action 2: Reduce negative impacts of poor water quality where necessary
- Action 3: Clarify and reduce the effects of introduced species on all life stages by conducting and applying scientific investigations
- Action 4: Reduce the loss of individuals to entrainment
- Action 5: Establish a redundancy and resiliency enhancement program
- Action 6: Increase juvenile survival and recruitment to spawning populations
- Action 7: Maintain and increase the number of recurring, successful spawning populations
- Action 8: Establish a Klamath Basin Sucker Recovery Implementation Program

5.1.7 Critical Habitat

Critical habitat for LRS and SNS was designated on December 11, 2012 (77 FR 73739-73768 [2012]) and includes approximately 234 km of streams and 47,691 hectares of lakes and reservoirs for LRS and approximately 219 km of streams and 50,015 hectares of lakes and reservoirs for SNS in the Klamath River Basin (Figure 5-4).

The current condition of critical habitat for LRS and SNS is degraded. Loss and alteration of habitats (including spawning and rearing habitats) were major factors leading to the listing of both species (53 FR 27130–27134 [1988]) and continue to be significant threats to recovery (77 FR 73740-73768 [2012]; USFWS, 2019c). In addition, poor water quality, nonnative predators, and disease in remaining habitats appear to interact to create a critical bottleneck for juvenile survival and recruitment. Climate change may exacerbate the effects of hydrologic modifications, reducing access to spawning grounds and increasing the frequency and duration of stressful temperature regimes (77 FR 73739-73768 [2012]). The ongoing removal of lower Klamath River dams will have no impact on LRS and SNS critical habitat since all designated critical habitat is upstream of Keno Dam (Renewal Corporation, 2021).

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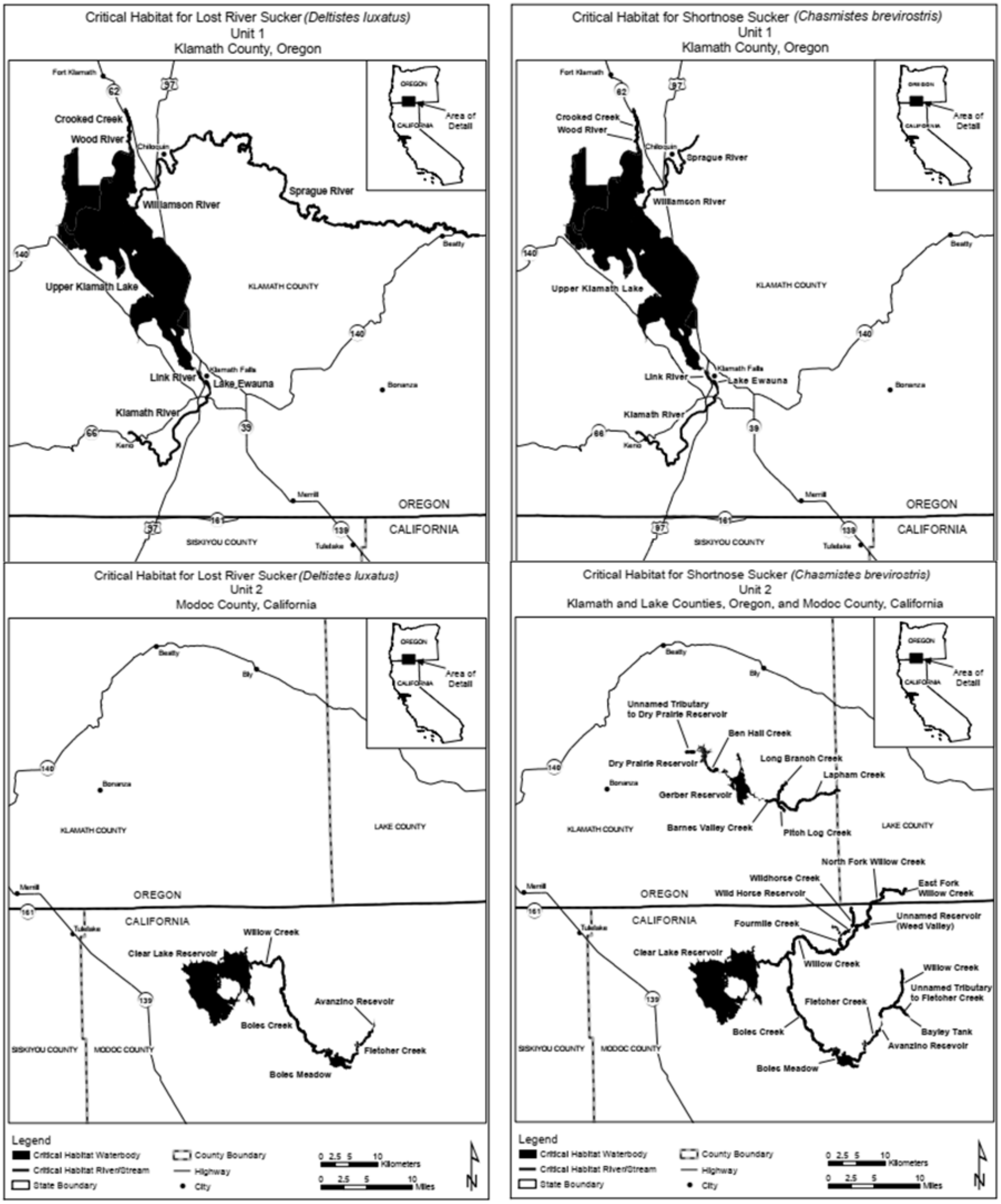
[4] Sink populations are populations in low quality habitat that are not self-sustaining (i.e., birth rates are lower than death rates).



Modified from: 77 FR 73739-73768 (2012)

Figure 5-4. Critical habitat for Lost River and Shortnose Suckers

5.1.7.1 Physical and Biological Features

USFWS (2020a) identified three physical and biological features of critical habitat necessary for the survival and recovery of the two species: 1) water; 2) spawning and rearing habitat; and 3) food. The following statuses of each physical and biological feature were excerpted directly from USFWS (2020a):

Water *This physical or biological feature can be summarized as sufficient water quantity and suitable water quality necessary to support the life history and to provide for the conservation of the species. Water quantity and water quality vary within and among sites and across multiple time scales. In general, the climate in recent years has been drier than average, which can limit the water needed to meet the needs of the species, including connectivity to spawning areas, particularly the UKL shoreline springs (Burdick et al., 2015) and tributaries to reservoirs in the Lost River Basin (Hewitt and Hayes 2013). Water quality is poorer for UKL and Lake Ewauna compared to other designated critical habitat (Clear Lake Reservoir and Gerber Reservoir), though data for the latter are comparatively sparse.*

Spawning and Rearing Habitat *Spawning habitat exists at the UKL shoreline springs, Williamson River, Sprague River, Willow Creek, Boles Creek, Barnes Valley Creek, and Ben Hall Creek. Of these, only the UKL shoreline springs occur within the action area. The UKL shoreline springs may also become desiccated to some degree if lake levels drop substantially during the spawning season. Overall, spawning habitat has decreased compared to historical conditions, in terms of either actual spatial extent or functioning.*

Rearing habitat is present within UKL, Clear Lake Reservoir, and Gerber Reservoir, as well as their tributaries, and the majority of rearing habitat occurs within the action area. Limited documentation of rearing of suckers in the tributaries indicates this can occur (Hayes and Rasmussen 2017, entire), but it is unclear to what extent this occurs in any of the populations. Larvae and juveniles primarily utilize vegetated areas along the fringes of UKL until they move into the deeper areas of the lake as they grow (see Sections 6.2.3 and 6.2.4). However, in Gerber and Clear Lake Reservoirs very little of this type of habitat exists in some years; nevertheless, juveniles are able to survive to recruit to adults with regularity. It is unknown whether the scarcity of emergent vegetated habitat affects the proportion of individuals that rear in the tributaries or whether the fish simply exploit other niches within the lake.

Food *Very little empirical data exists on the quantity, quality, and availability of food throughout the designated critical habitat, but the available data suggest large quantities of food are available (Stauffer-Olsen et al., 2017).*

5.2 Effects Analysis

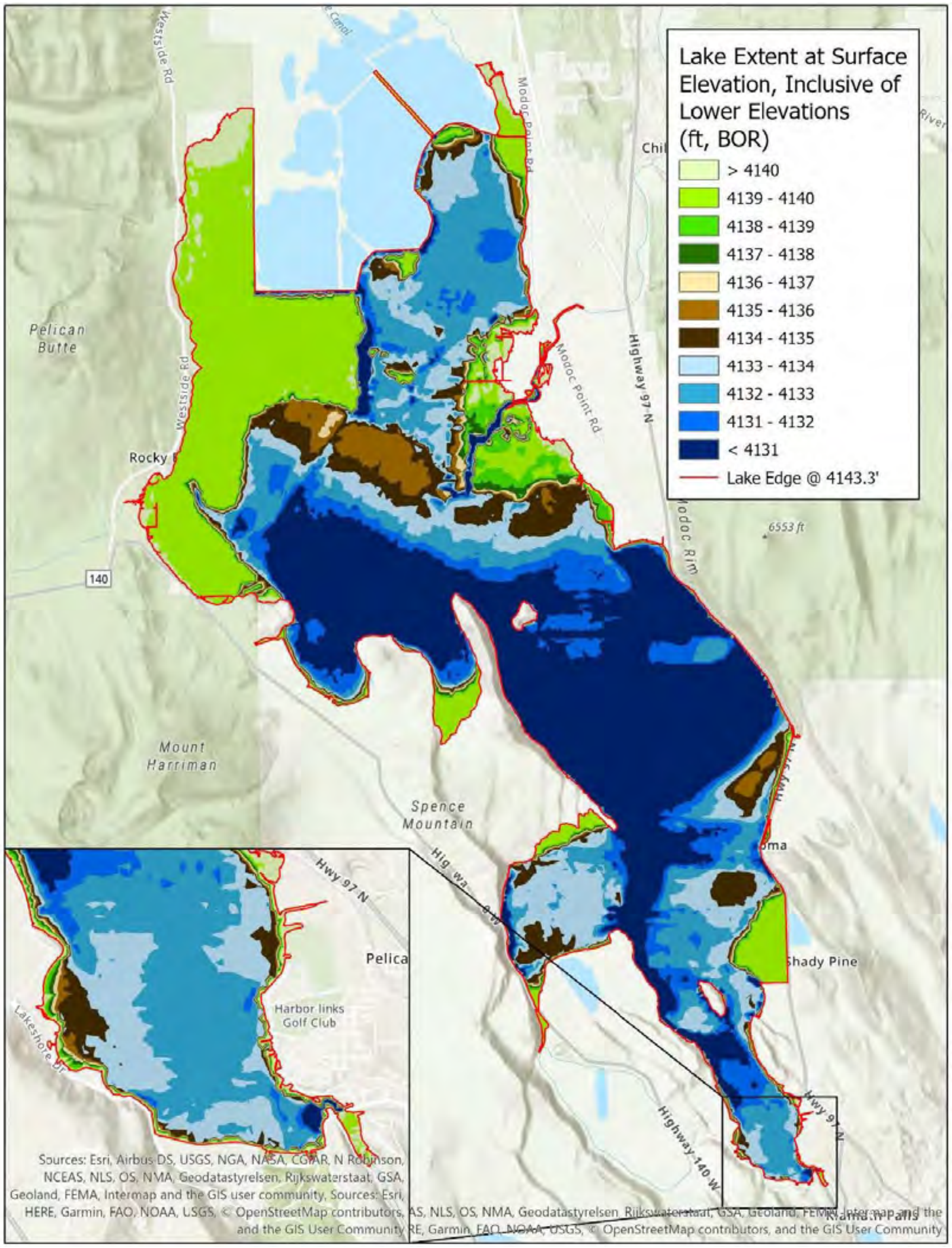
The following sections summarize potential effects of the Proposed Action to LRS and SNS by life stage and stressors. Chapter 4 shows how the seasonal operations of the Project change UKL elevations and Klamath River flows as well as Clear Lake and Gerber Reservoir levels in different locations and under different hydrologic conditions. APPENDIX B summarizes when fish may be present in different locations based on historical monitoring in the Klamath Basin.

The Revised Recovery Plan for the LRS and the SNS (USFWS, 2013) identifies two recovery units for both species: (1) the UKL recovery unit; and (2) the Lost River sub-basin recovery unit. This analysis anticipates the effects of the Proposed Action on these species relative to a MS scenario unless otherwise noted. Because Reclamation uses the KBPM to manage water storage and deliveries from the west side of the Project (UKL sub-unit), the modeled Proposed Action scenario was compared to a modeled MS scenario over the 32-year period of record. Reclamation does not use a modeled approach to predict water storage and deliveries for east side operations (e.g. Lost River sub-unit; Clear Lake and Gerber reservoirs), but instead predicts how a continuation of storage and deliveries similar to those that have occurred in the period of record (e.g., delivering approximately 35 TAF from each Clear Lake and Gerber reservoirs) would affect SNS and LRS relative to future conditions without the action.

The Lost River Basin recovery unit is comprised of the following management units: Clear Lake Reservoir and tributaries, Tule Lake, Gerber Reservoir and tributaries, and Lost River proper (USFWS, 2013). While robust information about the timing, triggers, and basic needs for spawning migrations, as well as meaningful annual survival estimates for both species have been available from UKL for past consultations, this information was not available for suckers in Clear Lake until the 2018 Biological Assessment and 2019 BiOp consultation. Even still, few LRS are tagged in Clear Lake, limiting researcher's ability to estimate annual survival with meaningful confidence intervals (CI; Hewitt et al., 2021). information on early sucker life history ecology and habitat use within the Lost River watershed, particularly Tule Lake, Lost River, and both Clear Lake and Gerber reservoirs, is sparse, though juvenile monitoring has occurred in Clear Lake since 2015 (Burdick et al., 2018). Given a lack of direct observations, larval sucker ecology in the Lost River watershed is assumed to be similar to UKL, except for the use of emergent vegetation by larval and juvenile suckers. Permanent emergent vegetation is generally scarce or absent along the shorelines of Clear Lake and Gerber reservoirs (USFWS, 2019a). It is possible that high turbidity at both of these locations provides cover to early sucker life history stages (USFWS, 2019a).

Upper Klamath Lake Seasonally in the Proposed Action, lake levels in UKL are higher in the winter, spring, and early summer and lower in late summer and fall. Lake levels under the Proposed Action are lower than MS scenario throughout the entire year and would likely range from 4,139.2 to 4,142.2 ft (Reclamation datum). Under the MS scenario, UKL levels would likely range from 4,141.6 to 4,143.3 ft (Reclamation datum). Under the MS scenario, lake levels remain higher through spring, summer, and early fall before water is released in October and November to prepare for winter and spring precipitation events and flood control resulting in substantive drop in lake elevation through the course of the fall (Figure 4-1).

The Proposed Action provides variable amounts of habitat for each sucker life history stage, including embryos, pre- and post-swim up larvae, age-0 (also called young of the year; YOY) juveniles, older juveniles, and adults, in UKL as hydrologic conditions allow. Each sucker life history stage (USFWS, 2019a, Figure 6-1) has different habitat needs and specific seasonal time periods when they use each habitat type. In comparison to the MS scenario, modeled UKL lake levels under the Proposed Action are much lower throughout the year, and the end of season (end of September) lake levels are substantially lower than those that would occur in the MS scenario (Figure 5-5).



Source: Reclamation datum

Figure 5-5. Relative water surface areas of Upper Klamath Lake at various low-water elevations ranging from 4,140 ft to less than 4,131 ft

Keno Impoundment The maximum capacity of the LRDC is approximately 3,000 cfs. Runoff in the Lost River watershed generally occurs very quickly. During rain events and with the annual snowmelt, the LRDC would likely release 3,000 cfs to the Klamath River for extended periods, but runoff generally diminishes to less than 100 cfs in mid-summer each year.

With the gates open and stoplogs removed on LRD, the water surface elevation on UKL is not expected to exceed 4,142.0 ft except under extreme hydrologic circumstances. When the water surface elevation of the lake is at 4,142.0 ft, the maximum release capacity (depending on inflows) is approximately 4,000 cfs. Between the releases from LRD and the discharges from the LRDC, the maximum combined flow in the Klamath River at Keno Dam is estimated to be approximately 7,500 cfs.

Flows under the Proposed Action are lower than the MS in late-fall (October and November), winter, and early-spring (March); higher in April; lower in May; and higher in summer through early fall (September). Flows under the Proposed Action would likely range from 723 cfs in late-summer to 2,078 cfs in mid-spring (Reclamation datum). Flows under the MS scenario would likely range from 362 cfs in the late-summer to 2,975 cfs in late-fall (Reclamation datum). Under the MS scenario, lake levels remain higher through spring, summer, and early fall before water is released in October and November to prepare for winter and spring precipitation events and flood control resulting in substantive drop in lake elevation through the course of the fall (Figure 4-1).

Clear Lake Under the MS scenario, the Clear Lake Dam gates are fully open and are estimated to have a maximum discharge of 780 cfs. Project diversion canal gates downstream remain closed. Thus, under the MS scenario, Clear Lake Reservoir is a smaller, temporary lake during inflow events. At other times of the year, Clear Lake Reservoir would likely be a small lake on the west lobe and a wet meadow on the east lobe.

Management of Clear Lake Reservoir under the Proposed Action will continue the ongoing operation to provide for a minimum surface elevation of no less than 4,520.6 ft on September 30 each year. Dam releases become impaired at a surface elevation below 4,522 ft due to a sediment deposit between the east lobe and Clear Lake Dam (Sutton and Ferrari, 2010). Similar to processes described in past consultations (USFWS, 2002, 2003, 2019a, 2020a, 2023a, 2023b; NMFS and USFWS, 2013) around April 1 of each year, the April through September inflow forecast, current reservoir elevation, estimated leakage and evaporative losses, and an end of September minimum elevation of 4,520.6 ft are used to determine available irrigation water from Clear Lake Reservoir. The amount of irrigation water available is periodically updated with new inflow forecasts and surface elevations as the irrigation season progresses. In-season updates inform the decisions to curtail or terminate irrigation deliveries to avoid going below the minimum surface elevation.

Gerber Reservoir The Proposed Action for Gerber Reservoir is to operate the reservoir volume so that the surface elevation is at or above 4,798.1 ft annually on September 30. Reclamation determines the available irrigation supply, around April 1 of each year, by evaluating the annual April through September inflow forecast, current reservoir elevation, estimated leakage and evaporative losses, and an end of September minimum elevation of 4,798.1 ft. The amount of irrigation water available is updated with new inflow forecasts and surface elevations as the irrigation season progresses. In-season updates inform the decisions to curtail or terminate irrigation deliveries to avoid going below the minimum surface elevation.

Under the MS scenario, the Gerber Dam gates are fully open and are estimated to have a maximum discharge of 900 cfs. Project diversion canal gates downstream remain closed. Thus, under the MS scenario, Gerber Reservoir is a small, temporary lake during inflow events that exceed 900 cfs which occur for about 2-6 weeks annually from February through April. At other times of the year, Gerber Reservoir will resemble small to medium creeks, similar to the three primary tributaries.

Tule Lake The MS scenario for Tule Lake would have substantially higher surface elevations as water that is typically stored in Clear Lake and Gerber reservoirs for irrigation would flow through open dam gates, down the Lost River, and terminate in Tule Lake. In the Proposed Action, approximately 35 TAF each from Clear Lake and Gerber reservoirs is used for irrigation, and little of that water makes it as return flows to Tule Lake Sumps. Wet years would result in a much higher volume of water (greater than 70 TAF) from Gerber and Clear Lake watersheds making its way to Tule Lake. Dry years would result in lower flows down the Lost River, and ultimately lower inflows to Tule Lake. Regardless of hydrologic conditions in any given year, the MS scenario for Tule Lake would be significantly higher surface elevations than in the Proposed Action.

Small populations of LRS and SNS are present in Tule Lake, which is comprised of two sumps called Sump 1A (9,000 acres [3,642 hectares]) and Sump 1B (4,000 acres [1,619 hectares]). In a study of radio-tagged suckers placed in Tule Lake Sump 1B, all moved into Sump 1A when 1A became accessible. Within Sump 1A, radio-tagged suckers have shown preference, especially during the summer months for the “donut hole”, or the deepest spot in Tule Lake. The populations in Tule Lake are thought to be maintained by emigration of individuals from UKL, Clear Lake Reservoir, and/or Gerber Reservoir. Historically, surface elevations were 4,034.6 ft from April 1 to September 30, and 4,034.0 ft from October 1 to March 31. Each irrigation season in the Proposed Action, 43,000 AF from UKL is dedicated to the NWRs for the purpose of keeping Lower Klamath NWR Unit 2 and Tule Lake NWR Sump 1A at specified surface water elevations to maintain habitat for endangered suckers at these locations. The dedicated UKL supply can be delivered to the NWRs from April-October, as required, to overcome evaporative or other losses that may impact available habitat. The rate of cumulative delivery should not exceed the rate that would occur with uniform daily delivery of the dedicated supply from April-October.

These surface elevations will provide some habitat with water depth greater than 3 ft in the area that adult suckers have been observed during summer months.

5.2.1 Adults

LRS and SNS in the adult life stage are present year-round in the UKL and the Lost River sub-units. There is no distinct peak period.

The Stressors that influence LRS and SNS adults are water quality, habitat alteration, predation (avian), disease, stranding, entrainment, and genetic diversity/introgression. Stressors that may change at a level that is insignificant or discountable include the following:

- Stranding - A very small number of adults may be stranded in canals to Clear Lake Reservoir, Gerber Reservoir, and the Lost River.
- Genetic Diversity/Introgression - The Proposed Action will reduce habitat connectivity and maintain genetic distinctions present in the Lost River sub-basin, reducing introgression. Populations of suckers throughout the Lost River sub-unit are genetically distinct and exhibit some introgression (Dowling et al., 2016; Smith et al., 2020). Hybridization has been documented throughout the Lost River sub-unit..

Stressors exacerbated, potentially resulting in incidental take, and potentially ameliorated by the Proposed Action are described below by location.

5.2.1.1 Water Quality

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to decreased water quality in the fall. Both lethal and sub-lethal impacts related to decreased water quality on adult suckers are anticipated as a result of the Proposed Action within UKL.

UKL is classified as hypereutrophic, and this condition combined with current nutrient loading from the watershed and lake sediment facilitates extensive cyanobacterial blooms that result in large diel fluctuations in DO and pH, high concentrations of the hepatotoxin microcystin, and toxic levels of un-ionized ammonia during bloom decomposition (Bortleson and Fretwell, 1993; Boyd et al., 2002; Walker et al., 2012). Together, these conditions create a suboptimal environment for native aquatic biota and likely play a role in the decline of ESA-listed SNS and LRS (Perkins et al., 2000a). Indeed, in recent decades, UKL has experienced serious water quality issues that have resulted in fish die-offs, as well as re-distribution of fish in response to changes in water quality (Buettner and Scoppettone, 1990; Banish et al., 2007, 2009).

Surface elevation is one of many factors that influences water quality parameters in UKL (Wherry and Schenk, 2024). Kann and Walker (2020) suggest an increased probability of suboptimal water quality in UKL outside a certain range of water surface elevations; both high and low water surface elevations in UKL have been associated with higher probabilities of exceeding sucker stress thresholds at various points during June 15-September 1 (Kann and Walker, 2020). Kann and Walker (2020) suggest water surface elevations near the long-term median have generally provided the lowest risk for poor water quality, through the avoidance of elevations at which the highest and lowest DO concentrations occur. However, the long-term median defined by Kann and Walker (2020) is most similar to the water surface elevation experienced in 2017, when a large-scale adult sucker mortality event was observed on UKL (Skinner, 2017; Krause et al., 2017). When Krause et al. (2022) assessed adult sucker survival relative to water surface elevation and water quality parameters, no models with these parameters explained adult sucker survival. Poor water quality remains one of many parameters hypothesized to contribute to poor juvenile survival in UKL (Perkins et al., 2000a). Juvenile survival relative to water quality has not been assessed because there has been no variation in juvenile survival; juvenile survival has been essentially zero in all water year types, and all observed water surface elevation levels in UKL since the mid-1990s. In addition to water surface elevation, parameters that influence water quality in UKL are temperature, inflows, and external phosphorus loading (Wherry and Schenk, 2024). Under the Proposed Action, water surface elevations during these months fall above and below the long-term median (Section 5.2.1.2; Kann and Walker, 2020), which may contribute to poor water quality events in UKL.

The most recent, best available science does not demonstrate a direct, consistent, and discernable relationship between low UKL surface elevation, poor water quality, and mortality of adult suckers (Wherry and Schenk, 2024; Kann and Walker, 2020; Krause et al., 2022). However, water quality is still discussed as a stressor given that the best available science neither confirms nor disconfirms a relationship (i.e., "not anticipated to effect"). For further detail on studies and analyses between lake level and water quality studies for UKL see the (Wood et al., 1996; NRC, 2004; Morace, 2007; Wherry and Schenk, 2024).

Lower surface elevations may result in warmer water temperatures during the summer and fall months, although lacking specific observations, the extent that water temperatures would increase under the Proposed Action is unknown. Lower lake surface elevations could result in increased mixing on windy days, which could mix more soft sediments into the water column which could increase turbidity and increase available nutrients. As a result, DO concentrations could also increase at low lake elevations if stratification events occur less frequently. It is unclear if increased mixing (due to low surface elevations) on windy days, would be a net-benefit (due to higher DO concentrations and higher turbidity-similar conditions to Clear Lake and Gerber reservoirs, which may reduce sunlight available for AFA photosynthesis) or a negative effect as increased nutrients may increase growth of AFA and other cyanobacteria. On calm days that cause the cyanobacteria bloom to crash, low lake elevations, such as those in the Proposed Action, could result in more stressful conditions for suckers because there are fewer areas for suckers to seek water-quality refuge.

The Proposed Action is anticipated to negatively influence water quality in UKL through reduced surface elevations, and thus may negatively impact suckers in UKL through the possibility of periodic concentrating of fish in limited habitat during late summer or early fall months when disease could be more-readily spread among individuals (Section 5.2.1.4). When water quality conditions are poor, adult suckers have been observed seeking refuge in Pelican Bay beginning in mid-July and lasting through September (Banish et al., 2009). Adverse water quality will likely impact suckers in UKL at both the individual and the population levels (Perkins et al., 2000b; Kann and Walker 2020).

Keno Impoundment Relative to surface elevation, the Proposed Action is anticipated to result in water quality conditions that are similar to those observed under the MS scenario. When flows are similar among the two scenarios, the MS scenario is anticipated to result in water quality conditions that are no different than those that would occur under the Proposed Action, although direct observations in the Keno Impoundment are not available. However, in the fall months when flows are substantially higher due to flood control, water quality conditions are likely improved under MS scenario relative to those in the Proposed Action. Water temperatures would be lower and DO concentrations would be higher. Additionally, any season when flows are greater in the Proposed Action relative to the MS scenario, water quality in this reach (which is typically characterized as having some of the worst water quality in the basin), would be improved.

Despite the relatively high tolerance for poor water quality by LRS and SNS, suckers are likely affected by impaired summer water quality in the Keno Impoundment (Saiki et al., 1999; NRC 2004). The Proposed Action includes continued surface water releases from UKL to this reach for Project irrigators and other downstream needs and thus will likely influence water quality in the Keno Impoundment. Reclamation suspects that deliveries under the Proposed Action will have little return flows to the Keno Impoundment, which may alleviate some concerns about the quality (specifically nutrient load) of water returning from the Project.

Two sources of nutrients into the Keno Impoundment from the Project include the LRDC and the KSD. Water returning to the Klamath River from these facilities contains nutrients, organics, and sediment. The use of agrichemicals on Project lands, particularly fertilizers, may increase nutrient concentrations of flows returning to the Klamath River via the LRDC and the KSD. However, the quality of water entering, within, and leaving the Keno Impoundment is largely a result of the export of algal biomass from UKL, and subsequent decomposition within this reach (ODEQ, 2017). Adverse water quality events in the Keno Impoundment impact suckers that reside there. Quantifying the role of return flows in creating adverse water quality events is difficult to ascertain, because the eutrophic outflow from UKL confounds the ability to separate water quality effects of the Project from other factors. However, there is evidence to suggest that discharge from the LRDC can have a substantial negative impact on DO concentrations at Miller Island in the Keno Impoundment, though the magnitude and duration of the effect is less than that resulting from releases from UKL (ODEQ, 2017) and is highly dependent on Project operations.

Improvements in Project infrastructure that allow recirculation of return flows within the Project may reduce the volume of return flow reaching the Klamath River. Similarly, the Proposed Action does not count re-diversion of return flows against Project Supply in the SS (meaning that Project irrigators are likely to redivert this water), which will also likely result in reduced return flow to the Klamath River. Finally, the Project may reduce overall nutrient loads to the Klamath River given that only about 30% of UKL/Klamath River water diverted onto the Project returns to the Klamath River (ODEQ, 2017).

The Proposed Action has impacts to water quality in the Keno Impoundment reach of the Klamath River. The impact of the amount of nutrients from the Proposed Action (e.g., nutrient loading from run-off of project fields) is minimal relative to the large contribution of nutrient and organic matter arriving from UKL. As such, Reclamation concludes that the Proposed Action is likely to have moderate effect on nutrient loading to Keno Impoundment and Klamath River.

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to increased water quality in the fall. Beneficial impacts related to increased water quality on adult suckers are anticipated as a result of the Proposed Action within Clear Lake.

Historically, water quality monitoring over a wide range of lake levels and years documented an environmental baseline of water temperatures and DO concentrations that were periodically stressful to suckers but generally adequate for sucker survival (Reclamation, 1994b, 2000, 2001a, 2007). At Clear Lake, increased water levels in the fall under the Proposed Action may result in improved water quality, particularly lower water temperatures and higher DO.

At Clear Lake Reservoir, lower water levels, regardless of the proposed action, may result in degraded water quality, particularly higher water temperatures and lower DO. However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival (Reclamation, 1994a, 2000, 2001b, 2007).

Low lake levels, should they occur, in Clear Lake Reservoir pose an unquantified risk to listed suckers from adverse water quality (USFWS, 2008). In October 1992, the water surface elevation of Clear Lake was as low as 4,519.4 ft before the onset of a hard winter, and no fish die-offs were observed, although suckers showed poor condition factors in the following spring (Reclamation, 1994b). It is uncertain if water quality conditions or crowding and competition for resources were responsible for impacts to suckers following the winter 1992 to 1993.

The proposed minimum lake level for Clear Lake at the start of the winter period from October to February is 4,520.6 ft. This elevation is anticipated to provide adequate water depths for protection against winter-kill of suckers (USFWS, 2008). Implementation of the Proposed Action is not anticipated to substantially impact water quality as sucker habitat in Clear Lake Reservoir.

Under MS, Clear Lake would become confined to the west lobe and water quality parameters would have warmer temperatures and lower DO concentrations relative to the Proposed Action. Surface elevation under the MS scenario will be much lower than the Proposed Action, which could increase risk to suckers as a result of winter-die-off; however, this is an unquantified risk that may resemble impacts that were observed in winter 1992 (Reclamation, 1994b).

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to increased water quality in the fall. Beneficial impacts related to increased water quality on adult suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

Historically, water quality monitoring over a wide range of lake levels and years documented an environmental baseline of water temperatures and DO concentrations that were periodically stressful to suckers but generally adequate for sucker survival (Reclamation 1994a, 2000, 2001b, 2007). At Gerber Reservoir, increased water levels in the fall under the Proposed Action may result in improved water quality, particularly lower water temperatures and higher DO.

Periodic stratification during summer and fall in the deepest portion of Gerber Reservoir can result in DO concentrations that are stressful to suckers (Piaskowski and Buettner, 2003). Stratification at Gerber Reservoir has been observed persisting for less than a month, over a small portion of the reservoir near the dam (Piaskowski and Buettner, 2003) and is likely more the result of meteorological conditions than lake surface elevations.

Blue-green algae blooms can reach densities high enough to prompt advisories from the state of Oregon in the fall and winter, but it is unclear if these blooms are associated with Project operations or if they directly or indirectly impact SNS.

The MS scenario results in temporary storage behind Gerber Dam because inflows from Barnes Valley and Ben Hall tributaries would exceed outflow in Miller Creek in some wet springs when snow-melt is at its maximum. Water quality of the remaining streamflow is anticipated to be that of ambient conditions characterized by moving water having a lower temperature and higher DO than impounded water. However, any reference to water quality relative to suckers in the Klamath Basin typically is in discussion of lake habitats. The Proposed Action results in lake habitat with periodic low surface elevations at Gerber Reservoir during late summer and fall (Reclamation, 2018). These lower surface elevations could result in higher pH, warmer water temperatures, and lower DO. DO impacts result through concentrating fish into a small, remaining pool. Water quality monitoring over a wide range of lake levels and years has documented water quality conditions that are periodically stressful to suckers but were generally adequate for sucker survival (Reclamation 2001b, 2007; Piaskowski and Buettner 2003; Phillips and Ross, 2012). The Proposed Action is anticipated to result in water quality that is also adequate for sucker survival. The Proposed Action may infrequently impact SNS in Gerber Reservoir by contributing to degraded water quality conditions through low surface elevations. The adverse impacts can be to both individuals and populations through loss of individual body condition or loss of individuals through mortality.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action (relative to the MS scenario where gates are open in Gerber and Clear Lake) will lead to decreased water quality in the summer and fall. Both lethal and sub-lethal impacts related to decreased water quality on adult suckers are anticipated as a result of the Proposed Action within Tule Lake.

Tule Lake is classified as highly eutrophic because of high nutrient concentrations and resultant elevated biological productivity (ODEQ, 2017). Tule Lake water quality is affected primarily by the import of UKL surface water through the LRDC and A Canal during the irrigation season, and secondarily by local runoff during winter and spring months from lands below Lost River Diversion Dam on the Lost River. Also, contributing to the eutrophic status of Tule Lake is its shallow bathymetry and internal nutrient cycling from lake sediment. Water quality can vary seasonally and diurnally, especially in summer. Because of shallow depths in Tule Lake sumps (low relative to the MS scenario where all east-side water goes down the Lost River to Tule Lake), the Proposed Action may contribute to the poor water quality in Tule Lake simply because there will be much less water (USFWS, 2008). Poor water quality in Tule Lake is associated with high nutrient concentrations and pesticides in surface water inflows into Tule Lake (USFWS, 2019a). These conditions are thought to reduce the body condition and survivorship of individual suckers, especially for younger suckers that have higher metabolic rates. While water quality may negatively affect suckers, especially young suckers in Tule Lake, there are very few suckers present in Tule Lake.

Lost River Proper Decreased flows in the Lost River as a result of the Proposed Action will lead to decreased water quality in the summer and fall. Both lethal and sub-lethal impacts related to decreased water quality on adult suckers are anticipated as a result of the Proposed Action within the Lost River.

Lost River is classified as hypereutrophic, and thus water quality conditions are often suboptimal for listed suckers. Nutrient loading, greatest in the middle and lower portions of the Lost River watershed (Schenk et al., 2018), contribute to growth and subsequent senescence of algae, macrophytes, and organics, which facilitates a cycle of high pH and suboptimal or lethal DO and toxic ammonia concentrations (ODEQ, 2017).

Run-off and drain water likely contain nutrients, organics, and sediment, which have adverse effects to LRS and SNS habitat by deteriorating water quality (USFWS, 2008). The effects under the Proposed Action would most likely be due to low DO concentration from decay of algae and macrophytes, and from organics that decompose and consume oxygen (USFWS, 2008). Adverse effects to LRS and SNS from Project runoff and drainage are most likely to occur in the middle and lower Lost River system because these habitats are downstream from large agricultural areas (USFWS, 2008) and would most likely occur in the summer and fall. It is difficult to partition and assess water quality impacts related to nutrients between those carried on return flows and those carried on waters from Clear Lake Reservoir, Gerber Reservoir, and accretions in the Lost River. However, periods of adverse water quality, regardless of the source in the Lost River, adversely impact individual suckers that are present. The Proposed Action will adversely impact water quality in the Lost River through an incremental contribution of nutrients transported on return flows.

5.2.1.2 Habitat Alteration

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to a decrease in suitable habitat for adult suckers in the spring and fall. Both lethal and sub-lethal impacts related to habitat reduction on adult suckers are anticipated as a result of the Proposed Action within UKL.

Shoreline Spawning Habitat For the subpopulation of LRS that spawn at shoreline springs in UKL, spawning starts as early as the beginning of March, peaks in April, and can last through May (Buettner and Scoppettone, 1990; Barry et al., 2007b; Janney et al., 2009; Burdick et al., 2015b; Hewitt et al., 2018). Burdick et al. (2015b) observed fewer sucker detections at the lakeshore spawning areas in 2010, when lake surface elevation was lower than 4,141.3 ft throughout the spawning season. These results suggest that lake surface elevation at or above 4,142.0 ft by the beginning of March (or earlier) is important for lakeshore spawning access and activity. Lake elevations in 2010 were 4,140.49 ft in March, 4,141.00 ft in April, and 4,141.28 ft in May (Figure 5-6). During 2010 there were fewer suckers observed at the springs area (14% fewer females and 8% fewer males) and of the suckers observed, each spent less time at spawning grounds (36% less for females, 20% less for males) than other years when UKL elevations were 4,142 ft or greater (Burdick et al., 2015b). A lake surface elevation of 4,142.0 ft provides approximately 74% of shoreline spawning habitat inundated to a depth of at least 1.0 ft (Burdick et al., 2015b, Figure 4). Because of the amount of habitat provided at this elevation, USFWS (2019a) has determined that lake levels less than 4,142.0 ft will result in adverse effects to suckers.

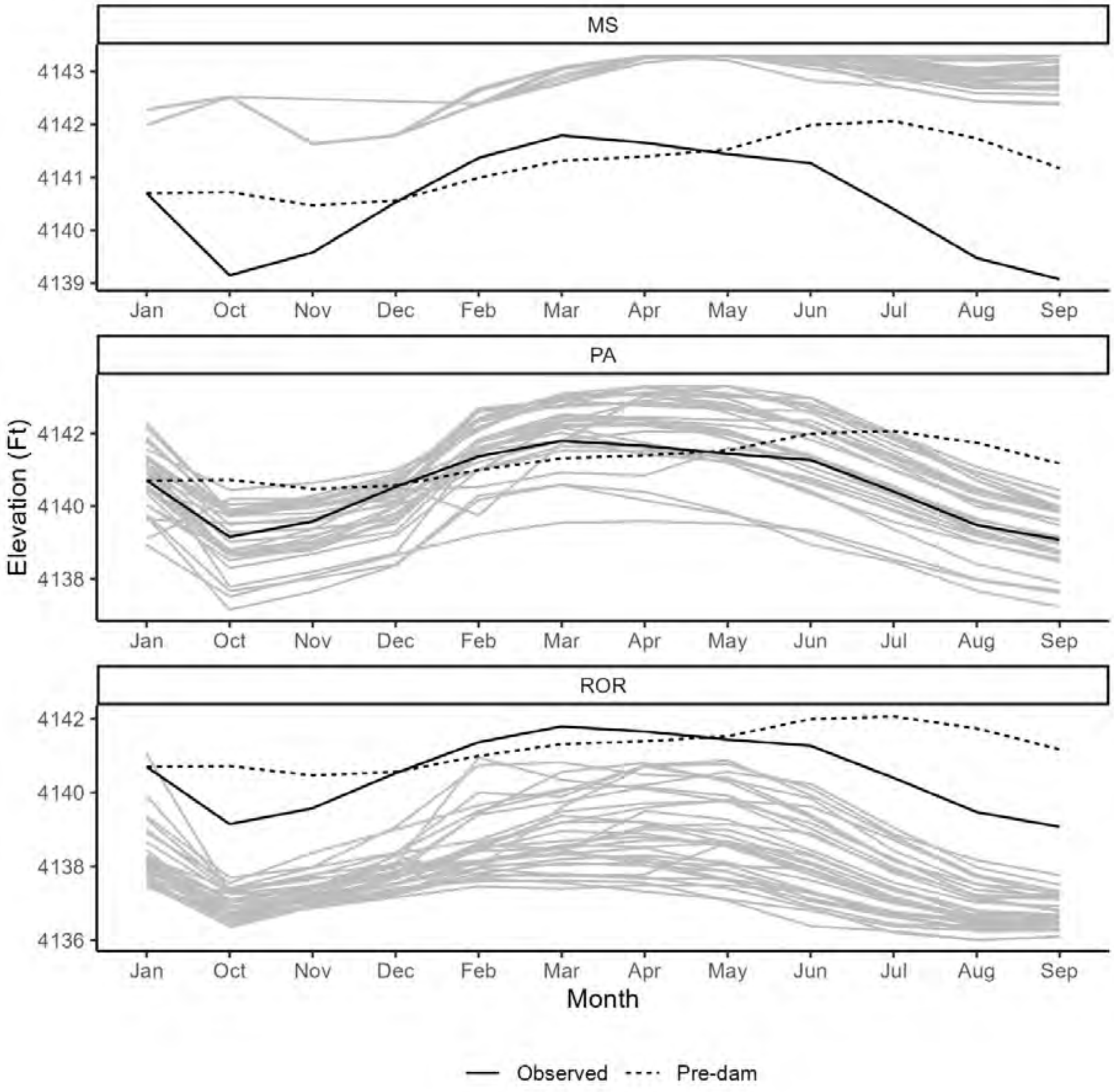


Figure 5-6. Modeled Upper Klamath Lake surface elevation for the Interim Operations Plan, Maximum Storage, Proposed Action, and Flow Through (Run-of-River) scenarios over the period of record (gray lines), the observed lake surface elevation in 2010 when spawning at the shoreline springs was reduced by lake elevations (black solid line), and the average end of month elevations prior to the installations of Link River Dam (1906-1921; black dashed line)

The LRD and dikes surrounding UKL allow for surface elevations to be greater under the Proposed Action than those provided by the natural reef. The natural reef was notched in 1921 to allow UKL elevations to go lower than lake elevations that occurred prior to notching or pre-dam (Figure 5-6). The LRD gates in the MS scenario are in the fully-closed position, so lake elevations are expected to mimic inflows and accretions, with some uncertainty surrounding water residency time and evaporative losses. The MS scenario may result in more spawning habitat and more time for shoreline spawning LRS although beyond a certain elevation higher lake levels may not result in improved habitat. The amount of unusable spawning substrate varies with lake elevation at the various shoreline spawning areas. In the MS scenario, at least 74% of shoreline spawning habitat would be available for LRS in average years (averages for end of month March would be 4,142.9 ft, end of month April would be 4,143.3 ft, and end of month May would be 4,143.3 ft; Burdick et al., 2015b, Table 5-4, Table 5-5). It is likely that more suckers will spawn for longer durations in the MS scenario compared to the Proposed Action.

Table 5-4. Summary statistics for simulated end of month elevations for Upper Klamath Lake under the Maximum Storage scenario over the 32-year Period of Record

Month	Average ± Standard Deviation (ft)	Minimum, Maximum (ft)	Number of Years ≤ 4,142.0 ft (% of years)[1]
February	4,142.5 ± 0.1	4,142.4, 4,142.7	0,0
March	4,142.9 ± 0.1	4,142.8, 4,143.1	0, 0
April	4,143.3 ± 0.02	4,143.2, 4,143.3	0, 0
May	4,143.3 ± 0.01	4,143.2, 4,143.3	0, 0
June	4,143.2 ± 0.1	4,142.8, 4,143.3	0, 0

Note: 1. Number of years when lake elevations are projected to be less than or equal to 4,142.0 ft end of month during the spawning season (February to May) identified by Burdick et al. (2015b) and USFWS (2019a) as minimum lake elevations unlikely to limit the duration or number of individuals spawning at lakeshore spawning grounds.

Table 5-5. Summary statistics for simulated end of month elevations for Upper Klamath Lake under the Proposed Action scenario over the 32-year Period of Record

Month	Average ± Standard Deviation (ft)	Minimum, Maximum (ft)	Number of Years ≤ 4,142.0 ft (% of years)[1]
February	4,141.5 ± 0.8	4,139.2, 4,142.7	22, 0.69
March	4,142.1 ± 0.8	4,139.5, 4,143.1	11, 0.34
April	4,142.2 ± 1.0	4,139.6, 4,143.3	10, 0.31
May	4,142.0 ± 1.0	4,139.5, 4,143.3	13, 0.41
June	4,141.5 ± 1.1	4,138.9, 4,143.0	19, 0.59

Note: 1. Number of years when lake elevations are projected to be less than or equal to 4,142.0 ft end of month during the spawning season (February to May) identified by Burdick et al. (2015b) and USFWS (2019a) as minimum lake elevations unlikely to limit the duration or number of individuals spawning at lakeshore spawning grounds.

The modeled output from the period of record indicates that the Proposed Action is predicted to provide lake elevations greater than or equal to 4,142 ft in 31% of years at end of month February, 66% of years at end of month March, 69% of years at end of month April, 60% of end of month May, and 41% of end of month June) (Table 5-5). The earliest February spawners will have lake elevations greater than 4,142 ft in only 10 of 32 years under the Proposed Action. However, lake elevations, and therefore the amount of spawning habitat inundated, will typically increase during March and April, with lake elevations greater than 4,142 ft in 21 and 22 of 32 years, respectively (Table 5-5, Table 5-6). The modeled output includes the reconnection of Agency Barnes Unit which has an increased bathymetry and SA in UKL. The new habitat created by Agency Barnes reconnection is expected to increase the amount of rearing habitat for juvenile suckers, which may benefit suckers more than the loss of spawning habitat in years when water surface elevation doesn’t reach 4,142 throughout all of March and April (USFWS, 2023a).

The modeled output for the Proposed Action (Table 5-6, Table 5-7) indicates that the frequency at which reduced habitat may concentrate spawning or compel suckers to skip spawning at the shoreline areas is relatively high. The extent that slightly lower than 4,142-foot lake elevations at the end of February in 22 of 32 years, or 69% of the time, affects lakeshore spawners is unclear but is likely to be significant. However, LRS have high reproductive output (Perkins et al., 2000b) that may offset occasional low reproduction years when conditions are poor with substantial gains in years when spawning habitat conditions are good if juveniles survive.

Table 5-6. Modeled end of month Upper Klamath Lake surface elevations (feet above mean sea level, Reclamation datum) under the Proposed Action scenario for the Period of Record (water year 1991 – through water year 2022)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991	4,140.3	4,141.0	4,141.5	4,141.5	4,141.4	4,140.7	4,139.9	4,139.0	4,138.5	4,138.3	4,138.7	4,139.2
1992	4,139.7	4,140.2	4,140.6	4,140.4	4,139.8	4,138.9	4,138.5	4,137.7	4,137.2	4,137.1	4,137.6	4,138.4
1993	4,139.1	4,139.7	4,141.7	4,143.1	4,143.0	4,143.0	4,141.8	4,140.9	4,140.2	4,140.2	4,140.2	4,140.6
1994	4,141.1	4,141.6	4,142.0	4,141.6	4,141.2	4,140.4	4,139.4	4,138.4	4,137.9	4,137.8	4,138.2	4,138.7
1995	4,139.6	4,141.0	4,142.3	4,142.9	4,143.1	4,142.8	4,142.0	4,140.7	4,139.8	4,139.5	4,139.6	4,140.7
1996	4,141.8	4,142.7	4,142.9	4,143.1	4,143.3	4,142.6	4,141.5	4,140.4	4,139.8	4,139.8	4,140.1	4,140.6
1997	4,142.3	4,142.6	4,142.7	4,142.9	4,142.7	4,142.2	4,141.3	4,140.4	4,140.0	4,139.9	4,140.0	4,140.3
1998	4,141.4	4,142.4	4,143.1	4,143.1	4,143.3	4,143.0	4,142.0	4,140.8	4,140.0	4,139.8	4,140.0	4,140.1
1999	4,141.1	4,142.1	4,143.1	4,143.3	4,143.1	4,142.7	4,141.7	4,140.9	4,140.2	4,140.0	4,140.2	4,140.8
2000	4,141.9	4,142.6	4,142.9	4,143.3	4,143.0	4,142.2	4,141.2	4,140.0	4,139.6	4,139.7	4,140.0	4,140.5
2001	4,141.2	4,141.8	4,142.5	4,142.4	4,141.9	4,140.9	4,140.1	4,139.2	4,138.7	4,138.7	4,139.1	4,140.0
2002	4,140.8	4,141.6	4,142.2	4,142.3	4,142.0	4,141.3	4,140.3	4,139.3	4,138.7	4,138.7	4,139.0	4,139.5
2003	4,140.5	4,141.4	4,141.8	4,142.0	4,142.0	4,141.4	4,140.4	4,139.5	4,139.0	4,138.8	4,139.0	4,139.8
2004	4,140.5	4,141.5	4,142.3	4,142.4	4,142.1	4,141.3	4,140.5	4,139.3	4,138.7	4,138.6	4,138.9	4,139.6
2005	4,140.0	4,140.5	4,140.9	4,140.8	4,141.6	4,141.4	4,140.5	4,139.5	4,138.8	4,138.7	4,139.4	4,140.5
2006	4,142.2	4,142.4	4,142.8	4,143.3	4,143.3	4,142.7	4,141.9	4,140.7	4,139.9	4,139.9	4,140.3	4,140.9
2007	4,141.3	4,142.2	4,143.0	4,143.1	4,142.6	4,141.8	4,141.0	4,140.2	4,139.6	4,139.8	4,140.0	4,140.4
2008	4,141.1	4,141.6	4,142.1	4,142.5	4,142.4	4,142.4	4,141.4	4,140.5	4,139.8	4,139.8	4,140.2	4,140.6
2009	4,141.3	4,141.8	4,142.4	4,142.4	4,142.2	4,142.0	4,141.0	4,140.1	4,139.5	4,139.5	4,139.7	4,140.0
2010	4,140.7	4,141.4	4,141.8	4,141.7	4,141.4	4,141.3	4,140.4	4,139.5	4,139.1	4,139.1	4,139.6	4,140.5
2011	4,141.6	4,142.2	4,142.9	4,142.8	4,142.7	4,142.6	4,142.0	4,141.1	4,140.4	4,140.4	4,140.6	4,141.0
2012	4,141.8	4,142.3	4,142.8	4,142.8	4,142.7	4,142.2	4,141.3	4,140.4	4,139.9	4,139.8	4,140.1	4,140.7
2013	4,141.1	4,141.7	4,142.3	4,142.4	4,141.9	4,141.1	4,140.3	4,139.6	4,139.2	4,139.3	4,139.4	4,139.6
2014	4,140.0	4,141.0	4,141.6	4,141.6	4,141.2	4,140.3	4,139.6	4,139.0	4,138.5	4,138.5	4,138.8	4,140.0
2015	4,140.6	4,141.6	4,142.2	4,141.7	4,141.3	4,140.6	4,139.9	4,139.2	4,138.7	4,138.6	4,138.8	4,139.6
2016	4,140.4	4,141.4	4,142.5	4,142.4	4,142.0	4,141.4	4,140.5	4,139.5	4,138.9	4,139.2	4,139.6	4,140.1
2017	4,140.8	4,142.4	4,143.1	4,143.0	4,142.7	4,142.2	4,141.2	4,140.4	4,139.9	4,139.8	4,140.0	4,140.4
2018	4,141.0	4,141.5	4,142.2	4,142.2	4,142.0	4,141.4	4,140.5	4,139.7	4,139.1	4,139.0	4,139.2	4,139.7
2019	4,140.5	4,141.2	4,141.8	4,143.0	4,142.8	4,142.2	4,141.2	4,140.3	4,139.8	4,139.7	4,139.8	4,140.3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	4,140.9	4,141.5	4,141.8	4,141.4	4,141.2	4,140.8	4,140.0	4,139.3	4,138.8	4,138.7	4,139.0	4,139.3
2021	4,139.8	4,140.3	4,140.6	4,140.2	4,139.8	4,139.3	4,138.5	4,138.0	4,137.6	4,137.7	4,138.0	4,138.4
2022	4,138.9	4,139.2	4,139.5	4,139.6	4,139.5	4,139.3	4,138.7	4,138.0	4,137.7	4,137.5	NA	NA

Table 5-7. Modeled percent exceedances for Upper Klamath Lake end-of-month surface elevations (feet above mean sea level, Reclamation datum) under the Proposed Action scenario for the Period of Record (water year 1991 through water year 2022)

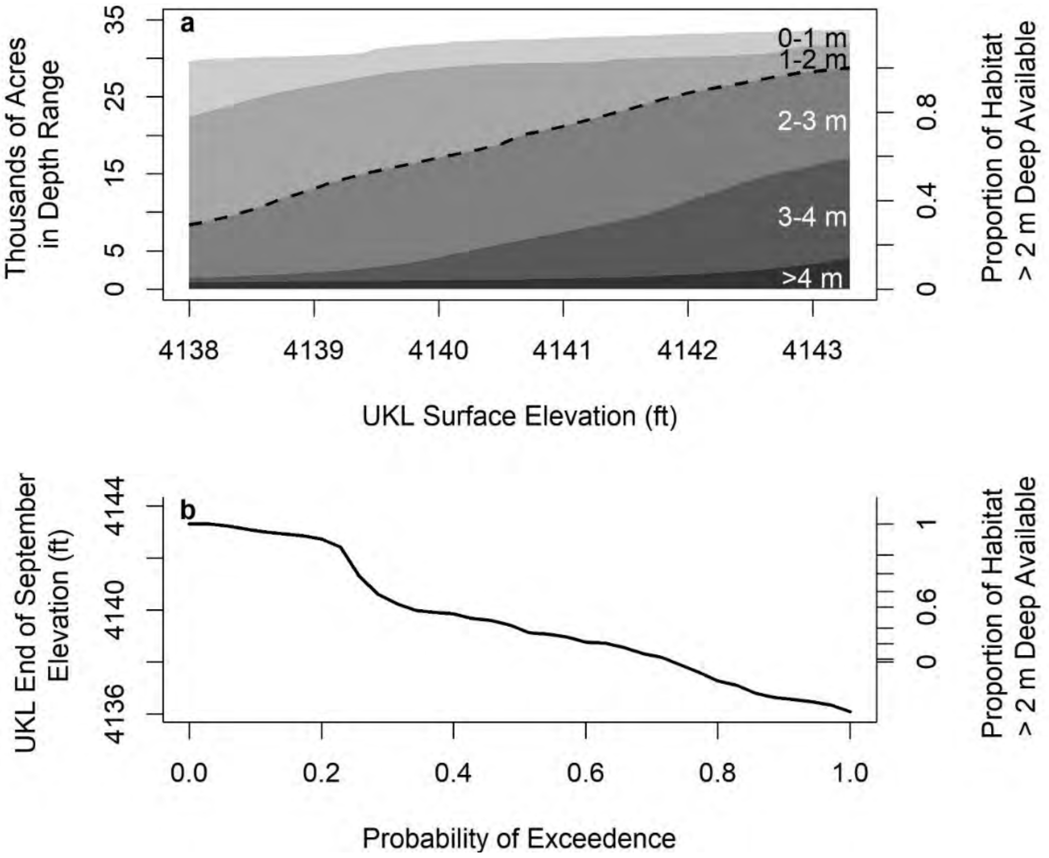
Exceedance Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
95%	4,137.8	4,138.0	4,138.1	4,138.0	4,137.7	4,137.3	4,136.7	4,136.4	4,136.4	4,136.7	4,137.1	4,137.5
90%	4,138.0	4,138.1	4,138.4	4,138.5	4,138.6	4,137.9	4,137.1	4,136.6	4,136.6	4,136.9	4,137.2	4,137.7
85%	4,138.2	4,138.5	4,139.0	4,139.2	4,139.0	4,138.3	4,137.4	4,136.8	4,136.7	4,137.0	4,137.4	4,137.9
80%	4,138.8	4,139.3	4,139.7	4,140.1	4,139.8	4,139.2	4,138.2	4,137.4	4,137.2	4,137.3	4,137.7	4,138.2
75%	4,139.6	4,140.1	4,140.6	4,140.7	4,140.4	4,139.8	4,138.8	4,138.0	4,137.6	4,137.5	4,138.0	4,138.6
70%	4,140.1	4,141.0	4,141.4	4,141.1	4,141.2	4,140.4	4,139.6	4,138.8	4,138.3	4,138.3	4,138.8	4,139.5
65%	4,140.5	4,141.4	4,141.8	4,141.7	4,141.5	4,140.9	4,140.0	4,139.0	4,138.5	4,138.6	4,139.0	4,139.7
60%	4,140.8	4,141.5	4,142.2	4,142.0	4,141.9	4,141.1	4,140.2	4,139.3	4,138.7	4,138.7	4,139.2	4,140.0
55%	4,141.0	4,141.6	4,142.4	4,142.4	4,142.0	4,141.4	4,140.4	4,139.5	4,138.9	4,138.9	4,139.3	4,140.1
50%	4,141.1	4,141.9	4,142.5	4,142.7	4,142.4	4,141.7	4,140.6	4,139.6	4,139.1	4,139.1	4,139.5	4,140.3
45%	4,141.2	4,142.1	4,142.8	4,143.0	4,142.6	4,142.1	4,141.0	4,140.0	4,139.3	4,139.5	4,139.8	4,140.5
40%	4,141.5	4,142.4	4,142.8	4,143.1	4,142.8	4,142.4	4,141.3	4,140.3	4,139.7	4,139.7	4,140.0	4,140.6
35%	4,141.9	4,142.4	4,142.8	4,143.2	4,143.1	4,142.6	4,141.5	4,140.4	4,139.8	4,139.8	4,140.2	4,140.8
30%	4,142.0	4,142.4	4,142.8	4,143.3	4,143.2	4,142.8	4,141.8	4,140.7	4,140.0	4,140.0	4,140.4	4,141.1
25%	4,142.0	4,142.4	4,142.8	4,143.3	4,143.3	4,143.0	4,142.2	4,141.6	4,141.3	4,141.4	4,141.4	4,141.8
20%	4,142.0	4,142.4	4,142.9	4,143.3	4,143.3	4,143.2	4,143.0	4,142.7	4,142.7	4,142.5	4,141.6	4,141.8
15%	4,142.0	4,142.4	4,143.0	4,143.3	4,143.3	4,143.3	4,143.1	4,142.8	4,142.9	4,142.5	4,141.6	4,141.8
10%	4,142.3	4,142.6	4,143.1	4,143.3	4,143.3	4,143.3	4,143.1	4,143.0	4,143.0	4,142.5	4,141.6	4,141.8
5%	4,142.3	4,142.7	4,143.1	4,143.3	4,143.3	4,143.3	4,143.2	4,143.1	4,143.2	4,142.5	4,141.6	4,141.8

Effects to Habitat of Adults in Upper Klamath Lake Telemetry studies have found adult suckers in open water in the portion of UKL north of Bare Island from June to September (Peck, 2000; Reiser et al., 2001; Banish et al., 2007). The amount of preferred habitat for adult suckers varies with lake elevation. Following the approach used in USFWS's 2019 BiOp (USFWS, 2019a), the area of preferred depths available was quantified using a bathymetric layer from various sources (Shelly et al., 2019; USFWS, 2019a) and lake elevations from the modeled period of record output. The analysis is for habitat available in UKL north of latitude 24°24′47″ N, including Shoalwater Bay, Ball Bay, and the Delta because radio-telemetry studies have found suckers primarily use this area during summer months (Banish et al., 2009). In the summer, both species are found primarily in water 6.6 to 13.1 ft (2 to 4 m) deep and avoid water less than 6.6 ft (2 m; Banish et al., 2009). Suckers were never observed in water depths greater than 25 ft (8 m; Banish et al., 2007). Deep water may provide refuge from poor water quality such as warm temperatures, protection from avian predators, and access to preferred food resources (Banish et al., 2009).

The lowest end of September UKL surface elevation is 4,138.33 ft (1,261.36 m) and only occurs during extremely dry years. In the northern portion of UKL, approximately 9,428 acres (3,815 hectares) or 33% of available habitat greater than 6.6 ft (2 m) is available at 4,138.33 ft (1,261.37 m) lake elevation (Figure 5-7). While suckers prefer depths greater than 6.6 ft (2 m), Banish et al. (2009) found radio-tagged suckers frequently used areas in the northern part of UKL including Ball Bay, and the areas north of Ball Point, between Ball Bay and Fish Banks, between Eagle Ridge and Bare Island, and the area north of Ball Bay to the mouth of Pelican Bay (Banish et al., 2009). Distribution is likely associated with food resources, water quality, and predation risk. Thus, the actual amount of preferred habitat greater than 6.6 ft (2 m) deep is likely less than 9,428 acres.

After water quality conditions improve in late summer, adult suckers are distributed throughout the lake (Banish et al., 2007). Thus, lake elevations don't appear to define preferred habitat from November to February (USFWS, 2019a). Lake elevations are typically increasing during this time, though low DO concentrations may occur when ice cover prevents oxygen exchange with the atmosphere (Reclamation, 2012b). Low DO events in the winter do not appear to compromise adult suckers.

While winter water quality conditions are not often considered to be causes of mortality for adult suckers, summer water quality conditions can be stressful, and have been identified as contributing or causing adult fish die-offs (Perkins et al., 2000a). When water quality conditions are poor, adult suckers have been observed seeking refuge in Pelican Bay beginning in mid-July and lasting through September (Banish et al., 2009). The entrance to Pelican Bay is shallow, and while water quality is good in this location, low lake elevations may limit suckers' use of this refugia.



Notes: Source: Shelly et al. (2019). LRS and SNS tend to avoid depths less than 2 m, except when seeking refuge from poor water quality conditions. Shaded areas representing the area in depth categories are stacked, and the dashed line represents the available area (or proportion) of habitat deeper than 2 m relative to availability at full pool.

Figure 5-7. Availability of habitat of various depths in Upper Klamath Lake north of latitude 24°24′47″N—including all of Ball Bay, Shoalwater Bay, and the Williamson River Delta—at varying surface elevations based on UKL bathymetry (A) and the expected frequency of lake elevations and the associated proportion of habitat deeper than 2 m that is available under the Proposed Action based on the model Period of Record (B)

Adult suckers in UKL have also been observed in small numbers in the Delta, which is somewhat deeper than the entrance to Pelican Bay (USFWS, 2019a). The Delta also has better water quality than UKL and may be a refuge for suckers during poor water quality events. Limited areas of refuge (Pelican Bay and the Delta) may result in over-crowding of suckers during poor water quality events. Over-crowding could spread disease among individual suckers and deplete food resources. See Section 5.2.1.3 for further discussion on how low elevations in Pelican Bay may affect predation risk.

Keno Impoundment

Effects to Habitat Little is known about habitat use in the Keno Impoundment by older juvenile and adult suckers. Limited available information suggests adult suckers still migrate into the Link River during the spring and summer (Piaskowski, 2003; Kyger and Wilkens, 2011), and juveniles apparently reside in the Link River, Lake Ewauna, and/or the Keno Impoundment below the LRD throughout most of the year (USFWS, 2002; Phillips et al., 2011). Some efforts to evaluate sucker passage at the Link River fish ladder have observed congregations of adult suckers in Lake Ewauna near the Link River during late winter and spring months (Kyger and Wilkens, 2011, 2012). However, this effort did not survey elsewhere in the Keno Impoundment for adult suckers at that time of year or attempt to define adult sucker habitat in Lake Ewauna. The relatively low number of tagged adult suckers detected at the Link River fish ladder and the relatively high recapture of tagged suckers in the Keno Impoundment, in relationship to the numbers of adult suckers that were tagged in 2008 through 2010 (Kyger and Wilkens, 2011) suggests adult suckers do not exit the Keno Impoundment in high numbers or with much frequency. It is likely that older juvenile and adult suckers in the Keno Impoundment occupy similar habitats as suckers in UKL, such as areas that provide depth and access to water quality refuge. The lower Link River is an important water quality refuge area for juvenile and adult suckers during periods of low DO in the Keno Impoundment (USFWS, 2007c). It is assumed that older juveniles and adult suckers in the Keno Impoundment use water depth as they do in UKL.

Under the MS scenario, surface elevations are expected to be lower than those in the Proposed Action. Under the MS scenario, flows into the Keno Impoundment and via the Link River and LRDC will vary seasonally and mimic the summation of all flows into UKL (e.g., Williamson and Wood rivers) plus accretions, and accretions from the east side of the basin and Gerber and Clear Lake basins. However, they are expected to remain lower with less water leaving UKL. This flow regime could negatively impact habitat for older juvenile and adult suckers in this reach when flows are lower than those in the Proposed Action. If flows are ever higher than those in the Proposed Action, suckers in this area may benefit.

The surface elevation of Proposed Action is not expected to impact offshore, deeper habitats available to older juvenile and adult suckers. The Proposed Action is not anticipated to appreciably impact flows in the Link River during summer months when suckers use the lower Link River as water quality refuge. However, reduced flows during the spring, a result of building storage capacity in reservoirs, may impair habitat conditions relative to the WOA scenario.

Access to Spawning and Other Habitat Large sucker spawning aggregations have not been observed in the Link River. However, spawning habitat is available in the Link River and there was one documented case of spawning activity in the lower Link River upstream of the West Side hydropower facility during May 2007 (Smith and Tinniswood, 2007). Sucker spawning has not been observed in the Klamath River downstream of the Link River mouth to the Keno Dam (Buchanan et al., 2011), and generally, the low gradient, slow moving water, and fine sediments are unlikely to provide adequate spawning habitat in this reach. While few tagged adult suckers move around in the Link River, it appears that their movements are not constrained; up to 100 LRS and SNS are detected on the antenna array in the Link River each year (B. Hayes, USGS, pers.

comm., 10/19/18). Additionally, suckers have been detected moving up and down using a fish ladder on the LRD.

The Proposed Action includes the release of surface water from UKL through the LRD (Chapter 3) and these releases during spring months are likely adequate for spawning in and movement through the Link River. The frequency of brief but higher flows and velocities (than the MS scenario), resulting from the Proposed Action may periodically hinder passage in the Link River for small suckers. The Proposed Action likely results in a small reduction in ability to move through the Link River (and fish ladder) when high flows occur under the Proposed Action, especially for juvenile suckers. However, most of the year, the Proposed Action is not likely to affect access to spawning or other habitat for suckers in this reach.

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to an increase in suitable sucker habitat year-round. Beneficial impacts related to an increase in habitat on adult suckers are anticipated as a result of the Proposed Action within Clear Lake.

Effects to Spawning and Migration Habitat When water is stored in Clear Lake Reservoir, surface elevations increase; when water is delivered from Clear Lake to irrigators, lake surface elevations decrease. Storing water in Clear Lake Reservoir benefits populations of both SNS and LRS. The geomorphology of Clear Lake is such that the area may not have provided lake habitat, thus it is unclear how often suckers from the historical Tule Lake and Lost River populations would have spawned in Willow Creek and other tributaries to Clear Lake instead of in the Lost River. Low lake levels can adversely affect LRS and SNS by limiting access to Willow Creek (USFWS, 2002, 2003, 2008; Hewitt et al., 2021). The Proposed Action to store and divert surface water from Clear Lake Reservoir while maintaining an end of September minimum surface elevation of 4,520.6 ft each year will adversely impact adult suckers only in years when lake elevations are at this minimum, followed by a year (or years) when lake elevations do not increase by 3.4 ft to 4,524 ft or greater prior to the end of February or March; and during any spawning season when lake elevations are less than 4,524 ft. Suckers in Clear Lake are opportunistic spawners; moving into tributaries as early as March during large inflow events when temperatures are 6℃. Spawning in Clear Lake may be limited in years following 4,520.6 ft end of month September lake level. The exception to this is when tributary inflows are large in January, February, and March such that lake elevation reaches 4,524 ft and flows remain high in Willow Creek. While not an annual occurrence, these events do occur; for example, lake levels increased by more than 5 ft by the end of February in water years 2016 and 2017.

While the 4,520.6-ft September end of month minimum is established, this minimum has not occurred with great frequency. For the period of record (water years 1911 to 2023), end of September elevations were at or below 4,520.6 ft in only 9 years (8%; Table 5-8). Spawning migrations in Willow Creek have been remotely monitored since 2006 and flows in Willow Creek have been remotely monitored since 2013. However, lake levels were too low in 2014 and 2015 for suckers to access Willow Creek. Thus, little is known about annual frequency, seasonal timing, and flows (e.g., cfs) necessary for suckers to make a spawning migration.

Table 5-8. Probability of exceedance of end of month Clear Lake surface elevations derived from model output for the 113-year period of record (1911-2023) under the Proposed Action

Exceedance Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
95%	4,519.1	4,519.1	4,519.3	4,520.0	4,521.2	4,521.8	4,522.3	4,521.7	4,521.0	4,520.2	4,519.6	4,519.2
90%	4,520.9	4,520.9	4,521.1	4,521.7	4,521.9	4,523.7	4,524.1	4,524.0	4,523.2	4,522.2	4,521.5	4,521.1
85%	4,521.6	4,521.8	4,522.0	4,522.8	4,523.4	4,525.2	4,525.6	4,525.1	4,524.1	4,523.0	4,522.1	4,521.6
80%	4,522.2	4,522.3	4,523.1	4,523.7	4,524.4	4,525.9	4,526.2	4,525.9	4,524.8	4,523.8	4,522.7	4,522.1
75%	4,523.5	4,523.6	4,524.4	4,524.7	4,525.6	4,526.6	4,527.4	4,526.8	4,525.9	4,524.7	4,523.6	4,523.0
70%	4,524.3	4,524.4	4,525.1	4,525.6	4,526.3	4,527.2	4,528.5	4,528.0	4,527.3	4,526.1	4,525.0	4,524.3
65%	4,525.5	4,525.7	4,526.1	4,526.5	4,527.0	4,528.1	4,528.9	4,528.9	4,528.1	4,527.0	4,526.2	4,525.7
60%	4,526.0	4,526.0	4,526.7	4,527.0	4,527.7	4,529.2	4,529.9	4,529.5	4,528.9	4,527.8	4,526.8	4,526.3
55%	4,526.9	4,526.9	4,527.2	4,527.9	4,528.9	4,530.3	4,531.0	4,530.6	4,529.9	4,528.8	4,527.9	4,527.2
50%	4,527.6	4,527.5	4,528.2	4,528.7	4,529.8	4,530.7	4,531.7	4,531.4	4,530.4	4,529.4	4,528.4	4,527.8
45%	4,529.0	4,529.0	4,529.4	4,529.8	4,530.5	4,531.3	4,532.3	4,532.2	4,531.3	4,530.8	4,530.0	4,529.2
40%	4,529.7	4,529.7	4,529.8	4,530.6	4,531.5	4,532.1	4,533.5	4,533.2	4,532.4	4,531.4	4,530.6	4,529.9
35%	4,530.4	4,530.5	4,530.6	4,531.2	4,532.2	4,533.5	4,534.1	4,533.6	4,533.1	4,532.2	4,531.3	4,530.6
30%	4,531.1	4,531.1	4,531.4	4,532.0	4,533.4	4,533.9	4,534.8	4,534.5	4,533.8	4,532.6	4,531.9	4,531.2
25%	4,531.5	4,531.5	4,532.0	4,533.2	4,533.7	4,535.0	4,535.4	4,535.0	4,534.4	4,533.3	4,532.4	4,531.6
20%	4,533.0	4,533.0	4,533.2	4,533.9	4,534.3	4,535.7	4,536.6	4,536.1	4,535.4	4,534.7	4,533.8	4,533.2
15%	4,533.5	4,533.5	4,533.8	4,534.4	4,535.6	4,536.8	4,537.5	4,537.4	4,536.6	4,535.6	4,534.6	4,533.7
10%	4,534.1	4,534.0	4,534.2	4,535.1	4,536.2	4,537.8	4,538.3	4,537.8	4,537.0	4,535.9	4,535.0	4,534.3
5%	4,535.0	4,534.9	4,535.3	4,536.1	4,537.1	4,538.7	4,539.2	4,539.0	4,538.4	4,537.4	4,536.1	4,535.4

Lake levels in Clear Lake end above the elevation necessary for suckers to access spawning grounds in most years. In only the 15% driest years (85% exceedance) are lake elevations expected to be less than 4,524 ft during the following spring when suckers attempt to spawn in Willow Creek.

Seasonal increases of lake elevation in Clear Lake typically increase from end of month December to end of month April. The largest increases occur most often in March, but lake elevations also increase throughout February and April. Average ± standard deviation increases in lake level are 0.04 ± 0.26 ft in November, 0.39 ± 0.74 ft in December, 0.59 ± 0.88 ft in January, 0.87 ± 1.31 ft in February, 1.20 ± 1.67 ft in March, 0.72 ± 1.23 ft in April for the period of record. Understanding the seasonality of accretions provides a tool for managers to predict when lake elevations may be sufficient for suckers to access spawning tributaries and to understand the timing of discharge events in Willow Creek. Flows necessary for suckers to spawn in Willow Creek, as well as their frequency of occurrence, are expected to be better understood in the coming years.

Changes in lake elevation from end of month October to end of month April among years reflect differences in hydrologic conditions and varies among years, including decreasing 0.62 ft (water year 1977) during dry years and increasing 14.31 ft (water year 1956) during wet years. For the period of record, suckers are able to access Willow Creek for spawning when lake surface elevations are approximately 4,524.0 ft. Surface elevations of at least 4,524.0 ft were reached each spring by the end of February in 83% of years, the end of March in 88% of years, and the end of April in 89% of years. Thus, only in 11-17% of the driest years will lake elevations not be high enough for suckers to access Willow Creek until sometime in April, after the spawning season.

The Proposed Action is likely to impact the frequency with which adult suckers can make spawning migrations only in the driest years. However, as future operations are intended to be similar to historical operations, it is likely that the adult suckers will be able to access spawning grounds in Willow Creek greater than 80% of years (presuming inflows are also sufficient in Willow Creek to support a spawning migration). The Proposed Action at Clear Lake Reservoir is consistent with the historical operations at the reservoir; therefore, the impacts are not anticipated to be greater than those described in the environmental baseline (Chapter 2).

Surface elevations under the MS scenario at Clear Lake are anticipated to be much lower than with the Proposed Action. Under MS, the remaining lake habitat is the west lobe at a surface elevation of about 4520.5 ft. The east lobe likely does not contain water by about April or May and is best described as a wet meadow throughout much of the year. Thus, MS access to the known spawning tributary of Willow Creek, across a much shallower or non-existent east lobe, occurs with a much lower frequency than the Proposed Action.

Effects to Holding and Rearing Habitat The minimum surface elevation of 4,520.6 ft at the end of September under the Proposed Action preserves a lake surface area of 10,680 acres of habitat, of which 7,940 acres is at least 3 feet deep. At the minimum surface elevation of 4,520.6 ft, the west lobe averages approximately 5.5 ft of water depth. Of the 10,680 acres of habitat available at 4,520.6 ft lake elevation, 7,940 acres are at least 3 feet deep, 7,540 acres are 4 feet deep, and 7,100 acres are 5 feet deep. At the minimum surface elevation, the east lobe has a water depth of 7 inches, except for the pool nearest the dam into which Willow Creek flows. At 4,520.6 ft, the east lobe provides no habitat for suckers and the east lobe is dry at 4,520 ft. Despite 4,520.6 ft as the minimum, lake elevations have occasionally been below 4,520.6 ft, especially during dry years due to additional losses from evaporation and seepage. Lake elevations were less than 4,520.6 ft in 1 month or more in at least 10 years during the period of record. Throughout the full period of record, Clear Lake Reservoir lake elevations were at or below minimums (4,520.6 ft) at the end of September in 8% or fewer years. However, Clear Lake elevations were greater than 4,520.6 ft for at least some years because silting of the dam's approach channel made withdrawing more water impracticable below 4,523.0 ft and BiOp minimums were historically higher in Clear Lake (Reclamation, 1992). Perhaps as a result of different BiOp minimums or due to the current drier climatic cycle, the minimum threshold has occurred more often (14% of years) in the last 21 years. Still, it is relatively uncommon that Clear Lake Reservoir will get to minimum lake elevations.

In Clear Lake, the east lobe habitat is effectively unavailable for suckers when lake elevations are less than 4,523 ft (1,379 m) (USFWS, 2019a). Clear Lake elevations have been less than or equal to 4,523 ft (1,379 m) at some time during the year in 34% of years in the full period of record and more recently, in 60% of years since 2004. Although the Proposed Action has not changed since 1999, deliveries well in excess of the average demand from this reservoir have occurred in a few years within the recent period of record resulting in more frequent lake levels of 4,523 ft or less (conditions that cause adults suckers to avoid the east lobe). It is also possible that drier climatic conditions since that time have played a role in the increased frequency of lower reservoir elevations, a trend that may continue during the duration of this Proposed Action.

During the majority of months and years, surface elevations are anticipated to be above surface elevations that substantially impact older juveniles and adult suckers through reduced habitat. The Proposed Action is anticipated to adversely affect adult suckers only during infrequent periods of prolonged drought by reducing habitat availability, particularly lake surface area and depth. During consecutive years of low inflow, individual suckers may also experience reduced body condition, which can lead to mortality, and populations may contract in size if substantial numbers of adults are lost to mortality or individual reproductive health is compromised to the point that there is a reduction in recruitment.

Under the MS scenario, year-round surface elevations at Clear Lake are anticipated to be much lower than with the Proposed Action. Under the MS scenario, the remaining lake habitat is the west lobe at a surface elevation of about 4,520.5 ft, and the east lobe is likely dry by April or May. This results in considerably less habitat as surface area, shoreline, and areas of water depth for older juvenile and adult suckers when compared to the Proposed Action. Thus, under the MS scenario, Clear Lake would likely support a smaller population of suckers than it is expected to support with the Proposed Action, resulting in a beneficial impact from the Proposed Action.

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to an increase in suitable sucker habitat year-round. Beneficial impacts related to an increase in habitat on adult suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

Effects to Spawning and Migration Habitat Access to Gerber Reservoir tributaries, where SNS spawning occurs, requires a minimum surface elevation of about 4,805.0 ft during February through May (USFWS, 2008). During very dry years both Barnes Valley and Ben Hall creeks typically have low spring flows that may not provide adequate upstream passage for spawning adults regardless of lake elevations (Reclamation, 2001a). Although surface elevations at the end of September have been observed below the proposed minimum elevation of 4,798.1 ft in 5 years from the period of record (1925-2023) at Gerber Reservoir (1931, 1960, 1961, 1991, and 1992), surface elevations of at least 4,805.0 ft were reached each spring by the end of February in 94% of years, the end of March in 98% of years, and the end of April in all years for the period of record..

Based on review of surface elevations from the period of record for Gerber Reservoir, the Proposed Action, which maintains the current lake management of a minimum surface elevation at or above 4,798.1 ft at the end of September, will increase SNS access to spawning habitat during the succeeding spring months based on the hydrology of Gerber Reservoir. In only the 5% driest years (95% exceedance) are lake elevations expected to be less than 4,805 ft during the following spring when suckers attempt to spawn in the Gerber Reservoir tributaries (Table 5-9). The Proposed Action at Gerber Reservoir provides the benefit of improved spawning access for suckers residing upstream of Gerber Dam except for years with extreme dry conditions, and a negative impact for any suckers downstream of Gerber Dam as a result of no fish passage features.

Table 5-9. Probability of exceedance of end of month Gerber Reservoir surface elevations derived from model output for the 99-year period of record (1925-2023) under the Proposed Action

Exceedance Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
95%	4,797.9	4,797.9	4,800.2	4,800.5	4,804.7	4,809.1	4,809.0	4,807.6	4,804.2	4,801.5	4,798.8	4,798.2
90%	4,800.7	4,802.4	4,804.4	4,805.3	4,807.3	4,811.2	4,814.2	4,812.2	4,809.9	4,806.9	4,803.8	4,800.8
85%	4,803.3	4,804.7	4,806.8	4,807.6	4,808.5	4,813.9	4,817.7	4,817.5	4,814.9	4,810.7	4,806.6	4,803.3
80%	4,805.7	4,806.5	4,808.6	4,810.1	4,811.9	4,816.4	4,819.5	4,818.9	4,816.2	4,812.3	4,809.0	4,805.4
75%	4,806.9	4,807.4	4,809.2	4,812.0	4,814.2	4,818.1	4,821.3	4,819.8	4,816.8	4,813.3	4,809.8	4,806.8
70%	4,808.3	4,809.3	4,811.4	4,813.4	4,815.3	4,819.7	4,821.9	4,820.5	4,817.7	4,814.7	4,811.6	4,808.5
65%	4,810.5	4,810.9	4,812.8	4,814.4	4,816.5	4,821.1	4,822.9	4,821.2	4,818.9	4,815.4	4,812.9	4,810.4
60%	4,812.1	4,812.0	4,814.3	4,816.2	4,817.5	4,822.1	4,824.7	4,822.9	4,820.3	4,816.9	4,814.0	4,811.8
55%	4,813.7	4,814.1	4,815.3	4,816.6	4,818.0	4,823.4	4,825.8	4,825.0	4,822.3	4,819.4	4,816.3	4,813.9
50%	4,814.6	4,815.2	4,817.0	4,817.4	4,819.9	4,824.6	4,827.3	4,825.9	4,823.3	4,820.7	4,817.8	4,815.3
45%	4,816.7	4,816.6	4,818.3	4,817.9	4,820.8	4,825.4	4,828.3	4,827.0	4,824.5	4,821.1	4,818.7	4,817.2
40%	4,817.6	4,817.7	4,820.1	4,820.3	4,821.6	4,826.0	4,829.2	4,827.9	4,825.5	4,822.7	4,820.4	4,818.4
35%	4,819.6	4,819.8	4,820.6	4,820.8	4,823.0	4,826.9	4,830.1	4,829.3	4,827.7	4,824.9	4,821.9	4,819.8
30%	4,820.6	4,820.6	4,821.5	4,821.4	4,823.4	4,828.3	4,831.6	4,830.7	4,829.3	4,826.3	4,823.3	4,820.7
25%	4,821.0	4,821.7	4,822.4	4,823.2	4,824.8	4,830.5	4,832.1	4,831.9	4,829.7	4,826.8	4,823.5	4,821.2
20%	4,822.0	4,822.5	4,823.0	4,824.3	4,826.4	4,831.7	4,834.1	4,833.0	4,830.4	4,827.3	4,824.5	4,822.5
15%	4,822.8	4,823.0	4,824.1	4,825.7	4,828.4	4,832.6	4,834.9	4,833.6	4,831.2	4,828.1	4,825.3	4,823.5
10%	4,824.2	4,824.4	4,825.3	4,826.9	4,830.7	4,834.4	4,835.5	4,834.4	4,832.2	4,829.5	4,826.9	4,824.5
5%	4,825.5	4,825.5	4,827.5	4,829.7	4,833.1	4,835.6	4,835.8	4,834.9	4,833.2	4,830.7	4,828.0	4,825.7

Effects to Holding and Rearing Habitat The effects of low water elevations at Gerber Reservoir on the resident SNS population in terms of population size, age-class distribution, recruitment, or decreased body condition are not fully understood. However, available information (Leeseberg et al., 2007; Reclamation, 2018) indicates that the Gerber Reservoir sucker population has remained viable under the past management regime (USFWS, 2008).

The Proposed Action of storing and diverting inflows at Gerber Reservoir includes the beneficial impact of maintaining at least some lake habitat year-round, in all years. The resulting surface elevations at Gerber Reservoir from the Proposed Action, which will resemble the range and frequency of past surface elevations, will have beneficial impacts through increased lake habitat during wet hydrologic conditions and negative impacts at low elevations when dry conditions persist. It is unlikely that the Proposed Action will limit the persistence of SNS in Gerber Reservoir.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to a decrease in suitable habitat for adult suckers year-round. Both lethal and sub-lethal impacts related to habitat reduction on adult suckers are anticipated as a result of the Proposed Action within Tule Lake.

Effects to Spawning and Migration Under the Proposed Action, Tule Lake sumps would likely contract in size during dry conditions and adult suckers may not be able to migrate upstream of Anderson Rose Dam (gates open) up to at least the Lost River Diversion Dam on inflow events.

Most past consultations established a minimum surface elevation of 4,034.6 ft from April 1 to September 30 for Tule Lake Sump 1A to provide access to spawning areas below Anderson Rose Diversion Dam (USFWS, 2002, 2008; NMFS and USFWS, 2013) and for delivery of irrigation water to lands east and south of Sump 1A. However, despite some SNS and LRS observed making a spawning run up the Lost River, spawning appears to be limited by a lack of suitable substrates and flows from the Anderson Rose Dam. Thus, sucker populations in Tule Lake do not successfully reproduce. The Proposed Action includes management of Tule Lake Sump 1A for a minimum surface elevation of 4,034.0 ft throughout the year. Based on the best available information, this surface elevation is not expected to limit sucker access into the lower Lost River. Operation of Anderson Rose Dam under the Proposed Action in the lower Lost River impacts the travel distance of adult suckers attempting to spawn.

Effects to Holding and Rearing Habitat Under the Proposed Action water depth as cover for older juvenile and adult suckers will be limited due to the shallow bathymetry of the Tule Lake sumps (less than 4 ft [1.2 m]). Surface elevations in Tule Lake Sump 1A of 4,034.0 ft may provide adequate habitat (though never preferred depth; 6.6 ft [2 m]) with some areas where water depth is greater than 3 ft for adults; however, there is continued concern about the shallow bathymetry of the sumps, the possibility of continued sedimentation, and high predation risk for suckers by American White Pelicans (USFWS, 2008, 2019a). Some of the sedimentation may be from lands that use Project water. The Proposed Action may adversely impact older juvenile and adult suckers in Tule Lake Sump 1A due to limiting habitat, largely water depth.

Lost River Proper Reduced flows in the Lost River as a result of the Proposed Action will lead to a decrease in suitable habitat for adult suckers year-round. Both lethal and sub-lethal impacts related to habitat reduction on adult suckers are anticipated as a result of the Proposed Action within the Lost River.

Effects to Spawning and Migration Much of the fish habitat, including spawning habitats, in both the upper and lower Lost River is fragmented by the presence of dams and irregular flows that affect adult sucker movements (Reclamation, 2009; Kirk et al., 2010; Shively et al., 2000b). The Proposed Action, which seasonally controls flows in the Lost River, will result in adverse impacts by limiting adult sucker access to spawning habitat in the Lost River and its tributaries.

Effects to Habitat Based on Shively et al. (2000b), older juvenile and adult endangered suckers reside in impounded areas or deep pools in the Lost River except during the spring spawning period when they migrate (Reclamation, 2001b; USFWS, 2002; Sutton and Morris, 2005). Most of the adult sucker observations in the Lost River are from the upper Lost River above Bonanza, Oregon, (Shively et al., 2000b). There are few older juvenile or adult suckers residing in the lower Lost River below Lost River Diversion Dam (Reclamation, 2001b; USFWS, 2002).

Dams and historical channelization fragmented adult sucker habitat in the Lost River in the same way it has for earlier life history stages: habitat quality is degraded, and connectivity is reduced (Reclamation, 2009). Increased crowding of adult suckers into remaining available habitat at either the impoundments or deep pools and following reduced flows at the end of the irrigation season adversely impact individual adult suckers in the Lost River. Inflows from groundwater and low elevation runoff during weather events in the fall and winter periodically lessen the impacts of reduced habitat during the fall and winter months by reconnecting isolated areas of habitat (i.e., reservoirs and deep pools).

As with earlier life history stages, seasonal flow diversions under the Proposed Action, particularly flow reduction at the end of irrigation season in the Lost River, will have negative impacts to habitat for older juveniles and adult suckers in the Lost River.

5.2.1.3 Predation (Avian)

Upper Klamath Lake…Lower surface elevations in UKL as a result of the Proposed Action will lead to increased risk of avian predation of adult suckers in the spring, summer, and fall. Lethal impacts related to increased predation on adult suckers are anticipated as a result of the Proposed Action within UKL.

When water quality conditions are poor, adult suckers have been observed seeking refuge in Pelican Bay beginning in mid-July and lasting through September (Banish et al., 2009). The entrance to Pelican Bay is shallow, and while water quality is good in this location, low lake elevations may limit suckers’ use of this refugia. The shallow and clear water of Pelican Bay may increase suckers’ risk of avian predation. For example, American White Pelicans can prey upon suckers as large as 730 mm length, and pelicans typically forage in water 3.3-6.6 ft (1-2 m) deep (Anderson, 1991; McMahon and Evans, 1992; Findholt and Anderson, 1995a, 1995b). Suckers are more vulnerable to pelican predation when water depth is less than 6.6 ft (2 m) and

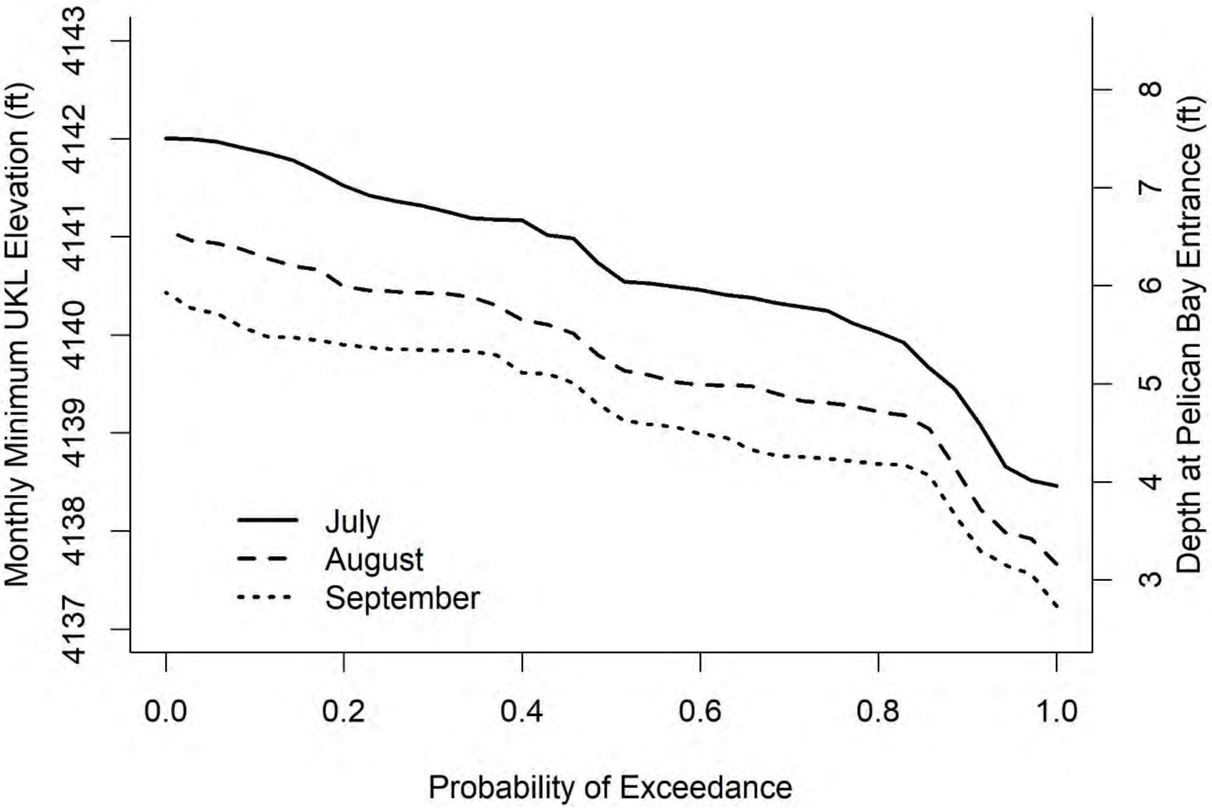
Scoppettone et al. (2014) suggested water depths greater than 3.3 ft (1 m) may reduce pelican foraging success on suckers.

The northern portion of UKL and specifically Pelican Bay, has been identified as important habitat for older juveniles and adults to seek refuge from poor water quality (Banish et al., 2009). Adequate depth is necessary for suckers to safely access water quality refuge areas in Pelican Bay and preferred habitat in mid-September. Suckers seeking water quality refugia in Pelican Bay are likely to be more vulnerable to predation by American White Pelicans, especially during dry years. The bottom elevation of Pelican Bay is 4,134.5 ft (1,260.2 m; Shelly et al., 2019). The lowest UKL surface elevation in the model period of record in July through September was 4,137.2 ft, which results in 2.6 ft (0.9 m) of water to the entrance of Pelican Bay (Table 5-10). This is shallower than 3.3 ft (1 m), so provides little protection for suckers against the most severe impacts to predation (Scoppettone et al., 2014). Also, the depth of the entrance to Pelican Bay is expected to be between 4 and 6 ft (1.2 and 1.8 m) during August and September in all but the wettest years, which may result in increased risk of predation for suckers by pelicans (Table 5-10, Figure 5-8).

Table 5-10. Water depths at the entrance to Pelican Bay at various Upper Klamath Lake elevations

Lake Surface Elevation (ft)	Depth of Entrance to Pelican Bay (ft)
4,143.0 (1,262.8 m)	8.5 (2.6 m)
4,142.5 (1,262.6 m)	8.0 (2.4 m)
4,142.0 (1,262.5 m)	7.5 (2.3 m)
4,141.5 (1,262.3 m)	7.0 (2.1 m)
4,141.0 (1,262.2 m)	6.5 (2.0 m)
4,140.5 (1,262.0 m)	6.0 (1.8 m)
4,140.0 (1,261.9 m)	5.5 (1.7 m)
4,139.5 (1,261.7 m)	5.0 (1.5 m)
4,139.0 (1,261.6 m)	4.5 (1.4 m)
4,138.5 (1,261.4 m)	4.0 (1.2 m)
4,138.0 (1,261.3 m)	3.5 (1.1 m)
4,137.5 (1,261.1 m)	3.0 (0.9 m)
4,137.0 (1,261.0 m)	2.5 (0.8 m)

Notes: The minimum bottom elevation at the entrance to the bay is approximately 4,134.5 ft (1,260.2 m; Shelly et al., 2019).



Note: Suckers are expected to avoid depths shallower than 1 m (3.3 ft; gray line).

Figure 5-8. Probability of exceedance of monthly minimum Upper Klamath Lake surface elevation in July (solid line), August (long dashes), and September (short dashes) under the PA for the model Period of Record and the associated depth at the entrance to water quality refuge contained in Pelican Bay

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to decreased risk of avian predation of adult suckers year-round. Beneficial impacts related to decreased predation on adult suckers are anticipated as a result of the Proposed Action within Clear Lake.

When lake levels are low, surface area and depth of habitat are reduced for suckers. Sucker populations are concentrated as evidenced by increased trammel net catches at low lake elevations (Hewitt and Hayes, 2013). While not fully understood, avian predation, including but not limited to Double-Crested Cormorants and American White Pelicans, is higher when lake elevations are low. This has been detected in lower survival estimates of adult suckers during low lake elevations, and in greater proportions of available passive integrated transponder (PIT) tags found at nesting colonies and loafing areas (Evans et al., 2016; see Section 5.1.6). In Clear Lake, increased lake levels will provide more depth as cover for adult suckers holding in Clear Lake to avoid avian predation.

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to decreased risk of avian predation of adult suckers year-round. Beneficial impacts related to decreased predation on adult suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

As described above, avian predation is higher when lake elevations are low. In Gerber Reservoir, increased lake levels will provide more depth as cover for juvenile suckers holding in Gerber Reservoir to avoid avian predation.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to increased risk of avian predation of adult suckers year-round. Lethal impacts related to increased predation on adult suckers are anticipated as a result of the Proposed Action within Tule Lake.

As described above, avian predation is higher when lake elevations are low. Reduced lake elevations in Tule Lake Sumps across all seasons will provide less depth as cover for juvenile suckers to avoid avian predation.

Lost River Proper Reduced flows in the Lost River as a result of the Proposed Action will lead to increased risk of avian predation of adult suckers year-round. Lethal impacts related to increased predation on adult suckers are anticipated as a result of the Proposed Action within the Lost River.

As described above, avian predation is higher when lake elevations and river flows are low. Reduced flows in the Lost River across all seasons will provide less depth as cover for adult suckers to avoid avian predation.

5.2.1.4 Disease

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to increased risk of disease in adult suckers in the fall. Lethal impacts related to increased disease on adult suckers are anticipated as a result of the Proposed Action within UKL.

Adult suckers in UKL have also been observed in small numbers in the Delta, which is somewhat deeper than the entrance to Pelican Bay (USFWS, 2019a). The Delta also has better water quality than UKL and may be a refuge for suckers during poor water quality events. Limited areas of refuge (Pelican Bay and the Delta) may result in over-crowding of suckers during poor water quality events. Over-crowding could spread disease among individual suckers and deplete food resources.

The Proposed Action will influence fish disease in UKL through the possibility of periodic, but infrequent, concentrating of fish in limited habitat during the fall months when disease could be more-readily spread among individuals (Buettner, 2007, pers. comm. cited in USFWS, 2008).

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to decreased risk of disease in adult suckers in the summer and fall. Beneficial impacts related to decreased rates of disease on adult suckers are anticipated as a result of the Proposed Action within Clear Lake.

When lake levels are low, surface area and depth of habitat are reduced for suckers. Sucker populations are concentrated as evidenced by increased trammel net catches at low lake elevations (Hewitt and Hayes, 2013). Crowding may result in increased parasite levels or decreased growth rates due to limited resources. For example, when lake levels were low in 1992, body condition decreased slightly and afflictions increased, though these effects were no longer apparent by summer (Reclamation, 1994b). Increased lake levels in the summer and fall will provide less disease and parasite transmission for adult suckers holding in Clear Lake.

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to decreased risk of disease in adult suckers in the summer and fall. Beneficial impacts related to decreased rates of disease on adult suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

As described above, low lake levels can reduce habitat and increase crowding, thereby increasing parasite levels or reducing growth rates. Increased lake levels in the summer and fall will provide less disease and parasite transmission for adult suckers holding in Gerber Reservoir.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to increased risk of disease in adult suckers in the summer and fall. Lethal impacts related to increased rates of disease on adult suckers are anticipated as a result of the Proposed Action within Tule Lake.

Reduced surface elevations in the summer and fall in Tule Lake may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality (Reclamation, 2007).

Lost River Reduced flows in the Lost River as a result of the Proposed Action will lead to increased risk of disease in adult suckers in the summer and fall. Lethal impacts related to increased rates of disease on adult suckers are anticipated as a result of the Proposed Action within Tule Lake.

Reduced flows in the summer and fall in both the upper and lower Lost River may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality (Reclamation, 2007).

5.2.1.5 Entrainment

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to increased entrainment of adult suckers in the spring. Both lethal and sub-lethal impacts related to entrainment on adult suckers are anticipated as a result of the Proposed Action within UKL.

The Proposed Action may result in more fish carried from UKL at the LRD through the seasonal operation to store and divert water. The Proposed Action results in more water through LRD than MS from April through October when diversions are made into A Canal.

The Proposed Action will adversely impact adult suckers through entrainment on diverted water through numerous diversion points, principally at A Canal and LRD. The numbers of suckers will vary annually dependent on the amount of water transported and the numbers of suckers exposed to entrainment, which is potentially a function wind speed and direction and water quality. Relatively low numbers of adult suckers entrained from UKL are anticipated due to the screening of the A Canal (Gutermuth et al., 2000b, 2000a; USFWS, 2007b, 2008; Tyler, 2012).

Sucker entrainment losses at LRD and A Canal resulting from the Proposed Action can be estimated. Based on estimates for sucker entrainment by life history stages (Gutermuth et al., 2000b, 2000a) and applying assumptions to account for changes since the Gutermuth et al. efforts (e.g., construction of A Canal fish screen and bypass, reduced sucker populations in UKL), entrainment estimates can be calculated from modeled output. Applying seasonal occurrences of sucker life history stages, based on Gutermuth et al. (2000b, 2000a), to the volume of water that Reclamation anticipates delivering through the Link River and A Canal and a sucker population reduction of approximately 80% (USFWS, 2013), the Proposed Action could result in about 131 adult suckers encountering or passing infrastructure at either LRD or A Canal fish screen and trash rack (Table 5-11). Reclamation is not distinguishing between harass and harm for the incidental take of suckers as a result of entrainment. Entrainment has adverse impacts to adults of both species of suckers. Sucker entrainment at LRD and A Canal will occur under the Proposed Action. Construction and continued operation of the A Canal fish screen reduces the negative impact of entrainment by preventing juvenile and adult suckers from entering the Project canal system.

Table 5-11. Estimated sucker entrainment at Link River and A Canal for the Proposed Action from the period of record based on seasonal periodicity of life history stages and previous estimates of Gutermuth et al. (2000b, 2000a) with assumption of an 80% reduction in Upper Klamath Lake sucker populations since Gutermuth et al., estimated entrainment

Year	Larvae at Link River	Larvae at A Canal	Juveniles at Link River	Juveniles at A Canal	Adults at Link River	Adults at A Canal
1991	1,012,142.9	158,540.8	12,278.8	18,067.8	76.2	0
1992	919,345.7	66396.1	5,328.4	4,419.6	66.5	0
1993	1,921,375.0	294223.0	22,493.0	36,911.3	102.3	0
1994	1,151,482.7	137,750.0	8,729.5	10,538.7	76.7	0
1995	1,436,865.9	285,777.1	24,215.9	39,734.6	110.2	0
1996	1,791,323.4	328,249.4	24,423.6	39,745.8	114.3	0
1997	1,509,225.8	326,661.2	19,775.9	30,729.7	106.8	0
1998	2,436,536.2	274,123.6	30,152.8	50,139.1	130.7	0

Year	Larvae at Link River	Larvae at A Canal	Juveniles at Link River	Juveniles at A Canal	Adults at Link River	Adults at A Canal
1999	2,474,475.7	454,370.8	28,666.3	47,648.7	124.4	0
2000	1,803,235.5	378,538.5	21,722.6	35,327.6	101.9	0
2001	1,178,685.8	246,724.3	15,726.6	25,054.7	78.9	0
2002	1,349,721.1	241,965.7	14,841.4	22,390.0	86.7	0
2003	1,293,788.9	231,128.1	16247.9	25,310.0	87.1	0
2004	1,230,709.6	272,809.3	17,886.2	27,914.9	95.4	0
2005	1,095,184.7	168,381.9	16,489.8	25,938.4	85.9	0
2006	2,290,687.5	436,196.0	28,055.8	47,588.1	112.5	0
2007	1,445,889.5	325,427.9	18,027.4	29,291.4	84.8	0
2008	1,499,781.8	265,266.6	19,343.6	31,129.8	94.0	0
2009	1,338,190.5	234,086.6	17,424.1	27,617.5	88.8	0
2010	1,176,139.9	176,952.4	13,622.5	20,370.7	81.3	0
2011	2,001,294.7	290,990.4	21,606.3	35,452.6	98.3	0
2012	1,518,903.4	263435.4	18,341.5	29,397.3	90.3	0
2013	1,224,294.2	205,267.2	13,355.5	19,706.8	82.3	0
2014	986,582.6	148,319.8	10,115.0	13,671.2	74.6	0
2015	1,093,744.3	140,621.4	10,728.8	14,788.5	76.3	0
2016	1,320,182.3	219,904.3	14,762.6	21753.7	91.3	0
2017	2,193,631.5	325,913.7	21,834.6	35,199.3	105.5	0
2018	1,222,425.6	174,174.4	17,067.8	26,293.0	94.4	0
2019	1,317,558.5	303,721.5	20,204.0	32,627.3	97.0	0
2020	1,115,279.5	137,021.3	10,349.7	13215.3	83.9	0
2021	962,011.1	76,716.7	7,145.5	7,847.6	70.4	0
2022	884,138.9	47,891.1	4,685.0	2,482.5	72.1	0
Minimum	884,138.9	47,891.1	4,685.0	2,482.5	66.5	0
Average	1,426,635.6	232,892.1	16,676.8	25,781.4	91.2	0
Maximum	2,474,475.7	454,370.8	30,152.8	50,139.1	130.7	0

Note: Estimates assume encounters at the A Canal fish screen and trash rack result in entrainment.

Keno Impoundment Unscreened diversions from the Keno Impoundment have an adverse impact to individual suckers at each life history stage. The impacts due to the loss of larval, juvenile, and adult suckers are uncertain (PacifiCorp, 2012) but the magnitude of impacts is likely related to the amount of water diverted and both the seasonal and diurnal timing of diversions.

Under the MS scenario, deliveries to irrigation districts and the Lower Klamath NWR would continue as some of these gates are privately owned and Reclamation has no discretionary control over privately-owned gates. Because fish screens are not present at Ady and North canal diversion points or at multiple other diversion sites, suckers that do not find their way to Lower Klamath NWR would be considered entrained in canals, ditches, or fields. If under the MS scenario, Lower Klamath NWR diverts their full water right (113,000 AF), conditions at Lower Klamath NWR may provide improved habitat (relative to the Proposed Action) dependent upon management practices.

Lost River Proper Reduced flows in the Lost River as a result of the Proposed Action will lead to increased entrainment of adult suckers in the spring. Both lethal and sub-lethal impacts related to entrainment on adult suckers are anticipated as a result of the Proposed Action within the Lost River.

The Proposed Action increases entrainment potential through unscreened diversions in the Lost River. The impact of entrainment through these diversions poses an unquantified adverse impact to individual suckers at each life history stage. Both lethal and non-lethal impacts related to entrainment are anticipated as a result of the Proposed Action within the Lost River, consistent with what has been described in the environmental baseline (Chapter 2).

5.2.2 Eggs and Larvae

The LRS and SNS incubation period is from February through June in the UKL and Lost River sub-units, with a peak period running from March through June. The larval development period of LRS and SNS is from March through July, with no distinct peak period.

The stressors that influence LRS and SNS eggs and larvae are water quality, habitat reduction, predation (avian), predation (fish), and entrainment. The Proposed Action is not anticipated to change the following stressors: water quality, predation (avian), and predation (fish).

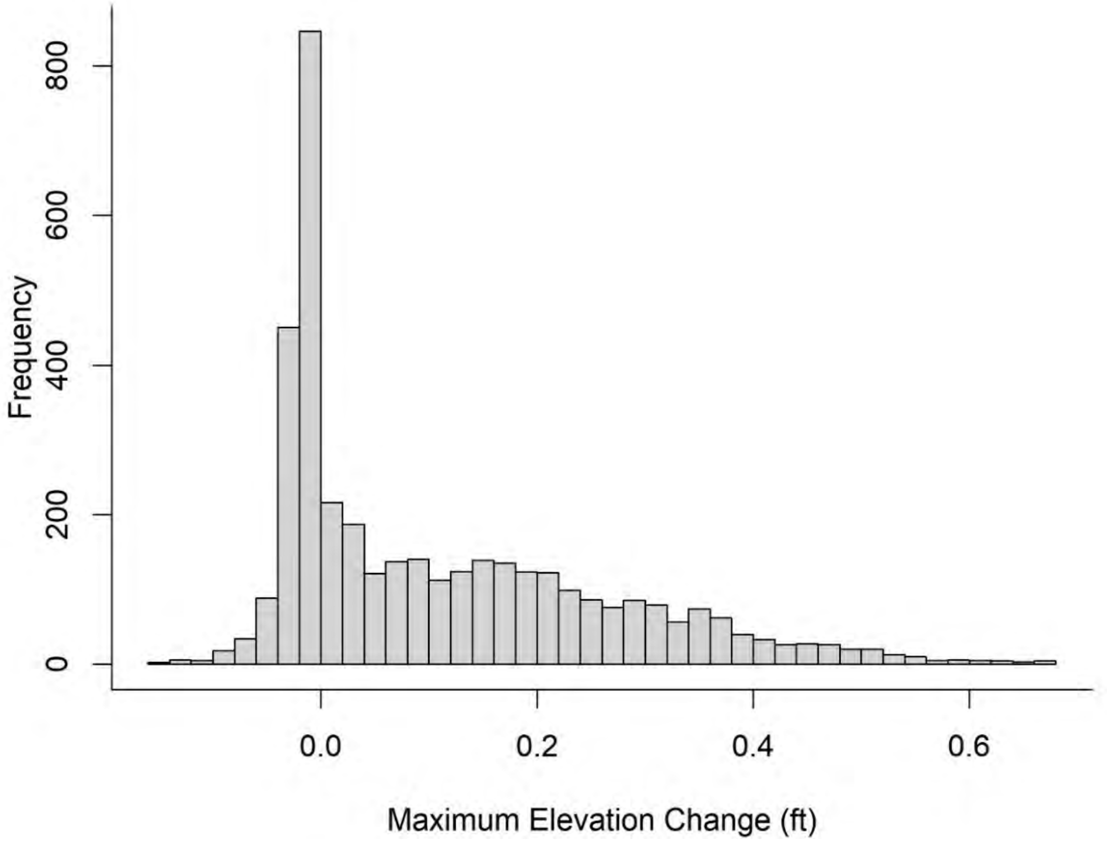
Stressors exacerbated, potentially resulting in incidental take, and potentially ameliorated by the Proposed Action are described below by location.

5.2.2.1 Habitat Alteration

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to a decrease in suitable habitat for sucker larvae in the spring and may increase the risk of desiccation and spatial super-imposition. Both lethal and sub-lethal impacts related to habitat reduction on sucker larvae are anticipated as a result of the Proposed Action within UKL.

Embryo and Larval Pre-swim-up (incubation) Habitat at Shoreline Springs in Upper Klamath Lake
Changes in lake levels under the Proposed Action would vary seasonally relative to inflows and accretions. Under the Proposed Action, lake levels are predicted to increase or remain consistent throughout the period of larval development. Lake elevations during spring months, especially March and April, which coincide with the majority of embryo and larval development, are expected to have the highest lake elevations of 4,142 ft. or greater in most years. Thus, the Proposed Action provides lake elevations sufficient to maintain adequate shoreline spawning habitat (Figure 4-1; Table 5-6) for embryo and larvae development, and lake levels are likely to stay high enough for embryos and larvae to be protected from desiccation in most years. Under the MS scenario, seasonal dynamics will be similar and lake levels will be higher often exceeding 4142 ft. However, beyond a certain point it is likely that higher lake levels will not result in further increases to shoreline spawning habitat and may indeed decrease from peak.

LRS embryos deposited at shoreline springs and pre-swim-up larvae typically develop within 3 weeks following spawning and fertilization (Coleman et al., 1988). If lake elevations that provided sufficient depth for spawning decrease rapidly, embryos and larvae may be susceptible to exposure and desiccation. LRS have been observed spawning in water as shallow as 0.6 ft (0.18 m) (Buettner and Scoppettone, 1990) so surface elevation changes greater than 0.6 ft within 3 weeks will impact this life stage at the shallowest spawning sites. Under the Proposed Action scenario, lake elevations are expected to rarely decrease at a rate equal to or greater than 0.6 ft in 3 weeks (Figure 5-9). During the modeled period of record, the maximum surface level decrease within 3 weeks of any date in March-May from the Proposed Action was 0.67 ft. The maximum decrease in surface elevation in 3 weeks of any March-May date was less than 0.40 ft in 95% of cases and less than 0.53 ft in 99% of cases (Figure 5-9). Therefore, during years when lake levels are high enough for suckers to use shoreline spawning habitat, the Proposed Action will provide adequate protections for developing embryos and larvae. However, lake levels less than 4,142 ft will substantially reduce shoreline habitat availability for developing embryos and swim up larvae.



Note: Positive numbers are decreases in surface elevation and changes greater than 0.6 ft may dewater Lost River sucker embryos at the shallowest sites.

Figure 5-9. Frequency of maximum surface elevation changes in Upper Klamath Lake within 3 weeks of potential egg deposition dates (all dates in March-May) for the modeled Proposed Action period of record (1991-2022)

Larval Sucker Rearing Habitat in Upper Klamath Lake Shallow, near-shore areas, particularly with emergent vegetation, provide habitat for larval suckers (especially SNS; USFWS, 2008). This type of vegetation affords larval suckers with some protection from predators (Markle and Dunsmoor, 2007), more diverse food resources (Cooperman and Markle, 2004), and protection from turbulence during storm events (The Klamath Tribes, 1996). Larval suckers begin to appear in UKL in March, with peak abundance occurring in mid-May to mid-June. Larvae transform to juveniles by mid- to late-July (Buchanan et al., 2011).

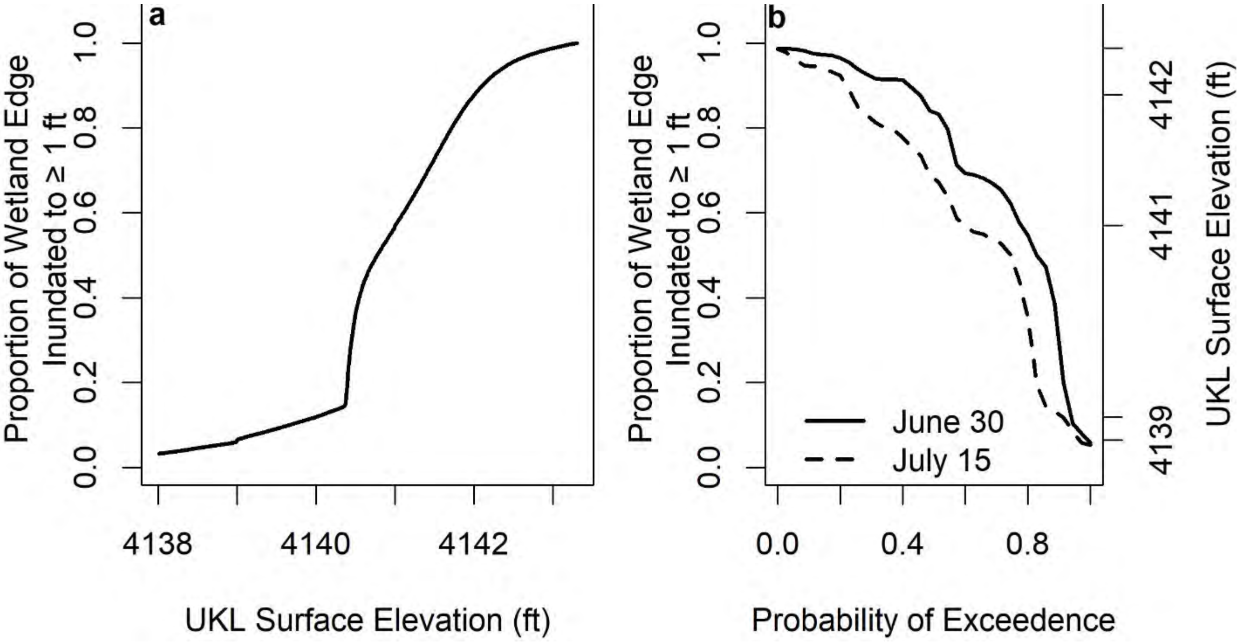
Although emergent wetland habitat exists at locations around UKL, wetlands at the Delta are particularly important (USFWS, 2008). Wetlands at the Delta are adjacent to the major source of larvae emigrating from spawning areas in the Williamson and Sprague rivers (Dunsmoor et al., 2000), and this area consistently has the highest densities of larvae in UKL during late spring surveys (Terwilliger et al., 2004).

The amount of emergent vegetation inundated at least one-foot decreases with lake elevations such that at 4,140.8 ft (1,262.1 m) about 50% of emergent wetland habitat is available (Figure 5-10a). Nursery habitat for larval suckers is influenced by lake elevations (Dunsmoor et al., 2000; Terwilliger 2006; Markle and Dunsmoor, 2007). Lake elevations that decrease quickly are likely to reduce larval survival by reducing food resources, increasing exposure to predation, or by displacement. Decreasing lake elevations under the Proposed Action are associated with decreases in accretions and inflows, increased water deliveries, and increased flows in the Klamath River. Larvae, whose movements are vulnerable to river and lake currents, could be carried to open water or entrained in the outlet of Upper Klamath Lake if lake elevations decrease rapidly.

Wetland availability for developing sucker larvae in the Proposed Action scenario would be lower than under MS but still adequate. The majority of wetlands important for larval and juvenile suckers are at lake elevations greater than 4,140 ft, and almost no wetland-edge habitat is available for lake elevations less than 4,138 ft (Figure 5-10a). When lake elevations are less than 4,140.8 ft (1,262.1 m) and less than 50% wetland-edge habitat is available, predation, starvation, and entrainment in the outlet of the lake are real risks to larvae (USFWS, 2019a). However, under the Proposed Action, lake levels would exceed 4,140.8 ft in ~80% of the modeled period of record on June 30 and ~75% on July 15th (Figure 5-10b).

The driest conditions in the modeled period of record occur in water year 1992 where approximately 6% of wetland-edge habitat is inundated to at least 1 ft at the end of June when lake elevations are 4,138.9 ft (1,261.5 m) and on July 15 when elevations are 4,138.8 (1,261.8 m). These conditions only occur in 3 of 32 years in the period of record, and these conditions are considered unlikely to occur under the Proposed Action. In most years (25 of 32 years; 78%), 50% or more wetland-edge habitat will be inundated with at least 1 ft of water on July 15. Thus, the majority of wetland-edge habitat will be available for larval suckers through mid-July when they are typically large enough to be considered juveniles. When lake elevations are less than 4,140.8 ft (1,262.1 m) and less than 50% wetland-edge habitat is available, predation, food resources become limited, and entrainment in the outlet of the lake are real risks to larvae. The proposed lake elevations will likely provide sufficient larval rearing habitat in most years.

Changes in wetland depth have been identified as beneficial for wetland development and maintenance, and in this way, changes in lake elevation, as a function of Project operations may benefit suckers if wetland habitat is improved (Middleton, 1999).



Note: Panel A modified from USFWS BiOp (2019a) and Hereford and Roberts (2019). Panel B modified from USFWS BiOp (2019a).

Figure 5-10. The proportion of emergent wetland-edge habitat inundated at least 1 foot relative to Upper Klamath Lake surface elevation (A) and the probability of exceedance and the proportion of wetland-edge habitat inundated at least 1 foot on June 30 (solid line) and July 15 (dashed line) derived from model output for the 32-year period of record (B)

Keno Impoundment All life stages of listed suckers have been found in the Link River in recent years, based on monitoring below UKL and the LRD. This habitat is primarily a migration corridor for large numbers of larval and juvenile suckers dispersing downstream from UKL (Gutermuth et al., 2000b; Foster and Bennetts, 2006). Young suckers often migrate to the Keno Impoundment; however, it is unclear if this is a destination that meets their needs or if their pre-settlement life history was such that they migrated to other lake habitats, such as the historical Lower Klamath and Tule lakes.

The Keno Impoundment is relatively shallow (average depth of 7.5 ft) and long (22.5 miles) and receives most of its water from UKL via the Link River (PacifiCorp, 2012). Substantial quantities of water are also diverted from and discharged to the Keno Impoundment through and from facilities managed by Reclamation and several private permit holders (USFWS, 2007c). Due to overall reductions in irrigation deliveries under the Proposed Action, Reclamation anticipates that Project return flows in the Keno Impoundment may be reduced.

YOY juvenile suckers in the Keno Impoundment likely use near-shore habitats of emergent vegetation or the transition zones between vegetation and open water. More YOY juvenile suckers were captured in trap nets fished close to the shoreline near emergent vegetation than in open water areas in Lake Ewauna of the Keno Impoundment (Tyler and Kyger, 2012). Furthermore, sampling in a reconnected wetland bordered by North and Ady canals captured more YOY juvenile suckers in transition zones near emergent vegetation than in open water or in vegetation (Phillips et al., 2011).

Surface elevations in the WOA scenario are expected to be consistent with PacifiCorp's past operations at Keno Dam, which provided for a surface elevation in this reach of 4,085.5 ft. This operation is consistent with past operations of surface elevations in the Keno Impoundment. The ongoing management to operate for stable surface elevations in the Keno Impoundment impacts development of additional wetland habitats and degrades the quality of existing wetlands through controlled water depth (USFWS, 2007c). However, stable surface elevations do provide sucker access to the established wetland habitats for rearing during sucker early life history stages. It is anticipated that the Proposed Action surface elevation will be higher than those under MS. Relative to surface elevations, the Proposed Action will not impact YOY juvenile habitat in the Keno Impoundment. Any adverse impacts from this Proposed Action would result from seasonally decreased flows relative to flows in the WOA scenario.

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to an increase in suitable larval sucker habitat in the spring. Beneficial impacts related to an increase in habitat on larval suckers are anticipated as a result of the Proposed Action within Clear Lake.

Sucker habitat requirements are less understood for endangered sucker populations in the Lost River Basin. At Clear Lake Reservoir, larval and YOY juvenile suckers likely use habitat similar to older juveniles and adults including depth, surface area, and areas near-shore. Earlier life history stages may show more association with the shoreline at Clear Lake Reservoir than later stages; however, shoreline and lake surface area both decrease with reduced surface elevations. Thus, the description of UKL surface area and depth as habitat for adult suckers is applicable to larvae and both YOY and older juveniles (Section 5.2.1.2). The Proposed Action of storing and diverting inflows at Clear Lake Reservoir includes the beneficial impact of maintaining at least some lake habitat year-round, in all years. The MS scenario at Clear Lake Reservoir removes most or all lake habitat. All assumptions about habitat for larvae and YOY juveniles are based on a lake environment. Thus, under the MS scenario there is little to no habitat for these life history stages at Clear Lake Reservoir.

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to an increase in suitable larval sucker habitat in the spring. Beneficial impacts related to an increase in habitat on larval suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

Sucker habitat requirements are less understood for endangered sucker populations in the Lost River Basin. Assumptions regarding sucker habitat use at each life history stage are based on observations from UKL and are described in the Clear Lake Reservoir section above. The description of UKL lake surface area and depth as habitat for older juvenile and adult suckers is applicable to larvae and both YOY and older juveniles (Section 5.2.1.2). The Proposed Action of storing and diverting inflows at Gerber Reservoir includes the beneficial impact of maintaining at least some lake habitat year-round, in all years. The MS scenario at Gerber Reservoir removes most or all lake habitat. All assumptions about habitat for larvae and YOY juveniles are based on a lake environment. Thus, under the MS scenario there is little to no habitat for these life history stages at Gerber Reservoir.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to a decrease in suitable habitat for sucker larvae in the spring and may increase the risk of desiccation and spatial super-imposition. Both lethal and sub-lethal impacts related to habitat reduction on sucker larvae are anticipated as a result of the Proposed Action within Tule Lake.

Larval suckers need wetland-edge and wetland habitat for food resources and protection from predation. Wetland habitat is reduced at lower lake elevations. The habitat available for larval and juvenile suckers is substantially reduced under the Proposed Action compared to the MS scenario. However, because there are very few larval and juvenile suckers in Tule Lake, the wetland area of Tule Lake Sump 1A near the Lost River mouth likely provides sufficient habitat, assuming that larval and YOY juvenile suckers in Tule Lake use near-shore and vegetated habitats similar to suckers in UKL. The proposed minimum surface elevation of 4,034.0 ft (1,229.6 m) should provide sufficient habitat for these life stages. The Proposed Action likely provides for a minimum amount of lake habitat that is not provided for under a MS condition but constrains increases of habitat that would not occur under the MS scenario.

Lost River Proper Reduced flows in the Lost River as a result of the Proposed Action will lead to a decrease in suitable habitat for sucker larvae in the spring and may increase the risk of desiccation and spatial super-imposition. Both lethal and sub-lethal impacts related to habitat reduction on sucker larvae are anticipated as a result of the Proposed Action within the Lost River.

Very few larval and YOY juvenile suckers are likely to be present in the Lost River because dams fragment the habitat and prevent adult sucker movements for spawning. Additionally, there is little spawning and rearing habitat, and water quality is poor in the Lost River. However, reduced flows as a result of the Proposed Action will lead to a reduction of what little suitable habitat exists and may increase the risk of desiccation and spatial super-imposition.

5.2.2.2 Entrainment

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to increased entrainment of larval suckers in the spring. Both lethal and sub-lethal impacts related to entrainment on larval suckers are anticipated as a result of the Proposed Action within UKL.

The Proposed Action may result in more fish carried from UKL at the LRD through the seasonal operation to store and divert water. The Proposed Action results in more water through LRD than the MS scenario from April through September when diversions are made into A Canal.

The Proposed Action will adversely impact sucker larvae through entrainment on diverted water through numerous diversion points, principally at A Canal and LRD. The numbers of sucker larvae at each life history stage will vary annually dependent on the amount of water transported and the number of larvae exposed to entrainment, a function of annual sucker production at earliest life history stages and perhaps other factors such as wind speed and direction and water quality.

Sucker entrainment losses at LRD and A Canal resulting from the Proposed Action can be estimated. Based on estimates for sucker entrainment by life history stages (Gutermuth et al., 2000b, 2000a) and applying assumptions to account for changes since the Gutermuth et al. efforts (e.g., construction of A Canal fish screen and bypass, reduced sucker populations in UKL), entrainment estimates can be calculated from modeled output. Applying seasonal occurrences of sucker life history stages, based on Gutermuth et al. (2000b, 2000a), to the volume of water that Reclamation anticipates delivering through the Link River and A Canal and a sucker population reduction of approximately 80% (USFWS, 2013), the Proposed Action could result in about 2.9 million sucker larvae encountering or passing infrastructure at either LRD or A Canal fish screen and trash rack (Table 5-11). Reclamation is not distinguishing between harass and harm for the incidental take of suckers as a result of entrainment. Entrainment has adverse impacts to larvae of both species of suckers. Sucker entrainment at LRD and A Canal will occur under the Proposed Action.

Keno Impoundment Unscreened diversions from the Keno Impoundment have an adverse impact to individual suckers at each life history stage. The impacts due to the loss of larval, juvenile, and adult suckers are uncertain (PacifiCorp, 2012) but the magnitude of impacts is likely related to the amount of water diverted and both the seasonal and diurnal timing of diversions.

Under the MS scenario, deliveries to irrigation districts and the Lower Klamath NWR would continue as some of these gates are privately owned and Reclamation has no discretionary control over privately-owned gates. Because fish screens are not present at Ady and North canal diversion points or at multiple other diversion sites, suckers that do not find their way to Lower Klamath NWR would be considered entrained in canals, ditches, or fields. If under the MS scenario Lower Klamath NWR diverts their full water right (113,000 AF), conditions at Lower Klamath NWR may provide improved habitat (relative to the Proposed Action), dependent upon management practices.

The Proposed Action results in entrainment of sucker early life history stages at Project features (i.e., Ady, LRDC, and small canals delivery to Plevna) adjacent to Keno Impoundment similar to entrainment that would occur in the MS scenario except that conditions at Lower Klamath NWR may provide adequate habitat for suckers such that they would not be considered entrained.

Lost River Proper Reduced flows in the Lost River as a result of the Proposed Action will lead to increased entrainment of larval suckers in the spring. Both lethal and sub-lethal impacts related to entrainment on larval suckers are anticipated as a result of the Proposed Action within the Lost River.

Under the MS scenario, entrainment losses at Reclamation's diversions from the Lost River are absent. The Proposed Action increases entrainment potential through unscreened diversions in the Lost River. The impact of entrainment through these diversions poses an unquantified adverse impact to individual suckers at each life history stage. Both lethal and non-lethal impacts related to entrainment are anticipated as a result of the Proposed Action within the Lost River, consistent with what has been described in the environmental baseline (Chapter 2).

5.2.3 Juveniles

LRS and SNS in the juvenile life stage are present year-round in the UKL and the Lost River sub-units. There is no distinct peak period.

The stressors that influence LRS and SNS juveniles are water quality, habitat reduction, predation (avian), predation (fish), disease, entrainment, and pollutants. The Proposed Action is not anticipated to change the following stressors: predation (fish).

Stressors exacerbated, potentially resulting in incidental take, and potentially ameliorated by the Proposed Action are described below by location.

5.2.3.1 Water Quality

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to decreased water quality in the summer and fall. Both lethal and sub-lethal impacts related to decreased water quality on juvenile suckers are anticipated as a result of the Proposed Action within UKL.

UKL is classified as hypereutrophic, and this condition combined with current nutrient loading from the watershed and lake sediment facilitates extensive cyanobacteria blooms that result in large diel fluctuations in DO and pH, high concentrations of the hepatotoxin microcystin, and toxic levels of un-ionized ammonia during bloom decomposition (Bortleson and Fretwell, 1993; Boyd et al., 2002; Walker et al., 2012). Together, these conditions create a suboptimal environment for native aquatic biota and likely play a role in the decline of ESA-listed SNS and LRS (Perkins et al., 2000a). Indeed, in recent decades, UKL has experienced serious water quality issues that have resulted in fish die-offs, as well as re-distribution of fish in response to changes in water quality (Buettner and Scoppettone, 1990; Banish et al., 2007, 2009).

The best available science does not demonstrate a direct, consistent, and discernable relationship between UKL elevation and water quality. For further detail on studies and analyses between lake level and water quality studies for UKL see the 2019 USFWS BiOp (USFWS, 2019a).

Lacking direct observations of water quality or direct, consistent, and discernable relationships in water quality in UKL to differences in water quality under the Proposed Action and/or MS conditions, water quality is anticipated to be no different than that observed from a historical context. Lower surface elevations may result in warmer water temperatures during the summer and fall months, although lacking specific observations, the extent that water temperatures would increase under the Proposed Action is unknown. Lower lake surface elevations could result in increased mixing on windy days, which could mix more soft sediments into the water column which could then increase turbidity and available nutrients. As a result, DO concentrations could also increase at low lake elevations if stratification events occur less frequently. It is unclear if increased mixing (due to low surface elevations) on windy days would be a net-benefit (due to higher DO concentrations and higher turbidity-similar conditions to Clear Lake and Gerber reservoirs, which may reduce sunlight available for AFA photosynthesis) or a negative effect as increased nutrients may increase growth of AFA and other cyanobacteria. On calm days that cause the cyanobacteria bloom to crash, low lake elevations, such as those in the Proposed Action, could result in more stressful conditions for suckers because there are fewer areas for suckers to seek water-quality refuge.

The Proposed Action is not anticipated to influence water quality in UKL aside from the possibility of periodic, but infrequent, concentrating of fish in limited habitat during late summer or early fall months when disease could be more-readily spread among individuals (Section 5.2.3.4). When water quality conditions are poor, juvenile suckers have been observed seeking refuge in Pelican Bay beginning in mid-July and lasting through September (Banish et al., 2009). Adverse water quality will likely impact suckers in UKL at both the individual and the population levels (Perkins et al., 2000b) but lacking direct observations of water quality conditions at low lake elevations similar to those under the Proposed Action, it is difficult to say with certainty how suckers would be impacted.

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to increased water quality in the fall. Beneficial impacts related to increased water quality on juvenile suckers are anticipated as a result of the Proposed Action within Clear Lake.

Historically, water quality monitoring over a wide range of lake levels and years documented an environmental baseline of water temperatures and DO concentrations that were periodically stressful to suckers but generally adequate for sucker survival (Reclamation, 1994a, 2000, 2001a, 2007). At Clear Lake, increased water levels in the fall under the Proposed Action may result in improved water quality, particularly lower water temperatures and higher DO.

At Clear Lake Reservoir, lower water levels may result in degraded water quality, particularly higher water temperatures and lower DO. However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival (Reclamation, 1994a, 2000, 2001a, 2007).

Low lake levels in Clear Lake Reservoir pose an unquantified risk to listed suckers from adverse water quality (USFWS, 2008). In October 1992, the water surface elevation of Clear Lake was as low as 4,519.4 ft before the onset of a hard winter, and no fish die-offs were observed, although suckers showed poor condition factors in the following spring (Reclamation, 1994b). It is uncertain if water quality conditions or crowding and competition for resources were responsible for impacts to suckers following the winter 1992 to 1993.

The proposed minimum lake level for Clear Lake at the start of the winter period from October to February is 4,520.6 ft. This elevation is anticipated to provide adequate water depths for protection against winter-kill of suckers (USFWS, 2008). Implementation of the Proposed Action is not anticipated to substantially impact water quality as sucker habitat in Clear Lake Reservoir.

Under MS, although Clear Lake becomes confined to the west lobe, water quality parameters are anticipated to largely remain unchanged in comparison to the Proposed Action. Surface elevation under the MS scenario will be lower than the Proposed Action, which can increase risk to suckers as a result of winter-die-off; however, this is an unquantified risk that may resemble impacts that were observed in winter 1992 (Reclamation, 1994b).

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to increased water quality in the fall. Beneficial impacts related to increased water quality on juvenile suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

Historically, water quality monitoring over a wide range of lake levels and years documented an environmental baseline of water temperatures and DO concentrations that were periodically stressful to suckers but generally adequate for sucker survival (Reclamation, 1994a, 2000, 2001a, 2007). Periodic stratification during summer and fall in the deepest portion of Gerber Reservoir can result in DO concentrations that are stressful to suckers (Piaskowski and Buettner, 2003). Stratification at Gerber Reservoir has been observed persisting for less than a month, over a small portion of the Reservoir near the dam (Piaskowski and Buettner, 2003) and is likely more the result of meteorological conditions than lake surface elevations. Blue-green algae blooms can reach densities high enough to prompt advisories from the state of Oregon in the fall and winter, but it is unclear if these blooms are associated with Project operations or if they directly or indirectly impact SNS.

The MS scenario results in temporary storage behind Gerber Dam. Water quality of the remaining streamflow is anticipated to be that of ambient conditions characterized by moving water having a lower temperature and higher DO than impounded water. However, any reference to water quality relative to suckers in the Klamath Basin typically is in discussion of lake habitats. The Proposed Action results in lake habitat with periodic low surface elevations at Gerber Reservoir during late summer and fall (Reclamation, 2018). These lower surface elevations could result in higher pH, warmer water temperatures, and lower DO. DO impacts result through concentrating fish into a small, remaining pool. Water quality monitoring over a wide range of lake levels and years has documented water quality conditions that are periodically stressful to suckers but were generally adequate for sucker survival (Reclamation, 2001a, 2007; Piaskowski and Buettner, 2003; Phillips and Ross, 2012). The Proposed Action is anticipated to result in water quality that is also adequate for sucker survival, and increased water levels in the fall may result in improved water quality, particularly lower water temperatures and higher DO.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to decreased water quality in the summer and fall. Both lethal and sub-lethal impacts related to decreased water quality on juvenile suckers are anticipated as a result of the Proposed Action within Tule Lake.

Tule Lake is classified as highly eutrophic because of high nutrient concentrations and resultant elevated biological productivity (ODEQ, 2017). Tule Lake water quality is affected primarily by the import of UKL surface water through the LRDC and A Canal during the irrigation season, and secondarily by local runoff during winter and spring months from lands below Lost River Diversion Dam on the Lost River. Also, contributing to the eutrophic status of Tule Lake is its shallow bathymetry and internal nutrient cycling from lake sediment. Water quality can vary seasonally and diurnally, especially in summer. Because of shallow depths in Tule Lake sumps, the water level management in the Proposed Action may contribute to the poor water quality in Tule Lake (USFWS, 2008). Poor water quality in Tule Lake is associated with high nutrient concentrations and pesticides in surface water inflows into Tule Lake (USFWS, 2019a). These conditions are thought to reduce the body condition and survivorship of individual suckers, especially for younger suckers that have higher metabolic rates. While water quality may negatively affect suckers, especially young suckers in Tule Lake, there are very few suckers present, and even fewer young suckers due to lack of spawning habitat available below Anderson Rose Dam.

Lost River Proper Decreased flows in the Lost River as a result of the Proposed Action will lead to decreased water quality in the summer and fall. Both lethal and sub-lethal impacts related to decreased water quality on juvenile suckers are anticipated as a result of the Proposed Action within the Lost River.

Lost River is classified as hypereutrophic, and thus water quality conditions are often suboptimal for listed suckers. Nutrient loading, greatest in the middle and lower portions of the Lost River watershed (Schenk et al., 2018), contribute to growth and subsequent senescence of which facilitates a cycle of high pH and suboptimal or lethal DO and toxic ammonia concentrations (ODEQ, 2017).

Run-off and drain water likely contain nutrients, organics, and sediment, which have adverse effects to LRS and SNS habitat by deteriorating water quality (USFWS, 2008). The effects under the Proposed Action would most likely be due to low DO concentration from decay of algae and macrophytes, and from organics that decompose and consume oxygen (USFWS, 2008). Adverse effects to LRS and SNS from Project runoff and drainage are most likely to occur in the middle and lower Lost River system because these habitats are downstream from large agricultural areas (USFWS, 2008) and would most likely occur in the summer and fall. It is difficult to partition and assess water quality impacts related to nutrients between those carried on return flows and those carried on waters from Clear Lake Reservoir, Gerber Reservoir, and accretions in the Lost River. However, periods of adverse water quality, regardless of the source in the Lost River, adversely impact individual suckers that are present. The Proposed Action will adversely impact water quality in the Lost River through an incremental contribution of nutrients transported on return flows.

5.2.3.2 Habitat Alteration

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to a decrease in suitable habitat for juvenile suckers in the spring and fall. Both lethal and sub-lethal impacts related to habitat reduction on juvenile suckers may result of the Proposed Action within UKL.

Effects to Habitat of Older (Age 1+) Juveniles in Upper Klamath Lake Little is known about specific habitat needs for age 1+ juveniles because very few have been captured in UKL. The limited data available suggests that age-1+ juvenile suckers have habitat preferences more similar to adult suckers than larval suckers (Burdick et al., 2009c; Burdick and Vanderkooi, 2010). Telemetry studies have found adult suckers in open water in the portion of UKL north of Bare Island from June to September (Peck, 2000; Reiser et al., 2001; Banish et al., 2007). The amount of preferred habitat for suckers varies with lake elevation. Following the approach used in USFWS’s 2019 BiOp (USFWS, 2019a) the area of preferred depths available was quantified using a bathymetric layer from various sources (Shelly et al., 2019; USFWS, 2019a) and lake elevations from the modeled period of record output. The analysis is for habitat available in UKL north of latitude 24°24’47”N, including Shoalwater Bay, Ball Bay, and the Delta because radio-telemetry studies have found suckers primarily use this area during summer months (Banish et al., 2009). In the summer, both species are found primarily in water 6.6 to 13.1 ft (2 and 4 m) deep and avoid water less than 6.6 ft (2 m; Banish et al., 2009). Suckers were never observed in water depths greater than 25 ft (8 m; Banish et al., 2007). Deep water may provide refuge from poor water quality such as warm temperatures, protection from avian predators, and access to preferred food resources (Banish et al., 2009).

The lowest end of September UKL surface elevation is 4,138.33 ft (1,261.36 m) and only occurs during extremely dry years. In the northern portion of UKL, approximately 9,428 acres (3,815 hectare) or 33% of available habitat greater than 6.6 ft (2 m) is available at 4,138.33 ft (1,261.37 m) lake elevation (Figure 5-7). While suckers prefer depths greater than 6.6 ft (2 m), Banish et al. (2009) found radio-tagged suckers frequently used areas in the northern part of UKL including Ball Bay, and the areas north of Ball Point, between Ball Bay and Fish Banks, between Eagle Ridge and Bare Island, and the area north of Ball Bay to the mouth of Pelican Bay (Banish et al., 2009). Distribution is likely associated with food resources, water quality, and predation risk. Thus, the actual amount of preferred habitat greater than 6.6 ft (2 m) deep is likely less than 9,428 acres.

After water quality conditions improve in late summer, suckers are distributed throughout the lake (Banish et al., 2007). Thus, lake elevations don’t appear to define preferred habitat from November to February (USFWS, 2019a). Lake elevations are typically increasing during this time, though low DO concentrations may occur when ice cover prevents oxygen exchange with the atmosphere (Reclamation, 2012b). Low DO events in the winter do not appear to compromise adult suckers.

While winter water quality conditions are not often considered to be causes of mortality for adult suckers, summer water quality conditions can be stressful, and have been identified as contributing to or causing adult fish die-offs (Perkins et al., 2000a). When water quality conditions are poor, adult suckers have been observed seeking refuge in Pelican Bay beginning in mid-July and lasting through September (Banish et al., 2009). The entrance to Pelican Bay is shallow, and while water quality is good in this location, low lake elevations may limit suckers' use of this refugia. See Section 5.2.3.3 for further discussion on how low elevations in Pelican Bay may affect predation risk.

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to an increase in suitable larval sucker habitat in the spring. Beneficial impacts related to an increase in habitat on larval suckers are anticipated as a result of the Proposed Action within Clear Lake.

Sucker habitat requirements are less understood for endangered sucker populations in the Lost River Basin. At Clear Lake Reservoir, older juvenile suckers likely use habitat similar to larval and YOY juveniles and adults including depth, surface area, and areas near-shore. Earlier life history stages may show more association with the shoreline at Clear Lake Reservoir than later stages; however, shoreline and lake surface area both decrease with reduced surface elevations. Thus, the description of UKL lake surface area and depth as habitat for adult suckers is applicable to larvae and both YOY and older juveniles (Section 5.2.1.2).

The Proposed Action of storing and diverting inflows at Clear Lake Reservoir includes the beneficial impact of maintaining at least some lake habitat year-round, in all years. The MS scenario at Clear Lake Reservoir removes most or all lake habitat. All assumptions about habitat for older juveniles are based on a lake environment. Thus, under the MS scenario there is little to no habitat for these life history stages at Clear Lake Reservoir.

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to an increase in suitable larval sucker habitat in the spring. Beneficial impacts related to an increase in habitat on larval suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

Sucker habitat requirements are less understood for endangered sucker populations in the Lost River Basin. Assumptions regarding sucker habitat use at each life history stage are based on observations from UKL and are described in Clear Lake Reservoir sections above. The description of UKL lake surface area and depth as habitat for YOY juvenile and adult suckers is applicable to older juveniles (Section 5.2.1.2). The Proposed Action of storing and diverting inflows at Gerber Reservoir includes the beneficial impact of maintaining at least some lake habitat year-round, in all years. The MS scenario at Gerber Reservoir removes most or all lake habitat. All assumptions about habitat for older juveniles are based on a lake environment. Thus, under the MS scenario there is little to no habitat for these life history stages at Gerber Reservoir.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to a decrease in suitable habitat for juvenile suckers year-round. Both lethal and sub-lethal impacts related to habitat reduction on juvenile suckers are anticipated as a result of the Proposed Action within Tule Lake.

Young of Year Juveniles In comparison to the MS scenario, the habitat available for juvenile suckers is substantially reduced under the Proposed Action. However, because there are very few juvenile suckers in Tule Lake, the wetland area of Tule Lake Sump 1A near the Lost River mouth likely provides sufficient habitat, assuming that juvenile suckers in Tule Lake use near-shore and vegetated habitats similar to suckers in UKL. The proposed minimum surface elevation of 4,034.0 ft (1,229.6 m) should provide sufficient habitat for these life stages. The Proposed Action likely provides for a minimum amount of lake habitat that a MS condition does not but constrains increases of habitat that would not occur under the MS scenario.

Older Juveniles Under the Proposed Action, water depth as cover for older juvenile suckers is limited due to the shallow bathymetry of the Tule Lake sumps (less than 4 ft, 1.2 m). Surface elevations in Tule Lake Sump 1A of 4,034.0 ft may provide adequate habitat (though never preferred depth; 6.6 ft [2 m]) with some areas where water depth is greater than 3 ft for older juveniles and adults; however, there is continued concern about the shallow bathymetry of the sumps, the possibility of continued sedimentation, and high predation risk for suckers by American White Pelicans (USFWS, 2008, 2019a). Some of the sedimentation may be from lands that use Project water. The Proposed Action may adversely impact older juvenile suckers in Tule Lake Sump 1A due to limiting habitat, largely water depth. The Proposed Action likely provides for a minimum amount of lake habitat that the MS scenario does not but constrains increases of habitat that would not occur under MS.

Lost River Proper Reduced flows in the Lost River as a result of the Proposed Action will lead to a decrease in suitable habitat for juvenile suckers year-round. Both lethal and sub-lethal impacts related to habitat reduction on juvenile suckers are anticipated as a result of the Proposed Action within the Lost River.

Young of Year Juveniles Very few YOY juvenile suckers are likely to be present in the Lost River because dams fragment the habitat and prevent adult sucker movements for spawning. Additionally, there is little spawning and rearing habitat, and water quality is poor in the Lost River. As a result of the Proposed Action’s use of the Lost River for water delivery during the irrigation season and flood control during fall and winter, individual YOY juveniles are adversely impacted through a reduction of habitat availability. During the irrigation season, habitats in the Lost River are suitable for early sucker life history stages. However, beginning in October, fall and winter habitats become fragmented as irrigation flows in the Lost River recede. Periodic weather and low elevation runoff events will temporarily increase Lost River flows during fall and winter and may temporarily allow connectivity between impounded areas and deep pools. Reduced flows in the fall and winter in both the upper and lower Lost River may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality (Reclamation, 2007). The Proposed Action will contribute to poor habitat conditions for YOY juvenile suckers in the Lost River.

Older Juveniles Based on Shively et al. (2000b), older juvenile suckers reside in impounded areas or deep pools in the Lost River except during the spring spawning period when they migrate (Reclamation, 2001b; USFWS, 2002; Sutton and Morris, 2005). Most of the sucker observations in the Lost River are from the upper Lost River above Bonanza, Oregon (Shively et al., 2000b). There are few older juvenile suckers residing in the lower Lost River, below Lost River Diversion (Wilson) Dam (Reclamation, 2001b; USFWS, 2002).

Dams and historical channelization fragmented juvenile sucker habitat in the Lost River in the same way it has for other life history stages; habitat quality is degraded, and connectivity is reduced (Reclamation, 2009). Increased crowding of juvenile suckers into remaining available habitat at either the impoundments or deep pools and reduced flows at the end of the irrigation season adversely impact individual juvenile suckers in the Lost River. Inflows from groundwater and low elevation runoff during weather events in the fall and winter periodically lessen the impacts of reduced habitat during the fall and winter months by reconnecting isolated areas of habitat (i.e., reservoirs and deep pools).

As with earlier life history stages, seasonal flow diversions under the Proposed Action, particularly flow reduction at the end of irrigation season in the Lost River, will have negative impacts to habitat for older juvenile suckers in the Lost River.

5.2.3.3 Predation (Avian)

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to increased risk of avian predation of juvenile suckers in the spring, summer, and fall. Lethal impacts related to increased predation on juvenile suckers are anticipated as a result of the Proposed Action within UKL.

Avian predation threats for juvenile suckers are similar to those for adults (Section 5.2.1.3), though juveniles are more vulnerable than adults in two major ways. First, due to their smaller size they are preyed upon by large and small avian predators. Second, juveniles are expected to use more wetland habitat than adult suckers, where avian predators, and the diseases and parasites that they carry, are prevalent. Thus, juvenile suckers experience increased predation in the Proposed Action than the MS scenario because surface elevations are lower in the Proposed Action and provide less protection.

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to decreased risk of avian predation of juvenile suckers year-round. Beneficial impacts related to decreased predation on juvenile suckers are anticipated as a result of the Proposed Action within Clear Lake.

When lake levels are low, surface area and depth of habitat are reduced for suckers. Sucker populations are concentrated as evidenced by increased trammel net catches at low lake elevations (Hewitt and Hayes, 2013). While not fully understood, avian predation, including but not limited to Double-Crested Cormorants and American White Pelicans, is higher when lake elevations are low. This has been detected in lower survival estimates of juvenile suckers during low lake elevations, and in greater proportions of available PIT tags found at nesting colonies and loafing areas (Evans et al., 2016). In Clear Lake, increased lake levels will provide more depth as cover for juvenile suckers holding in Clear Lake to avoid avian predation.

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to decreased risk of avian predation of juvenile suckers year-round. Beneficial impacts related to decreased predation on juvenile suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

As described above for Clear Lake, avian predation is higher when lake elevations are low. In Gerber Reservoir, increased lake levels will provide more depth as cover for juvenile suckers holding in Gerber Reservoir to avoid avian predation.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to increased risk of avian predation of juvenile suckers year-round. Lethal impacts related to increased predation on juvenile suckers are anticipated as a result of the Proposed Action within Tule Lake.

As described above, avian predation is higher when lake elevations are low. Reduced lake elevations in Tule Lake Sumps across all seasons will provide less depth as cover for juvenile suckers to avoid avian predation.

Lost River Proper Reduced flows in the Lost River as a result of the Proposed Action will lead to increased risk of avian predation of juvenile suckers year-round. Lethal impacts related to increased predation on juvenile suckers are anticipated as a result of the Proposed Action within the Lost River.

As described above, avian predation is higher when lake elevations are low. Reduced flows in the Lost River across all seasons will provide less depth as cover for juvenile suckers to avoid avian predation.

5.2.3.4 Disease

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to increased risk of disease in juvenile suckers in the fall. Lethal impacts related to increased disease on juvenile suckers are anticipated as a result of the Proposed Action within UKL. Juvenile suckers appear to be more vulnerable to disease and parasites than adult suckers, though this impact is expected to be similar among the life stages (Section 5.2.1.4).

The Proposed Action will influence fish disease in UKL through the possibility of periodic, but infrequent, concentrating of fish in limited habitat during the fall months when disease could be more-readily spread among individuals (Buettner, 2007, pers. comm. cited in USFWS, 2008).

Clear Lake Higher surface elevations in Clear Lake as a result of the Proposed Action will lead to decreased risk of disease in juvenile suckers in the summer and fall. Beneficial impacts related to decreased rates of disease on juvenile suckers are anticipated as a result of the Proposed Action within Clear Lake.

When lake levels are low, surface area and depth of habitat are reduced for suckers. Sucker populations are concentrated as evidenced by increased trammel net catches at low lake elevations (Hewitt and Hayes, 2013). Crowding may result in increased parasite levels or decreased growth rates due to limited resources. For example, when lake levels were low in 1992, body condition decreased slightly and afflictions increased, though these effects were no longer apparent by summer (Reclamation, 1994b). Increased lake levels in the summer and fall will provide less disease and parasite transmission for juvenile suckers holding in Clear Lake.

Gerber Reservoir Higher surface elevations in Gerber Reservoir as a result of the Proposed Action will lead to decreased risk of disease in juvenile suckers in the summer and fall. Beneficial impacts related to decreased rates of disease on juvenile suckers are anticipated as a result of the Proposed Action within Gerber Reservoir.

As described above for Clear Lake, low lake levels can reduce habitat and increase crowding, thereby increasing parasite levels or reducing growth rates. Increased lake levels in the summer and fall will provide less disease and parasite transmission for juvenile suckers holding in Gerber Reservoir.

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to increased risk of disease in juvenile suckers in the summer and fall. Lethal impacts related to increased rates of disease on juvenile suckers are anticipated as a result of the Proposed Action within Tule Lake.

Reduced surface elevations in the summer and fall in Tule Lake may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality (Reclamation, 2007).

Lost River Reduced flows in the Lost River as a result of the Proposed Action will lead to increased risk of disease in juvenile suckers in the summer and fall. Lethal impacts related to increased rates of disease on juvenile suckers are anticipated as a result of the Proposed Action within Tule Lake.

Reduced flows in the summer and fall in both the upper and lower Lost River may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality (Reclamation, 2007).

5.2.3.5 Entrainment

Upper Klamath Lake Lower surface elevations in UKL as a result of the Proposed Action will lead to increased entrainment of adult suckers in the spring. Both lethal and sub-lethal impacts related to entrainment on adult suckers are anticipated as a result of the Proposed Action within UKL.

The Proposed Action may result in more fish carried from UKL at the LRD through the seasonal operation to store and divert water. The Proposed Action results in more water through LRD than the MS scenario from April through September when diversions are made into A Canal.

The Proposed Action will adversely impact juvenile suckers through entrainment on diverted water through numerous diversion points, principally at A Canal and LRD. The number of suckers at each life history stage will vary annually dependent on the amount of water transported and the number of suckers exposed to entrainment at each life history stage, a function of annual sucker production at earliest life history stages, and perhaps other factors such as wind speed and direction and water quality. Relatively low numbers of older juvenile suckers entrained from UKL are anticipated due to the screening of the A Canal (Gutermuth et al., 2000b, 2000a; USFWS, 2007b, 2008; Tyler, 2012).

Sucker entrainment losses at LRD and A Canal resulting from the Proposed Action can be estimated. Based on estimates for sucker entrainment by life history stages (Gutermuth et al., 2000b, 2000a) and applying assumptions to account for changes since the Gutermuth et al. efforts (e.g., construction of A Canal fish screen and bypass, reduced sucker populations in UKL), entrainment estimates can be calculated from modeled output. Applying seasonal occurrences of sucker life history stages, based on Gutermuth et al. (2000b, 2000a), to the volume of water that Reclamation anticipates delivering through the Link River and A Canal and a sucker population reduction of approximately 80% (USFWS, 2013), the Proposed Action could result in about 80,292 juvenile suckers encountering or passing infrastructure at either LRD or A Canal fish screen and trash rack (Table 5-11). Reclamation is not distinguishing between harass and harm for the incidental take of suckers as a result of entrainment. Entrainment has adverse impacts to juveniles of both species of suckers. Sucker entrainment at LRD and A Canal will occur under the Proposed Action. Construction and continued operation of the A Canal fish screen reduces the negative impact of entrainment by preventing juvenile and adult suckers from entering the Project canal system.

Keno Impoundment Unscreened diversions from the Keno Impoundment have an adverse impact to individual suckers at each life history stage. The impacts due to the loss of juvenile suckers are uncertain (PacifiCorp, 2012) but the magnitude of impacts is likely related to the amount of water diverted and both the seasonal and diurnal timing of diversions.

Under the MS scenario, deliveries to irrigation districts and the Lower Klamath NWR would continue as some of these gates are privately owned and Reclamation has no discretionary control over privately-owned gates. Because fish screens are not present at Ady and North canal diversion points or at multiple other diversion sites, suckers that do not find their way to Lower Klamath NWR would be considered entrained in canals, ditches, or fields. If under the MS scenario, Lower Klamath NWR diverts their full water right (113,000 AF), conditions at Lower Klamath NWR may provide improved habitat (relative to the Proposed Action) dependent upon management practices.

The Proposed Action results in entrainment of sucker early life history stages at Project features (i.e., Ady, LRDC, and small canals delivery to Plevna) adjacent to Keno Impoundment similar to entrainment that would occur in the MS scenario except that conditions at Lower Klamath NWR may provide adequate habitat for suckers such that they would not be considered entrained.

Lost River Proper Reduced flows in the Lost River as a result of the Proposed Action will lead to increased entrainment of juvenile suckers in the summer. Both lethal and sub-lethal impacts related to entrainment on juvenile suckers are anticipated as a result of the Proposed Action within the Lost River.

Under the MS scenario, entrainment losses at Reclamation's diversions from the Lost River are absent. The Proposed Action increases entrainment potential through unscreened diversions in the Lost River. The impact of entrainment through these diversions poses an unquantified adverse impact to individual suckers at each life history stage. Both lethal and non-lethal impacts related to entrainment are anticipated as a result of the Proposed Action within the Lost River, consistent with what has been described in the environmental baseline (Chapter 2).

5.2.3.6 Pollutants

Tule Lake Lower surface elevations in Tule Lake as a result of the Proposed Action will lead to increased presence of pollutants in juvenile suckers in the summer and fall. Lethal impacts related to increased pollutants on juvenile suckers are anticipated as a result of the Proposed Action within Tule Lake.

Surveys regarding pesticide impacts to suckers have largely focused on the Tule Lake Sumps as a likely place that agrochemicals may accumulate within the Project. The risk to the suckers posed by pesticide use is dependent on many factors, including chemical toxicity, mobility, persistence, amount applied, groundwater-surface water interaction, application method, and proximity of application area relative to nearby water bodies. Once in a waterbody, pesticides volatilize, degrade, settle to the bottom with sediment or remain in the water column where they are diluted (USFWS, 2008). Studies on pesticide use on the leased lands with Tule Lake NWR concluded that pesticide use does not likely pose a threat to LRS and SNS in the Tule Lake Sumps when label directions are followed and when appropriate buffers are in place (USFWS, 2008).

5.3 Critical Habitat Analysis

Critical habitat for LRS and SNS was designated on December 11, 2012 (77 FR 73739-73768 [2012]) and includes approximately 234 km of streams and 47,691 hectares of lakes and reservoirs for LRS and approximately 219 km of streams and 50,015 hectares of lakes and reservoirs for SNS in the Klamath River Basin.

In defining the physical and biological features and habitat characteristics required for LRS and SNS conservation, USFWS identified physical and biological features essential to the conservation of LRS and SNS in areas occupied at the time of listing, focusing on the features' primary constituent elements. Physical and Biological Features (PBFs) specific to self-sustaining LRS and SNS populations are: (1) water; (2) spawning and rearing habitat; and (3) food (77 FR 73740). For a more detailed discussion, see Section 5.1.7.

5.3.1 Water

5.3.1.1 Upper Klamath Lake and Tributaries

While there has been some concern that Project operations may affect UKL water quality through management of UKL elevation, the best available science has not demonstrated a clear, discernible, and consistent relationship between UKL elevation and water quality. This does not mean that UKL elevation or water depth does not have an effect on water quality, only that the best available science has not demonstrated a clear, consistent, and discernable relationship especially within the range of UKL elevations observed from 1990 to 2016, nor over the range of UKL elevations analyzed in the KBPM output for the period of record (Sections 5.2.1.1 and 5.2.3.1). The Proposed Action and its resulting surface elevations could potentially influence nutrient cycling within UKL (Wood et al., 1996; NRC, 2004; Morace, 2007; Wherry and Schenk, 2024). At present, the empirical information lacks a causal link between water quality impacts (both negative and positive) and surface elevations in UKL.

The Proposed Action is unlikely to impact sedimentation or nutrient input into UKL because much of the input of lake nutrients occurs upstream of UKL and independent of Project operations (NMFS and USFWS, 2013). Nutrients available in the lake substrates (e.g., internal nutrient loading) are not likely influenced by the surface elevations in the Proposed Action, although the storage and delivery of water from UKL could impact amounts of nutrients both stored and exported from UKL. The net effect of water storage and delivery in UKL on nutrient cycling is not well understood but could have both negative and positive impacts on water quality.

The Proposed Action has no effect on water quality in the tributaries to UKL within the critical habitat for LRS and SNS. Much of this critical habitat in the tributaries is above the influence of water storage in UKL. Water management described in the Proposed Action will only impact the lower reaches of the Williamson River, which are those reaches that are influenced by UKL surface elevations (NMFS and USFWS, 2013).

Relative to the MS scenario, water quality in the PA may be reduced. As discussed above, surface elevation is one of many factors that influences water quality parameters in Upper Klamath Lake (Wherry and Schenk 2024). Kann and Walker (2020) suggest an increased probability of suboptimal water quality in UKL outside a certain range of water surface elevation's; both high and low water surface elevation's in UKL have been associated with higher probabilities of exceeding sucker stress thresholds at various points during the June 15*th*-September 1*st* (Kann and Walker, 2020). Kann and Walker (2020) suggest water surface elevations near the long-term median have generally provided the lowest risk for poor water quality, through the avoidance of elevations at which the highest and lowest DO concentrations occur. However, the long-term median defined by Kann and Walker (2020) is most similar to water surface elevation experienced in 2017, when a large-scale adult sucker mortality event was observed in Upper Klamath Lake (Skinner, 2017; Krause et al., 2017). When Krause et al. (2022) assessed adult sucker survival relative to water surface elevation and water quality parameters, no models with these parameters explained adult sucker survival. Poor water quality remains one of many parameters hypothesized to contribute to poor juvenile survival in Upper Klamath Lake (Burdick et al., 2017). Juvenile survival relative to water quality has not been assessed because there has been no variation in juvenile survival; juvenile survival has been essentially zero in all water year types, and all observed water surface elevation levels in UKL since the mid-1990s. In addition to water surface elevation, parameters that influence water quality in UKL are temperature, inflows, and external phosphorus loading (Wherry and Schenk 2024). Under the PA, water surface elevation's during these months fall above and below the long-term median (Table 5-8; Kann and Walker, 2020), which may contribute to poor water quality events in UKL.

The most recent, best available science does not demonstrate a direct, consistent, and discernable relationship between low UKL surface elevation, poor water quality, and mortality of adult suckers (Wherry and Schenk, 2024; Kann and Walker, 2020; Krause et al., 2022). For further detail on studies and analyses between lake level and water quality studies for UKL see Wood et al., 1996; NRC, 2004; Morace, 2007; and Wherry and Schenk, 2024.

Higher surface elevations may result in cooler water temperatures during the summer months, although lacking specific observations, the extent that water temperatures would decrease under the MS scenario is unknown. Higher lake surface elevations under the MS scenario could decrease mixing on windy days, which could decrease turbidity and available nutrients. As a result, DO concentrations could also increase at deeper lake depths if stratification events occur less frequently. It is unclear if decreased mixing (due to high surface elevations) on windy days, would be a negative effect (due to lower DO concentrations, and lower turbidity-similar conditions to Clear Lake and Gerber reservoirs, which may reduce sunlight available for AFA photosynthesis) or a net-benefit as decreased nutrients may decrease growth of AFA and other cyanobacteria. Regardless, lacking direct observations of water quality conditions at high lake elevations similar to those in the MS scenario, it is difficult to say precisely how suckers would be impacted.

5.3.1.2 Keno Impoundment

Under the Proposed Action, flows for agriculture and downstream environmental needs will be released from LRD. Surface elevations in the Keno Impoundment will be maintained between 4,085.0 and 4,086.5 feet above sea level (Reclamation datum). Reclamation does not anticipate water depth to be different in Keno Impoundment under the Proposed Action or the MS scenario.

The poor quality of water entering, within, and leaving the Keno Reservoir is largely due to poor quality water from UKL containing large amounts of organic matter with an associated high BOD (Doyle and Lynch, 2005; Deas and Vaughn, 2006). Water from UKL, and the organic matter and nutrients carried with the water, may incrementally reduce water quality in the Keno Reservoir, particularly during warm weather periods. It is expected that operations of the Proposed Action will be similar to the MS scenario as nutrient loading and pesticide use will likely continue.

Under the MS scenario, nutrient loading and pesticides are expected to be similar; flows from LRDC would be minimal as the majority of the water from Clear Lake and Gerber watersheds would flow down the Lost River and into Tule Lake. While there are differences in the volume of water flowing through the Keno Impoundment, all water coming from UKL contains high concentrations of nutrients, AFA, and other organic matter. It is unlikely that water quality conditions would be significantly different for the MS scenario in comparison to the Proposed Action in the Keno Impoundment reach.

5.3.1.3 Clear Lake and Tributaries

No water quality impact is anticipated in the west lobe of Clear Lake in the MS scenario. The east lobe of Clear Lake would largely resemble a shallow lake or wet meadow during spring months and would be mostly non-watered in late summer through winter under the MS scenario. Reclamation assumes suckers would not inhabit the east lobe under the MS scenario. Thus, lake habitat of surface area and depth at Clear Lake reservoir is confined to the west lobe. Under the Proposed Action, more lake habitat is expected, creating a beneficial impact to critical habitat in Clear Lake. The Proposed Action is not anticipated to affect water quality in the Clear Lake Reservoir or its tributaries.

Relative to the MS scenario where CL dam gates are open, the PA would result in much more open water lake habitat in most years, and increased connectivity of lake habitat to spawning habitat in Willow Creek. However, low water levels in Clear Lake Reservoir could periodically reduce the amount of available habitat with water depth suitable for older life history stages of both LRS and SNS in the PA. Particularly, in consecutive drought years, the Proposed Action may decrease the amount of critical habitat in Clear Lake Reservoir to shallower depths that may become periodically limiting to sucker use. The minimum Clear Lake Reservoir elevation will likely provide adequate protection from drought in most years. Extended drought may result in a significant reduction in lake area and depth. Several years of drought could result in low water surface elevation in Clear Lake Reservoir and could limit or eliminate connectivity between Clear Lake Reservoir and spawning grounds in Willow Creek. Access to spawning habitat in Willow Creek may not occur in some years with water surface elevation less than ~4,523 ft and low flows in Willow Creek (Hewitt et al., 2021).

At Clear Lake Reservoir, lower water levels may result in degraded water quality, particularly higher water temperatures and lower DO. Consequently, very low lake levels in Clear Lake Reservoir during consecutive drought years could adversely impact water quality (USFWS, 2008; NMFS and USFWS, 2013). However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival (Reclamation, 1994b, 2001a, 2007).

5.3.1.4 Gerber Reservoir and Tributaries

Under the MS scenario, Gerber Reservoir would likely be a small lake for several weeks in mid-February through April when inflows exceed the gate openings on the dam (about 900 cfs). Thus, under the MS scenario, designated critical habitat, defined as sufficient water depth and volume, would be negatively impacted in Gerber Reservoir. The Proposed Action may reduce surface area, water depth, and shoreline areas as habitat during periods of prolonged drought at Gerber Reservoir; however, when compared to MS, the Proposed Action has a beneficial impact of providing designated critical habitat for suckers in the reservoir as defined by adequate surface area, depth, and sufficient water quality. Low water surface elevation in the MS scenario

Gerber Reservoir would eliminate access to spawning tributaries in Ben Hall and Barnes Valley. Low lake elevations may also result in degraded water quality including higher pH values and lower DO concentration. Water quality monitoring over a wide range of lake levels and years has documented water quality conditions that are periodically stressful to suckers but were generally adequate for SNS survival (Reclamation, 2001a, 2007; Piaskowski and Buettner, 2003; Phillips and Ross, 2012).

5.3.2 Spawning and Rearing Habitat

5.3.2.1 Upper Klamath Lake and Tributaries

A subpopulation of LRS begins spawning at the shoreline area as early as the beginning of March, peaks in April, and can last through May (Buettner and Scoppettone, 1990; Barry et al., 2007b; Janney et al., 2009; Burdick et al., 2015b; Hewitt et al., 2018). As discussed in Section 5.2.1.2, the Proposed Action will result in lake surface elevations that inundate 74% or more of shoreline spawning habitat with 1 ft or more of water (a UKL elevation of at least 4,142 ft) in all months from the end of February to the end of June in 10 of 32 years (31%). There is more spawning habitat (i.e., higher lake levels and more years above 4,142 ft) in all years of the MS scenario relative to the Proposed Action. However, beyond a certain lake elevation, spawning habitat will not increase and may actually decline though this level is not currently known. An objective of the Proposed Action is to store water in UKL from November through March. This objective results in end of month lake elevations in February through May which, in most years, provides sufficient depths for lakeshore spawning LRS populations.

The modeled output from the period of record indicates that the Proposed Action provides lakeshore-spawning suckers with UKL elevations sufficient to inundate 74% or more of shoreline spawning habitat with 1 ft or more of water (a UKL elevation of at least 4,142 ft) in all months from the end of February to the end of June in 10 of 32 years (31%). More specifically, the Proposed Action is predicted to provide lake elevations greater than or equal to 4,142 feet in 31% of years at end of month February, 66% of years at end of month March, 69% of years at end of month April, 60% of end of month May, and 41% of end of month June (Table 5-5). The earliest February spawners will have lake elevations greater than 4,142 ft in only 11 of 32 years under the Proposed Action. However, lake elevations, and therefore the amount of spawning habitat inundated, will typically increase during March and April, with lake elevations greater than 4,142 ft in 21 and 22 of 32 years, respectively (Table 5-5, Table 5-6).

In the 32-year period of record analyzed, there were 22 years (model years 1991-1995, 2001-2005, 2008-2010, 2013-2016 and 2018-2022) where the surface elevation of UKL did not reach at least 4,142 ft by the end of February (Table 5-5 and Table 5-6). Additionally, the Proposed Action provides suckers lake surface elevations at or above 4,142 ft by the end of March in 66% of years (Table 5-7).

The MS scenario provides depths with surface elevations of 4,142 ft in end of month February to end of month May in all years. UKL surface elevation of 4,142 ft has been identified by USFWS as protective of eastside shoreline spawning habitat for LRS. The MS scenario results in higher lake elevations and the project is operated only for specific purposes (e.g., flood control, 50 cfs to

VBDC and Tribal Boat Dance). The consequences for shoreline spawning LRS habitat under the MS scenario are unclear, but it is likely that, beyond some maximum elevation, spawning habitat would plateau and possibly even decline. Therefore, it is difficult to determine the precise impacts to spawning habitat of the MS scenario.

Under the Proposed Action, lake levels are predicted to increase or remain consistent throughout the period of larval development (Figure 4-1). Lake elevations during spring months, especially March and April, which coincide with the majority of embryo and larval development, are expected to have the highest lake elevations of 4,142 ft or greater (Table 5-8). Thus, the Proposed Action provides lake elevations sufficient to maintain adequate shoreline incubation habitat for embryo and larvae development, and lake levels are likely to stay high enough for embryos and larvae to be protected from desiccation.

If lake elevations that provided sufficient depth (i.e., 4,142 ft) for spawning decrease rapidly, embryos and larvae may be susceptible to exposure and desiccation. Surface elevation changes greater than 0.6 ft (Buettner and Scoppettone, 1990) within 3 weeks (Coleman et al., 1988) will impact this life stage at the shallowest spawning sites. Under the Proposed Action scenario, lake elevations are expected to rarely decrease at a rate equal to or greater than 0.6 ft in 3 weeks (Figure 5-9).

Wetland availability for developing sucker larvae in the Proposed Action scenario would be lower than under MS but still adequate. Shallow, near-shore areas, particularly with emergent vegetation, provide habitat for larval suckers (especially SNS; USFWS, 2008). Although emergent wetland habitat exists at locations around UKL, wetlands at the Delta are particularly important (USFWS, 2008). When lake elevations are less than 4,140.8 ft (1,262.1 m) and less than 50% wetland-edge habitat is available, predation, starvation, and entrainment in the outlet of the lake are real risks to larvae (USFWS, 2019a). However, under the Proposed Action, lake levels would exceed 4,140.8 ft in ~80% of the modeled period of record on June 30 and ~75% on July 15th (Figure 5-10b). While juvenile suckers have been found equally in open water and wetland habitat (Burdick et al., 2009) the reconnection of Agency Barnes Unit is expected to increase the amount of available habitat for rearing suckers (USFWS, 2023a).

Little is known about specific habitat needs for age 1+ juveniles because very few have been captured in UKL (Sections 5.2.1.2 and 5.2.3.2). The limited data available suggests that age-1+ juvenile suckers have habitat preferences more similar to adult suckers than larval suckers (Burdick et al., 2009c; Burdick and Vanderkooi, 2010). The lowest end of September UKL surface elevation is 4,138.33 ft (1,261.36 m) and only occurs during extremely dry years. In the northern portion of UKL, approximately 9,428 acres (3,815 hectares) or 33% of available habitat greater than 6.6 ft (2 m) is available at 4,138.33 ft (1,261.37 m) lake elevation (Figure 5-7). While suckers prefer depths greater than 6.6 ft (2m), distribution is likely associated with food resources, water quality, and predation risk. Thus, the actual amount of preferred habitat greater than 6.6 ft (2 m) deep is likely less than 9,428 acres. However, these conditions are not a regular occurrence, and the Proposed Action is not expected to affect the availability of these deep-water habitats.

After water quality conditions improve in late summer, suckers are distributed throughout the lake (Banish et al., 2007). Thus, lake elevations don't appear to define preferred habitat from November to February (USFWS, 2019a) and winter water quality conditions are not often considered to be causes of mortality for adult suckers. The Proposed Action may affect a limited number of individual habitats, wide dispersal of suckers starting in late summer and improved winter water quality make substantial effects to sucker habitat unlikely.

The northern portion of UKL and specifically Pelican Bay, has been identified as important habitat for older juveniles and adults to seek refuge from poor water quality (Banish et al., 2009). Adequate depth is necessary for suckers to safely access water quality refuge areas in Pelican Bay and preferred habitat in mid-September. The lowest UKL surface elevation in the model period of record in July through September resulted in 2.6 ft (0.9 m) of water to the entrance of Pelican Bay (Table 5-10), which is shallower than the predation protection threshold of 3.3 ft (1 m; Scoppettone et al., 2014). Also, the depth of the entrance to Pelican Bay is expected to be between 4 and 6 ft (1.2 and 1.8 m) during August and September in all but the wettest years, which may result in increased risk of predation for suckers by pelicans (Table 5-10, Figure 5-8). Therefore, the Proposed Action may impact sucker access to preferred refuge habitat.

5.3.2.2 Keno Impoundment

Spawning activity in the lower Link River, upstream of the West Side hydropower facility, was observed during May 2007 (Smith and Tinniswood, 2007). No other spawning habitat exists between LRD and Keno Dam (Buchanan et al., 2011). The Proposed Action releases water from UKL at LRD for downstream needs. The releases under the Proposed Action are anticipated to have no impact to spawning habitat in the Link River. Under the MS scenario, flows from LRD would be higher than under the Proposed Action throughout late-fall, winter, and most of spring. It is unclear if increased flows would improve or impair potential spawning habitat in the Link River in the MS scenario. In either scenario, access would be available for suckers. Thus, Reclamation concludes since there has only been one observed case of suckers spawning in the Link River, the effects of the Proposed Action and the MS scenarios would be similar for spawning suckers in the Link River.

The ongoing management to operate for stable surface elevations in the Keno Reservoir impacts development of additional wetland habitats and degrades the quality of existing wetlands through controlled water depth (USFWS, 2007d). However, stable surface elevations do provide sucker access to the established wetland habitats for rearing during sucker early life history stages. The Proposed Action has some negative effects to the recovery-support function of critical habitat in Keno Reservoir for both LRS and SNS (NMFS and USFWS, 2013).

Since Keno Impoundment surface elevations continue to be operated for stability, the presence of and ease of access to wetland habitats would not differ between scenarios. As such, both scenarios would provide access to adjacent wetland habitat, but stagnant impoundment elevations may degrade the quality of these wetlands.

5.3.2.3 Clear Lake and Tributaries

Access to spawning and rearing habitat would be negatively impacted under the MS scenario. Because dam gates in Clear Lake Reservoir are open, the MS scenario results in the absence of an east lobe, which is the migration route for sucker spawning in Willow Creek. Under the Proposed Action, surface area and depths in the east lobe are sufficient to provide access to Willow Creek, the only spawning habitat upstream of Clear Lake in most years. Suckers are able to access Willow Creek when lake surface elevations are approximately 4,524.0 ft and creek discharge is sufficient (exact cfs not specified, Hewitt et al., 2021). Surface elevations of at least 4,524.0 ft were reached each spring by the end of February in 83% of years, the end of March in 88% of years, and the end of April in 89% of years. A minimum lake elevation of 4,520.6 feet above mean sea level by the end of September each year is intended to conserve lake surface area and water depth as fish habitat into the winter months and into the following year. This lake elevation is also intended to reduce the likelihood of reduced spawning access the following spring. Extended drought may result in consecutive years of reduced surface elevations which are likely to adversely impact access to Willow Creek. The Proposed Action is not anticipated to affect spawning habitat in the tributaries to Clear Lake Reservoir.

Relatively little is known about rearing habitat requirements at Clear Lake Reservoir. Assuming that lake surface area, water depth, and shoreline are important components of rearing habitat, then the amount of habitat available in any given year will fluctuate relative to surface elevations. The Proposed Action may periodically reduce rearing habitat in Clear Lake Reservoir at low surface elevations when habitat contracts. However, the amount of lake habitat would be substantially increased under the Proposed Action in comparison to the MS scenario.

5.3.2.4 Gerber Reservoir and Tributaries

The Proposed Action is not anticipated to impact spawning habitat at Gerber Reservoir. Sucker access into Barnes Valley and Ben Hall creeks, the principal spawning tributaries for suckers in Gerber Reservoir, requires a minimum spring (February through April) elevation of about 4,805.0 ft (USFWS, 2008). Surface elevations of at least 4,805.0 ft were reached each spring by the end of February in 94% of years, the end of March in 98% of years, and the end of April in all years for the period of record. However, in very dry years both Barnes Valley and Ben Hall creeks typically have low spring flows that may not provide adequate upstream passage for spawning adults regardless of lake elevations (Reclamation, 2001a).

The Proposed Action is anticipated to have minimal impact to rearing habitat at Gerber Reservoir. At Gerber Reservoir, larval and juvenile suckers likely use lake surface area, water depth, and shoreline as habitat. At 4,800 ft, the surface area of the lake decreases to about 750 surface acres. As lake surface elevation decreases so does the amount of available rearing habitat.

5.3.3 Food

5.3.3.1 Upper Klamath Lake and Tributaries

Neither the Proposed Action nor the MS scenario are anticipated to appreciably reduce food availability in UKL due to the relatively high abundance of zooplankton and benthic macro-invertebrates in UKL (Hazel, 1969). While it is possible that high lake levels under the MS scenario could result in substantially reduced habitat diversity causing zooplankton and benthic macro- invertebrates dependent upon wetland habitat to be less abundant, a lack of direct observation of the MS scenario makes the likelihood of this result unclear. Therefore, the Proposed Action is not anticipated to affect food resources for suckers in UKL (NMFS and USFWS, 2013) and does not differ substantially from the MS scenario.

5.3.3.2 Keno Impoundment

Abundance of benthic macro-invertebrates is high in the Lost River (Shively et al., 2000b) and UKL (Hazel, 1969). There is a lack of information on prey species abundance in the Link to Keno Reservoir reach; however, under the Proposed Action, prey species are assumed to be relatively high as the water at this location arrives primarily from UKL.

Under the MS scenario, prey species are expected to be similar. Generally, there are fewer benthic macro-invertebrates and zooplankton in waters from Gerber and Clear Lake, though it is unclear if having some proportion of water from these bodies would change diversity, abundance, or both. As such, Reclamation does not anticipate food resources to be different between the Proposed Action and the MS scenarios.

5.3.3.3 Clear Lake and Tributaries

Abundance of benthic macro-invertebrates is high in the Lost River (Shively et al., 2000b) and UKL (Hazel, 1969). There is a lack of information on prey species abundance in Clear Lake Reservoir. Based on the abundance of macro-invertebrates in other basin waters, Reclamation assumes that prey species are also relatively high in Clear Lake Reservoir. Prolonged drought may concentrate fish into remaining habitat and reduce food availability through competition in Clear Lake Reservoir. Although prey species may be entrained on water delivery from Clear Lake, the Proposed Action is not anticipated to appreciably reduce food availability based on the assumption that prey species are abundant. Food resources are expected to be appreciably reduced under the MS scenario as lake area would be confined to the west lobe. The seasonally wet east lobe is not anticipated to provide a prey base for suckers under the MS scenario.

5.3.3.4 Gerber Reservoir and Tributaries

Food resources for suckers, such as zooplankton and macro-invertebrates, are anticipated to be less under the MS scenario as compared to the Proposed Action. It is assumed that zooplankton and benthic macro- invertebrate abundance in Gerber Reservoir is similar to other aquatic lake environments in the Upper Klamath Basin (Hazel, 1969; Shively et al., 2000b) under the Proposed Action. The Proposed Action provides for food availability in the lake environment except during prolonged drought, which may concentrate fish into remaining habitat and reduce food availability through competition in Gerber Reservoir. Food resources are expected to be appreciably reduced under the MS scenario as lake area will be confined. The remaining creek channels are anticipated to provide limited prey base for suckers under the MS scenario.

5.4 Effects of Operation and Maintenance Activities Associated with Klamath Project Operation

Under the Proposed Action, gates at Gerber Dam, Clear Lake Dam, LRD and fish ladder, Lost River Diversion (Wilson) Dam, the LRDC, and A Canal are exercised twice each year before and after irrigation season, March through November. The exercising of irrigation gates will likely have short-term, temporary impacts to larval, juvenile, and adult suckers in the immediate vicinity of the dams during exercise operations. It is anticipated that most individuals will move away from the exercised gate due to the sudden change in the surrounding environment; however, an unknown quantity of individuals may be entrained through the gates during exercises. The component of the Proposed Action that includes O&M of Project facilities related to dam and diversion gates is anticipated to possibly have adverse impacts to suckers largely through harassment and entrainment. Sucker captive rearing and funding of sucker-related habitat restoration projects are anticipated to offset some adverse impacts due to O&M of Project facilities.

Under MS, the exercise of O&M at Project facilities, principally gates and diversion structures, will still be necessary to provide for operations. Therefore, under the MS scenario, impacts to suckers from O&M activities are expected to be similar and are not discussed separately.

5.4.1 Effects of Clear Lake Dam Maintenance

Typically, once each year before the start of irrigation season in March or April, gates at Clear Lake Dam are opened to flush sediment that accumulates in front of the dam gates. This activity creates a maximum release of 200 cfs and lasts for approximately 30 minutes. Periodically, the fish screens at Clear Lake Dam need to be manually cleaned during the irrigation season dependent on lake elevations and sediment. During the cleaning, one of the two fish screen sets is always in place to prevent entrainment of juvenile and adult fishes.

Sudden opening of the Clear Lake Dam gate may entrain individual larval, juvenile, and adult suckers, but it is anticipated that a number of fish will move away from the disturbance created by the open gate. However, it is likely that a small number of suckers at each life history stage could be entrained through the dam during a 30-minute flushing release. The downstream transport of sediment into the Lost River during gate openings is short-term and temporary in nature with most of the sediment settling in pools in the upper Lost River between Clear Lake Reservoir and Malone Reservoir.

5.4.2 Effects of A Canal Headworks Maintenance

Gates at A Canal are only operated and exercised with the fish screens in place. Should an occasion occur where the fish screens become inoperable during irrigation season, it is likely that all flows will need to be truncated in order to replace or repair the fish screen. These activities at A Canal are not anticipated to impact suckers, as the truncation of flow will eliminate the risk of fish entrainment. At the end of irrigation season, the A Canal gates are closed and the forebay between the trash rack and head gates is slowly dewatered. Annual fish salvage occurs within the dewatered forebay during late October or early November. During the fish salvage, up to 1,500 YOY and older juvenile suckers are captured through seining and electrofishing (Kyger and Wilkens, 2011, 2012; Reclamation, 2018).

Continued monitoring (and fish salvage when fish are observed) in the A Canal forebay during the week following initial salvage indicates very few fish remain in the forebay (Kyger and Wilkens, 2011, 2012). Salvaged suckers were typically measured, tagged, and returned to UKL. Since 2016, salvaged suckers are treated for infections by USFWS prior to tagging and releasing to UKL. Adverse impacts to several hundred juvenile suckers are anticipated during this salvage process through stress. Observed mortality of salvaged suckers has been relatively low; however, stranding prior to, or in absence of, fish salvage results in mortality (Kyger and Wilkens, 2012).

5.4.3 Effects of Lost River Diversion Channel Maintenance

Inspection of the gates and canal banks within the LRDC takes place once every 6 years. Inspections require a drawdown of water within the channel and can occur any time of the year. A drawdown of the channel would be coordinated with fish biologists to ensure adequate water is left to improve fish survival in pools during short-term periods of low water levels. During drawdown, pools will be monitored to prevent stress to fish stranded until flows return. Adverse impacts in the form of stress are anticipated at each sucker life history stage but will likely be short term and temporary in nature. If necessary due to inadequate depth or disconnection between remaining pools, suckers will be salvaged from the remaining LRDC pools. Fish salvage is anticipated to result in harassment of up to 50 suckers, usually YOY or older juvenile life stage, during each occurrence. It is likely that stress will lead to harm of fewer than five suckers during each occurrence. Fish salvage will be coordinated with USFWS prior to the occurrence to determine the appropriate treatment and release sites for captured suckers. When practical, drawdown of the LRDC will occur during late fall through early winter when fewer suckers may be present in the channel to reduce impacts to suckers.

5.4.4 Effects of Link River Dam Fish Ladder Maintenance

Gates to the LRD fish ladder are exercised twice each year: once between January and April, and again between October and December. While the gates are exercised, the fish ladder is often dewatered, and the entire structure is inspected. Fish are salvaged from the ladder while dewatered and returned to either the Link River or UKL. These activities have a short-term, temporary impact to suckers in and adjacent to the ladder. No more than five suckers of any life history stage have been encountered in the fish ladder during previous fish ladder inspections.

5.4.5 Effects of Canals, Laterals, and Drains Maintenance

Nearly all canals, laterals, and drains are annually dewatered at the end of irrigation season, as late as November and early December for Project canals in California. Canals remain dewatered until the following spring (as early as late March) except for localized precipitation runoff. In an effort to minimize effects associated with dewatering canals, Reclamation has proposed a conservation measure for the salvaging of suckers from Project canals in both Oregon and California (Section 5.4.9). Some maintenance of canals occurs during irrigation season, such as removal of plant material from trash racks at water control structures. These temporary activities are not anticipated to impact suckers.

Most canal, lateral, and drain maintenance occurs while canals are dewatered and includes removal of sediment, vegetation, concrete repair, and culvert/pipe replacement. Gates, valves, and equipment associated with canals and facilities are exercised before and after the irrigation season (i.e., before April and after October). In the past, these activities have typically occurred after dewatering of the canals and after fish salvage of Project canals. Some activities, such as culvert and pipe replacement, may temporarily increase sediment transportation. Based on the presence and abundance of suckers in Project canals (Kyger and Wilkens, 2011, 2012), adverse impacts to suckers are anticipated in regard to seasonal canal dewatering and routine maintenance on canal infrastructure. Most impacts such as increase in sedimentation are temporary and result in stress for fish. Other impacts may include mortality through long-term stranding, such as may occur when canals are dewatered, and pools become disconnected. Fish salvage of remaining pools following dewatering has prevented mortality losses of approximately 100 to 1,000 juvenile suckers each year since 2008 (Kyger and Wilkens, 2012).

5.4.6 Effects of Pest Control

Roads and dikes are mowed as necessary from March through October to control plant growth. Some pest control along dikes and on Reclamation property require the application of pesticides. Reclamation applies pesticides annually from February through October at select areas in accordance with approved Pesticide Use Proposals and product labels. For the most recent Comprehensive Conservation Plan and Environmental Impact Statement regarding the use of pesticides on Reclamation and USFWS property including for Lower Klamath, Clear Lake, Tule Lake, Upper Klamath, and Bear Valley NWRs, see USFWS (2016). For additional information on pesticide and herbicide applications see Section 2.4.1.

5.4.7 Effects of Right-of-Way and Access Maintenance

Right-of-way and access maintenance may temporarily cause sedimentation into adjacent waterways, principally canals. Gravel is periodically added to roadbeds or boat ramps and vehicle access points. Roadbeds are periodically re-graded. The impact of sedimentation is likely to have a temporary impact to individual suckers that may be present. When these activities occur, seasonal consideration and soil retention cloth are used to mitigate sedimentation of waterways.

5.4.8 Effects of Water Measurement

Water measurement devices, such as gages, require annual maintenance to flush sediments from stilling wells, replace faulty gages, or modification/replacement of supporting structures. Flushing sediment from stilling wells occurs during irrigation season (April through October) and may temporarily increase sedimentation downstream of the gage. Sediment volumes are often very small, and the sediment settles a short distance downstream. In some instances, when a large amount of sediment is present, the sediment is removed from the stilling well and deposited at nearby upland locations. Other activities, such as replacement or repositioning of a measurement device and associated infrastructure, may require the construction of a small, coffer dam or be conducted during low flow periods. Measurement device sites are anticipated to need replacement or repair once every 5 to 10 years. If construction of a coffer dam is required, then fish will be salvaged from behind the dam prior to replacement of infrastructure.

Replacement or repositioning of a site will have short-term adverse impacts to suckers. Suckers will likely avoid the disturbance during activity but may need to be captured and moved to a location further from the impacted area. Replacement of equipment and flushing of stilling wells will have temporary impacts to suckers present in the immediate area of the gage. Most of these impacts are anticipated as non-lethal stress during site activity. If fish salvage is necessary, as in the instance that a coffer dam is needed to conduct repairs or replacement, it is anticipated that no more than 50 suckers of all life history stages will be encountered (harassed) for each occurrence. Fish salvage, and its non-lethal impacts, are likely the best approach to removing suckers away from additional harm due to these activities.

5.4.9 Conservation Measures

5.4.9.1 Fish Salvage

Fish salvage at Project canals occurs when canals are: (1) temporarily dewatered for a discrete action related to maintenance and/or repairs at Project facilities inclusive of canals, canal banks, levees, water control structures, and drain features (Section 5.4.5), and (2) when canal systems are dewatered at the end of each irrigation season. Under both circumstances fish are salvaged from pools where they are stranded.

Reclamation proposes, in coordination with USFWS, to continue the salvage of suckers both for routine maintenance and repair at Project structures and at conclusion of the irrigation season when project canals, laterals, and drains are dewatered consistent with past salvage efforts since 2005.

At conclusion of each irrigation season, Reclamation will coordinate fish salvage activities with irrigation districts, principally KID and TID. Future fish salvage of the canal system will include areas where suckers are annually encountered in reliable numbers since 2005, including the A Canal forebay, C4 Canal, D1 Canal, and D3 Canal within the KID and J Canal within the TID. Other locations within the Project canals will be periodically checked during dewatering, and fish will be salvaged if deemed feasible and productive. Reclamation will also continue to pursue alternative methods of dewatering canals, laterals, and drains and which could result in less sucker presence within these facilities at the end of the irrigation season. Fish salvage will be coordinated with USFWS each year.

Reclamation will coordinate with USFWS on the disposition of endangered suckers resulting from salvage activities, including release to natural waters or retention for disease treatments, studies, and captive rearing.

5.4.9.2 Sucker Captive Rearing Program

Since 2000, Reclamation has supported various conservation measures within the upper Klamath Basin which have resulted in significant improvements to the Baseline (including fish screen installation at A Canal and Geary Canal, removal of Chiloquin Dam on the lower Sprague River, fish passage at LRD, increasing wetland and lake habitat at the Williamson River Delta, and annual salvage of suckers from canals). However, there are few, if any, practicable options for reducing incidental take which is an effect of the Project.

Reclamation proposes to continue support of a captive rearing effort by USFWS for LRS and SNS. The intention is to improve the numbers of suckers reaching maturity in UKL. Ultimately, the function of a captive rearing program would be to promote survival and recovery of the sucker populations that suffer losses from entrainment as a result of the Project or other threats. Captive propagation is already an important part of listed fish recovery efforts nation-wide, including at least three sucker species (i.e., June sucker, razorback sucker, and robust redhorse sucker).

6 Southern Oregon Northern California Coast Coho Salmon

6.1 Range-Wide Status of Species and Critical Habitat

6.1.1 Endangered Species Act Listing Status

The SONCC Coho Salmon ESU was listed as threatened by NMFS in 1997 (62 FR 24588 [1997]). The ESU listing was maintained in 2014 and a recovery plan was established the same year (79 FR 20802 [2014]; NMFS, 2014) This ESU included populations spawning in coastal watersheds from Elk River, Oregon, to Mattole River, California. The threatened status was reaffirmed in 2005, including the addition of three hatchery stocks (Cole Rivers, Trinity River, and Iron Gate hatcheries) for inclusion within the ESU (70 FR 37160 [2005]), and was reaffirmed again in 2016 (NMFS, 2016a).

6.1.2 Life History and Habitat Requirements

Coho Salmon within the SONCC ESU generally exhibit a 3-year life cycle. Anadromous adults begin their freshwater spawning migration in the late summer and fall, spawn by mid-winter, and are semelparous. The run and spawning times vary between and within populations. Eggs incubate in redds (gravel nests excavated by spawning females) before hatching as alevins (a larval life stage dependent on food stored in a yolk sac). Once most of the yolk sac is absorbed, the 30- to 35-millimeter fish begin emerging from the gravel and are called fry (NRC, 2004). Fry habitat is mainly shallow stream margins for both foraging and safety from predators. Coho Salmon fry then grow and develop through about mid-June when they are about 50 to 60 millimeters and transition to the parr (juvenile) stage. Both fry and juvenile stages are collectively referred to as YOY, and individual fish produced during the same year are considered from the same “year class” or cohort. Juveniles compete for stream habitat with other juvenile fish (Quinn, 2005). Juveniles rear in fresh water for up to 15 months, then migrate to the ocean as smolts in the spring. This habitat allows them the chance to grow before migrating to larger rivers and the marine environment. Coho Salmon typically spend two growing seasons in the ocean before returning to their natal stream to spawn as 3-year-olds. Some precocious males, called jacks, return to spawn after only 6 months at sea. Details for each of these life stages are provided in the following subsections.

6.1.2.1 Marine Rearing

Coho Salmon generally spend between 16 and 20 months rearing in the marine environment, though some early-maturing males may only rear for 1 year. Upon entering the ocean they feed on plankton in the nearshore environment, and as they grow, they move farther out, switching to a diet of larger prey such as herring and squid (Groot et al., 1995). Marine survival is influenced by a number of interacting factors including prey abundance, predator density, degree of intra-specific competition (including hatchery fish), and sport and commercial fisheries (NRC, 1996).

The relative importance of these factors is directly affected by ocean conditions (NRC, 2004), particularly increasing water temperatures. Increases in water temperature influence survival in most life-stages of Coho via heat stress, changes in growth and development rates, lowering resistance to disease (NMFS 2016), and by shifting feeding opportunities. Changes in feeding opportunities are particularly important as zooplankton communities shift to favor more warm-water-tolerant species that lack the lipid-rich tissue that colder-water species possess. For example, in 2016, the biomass of lipid-rich northern copepod species was the lowest ever observed, while in 2017, the lipid-deplete tropical and sub-tropical southern copepods had the highest biomass in recent records (Peterson et al., 2017). This finding coincided with an ocean-warming event in 2014, referred to as the "Warm Blob," characterized by exceptionally high epipelagic ocean temperatures in the Northeast Pacific Ocean.

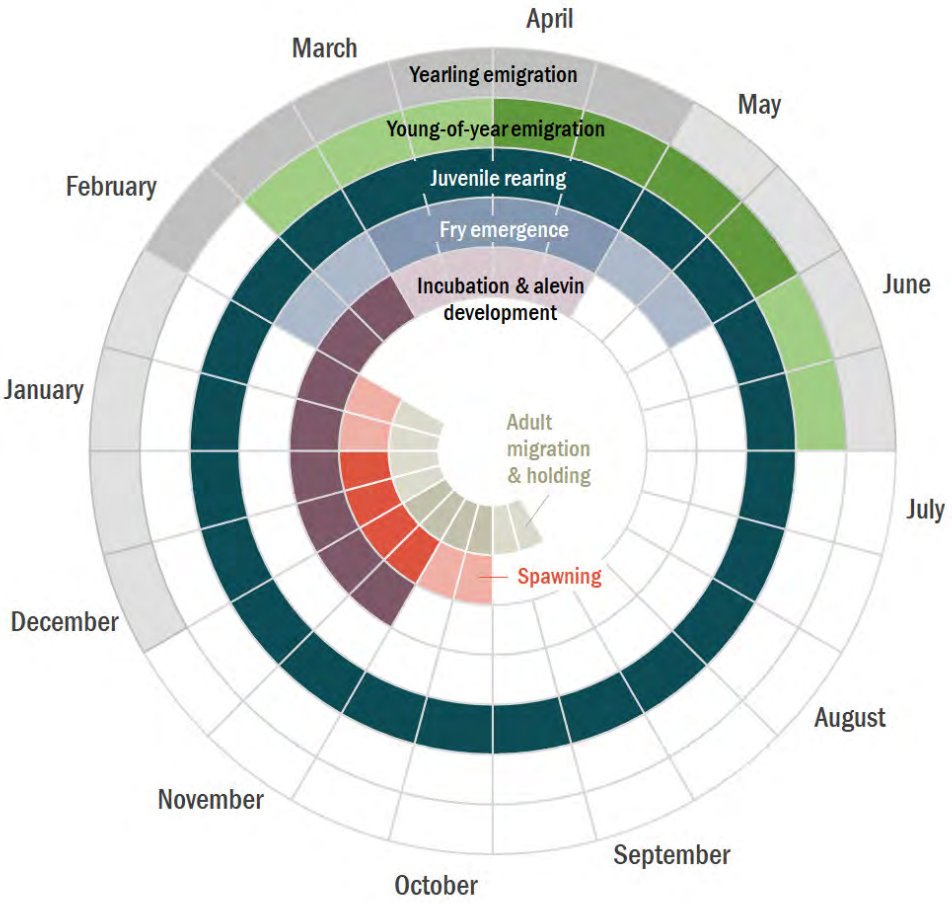
The Warm Blob initially formed in the Gulf of Alaska in 2013 and moved across the North Pacific in the spring of 2014 (Peterson et al., 2017), affecting the Baja, southern, and central coasts of California. Between November 2015 and January 2016, warm conditions were exacerbated as the Warm Blob was met by an unusually strong El Niño Southern Oscillation event in the Northeast Pacific Ocean. These conditions initiated a series of cascading trophic events creating conditions that no longer provided favorable growth opportunities for Pacific salmon. For example, Pacific salmon prey were dominantly larval rockfish and anchovies, indicators of poor feeding opportunities (Peterson et al., 2017). Consistent with this, pelagic surveys in the Northern California Current (spanning the Canadian border to Cape Blanco, Oregon) indicate dramatic declines in Coho Salmon abundance between 2014 and 2017 (Morgan et al., 2019). These trends likely reflect both trophic changes in oceanic conditions and local processes, which also contribute to low adult returns. Consequently, Columbia River Coho Salmon returns were some of the lowest ever recorded during this period (Peterson et al., 2017).

Marine survival for populations south of Northern British Columbia, including the Klamath River, are typically below average in comparison to other northern states and provinces (Coronado & Hilborn, 1998) and highly variable from year-to-year (Nickelson, 2006). For example, marine survival of Coho Salmon smolts released from Fall Creek Hatchery (Alsea River, Oregon) ranged from near 0 to 10% from 1970 to 1994; low survival was attributed to ocean temperature and coastal upwelling (Emmett & Schiewe, 1997). Moreover, Pearcy (1992) speculated that protected bays, inlets, and shallow littoral areas that favor survival are rare off California and Oregon and may contribute to these populations' poor marine survival rates. In addition, oceanographic variability, resulting from inter-annual fluctuations in the intensity of upwelling or El Niño Southern Oscillation events, appears to be greater in the southern part of the species' range (Lestelle, 2007).

Smolt-to-adult return (SAR) rates provide insight into salmon ocean survival. For example, Lindley et al. (2009) suggested the poor performance of Sacramento River Fall Chinook Salmon in the 2004 and 2005 brood years resulted from anomalous ocean conditions including weak upwelling, warm sea surface temperatures, and low prey densities. These findings were supported by near-normal smolt abundance estimates at the entrance to the estuary and typical freshwater rearing conditions for both brood years. In recent years, Coho SAR rates in the Shasta and Scott rivers have ranged from 0.5 to 16% (Chesney & Knechtle, 2015; Magranet & Yokel, 2017). Just south of the Klamath River Basin in Freshwater Creek, a tributary to Humboldt Bay, SAR rates have remained relatively low since 2007 ranging from 0.01 to 0.05%. Warm temperatures, strongly positive Pacific Decadal Oscillation values, as well as lipid-depleted zooplankton populations continue to contribute significantly to the poor observed and predicted SAR values since 2014 (Peterson et al., 2017). Moreover, Peterson et al., (2017) estimated SAR in 2017 to be less than 2% for all Pacific Northwest Coho Salmon, consistent with observed declining trends.(Peterson et al., 2017).

6.1.2.2 Adult Freshwater Migration

Freshwater migration of adult Coho Salmon occurs from mid-August to mid-December with a peak between mid-October and mid-November (NMFS, 2019)(Figure 6-1). River entry timing is influenced by many factors, including river flow and temperature. Salmon migration into natal tributary streams often occurs during higher fall flows (Koski, 1966). Pulses of flow in response to rain (freshets) or reservoir releases in the fall are critical to run timing; a lack of fall rains can delay migration and spawning as fish hold in the vicinity of stream mouths awaiting these freshets. During fall, ambient air and water temperatures generally decrease while rainfall events increase in frequency (NMFS 2010), encouraging adult migration into tributaries for spawning. SONCC Coho populations tend to have later run timing over a wider range of months (i.e., late-August to Mid-February; Weitkamp et al., 1995). Flow and temperature conditions in tributaries determine availability of and access to spawning habitat (Sutton, 2007).



Notes: data from NRC (2004) and FERC (2022). Within a ring, darker colors indicate peak periods for a life stage.

Figure 6-1. Summary of temporal life stage domains for Klamath River Coho Salmon

6.1.2.3 Spawning and Incubation

Coho Salmon migrate into spawning areas in smaller tributaries, and spawning grounds are generally within 240 km of the coast (Godfrey, 1965). Large river systems within the ESU historically supported Coho Salmon in their upper tributaries (Williams et al., 2006a). Coho Salmon prefer to spawn in tributaries, rather than mainstem rivers that may not have sufficient substrate, depth, and DO for egg development. Tributaries appear to play an important role in Coho spawning activities in the mainstem Klamath River, and Magneson and Gough (2006) found all mainstem redds were constructed within approximately 1 RM of a tributary mouth, highlighting the importance of tributary confluences in spawning site-selection (Reclamation, 2020a).

Adult fish may wait on spawning grounds for days to months prior to spawning. Females prepare their redds soon after arriving at suitable spawning habitat, which is generally at the head of a riffle just below a pool with small- to medium-sized gravel. Eggs are dispersed among pockets in the redds (Sandercock, 1991). The number of eggs deposited by a female (fecundity) varies widely, based primarily on size and/or migration distance (Kinnison et al., 2001). Females cover the redds with gravel and guard them until their death (Weitkamp et al., 1995).

Coho Salmon embryos develop within and hatch from fertilized eggs in 8 to 12 weeks, then remain in the gravel as alevins for another 4 to 10 weeks (Sandercock, 1991). During this period, they absorb nutrients stored in the yolk sac and develop into the fry life stage before emerging from the gravel as 30- to 50-millimeter fish (NRC, 2004). Emergence timing depends on water temperature and DO levels. Survival to emergence depends on scour and gravel movement with winter flooding accounting for a high proportion of losses. Average egg-to-fry survival for Coho Salmon in Oregon and California is variable, ranging from 27.1-74.3% (Briggs, 1953; Koski, 1966).

6.1.2.4 Rearing and Outmigration

Fry begin emerging in mid-February and continue through mid-May (Leidy and Leidy, 1984). After emergence from spawning gravels, Coho Salmon fry distribute themselves upstream and downstream, seeking favorable rearing habitat (Sandercock, 1991). Although little is known about the drivers of Coho Salmon fry movements immediately after emergence (Quinn, 2005), early emigration of fry is common.

Coho fry prefer slower velocities, favoring velocities between 0.33 and 1.64 ft/s (0.1 and 0.5 m/s), but occupy habitats ranging from 0 to 3.51 ft/s (1.07 m/s; (Hardy et al., 2006). They use habitat with water depths ranging from 0.2 to 2.89 ft (0.06 to 0.88 m), favoring depths between 0.69 and 1.31 feet deep (0.21 and 0.40 m; (Hardy et al., 2006). Coho fry prefer stream temperatures between 12 and 14°C; (Moyle, 2002), and Coho are often associated with habitats containing large woody debris and other in-stream cover (Hardy et al., 2006; Nielsen, 1992).

Some Coho Salmon fry migrate to estuarine habitats during summer and then back into freshwater habitats over winter (Koski, 2009), while others remain in the estuary for the duration of their rearing (Hoem Neher et al., 2013).

Relocation and other movement patterns of juvenile Coho Salmon show considerable variation, as juveniles seek low velocity environments to avoid unfavorable hydraulic conditions rearing (Sandercock, 1991) and nursery streams to optimize foraging opportunities (Bryant, 1983). Juvenile Coho begin downstream migration as smolts between February and June, the timing of which is a response to fish-size, flow conditions, water temperature, DO, photoperiod, and food availability (Shapovalov and Taft, 1954).

While there is no sharp physiological distinction between the fry and juvenile life-stages in Coho, juveniles are characterized by increasing territoriality. Juvenile Coho remain closely associated with slow velocity, low-gradient habitats (Lestelle, 2007; Quinn, 2005). They feed on insect drift, generally within an established territory, orienting upstream so they may dart out and grab food. Establishing feeding territories is a characteristic of most juvenile salmonids in streams and represents an important tradeoff between energy spent obtaining food and energy spent defending foraging territory. Moreover, juvenile Coho will form a foraging hierarchy and exhibit three general behavioral patterns: dominants, subdominants, and floaters (Nielsen, 1992).

Lestelle (2010) characterized juvenile Coho Salmon seasonal habitat use and movement patterns according to four patterns: spring re-distribution (and rearing), summer rearing, fall re-distribution (and rearing), and winter rearing. The spring re-distribution/rearing pattern can include small-scale movements within a tributary to areas with deeper water or large-scale movements both upstream (Hay, 2004; CDFW, 2016) and downstream (CDFW, 2016). Chesney et al. (2009) observed large-scale movements in the Shasta River as juvenile Coho Salmon migrated over 4 miles upstream to areas of cold, spring inflow after they experienced a rapid increase in maximum daily water temperatures.

Summertime movement patterns are largely driven by increases in water temperature. The thermal stress threshold is approximately 17°C for juvenile Coho Salmon rearing, and continued exposure to temperatures this high can lead to death (reviewed in Richter and Kolmes, 2005). At these temperatures, juvenile Coho redistribute to rear in cooler tributaries or move downstream to thermal refugia, which can shorten their subsequent seaward migration during the smolt stage. This strategy may enhance survival for juveniles contending with parasites such as *Ceratonova shasta* (Manhard et al., 2018), which can become especially virulent under warm water conditions.

Fall re-distribution begins in September as declining water temperatures, increasing flows, and increasing water velocities cue juvenile fish movements to off-channel habitats such as ponds, floodplains, and higher-order tributaries (Peterson, 1982; Swales and Levings, 1989; Quinn, 2005), which provide shelter from high velocities that often occur during high flows during fall and winter. The most extensive fall re-distribution of juvenile Coho Salmon occurs as individuals seek over-wintering habitats (Soto et al., 2016), where most juveniles remain until they emigrate as smolts the following spring.

During winter rearing, Coho Salmon seek low velocity habitats to overwinter (Bisson et al., 1987), particularly off-channel habitats such as alcoves, backwaters, and off-channel ponds (Swales et al., 1986, 1988; Nickelson et al., 1992; Bell et al., 2001). The availability of these overwintering habitats is one of the most important factors influencing the survival of juvenile Coho Salmon in streams (Moyle, 2002). These habitats provide cover from predators and buffer fish from high discharge events that might otherwise flush fish out of the rivers in a premature emigration or lead to mortality (McMahon and Hartman, 1989; Sandercock, 1991).

Juvenile Coho transform into smolts in preparation for moving into the saltwater environment. This transformation involves many complex processes including changes in morphology, physiology, and behavior (Folmar & Dickoff, 1980; Hoar, 1976; Wedemeyer et al., 1980). The timing of smoltification is a response to fish-size, flow conditions, water temperature, DO, photoperiod, and food availability (Shapovalov and Taft, 1954). During this process, smolts seek cover features (e.g., woody debris) that provide protection from high current velocities and predation. Shelter from higher velocities may be particularly important in preventing premature displacement (Hartman et al. 1982) since smolts exhibit reduced swimming abilities (Flagg and Smith 1981).

Starting in March, SONCC Coho Salmon smolts begin migrating downstream, and continue their outmigration into June, when they are between 90- and 112-mm fork length. Fish size, flow conditions, water temperature, DO, day length, and food availability all affect emigration timing and travel rates (Shapovalov and Taft, 1954). Arrival in coastal waters is timed with the availability of food, which is critical to survival (Walters et al., 1978). Estuarine residence time is based on a variety of factors but can last from days to a few weeks (Miller and Sadro, 2003; Clements et al., 2012; Pinnix et al., 2013; Jones et al., 2014).

6.1.3 Species Status/Viability Parameters

The status of SONCC Coho Salmon is presented within the framework provided by the VSP parameters, a framework used to assess viability and extinction risk, established by McElhany et al., 2000: abundance, productivity, population spatial structure, and diversity.

6.1.3.1 Abundance and Productivity

Abundance and productivity appear to have declined between the most recent status reviews (Williams et al., 2011, 2016). Most of the 30 independent populations in the ESU now are at high risk for extinction, and the remainder are at moderate risk (Table 6-1). No populations are at low risk of extinction and all core populations are thousands short of the numbers needed for recovery (Williams et al., 2016). This is because most are near or below their depensation threshold, which is the minimum numbers of spawners required to sustain the population. The productivity of a population is related to the number of offspring produced per generation and reflects the rapidity with which a population can recover after disturbance (Mobrand et al., 1997). Generally, declining productivity equates to declining abundance (Atlas et al., 2015). VSP criteria set a minimum duration of 12 years for reliable determination of population trend. The very limited populations (Scott and Shasta rivers) for which time-series of at least 12 years is available cannot determine whether Coho Salmon populations within the SONCC ESU are increasing or decreasing, as the 95% confidence intervals for the slope of the regression lines overlap zero (NMFS, 2019) (Table 6-1).

Table 6-1. Viability metrics for independent populations of Southern Oregon Northern California Coast Coho Salmon Evolutionary Significant Unit

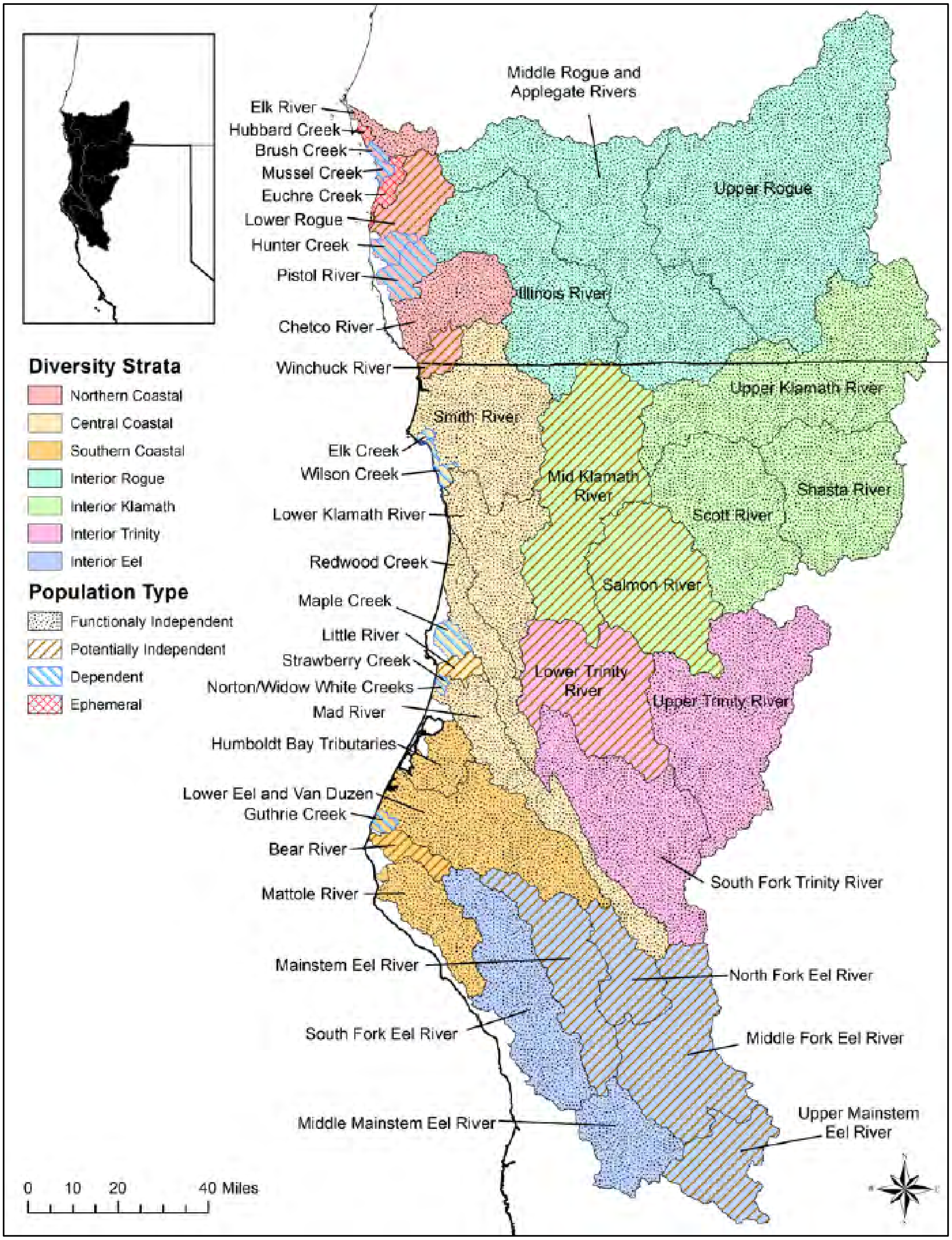
Stratum	Population	Years	$\bar{N}_{a(arith)}$	$\bar{N}_{a(geom)}$	$\bar{N}_{g(harm)}$	$\hat{C}$	$\hat{T}$ (95% CI)
Northern Coastal Basins	Elk River	-	-	-	-	-	-
Northern Coastal Basins	Lower Rogue River	-	-	-	-	-	-
Northern Coastal Basins	Checto River	-	-	-	-	-	-
Northern Coastal Basins	Winchuck River	-	-	-	-	-	-
Central Coastal Basins	Smith River [a,b] (redd estimate)	2	355	331	NA	NA	-
Central Coastal Basins	Lower Klamath River	-	-	-	-	-	-
Central Coastal Basins	Redwood Creek[b,c] (redd estimate)	4	529	516	NA	NA	-
Central Coastal Basins	Maple Creek/Big Lagoon[d]	-	-	-	-	-	-
Central Coastal Basins	Little River	-	-	-	-	-	-
Central Coastal Basins	Mad River	-	-	-	-	-	-
Southern Coastal Basins	Humboldt Bay tributaries[b,e] (redd estimate)	4	1,038	919	NA	NA	-
Southern Coastal Basins	Low. Eel/Van Duzen rivers	-	-	-	-	-	-
Southern Coastal Basins	Bear River[a]	-	-	-	-	-	-
Southern Coastal Basins	Mattole River[b,f] (redd estimate)	2	47	46	NA	NA	-
Interior – Rogue	Illinois River	-	-	-	-	-	-
Interior – Rogue	Mid. Rogue/Applegate rivers	-	-	-	-	-	-
Interior – Rogue	Upper Rogue River	-	-	-	-	-	-
Interior – Klamath	Middle Klamath River	-	-	-	-	-	-
Interior – Klamath	Upper Klamath River	-	-	-	-	-	-
Interior – Klamath	Salmon River	-	-	-	-	-	-
Interior – Klamath	Scott River[g] (video weir – adults)	8	810	404	1,713	NA	0.145 (-0.389, 0.678)
Interior – Klamath	Shasta River[h] (video weir – adults)	14	127	84	252	0.87	-0.094 (-0.231, 0.044)
Interior – Trinity	South Fork Trinity River	-	-	-	-	-	-
Interior – Trinity	Lower Trinity River	-	-	-	-	-	-
Interior – Trinity	Upper Trinity River	-	-	-	-	-	-
Interior – Eel	South Fork Eel River[b,i] (redd estimate)	4	1,347	1,310	NA	NA	-
Interior – Eel	Mainstem Eel River	-	-	-	-	-	-
Interior – Eel	North Fork Eel River[d]	-	-	-	-	-	-

Stratum	**Population**	**Years**	$\bar{N}_{a(arith)}$	$\bar{N}_{a(geom)}$	$\bar{N}_{g(harm)}$	$\hat{C}$	$\hat{T}$ **(95% CI)**
Interior – Eel	Middle Fork Eel River[d]	-	-	-	-	-	-
Interior – Eel	Middle Mainstem Eel River	-	-	-	-	-	-
Interior – Eel	Upper Mainstem Eel River[d]	-	-	-	-	-	-

Notes:
Source: Williams et al. (2016)
NA indicates not available or applicable; dash (-) indicates no estimate of appropriate spatial scale or sampling design for viability analysis. Trends are shown only for populations where time series is at least 6 years.
a – Data from Garwood and Larson (2014). Data available for 2011 and 2012, data for 2013 and 2014 not available at time of analysis.
b – Redd counts (estimates), not adult escapement.
c – Data from Ricker et al. (2014a, 2014b, 2014c, and 2014d); data from 2010 to 2013.
d – Population unit designated by Williams et al. (2006a and 2008), not included in NMFS (2014).
e – Data from Ricker et al. (2015a, 2015b, 2015c, and 2015d); data from 2010 to 2013.
f – Data from Ricker and Lindke, 2014 and Ricker et al., 2014e; data for 2011 and 2012.
g – Data from Knechtle, (2015); data from 2007 to 2014.
h – Data from Knechtle and Chesney (2014); data from 2001 to 2014.
i – Data from Ricker et al. (2015e, 2015f, 2015g, and 2015h); data from 2010 to 2013.

6.1.3.2 Spatial Structure

The SONCC Coho Salmon ESU includes populations from the Elk River (Oregon) to the Mattole River (California) and is divided into seven diversity strata, comprising 40 populations (Figure 6-2). Gilbert-Horvath et al. (2016) reaffirmed the SONCC Coho Salmon ESU boundaries through genetic analysis (Reclamation, 2020a). The genetic and life history diversity of populations of SONCC Coho Salmon is inadequate to contribute to a viable ESU, given the significant reductions in abundance and distribution (NMFS, 2019). The SONCC Coho Salmon distribution within the ESU is reduced and fragmented (NMFS, 2019), as evidenced by an increasing number of previously occupied streams from which SONCC Coho Salmon are now absent (NMFS, 2001; Good et al., 2005; Williams et al., 2011, 2016). Although extant populations can still be found in all major river basins within the ESU (70 FR 37160 [2005]), extirpations, loss of brood years, and sharp declines in abundance in several locations have contributed to fragmentation (NMFS, 2019). The genetic and life history diversity of populations of SONCC Coho Salmon is likely very low. The SONCC Coho Salmon ESU is currently considered likely to become endangered within the foreseeable future in all or a significant portion of its range, and there is heightened risk to the persistence of the ESU as VSP parameters continue to decline and no improvements have been noted since the previous status review in 2011 (Williams et al., 2016).



Source: Williams et al. (2006a)

Figure 6-2. The Southern Oregon Northern California Coast Coho Salmon Evolutionary Significant Unit

6.1.3.3 Diversity

The genetic and life history diversity of SONCC Coho Salmon populations is assumed to be very low and inadequate to contribute to a viable ESU based on the reductions in abundance and the fragmented distribution of extant populations (NMFS, 2019). The primary factors affecting the diversity of SONCC Coho Salmon ESU appear to be low population abundance and the influence of hatcheries and out-of-basin introductions (NMFS, 2014). Although the operation of a hatchery tends to increase the abundance of returning adults (70 FR 37160 [2005]), the reproductive success of hatchery-born salmonids spawning in the wild can be less than that of naturally produced fish (Araki et al., 2007). Because the main stocks in the SONCC Coho Salmon ESU (e.g., Rogue, Klamath, and Trinity rivers) exhibit low genetic diversity, remain heavily influenced by hatcheries, and have little natural production in mainstem rivers (Weitkamp et al., 1995, Good et al., 2005), many of these populations are at high risk of extinction.

6.1.3.4 Overall Status

In the most recent 5-year status review (Williams et al., 2016) and the previous NMFS 2019 BiOp (NMFS, 2019), NMFS indicated that many populations within the ESU are at a high risk of extinction (Table 6-2).

Table 6-2. Southern Oregon Northern California Coast Coho Salmon Evolutionary Significant Unit Core and Non-Core 1 populations and their predicted current risk of extinction based on available information

Stratum	Population	Estimated Extinction Risk
Northern Coastal Basin	Elk River	High*
Northern Coastal Basin	Lower Rogue River	High*
Northern Coastal Basin	Chetco River	High*
Northern Coastal Basin	Winchuck River	High*
Interior Rogue River	Illinois River	High*
Interior Rogue River	Middle Rogue/Applegate	High*
Interior Rogue River	Upper Rogue River	Moderate**
Central Coastal Basin	Smith River	High*
Central Coastal Basin	Lower Klamath River	High*
Central Coastal Basin	Redwood Creek	High*
Central Coastal Basin	Little River	Moderate**
Central Coastal Basin	Mad River	High*
Interior Klamath	Middle Klamath River	Moderate**
Interior Klamath	Upper Klamath River	High*
Interior Klamath	Shasta River	High*
Interior Klamath	Scott River	Moderate**
Interior Klamath	Salmon River	High*
Interior Trinity	Lower Trinity River	High*
Interior Trinity	South Fork Trinity River	High*
Interior Trinity	Upper Trinity River	Moderate**
South Coastal Basin	Humboldt Bay tributaries	Moderate**
South Coastal Basin	Lower Eel/Van Duzen	High*

Stratum	Population	Estimated Extinction Risk
South Coastal Basin	Mattole River	High*
Interior Eel	Mainstem Eel River	High*
Interior Eel	Middle Mainstem Eel River	High*
Interior Eel	South Fork Eel River	Moderate**

Notes: Single asterisk and red highlight signify a high extinction risk; double asterisk and yellow highlight signify a moderate extinction risk. Source: Adapted from Williams et al. (2016)

6.1.4 Limiting Factors, Threats, and Stressors

6.1.4.1 Historical and Current Limiting Factors and Stressors

The factors that have contributed to the decline of SONCC Coho Salmon populations were documented at the time the species were listed (62 FR 24588 [1997]) and summarized in the subsequent recovery plan (NMFS, 2014). Specifically, NMFS evaluated the status of SONCC Coho Salmon using the following five-factor analysis within ESA listing regulations in 50 CFR § 424 (text from NMFS [2014] is italicized and cited):

1. The present or threatened destruction, modification, or curtailment of its habitat or range
   The habitat factors for the decline of SONCC Coho Salmon are as follows: Channel morphology changes, substrate changes, loss of instream roughness, loss of estuarine habitat, loss of wetlands, loss/degradation of riparian areas, declines in water quality (e.g., elevated water temperatures, reduced dissolved oxygen, altered biological communities, toxics, elevated pH, and altered stream fertility), altered streamflows, fish passage impediments, elimination of habitat, and direct take (62 FR 24588, May 6, 1997). The major activities responsible for the decline of Coho Salmon were identified as follows: logging, road building, grazing and mining activities, urbanization, stream channelization, dams, wetland loss, beaver trapping, water withdrawals, and unscreened diversions for irrigation (62 FR 24588, May 6, 1997).

2. Overutilization for commercial, recreational, scientific, or educational purposes
   Overfishing in non-tribal fisheries was identified as a significant factor in the decline of Coho Salmon (62 FR 24588, May 6, 1997). Significant overfishing occurred from the time marine survival turned poor for many stocks (ca. 1976) until the mid-1990s when harvest was substantially curtailed. This overfishing compromised escapement levels. The contribution of recreational fisheries to the decline was unknown at the time of listing. Tribal harvest was not considered to be a major factor for the decline of Coho Salmon in either the Klamath River basin or Trinity River basin (62 FR 24588, May 6, 1997). Collection for scientific research and educational programs was believed to have little or no impact on Coho Salmon populations in the SONCC Coho Salmon ESU at the time of listing (62 FR 24588, May 6, 1997).

3. Disease or predation
   At the time of listing, disease and predation were not believed to be major factors

contributing to the overall decline of Coho Salmon, although it was recognized that they may have had substantial impacts in local areas (62 FR 24588, May 6, 1997).

4. The inadequacy of existing regulatory mechanisms
   The Northwest Forest Plan has important benefits for Coho Salmon, but its overall effectiveness in conserving SONCC Coho Salmon is limited by the extent of federal lands and the fact that Federal land ownership is often not uniformly distributed. Federal lands are often located in the upper reaches of watersheds or river basins, upstream of much of the most suitable Coho Salmon rearing habitat. In addition, in some areas Federal lands are distributed in a checkerboard fashion, which results in fragmented landscapes.
   California's forest practice rules (CFPRs), which regulate timber harvest, contained provisions that can be protective of Coho Salmon if fully implemented, but found the ability of these rules to protect Coho Salmon could be improved (62 FR 24588, May 6, 1997). In particular, the CFPRs did not adequately address large woody debris recruitment, streamside tree retention to maintain bank stability, and canopy retention standards that assure stream temperatures are properly functioning for all life stages of Coho Salmon.
   Oregon's Forest Practices Act (OFPA) did not have implementing rules that adequately protect Coho Salmon habitat. NMFS (62 FR 24588, May 6, 1997) determined that there was a low probability that adequate LWD recruitment could be achieved under the requirements of the OFPA. The OFPA was also found to not adequately consider and manage timber harvest and road construction on sensitive, unstable slopes subject to mass wasting, nor did it address cumulative effects. In particular, the OFPA was found to not provide adequate protection for the production and introduction of large woody debris (LWD) to medium, small, and non-fish bearing streams (62 FR 24588, May 6, 1997).
   The Army Corps of Engineers (ACOE) regulates removal and fill activities under section 404 of the Clean Water Act (CWA), and the Oregon Division of State Lands (DSL) manages the state-permitted portion of the removal fill laws. At the time of listing, neither the ACOE nor the DSL had in place any process to address the additive effects of the continued development of waterfront, riverine, coastal, and wetland properties (62 FR 24588, May 6, 1997).
   The final rule described fishery regulations implemented in 1994 which are more protective of SONCC Coho Salmon than were historical regulations (62 FR 24588, May 6, 1997). Specifically, in 1994 the Pacific Fishery Management Council (PFMC) recommended harvest rates below those allowed at that time, and the PFMC recommended prohibiting the retention of Coho Salmon south of Cape Falcon, Oregon, resulting in the closure of commercial ocean fishing for Coho Salmon in California in 1994. Oregon began marking all hatchery fish to aid in more accurate estimates of natural returns. Oregon regulations for ocean fisheries within 3 miles of shore had generally conformed to these more protective regulations. In 1995, ocean recreational fishing for Coho Salmon was closed from Cape Falcon to Horse Mountain.

5. Other natural or human-made factors affecting its continued existence
   NMFS determined that long-term trends in rainfall and marine productivity associated with atmospheric conditions in the North Pacific Ocean likely have a major influence on Coho Salmon production (62 FR 24588, May 6, 1997). The effects of extended drought on water

> *supplies and water temperatures were recognized as a major concern for California populations of Coho Salmon. Poor ocean conditions were believed to have played a prominent role in the decline of Coho Salmon populations in Oregon and California (62 FR 24588, May 6, 1997).*
> *The widespread use of artificial propagation of Coho Salmon was recognized to have had a significant negative impact on the production of West Coast Coho Salmon (62 FR 24588, May 6, 1997). Potential problems associated with hatchery programs include: genetic impacts on indigenous, naturally-reproducing populations; disease transmission; predation on wild fish; depletion of wild stock to increase brood stock; and replacement rather than supplementation of wild stocks through competition and continued annual introduction of hatchery fish. Advancement and compression of run timing has also been a common effect of hatchery programs.*

6.1.4.2 Updated Threats

Water Quality and Quantity Worsening instream flow conditions during summer rearing is a primary factor inhibiting recovery. In addition, high water temperatures driven by drought and low flows have contributed to unsuitable habitat conditions throughout the ESU. Finally, the continuing lack of quality winter and summer rearing habitats is a key stressor for the species (Williams et al., 2016). Despite considerable habitat restoration efforts, NMFS concluded that the risk to SONCC Coho Salmon persistence is due to habitat destruction and modification that has increased since the last status review (Williams et al., 2016).

The *2016 5-Year Review: Summary & Evaluation of Southern Oregon Northern California Coast Coho Salmon* summarizes the impact of marijuana cultivation and other agricultural practices on Coho Salmon:

An increasing contributor to low-flow conditions is the emergence of marijuana cultivation in many important watersheds of the SONCC Coho Salmon recovery domain. The SONCC domain is dominated by sparsely populated forestland, which along with the area's ideal dry summer growing conditions, have contributed to parts of the California portion becoming the nation's epicenter for outdoor marijuana cultivation. Although the number of plants grown each year in California is unknown, water diversions required to support these plants is placing a high demand on a limited supply of water (Bauer et al. 2015). Most diversions for marijuana cultivation occur at headwater springs and streams, thereby removing the coldest, cleanest water at the most stressful time of the year for Coho Salmon (Bauer, S., pers. comm. 2013b). Based on an estimate from the medical marijuana industry, each marijuana plant may consume 900 gallons of water per growing season (Humboldt Growers Association [HGA] 2010). Bauer et al. (2015) evaluated four watersheds within the California portion of the SONCC ESU known to support prolific marijuana cultivation and concluded that water demand for marijuana cultivation exceeded streamflow during low-flow periods in three of the watersheds.

Reduced flow results in shallower, smaller, and less complex pools where Coho Salmon juveniles over-summer (May and Lee 2004). Another potential result of low summer flow is loss of hydraulic connectivity in riffles (Magoulick and Kobza 2003), reducing food availability for juvenile salmonids and hence reducing growth rates (Stillwater Sciences and Dietrich 2002, McBain and

Trush 2012), increasing likelihood of starvation. With loss of connectivity, fish movement is restricted to single habitat units where they must expend energy to roam for food and become more vulnerable to predation (Magoulick and Kobza 2003).

The consumptive use of water for agricultural practices is expected to negatively impact one or more of the VSP criteria for the interior Klamath coho populations because it reduces summer and fall discharge of tributaries that the populations use (Van Kirk and Naman 2008); and low flows in the summer have been cited as limiting Coho Salmon survival in the Klamath Basin (CDFG 2002, NRC 2004). Specifically, the spatial structure, population abundance, and productivity can be impacted by agricultural activities. Altered flows likely interfere with environmental cues that initiate distribution of juvenile Coho Salmon in the river, alter seaward migration timing, and potentially impact other important ecological functions, leaving juveniles exposed to a range of poor quality habitat, and prolonged exposure to stressful over wintering and summer rearing conditions.

Rearing Habitat The *2016 5-Year Review : Summary & Evaluation of Southern Oregon Northern California Coast Coho Salmon* summarizes the threats to Coho Salmon rearing habitat:

The paucity of both instream and off-channel habitat in freshwater and the stream-estuary ecotone is an ongoing concern. Rearing Coho Salmon require pools of cool water to survive the warm summer months, and low-velocity off-channel areas during the winter to avoid being swept downstream during high flows. The lack of both summer- and winter-rearing habitat is a key stresses to this species (NMFS 2014).

Many streams within the SONCC ESU remain straightened, diked, and leveed, which results in unsuitable rearing habitat for Coho Salmon. Channel simplification causes indirect changes in the timing of peak flows, increases in the frequency of scour events, and changes in the movement of sediment through the system (IMST 2002). During winter, juvenile Coho Salmon select habitats with low water velocity such as alcoves, side channels, backwaters, beaver ponds, riverine ponds, and deep rootwad-formed pools. These habitats provide cover from predators and protection from high discharge, factors that may cause emigration and mortality of overwintering salmonids (Bell et al. 2001).

A significant contributor to lack of floodplain and channel structure in the SONCC Coho Salmon ESU is a paucity of instream large wood. Coho salmon juveniles favor pools that contain shelter provided by large wood (Reeves et al. 1989). Past and current timber harvest practices have degraded riparian forests across the SONCC Coho Salmon ESU, decreasing the number of large conifers in riparian zones, and reducing the potential for recruitment of long-lasting large wood (Sedell et al. 1988, Benda and Bigelow 2014). As a result, the amount of large wood in streams is currently far lower than historical levels, resulting in a reduced capacity of stream habitats to support Coho Salmon.

Harvest Commercial and recreational harvest trends and take that is related to research and monitoring have remained low and relatively stable and therefore remains unchanged from the last status review (Williams et al., 2016).

Disease or Predation After SONCC Coho Salmon were listed, both disease and predation were determined to be more substantial issues. Ceratomyxosis, caused by *C. shasta*, is an important source of mortality affecting juvenile Coho Salmon in the Klamath Basin (Nichols et al., 2003) and was only described for the Klamath River Basin. Severe infection of juvenile Coho Salmon by *C. shasta* may contribute to declining adult Coho Salmon returns in the Klamath Basin (Foott et al., 2010). Foott et al. (1999) found that when water temperatures are under 17°C, Klamath River salmonids appear to be more resistant to ceratomyxosis. The risk of mortality from ceratomyxosis was lowest as water temperatures increased from 13 to 15°C and was greatest as temperatures increased from 18 to 21°C (Ray et al., 2012). Similarly, predation by other hatchery salmonids, non-native Sacramento Pikeminnow (*Ptychocheilus grandis*), and other non-native species have contributed to population declines (NMFS, 2014). The effects of disease and predation have been exacerbated by ongoing drought and water temperature increases.

Regulatory Mechanisms Existing regulations related to state forest practices, state agricultural regulations, water quality programs, and beaver protection have been inadequate to protect Coho Salmon habitat and habitat functions within the SONCC ESU (Williams et al., 2016). New or improved regulations have only slightly contributed to improved Coho Salmon habitat protection and preservation. These include aquatic life criteria for contaminants; BiOps to minimize contaminants from impervious surfaces; Coho Habitat Enhancement Leading to Preservation Act to facilitate fish habitat improvement projects; suction dredge mining restrictions; temporary fishing closures, the Iron Gate HGMP for Coho Salmon, the Fall Creek HGMP; and regulation of marijuana cultivation to better manage waste discharges.

Other Natural or Human-Made Factors Changes in environmental conditions have further degraded the viability of the SONCC Coho ESU and significant negative changes to some natural factors have occurred since the first status review (Williams et al., 2016). These include persistent drought conditions, poor ocean productivity and marine survival, climate change, and increased fire frequency. Climate change is expected to result in warmer water temperatures, greater flow during winter, and less flow during summer (Dettinger et al., 2015). Because SONCC Coho Salmon are already near the southern boundary of the overall species distribution, increasing temperatures may soon exceed thermal tolerance thresholds (NMFS, 2016b). Increases in water temperatures may also exacerbate existing disease issues associated with *C. Shasta* parasitism (Ray et al., 2015).

In accordance with the Clean Water Act, the Klamath River Temperature TMDL is allocated to the sources of elevated temperature in the watershed. The Iron Gate Fish Hatchery is the one point-source heat load in the Klamath River watershed. The interstate water quality objective for temperature prohibits the discharge of thermal waste to the Klamath River, and therefore the waste load allocation for Iron Gate Hatchery is set to zero, as monthly average temperatures. The TMDL addresses elevated temperatures from natural and non-point anthropogenic sources. The non-point sources include: (1) excess solar radiation, expressed as its inverse, shade; (2) heat loads associated with increased sediment loads; (3) heat loading from impoundments; and (4) heat loads from Oregon. The assigned load allocations for temperature are expressed in Table 6-3.

Table 6-3. Temperature load allocations source allocation excess solar radiation (expressed as effective shade)

Source	Allocation[1]
Excess Solar Radiation (expressed as effective shade)	The shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire.
Increased Sediment Loads	Zero temperature increase caused by substantial human-caused sediment-related channel alteration[2].
Impoundment Discharges	Zero temperature increase above natural temperatures[3]

Notes:
Source: NCRWQCB (2010)
1. Natural temperatures are those water temperatures that exist in the absence of anthropogenic influences and are equal to natural background.
2. These allocations are assigned to the Klamath River Middle and Lower Hydrologic Areas. Major tributaries are not assigned temperature allocations because the Scott, Shasta, and Salmon River watersheds already have assigned allocations, and the Lost and Trinity rivers are not listed as impaired for temperature.
3. Substantial human-caused sediment-related channel alteration: "A human-caused alteration of stream channel dimensions that increases channel width, decreases depth, or removes riparian vegetation to a degree that alters stream temperature dynamics and is caused by increased sediment loading."

The Klamath River TMDLs for California are calculated to attain and maintain Site Specific Objectives (SSOs) for DO in the Klamath River in California. The SSOs for DO and associated DO load allocations are the primary driver in establishing the nutrient and organic matter loading capacity for the river reaches of the Klamath River in California. Stateline and tributary allocations for the nutrients (total nitrogen [TN] and total phosphorus [TP]) and organic matter (carbonaceous biochemical oxygen demand [CBOD]) were set to ensure that the site-specific DO objectives are met in the river reaches in California. Thus, achievement of the Klamath River Nutrient and Organic Matter TMDL constitutes achievement of the Klamath River DO TMDL, except in Copco 1 and 2 and Iron Gate reservoirs, which were assigned additional nutrient load allocations. The TP TMDL for the Klamath River in California equals 1,845 pounds per day. The TN TMDL for the Klamath River in California equals 14,985 pounds per day. The organic matter (CBOD) TMDL for the Klamath River in California equals 143,019 pounds per day (NCRWQCB, 2010).

Coho Salmon abundance has reduced in some populations to the extent that depensatory mechanisms may increase the risk of population and ESU extirpation. As a result, NMFS concluded that other natural or human-made factors have increased the risk to the persistence of the SONCC Coho Salmon ESU (Williams et al., 2016).

6.1.5 Recovery Plan

The recovery plan for the SONCC Coho Salmon ESU was finalized in 2014 (NMFS, 2014). Key details are summarized below.

6.1.5.1 Recovery Metrics

NMFS (2014) provides a summary of recovery metrics adapted below as Table 6-4. In NMFS' professional judgement this is the most rapid way to achieve a viable ESU. All recovery metrics in all four parameters must be met to consider the ESU recovered.

Table 6-4. Recovery metrics for Southern Oregon Northern California Coast Coho Salmon

VSP Parameter	**Population Role**[1]	**Biological Recovery Objective**	**Recovery Metrics**[2]
Abundance	Core	Achieve a low risk of extinction[3]	The geometric mean of wild adults over 12 years meets or exceeds the "low risk threshold" of spawners for each core population[3,4,5]
Abundance	Non-Core 1	Achieve a moderate or low risk of extinction[3]	The annual number of wild adults is greater than or equal to four spawners per Intrinsic Potential-km for each non-core population[3]
Productivity	Core and Non-Core 1	Population growth rate is not negative	Slope of regression of the geometric mean of wild adults over the time series ≥ zero[5]
Spatial Structure	Core and Non-Core 1	Ensure populations are widely distributed	Annual within-population juvenile distribution ≥ 80%[5] of habitat[6,7] (outside of a temperature mask[8])
Spatial Structure	Non-Core 2 and Dependent	Achieve inter- and intra- stratum connectivity	≥ 80% of accessible habitat[5] is occupied in years[9] following spawning of cohorts that experienced high marine survival[10]
Diversity	Core and Non-Core 1	Achieve low or moderate hatchery impacts on wild fish	pHOS< 0.05
Diversity	Core and Non-Core 1	Achieve life-history diversity	Variation is present in migration timing, age structure, size, and behavior. The variation in these parameters[11] is retained.

Notes:

Adapted from NMFS (2014)

1. The population roles are Core, Non-Core 1, Non-Core 2, and Dependent. Core populations are independent, likely to respond to recovery actions and quickly achieve a low extinction risk. Non-Core 1 populations (all but four populations other than "Core") will remain at least moderate risk of extinction even in a recovered state. Non-Core 2 populations (remaining four independent populations) are thought to be extirpated. Non-Core 2 and Dependent populations will support emigrants from other populations in a recovered ESU.
2. All applicable criteria must be met for each population for the ESU to be viable.
3. See Table 4-2 in NMFS (2014) for specific spawner abundance requirements needed to meet this objective.
4. In the Shasta, Upper Trinity, and Upper Rogue River populations, Intrinsic Potential above some anthropogenic dams was excluded from the spawner target, so the low-risk threshold for these populations is based on the Intrinsic Potential downstream of those dams.
5. Assess for at least 12 years, striving for a coefficient of variation of 15% or less at the population level (Crawford and Rumsey, 2011).
6. Based on available rearing habitat within the watershed (Wainwright et al., 2008). For purposes of these biological recovery criteria, "available" means accessible. 80% of habitat occupied relates to a truth value of +1.0, indicating the

statement "juveniles occupy a high proportion of the available rearing habitat within the watershed" is true (Wainwright et al., 2008).
7. The average for each of the 3-year classes over the 12-year period used for delisting evaluation must each meet this criterion. Strive to detect a 15% change in distribution with 80% certainty (Crawford and Rumsey, 2011).
8. Williams et al. (2008) identified a threshold air temperature, above which juvenile Coho Salmon generally do not occur, and identified areas with air temperatures over this threshold. These areas are considered to be within the temperature mask.
9. If YOY are sampled, sampling would occur the spring following spawning of the cohorts experiencing high marine survival. If 1+ juveniles are sampled, sampling would occur approximately 1.5 years after spawning of the cohorts experiencing high marine survival, but before outmigration to the estuary and ocean.
10. High marine survival is defined as 10.2% for wild fish and 8% for hatchery fish (Sharr et al., 2000). If marine survival is not high, then this criterion does not apply.
11. This variation is documented in the population profiles in Chapters 7 to 46 of NMFS, 2014.

6.1.5.2 Key Recovery Actions

Several important habitat protection and restoration measures have been enacted and are expected to benefit SONCC Coho Salmon. These include improvements to California's Forest Practices Act Road Rules, the creation of a new Groundwater Sustainability Management Act to protect groundwater resources, initiation of Oregon's Integrated Water Resource Strategy to improve management of instream flows and water management, the removal of Wimer and Fielder dams on the Rogue River to improve fish passage, and the implementation of multiple habitat restoration projects by California's Fisheries Restoration Grants Program and Oregon's Watershed Enhancement Board (Williams et al., 2016). Additionally, The SONCC Coho Salmon Recovery Plan includes over 4,000 specific recovery actions and their respective priorities (NMFS, 2014). These include approximately 395 actions for the Klamath River. Recovery actions include:

- Removal of or establishment of passage at dams
- Reducing unpermitted diversions
- Ensuring sufficient water quantity and quality
- Restoring in-channel habitat and upslope ecological function
- Creating suitable estuarine nurseries
- Managing fisheries
- Reducing detrimental effects of land use activities
- Decreasing disease and non-native predator species
- Operating hatcheries consistent with recovery goals

Each recovery goal is assigned a priority based on whether it would: 1) prevent significant population/habitat decline; 2) address key limiting stress/threat; 3) help a high extinction risk population; and/or 4) immediately benefit Coho Salmon. Further details including the priority of specific recovery actions by population can be found in Chapters 5 and 7 – 46 of NMFS (2014).

6.1.6 Critical Habitat

Critical habitat for the SONCC Coho Salmon ESU was formally designated on May 5, 1999 (64 FR 24049 [1999]) and includes all accessible waterways, substrate, and adjacent riparian zones between Cape Blanco, Oregon, and Punta Gorda, California. Exclusions to the critical habitat include:

- Areas above specific dams identified in the Federal Register notice
  The Federal Register presently includes IGD and therefore the Klamath River upstream of the dam is not listed in the SONCC Coho Salmon ESU and it is not critical habitat. However, with removal of the Lower Klamath Project dams, which include IGD, it is expected this will change. Therefore, this Biological Assessment assumes the area above IGD to at least Keno Dam will be designated as Critical Habitat within the time frame of this consultation.
- Areas above longstanding, natural barriers to fish passage (i.e., natural waterfalls)
- Tribal lands

In designating critical habitat for the SONCC Coho Salmon ESU, NMFS identified the following physical or biological features that are essential to conservation of the species:

- Juvenile summer and winter rearing areas
- Juvenile migration corridors
- Areas for growth and development to adulthood
- Adult migration corridors
- Spawning areas

Within these areas, Coho Salmon critical habitat includes adequate levels of the following features:

- Substrate
- Water quality
- Water quantity
- Water temperature
- Water velocity
- Cover/shelter
- Food
- Riparian vegetation
- Space

- Safe passage conditions

Also, designated freshwater and estuarine habitat includes riparian habitat with the following functions:

- Shade
- Sediment
- Nutrient or chemical regulation
- Stream bank stability
- Large wood input

Critical habitat for SONCC was summarized in the NMFS Dam BiOp [2016a] and the NMFS BiOp [2019]:

The condition of SONCC Coho Salmon critical habitat, specifically its ability to provide for their conservation, has been degraded from conditions known to support viable salmonid populations. NMFS has determined that currently depressed population conditions are, in part, the result of the following human induced factors affecting critical habitat: overfishing, artificial propagation, logging, agriculture, mining, urbanization, stream channelization, dams, wetland loss, and water withdrawals (including unscreened diversions for irrigation). Impacts of concern include altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion into streams from upland areas (Weitkamp et al. 1995; 70 FR 37160 (June 28, 2005); 64 FR 24049 (May 5, 1999)). Diversion and storage of river and stream flow has dramatically altered the natural hydrologic cycle in many of the streams within the ESU. Altered flow regimes can delay or preclude migration, dewater aquatic habitat, and strand fish in disconnected pools, while unscreened diversions can entrain juvenile fish.

The factors that caused declines include hatchery practices, ocean conditions, habitat loss due to dam building, degradation of freshwater habitats due to a variety of agricultural and forestry practices, water diversions, urbanization, over-fishing, mining, climate change, and severe flood events exacerbated by land use practices (Good et al. 2005; Williams et al. 2016b). Sedimentation and loss of spawning gravels associated with poor forestry practices and road building are particularly chronic problems that can reduce the productivity of salmonid populations. Late 1980s and early 1990s droughts and unfavorable ocean conditions were identified as further likely causes of decreased abundance of SONCC Coho Salmon (Good et al. 2005). From 2014 through 2016, the drought in California reduced stream flows and increased temperatures, further exacerbating stress and disease. Drought conditions returned to the Klamath Basin in 2020 (Reclamation 2020c), and the state of Oregon declared a state of drought emergency in the upper Klamath River Basin in early 2021 due to unusually low snow pack and lack of precipitation (Oregon 2021). Reduced flows can cause increases in water temperature, resulting in increased heat stress to fish and thermal barriers to migration.

One factor affecting the range wide status and aquatic habitat at large is climate change. The best available information suggests that the earth's climate is warming, and that this could significantly impact ocean and freshwater habitat conditions, and thus the survival of species subject to this consultation. Recent evidence suggests that climate and weather is expected to become more extreme, with an increased frequency of drought and flooding (IPCC, 2019). Per NMFS (2019), "*Average annual Northwest air temperatures have increased by approximately 1°C since 1900, or about 50 percent more than the global average warming over the same period (ISAB, 2007). The latest climate models project a warming of 0.1°C to 0.6°C per decade over the next century.*"

Per NMFS (2019), "*For Northern California and Southern Oregon, most models project heavier and warmer precipitation, which could affect stream flows. Extreme wet and dry periods are projected, increasing the risk of both flooding and droughts (DWR 2013). Annual precipitation could increase by up to 20 percent over northern California. A greater proportion of precipitation events occurring during the mid-winter months is likely to occur as intense rain and rain-on-snow events that are likely to lead to higher numbers of landslides and greater and more severe floods (Luers et al. 2006, Doppelt et al. 2008).*" Climate change effects on stream temperatures within Northern California are already apparent. For example, in the Klamath River, Bartholow (2005) observed a 0.5ºC per decade increase in water temperature since the early 1960s and model simulations predict a further increase of 1-2 ºC over the next 50 years (Perry et al., 2011). Heavier winter rainstorms from warming may lead to increased flooding and high-flow events that result in scouring of riverbeds, smothering redds, and increasing suspended sediment in systems. In the summer, decreased stream flows and increased water temperature can reduce salmon habitat and impede migration (Southern Resident Orca Task Force, 2019). Per NMFS 2019, "*Overall, there will be earlier and lower low-flows and earlier and higher high-flows. Increased flooding is likely to scour salmon eggs from their redds and displace overwintering juveniles, while lower low flows are likely to increase summer water temperatures and decrease available salmon habitat.*"

Per NMFS 2019, "*Water temperature is likely to increase overall, with higher maximum temperatures along with higher minimum temperatures in streams. Increases in winter and spring temperature regimes are likely to include, but are not limited to, depletion of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, increased bio-energetic and disease stresses on fish, and increased competition among species. In addition, the increase in summer water temperatures are likely to be especially dramatic since flows in many streams are expected to continue decreasing as a result of decreasing snowpack (Luers et al. 2006, Crozier et al. 2008, Doppelt et al. 2008, Crozier 2016). This loss of snowpack will continue to create lower spring and summertime flows while additional warming will cause earlier onset of runoff in streams.*"

Per NMFS 2019, "*Marine ecosystems and habitats important to juvenile and adult salmonids are likely to experience changes in temperatures, circulation, water chemistry, and food supplies (Feely 2004, Osgood 2008, Turley 2008, Abdul-Aziz et al. 2011, Doney et al. 2012). These changes are likely to have deleterious impacts on Coho Salmon growth and survival while at sea. Ocean acidification also has the potential to affect the phytoplankton community due to the likely loss of* *most calcareous shell-forming species such as pteropods (Crozier 2016). Related direct effects to Coho Salmon likely include decreased growth rates due to ocean acidification and increased metabolic costs due to the rise in sea surface temperature (Portner and Knust 2007).*"

In coastal and estuarine ecosystems, the threats from climate change largely come in the form of sea level rise and the loss of coastal wetlands. Sea levels will likely rise exponentially over the next 100 years, with possibly a 43-84 cm rise by the end of the 21st century (IPCC, 2019). This rise in sea level will alter the habitat in estuaries and either provide an increased opportunity for feeding and growth or in some cases will lead to the loss of estuarine habitat and a decreased potential for estuarine rearing. Marine ecosystems face an entirely unique set of stressors related to global climate change, all of which may have deleterious impacts on growth and survival while at sea. In general, the effects of changing climate on marine ecosystems are not well understood given the high degree of complexity and the overlapping climatic shifts that are already in place (e.g., El Niño, La Niña, and Pacific Decadal Oscillation) and will interact with global climate changes in unknown and unpredictable ways. Overall, climate change is believed to represent a growing threat, and will challenge the resilience of SONCC Coho Salmon.

6.1.6.1 Physical and Biological Features

The physical and biological features of Coho Salmon freshwater habitat depend on lateral (e.g., floodplain and riparian), vertical (e.g., hyporheic), and longitudinal (i.e., along the length of the stream itself) connectivity to create suitable habitat conditions for spawning, rearing, and migration. The following attributes measure habitat suitability:

- Water quality (e.g., DO, nutrients, temperature)
- Water quantity, depth, and velocity
- Riparian-stream-marine energy exchanges
- Channel gradient and stability
- Prey availability
- Cover and habitat complexity (e.g., large woody debris, pools, aquatic and terrestrial vegetation)
- Space
- Habitat connectivity from headwaters to the ocean (e.g., dispersal corridors, floodplain connectivity
- Groundwater-stream interactions
- Substrate composition

6.2 Status of the Species in the Action Area

The distribution of SONCC Coho Salmon within the whole ESU is reduced and fragmented, as evidenced by an increasing number of previously occupied streams from which SONCC Coho Salmon are now absent (NMFS, 2001; Good et al., 2005; Williams et al., 2011, 2016). The distribution of SONCC Coho Salmon is expected to change with the removal of the four Lower Klamath River dams.

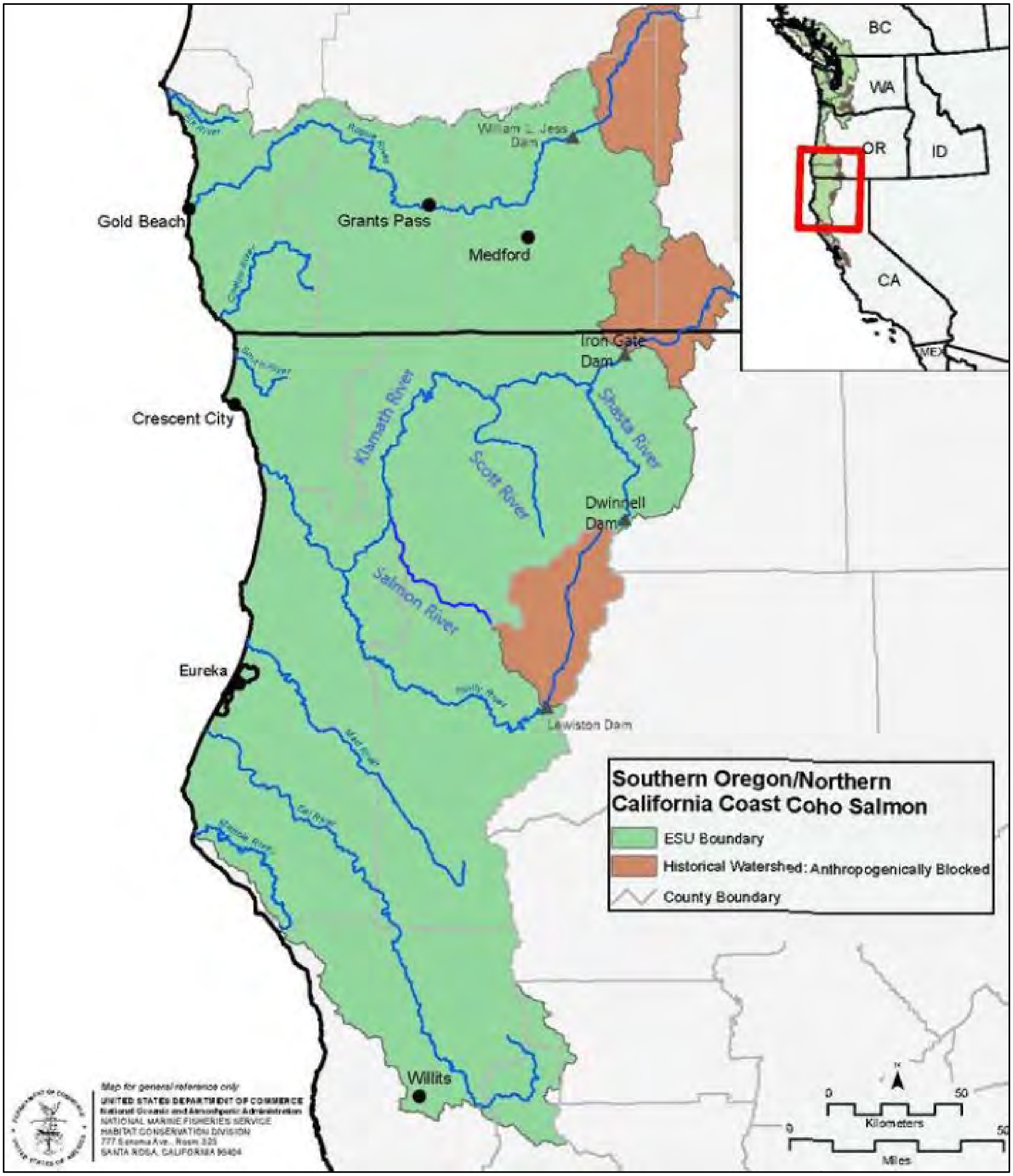
6.2.1 Distribution/Spatial Structure in the Action Area

Populations of SONCC Coho Salmon in the Klamath River include the following areas (NMFS, 2019; Figure 6-2):

- The Upper Klamath River (comprised of tributaries and mainstem Klamath River from the mouth of Portuguese Creek at RM 128 upstream to IGD at RM 190 excluding the Shasta and Scott rivers)
- The Middle Klamath River (comprised of tributaries and mainstem Klamath River from the Trinity River confluence at RM 43 upstream to the mouth of Portuguese Creek excluding the Salmon River)
- The Lower Klamath River (comprised of tributaries and mainstem Klamath River from the Trinity River confluence at RM 43 to the Klamath River mouth)
- The Salmon River (RM 66)
- The Scott River (RM 144)
- The Shasta River (RM 177)

Klamath River Coho Salmon are expected to increase their range (Figure 6-3) with the removal of the lower four Klamath River dams, including tributary and mainstem habitats up to Spencer Creek, which is the hypothesized upstream extent of their historical range.(ODFW & the Klamath Tribes, 2021).

The distribution of Klamath River Coho Salmon is reduced and fragmented, as noted for the entire ESU (NMFS, 2019). Populations still exist within all Klamath River stratum, and improvements are expected following lower Klamath dam removal (Renewal Corporation, 2021). The removal of the lower Klamath River mainstem dams may produce short-term river-tributary connectivity challenges due to increased suspended sediment concentrations and mobility (Renewal Corporation, 2021). However, over the long-term, the removal is expected to restore access to at least 76 miles of additional habitat (Williams et al., 2009; NMFS, 2007) including 53 miles of mainstem and tributary habitat and 22.4 miles currently inundated by reservoirs (Cunanan, 2009). This will result in a broader spatial distribution of SONCC Coho Salmon immediately downstream of the Action Area.



Source: NMFS (2019)

Figure 6-3. Historical and present range of Southern Oregon Northern California Coast Coho Salmon

6.2.2 Species Status/Viability Metrics

The status of SONCC Coho Salmon in the Action Area is presented in this section within the framework provided by the VSP (Section 6.1.3). Note: population spatial structure, including information on current and historical distribution is discussed in Section 6.1.3 and will not be discussed further here. Quantitative population level estimates of abundance and productivity greater than the minimum duration under the viability criteria (i.e., 12 years) were lacking for nearly all populations in the Action Area. Therefore, this assessment uses existing information, such as the Recovery Plan for SONCC Coho Salmon (NMFS, 2014) and the 2016 SONCC Status Review (Williams et al., 2016) to qualitatively assess the status of the Klamath population.

In the Klamath River Basin, Nickelson (2006) found that the marine survival of hatchery-produced Coho Salmon was highly variable from year to year and presumed that wild Coho Salmon survival is similarly variable. It was estimated that the survival of Klamath River Coho Salmon originating from Iron Gate Hatchery ranged from 0.12% to 5.7% from 1977 to 2001 (Nickelson 2006).

6.2.2.1 Abundance and Productivity

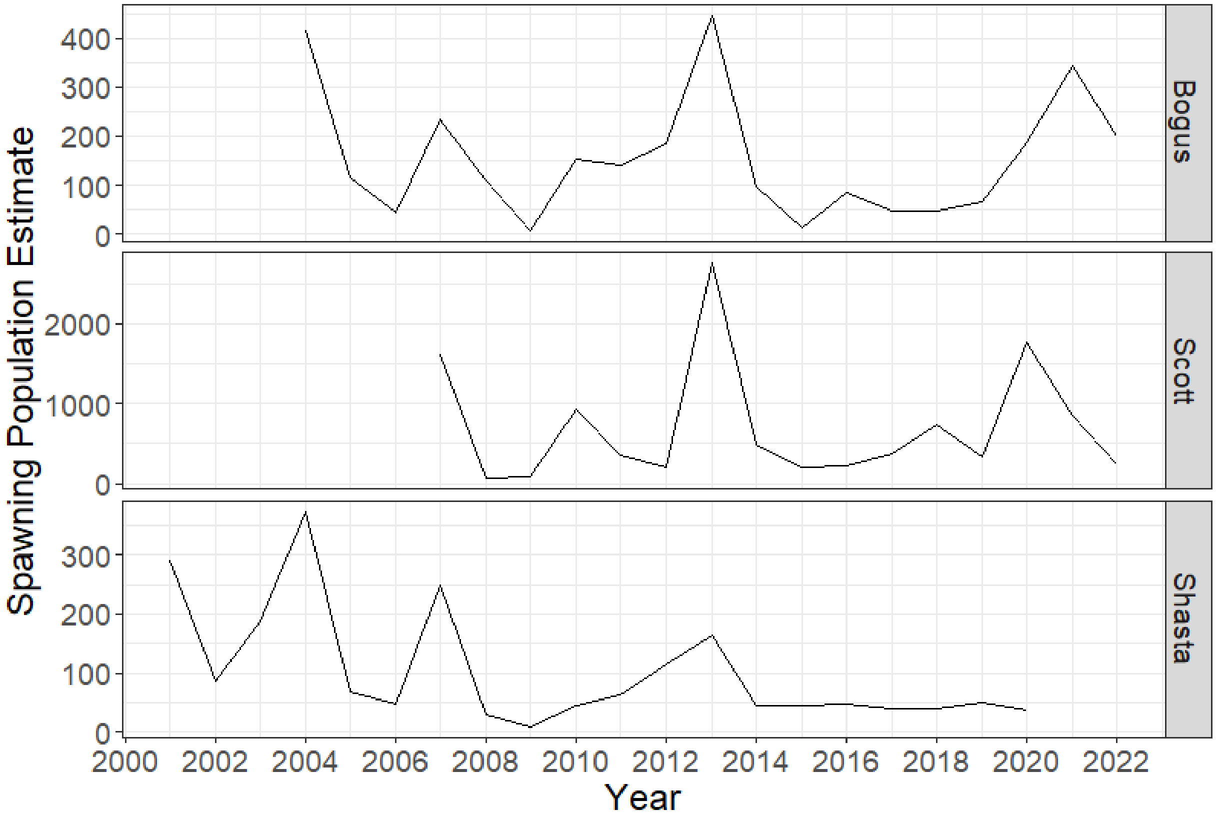
The Shasta and Scott River adult video weir monitoring projects are the longest-term population scale monitoring effort for SONCC Coho Salmon. Only the Shasta River dataset met the minimum duration (12-years) at the most recent status update. However, more recent data from both the Scott and Shasta rivers for the years 2015-2020 have been analyzed and are presented here, consistent with the approach outlined in Williams et al. (2016). Also, a long-term adult weir monitoring dataset for Bogus Creek (CA) that meets the minimum duration criteria was analyzed consistent with Williams et al. (2016) and included (Table 6-5).

Table 6-5. Viability metrics for Bogus, Scott, and Shasta River spawning populations of Southern Oregon Northern California Coast Coho Salmon Evolutionary Significant Unit

Stratum	Population	Data Source	Years	$\bar{N}_{Geom}$	T (95% CI)
Interior – Klamath[1]	Bogus Creek[2]	Knechtle and Giudice, 2022	2004 –2022 (19)	102	0.002 (-0.096, 0.100)
Interior – Klamath[1]	Scott River	Knechtle and Giudice, 2022	2007 – 2022 (16)	427	0.044 (-0.081, 0.170)
Interior – Klamath[1]	Shasta River	Giudice and Knechtle, 2022	2001 – 2020 (20)	*69**	**-0.075 (-0.141, -0.010)****

Notes:
1. All other Klamath River populations do not have abundance estimates of appropriate duration and have been omitted.
2. Bogus Creek was not specifically named or included in previous analyses, but greater than 12 years of weir data now exist, so it was analyzed using the same methods.
* Means below depensation threshold in *italics* and denoted with asterisk.
** Slopes significantly different from zero are in **bold** and denoted with double asterisk.

Estimates of mean abundance remain above the depensation threshold for Scott River Coho (i.e., 250 fish) and below the depensation threshold for Shasta River Coho (i.e., 144 fish) incorporating the most current data (Table 6-5; Figure 6-4). This is consistent with the most recent 5-year Status Review (Williams et al., 2016) (Table 6-1). In individual years, both populations are consistently below their depensation thresholds (Figure 6-4).

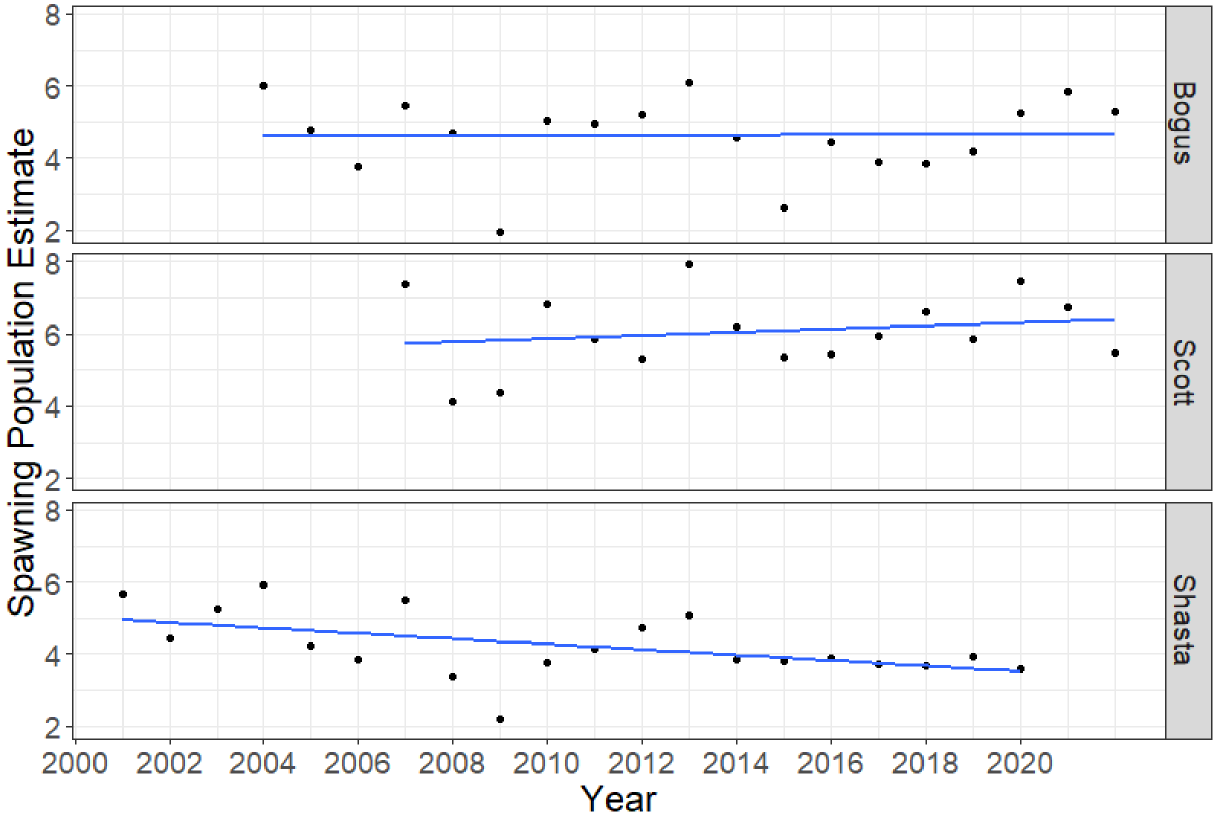


Source: Data from Knechtle and Giudice (2022); Giudice and Knechtle (2022)

Figure 6-4. Adult Spawning population abundance for Bogus, Scott, and Shasta River populations of Southern Oregon Northern California Coast Coho Salmon

Since the last 5-year Status Review, the mean population estimates of all three populations in the Klamath River Basin did not show an increasing trend. The abundance trends for Bogus Creek and Scott River did not differ from zero (Figure 6-5; Table 6-6) either at the last Status Review or through the most recently reported data. This indicates no statistically significant trend (i.e., increasing or decreasing). However, Shasta River Coho Salmon do demonstrate a significant, decreasing trend after incorporating data collected since the last Status Review (i.e., 2014-2020).

The drawdown and concurrent sediment release from the removal of lower Klamath River dams is expected to adversely affect spawning sites, food resources, and water quality over the short-term (less than 2 years following dam removal) potentially resulting in a reduction in abundance and productivity of SONCC Coho Salmon in the Action Area (Renewal Corporation, 2021). However, the long-term creation of more natural substrate, quality spawning sites, enhanced food resources, expanded riparian habitat, and improved water quality along with reduced disease presence is likely to improve the abundance and productivity of SONCC Coho Salmon in the Action Area (Renewal Corporation, 2021).



Source: Data from Knechtle and Giudice (2022, 2023); Giudice and Knechtle (2022)

Figure 6-5. Population trends (natural log abundance) for Bogus, Scott and Shasta River populations of Southern Oregon Northern California Coast Coho Salmon

Table 6-6. Klamath River Coho Salmon Evolutionary Significant Unit Core and Non-Core 1 populations and their predicted current risk of extinction

Stratum	Population	Depensation Threshold (Geometric Mean)
Central Coast Basin	Lower Klamath River	205
Interior Klamath	Middle Klamath River	113
Interior Klamath	Upper Klamath River	425
Interior Klamath	Shasta River	144
Interior Klamath	Scott River	250
Interior Klamath	Salmon River	114

Source: Table 2-3 in Williams et al. (2008)

6.2.2.2 Diversity

The Central Coastal Basin and Interior Klamath diversity strata do not support a single viable population per the Technical Recovery Team's viability criteria (low extinction risk; Williams et al., 2008) nor is either stratum considered viable as a whole. The SONCC Recovery Plan assessed the Middle Klamath and Scott River populations as moderate extinction risk and the Lower Klamath, Upper Klamath, Shasta River, and Salmon River populations as high extinction risk (Table 6-2; Table 6-6). Also, four of six independent populations are considered high risk for extinction and the remaining two are moderate.

All evidence indicates that the Klamath River populations are low and of unknown trend or declining (NMFS, 2014). Population abundance and productivity are low, in some cases below depensation either on average or during individual years. However, most population trends are indistinguishable from zero (i.e., unknown if increasing or decreasing). All populations are at a high-moderate risk of extinction, and neither diversity strata support a single viable population though all diversity strata are occupied.

6.2.3 Importance of Population(s) within Action Area to Overall Species Viability and Extinction Risk

NMFS (2019) and other documents have not explicitly assessed the importance or priority of individual strata or populations. However, the importance of the Klamath River populations can be inferred from both their population role and proportion of spawners they are expected to contribute to the ESU. Four of the six Klamath River populations (i.e., Lower and Upper Klamath, Scott, and Shasta) are classified as "Core" populations per the SONCC Recovery Plan (Table 6-2; NMFS, 2014). The remaining two populations (i.e., Middle Klamath and Salmon River) are classified as "Non-Core 1." Core populations represent key independent populations that are required to be at low extinction risk with a stable or positive population trend in a recovered state. Non-Core 1 populations are required to be at no more than moderate extinction risk also with a stable or positive population trend. The six populations combined represent a substantial plurality of the ESU's total abundance and productivity targets (Williams et al., 2016, Table 6). These populations are critical to achieving targets set forth in the SONCC Recovery Plan.

Klamath River Coho Salmon populations are critically important to species viability and extinction risk for the SONCC Coho Salmon ESU. Klamath River Coho Salmon populations also represent the entirety of one diversity stratum (i.e., Interior Klamath River) and a substantial portion, in terms of spawner abundance targets, of another (i.e., Central Coastal basins). These populations must remain extant and healthy to preserve spatial structure and diversity criteria under the SONCC Recovery Plan. They are high value populations that contribute substantially to the abundance, productivity, spatial structure, and diversity of the SONCC ESU.

6.3 Effects Analysis

The following sections summarize potential effects of the Proposed Action to Coho Salmon by life stage and stressors. Chapter 4 shows how the seasonal operations of the Project change UKL elevations and Klamath River flows in different locations and under different hydrologic conditions. APPENDIX B summarizes when fish may be present in different locations based on historical monitoring in the Klamath Basin.

6.3.1 Adults

The period of adult migration and holding is from September to February (i.e., FW) with the peak period lasting from October through November at the Klamath River – Keno Dam to the IGD and Klamath River – IGD (and tributaries) to Mouth (Figure 6-1). Adult spawning runs from October through January (i.e., FW) with the peak period lasting from November through December.

The Stressors that influence Coho Salmon adults are as follows: dewatering, disease, habitat quantity and quality, restoration, sedimentation, water quality – dissolved oxygen (DO), water quality – nutrients, and water quality – temperature.

The Proposed Action is not anticipated to change the following stressors that impact Adult Coho Salmon:

- Dewatering in spring, summer, and fall as flows at this time of year are adequate and higher than the MS scenario and ramping rates are protective.
- Disease during fall and winter in the Klamath River from Keno Dam to the mouth as water temperatures are cold and Klamath River Salmonids are not known to experience disease with cold water temperatures.
- Restoration during summer in the Klamath River from the IGD to the mouth. Restoration may exacerbate existing stressors during the construction period and over the short-term. However, restoration is expected to be beneficial over the long-term.
- Sedimentation during summer in the Klamath River from the IGD to the mouth. Higher flows may mobilize and deposit more fine sediments. However, adults are highly mobile and tolerant of suspended sediments.
- DO during winter in the Klamath River from Keno Dam to the IGD and during summer, fall, and winter in the Klamath River from the IGD to the mouth. DO concentrations in the winter are saturated due to low water temperatures. DO levels are not expected to decrease to sub-lethal levels for Coho in summer and fall.
- Nutrients during winter in the Klamath River from Keno Dam to mouth and during summer, fall, and winter in the Klamath River from the IGD to the mouth. Nutrients are not a limiting factor in winter or fall. Higher flows may mobilize nutrients downstream in the form of UKL algal blooms in summer. However, higher flows will also dilute incoming nutrients reducing their effect.

Stressors that may change at a level that is **insignificant or discountable** include the following:

- Habitat Quantity and Quality is anticipated to increase during summer from the IGD to the mouth and to decrease during winter in the Klamath River from Keno Dam to the mouth. In summer, the Proposed Action is anticipated to result in slightly higher summertime flows, which may increase habitat quantity in this reach by a negligible amount. In winter, the Proposed Action is anticipated to result in reduced winter flows, which may reduce quality and quantity of habitat in this reach by a negligible amount. However, adults are sufficiently mobile to re-locate to deeper habitat, so spawning Coho Salmon are anticipated to be able to sufficiently access habitat (deep pools) to successfully hold and spawn within this reach.

- DO is anticipated to decrease during fall in the Klamath River from Keno Dam to the former IGD. The Proposed Action is anticipated to result in substantially lower flows relative to the MS scenario during fall in this reach, which may interact with already low DO levels in Keno Impoundment to decrease DO levels downstream. However, DO levels are not expected to decrease to harmful levels for Coho (Dahlberg et al., 1968; Davis, 1975; Davis et al., 1963).

- Nutrients are anticipated to decrease during summer in the Klamath River from Keno Dam to the IGD. The Proposed Action is anticipated to result in increased flows during summer in this reach, which may dilute incoming nutrients.

- Water temperature is anticipated to increase during summer from Keno Dam to the IGD. The Proposed Action is anticipated to increase flow during summer in this reach, but as this additional flow comprises warmer water from UKL, this may lead to slightly increased downstream temperatures that reduce the effectiveness of cold water refugia for migrating adults.

- Water temperature is anticipated to increase during fall and decrease during winter in the Klamath River from Keno Dam to the mouth. During fall, substantially lower flows resulting from the Proposed Action may result in higher water temperatures; however, decreasing solar radiation during these months will minimize the magnitude of this effect as water temperatures are seasonally decreasing, particularly in October and November. Winter water temperature may be affected by the Proposed Action, but temperature never gets outside the preferred range for the species during these months. Lower flows relative to MS scenario may result in the formation of frazil and/or anchor ice in winter, but adults are highly mobile and can avoid such ice in other areas/systems, especially as they prefer deep pools during winter (Reclamation, 2020a).

Stressors that are exacerbated—potentially resulting in incidental take—and those that are potentially ameliorated by the Proposed Action are described in Sections 6.3.1.1 through 6.3.1.5. Conservation measures included as part of the Proposed Action to avoid or compensate for adverse effects are also described in Sections 6.4.

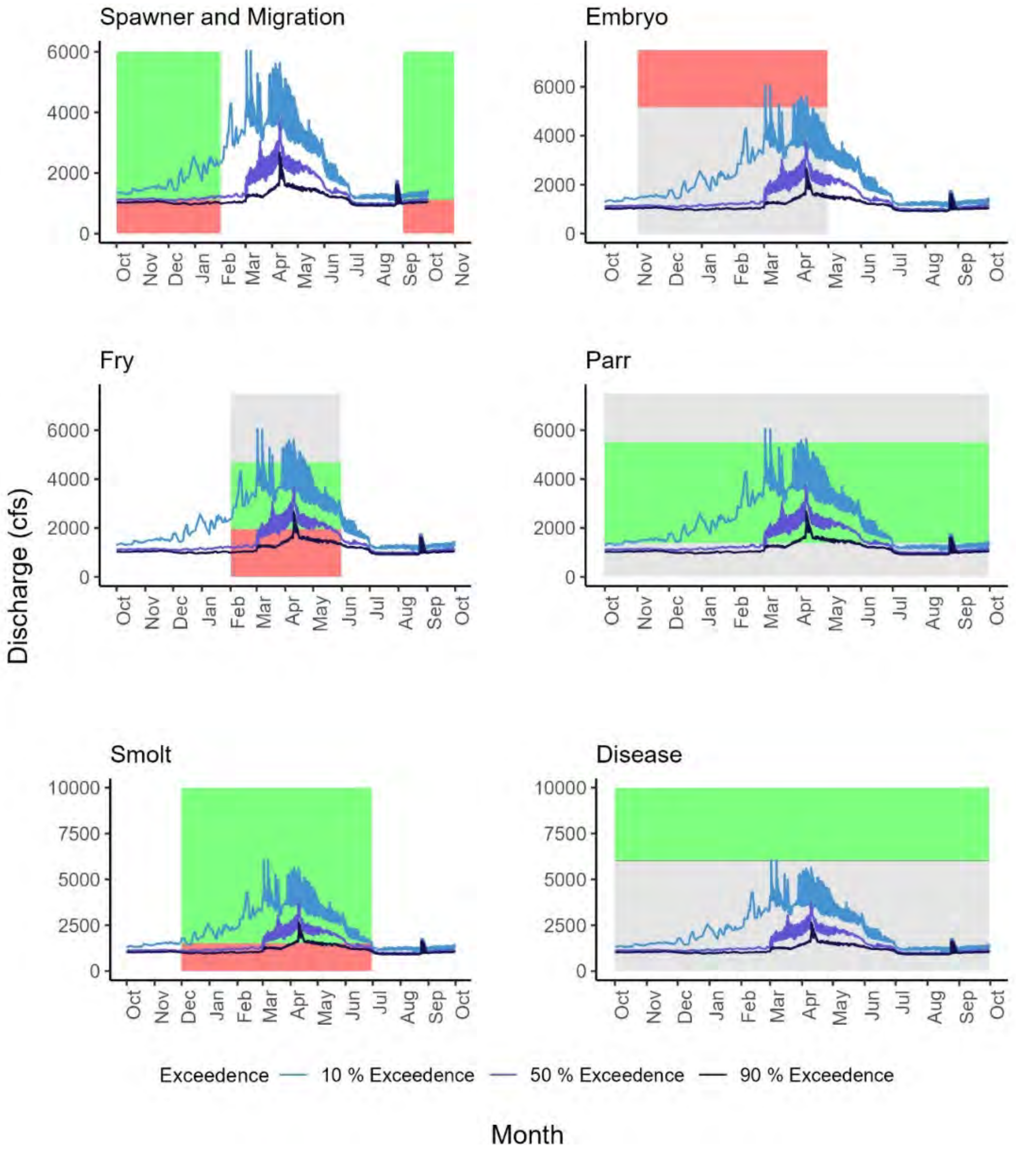
6.3.1.1 Habitat Quantity and Quality

During summer, the Proposed Action is anticipated to increase the amount of adult Coho Salmon habitat in the Klamath River from Keno Dam to the IGD. Higher flows will result in increased habitat quantity throughout this area.

During fall, the Proposed Action is anticipated to reduce the quantity and quality of adult Coho Salmon habitat in the Klamath River from Keno Dam to the mouth. Substantially lower flows relative to MS scenario in October and November will reduce the quantity and quality of habitat available.

Analysis Description This analysis of existing literature provides a tool for assessing the effects of different flows on several key life stages of Coho. Flow provides a reasonable proxy for habitat quality and quantity as it affects most other factors impacting Coho Salmon habitat including DO, temperature, and nutrients. The utility of this approach is to examine the relationship between specific flow conditions predicted for the Proposed Action and positive and negative thresholds for physiological and behavioral effects on Coho Salmon based on existing literature.

Figure 6-6 shows the intersection between the 90%, 50%, and 10% exceedance flows at IGD if the Proposed Action was implemented during the period of record (1991-2019) and the generalized effects of flow ranges and thresholds on Coho Salmon adults, embryos, juveniles, smolts, and disease risks to fish. Flow ranges can affect survival, successful reproduction, and/or growth. The length of each rectangle represents the period that each life-stage is active in the freshwater environment while the height indicates the range of flows. Green shading reflects ranges of positive effects, red reflects ranges of negative effects and grey is unknown.



Notes: Numbers in the plotting area indicate the metadata references: 1. Guillen, (2003); 2. USFWS (2016); 3. Holmquist-Johnson and Milhous (2010); 4. Ericksen et al. (2007); 5. Hardy et al. (2006); 6. David et al. (2017a); 7. David et al. (2017b); 8. Beeman et al. (2012). The 90%, 50%, and 10% exceedances from IGD are indicated by the colored blue lines. Red rectangles represent temperature ranges with negative impacts to the life stage shown. Green rectangles represent positive impacts to life stage shown.

Figure 6-6. Analysis of the temporal effects of different flow ranges on Coho Salmon adults, embryos, juveniles, and smolts, and fish affected by disease mitigation

Analysis Results Adult freshwater migration occurs from September through mid-January (Hardy et al., 2006). Guillen (2003) asserted that adult Chinook migration was inhibited in 2002 as a result of extreme low flows, which can limit the depth of water available for cover and navigation as well as olfactory cues from natal streams. Coho have been shown to respond similarly to low-flow conditions (Sandercock, 1991), and therefore Reclamation has assumed that the observations of Guillen (2003) apply to Coho as well (Figure 6-6). Flow releases in September

2002 at IGD averaged 759 cfs (Lynch and Risley, 2003); a significant reduction in flow from unimpaired discharges (>1,110 cfs) estimated by Hardy and Adley (2001). Under the Proposed Action, adults Coho Salmon are within their optimum flows 78% of the migration during half the modeled period of record (i.e., 50% exceedance; Figure 6-6, Table 6-7). This demonstrates that, while the Proposed Action is a reduction in habitat from MS, it nonetheless provides optimum flow conditions in adult migration corridors (Section 6.4) in at least half of years.

Table 6-7. The number of days Coho are positively or negatively affected by Proposed Action exceedance flows simulated by the Klamath Basin Planning Model over the period of record, 1991-2022

Life Stage	10% Exceed. Below Optima	10% Exceed. Within Optima	10% Exceed. Above Optima	50% Exceed. Below Optima	50% Exceed. Within Optima	50% Exceed. Above Optima	90% Exceed. Below Optima	90% Exceed. Within Optima	90% Exceed. Above Optima
Adult Migration	0 (0%)	153 (100%)	0 (0%)	34 (22%)	119 (78%)	0 (0%)	153 (100%)	0 (0%)	0 (0%)
Embryo/ Alevin	0 (0%)	180 (99%)	1 (1%)	0 (0%)	181 (100%)	0 (0%)	0 (0%)	181 (100%)	0 (0%)
Fry	0 (0%)	106 (88%)	14 (12%)	56 (47%)	64 (53%)	0 (0%)	118 (98%)	2 (2%)	0 (0%)
Parr	104 (28%)	260 (71%)	1 (0%)	267 (73%)	98 (27%)	0 (0%)	305 (84%)	60 (16%)	0 (0%)
Smolt	5 (2%)	207 (98%)	0 (0%)	119 (56%)	93 (44%)	0 (0%)	180 (85%)	32 (15%)	0 (0%)
Disease	365 (100%)	0 (0%)	0 (0%)	365 (100%)	0 (0%)	0 (0%)	365 (100%)	0 (0%)	0 (0%)

Note: Parentheses indicate the percentage of days affected of the total days each life stage is active.

Flows would likely be higher during fall and winter under the MS scenario than if the Proposed Action were implemented. Therefore, the Proposed Action may negatively impact adult Coho during the adult migration and spawning period, in relation to the MS scenario. However, in the summer flows will be higher under the Proposed Action, relative to MS, thereby positively impacting Coho Salmon. For additional habitat effects modeling and discussion, see Section 6.4.

6.3.1.2 Sedimentation

During fall and winter, the Proposed Action is anticipated to result in beneficial effects regarding sedimentation stressors for adult Coho Salmon in the Klamath River from Keno Dam to the mouth. Lower flows relative to MS scenario are likely to reduce sediment mobilization. Fish respiration will likely improve as will prey availability.

The Proposed Action will result in lower peak flows during the fall and winter (Table 6-8) relative to the Proposed Action (Table 6-9 and Table 6-10; see also Tables 4-2 and 4-3) these lower flows will reduce the volume of sediment mobilized downstream. This will result in beneficial impacts to migration Coho Salmon adults. These higher flows are not expected to impact spawning adults as redds are generally already built in areas of high flow.

Table 6-8. Daily average Iron Gate Dam exceedance flows for the Proposed Action, 1991-2022

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	1,012	1,019	962	969	996	1,131	1,422	1,265	1,071	918	914	998
90%	1,023	1,044	985	992	1,020	1,237	1,565	1,372	1,154	927	925	1,010
85%	1,032	1,061	1,003	1,022	1,050	1,276	1,637	1,483	1,208	940	934	1,027
80%	1,049	1,073	1,023	1,041	1,069	1,310	1,670	1,533	1,235	948	945	1,038
75%	1,065	1,083	1,039	1,061	1,088	1,362	1,742	1,612	1,260	958	955	1,049
70%	1,079	1,095	1,052	1,081	1,108	1,425	1,882	1,676	1,275	972	967	1,059
65%	1,091	1,105	1,065	1,097	1,131	1,504	1,980	1,755	1,301	980	975	1,069
60%	1,105	1,115	1,079	1,121	1,160	1,584	2,090	1,815	1,319	990	988	1,081
55%	1,118	1,122	1,100	1,151	1,198	1,724	2,204	1,877	1,338	999	1,005	1,096
50%	1,130	1,132	1,119	1,187	1,231	1,866	2,296	1,932	1,360	1,009	1,019	1,109
45%	1,137	1,142	1,143	1,223	1,303	2,049	2,523	2,026	1,398	1,023	1,041	1,122
40%	1,149	1,163	1,171	1,258	1,380	2,306	2,691	2,141	1,442	1,040	1,062	1,133
35%	1,165	1,188	1,205	1,316	1,476	2,556	2,863	2,306	1,502	1,077	1,080	1,146
30%	1,199	1,217	1,259	1,404	1,558	2,892	3,004	2,526	1,572	1,096	1,115	1,166
25%	1,253	1,267	1,346	1,538	1,801	3,079	3,247	2,642	1,608	1,134	1,165	1,182
20%	1,296	1,319	1,526	1,779	2,242	3,293	3,560	2,759	1,668	1,159	1,229	1,204
15%	1,329	1,436	1,754	1,997	2,694	3,504	4,116	2,999	1,798	1,200	1,306	1,233
10%	1,421	1,543	1,977	2,333	3,307	3,969	4,710	3,325	1,981	1,252	1,363	1,291
5%	1,540	1,860	3,024	3,747	4,708	5,004	5,543	4,222	2,421	1,334	1,562	1,443

Table 6-9. Daily average Iron Gate Dam exceedance flows for the Without Action, 1991-2022

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	620	2,648	1,145	826	739	719	714	707	620	613	605	599
90%	640	2,817	1,270	971	887	751	753	917	632	619	612	609
85%	661	2,886	1,349	1,152	1,041	789	866	1,126	651	625	619	618
80%	683	2,950	1,406	1,301	1,122	894	1,153	1,258	679	633	622	627
75%	706	3,024	1,454	1,406	1,206	1,042	1,355	1,386	697	641	628	636
70%	728	3,084	1,523	1,520	1,281	1,298	1,491	1,500	725	650	633	640
65%	754	3,133	1,601	1,594	1,402	1,513	1,615	1,623	776	656	640	647
60%	1,927	3,186	1,667	1,649	1,485	1,705	1,749	1,745	861	667	645	654
55%	2,354	3,233	1,726	1,702	1,571	1,874	1,855	1,887	950	675	653	663
50%	2,459	3,295	1,789	1,762	1,696	2,015	2,007	2,049	1,050	682	661	674
45%	2,543	3,352	1,871	1,849	1,822	2,229	2,143	2,328	1,186	689	666	685
40%	2,600	3,417	1,973	1,977	1,981	2,502	2,335	2,548	1,322	700	676	693
35%	2,643	3,482	2,101	2,123	2,142	2,713	2,558	2,775	1,480	711	686	702
30%	2,715	3,543	2,210	2,277	2,393	2,888	2,783	3,013	1,652	726	696	710

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
25%	2,794	3,613	2,319	2,496	2,707	3,111	3,044	3,226	1,808	743	704	718
20%	2,872	3,701	2,502	2,854	3,087	3,390	3,417	3,419	2,045	771	713	726
15%	2,973	3,806	2,815	3,373	3,431	3,696	3,809	3,751	2,243	827	724	738
10%	3,085	3,960	3,223	3,885	4,105	4,185	4,361	4,096	2,782	979	740	778
5%	3,307	4,224	3,973	5,484	5,327	4,956	4,805	4,533	3,492	1,265	792	1,071

Table 6-10. Difference between Proposed Action and Without Action daily average Iron Gate Dam exceedance flows, 1991-2022

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	392	-1,629	-184	143	256	412	708	558	451	304	308	399
90%	383	-1,773	-285	21	133	486	811	456	522	308	312	401
85%	371	-1,825	-346	-130	9	487	771	357	556	315	315	409
80%	366	-1,877	-383	-260	-53	416	517	275	556	315	323	411
75%	359	-1,940	-415	-344	-119	319	387	226	563	317	327	413
70%	351	-1,989	-471	-440	-174	126	390	176	551	322	334	419
65%	336	-2,028	-535	-496	-271	-9	365	131	525	324	335	422
60%	-822	-2,072	-587	-528	-325	-121	341	70	457	323	342	427
55%	-1,236	-2,111	-626	-551	-373	-150	349	-9	388	325	353	433
50%	-1,330	-2,163	-671	-575	-465	-149	289	-118	310	327	358	435
45%	-1,405	-2,210	-728	-626	-519	-180	380	-301	211	333	374	437
40%	-1,452	-2,254	-801	-719	-601	-196	355	-408	120	340	386	440
35%	-1,478	-2,294	-896	-807	-665	-157	305	-469	22	367	394	444
30%	-1,516	-2,326	-951	-873	-836	4	221	-487	-80	370	419	455
25%	-1,541	-2,346	-972	-958	-906	-32	203	-584	-200	391	461	464
20%	-1,576	-2,382	-976	-1,076	-846	-97	143	-660	-376	388	516	478
15%	-1,644	-2,370	-1,061	-1,376	-737	-191	307	-752	-445	372	582	494
10%	-1,664	-2,417	-1,246	-1,551	-798	-216	349	-771	-802	274	622	512
5%	-1,767	-2,364	-949	-1,737	-619	47	738	-311	-1,071	69	770	371

Note: Green shading denotes positive number; pink and (- sign) denotes negative number.

Substantial legacy sediment load is currently present and available for transport in the former reservoir reaches downstream as a result of dam removal. Effects of transport of these sediments have already been consulted on as part for the Renewal Corporation's 2021 Biological Assessment (Renewal Corporation, 2021; per J. Simondet, pers. comm. 04/19/24). The Proposed Action is not expected to impact these sediments given the lower flows as compared to MS scenario.

6.3.1.3 Dissolved Oxygen

During summer, the higher flows under the Proposed Action may result in beneficial effects regarding DO stressors for adult Coho Salmon in the Klamath River from Keno Dam to IGD. However, the complex interaction of DO, temperature, and nutrients will likely render these effects negligible and uncertain.

Low DO concentrations immediately downstream of IGD do occur during the summer. These low DO concentrations were largely driven by the effects of the PacifiCorp Hydroelectric Project (NMFS, 2007). However, the highly eutrophic outflow from UKL was also a driving factor and is expected to continue post-dam removal.

Project operations may influence DO concentrations since they directly affect Klamath River discharge, which is related to DO concentration at certain Klamath River sites (Asarian and Kann, 2013). Because DO is affected by algal blooms, temperature, and discharge, the effect of the Proposed Action on DO cannot be precisely determined.

Stimulation of any kind of plant growth can affect DO concentrations. As NMFS 2019 stated, "*While [an] increase in nutrients in the mainstem Klamath River between IGD (RM 190) and Seiad Valley (RM 129) is not likely to have a direct influence on periphyton growth, the […] reduction of mainstem flows has a larger effect on periphyton and its influence on DO concentration. Several mechanisms are responsible for flow effects on periphyton biomass. Some of these include the relationship between flow and water temperature, water depth, and water velocity. When low flows lead to warmer water temperature, periphyton growth likely increases (Biggs 2000). High flows increase water depth, which likely reduce light penetration in the river. Conversely, low flows generally decrease water depth, which increases periphyton photosynthesis. Low water depth also disproportionally amplifies the relative water quality effects of periphyton (i.e., diel cycles of DO would be magnified) because the ratio between the cross-sectional area and channel width decreases (i.e., mean depth decreases). In other words, the inundated periphyton biomass would have greater water quality effect on the reduced water column.*"

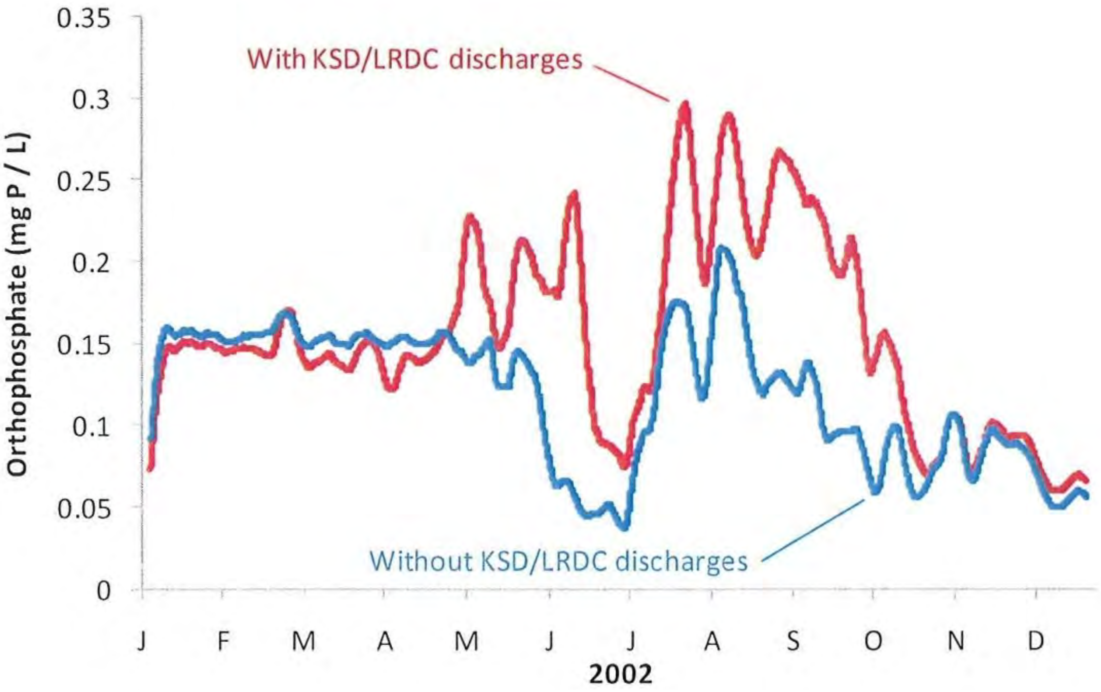
In late summer, the Proposed Action could potentially result in a slight increase in DO relative to MS scenario. Higher downstream flows under the Proposed Action may contribute to improved DO concentrations. However, this beneficial effect will likely be mediated by an increase in temperature (Section 6.3.1.5) as a result of warm water releases downstream from UKL. Additionally, these releases may transport nutrients, algal blooms, and organic detritus downstream which could further reduce DO. Under the MS scenario, flows may fall below minimums (Section 6.3.1.1) established by the Proposed Action, resulting in lower DO but the release of warm water from UKL and transport of nutrients, algal blooms, and other organic detritus may act to mitigate this effect. While the Proposed Action could result in beneficial effects to DO the complex interaction of DO, temperature, and nutrients will likely render these effects negligible and uncertain.

6.3.1.4 Nutrients

During fall, the Proposed Action is anticipated to result in increased nutrient loading in the Klamath River from Keno Dam to IGD. Substantially lower flows relative to the MS scenario may result in higher concentrations of nutrients in the form of algae transported downstream from Keno Impoundment. Higher nutrients may result in higher rates of decomposition in the reach further reducing DO levels.

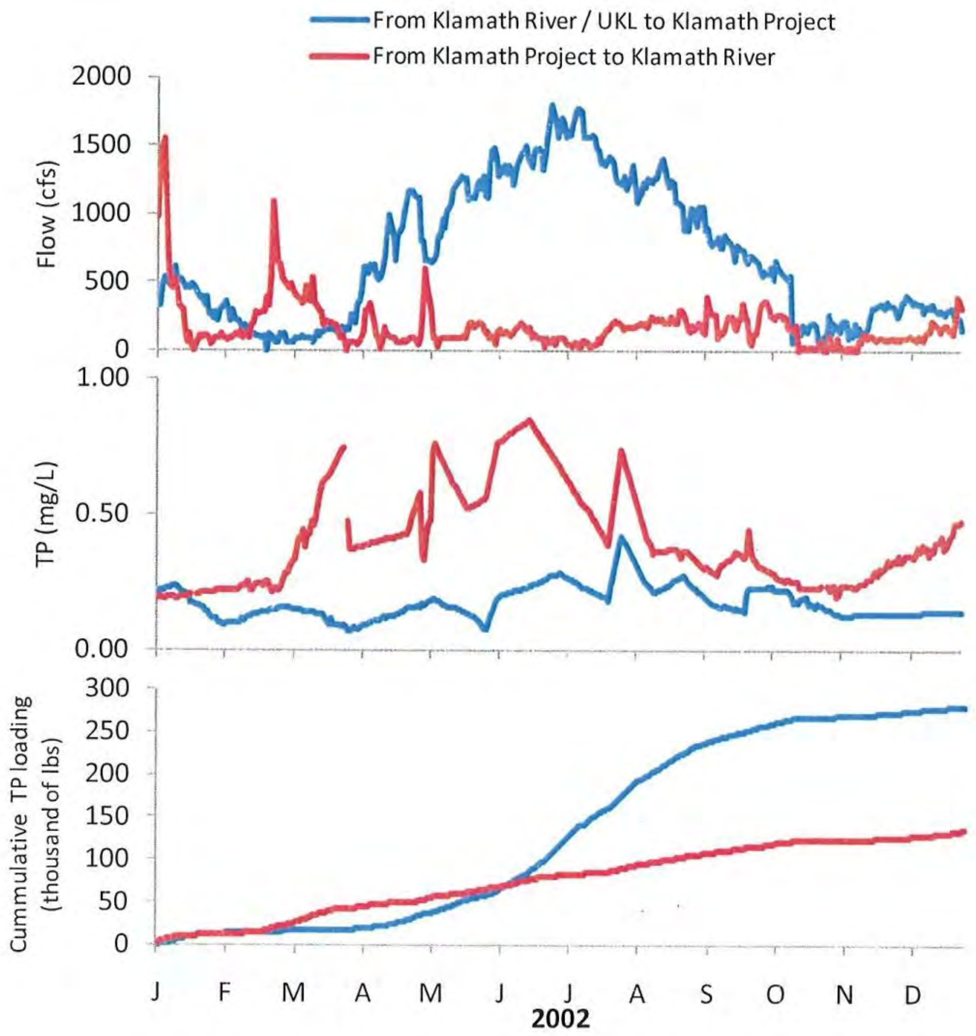
Project return flows from the LRDC and Klamath Straits Drain (KSD) contribute nutrient load to the Klamath River (Figure 6-7; Figure 6-8), although UKL is the source of greatest nutrient and

BOD loads. In particular, UKL exports substantial AFA biomass during the irrigation season (NRC, 2004; ODEQ, 2017; Schenk et al., 2018). During the irrigation season, very little water from the Project and Lost River watershed flows to the Klamath River. Generally, the Project has been characterized as a nutrient sink, rather than source (ODEQ, 2017; Schenk et al., 2018), given that only 30% of UKL/Klamath River water entering the Project is returned to the Klamath River (ODEQ, 2017). However, there is evidence to suggest that discharge from the LRDC can have a substantial negative impact on DO concentrations at Miller Island in the Keno Impoundment, though the magnitude and duration of the effect is less than that resulting from releases from UKL (ODEQ, 2017) and is highly dependent on Project operations.



Source: ODEQ (2017)

Figure 6-7. Klamath River model results from just downstream of Klamath Straits Drain discharge



Note: TP concentrations are weighted based on relative flow rates. Source: ODEQ (2017)

Figure 6-8. Flow, concentration, and cumulative loading analysis of Klamath Project

Per NMFS 2019, "*Nutrient concentrations decline with distance downstream due to dilution by tributaries …; however, enough nutrients pass through [...] to still support abundant growth of periphyton in the mainstem Klamath River below IGD. Total phosphorus will slightly increase downstream of IGD [site] because of the increased nutrient concentrations released from the Klamath Straights Drain or the Lost River Diversion Channel in the summer and fall.*"

"*The (NRC 2004) stated that stimulation of any kind of plant growth can affect DO concentration. However, because nutrient concentration is only one factor influencing periphyton growth, the small increase in nutrients may not necessarily increase periphyton growth. Other factors influencing periphyton growth include light, water depth, and flow velocity. In addition, many reaches of the Klamath River currently have high nutrient concentrations that suggest neither phosphorus nor nitrogen is likely limiting periphyton growth. Thus, an increase in nutrient concentration would not necessarily result in worse DO and pH conditions.*"

Outside of the SS irrigation season, water quality in the Keno Impoundment is greatly improved, owing to lower water temperatures, and increase DO concentrations as a result of reduced biomass exported from UKL, and increased oxygen saturation with reduced water temperatures (ODEQ, 2017). During this period, the LRDC, which drains the Lost River watershed and the Project, flows towards the Klamath River, and thereby contributes some nutrient and BOD load to the Klamath River (Schenk et al., 2018). However, this additional load tends to be relatively small compared to the total load from UKL (Schenk et al., 2018).

In conclusion, although the Project does contribute nutrient load to the Klamath River via the LRDC and KSD, and there is substantial export of algal biomass from UKL, it is not known with certainty at this time how this increase in nutrient concentration within the Keno Impoundment impacts the nutrient concentration below Keno Dam. Additionally, there is suggestion that the Project acts as a nutrient sink, reducing nutrient load from UKL to the Klamath River through diversions at the A Canal headworks and North and Ady canals. Similarly, improvements in Project infrastructure that allow recirculation of return flows within the Project may reduce the volume of return flow (and nutrient load) reaching the Klamath River. Furthermore, the Proposed Action does not count re-diversion of return flows against Project Supply in the SS; Project irrigators are likely to redivert this water, which could result in reduced return flow to the Klamath River relative to that observed WOA.

Given the upstream impacts on nutrient loads, there is not expected to be much difference between the MS scenario and the Proposed Action with regards to nutrients. However, during the late summer and early fall prior to flood control discharges under the MS scenario, UKL will be at its lowest elevation and the decreased pool size could contribute to reduced water quality parameters in the river, such as nutrient loading. Also, while the Proposed Action's increase in nutrients in the mainstem Klamath River is not likely to have a direct effect on periphyton growth, the Proposed Action's reduction of mainstem flows relative to MS in the fall may have an effect on periphyton and thereby influence DO concentration.

6.3.1.5 Water Temperature

During summer, the Proposed Action is anticipated to result in increased water temperatures in the Klamath River from IGD to the mouth. Higher flows will release more water downstream. During summer, tributary flow, which may be cooler water, is reduced and contributes less proportional to the releases from UKL. The release of warmer water from UKL may reduce the quantity and effectiveness of cold water refugia downstream.

Klamath River water temperatures are largely correlated with air temperature. Generally, ambient air temperatures in the fall and winter in the Klamath Basin do not result in water temperatures that would negatively affect salmonids.

In addition to air temperature, there is also evidence that Klamath River discharge affects water temperature. Asarian and Kann (2013) found statistically significant negative relationships between mean monthly flow and mean water temperature for June and July (2001-2011) at lower river sites: Orleans, Weitchpec, Tully Creek, and Turwar. There were no significant relationships between flow and water temperature at the sites most affected by IGD releases (i.e., immediately below IGD, Seiad Valley), suggesting that IGD flow releases influenced water temperatures less than factors affecting flow below Seiad Valley, such as tributary inflow. With the removal of IGD, factors affecting flow below Seiad Valley are expected to become the primary influence on water temperatures.

Given the statistically significant relationship between water temperature and discharge below Seiad Valley, Reclamation analyzed the effect of IGD flow releases simulated from the Proposed Action on Klamath River water temperatures using the RBM10 (Yearsley et al., 2001, 2009; Perry et al., 2011). The RBM10 is a heat budget model that allows the user to model the effects of discharge on water temperature at numerous points along a river channel (Perry et al., 2011). Reclamation analyzed RBM10 output from January 1, 1991, to December 31, 2022, for RMs 174.0 (downstream of the confluence with the Shasta River), 136.8 (downstream of the confluence with the Scott River), and 62.5 (downstream of the confluence of the Salmon River) (Table 6-11 through Table 6-13). Reclamation determined that this combination of sites and months was appropriate to assess the effect of the Proposed Action over the periods and locations relevant for juvenile outmigration, juvenile rearing, and adult migration. The period from 1991-2022 was selected because the model is only parameterized (e.g., with meteorological data) through 2022 and this period was believed to better reflect the meteorological and climatological conditions of the consultation period. The RBM10 output indicates that modeled temperatures expected under the Proposed Action from 1980-2017 could result in small temperature increases (i.e., no more than 0.6°C) in water temperatures at the four sites assessed during this period relative to the MS scenario. Given this, Reclamation concludes that the IGD releases modeled under the Proposed Action will have minor effects on water temperature at the four nodes examined.

Table 6-11. A comparison of daily average Klamath River water temperatures at river mile 174.0 (just below the confluence with the Shasta River) modeled under the Proposed Action and the maximum storage scenario, averaged by month for March – October 1991-2021

Year	[1]Mar	[1]Apr	[1]May	[1]Jun	[1]Jul	[1]Aug	[1]Sep	[1]Oct	[2]Mar	[2]Apr	[2]May	[2]Jun	[2]Jul	[2]Aug	[2]Sep	[2]Oct	[3]Mar	[3]Apr	[3]May	[3]Jun	[3]Jul	[3]Aug	[3]Sep	[3]Oct
1991	7.1	10.2	12.1	16.7	20.7	21.7	19.9	16.1	7.0	10.3	12.3	17.3	21.1	22.0	20.0	16.1	0.1	-0.2	-0.2	-0.6	-0.4	-0.3	-0.1	0
1992	8.3	11.9	16.5	19.6	22.2	22.6	19.6	14.6	8.4	12.0	17.1	20.3	22.5	22.8	19.5	14.4	-0.1	-0.1	-0.6	-0.7	-0.3	-0.2	0.1	0.2
1993	7.4	10.0	15.6	17.8	20.0	20.6	18.2	13.9	7.2	9.8	15.4	17.5	20.4	20.7	18.1	14.3	0.2	0.2	0.2	0.3	-0.4	-0.1	0.1	-0.4
1994	7.9	11.0	15.0	18.6	22.3	22.5	19.1	13.7	8.5	11.4	15.3	19.4	22.7	22.7	19.2	13.2	-0.6	-0.4	-0.3	-0.8	-0.4	-0.2	-0.1	0.5
1995	8.6	9.9	14.1	17.3	21.1	21.6	19.4	13.9	8.5	9.8	13.9	17.2	21.1	21.8	19.6	13.8	0.1	0.1	0.2	0.2	0.0	-0.2	-0.2	0.1
1996	8.0	11.5	13.7	18.0	22.2	22.3	18.0	13.7	8.1	11.6	13.7	18.2	22.6	22.5	17.7	14.0	-0.1	-0.1	0.0	-0.2	-0.4	-0.2	0.4	-0.3
1997	7.9	10.9	15.4	18.6	21.0	22.2	19.1	14.6	8.1	11.1	15.4	18.6	21.4	22.6	19.1	14.7	-0.2	-0.2	0.0	0.0	-0.4	-0.4	0.0	-0.1
1998	8.0	8.7	12.1	17.1	22.1	23.6	21.3	14.1	8.1	9.0	12.1	17.0	22.4	23.7	20.9	14.5	-0.1	-0.3	0.0	0.1	-0.3	-0.1	0.4	-0.4
1999	5.9	8.0	11.6	16.8	21.4	21.6	19.9	15.1	6.0	8.1	11.6	16.6	21.6	21.6	20.0	15.3	-0.1	-0.2	0.0	0.2	-0.2	0.0	-0.1	-0.2
2000	7.4	11.4	13.2	18.1	21.8	22.7	19.4	14.0	7.4	11.5	13.0	18.0	22.1	22.8	19.4	14.4	0.0	-0.2	0.2	0.2	-0.3	-0.1	0.1	-0.4
2001	7.8	10.1	14.4	19.4	21.7	22.6	20.5	15.3	7.8	10.3	14.9	20.1	22.1	22.8	20.4	15.0	0.0	-0.2	-0.5	-0.7	-0.4	-0.2	0.1	0.3
2002	8.0	10.9	13.9	18.6	23.2	22.7	20.1	14.8	7.9	11.0	13.9	19.5	23.5	22.7	20.1	14.5	0.1	-0.1	0.0	-0.9	-0.3	0.0	0.0	0.3
2003	8.6	10.1	12.5	19.2	22.9	23.3	20.0	15.2	8.9	10.1	12.2	19.6	23.1	23.2	19.7	15.1	-0.3	0.0	0.3	-0.4	-0.2	0.1	0.3	0.1
2004	9.4	11.9	14.6	18.6	21.8	23.1	19.8	15.0	9.2	12.1	14.8	19.4	22.2	23.2	19.5	14.8	0.2	-0.2	-0.2	-0.9	-0.4	-0.1	0.3	0.2
2005	9.1	11.3	14.2	17.2	22.0	23.1	19.7	14.1	9.5	11.6	13.8	17.1	22.6	23.3	19.5	13.9	-0.4	-0.3	0.4	0.2	-0.6	-0.2	0.3	0.2
2006	6.1	9.2	16.9	18.9	22.8	22.6	18.2	13.2	6.3	9.2	16.8	18.9	22.9	22.5	18.0	13.5	-0.2	0.0	0.1	0.1	-0.1	0.1	0.3	-0.3
2007	7.9	12.2	15.2	19.6	22.2	21.9	19.0	12.7	7.6	12.3	15.3	19.8	22.6	22.2	18.9	13.0	0.3	-0.1	-0.1	-0.2	-0.4	-0.3	0.2	-0.3
2008	6.6	10.3	15.6	18.8	23.0	22.4	19.9	14.0	6.7	10.4	15.6	18.6	23.3	22.5	20.0	14.4	-0.1	-0.1	0.0	0.3	-0.3	-0.1	-0.1	-0.4
2009	7.3	11.0	15.8	20.0	23.3	22.3	19.5	13.8	7.5	11.0	15.5	19.9	23.8	22.4	19.5	13.8	-0.2	0.0	0.3	0.1	-0.5	-0.1	0.0	0.0
2010	8.3	10.2	13.6	18.7	22.9	22.5	18.4	15.2	8.3	10.1	13.7	18.5	23.2	22.7	18.4	15.4	0.0	0.1	-0.1	0.2	-0.3	-0.2	0.1	-0.2
2011	6.6	9.6	13.3	17.9	21.9	22.7	19.9	15.1	6.6	9.8	13.3	17.6	21.7	22.9	19.7	15.5	0.0	-0.2	0.0	0.3	0.2	-0.2	0.3	-0.4
2012	6.5	10.2	16.7	19.0	22.5	22.9	19.5	15.6	6.6	10.2	16.6	18.9	22.8	23.1	19.6	15.7	-0.1	-0.1	0.1	0.1	-0.3	-0.2	-0.1	-0.1
2013	7.9	12.2	16.9	20.2	22.9	22.1	20.2	13.4	8.2	12.2	17.1	20.6	23.3	22.2	20.2	13.6	-0.3	0.1	-0.2	-0.4	-0.4	-0.1	0.0	-0.2
2014	9.7	13.5	17.9	20.5	23.5	22.4	19.6	15.0	9.7	13.6	18.1	20.9	23.9	22.5	19.8	15.2	0.0	-0.1	-0.2	-0.4	-0.4	-0.1	-0.2	-0.2
2015	10.3	12.8	16.3	21.5	23.3	21.8	18.6	15.6	10.4	13.4	16.8	22.1	23.6	22.0	18.6	15.6	-0.1	-0.6	-0.5	-0.6	-0.3	-0.2	0.0	0.0
2016	8.7	13.8	16.7	20.4	21.4	22.3	18.8	13.9	8.2	13.9	16.8	20.8	21.8	22.6	18.8	14.3	0.5	-0.2	-0.1	-0.4	-0.4	-0.3	0.0	-0.4

Year	[1]Mar	[1]Apr	[1]May	[1]Jun	[1]Jul	[1]Aug	[1]Sep	[1]Oct	[2]Mar	[2]Apr	[2]May	[2]Jun	[2]Jul	[2]Aug	[2]Sep	[2]Oct	[3]Mar	[3]Apr	[3]May	[3]Jun	[3]Jul	[3]Aug	[3]Sep	[3]Oct
2017	8.9	10.5	15.3	20.6	23.1	23.1	19.7	13.2	8.8	10.6	15.2	20.5	23.4	23.1	19.4	13.5	0.1	-0.1	0.1	0.1	-0.3	0.0	0.3	-0.3
2018	7.2	11.4	17.5	20.6	23.1	22.2	18.6	14.1	7.1	11.4	17.6	21.0	23.5	22.4	18.4	14.4	0.1	0.0	-0.1	-0.4	-0.4	-0.2	0.2	-0.3
2019	6.8	11.2	16.4	20.7	22.4	21.9	19.2	13.1	6.8	11.0	16.3	20.8	22.7	22.2	19.0	13.5	0.0	0.2	0.1	-0.2	-0.3	-0.3	0.2	-0.4
2020	8.3	12.4	16.7	19.6	22.0	22.3	19.2	15.4	8.7	13.4	16.7	19.9	22.4	22.6	19.3	15.4	-0.4	-1.0	0.0	-0.4	-0.4	-0.3	-0.1	0.0
2021	7.6	12.2	16.7	19.4	23.5	22.6	18.7	13.9	7.8	12.9	17.0	20.1	23.8	22.8	18.7	13.6	-0.2	-0.8	-0.3	-0.7	-0.3	-0.2	-0.1	0.3
Ave.	7.9	11.0	15.0	19.0	22.3	22.4	19.4	14.4	7.9	11.1	15.1	19.2	22.6	22.6	19.3	14.5	-0.6	-0.1	-0.1	-0.2	-0.3	-0.2	0.1	-0.1
Min.	5.9	8.0	11.6	16.7	20.0	20.6	18.0	12.7	6.0	8.1	11.6	16.6	20.4	20.7	17.7	13.0	-0.6	-1.0	-0.6	-0.9	-0.6	-0.4	-0.2	-0.4
Max.	10.3	13.8	17.9	21.5	23.5	23.6	21.3	16.1	10.4	13.9	18.1	22.1	23.9	23.7	20.9	16.1	0.5	0.2	0.4	0.3	0.2	0.1	0.4	0.5

Notes:
Negative numbers in the columns reporting differences refer to a reduction in temperature under the Proposed Action, relative to those under the MS scenario.
1. Proposed Action Temperature (°C)
2. MS Temperature (°C)
3. Temperature (°C) Difference

Table 6-12. A comparison of daily average Klamath River water temperatures at river mile 136.8 (just below the confluence with the Scott River) modeled under the Proposed Action and the maximum storage scenario, averaged by month for March – October 1991-2021

Year	[1]Mar	[1]Apr	[1]May	[1]Jun	[1]Jul	[1]Aug	[1]Sep	[1]Oct	[2]Mar	[2]Apr	[2]May	[2]Jun	[2]Jul	[2]Aug	[2]Sep	[2]Oct	[3]Mar	[3]Apr	[3]May	[3]Jun	[3]Jul	[3]Aug	[3]Sep	[3]Oct
1991	7.0	10.7	12.9	17.8	23.1	23.3	20.6	16.1	7.1	10.7	12.9	18.4	23.5	23.9	20.9	16.3	-0.1	0.0	0.0	-0.6	-0.4	-0.6	-0.3	-0.2
1992	9.0	12.1	17.8	21.7	24.0	24.0	20.0	14.4	9.5	12.5	18.8	22.9	24.7	24.7	20.2	14.6	-0.5	-0.4	-1.0	-1.2	-0.7	-0.7	-0.2	-0.2
1993	8.7	10.1	15.0	17.9	21.0	21.6	18.6	13.7	8.3	9.9	15.1	17.8	21.4	21.9	18.9	14.0	0.4	0.2	-0.1	0.1	-0.4	-0.3	-0.3	-0.3
1994	8.5	11.7	16.2	19.6	24.2	23.7	19.9	13.4	9.3	11.9	16.0	21.4	25.4	24.3	20.3	13.2	-0.8	-0.3	0.2	-1.8	-1.2	-0.6	-0.4	0.2
1995	8.1	9.8	13.6	16.8	22.1	22.4	20.0	14.0	8.2	9.9	13.6	16.9	22.3	22.8	20.5	13.9	-0.1	0.0	0.0	-0.1	-0.2	-0.4	-0.5	0.1
1996	8.6	11.4	14.1	19.1	23.4	23.2	18.2	13.7	8.7	11.4	14.0	19.2	24.4	23.8	18.0	13.9	-0.1	-0.1	0.1	0.0	-1.0	-0.6	0.1	-0.2
1997	8.3	11.3	16.4	19.5	22.1	23.1	19.6	14.4	8.5	11.5	16.4	19.4	23.0	23.8	19.5	14.6	-0.2	-0.3	0.0	0.1	-0.9	-0.7	0.1	-0.2
1998	9.0	8.9	12.6	17.5	22.7	24.4	21.6	13.8	9.1	8.8	12.7	17.5	22.7	25.0	21.3	14.2	-0.1	0.1	-0.1	0.1	0.0	-0.6	0.3	-0.4
1999	6.5	8.6	11.9	18.1	22.3	22.4	20.4	15.1	6.4	8.8	11.9	17.9	22.9	22.4	20.6	15.2	0.1	-0.2	0.0	0.2	-0.6	0.0	-0.2	-0.1
2000	7.8	11.8	13.4	18.9	22.8	23.7	19.9	14.0	7.8	12.0	13.2	18.7	23.4	24.1	19.8	14.3	0.0	-0.2	0.2	0.2	-0.6	-0.4	0.1	-0.3
2001	8.5	10.6	16.4	20.7	23.7	23.7	20.9	15.3	8.5	10.7	16.6	22.3	23.9	24.1	21.1	15.0	0.0	-0.1	-0.2	-1.6	-0.2	-0.4	-0.2	0.3
2002	7.7	11.7	14.4	19.4	25.0	23.6	20.6	15.1	7.7	11.9	14.4	20.4	25.3	24.0	20.8	15.0	0.0	-0.2	0.0	-1.0	-0.3	-0.4	-0.2	0.1
2003	8.7	10.0	13.2	20.4	24.4	23.8	20.3	15.3	8.8	10.0	13.0	20.6	24.5	23.9	20.5	15.1	-0.1	-0.1	0.2	-0.2	-0.1	-0.1	-0.2	0.2
2004	10.3	11.6	14.7	19.7	23.8	24.3	19.9	14.6	10.3	11.6	14.7	20.6	24.0	24.6	19.9	14.3	0.0	0.0	0.0	-0.9	-0.2	-0.3	0.0	0.3
2005	9.0	11.2	14.0	17.3	24.0	24.5	19.9	14.2	9.3	11.2	13.9	17.5	24.6	24.8	20.0	14.0	-0.3	0.0	0.1	-0.1	-0.6	-0.3	-0.1	0.2
2006	6.4	9.4	16.0	19.2	23.8	23.4	18.7	13.3	6.5	9.5	16.1	19.1	24.0	23.5	18.5	13.4	-0.1	0.0	-0.1	0.1	-0.2	-0.1	0.1	-0.1
2007	8.2	12.4	15.9	20.6	24.0	23.3	19.2	12.6	7.9	12.5	16.0	21.3	24.3	23.7	19.3	12.8	0.3	0.0	-0.1	-0.6	-0.3	-0.4	-0.1	-0.2
2008	7.3	10.5	14.6	19.7	24.2	23.2	20.7	14.1	7.4	10.6	14.7	19.4	24.5	23.7	21.1	14.3	-0.1	-0.1	-0.1	0.3	-0.3	-0.5	-0.5	-0.2
2009	7.8	11.5	16.2	20.5	25.5	23.5	20.0	13.9	7.8	11.6	16.0	20.4	26.5	24.0	20.4	13.8	0.0	-0.1	0.2	0.1	-1.0	-0.5	-0.4	0.1
2010	8.1	10.0	12.8	16.8	24.3	23.8	18.7	15.0	8.2	10.2	12.8	17.1	24.6	24.4	18.9	15.4	-0.1	-0.3	0.0	-0.3	-0.3	-0.6	-0.2	-0.4
2011	6.7	9.6	13.0	16.1	20.9	23.6	20.1	15.2	6.6	9.6	13.0	16.2	21.2	23.9	20.2	15.3	0.1	0.0	0.0	0.0	-0.3	-0.3	0.0	-0.1
2012	6.7	10.2	16.0	19.4	24.3	24.5	20.2	15.3	6.7	10.2	15.9	19.5	24.6	25.0	20.6	15.8	0.0	0.0	0.1	-0.1	-0.3	-0.5	-0.4	-0.5
2013	8.3	12.1	17.4	21.3	25.1	23.3	20.8	13.7	8.8	12.1	17.4	22.1	25.5	23.6	21.0	13.8	-0.5	0.0	0.0	-0.8	-0.4	-0.3	-0.2	-0.1
2014	9.7	13.6	19.0	21.7	25.3	23.6	20.5	14.8	9.7	13.9	19.4	22.7	26.1	24.2	20.9	15.0	0.0	-0.3	-0.4	-1.1	-0.8	-0.6	-0.4	-0.2
2015	10.6	13.4	17.6	23.1	25.2	23.3	19.2	15.8	10.8	13.7	18.2	24.8	25.8	23.9	19.5	15.7	-0.2	-0.4	-0.6	-1.8	-0.6	-0.6	-0.3	0.1
2016	8.3	13.7	16.0	20.6	23.3	23.9	19.5	13.3	8.2	14.0	15.9	21.3	23.7	24.3	19.7	13.8	0.1	-0.3	0.1	-0.7	-0.4	-0.4	-0.3	-0.5

Year	[1]Mar	[1]Apr	[1]May	[1]Jun	[1]Jul	[1]Aug	[1]Sep	[1]Oct	[2]Mar	[2]Apr	[2]May	[2]Jun	[2]Jul	[2]Aug	[2]Sep	[2]Oct	[3]Mar	[3]Apr	[3]May	[3]Jun	[3]Jul	[3]Aug	[3]Sep	[3]Oct
2017	9.2	10.4	14.6	18.8	24.2	24.0	20.1	13.3	9.1	10.4	14.6	18.9	24.6	24.2	20.0	13.6	0.1	-0.1	0.0	-0.1	-0.4	-0.2	0.2	-0.3
2018	7.6	11.2	18.0	21.8	25.2	23.7	18.9	14.3	7.5	11.3	17.8	22.9	26.0	24.3	19.1	14.5	0.1	-0.1	0.2	-1.1	-0.8	-0.6	-0.2	-0.2
2019	7.7	11.1	15.3	20.9	24.1	23.5	19.5	13.3	7.7	11.0	15.4	20.8	24.4	23.9	19.5	13.3	0.0	0.1	-0.1	0.1	-0.3	-0.4	-0.1	0.0
2020	8.3	13.4	16.9	20.6	24.2	23.8	19.5	15.3	9.1	14.5	16.8	21.1	25.1	24.5	19.7	15.4	-0.8	-1.2	0.1	-0.5	-0.9	-0.7	-0.2	-0.1
2021	7.6	12.8	17.4	21.5	25.5	24.1	19.4	13.8	8.2	13.2	18.0	22.4	26.5	24.7	19.7	13.6	-0.6	-0.4	-0.6	-0.9	-1.0	-0.6	-0.3	0.2
Ave.	8.2	11.2	15.3	19.6	23.8	23.6	19.8	14.3	8.3	11.3	15.3	20.0	24.3	24.0	20.0	14.4	-0.1	-0.1	-0.1	-0.5	-0.5	-0.4	-0.2	-0.1
Min.	6.4	8.6	11.9	16.1	20.9	21.6	18.2	12.6	6.4	8.8	11.9	16.2	21.2	21.9	18.0	12.8	-0.8	-1.2	-1.0	-1.8	-1.2	-0.7	-0.5	-0.5
Max.	10.6	13.7	19.0	23.1	25.5	24.5	21.6	16.1	10.8	14.5	19.4	24.8	26.5	25.0	21.3	16.3	0.4	0.2	0.2	0.3	0.0	0.0	0.3	0.3

Notes:

Negative numbers in the columns reporting differences refer to a reduction in temperature under the Proposed Action, relative to those under the MS scenario.

1. Proposed Action Temperature (°C)
2. MS Temperature (°C)
3. Temperature (°C) Difference

Table 6-13. A comparison of daily average Klamath River water temperatures at river mile 62.5 (just below the confluence with the Salmon River) modeled under the Proposed Action and the maximum storage scenario, averaged by month for March – October 1991-2021

Year	[1]Mar	[1]Apr	[1]May	[1]Jun	[1]Jul	[1]Aug	[1]Sep	[1]Oct	[2]Mar	[2]Apr	[2]May	[2]Jun	[2]Jul	[2]Aug	[2]Sep	[2]Oct	[3]Mar	[3]Apr	[3]May	[3]Jun	[3]Jul	[3]Aug	[3]Sep	[3]Oct
1991	7.1	10.9	13.1	17.9	23.5	23.4	20.9	17.1	7.0	11.1	12.9	17.6	24.1	23.7	21.2	17.3	0.1	-0.2	0.2	0.3	-0.6	-0.3	-0.3	-0.2
1992	10.5	12.7	18.8	22.2	24.2	24.3	20.4	14.7	10.6	12.7	19.0	22.8	24.4	24.7	20.4	14.7	-0.1	0.0	-0.2	-0.6	-0.2	-0.4	0.0	0.0
1993	9.6	9.8	14.5	17.1	20.5	21.7	19.4	13.8	9.5	9.8	14.5	17.0	20.5	21.8	19.6	14.2	0.1	0.0	0.0	0.1	0.0	-0.1	-0.2	-0.4
1994	10.0	11.7	16.0	19.9	24.7	23.7	20.3	13.1	10.4	12.1	16.0	19.9	25.3	23.9	20.5	12.5	-0.4	-0.4	0.0	0.0	-0.6	-0.2	-0.3	0.6
1995	8.0	9.8	12.5	15.7	22.2	22.3	20.5	14.3	8.1	9.8	12.7	16.0	22.2	22.4	20.8	14.0	-0.1	0.0	-0.2	-0.3	0.0	-0.1	-0.3	0.3
1996	9.0	11.1	13.7	18.5	23.7	23.2	18.1	13.9	9.0	11.2	13.9	18.6	23.8	23.6	18.5	14.0	0.0	-0.1	-0.2	-0.1	-0.1	-0.4	-0.3	-0.1
1997	8.6	11.6	16.4	19.0	22.9	23.2	19.9	14.2	8.8	11.7	16.4	18.9	23.3	23.4	19.9	14.3	-0.2	-0.1	0.0	0.1	-0.4	-0.2	0.0	-0.1
1998	8.7	8.3	12.2	17.8	22.0	24.1	21.2	13.8	8.7	8.3	12.3	17.9	22.1	24.1	21.1	14.0	0.0	0.1	-0.1	-0.1	-0.1	0.0	0.1	-0.2
1999	7.1	9.3	11.8	17.8	22.1	22.5	20.7	15.2	7.2	9.8	11.8	17.8	22.0	22.4	20.8	15.3	-0.1	-0.5	0.0	0.0	0.1	0.1	-0.1	-0.1
2000	8.3	11.9	13.1	18.8	22.8	23.5	19.8	13.9	8.3	12.0	13.2	18.8	22.8	23.6	19.9	14.2	0.0	-0.1	-0.1	0.1	0.0	-0.1	-0.1	-0.3
2001	9.6	10.6	17.3	20.5	24.1	24.1	21.1	15.3	9.5	10.7	17.9	20.7	24.7	24.3	21.1	14.9	0.1	-0.1	-0.6	-0.1	-0.6	-0.2	0.1	0.4
2002	7.7	12.2	13.6	19.1	24.7	23.2	20.7	15.0	7.5	12.4	13.6	18.8	25.0	23.4	20.7	14.6	0.2	-0.2	0.0	0.3	-0.3	-0.2	-0.1	0.4
2003	8.4	9.3	12.2	18.5	23.6	23.4	20.5	15.2	8.5	9.4	12.1	18.3	23.5	23.4	20.4	15.1	-0.1	0.0	0.1	0.2	0.1	0.0	0.1	0.1
2004	10.8	11.4	13.5	19.2	23.3	24.2	19.8	14.7	10.7	11.3	13.5	19.1	23.4	24.3	19.6	14.4	0.1	0.1	0.0	0.1	-0.1	-0.1	0.3	0.3
2005	9.1	10.2	13.8	16.3	24.1	24.3	19.5	13.9	9.3	9.9	13.8	16.3	24.2	24.3	19.2	13.9	-0.2	0.3	0.0	0.0	-0.1	0.0	0.3	0.0
2006	6.5	9.6	15.6	18.1	23.4	22.8	18.3	13.0	6.6	9.6	15.7	18.1	23.4	22.8	18.3	13.3	-0.1	0.0	-0.1	-0.1	0.0	0.0	0.0	-0.3
2007	8.2	11.1	16.2	20.7	24.0	23.3	19.2	12.7	8.2	11.0	16.2	20.8	24.4	23.7	19.0	12.7	0.0	0.1	0.0	-0.1	-0.4	-0.4	0.2	0.0
2008	7.6	10.0	13.8	18.8	23.2	23.0	20.9	13.7	7.5	9.9	13.9	18.8	23.0	23.0	20.9	14.2	0.1	0.0	-0.1	-0.1	0.2	0.0	0.0	-0.5
2009	7.8	11.0	15.8	19.5	25.2	23.5	20.4	13.6	7.9	11.0	16.0	19.5	25.1	23.7	20.6	13.6	-0.1	0.1	-0.2	0.0	0.1	-0.2	-0.2	0.0
2010	8.3	9.2	10.9	14.6	23.0	23.2	18.7	15.1	8.2	9.3	10.8	14.9	22.8	22.9	18.7	15.1	0.1	-0.2	0.1	-0.3	0.2	0.3	0.0	0.0
2011	7.0	9.3	11.3	13.8	19.5	23.4	20.7	14.3	7.0	9.3	11.4	14.1	19.4	23.5	20.6	15.0	0.0	0.0	-0.1	-0.4	0.1	-0.1	0.0	-0.7
2012	6.8	10.1	14.8	17.9	23.3	24.2	20.4	15.1	6.8	10.0	14.8	17.7	23.4	24.4	20.6	15.3	0.0	0.1	0.0	0.2	-0.1	-0.2	-0.2	-0.2
2013	8.2	11.2	16.4	20.9	24.9	23.1	21.0	13.3	8.4	11.2	16.2	21.0	25.3	23.2	21.1	13.6	-0.2	0.0	0.2	-0.1	-0.4	-0.1	-0.1	-0.3
2014	9.8	12.8	18.3	22.0	25.5	23.7	20.8	14.8	9.8	12.9	18.4	22.2	25.9	24.1	21.1	14.8	0.0	-0.1	-0.1	-0.1	-0.4	-0.4	-0.4	0.0
2015	11.0	12.6	17.4	23.6	25.3	23.3	19.6	16.3	11.0	12.6	17.4	24.3	25.7	23.8	19.6	16.3	0.0	0.0	0.0	-0.7	-0.4	-0.5	-0.1	0.0
2016	8.5	12.2	14.9	20.4	23.3	24.2	19.8	12.3	8.5	12.1	14.9	20.1	23.8	24.4	19.9	13.0	0.0	0.1	0.0	0.3	-0.5	-0.2	-0.1	-0.7

Year	[1]Mar	[1]Apr	[1]May	[1]Jun	[1]Jul	[1]Aug	[1]Sep	[1]Oct	[2]Mar	[2]Apr	[2]May	[2]Jun	[2]Jul	[2]Aug	[2]Sep	[2]Oct	[3]Mar	[3]Apr	[3]May	[3]Jun	[3]Jul	[3]Aug	[3]Sep	[3]Oct
2017	9.0	10.0	12.8	16.3	23.5	23.7	20.2	13.1	9.0	10.0	12.9	16.3	23.3	23.7	19.8	13.4	0.0	0.0	-0.1	0.0	0.2	0.0	0.3	-0.3
2018	7.4	10.4	16.4	21.6	25.2	23.7	18.9	14.2	7.4	10.4	16.3	21.8	25.7	24.0	18.7	14.4	0.0	-0.1	0.1	-0.2	-0.5	-0.3	0.2	-0.2
2019	7.9	10.4	13.7	20.2	23.4	23.6	19.6	13.2	7.8	10.5	13.7	19.8	23.4	23.8	19.4	13.6	0.1	-0.1	0.0	0.3	0.0	-0.2	0.2	-0.4
2020	8.8	12.8	15.3	20.2	24.7	24.2	19.4	15.4	8.8	12.8	15.4	20.2	25.3	24.6	19.3	15.3	0.0	0.0	-0.1	0.0	-0.6	-0.4	0.1	0.1
2021	7.9	11.9	16.4	21.7	25.9	24.0	20.2	13.5	7.8	11.6	16.1	22.2	26.4	24.3	20.4	12.9	0.1	0.3	0.3	-0.4	-0.5	-0.3	-0.2	0.6
Ave.	8.5	10.8	14.6	19.0	23.6	23.5	20.0	14.2	8.5	10.8	14.6	19.0	23.8	23.7	20.0	14.3	0.0	0.0	0.0	-0.1	-0.2	-0.2	0.0	-0.1
Min.	6.5	8.3	10.9	13.8	19.5	21.7	18.1	12.3	6.6	8.3	10.8	14.1	19.4	21.8	18.3	12.5	-0.4	-0.5	-0.6	-0.7	-0.6	-0.5	-0.4	-0.7
Max.	11.0	12.8	18.8	23.6	25.9	24.3	21.2	17.1	11.0	12.9	19.0	24.3	26.4	24.7	21.2	17.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.6

Notes:

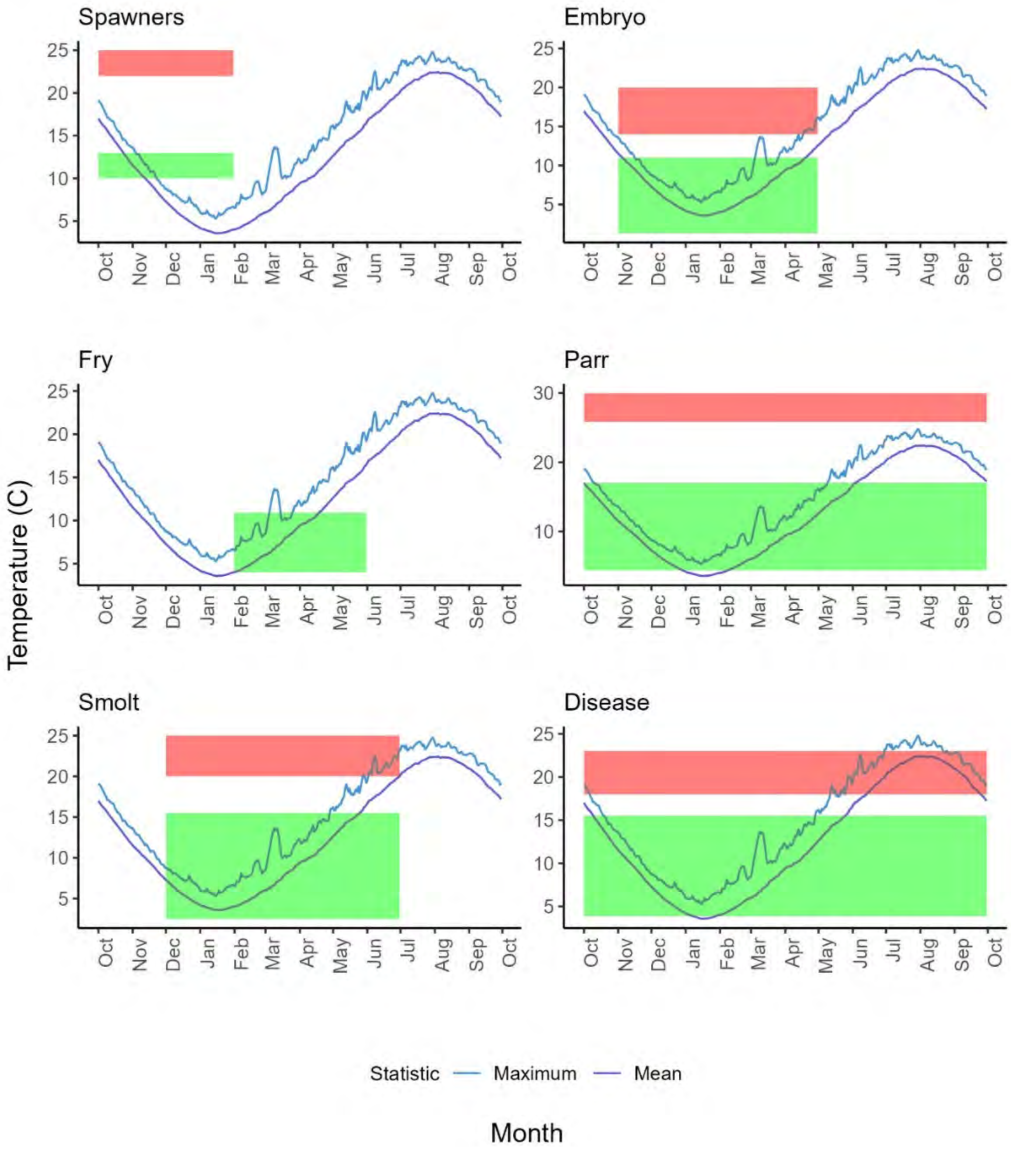
Negative numbers in the columns reporting differences refer to a reduction in temperature under the Proposed Action, relative to those under the MS scenario.

1. Proposed Action Temperature (°C)
2. MS Temperature (°C)
3. Temperature (°C) Difference

Analysis Description There is a dearth of continuous water temperature data in the mainstem Klamath River for the reach from IGD to the Shasta River, and consequently there are few studies that directly quantify the impact of temperature on Coho Salmon. This meta-analysis of existing literature in the Klamath River Basin, as well as other locations, provides a tool for assessing temperature effects on discrete Coho Salmon life stages. For this analysis, temperature data for the Proposed Action was simulated by the RBM10 as the average daily temperature for the period 1991-2022 for five locations between IGD and Humbug Creek: IGD to Bogus Creek (RM 189.8), Bogus Creek to Willow Creek (RM 187.3), Willow Creek to Cottonwood Creek (RM 183.6), Cottonwood Creek to the Shasta River (RM 179.4), and the Shasta River to Humbug Creek (RM 174). Because tributaries downstream of IGD (e.g., the Shasta, Scott, and Salmon rivers) substantially influence flow and temperature in the mainstem Klamath River, this analysis focused on the section of river between IGD and just below the confluence of the Shasta River where the Proposed Action is most likely to impact fish.

Sections regarding specific life stages of Coho will focus on the positive, negative, and lethal thresholds for behavioral and physiological effects of temperatures simulated for the Proposed Action. Since most life stages of Coho are negatively affected by high temperatures, an examination of both daily average and maximum daily average temperature for the period of record was performed. Figure 6-9 shows the intersection between the simulated Proposed Action temperatures between IGD and Humbug Creek (1991-2022) and the generalized effects of temperature on Coho Salmon adults, embryos, juveniles, smolts, as well as *C. shasta* spore conditions derived from existing literature resources. All life stages will be displayed here and will then be discussed in their respective sections in the effects analysis. Temperature can affect survival, successful reproduction, and development. The length of each rectangle represents the period that each life stage is active in the freshwater environment and the height indicates the range of temperatures described as having positive, negative, or lethal effects.

Reduced temperatures from the Proposed Action in spring and summer relative to the MS scenario will be a benefit to all life stages of Coho Salmon. Reclamation anticipates greater benefit from the MS scenario relative to the Proposed Action for fall water temperatures due to higher flows having a small temperature influence. However, fall is a time of year when high temperatures are not generally limiting.



Note: Red rectangles represent temperature ranges with negative impacts to the life stage shown. Green rectangles represent positive impacts to life stage shown.

Figure 6-9. Intersection between the simulated Proposed Action temperatures between Iron Gate Dam and Humbug Creek (1991-2022) and the generalized effects of temperature on Coho Salmon adults, embryos, juveniles, smolts, as well as *C. shasta* spore conditions derived from existing literature resources

Analysis Results for Adults Adult freshwater migration occurs from mid-September through mid-January (Hardy et al., 2006). Peak river entry of migrating Coho adults was observed after temperatures fell below 20°C (Strange, 2004), and 21 to 22°C was reported as the lethal limit for migrating adult Coho in the Columbia River during summer (Richter and Kolmes, 2005). Thirteen percent of the migration period had temperatures that would positively affect migrating adults under the Proposed Action (Table 6-14). There were 16 days under the Proposed Action that were considered lethal temperatures when we assessed daily average maximum temperatures. However, average daily temperatures over the period of record did not produce any lethal temperatures indicating migration conditions are typically satisfactory. It should be noted that modeled temperatures only cover the river reach between IGD and just below the confluence of the Shasta River, which includes only a portion of the migratory pathway for some fish.

Table 6-14. The number of days Coho are positively, negatively, or lethally affected by Proposed Action temperatures simulated by the River Basin Model-10 over the period of record 1980-2017

Life Stage	Daily Avg. Lethal Days	Daily Avg. (-) Days	Daily Avg. (+) Days	Daily Max. Lethal Days	Daily Max. (-) Days	Daily Max. (+) Days	Daily Min. Lethal Days	Daily Min. (-) Days	Daily Min. (+) Days
Adult Migration	0 (0%)	53 (35%)	20 (13%)	16 (10%)	57 (37%)	19 (12%)	0 (0%)	30 (100%)	0 (0%)
Adult Spawner	0 (0%)	23 (19%)	20 (16%)	0 (0%)	34 (28%)	19 (15%)	0 (0%)	9 (7%)	14 (11%)
Embryo/ Alevin	0 (0%)	16 (9%)	165 (91%)	13 (7%)	48 (27%)	120 (66%)	0 (0%)	0 (0%)	171 (94%)
Fry	0 (0%)	0 (0%)	77 (64%)	0 (0%)	0 (0%)	43 (36%)	0 (0%)	0 (0%)	77 (64%)
Parr	0 (0%)	121 (33%)	203 (56%)	0 (0%)	155 (42%)	210 (58%)	0 (0%)	79 (22%)	188 (52%)
Smolt	1 (0%)	35 (17%)	176 (83%)	31 (15%)	33 (16%)	148 (70%)	0 (0%)	17 (8%)	124 (58%)
Disease	103 (28%)	34 (9%)	207 (57%)	143 (39%)	31 (8%)	191 (52%)	71 (19%)	34 (9%)	166 (45%)

Notes:
Effects are based on meta-data analysis of literature. Parentheses indicate the percentage of days affected of the total days each life stage is active.

Spawning adults are typically active from October through mid-January (migration and spawning). Optimal temperatures for spawning range from 10 to 13°C and when temperatures exceed 20°C, ova will rapidly deteriorate (Richter and Kolmes, 2005). Fifteen percent of the spawning season had maximum daily temperatures that were optimal for spawning adults (Figure 6-9, Table 6-14). There were no days when daily average maximum temperatures under the Proposed Action were considered lethal indicating spawning conditions are typically satisfactory.

6.3.2 Embryos to Alevin

The period of incubation and alevin development goes from November through April with a peak period occurring from November through February at the Klamath River – Keno Dam to Iron Gate Dam and Klamath River – Iron Gate Dam (and tributaries) to Mouth (Figure 6-1).

The Stressors that influence Coho Salmon embryos and alevin are: redd dewatering, disease, habitat quantity and quality, restoration, sedimentation, water quality – DO, water quality – nutrients, water quality – temperature.

The Proposed Action is not anticipated to change the following stressors:

- Redd dewatering during spring in the Klamath River from Keno Dam to the mouth. Flows will be higher throughout the spring than they were in the winter when redds were built/constructed, thus, the Proposed Action will not dewater redds.
- Disease during winter, spring, and fall in the Klamath River from Keno Dam to the mouth as disease is not known to be an issue for this life stage.
- Restoration consulted on previously during spring in the Klamath River from the IGD to the mouth. Restoration projects funded and authorized un previous consultations may exacerbate existing stressors during the construction period and over the short-term. However, restoration is expected to be beneficial over the medium and long-term.
- Habitat Quantity and Quality during spring in the Klamath River from Keno Dam to the mouth. Flows will be higher throughout the spring than they were in the winter when redds were built/constructed, thus, the Proposed Action will not dewater redds.
- DO during spring in the Klamath River from Keno Dam to the mouth as DO is not a known limiting factor in spring.
- Nutrients during winter and spring in the Klamath River from Keno Dam to the mouth and during fall in the Klamath River from the IGD to the mouth as nutrients are not a known limiting factor in winter and spring.
- Water Temperature during spring in the Klamath River from Keno Dam to the mouth as water temperature is not a known limiting factor in spring.

There are no stressors for this life stage that may change at a level that is **insignificant or discountable**.

Stressors that are exacerbated—potentially resulting in incidental take—and those that are potentially ameliorated by the Proposed Action are described in Sections 6.3.2.1 through 6.3.2.6. Conservation measures included as part of the Proposed Action to avoid or compensate for adverse effects are also described in Sections 6.4.

6.3.2.1 Redd Dewatering

During fall and winter, the Proposed Action is anticipated to reduce flows in the Klamath River from Keno Dam to the mouth, which may desiccate redds or strand alevins. Consistent flows in the winter in this reach may reduce this effect while dynamic flows would result in increased stress from dewatering. Flows are projected to remain stable or increase slightly month to month in the winter, which may ameliorate potential redd desiccation.

The Proposed Action will likely reduce mainstem flows from October to February in all but above average water years (> 60% exceedance; Section 6.5.3, Table 6-10) relative to MS scenario. However, Coho Salmon eggs in the mainstem may not be dewatered. Stable or naturally increasing flows during the winter from storm events downstream of IGD will reduce the potential for dewatering of Coho Salmon eggs in the mainstem or side channels (Figure 4-2 and 4-3). In addition, redd dewatering is not expected to occur because of the conservative ramp-down rates proposed by Reclamation.

6.3.2.2 Habitat Quantity and Quality

During fall and winter, the Proposed Action is anticipated to reduce flows in the Klamath River from Keno Dam to the mouth, which may reduce the quantity and quality of habitat for Coho Salmon embryo and fry. Egg survival and alevin emergence is affected by interstitial flow. In the fall, decreased Klamath River flows are likely to decrease the hyporheic flows that influence DO and may increase sedimentation reducing egg and alevin essential functions and development.

Analysis Description See Section 6.3.1.1 for discussion of the analytical method.

Analysis Results Coho embryo development typically occurs from November through the end of March (Hardy et al., 2006). Only a small portion of natural Coho Salmon spawning occurs in the mainstem Klamath River (Dunne et al., 2011), thus minimizing the effects of the Proposed Action on this life stage. Nevertheless, high flows are likely to affect embryos via mechanical damage as substrate is moved or by physical displacement from the redd. Ericksen et al. (2007) estimated that scouring of spawning gravels (gravels with a median diameter of 2 inches) would occur at flows above 5,163 cfs in the Klamath River. There is a dearth of literature on the effects of flows below 5,163 cfs and, therefore, the effects of a low-flow scenario are unclear. Under the Proposed Action, Coho Salmon embryos and alevin are within their optimum flows 100% of the incubation period in the vast majority of the time (i.e., 90% exceedance; Figure 6-6, Table 6-14). This demonstrates that, while the Proposed Action is a reduction in habitat from MS, it nonetheless provides optimum incubation conditions (Section 6.4) in 90% of years.

There is very little information on how low-flow conditions affect Coho eggs; however, flows in excess of 5,163 cfs will negatively influence eggs (Ericksen et al., 2007). Based on flow conditions during the period of incubation (November – June) (Stillwater Sciences, 2009), neither an average (e.g., 2019; Figure 6-10) or low-flow water year (e.g., 2002; Figure 6-10) for the Proposed Action are likely to exceed this threshold. During a higher flow year (e.g., 1997; Figure 6-10) both the Proposed Action and MS scenario conditions result in flows high enough to scour redds, though the magnitude is much higher under MS. Thus, under average conditions there are no negative impacts to Coho embryos expected if the Proposed Action were implemented relative to the MS scenario condition. Further, during extreme low-flow water years it is unclear how ova would be impacted for either a MS scenario condition or Proposed Action condition. However, both scenarios are expected to have some impact under a high-flow water year.

For additional habitat effects modeling and discussion, see Section 6.4.

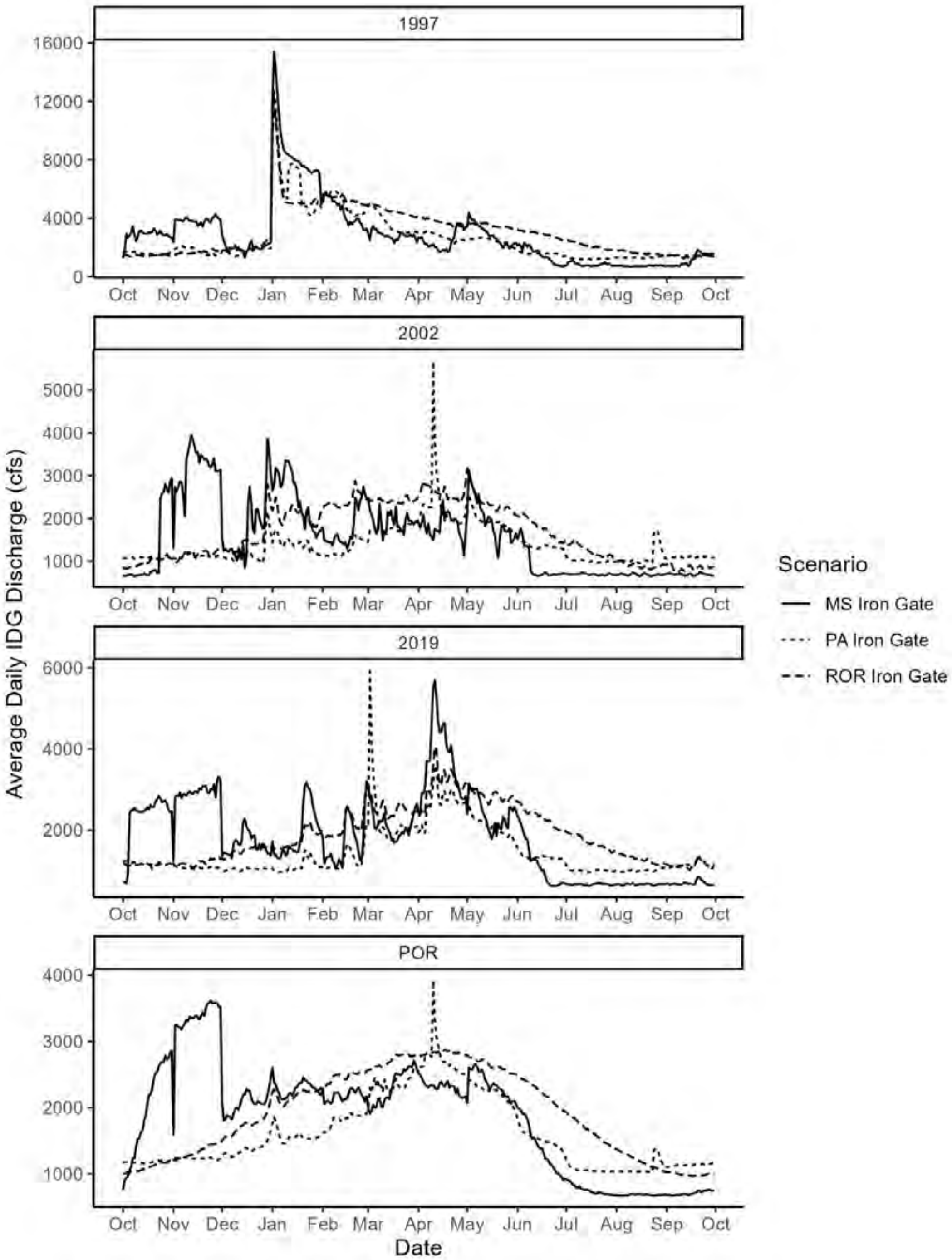


Figure 6-10. Simulated average daily discharge at Iron Gate Dam for a wet (1997), dry (2002), and average (2019) water year, and for the period of record (1980 –2022) for the Proposed Action, maximum storage, and run of river scenarios

6.3.2.3 Sedimentation

During fall, the Proposed Action is anticipated to decrease sedimentation stressors to Coho Salmon embryos and alevin in the Klamath River from Keno Dam to the mouth. Substantially lower flows during this season will likely decrease sediment mobilization in October and November. Intragravel passage by alevins will likely improve with reduced fine sediment deposition (Cedarholm & Reid, 1987).

The Proposed Action will result in lower peak flows during the fall and winter (Table 6-8) relative to the Proposed Action (Table 6-9, Table 6-10, Table 4-2, and Table 4-3) these lower flows will reduce the volume of sediment mobilized downstream. This will result in beneficial impacts to Coho salmon embryos and alevin.

Substantial legacy sediment load is currently present and available for transport in the former reservoir reaches downstream as a result of dam removal. Effects of transport of these sediments have already been consulted on as part for the Renewal Corporation’s 2021 Biological Assessment (Renewal Corporation, 2021; per J. Simondet, pers. comm. 04/19/24). The Proposed Action is not expected to impact these sediments given the lower flows as compared to MS scenario.

6.3.2.4 Dissolved Oxygen

During fall and winter, the Proposed Action is anticipated to reduce flows in the Klamath River from Keno Dam to the mouth, which may reduce DO levels. Substantially lower flows relative to the MS scenario and low DO in Keno impoundment will likely decrease DO levels downstream. Embryo and alevin are highly sensitive to DO levels making them more susceptible to decreases in interstitial DO.

The effects of reduced flows under the Proposed Action are consistent with the following excerpts from NMFS 2019:

…the warming effect [of reduced flows] *on water temperatures and longer transit times increases the probability that dissolved oxygen concentrations will decrease in the mainstem Klamath River downstream of IGD. In addition,* [of reduced flow] *also indirectly affects pH and dissolved oxygen through its interactions with periphyton, algae that grow attached to the riverbed.*

High levels of photosynthesis cause dissolved oxygen concentration to rise during the day and lower at night during plant respiration. Low dissolved oxygen concentration at night reduces rearing habitat suitability at night. Daily fluctuations of up to 2 mg/L of dissolved oxygen in the mainstem Klamath River downstream from IGD have been attributed to daytime algal photosynthesis and nocturnal algal/bacterial respiration. In addition, the overall effect of the conceptual linkages between flow and dissolved oxygen is supported by an analysis of 11 years of mainstem Klamath River water quality data that found that higher flows were strongly correlated with higher dissolved oxygen minimums and narrower daily dissolved oxygen range (Asarian and Kann 2013). Therefore, when the Proposed Action reduces mainstem flows…there will likely be a reduction to dissolved oxygen concentrations in the mainstem Klamath River between IGD and Orleans (RM 59).

Therefore, the reduction in mainstem flows resulting from the Proposed Action is expected to reduce DO concentrations in the mainstem Klamath river below Keno Dam. Low temperature and reduced photosynthesis in late-fall and winter may ameliorate these conditions to some extent.

6.3.2.5 Nutrients

During fall, the Proposed Action is anticipated to reduce flows in the Klamath River from Keno Dam to IGD. Substantially lower flows relative to the MS scenario may result in higher concentrations of nutrients in the form of algae transported downstream from Keno Impoundment. This higher nutrient load may result in higher rates of decomposition in the reach, further reducing DO levels.

The effect of the Proposed Action relative to MS scenario on embryo to alevin Coho Salmon in the fall is expected to be substantially similar to the effect on Adults. See Section 6.3.1.4 for detailed discussion.

6.3.2.6 Water Temperature

During fall and winter, the Proposed Action is anticipated to reduce flows in the Klamath River from Keno Dam to the mouth. During early fall, substantially lower flows may result in higher water temperatures. During late fall and winter, these low flow conditions may result in lower water temperatures that fall below optimal egg incubation temperatures and may lead to the accumulation of frazil and anchor ice. This ice accumulation could cause embryo or alevin mortality since these life stages are immobile and incapable of avoiding anchor ice within redds.

Analysis Description See Section 6.3.1.5 for discussion of the analytical method.

Analysis Results for Embryos to Alevin Coho embryo development typically occurs from November through the end of March (Hardy et al., 2006). Only a small portion of natural Coho Salmon spawning occurs in the mainstem of the Klamath River (Dunne et al., 2011), thus minimizing the effects of the Proposed Action on this life stage. Nevertheless, extreme temperatures can affect embryo survival when they fall below 1.3°C (Tang et al., 1987) or when they exceed 11°C (Richter and Kolmes, 2005). The lethal limit for Coho embryos is 14°C (Richter and Kolmes, 2005). The maximum daily average temperature for the Proposed Action was predicted to produce favorable conditions for embryo development for 66% of the incubation period (Figure 6-9, Table 6-14). The minimum daily average temperature for the Proposed Action was predicted to produce favorable conditions for embryo development for 94% of the incubation period. The average daily maximum temperature for the Proposed Action was predicted to produce lethal temperatures, however, 7% of days during the incubation period. This demonstrates that the Proposed Action will produce favorable thermal conditions for incubation the large majority of the time. Moreover, temperature is not known to be a substantial issue for Coho of any life stage during winter (Reclamation, 2020a) so effects, if any, are likely to be negligible.

6.3.3 Fry

The period of fry emergence occurs from February through May with a peak period in March and April at the Klamath River – Keno Dam to IGD and Klamath River – IGD (and tributaries) to Mouth (Figure 6-1).

The Stressors that influence Coho Salmon fry are dewatering/stranding, disease, habitat quantity and quality, restoration, sedimentation, water quality – DO, water quality – nutrients, and water quality – temperature, and entrainment (diversions).

The Proposed Action is not anticipated to change the following stressors:

- Stranding during March in the Klamath River from Keno Dam to IGD as flows are the same under the proposed action and the MS scenario.
- Disease during winter in the Klamath River from Keno Dam to the mouth as water temperatures are cold and Salmonids are not known to experience disease with cold water temperatures.
- Restoration during winter and spring in the Klamath River from the IGD to the mouth as restoration activities are not expected to take place during these periods. Also, restoration may exacerbate existing stressors during the construction period and over the short-term. However, restoration is expected to be beneficial over the medium to long-term.
- Sedimentation during March in the Klamath River from Keno Dam to IGD as flows are the same under the proposed action and the MS scenario.
- DO during winter and spring in the Klamath River from Keno Dam to IGD as DO concentrations will not be limiting in the winter and spring when water temperatures are cold to cool.
- Nutrients during winter and spring in the Klamath River from Keno Dam to the mouth as nutrients are not a known limiting factor in winter and spring.
- Water Temperature during spring in the Klamath River from Keno Dam to the mouth as Water temperature is not a known limiting factor in spring.
- Entrainment during winter and spring in the Klamath River from Keno Dam to IGD as Reclamation does not have water diversions in this area; existing diversions will continue to divert with or without Reclamation’s Proposed Action.

Stressors that may change at a level that is **insignificant or discountable** include the following:

- Habitat Quantity and Quality is anticipated to variably increase and decrease during spring in the Klamath River from the IGD to the mouth. During March and April, flows under the Proposed Action will be higher than under the MS scenario in this reach, potentially increasing rearing habitat for Coho Salmon fry. During May, flows under the Proposed Action will be lower than MS scenario in this reach, potentially decreasing rearing habitat for Coho Salmon fry. The combined magnitude of these effects will be negligible.
- Sedimentation is anticipated to decrease during winter in the Klamath River from Keno Dam to the mouth, and to variably increase and decrease during spring in the Klamath

River from Keno Dam to IGD, and from IGD to the mouth. During winter, flows under the Proposed Action will be reduced compared to MS scenario in the Klamath River from Keno Dam to the mouth. These lower flows will reduce the mobilization and deposition of sediment that was previously trapped behind the Lower Klamath Project dams. During April for the Klamath River from Keno Dam to IGD and during March and April for Klamath River from IGD to the mouth, flows under the Proposed Action will be greater than MS scenario potentially mobilizing sediment and increasing wetted areas for additional sediment inputs. This may affect fry essential functions and development though fry are somewhat mobile and have some ability to avoid the effects.

Stressors that are exacerbated—potentially resulting in incidental take—and those that are potentially ameliorated by the Proposed Action are described in Sections 6.3.3.1 through 6.3.3.5. Conservation measures included as part of the Proposed Action to avoid or compensate for adverse effects are also described in Sections 6.4.

6.3.3.1 Dewatering/Stranding

During winter and spring, the Proposed Action is anticipated to increase the risk of Coho Salmon fry stranding in the Klamath River from Keno Dam to the mouth. During winter, lower flows relative to MS scenario may result in fry stranding. Ramping rates may minimize this stressor.

Rapid changes in flows can pose a substantial risk stranding risk to Coho Salmon fry. As stated by NMFS 2019:

Rapid ramp-down of flows can strand Coho Salmon fry and juveniles if mainstem flow reductions accelerate the dewatering of lateral habitats. Stranded Coho Salmon fry disconnected from the main channel are more likely to experience fitness risks, becoming more susceptible to predators and poor water quality. Death from desiccation may also occur as a result of excessive ramp-down rates that dry up disconnected habitats. While stranding of Coho Salmon fry and juveniles can occur under a natural flow regime, artificially excessive ramp-down rates exacerbate stranding risks. Salmonid fry and juveniles are generally at the most risk from stranding than any salmonid life stage due to their swimming limitations and their propensity to use margins of the channel.

Reclamation is proposing conservative ramp-down rates consistent with natural conditions. NMFS concluded (NMFS, 2010a, 2019; NMFS and USFWS, 2013) that the ramp-down rates below 3,000 cfs adequately reduce the risk of stranding Coho Salmon fry and redds. Therefore, Reclamation believes that the ramp-down and ramp-up rates under the Proposed Action are not likely to adversely affect Coho Salmon redds, fry, or juveniles.

6.3.3.2 Habitat Quantity and Quality

During winter, the Proposed Action is anticipated to decrease Coho Salmon fry habitat quantity and quality in the Klamath River from Keno Dam to the mouth. Lower flows relative to MS scenario will likely decrease the area of available habitat. During spring, the Proposed Action is anticipated to variably decrease and increase Coho Salmon fry habitat quantity and quality in the Klamath River from Keno Dam to IGD. This area will be newly available habitat to Coho fry, thus, habitat availability and quality in this reach is unknown, and the effect of changing flows is unknown at this time.

Analysis Description See Section 6.3.1.1 for discussion of the analytical method.

Analysis Results Coho fry emerge as free-swimming fish February through mid-May (Hardy et al., 2006). Hardy et al. (2006) estimated maximum fry habitat availability occurs at flows between 1,954 cfs and 4,674 cfs. The fry life stage typically overlaps temporally with spring freshets in the Klamath River (Figure 6-6). Under the Proposed Action, Coho Salmon fry are within their optimum flows 53% of the rearing period in half of years (i.e., 50% exceedance; Figure 6-6, Table 6-14). This demonstrates that, while the Proposed Action is a reduction in habitat from MS, it nonetheless provides adequate incubation conditions (Section 6.4) in at least half of years. High flows during early spring could potentially displace fry if adequate refugia is unavailable. However, there is a data gap for the effects of high flow ranges on Coho fry in the Klamath.

During low flow years, the Proposed Action would likely improve flows for fry compared to the MS scenario during the emergence period. For example, 90% exceedance flows at IGD under the MS scenario range between 751 and 917 cfs (Table 6-9) whereas the Proposed Action 90% exceedance flows range between 1,020 and 1,565 cfs (Table 6-8). However, it should be noted that under both scenarios, low-flow conditions are below the optimal threshold (1,954 cfs) for fry. For average water years, there is likely no effect from the Proposed Action relative to the MS scenario, since there is adequate water for both conditions (Figure 6-10). For high water years, both scenarios result in flows > 4,674 cfs, above the optimal range for emerging fry. Given that very few adults spawn in the mainstem Klamath compared to tributaries, it is unlikely that emerging fry will be significantly impacted by the effects of the Proposed Action relative to MS conditions.

For additional habitat effects modeling and discussion, see Section 6.4.

6.3.3.3 Disease

During spring, the Proposed Action is anticipated to increase disease risk for Coho Salmon fry in the Klamath River from IGD to the mouth. Disease prevalence increases in the spring with an increase in spore density. However, natural flushing flows due to the spring freshet under the Proposed Action may somewhat mitigate spore density.

Water Temperature Analysis Description See Section 6.3.1.5 for discussion of the analytical method.

Water Temperature Analysis Results Salmonids in the Klamath River are exposed to a number of pathogens and diseases that can impact all life stages. *C. shasta* is the focal parasite of this meta-analysis. Fryer and Pilcher (1974) suggested that Coho infected with *C. shasta* exhibited high survival at a temperature range of 3.9 to 15.5°C and low survival at temperatures above 15.5°C. Similarly, Ray et al. (2012) found that temperatures between 18.0°C and 21.0°C were positively related to mortality. Furthermore, warm water temperatures are associated with higher *C. shasta* spore concentrations (Som et al., 2019) and springtime water temperatures above 12°C can significantly contribute to disease severity.

In a meta-analysis of *C. shasta* literature (Figure 6-9), the maximum of daily average temperatures simulated for the Proposed Action were likely to be in the lethal range for Coho Salmon for approximately 39% of the water year (Table 6-14) though these temperatures would be in the positive range 52% of the time. The combination of temperatures above 15.5°C and elevated spore concentrations likely result in elevated disease risk for Coho Salmon if those conditions coincide with the outmigration period. It is likely that the MS scenario produces warmer water temperatures, lower flows, and potentially elevated disease risk, relative to the Proposed Action.

Water Flow Analysis Description See Section 6.3.1.1 for discussion of the analytical method.

Water Flow Analysis Results Salmonids in the Klamath River are exposed to a number of pathogens and parasites that can impact all Coho Salmon life stages. *C. shasta* is the focal parasite of this meta-analysis, which is regarded as a prominent threat to juvenile salmonids in the Klamath River. High flow events can potentially disrupt the parasite's life-cycle by disrupting and constraining suitable habitat of the annelid host, *Manayunkia speciose* (*M. speciosa*), and thereby limiting effective parasite spore production (Bjork and Bartholomew, 2009; Malakauskas et al., 2013; Alexander et al., 2016). The Proposed Action seldom results in annelid-disrupting flows in excess of 6,000 cfs at IGD. Under the Proposed Action, annelid-disrupting flows do not occur under anything up to the 10% exceedance level (Figure 6-6, Table 6-14). While flows may occur above the 10% exceedance level, this is unlikely to result in appreciable disruption of annelids under the Proposed Action.

The magnitude of peak flows between February and June are higher under the Proposed Action compared to the MS scenario (Figure 6-10). The Proposed Action may reduce disease severity relative to MS scenario as a result of these higher magnitude flow events in the spring. However, the differences are so slight and do not reach the level of an annelid-disrupting that it seems unlikely that there would be any appreciable effect. Annelid-disrupting flows would likely only be reached during wet years (i.e., 1997; Figure 6-10) and even then, rarely. Given the limited data available on flow effects on parasites, spore concentrations, and infection rates for flows between 2,500 and 5,000 cfs, it is unclear how elevated flows under either the Proposed Action or WOA scenario would affect disease conditions.

6.3.3.4 Restoration

During spring, the Proposed Action is anticipated to increase restoration-associated stressors to Coho Salmon fry within the Klamath River from IGD to the mouth. Altered flows during this season may disrupt fry during restoration. Restoration may exacerbate existing stressors during the construction period and over the short-term. However, restoration is expected to be beneficial over the long-term.

Reclamation has previously funded and consulted on restoration projects (Section 2.4.6 and Table 2-2) that are expected to occur during the period of coverage for this consultation.

Reclamation has been advised (J. Simondet, pers. comm. 04/16/24) that take coverage for these projects has already been provided for in previous consultations. However, since any potential effects would occur during the timeframe of the current consultation, Reclamation provides a brief synopsis of previous effects analyses here.

Previously, authorized restoration activities that require instream activities will be implemented during low flow periods between June 15 and November 1. The specific timing and duration of each individual restoration project will vary depending on the project type, specific project methods, and site conditions. Implementing individual restoration projects during the summer and or low-flow period will minimize exposure to emigrating Coho Salmon smolts and adults at all habitat restoration project sites.

Most restoration projects have the potential to result in short-term adverse effects. Despite the different scope, size, intensity, and location of these proposed restoration actions, the potential adverse effects to Coho Salmon result from dewatering, fish relocation, channel realignment, structure placement, and increased sediment will be short-term. Dewatering, fish relocation, channel realignment, and structural placement may result in direct effects to listed salmonids, where a small percentage of individuals may be injured or killed. The effects from increased sediment mobilization into streams are usually indirect effects, where the effects to habitat, individuals, or both, are reasonably certain to occur and are later in time.

Riparian Habitat Restoration Riparian habitat restoration techniques, if done properly, should not have long-term negative effects on listed salmonids or their habitat. All vegetation planting or removal (in the case of exotic species) would likely occur on streambanks and floodplains adjacent to the wetted channel and activities should not occur in flowing water. Thus, the long-term benefit from riparian restoration would be the establishment of a vibrant, functional riparian corridor providing juvenile and adult fish with abundant food and cover. Degraded riparian systems restored during the duration of the Proposed Action will increase the likelihood of future survival and recovery for listed salmonids in the future.

Riparian fencing and vegetation restoration projects would result in increased stream shading and instream cover habitat for rearing juveniles, moderated stream temperatures, and improved water quality through pollutant filtering. Beneficial effects of constructing livestock exclusionary fencing in or near streams include the rapid regrowth of grasses, shrubs, and other vegetation released from grazing, and reduced nitrogen, phosphorous, and sediment loading into the stream environment (Brenner and Brenner, 1998; Line et al., 2000). Further, Owens et al. (1996) found that stream fencing has proven to be an effective means of maintaining appropriate levels of sediment inputs from uplands in the stream channel. Another documented, beneficial, long-term effect is the reduction in bankfull width of the active channel and the subsequent increase in pool area in streams (Magilligan and McDowell, 1997). Most riparian restoration projects contribute to a properly functioning ecosystem for listed species by providing additional habitat relative to their current condition.

Water Conservation Implementing water conservation measures under the Proposed Action will benefit Coho Salmon by returning instream flow at a time when Coho Salmon require adequate habitat to rear and migrate. Increasing instream flow levels by diminishing water diversions will provide juvenile Coho Salmon with better access to suitable rearing habitat, especially during the summer and early fall when flows are lowest. Water conservation projects are most likely to occur in the tributaries, such as the Shasta and Scott rivers.

Construction activities, such as developing alternative stock water supply, tailwater collection ponds, water storage tanks, and piping open ditches, may occur for specific water conservation projects. The activities typically take place away from critical habitat in diversion ditches or other contained locations away from natural stream channels. Any potential sediment mobilization, chemical contamination or other effects of dewatering are expected to be temporary in nature and are unlikely to reach the stream channel and cause negative effects to Coho Salmon individuals or habitat.

Reclamation’s previous funding for restoration activities implemented during the current Proposed Action will likely result in short-term negative effects during implementation, and the expectation is that the suite of restoration activities may result in long-term improvements to the function and role of critical habitat in the Action Area. The restoration activities will minimize habitat related effects of the Project by individually and comprehensively improving critical habitat conditions for Coho individuals, populations, and overall. Consequently, restoration projects funded under previous Proposed Actions will contribute to increased salmon habitats relative to the current Proposed Action or MS scenario.

6.3.3.5 Water Temperature

During winter, the Proposed Action is anticipated to increase temperature stressors for Coho Salmon fry (i.e., from decreased water temperature) in the Klamath River from Keno Dam to the mouth. Lower flows relative to MS scenario may result in the formation of frazil and/or anchor ice. Fry are relatively immobile and incapable of avoiding anchor ice formation in rearing habitat.

Analysis Description See Section 6.3.1.5 for discussion of the analytical method.

Analysis Results for Fry Coho fry emerge as free-swimming fish February through mid-May (Hardy et al., 2006), preferring temperatures between 4.0°C and 10.9°C (Tang et al., 1987). Fry were positively affected by maximum of daily average temperatures for the Proposed Action approximately 64% of days during their expected presence in the mainstem Klamath River (Figure 6-9, Table 6-14). Neither adverse nor lethal conditions for fry development occurred under maximum, minimum, or mean daily average temperatures. While temperatures in April and May exceeded the preferred thermal range, there is a data gap for temperature effects on Coho Salmon fry outside the optimal range. Given temperatures exceeded the optimum range for most of this development period, the Proposed Action will likely have some negative impacts on fry development. However, temperature is not known to be a substantial issue for Coho of any life stage during winter (Reclamation, 2020a) so effects, if any, are likely to be negligible.

6.3.4 Parr

The period of juvenile rearing is year-round at the Klamath River – Keno Dam to IGD and Klamath River – IGD (and tributaries) to Mouth (Figure 6-1). There is no distinct peak period.

The Stressors that influence Coho Salmon parr are dewatering/stranding, disease, habitat quantity and quality, restoration, sedimentation, water quality – DO, water quality – nutrients, water quality – temperature, and entrainment (diversions).

The Proposed Action is not anticipated to change the following stressors:

- Stranding during March in the Klamath River from Keno Dam to IGD as flows are the same under the proposed action and the MS scenario.
- Disease during fall and winter in the Klamath River from Keno Dam to the mouth as water temperatures are cold and Salmonids are not known to experience disease with cold water temperatures.
- Restoration during winter and spring in the Klamath River from IGD to the mouth as restoration activities are not expected to take place during these periods. Also, restoration may exacerbate existing stressors during the construction period and over the short-term. However, restoration is expected to be beneficial over the medium to long-term.
- Sedimentation March from Keno Dam to IGD as flows are the equivalent between the Proposed Action and MS scenarios.
- DO during winter and spring in the Klamath River from Keno Dam to the mouth as DO concentrations will not be limiting in winter and spring when water temperatures are cold to cool.
- Nutrients during winter and spring in the Klamath River from Keno Dam to the mouth, and during fall in the Klamath River from IGD to the mouth as nutrients are not a known limiting factor in winter, spring, and fall.
- Water Quality - Temperature during spring in the Klamath River from Keno Dam to the mouth as water temperature is not a known limiting factor in spring.
- Entrainment during winter and spring in the Klamath River from Keno Dam to IGD. Reclamation does not have water diversions in this area; existing diversions will continue to divert with or without Reclamation’s Proposed Action.

Stressors that may change at a level that is **insignificant or discountable** include the following:

- Stranding risk is expected to decrease in March and April and summer in the Klamath River from Keno Dam to IGD. Flows under the Proposed Action will be higher than under the MS scenario potentially reducing the risk of Coho Salmon parr stranding. The magnitude of these effects will be negligible. Stranding risk is expected to increase in the winter, fall and May as flows under the Proposed Action generally will be lower than MS scenario in the Klamath River from Keno Dam to the mouth, potentially increasing the risk of Coho Salmon parr stranding in this reach. However, Coho salmon parr are relatively mobile and able to select preferred habitat thereby making any likely increased or decreased risk insignificant or discountable. Also, ramping rates would reduce the effects of stranding.

- Disease is anticipated to decrease during summer in the Klamath River from IGD to the mouth during fall. Higher flows under the Proposed Action than under the MS scenario may create more rearing habitat leading to decreased crowing. Lower densities of rearing parr may decrease the potential for lateral transmission of disease though this decrease is likely negligible.
- Habitat Quantity and Quality in the Klamath River from IGD to the mouth may be slightly affected by the Proposed Action, with effects differing among seasons. During winter and spring, flows under the Proposed Action generally will be lower than MS scenario in this reach, potentially reducing the quantity and quality of Coho Salmon parr rearing habitat. During summer, flows under the Proposed Action will be greater than MS scenario in this reach, potentially increasing the quantity and quality of Coho Salmon parr rearing habitat. Coho salmon parr are relatively mobile and able to select preferred habitat thereby making any likely increased or decreased risk insignificant or discountable.
- Sedimentation is anticipated to decrease during winter in the Klamath River from Keno Dam to IGD and from IGD to the Mouth, to variably increase and decrease during spring in the Klamath River from Keno Dam to IGD, and from IGD to the mouth and to increase in summer from IGD to the mouth. During winter, flows under the Proposed Action will be reduced compared to MS scenario in the Klamath River from Keno Dam to the mouth. These lower flows will reduce the mobilization and deposition of sediment that was previously trapped behind the Lower Klamath Project dams. During April for the Klamath River from Keno Dam to IGD and during March and April for Klamath River from IGD to the mouth, flows under the Proposed Action will be greater than MS scenario potentially mobilizing sediment and increasing wetted areas for additional sediment inputs. During summer, flows under the Proposed Action will be greater than MS scenario in the Klamath River from Keno Dam to the mouth. These higher flows may mobilize and deposit more fine sediments. However, under all seasons, parr are relatively mobile and tolerant of suspended sediments.
- DO stressor is expected to increase in summer and fall in the Klamath River from Keno Dam to the Mouth. During summer, seasonally warmer water temperatures will naturally result in lower DO. Against that background condition, flows under the Proposed Action will be greater than under MS scenario in the Klamath River from Keno Dam to the mouth. During fall, flows under the Proposed Action generally will be lower than MS scenario in the Klamath River from Keno Dam to the mouth. Regardless of flows, already low DO in the Keno Impoundment may result in decreased DO levels downstream. However, DO levels are not expected to decrease to harmful levels for Coho (Dahlberg et al., 1968; Davis, 1975; Davis et al., 1963).
- Nutrient loading may increase during summer in the Klamath River from Keno Dam to the mouth. Higher flows may mobilize nutrients downstream in the form of UKL algal

blooms. However, higher flows will also dilute incoming nutrients reducing the magnitude of this effect.

- Water temperature is anticipated to increase during fall and decrease during winter in the Klamath River from Keno Dam to the mouth. During fall, substantially lower flows resulting from the Proposed Action may result in higher water temperatures; however, decreasing solar radiation during these months will minimize the magnitude of this effect as water temperatures are seasonally decreasing, particularly in October and November. Winter water temperature may be affected by the Proposed Action, but temperature never gets outside the preferred range for the species during these months. Lower flows relative to MS scenario may result in the formation of frazil and/or anchor ice in winter, but Parr are highly mobile and can avoid such ice in other areas/systems, especially as they prefer deep pools during winter (Reclamation, 2020a).

Stressors that are exacerbated—potentially resulting in incidental take—and those that are potentially ameliorated by the Proposed Action are described in Sections 6.3.4.1 through 6.3.4.9. Conservation measures included as part of the Proposed Action to avoid or compensate for adverse effects are also described in Sections 6.4.

6.3.4.1 Dewatering/Stranding

During spring, the Proposed Action is anticipated to increase the risk of Coho Salmon parr stranding in the Klamath River from Keno Dam to the mouth. Higher flows in April may push parr to margins, which could subsequently leave parr stranded in May when flows are reduced. Ramping rates may reduce the effect of changes in flow.

Mean base flows under the Proposed Action are expected to be within expected bounds to maintain tributary connectivity for re-distributing juveniles. Further, the Proposed Action maintains flows between July and October that more closely adhere to NMFS and USFWS (2013) base flow recommendations of 1,000 cfs (Section 6.5.3, Table 6-8); 95% exceedance flows under the WOA scenario during this same period (July to October) are predicted to fall well below 1,000 cfs (Section 6.5.3, Table 6-9) suggesting that tributary connectivity and fish access may be impaired under MS scenario in fall months.

Rapid changes in flows can pose a substantial risk stranding risk to Coho Salmon juveniles. As stated by NMFS 2019:

> *Rapid ramp-down of flows can strand Coho Salmon fry and juveniles if mainstem flow reductions accelerate the dewatering of lateral habitats. Stranded Coho Salmon fry disconnected from the main channel are more likely to experience fitness risks, becoming more susceptible to predators and poor water quality. Death from desiccation may also occur as a result of excessive ramp-down rates that dry up disconnected habitats. While stranding of Coho Salmon fry and juveniles can occur under a natural flow regime, artificially excessive ramp-down rates exacerbate stranding risks. Salmonid fry and juveniles are generally at the most risk from stranding than any salmonid life stage due to their swimming limitations and their propensity to use margins of the channel.*

Reclamation is proposing conservative ramp-down rates consistent with natural conditions. NMFS concluded (NMFS 2010a, 2019; NMFS and USFWS, 2013) that the ramp-down rates below 3,000 cfs adequately reduce the risk of stranding Coho Salmon fry and redds. Therefore, Reclamation believes that the ramp-down and ramp-up rates under the Proposed Action are not likely to adversely affect Coho Salmon redds, fry, or juveniles.

6.3.4.2 Disease

During spring, the Proposed Action is anticipated to increase the risk of disease for Coho Salmon parr in the Klamath River from IGD to the mouth. Disease prevalence increases in the spring with an increase in spore density.

Water Temperature Analysis Description See Section 6.3.1.5 for discussion of the analytical method.

Water Temperature Analysis Results Coho Salmon parr are expected to respond similarly to disease stressor as Coho Salmon fry. See Section 6.3.3.2 for a discussion of impacts of disease applicable to Coho Salmon parr.

6.3.4.3 Habitat Quantity and Quality

The Proposed Action is anticipated to reduce habitat quantity and quality for Coho Salmon parr in the Klamath River from Keno Dam to IGD during winter and spring, and from Keno Dam to the mouth during fall. Substantially lower flows relative to MS scenario will reduce the quantity and quality of available rearing habitat in the lower river during these seasons. During summer, the Proposed Action is anticipated to increase habitat quantity and quality for Coho Salmon parr in the Klamath River from Keno Dam to IGD, as higher flows will result in increased habitat throughout this reach. The reach between Keno and IGD will be newly available habitat to Coho parr, thus, habitat availability and quality in this reach is unknown, and the quantity of these effects from changing flows is unknown.

Analysis Description See Section 6.3.1.1 for discussion of the analytical method.

Analysis Results Juvenile Coho are present year-round in the Klamath River. Hardy et. al. (2006) estimated maximum parr habitat availability occurs at flows between 1,384 cfs and 5,507 cfs. Under the Proposed Action, Coho Salmon parr are within their optimum flows 27% of the rearing period in half of years (i.e., 50% exceedance; Figure 6-6, Table 6-14). This demonstrates that the Proposed Action will only provide adequate incubation conditions about a quarter of the incubation period (Section 6.4) in at least half of years. Parr are the life stage most affected by reductions in habitat quantity and quality and these are likely to adversely affect this life stage.

During low and average flow water years, juvenile Coho are likely to experience lower flows if the Proposed Action were implemented relative to the MS scenario in the fall and early-winter (Figure 6-10). However, during spring and summer, the Proposed Action typically produces higher flows than the MS scenario (Figure 6-10). Given the lack of information on flows outside the optimal range and on the likelihood and timing of Coho volitionally re-populating IGD to Keno Dam reach, it is unclear how this difference will affect rearing juveniles.

For additional habitat effects modeling and discussion, see Section 6.4.

6.3.4.4 Restoration

During summer, the Proposed Action is anticipated to increase restoration-associated stressors for Coho Salmon parr in the Klamath River from IGD to the mouth. Restoration may exacerbate existing stressors during the construction period and over the short-term. However, restoration is expected to be beneficial over the long-term.

Reclamation has previously funded and consulted on restoration projects (Section 2.4.6 and Table 2-2) that are expected to occur during the period of coverage for this consultation. Reclamation has been advised (J. Simondet, pers. comm. 04/16/24) that take coverage for these projects has already been provided for in previous consultations. However, since any potential effects would occur during the timeframe of the current consultation, Reclamation provided a brief synopsis of previous effects analyses in Section 6.3.3.4. Effects to Parr are not anticipated to be substantially different from those discussed above for Fry.

6.3.4.5 Sedimentation

During fall, the Proposed Action is anticipated to decrease sedimentation stressors to Coho Salmon parr in the Klamath River from Keno Dam to the mouth. Substantially lower flows during this season will likely decrease sediment mobilization in October and November. Fish respiration will likely improve as will prey availability.

The Proposed Action will result in lower peak flows during the fall and winter (Table 6-8) relative to the Proposed Action (Table 6-9, Table 6-10, Table 4-2, and Table 4-3) these lower flows will reduce the volume of sediment mobilized downstream. This will result in beneficial impacts to Coho salmon parr. These higher flows are not expected to impact spawning adults as redds are generally already built in areas of high flow.

Substantial legacy sediment load is currently present and available for transport in the former reservoir reaches downstream as a result of dam removal. Effects of transport of these sediments have already been consulted on as part for the Renewal Corporation’s 2021 Biological Assessment (Renewal Corporation, 2021; per J. Simondet, pers. comm. 04/19/24). The Proposed Action is not expected to impact these sediments given the lower flows as compared to MS scenario.

6.3.4.6 Dissolved Oxygen

During summer, the Proposed Action may result in increased DO in the Klamath River from Keno Dam to IGD, potentially benefiting Coho Salmon parr. Higher and more turbulent flows during this season may result in higher DO concentrations in this reach. However, the complex interaction of DO, temperature, and nutrients will likely render these effects negligible and uncertain. There is no DO monitoring in this reach at this time.

Higher downstream flows under the Proposed Action may contribute to improved DO concentrations. However, this beneficial effect may be mediated by an increase in temperature (Section 6.3.1.5) as a result of warm water releases downstream from UKL, transport of algal blooms, and decomposition of organic detritus downstream, which could further reduce DO. Under the MS scenario, flows may fall below minimums (Section 6.3.1.1) established by the Proposed Action, resulting in lower DO but decreased releases of warm water from UKL and transport of algal blooms and other organic detritus may act to mitigate this effect. Increased flows and their interaction with DO are expected to be substantially similar to those previously discussed for Adults. See Section 6.3.2.3 for the complete discussion.

The effects to parr of potential low DO levels are consistent with the following excerpt from NMFS 2019:

Low dissolved oxygen concentration can impair growth, swimming performance and avoidance behavior (Bjornn and Reiser 1991). Davis (1975) reported effects of dissolved oxygen levels on salmonids, indicating that at dissolved oxygen concentrations greater than 7.75 mg/L salmonids functioned without impairment, at 6.0 mg/L onset of oxygen-related distress was evident, and at 4.25 mg/L widespread impairment is evident. At 8 mg/L, the maximum sustained swimming performance of Coho Salmon decreased (Davis et al. 1963, Dahlberg et al. 1968). Low dissolved oxygen can affect fitness and survival by increasing the likelihood of predation and decreasing feeding activity (Carter 2005). Sublethal effects include increased stress, reduced growth, or no growth…

While the Proposed Action may result in beneficial effects to DO the effects could be negligible and are uncertain due to the interactions with water temperature, photosynthesis, and decomposition of organic detritus.

6.3.4.7 Nutrients

During fall, the Proposed Action is anticipated to increase nutrient loading stressors to Coho Salmon parr in the Klamath River from Keno Dam to IGD. Substantially lower flows relative to the MS scenario may result in higher concentrations of nutrients in the form of algae transported downstream from Keno Impoundment. Higher nutrients may result in higher rates of decomposition in the reach further reducing DO levels.

The effect of the Proposed Action relative to MS scenario on parr Coho Salmon in the fall is expected to be substantially similar to the effect on Adults. See Section 6.3.1.4 for detailed discussion.

6.3.4.8 Water Temperature

The Proposed Action is anticipated to increase water temperature-associated stressors to Coho Salmon parr in the Klamath River from Keno Dam to the mouth during summer, and from IGD to the mouth during fall. During summer, the Proposed Action will release more water downstream. However, this includes releases of warmer water from UKL, which may reduce the effectiveness of cold water refugia. Parr, which rear in shallower water along stream margins, may not be able to move to deeper, cool water refugia. During fall, substantially lower flows may result in higher water temperatures due to the existing head load in the river being concentrated in a smaller volume of water. However, decreasing solar insolation will lower seasonal water temperatures particularly in October and November.

Analysis Description See Section 6.3.1.5 for discussion of the analytical method.

Analysis Results for Parr The upper range used for negative effects of temperature on juvenile Coho was 17.0 – 25.8°C, which combined thermal ranges from several studies (25.8°C lethal limit, Beschta et al., 1987; >20.0°C, NRC, 2004; >17°C, Richter and Kolmes, 2005; Hillemeier et al., 2009; >19.9°C, Sutton and Soto, 2012; Adams and Bean, 2016). The maximum daily average temperatures for the period of record were predicted to negatively affect juvenile Coho for approximately 33% of their rearing period (Figure 6-9, Table 6-14), primarily during the summer and fall.

Rearing Coho were positively affected by temperatures approximately 56% of the year, mostly between winter and spring when temperatures were moderate under the Proposed Action. Overall, this demonstrates that the Proposed Action is expected to have a positive influence on rearing habitat a majority of the time.

6.3.4.9 Entrainment

During summer and fall, the Proposed Action is anticipated to increase entrainment stressors for Coho Salmon parr in the Klamath River from Keno Dam to IGD. The structure of the diversion headgates in this reach may increase entrainment due to higher flows. The diversions are not associated with the Project and thus, existing diversions will continue to divert with or without Reclamation's Proposed Action.

Entrainment can be a substantial risk to juvenile Coho Salmon. As stated by NMFS 2019:

Water diversions can greatly affect aquatic life when organisms are entrained into intake canals or pipes -- an estimated 10 million juvenile salmonids were lost annually through unscreened diversions in the Sacramento River alone (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council 1989). Once entrained, juvenile fish can be transported to less favorable habitat (e.g., a reservoir, lake or drainage ditch) or killed instantly by turbines. Fish screens are commonly used to prevent entrainment of juvenile fish in water diverted for agriculture, power generation, or domestic use.

The structure of the diversion headgates in this reach (i.e., wing walls reaching well out into the channel) may increase entrainment due to higher flows under the Proposed Action. The diversions are not owned by the Project and are, therefore, not under Reclamation's control. However, Reclamation is not currently proposing to fund any additional screening projects. Reclamation expects impacts from the Proposed Action, relative to MS from entrainment at non-Project diversions.

6.3.5 Smolts

The period of young-of-year emigration occurs from mid-February through mid-June with a peak period in April and May at the Klamath River – Keno Dam to IGD and Klamath River – IGD (and tributaries) to Mouth (Figure 6-1). The period of yearling smolt emigration occurs from December through June with a peak period in February and April at the Klamath River – Keno Dam to IGD and Klamath River – IGD (and tributaries) to Mouth.

The Stressors that influence Coho Salmon smolts are outmigration rates, dewatering/stranding, disease, habitat quantity and quality, restoration, sedimentation, water quality – DO, water quality – nutrients, water quality – temperature, and entrainment (diversions).

The Proposed Action is not anticipated to change the following stressors:

- Stranding during summer from IGD to the mouth as flows at this time of year are adequate and higher than the MS scenario and ramping rates are protective.
- Disease during winter in the Klamath River from Keno Dam to the mouth as water temperatures are cold and Salmonids are not known to experience disease with cold water temperatures.
- Restoration during winter, spring, and summer in the Klamath River from IGD to the mouth as restoration activities are not expected to take place during winter and spring. In summer, restoration may exacerbate existing stressors during the construction period and over the short-term. However, restoration is expected to be beneficial over the medium to long-term.
- Sedimentation during spring in the Klamath River from Keno Dam to IGD and during summer from IGD to the mouth. Higher flows may mobilize and deposit more fine sediments. However, smolts are highly mobile, migrating out of the system = and tolerant of suspended sediments.
- DO during winter and spring in the Klamath River from Keno Dam to the mouth as DO concentrations will not be limiting in winter and spring when water temperatures are cold to cool.
- Nutrients during winter and spring in the Klamath River from Keno Dam to the mouth as nutrients are not a known limiting factor in winter, and spring.
- Water Temperature during spring in the Klamath River from Keno Dam to the mouth as water temperature is not a known limiting factor in spring.

Stressors that may change at a level that is **insignificant or discountable** include the following:

- Outmigration Rate stressors may increase during March and May from Keno Dam to IGD and decrease during April and summer from IGD to the mouth. During March and May, reduced Klamath River flows from Keno Dam to IGD could mask the cue to migrate and increase travel time in this reach. Also, storing water in UKL reduces flow magnitude, which smolts use as cues to continue migration. Higher flows in April are likely beneficial because they may result in faster migration times. During April and summer, increased Klamath River flows from IGD to the mouth may increase the outmigration rate of Coho Salmon smolts (i.e., reduce this stressor). Survival of outmigrating smolts is increased with decreased outmigration time. Higher flows may enhance the cue to migrate.

- Stranding risk is expected to decrease in March and April and summer in the Klamath River from Keno Dam to IGD. Flows under the Proposed Action will be higher than under the MS scenario potentially reducing the risk of Coho Salmon smolt stranding. The magnitude of these effects will be negligible. Stranding risk is expected to increase in the winter, fall and May as flows under the Proposed Action generally will be lower than MS scenario in the Klamath River from Keno Dam to the mouth, potentially increasing the risk of Coho Salmon parr stranding in this reach. However, smolts generally outmigrate downstream using the mid-channel thalweg and are less likely to experience stranding or dewatering under most flow conditions. Also, ramping rates would reduce the effects of stranding.
- Habitat Quantity and Quality is anticipated to increase during summer from the IGD to the mouth, variable during spring in the Klamath River from Keno Dam to the mouth and to decrease during winter in the Klamath River from Keno Dam to the mouth. In summer, the Proposed Action is anticipated to result in slightly higher summertime flows, which may increase habitat quantity in this reach by a negligible amount. In spring, changes in flow associated with the Proposed Action may result in slight increases or decreases in Coho Salmon smolt habitat quantity and quality in the Klamath River from Keno Dam to the mouth, depending on the month. Higher or lower flows will increase or decrease habitat by a negligible amount that is likely discountable or insignificant. In winter, the Proposed Action is anticipated to result in reduced winter flows, which may reduce quality and quantity of habitat in this reach by a negligible amount. However, adults are sufficiently mobile to re-locate to deeper habitat, so spawning Coho Salmon are anticipated to be able to sufficiently access habitat (deep pools) to successfully hold and spawn within this reach.
- Sedimentation is anticipated to decrease during winter in the Klamath River from Keno Dam to IGD and from IGD to the Mouth, to variably increase and decrease during spring in the Klamath River from Keno Dam to IGD, and from IGD to the mouth and to increase in summer from IGD to the mouth. During winter, flows under the Proposed Action will be reduced compared to MS scenario in the Klamath River from Keno Dam to the mouth. These lower flows will reduce the mobilization and deposition of sediment that was previously trapped behind the Lower Klamath Project dams. During April for the Klamath River from Keno Dam to IGD and during March and April for Klamath River from IGD to the mouth, flows under the Proposed Action will be greater than MS scenario potentially mobilizing sediment and increasing wetted areas for additional sediment inputs. During summer, flows under the Proposed Action will be greater than MS scenario in the Klamath River from Keno Dam to the mouth. These higher flows may mobilize and deposit more fine sediments. However, under all seasons, smolts are relatively mobile and tolerant of suspended sediments.

- DO stressor is expected to increase in summer and fall in the Klamath River from Keno Dam to the Mouth. During summer, seasonally warmer water temperatures will naturally result in lower DO. Against that background condition, flows under the Proposed Action will be greater than under MS scenario in the Klamath River from Keno Dam to the mouth. During fall, flows under the Proposed Action generally will be lower than MS scenario in the Klamath River from Keno Dam to the mouth. Regardless of flows, already low DO in the Keno Impoundment may result in decreased DO levels downstream. However, DO levels are not expected to decrease to harmful levels for Coho (Dahlberg et al., 1968; Davis, 1975; Davis et al., 1963).
- Water temperature is anticipated to increase during summer and decrease during winter in the Klamath River from Keno Dam to the mouth. During summer, the Proposed Action is anticipated to increase flow in this reach, but as this additional flow comprises warmer water from UKL, this may lead to slightly increased downstream temperatures that reduce the effectiveness of cold water refugia for outmigrating smolts. However, the release of warmer water from UKL will not likely reach sub-lethal levels (Richter and Kolmes, 2005). Winter water temperature may be affected by the Proposed Action, but temperature never gets outside the preferred range for the species during these months. Lower flows relative to MS scenario may result in the formation of frazil and/or anchor ice in winter, but smolts are highly mobile and can avoid such ice in other areas/systems, especially as they prefer deep pools during winter (Reclamation, 2020a).
- Entrainment may decrease during May, in the Klamath River from Keno Dam to IGD due to decreased flow. The decrease may be insignificant or discountable. The diversions are not associated with the Project and thus, existing diversions will continue to divert with or without Reclamation’s Proposed Action.

Stressors that are exacerbated—potentially resulting in incidental take—and those that are potentially ameliorated by the Proposed Action are described in Sections 6.3.5.1 through 6.3.5.7 Conservation measures included as part of the Proposed Action to avoid or compensate for adverse effects are also described in Sections 6.4.

6.3.5.1 Outmigration Rates

During winter, the Proposed Action is anticipated to increase outmigration stressors for Coho Salmon smolts in the Klamath River from Keno Dam to the mouth. Reduced flows during this season in this reach will reduce the outmigration rate of smolts. Survival of outmigrating smolts is reduced with increased outmigration time (citation). The smoltification process reduces swimming ability in lotic systems, reducing survival (Flagg and Smith, 1981). Lower flows may mask the cue to migrate.

During spring and summer, the Proposed Action is anticipated to provide a beneficial effect for outmigrating Coho Salmon smolts in the Klamath River from Keno Dam to IGD. Higher flows decrease downstream migration time leading to higher survival rates.

The Proposed Action will likely adversely affect outmigrating Coho Salmon smolts during winter relative to the MS scenario due to lower flows (Section 6.3.1.1) increasing migration time.

Conversely, later migrating smolts may benefit from higher spring and summer flows relative to MS scenario. Other factors expected to affect smolt outmigration include increasing water temperature, decreasing DO concentration, increasing susceptibility to diseases, delaying outmigration times, and reducing habitat availability. These effects are discussed separately throughout this section for clarity. However, these stressors can affect Coho Salmon simultaneously, sequentially, or synergistically. Also, the Proposed Action incorporates flow variability, flow management, and restoration (previously funded and consulted on but implemented during the period of this consultation) which may offset some of the adverse effects of flow reductions.

Although the Proposed Action provides for reduced flows in winter and less flow variability in spring, the increased flows in April and May provide more discharge volume for smolt outmigration and likely increase the availability of rearing and off-channel refuge habitat for Coho Salmon smolts relative to the MS scenario. However, reductions in flow variability, as a result of the Proposed Action, would also reduce frequency of high flows reducing inundation of floodplains and side channels which represent important rearing habitat (NMFS, 2010a). While the Proposed Action increases flow in spring and summer and provides for some flow variability, reductions in winter flow and frequency of variable flows will likely adversely affect Coho Salmon smolts.

6.3.5.2 Dewatering/Stranding

During spring, the Proposed Action is anticipated to increase the risk of Coho Salmon smolts stranding in the Klamath River from Keno Dam to the mouth.

Mean base flows under the Proposed Action are expected to be within expected bounds to maintain tributary connectivity for re-distributing juveniles. Further, the Proposed Action maintains flows between July and October that more closely adhere to NMFS and USFWS (2013) base flow recommendations of 1,000 cfs (Section 6.5.3, Table 6-8); 95% exceedance flows under the WOA scenario during this same time period (July to October) are predicted to fall well below 1,000 cfs (Section 6.5.3, Table 6-9) suggesting that tributary connectivity and fish access may be impaired under MS scenario in fall months.

Rapid changes in flows can pose a substantial risk stranding risk to Coho Salmon fry. As stated by NMFS 2019:

Rapid ramp-down of flows can strand Coho Salmon fry and juveniles if mainstem flow reductions accelerate the dewatering of lateral habitats. Stranded Coho Salmon fry disconnected from the main channel are more likely to experience fitness risks, becoming more susceptible to predators and poor water quality. Death from desiccation may also occur as a result of excessive ramp-down rates that dry up disconnected habitats. While stranding of Coho Salmon fry and juveniles can occur under a natural flow regime, artificially excessive ramp-down rates exacerbate stranding risks. Salmonid fry and juveniles are generally at the most risk from stranding than any salmonid life stage due to their swimming limitations and their propensity to use margins of the channel.

Reclamation is proposing conservative ramp-down rates consistent with natural conditions. NMFS concluded (NMFS 2010a, 2019; NMFS and USFWS, 2013) that the ramp-down rates below 3,000 cfs adequately reduce the risk of stranding Coho Salmon fry and redds. Therefore, Reclamation believes that the ramp-down and ramp-up rates under the Proposed Action are not likely to adversely affect Coho Salmon redds, fry, or juveniles.

6.3.5.3 Disease

During spring and summer, the Proposed Action is anticipated to increase the risk of disease for Coho Salmon smolts in the Klamath River from IGD to the mouth. Disease prevalence increases in the spring with an increase in spore density. However, surface flushing flows under the Proposed Action may somewhat mitigate spore density. Moreover, crowding may be reduced due to higher flows than under MS scenario leading to lower densities of outmigrating smolts. This may decrease the potential for lateral transmission of disease.

Water Temperature Analysis Description See Section 6.3.1.5 for discussion of the analytical method.

Water Temperature Analysis Results Coho Salmon smolts are expected to respond similarly to disease stressor as Coho Salmon parr. See Section 6.3.3.2 for a discussion of impacts of disease applicable to Coho Salmon smolts.

6.3.5.4 Habitat Quantity and Quality

During winter, the Proposed Action is anticipated to reduce habitat quantity and quality for Coho Salmon smolts in the Klamath River from Keno Dam to IGD and to increase habitat quantity and quality during winter in this reach.

Analysis Description See Section 6.3.1.1 for discussion of the analytical method.

Analysis Results Smolts typically out-migrate through the Klamath River mainstem from mid-March through late- July. Beeman et al. (2012) predicted hatchery Coho smolt survival to exceed 80% at flows between 1,500 cfs and 10,000 cfs. During a particularly low-flow year in spring of 2015, observations of Coho were scarce when flows fell below 1,500 cfs (David et al., 2017b). Under the Proposed Action, Coho Salmon smolts are within their optimum flows 44% of the outmigration period in half of years (i.e., 50% exceedance; Figure 6-6 Table 6-14). This demonstrates that the Proposed Action provides adequate outmigration corridors and conditions (Section 6.4) in half of years.

During most of the out-migration period (March – June, peak period April and May), 90% exceedance flows at IGD are between 450 and 800 cfs lower during implementation of the MS scenario than for the Proposed Action (Table 6-10). Both scenarios include 90% exceedance flows <1,500 cfs, suggesting that under low-flow conditions, Coho smolts would be negatively affected by flows under both the MS and Proposed Action scenarios, but the magnitude may be greater if the Proposed Action were not implemented. During average or high-flow water year conditions, the Proposed Action would likely result in higher instream flow relative to the MS scenario, although both scenarios would produce flows within the range where smolt survival would be expected to exceed 80% (Table 6-8, Table 6-9).

For additional habitat effects modeling and discussion, see Section 6.4.

6.3.5.5 Dissolved Oxygen

During summer, the Proposed Action is anticipated to result in increased DO in the Klamath River from Keno Dam to IGD. Higher and more turbulent flows may result in higher DO concentrations in this reach. However, the complex interaction of DO, temperature, and nutrients will likely render these effects negligible and uncertain. There is no DO monitoring in this reach at this time.

Higher downstream flows under the Proposed Action may contribute to improved DO concentrations. However, this beneficial effect may be mediated by an increase in temperature (Section 6.3.1.5) as a result of warm water releases downstream from UKL, transport of algal blooms, and decomposition of organic detritus downstream which could further reduce DO. Under the MS scenario, flows may fall below minimums (Section 6.3.1.1) established by the Proposed Action, resulting in lower DO but decreased releases of warm water from UKL and transport of algal blooms and other organic detritus may act to mitigate this effect. Increased flows and their interaction with DO are expected to be substantially similar to those previously discussed for Adults. See Section 6.3.2.3 for the complete discussion.

The effects to parr of potential low DO levels are consistent with the following excerpt from NMFS 2019:

Low dissolved oxygen concentration can impair growth, swimming performance and avoidance behavior (Bjornn and Reiser 1991). Davis (1975) reported effects of dissolved oxygen levels on salmonids, indicating that at dissolved oxygen concentrations greater than 7.75 mg/L salmonids functioned without impairment, at 6.0 mg/L onset of oxygen-related distress was evident, and at 4.25 mg/L widespread impairment is evident. At 8 mg/L, the maximum sustained swimming performance of Coho Salmon decreased (Davis et al. 1963, Dahlberg et al. 1968). Low dissolved oxygen can affect fitness and survival by increasing the likelihood of predation and decreasing feeding activity (Carter 2005). Sublethal effects include increased stress, reduced growth, or no growth…

While the Proposed Action may result in beneficial effects to DO, the effects could be negligible and are uncertain due to the interactions with water temperature, photosynthesis, and decomposition of organic detritus.

6.3.5.6 Water Temperature

During summer, the Proposed Action is anticipated to result in increases in water temperature in the Klamath River from Keno Dam to the mouth. Higher flows will release more water downstream. The release of warmer water from UKL may reduce the quantity and effectiveness of cold water refugia downstream.

Analysis Description See Section 6.3.1.5 for discussion of the analytical method.

Analysis Results for Smolts Smolts typically out-migrate from the Klamath River mainstem from mid-March through late-July (Gough et al., 2015; David et al., 2017a). Richter and Kolmes (2005) suggested the threshold temperature range for smoltification is 2.5 – 15.5°C. Beeman et al. (2012) observed increased Coho Salmon smolt survival at temperatures greater than 10.0°C, however, a review of temperature effects on Chinook Salmon smolts indicated that physiological processes involved in smoltification are inhibited at temperatures >13.0°C (McCullough, 1999). For the purposes of this analysis, Reclamation considered temperatures from 15.5 – 30.0°C to result in negative effects on Coho smolts. Temperatures with the Proposed Action were likely to have positive effects for smolts for 83% of their active period (Figure 6-9, Table 6-14). Similar to migrating adults, these estimations only pertain to a small portion of the migratory pathway that is used by some smolts. Temperatures in the MS scenario are anticipated to be higher with a slightly higher percent of days with temperatures less tolerable to smolts due to reduced flows during spring and late summer.

6.3.5.7 Entrainment

During spring and summer, the Proposed Action is anticipated to increase the risk of Coho Salmon smolt entrainment in the Klamath River from Keno Dam to IGD. The structure of the diversion headgates in this reach may increase entrainment due to higher flows. The diversions are not associated with the Project and thus, existing diversions will continue to divert with or without Reclamation's Proposed Action.

Entrainment can be a substantial risk to juvenile Coho Salmon. As stated by NMFS 2019:

Water diversions can greatly affect aquatic life when organisms are entrained into intake canals or pipes -- an estimated 10 million juvenile salmonids were lost annually through unscreened diversions in the Sacramento River alone (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council 1989). Once entrained, juvenile fish can be transported to less favorable habitat (e.g., a reservoir, lake or drainage ditch) or killed instantly by turbines. Fish screens are commonly used to prevent entrainment of juvenile fish in water diverted for agriculture, power generation, or domestic use.

The structure of the diversion headgates in this reach (i.e., wing walls reaching well out into the channel) may increase entrainment due to higher flows under the Proposed Action. The diversions are not owned by the Project and are, therefore, not under Reclamation's control. Under previous consultations, Reclamation has funded fish screen projects as part of their restoration program. Reclamation expects impacts from the Proposed Action, relative to MS from entrainment at non-Project diversions.

6.4 Conservation Measures

Fish salvage at Project canals occurs when canals are: (1) temporarily dewatered for a discrete action related to maintenance and/or repairs at Project facilities inclusive of canals, canal banks, levees, water control structures, and drain features (Section 5.4.9), and (2) when canal systems are dewatered at the end of each irrigation season. Under both circumstances fish are salvaged from pools where they are stranded.

Reclamation proposes, in coordination with NMFS, to continue the salvage of SONCC Coho both for routine maintenance and repair at Project structures and at conclusion of the irrigation season when project canals, laterals, and drains are dewatered consistent with past salvage efforts.

At conclusion of each irrigation season, Reclamation will coordinate fish salvage activities with irrigation districts, principally KID and TID. Future fish salvage of the canal system will include areas where SONCC Coho are annually encountered in reliable numbers. Other locations within the Project canals will be periodically checked during dewatering, and fish will be salvaged if deemed feasible and productive. Reclamation will also continue to pursue alternative methods of dewatering canals, laterals, and drains and which could result in less SONCC Coho presence within these facilities at the end of the irrigation season. Fish salvage will be coordinated with NMFS each year.

Reclamation will coordinate with NMFS on the disposition of SONCC Coho resulting from salvage activities, including release to natural waters.

6.5 Critical Habitat Analysis

Critical habitat for the SONCC Coho Salmon ESU was formally designated on May 5, 1999 (64 FR 24049 [1999]) and includes all accessible waterways, substrate, and adjacent riparian zones between Cape Blanco, Oregon, and Punta Gorda, California. Exclusions to the critical habitat include:

- Areas above specific dams identified in the Federal Register notice
  The Federal Register presently includes IGD and therefore the Klamath River upstream of the dam is not listed in the SONCC Coho Salmon ESU and it is not critical habitat. However, with removal of the Lower Klamath Project dams, which includes IGD, it is expected this will change. Therefore, this Biological Assessment assumes the area above IGD to at least Keno Dam will be designated as Critical Habitat within the time frame of this consultation.
- Areas above longstanding, natural barriers to fish passage (i.e., natural waterfalls)
- Tribal lands

In designating critical habitat for the SONCC Coho Salmon ESU, NMFS identified spawning areas, adult migration corridors, juvenile summer and winter rearing areas, juvenile migration corridors, and areas for growth and development to adulthood as physical or biological features that are essential to conservation of the species. Within these areas, essential features of SONCC Coho Salmon critical habitat include adequate: substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions (NMFS 2014 from 64 FR 24049, May 5, 1999). For a more detailed discussion, see Section 6.1.6.

The critical habitat designation for Coho Salmon identifies essential physical and biological features which are those sites and habitat components that support one or more life stages and are described in the subsections below.

6.5.1 Effects on Designated Coho Salmon Critical Habitat

Effects of the Proposed Action on Coho Salmon critical habitat were assessed with a similar analytical approach to the 2013 BiOp (NMFS and USFWS, 2013), specifically Sections 11.4.1.2.3.1 and 11.4.1.2.3.2 to describe Proposed Action effects. This analysis contains an evaluation of the simulated Proposed Action flows relative to MS conditions.

Estimates of habitat availability were summarized for juvenile Coho Salmon at three sites (Trees of Heaven, Beaver Creek, and Klamath Community Center) downstream of IGD. This analysis excluded reaches below the Salmon River since IGD water releases represent the majority of river flow volume in the Klamath River and downstream inputs could potentially mask the effects of the Proposed Action on salmon habitat in upstream reaches. In the 2013 BiOp, effects of the Proposed Action on habitat area were assumed to be negative if there was both a positive relationship between flow and habitat area, and, if habitat area was less than 80% of the maximum prediction. Exceedance tables were used to highlight flow volumes predicted for the Proposed Action within each river reach and site that would be expected to reduce habitat availability. The exceedance table is intended to predict the frequency and timing of impacts to Coho habitat resulting from the Proposed Action.

The average amount of habitat available under the Proposed Action is equal to or greater than the MS scenario for all three sites with the exception of mid-October though late-November. The MS scenario’s substantial increase in habitat in the fall is driven by the need to spill large amounts of water though fall for flood control (Figure 4-12 through Figure 4-14). The average amount of habitat available under the Proposed Action remains above 80% of maximum at Trees of Heaven Campground throughout the year, remains below 80% of maximum except for one brief spike in spring for all scenarios at Beaver Creek, and remains above 80% of maximum at Klamath Community Center except for mid-summer to early-fall.

6.5.2 Habitat Area Simulation Models

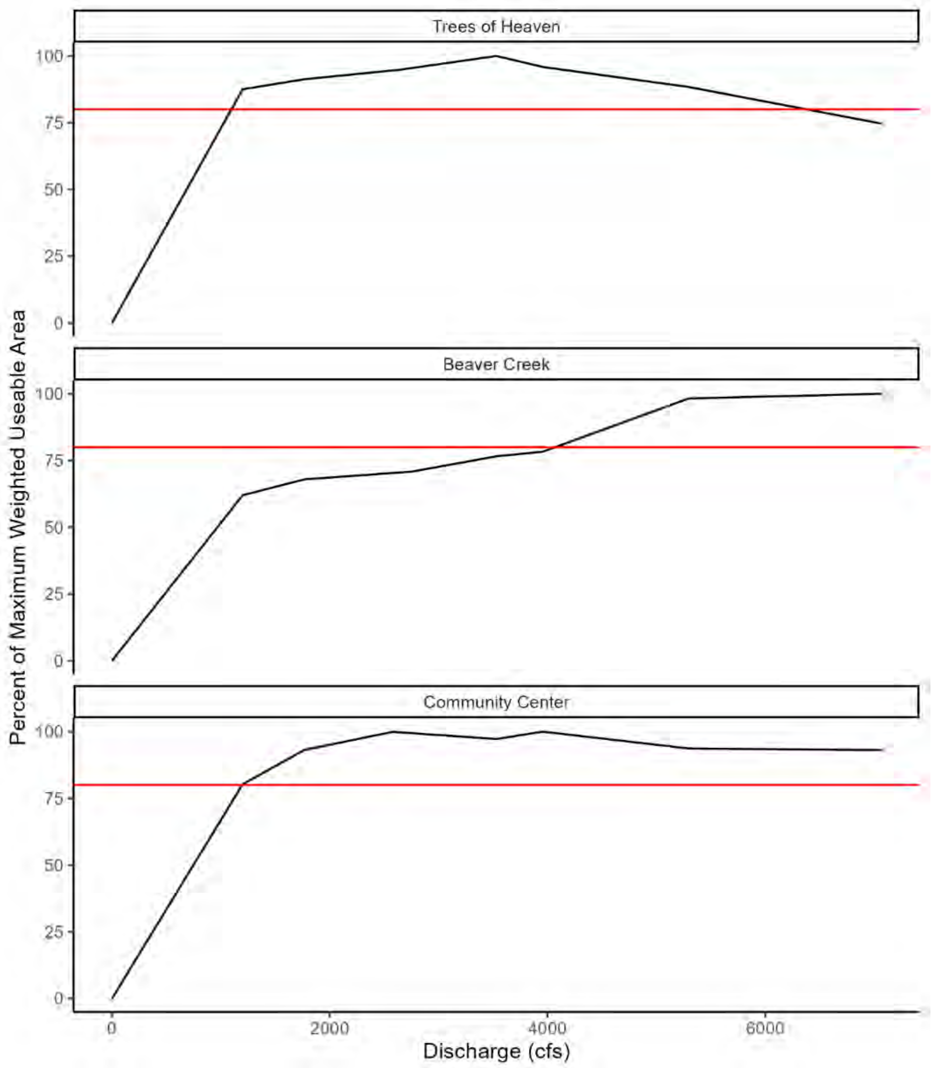
The Probability Density Function Model takes Coho habitat data from the Klamath and applies it to an occupancy model developed on the Trinity River. This model estimates probabilities of Coho presence/absence which are then scaled and applied to calculate a weighted usable habitat area (WUA). The occupancy model allows simultaneous estimation of both an ecological and detection process. In this case the ecological process is presence/absence of Coho Fry instead of abundance. For the ecological process, a model was fit having depth, velocity, and distance to cover as fixed effects, and for the detection process fixed effects of depth and each specific observer. The habitat model was originally developed and fit using data for Coho Salmon fry from a large-scale effort to assess how physical habitat variables related to the presence and abundance of juvenile salmonids in the restoration reach of the Trinity River (Smit et al., *accepted*). Som et al. (2018) provides extensive detail on the habitat sampling design upon which this model was developed.

To adapt this model to the Klamath River, data for depth, velocity and distance to cover was taken from Wright et al., 2014. Precise details on data collection and sampling design can be found there. The output of the logistic regression occupancy model was translated into a habitat quality metric having values between 0 and 1 by dividing all predicted presence probabilities by the maximum value calculated over the range of all observed ecological effects. This predicted probability is then multiplied by the area of the habitat units to determine a weighted usable area (WUA) for each of the three locations (Tree of Heaven Campground, Beaver Creek, and Klamath Community Center). The WUA is then used to determine the effects of various scenarios on habitat volume.

6.5.3 Habitat Areas Simulation Results

The effects of reduced flows on habitat availability for Coho Salmon depend on the flow volume and habitat area at each site (Figure 6-11). The following discussion provides general observations about potential flow impacts, and Figure 6-11 provides specific flow volumes predicted to impact Coho habitat availability as a result of the Proposed Action.

Under the Proposed Action, the Trees of Heaven and Klamath Community Center reached 80% of the maximum WUA on 90% and 81% of days, respectively, over the period of record (Figure 6-12; Table 6-15). Beaver Creek was the most impacted under the Proposed Action, reaching the 80% threshold on only 10% of days over the period of record.



Notes: Flows account for tributary accretions and were estimated for each habitat unit when calculating WUA. Gray horizontal bands indicate WUA values ≥ 80% of maximum.

Figure 6-11. Coho Salmon fry and parr habitat availability relative to mainstem flows for three sites downstream of Iron Gate Dam

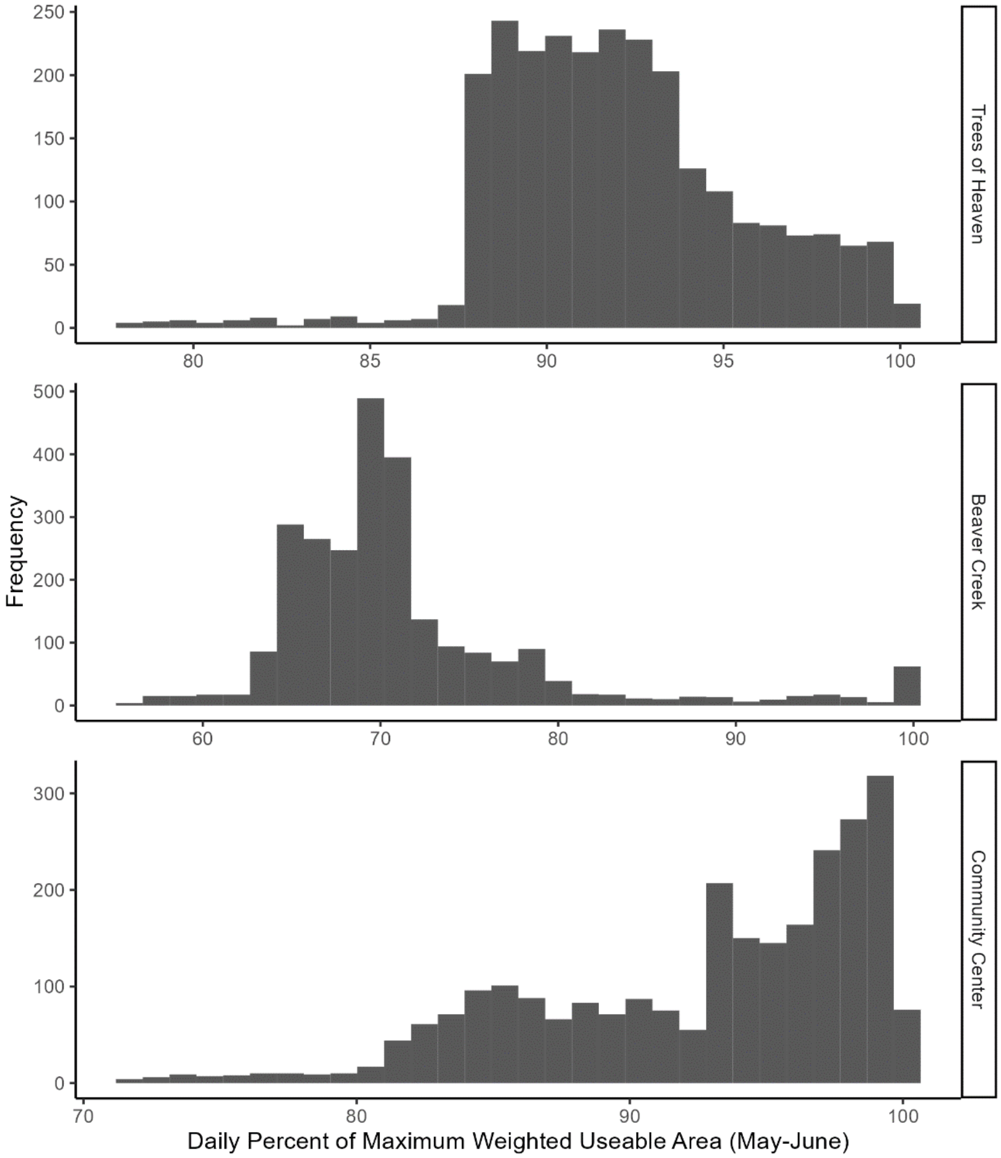


Figure 6-12. Predicted frequency of daily percent of maximum Weighted Usable Area values for Coho Salmon fry and parr in three reaches downstream of Iron Gate Dam during the months of May and June 1991-2022

Table 6-15. Number and percentage of days over the period of record at which habitat availability is at or above 80% of maximum Weighted Usable Area for three sites reaches for Coho Salmon

Sites	**Number of Days (#)**	**Percent of Days (%)**
Trees of Heaven	13861	90%
Beaver Creek	1452	9%
Community Center	12465	81%

The three sites responded very differently to the Proposed Action across a broad range of exceedance values (Table 6-16 through Table 6-18). Trees of Heaven and Klamath Community Center were relatively unaffected across a broad range of exceedances. While the effects of the Proposed Action are predicted to occur most frequently and substantially at the Beaver Creek site.

Table 6-16. Daily average mainstem flows (cfs) within nearest 5% exceedance for the Proposed Action that will likely reduce Coho Salmon juvenile habitat availability below 80% of maximum (blue highlight) at the Trees of Heaven Campground Site

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	1,127	1,210	1,192	1,228	1,292	1,464	1,721	1,522	1,206	970*	954*	1,053
90%	1,158	1,245	1,227	1,276	1,329	1,565	1,866	1,650	1,304	994*	972*	1,071
85%	1,179	1,272	1,253	1,325	1,389	1,621	1,955	1,742	1,352	1,015	990*	1,087
80%	1,202	1,288	1,282	1,367	1,438	1,686	2,064	1,849	1,397	1,034	1,004	1,105
75%	1,220	1,303	1,313	1,406	1,481	1,810	2,221	1,954	1,436	1,049	1,017	1,122
70%	1,239	1,318	1,345	1,450	1,540	1,954	2,394	2,086	1,480	1,061	1,028	1,137
65%	1,260	1,334	1,380	1,491	1,604	2,089	2,524	2,195	1,515	1,076	1,047	1,151
60%	1,284	1,352	1,430	1,544	1,674	2,251	2,721	2,297	1,568	1,094	1,064	1,167
55%	1,305	1,365	1,482	1,610	1,782	2,447	2,863	2,415	1,623	1,113	1,089	1,183
50%	1,322	1,385	1,562	1,676	1,855	2,636	3,185	2,556	1,677	1,134	1,115	1,209
45%	1,347	1,422	1,661	1,775	1,926	2,989	3,461	2,706	1,738	1,161	1,137	1,233
40%	1,379	1,471	1,762	1,898	2,055	3,329	3,740	2,883	1,827	1,189	1,171	1,249
35%	1,422	1,530	1,912	2,060	2,258	3,828	3,992	3,112	1,903	1,227	1,212	1,267
30%	1,471	1,621	2,055	2,382	2,468	4,131	4,283	3,334	2,004	1,274	1,241	1,290
25%	1,527	1,738	2,206	2,693	2,891	4,595	4,860	3,601	2,184	1,345	1,291	1,326
20%	1,574	1,821	2,452	3,119	3,555	5,106	5,365	3,822	2,336	1,400	1,359	1,376
15%	1,696	1,989	3,134	3,643	4,503	5,783	6,092	4,206	2,553	1,480	1,473	1,459
10%	1,806	2,266	4,169	4,187	5,656	6,762	6,607	4,736	3,050	1,569	1,533	1,559
5%	2,021	3,227	5,095	5,618	8,040*	8,059*	7,340	5,381	3,480	1,713	1,647	1,659

Note: * and blue highlight denote below 80% of maximum.

Table 6-17. Daily average mainstem flows (cfs) within nearest 5% exceedance for the Proposed Action that will likely reduce Coho Salmon juvenile habitat availability (blue highlight) at the Beaver Creek Site

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	1,139*	1,229*	1,232*	1,276*	1,346*	1,551*	1,843*	1,631*	1,249*	988*	962*	1,070*
90%	1,171*	1,275*	1,270*	1,344*	1,409*	1,647*	1,975*	1,756*	1,347*	1,015*	983*	1,086*
85%	1,195*	1,304*	1,298*	1,397*	1,474*	1,719*	2,094*	1,840*	1,405*	1,040*	1,002*	1,102*
80%	1,216*	1,322*	1,336*	1,457*	1,548*	1,791*	2,222*	1,963*	1,458*	1,065*	1,020*	1,119*
75%	1,235*	1,336*	1,374*	1,504*	1,596*	1,945*	2,389*	2,085*	1,505*	1,079*	1,034*	1,137*
70%	1,258*	1,352*	1,412*	1,568*	1,662*	2,100*	2,570*	2,264*	1,563*	1,097*	1,047*	1,153*
65%	1,280*	1,367*	1,449*	1,617*	1,741*	2,258*	2,744*	2,380*	1,608*	1,115*	1,065*	1,166*
60%	1,306*	1,387*	1,516*	1,680*	1,837*	2,445*	2,973*	2,506*	1,667*	1,138*	1,086*	1,182*
55%	1,329*	1,408*	1,585*	1,754*	1,952*	2,662*	3,148*	2,654*	1,739*	1,159*	1,112*	1,206*
50%	1,354*	1,434*	1,681*	1,839*	2,030*	2,886*	3,447*	2,825*	1,801*	1,188*	1,141*	1,228*
45%	1,382*	1,472*	1,807*	1,969*	2,133*	3,298*	3,751*	2,996*	1,870*	1,214*	1,173*	1,258*
40%	1,421*	1,525*	1,926*	2,102*	2,282*	3,729*	4,061	3,177*	1,972*	1,243*	1,211*	1,275*
35%	1,466*	1,588*	2,064*	2,349*	2,561*	4,217	4,452	3,445*	2,078*	1,292*	1,252*	1,297*
30%	1,514*	1,693*	2,221*	2,684*	2,836*	4,623	4,763	3,708*	2,223*	1,348*	1,286*	1,316*
25%	1,570*	1,814*	2,364*	3,127*	3,225*	5,073	5,309	4,023	2,471*	1,410*	1,333*	1,348*
20%	1,618*	1,915*	2,749*	3,561*	4,066	5,752	5,842	4,296	2,646*	1,498*	1,395*	1,406*
15%	1,732*	2,084*	3,505*	4,152	5,104	6,315	6,530	4,699	2,939*	1,598*	1,510*	1,494*
10%	1,855*	2,350*	4,621	4,861	6,475	7,396	7,117	5,236	3,398*	1,694*	1,584*	1,595*
5%	2,090*	3,509*	5,665	6,289	9,457	9,030	7,958	6,026	4,157	1,884*	1,694*	1,695*

Note: * and blue highlight denote likelihood of reduced habitat availability.

Table 6-18. Daily average mainstem flows (cfs) within nearest 5% exceedance for the Proposed Action that will likely reduce Coho Salmon juvenile habitat availability (blue highlight) at the Klamath Community Center Site

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	1,238	1,263	-	1,391	1,621	1,921	1,696	1,294	1,002*	966*	1,077*	1,148*
90%	1,298	1,303	-	1,470	1,711	2,060	1,818	1,372	1,031*	992*	1,097*	1,181*
85%	1,328	1,338	-	1,548	1,785	2,194	1,924	1,443	1,060*	1,011*	1,114*	1,206
80%	1,346	1,375	-	1,626	1,885	2,348	2,045	1,508	1,085*	1,031*	1,129*	1,227
75%	1,361	1,424	-	1,692	2,055	2,526	2,193	1,559	1,104*	1,045*	1,146*	1,250
70%	1,378	1,463	-	1,767	2,211	2,701	2,385	1,626	1,125*	1,063*	1,162*	1,273
65%	1,393	1,509	-	1,853	2,398	2,917	2,515	1,687	1,147*	1,081*	1,176*	1,296
60%	1,411	1,586	-	1,965	2,597	3,182	2,675	1,744	1,169*	1,107*	1,197*	1,325
55%	1,439	1,663	-	2,079	2,835	3,376	2,833	1,821	1,195*	1,130*	1,217	1,348
50%	1,476	1,771	-	2,171	3,098	3,711	3,015	1,899	1,229	1,163*	1,244	1,378
45%	1,514	1,903	-	2,293	3,538	3,995	3,240	1,979	1,256	1,198*	1,275	1,411
40%	1,574	2,032	-	2,512	4,022	4,357	3,397	2,084	1,285	1,244	1,296	1,455
35%	1,635	2,168	-	2,820	4,530	4,778	3,677	2,218	1,337	1,283	1,319	1,495
30%	1,762	2,339	-	3,115	4,952	5,146	3,987	2,385	1,407	1,320	1,343	1,544
25%	1,872	2,539	-	3,523	5,458	5,604	4,354	2,678	1,471	1,361	1,373	1,602
20%	1,982	2,924	-	4,437	6,191	6,223	4,673	2,870	1,571	1,426	1,430	1,650
15%	2,201	3,812	-	5,598	6,807	6,917	5,075	3,259	1,672	1,535	1,520	1,773
10%	2,421	5,027	-	7,191	8,022	7,553	5,666	3,664	1,806	1,616	1,621	1,900
5%	3,720	6,295	-	10,807	9,768	8,441	6,532	4,628	2,026	1,728	1,724	2,145

Note: * and blue highlight denote likelihood of reduced habitat availability.

Despite declines in habitat availability for Coho Salmon, specifically at Beaver Creek, the Proposed Action provides flow variability during precipitation and snowmelt events in the mainstem Klamath River that is reflective of actual hydrologic conditions above UKL. The Proposed Action also includes natural flushing flows and the flexibility to deviate from the formulaic approach to flexible flow accounting that can address both habitat availability and other potential factors (e.g., *C. shasta* spore concentrations, prevalence of infection) impacting Coho Salmon. These flow measures are expected to improve juvenile summer and winter rearing habitat as well as juvenile and adult migration corridors in the mainstem Klamath River.

Under the MS scenario, river discharge is anticipated to be generally higher from mid-fall (about October) through winter (about November) and relatively low in summer and fall. MS scenario flows will exhibit limited discharge variability as inflows will be retained until a large release in mid- to late-fall in preparation for winter precipitation and flood control. Flow variability is likely to be very limited and only to occur during flood control operations. There would be little to none of the high spring discharge corresponding with juvenile Coho presence in the Klamath River and is therefore anticipated to provide less juvenile Coho habitat. The low discharges of late summer and fall under the MS scenario are anticipated to contract habitat availability relative to the Proposed Action.

Relative to the MS scenario, the Proposed Action (Table 6-8) is predicted to cause flows from November to March between 5% and 60% exceedance probabilities to decline (Table 6-10; Table 6-9). However, during April, exceedance flows at all levels are expected to increase. Low flow periods in July, August, and September, are also expected to increase under the Proposed Action relative to the MS scenario, which may result in increased juvenile summer rearing habitat and migration corridors.

The Proposed Action does not include implementation flushing flows, as it did under the Services’ 2019 BiOp. Without a forced flushing flow every year, there may be opportunities to redistribute flow from large discharge events later into the spring months.

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7 Southern Resident Killer Whale

7.1 Status of Species and Critical Habitat

7.1.1 Endangered Species Act Listing Status

The SRKW DPS, composed of J, K, and L pods, was listed as endangered under the ESA in 2005 (70 FR 69903 [2005]). Prior to ESA listing, the SRKW population was designated as depleted under the Marine Mammal Protection Act in 2003 (68 FR 31980). A recovery plan for SRKW was completed by NMFS in 2008 (NMFS, 2008). The limiting factors described in the recovery plan include reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS, 2008). The most recent 5-year status review, completed in 2021, concluded that SRKWs should remain listed as endangered and presented recent information on the population, threats, and new research (NMFS, 2021b).

This section summarizes the status of SRKWs throughout their range, using information taken largely from the recovery plan (NMFS, 2008), recent 5-year review (NMFS, 2021b), as well as new data that became available more recently.

7.1.2 Life History and Habitat Requirements

SRKWs are a long-lived species, with late onset of sexual maturity (NMFS, 2008). Females produce up to six surviving calves over the course of their reproductive life span (Bain, 1990; Olesiuk et al., 1990). Compared to Northern Resident Killer Whales (NRKWs), which are a resident killer whale population with a sympatric geographic distribution ranging from coastal waters of Washington State and British Columbia north to Southeast Alaska, SRKW females appear to have reduced fecundity; the average interval between pregnancies for NRKW females is 4.9 years, while the interval for SRKW females is 6.1 years (Ward et al., 2013; Velez-Espino et al., 2014). Recent evidence has indicated that this reduced fecundity is largely due to nutritional limitation (Wasser et al., 2017). All age classes of SRKWs have reduced survival compared to other fish-eating populations of killer whales in the Northeast Pacific (Ward et al., 2013). Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the SRKW population (Bigg et al., 1990; Baird, 2000; Ford et al., 2000). Groups of related matrilines form pods. Three pods—J, K, and L—make up the SRKW population.

SRKWs primarily occupy waters in the coastal regions of Washington, Oregon, and British Columbia, but are known to travel as far south as Central California and as far north as Southeast Alaska (Section 7.1.3.1). The dynamic use of these habitats and feeding grounds is likely related to prey availability. Knowledge of prey location is thought to be passed down generationally between individuals (Ford et al., 1998). There is no documentation of specific breeding, calving, or resting areas (71 FR 69054 [2006]). SRKWs can tolerate a broad range of salinity, temperature, and turbidity (COSEWIC, 2008).

Information collated on strandings for all killer whale ecotypes by Raverty et al. (2020) as well as data collected from three SRKW strandings in recent years, have also contributed to knowledge of the health of the population and the impact of the threats to which they are exposed. Across the Northeast Pacific causes of death for stranded killer whales of various ages and ecotypes have included: congenital defects, malnutrition and emaciation, infectious disease, bacterial infections, and blunt force trauma (Raverty et al., 2020). Raverty et al. (2020) examined cause of death for 53 stranded whales, 22 of which had a definitive diagnosis. They reported on both proximate (process, disease, or injury that initiated process that led to death) and ultimate (final process that led to death) causes of death. Of the 22 stranded killer whales where a definitive diagnosis could be determined, nutritional causes were identified in 11 whales as either the proximate (n = 5) or ultimate cause of death (n = 6) (Raverty et al., 2020), though none of these whales were identified as SRKWs (some unknown but in unlikely locations for SRKW). However, this does highlight that nutritional causes of mortality occur in killer whales. Limiting factors, threats, and stressors to SRKWs are detailed further in Section 7.1.4.

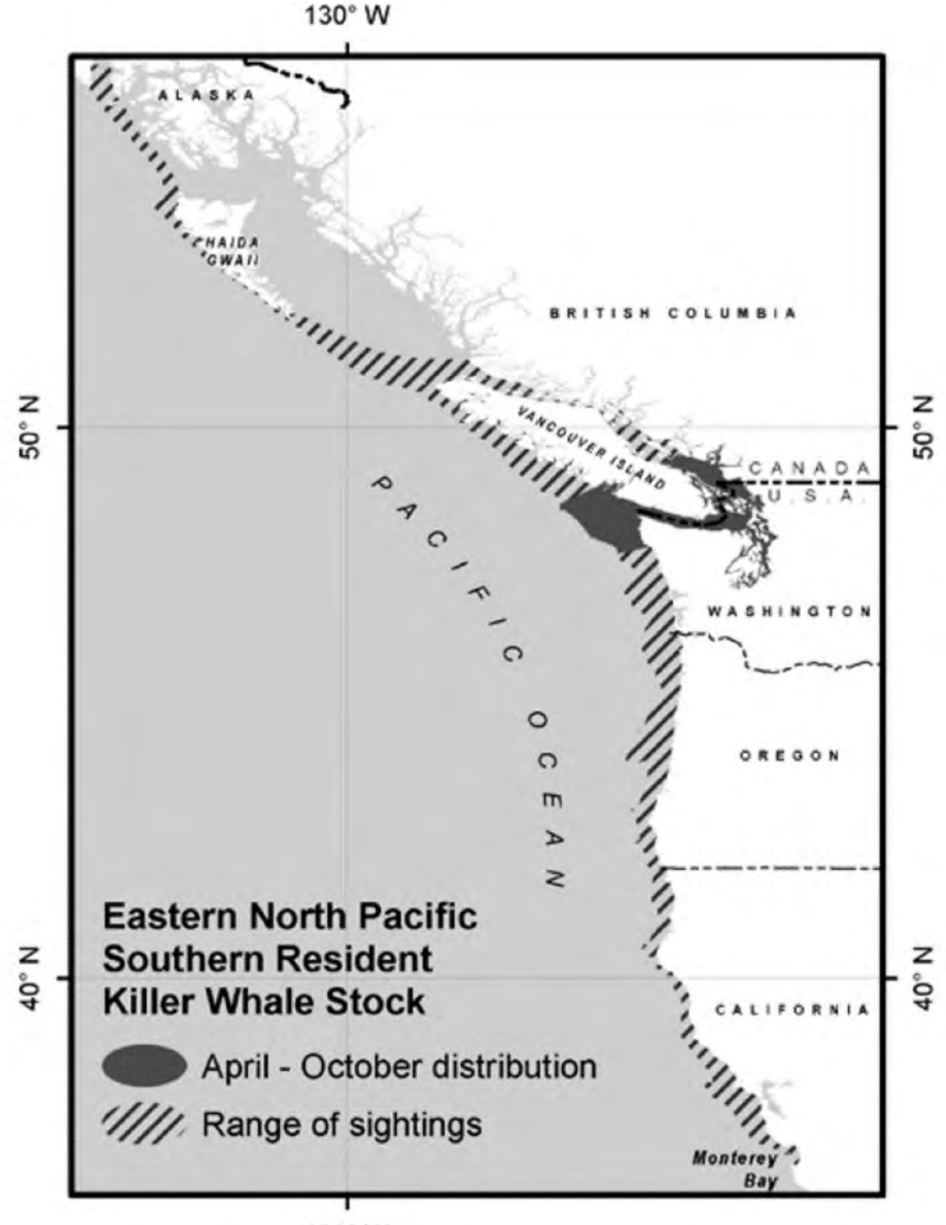
The Action Area includes nearshore portions of the Pacific Ocean where SRKW distribution overlaps with Klamath River Chinook Salmon. While the exact zone of overlap cannot be precisely defined based on current information, it has the potential to include coastal waters from northern California to the Columbia River in Oregon. Chinook Salmon (*Oncorhynchus tshawytscha*) are the preferred and dominant prey for all SRKW pods, and during fall and winter, SRKWs target Chinook Salmon stocks from the California Central Valley, Columbia River, and Puget Sound, with the majority of Chinook Salmon consumed originating from the Columbia River (Hanson et al., 2021). Removal of the lower Klamath River dams, underway concurrent with this document's development, is expected to restore access for Chinook Salmon to up to 300 miles of historical habitat (Huntington, 2006). This includes access to unique habitats such as groundwater springs that may provide thermal refuges for Chinook Salmon and other cold-water salmonids (Hamilton et al., 2011).

7.1.3 Species Status/Viability Parameters

7.1.3.1 Distribution/Spatial Structure

SRKWs occur throughout the coastal waters off Washington, Oregon, and Vancouver Island and their range can extend from central California to Southeast Alaska (Figure 7-1) (NMFS 2008a, 2021c; Hanson et al., 2013; Carretta et al., 2017, 2022; Ford et al., 2018). A comprehensive review of SRKW use of coastal waters is available in the Final Biological Report on SRKW critical habitat (NMFS, 2021c). SRKWs are highly mobile and can travel up to 86 miles (160 km) in a single day (Erickson, 1978; Baird, 2000), with seasonal movements likely tied to the migration of their primary prey, salmon. During the spring, summer, and fall months, the whales have typically spent 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 et al., 2000; Krahn et al., 2002; Hauser et al., 2007). Late summer and early fall movements of SRKWs 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 (Hauser et al., 2007; Hanson and Emmons, 2010). During fall and early winter, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of

Chum (*O. keta*), Coho (*O. kisutch*), and Chinook Salmon runs (Osborne, 1999; Hanson et al., 2010; Ford et al., 2016). Although seasonal movements are somewhat 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; NMFS, 2021c).



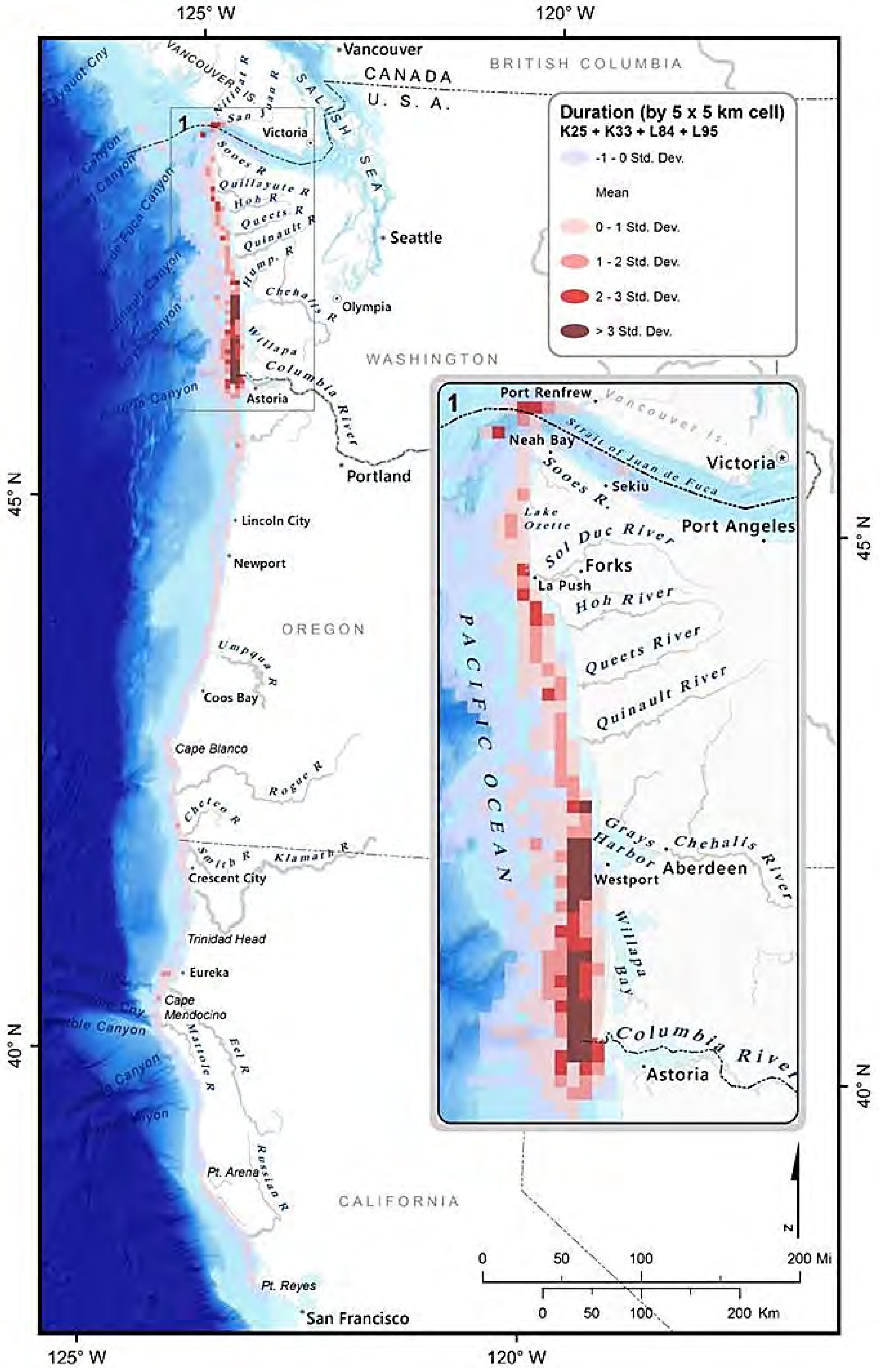
Source: Carretta et al., 2017

Figure 7-1. Approximate April - October distribution of the Eastern North Pacific Southern Resident Killer Whale stock (shaded area) and range of sightings (diagonal lines)

In recent years, several sightings and acoustic detections of SRKWs have been obtained off the Washington and Oregon coasts in the winter and spring (Hanson et al., 2010, 2013, 2017; Figure 7-2 and Figure 7-3). As part of a collaborative effort between the Northwest Fisheries Science Center (NWFSC), Cascadia Research Collective, and the University of Alaska, satellite-linked tags were deployed on eight male SRKWs (three tags on J pod members, two on K pod, and three on L pod) from 2012 to 2016 in Puget Sound or in the coastal waters of Washington and Oregon (Hanson et al., 2017). Over the course of the study, the eight satellite tags deployed were monitored for a range of signal contact durations from 3 days to 96 days depending on the tag, with deployment from late December to mid-May. The winter locations of the tagged whales included inland and coastal waters. The inland waters range occurs across the entire Salish Sea, from the northern end of the Strait of Georgia and Puget Sound, and coastal waters from central west coast of Vancouver Island, British Columbia, to northern California (Hanson et al., 2017). J pod spends more time during the winter and spring in the inland waters of Washington and British Columbia compared to K and L pods who spend the majority of their time in coastal waters during these seasons (Hanson et al., 2017).

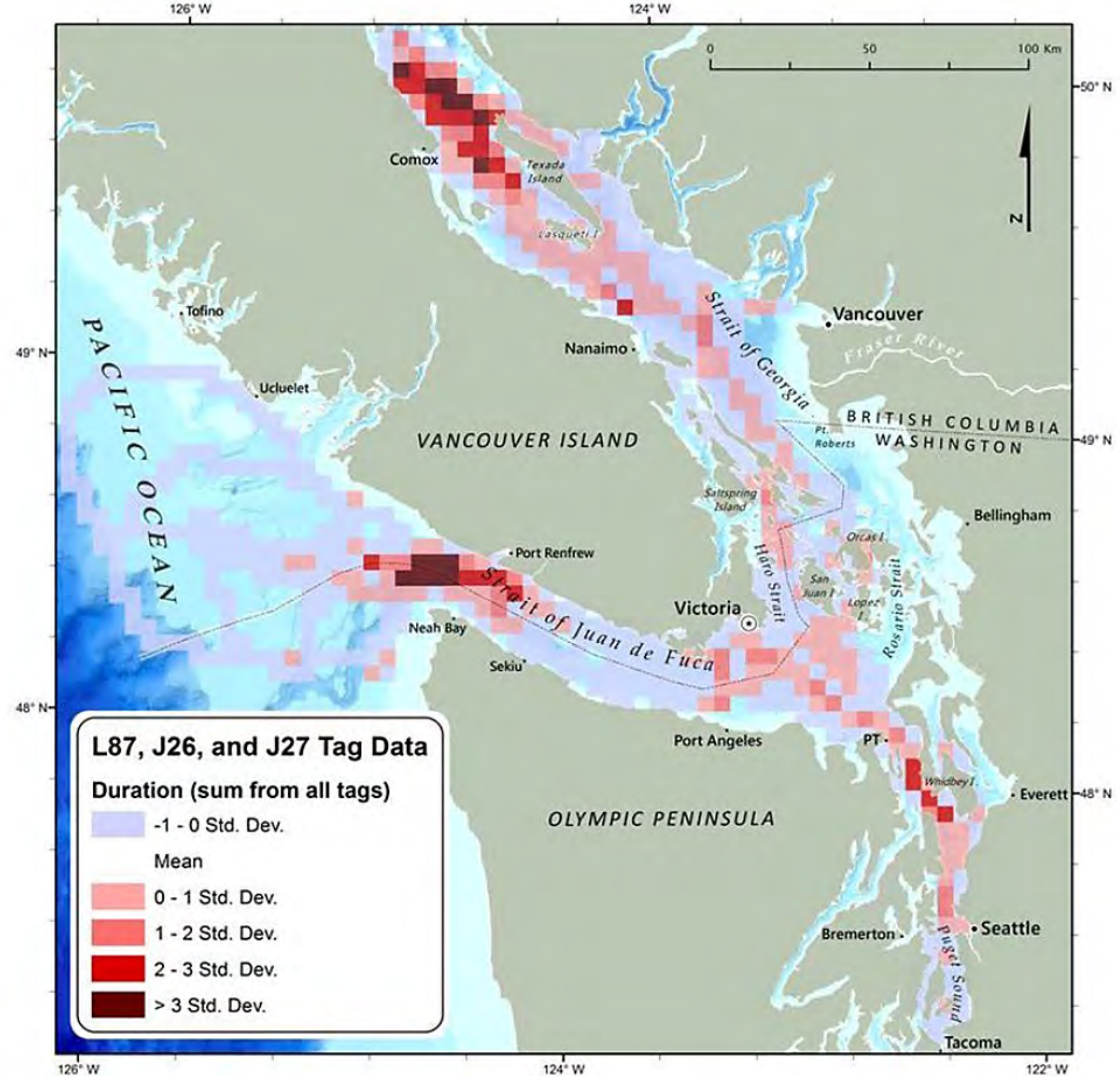
Passive acoustic recorders were deployed off the coasts of California, Oregon, and Washington in most years since 2006 to assess SRKW seasonal uses of these areas via the recording of stereotypic calls of the SRKWs (Hanson et al., 2013; Emmons et al., 2019). There were acoustic detections off the Washington coast in all months of the year, with greater than 2.4 detections per month from January through June and a peak of 4.7 detections per month in both March and April, indicating that the SRKW may be present in Washington coastal waters at nearly any time of year, more often than previously believed (Hanson et al., 2017). Acoustic recorders were deployed off Newport, Fort Bragg, and Port Reyes between 2008 through 2013, and SRKW were detected 28 times (Emmons et al., 2019). For areas off the coast of Oregon and California, the data available suggest considerable year-to-year variation in SRKW occurrence with their presence (K and L pod primarily) expected to be most likely during the winter and spring (NMFS, 2021c).

While the overall range of SRKWs has remained from Central California to Southeast Alaska since at least the 1860s, usage of the range has been changing. They regularly occupied Hood Canal in the early 1900s but have not been observed there since 1995. Their regular presence in the eastern Salish Sea during the summer was documented for 40 years but has been declining in recent years (Shields et al., 2018). Still, their wintertime use continues at similar levels to what it was decades ago. In the 1980s, they were observed in the southern part of their range about every 5 years, but now they are observed moving between California and British Columbia essentially every year.



Source: Hanson et al. (2017)

Figure 7-2. Duration of occurrence model for all unique K and L pod tag deployments during winter months

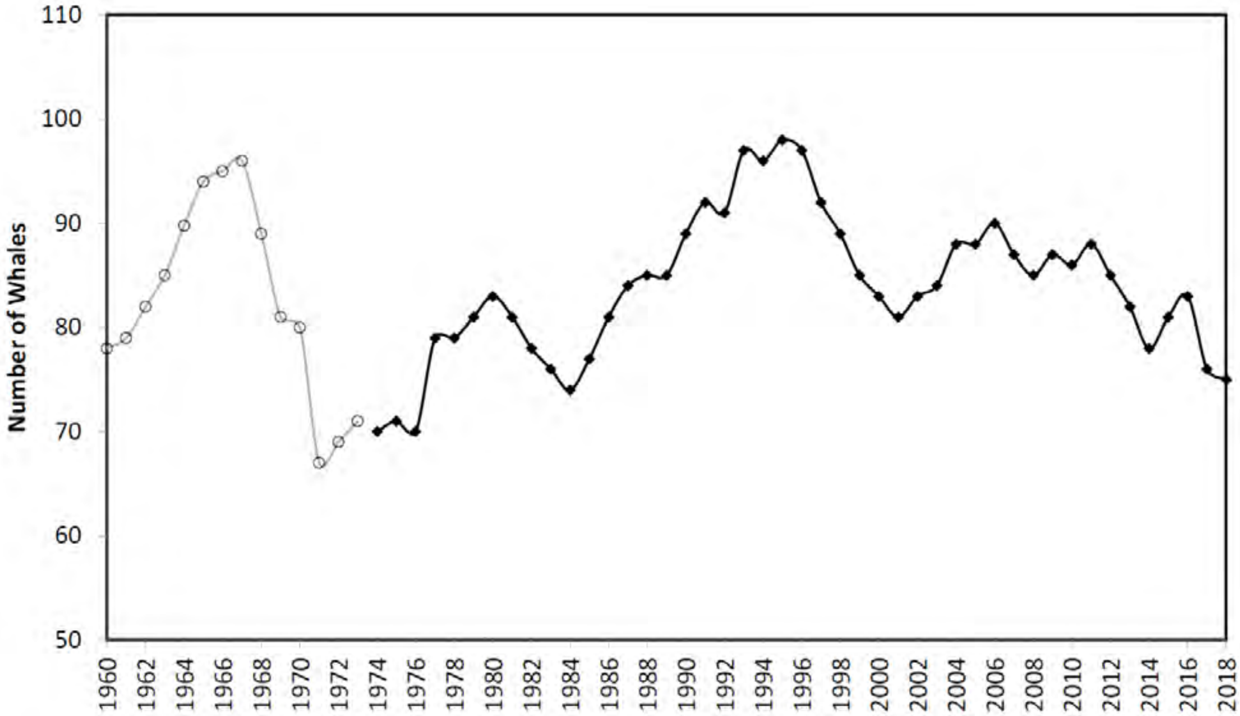


Source: Hanson et al. (2017)

Figure 7-3. Duration of occurrence model output for J pod tag deployments during winter months

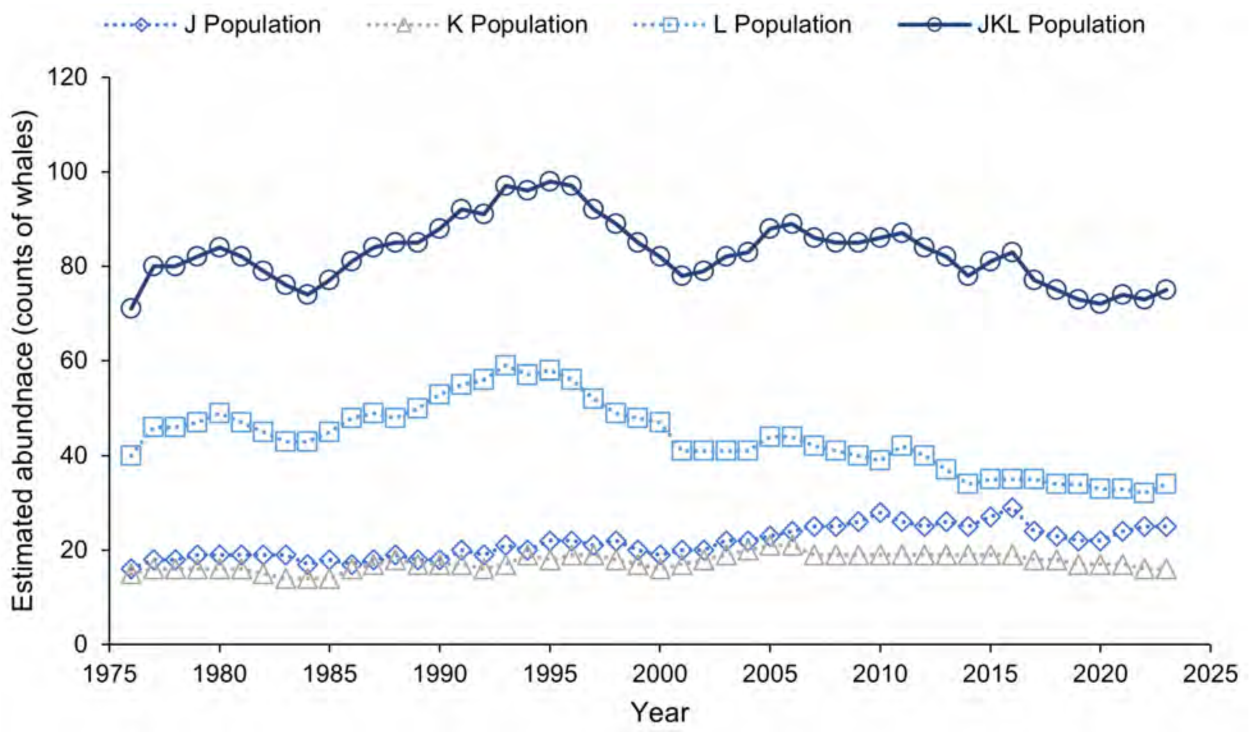
7.1.3.2 Abundance and Productivity

The population abundance estimate for SRKW DPS is 74 individual whales as of January 1, 2024 (CWR, 2024). At present, the SRKW population has declined to the lowest levels seen in over 30 years (Figure 7-4). Since censuses began in 1974, the J pod has steadily increased in size, while the K pod has remained stable, and the L Pod has generally vacillated around 40-50 whales except over the last decade, during which the L Pod has declined (Figure 7-5). Overall, the SRKW population suffered an almost 20% 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 an 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. In 2014 and 2015, there was a "baby boom" in the SRKW population that was the result of multiple successful pregnancies that occurred in 2013 and 2014. However, as of December 2018, the population has decreased to only 74 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 science panel report; 0.29%. As of July 2023, there is representation in all three pods, with 25 whales in J pod, 16 whales in K pod, and 34 whales in L pod (Figure 7-5).



Source: NMFS 2019 BiOp: Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from 1974-2018 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (CWR; unpublished data) and NMFS (2008a).

Figure 7-4. Population size and trend of Southern Resident Killer Whales, 1960-2018



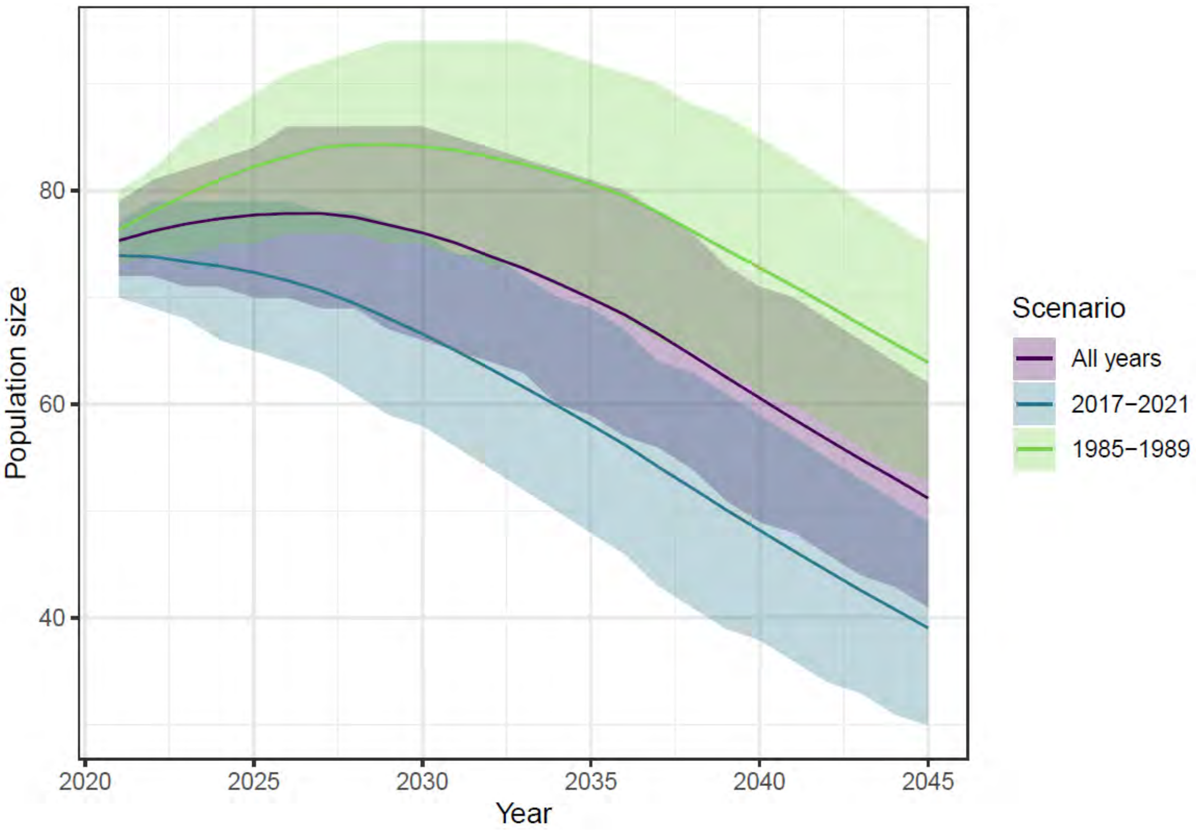
Source: CWR (2024)

Figure 7-5. Southern Resident Killer Whale J, K, and L pod counts, 1976-2023

Although the age and sex distribution is generally similar to that of NRKWs that are a stable and increasing population (Olesiuk et al., 2005), there are several demographic factors of the SRKW 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 mating 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 extinction risk and inform recovery (NWFSC unpublished data).

Seasonal mortality rates among SRKWs and NRKWs 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 newborn mortality that occurred outside of the summer season. At least 12 newborn calves (9 SRKWs and 3 NRKWs) 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 SRKW strandings in the last 5 years have contributed to 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.

The NWFSC continues to evaluate changes in fecundity and mortality rates and has updated the population viability analyses conducted for the 2004 Status Review for SRKWs and the 2011 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, population estimates including data from the last 5 years (2017-2021) project a downward trend over the next 25 years (Figure 7-6). The declining trend is in part due to the changing age and sex structure of the population (the sex ratio at birth was estimated at 55% male and 45% female following current trends), but also related to the relatively low fecundity rate observed over the period from 2017 to 2021 (when the same analyses are applied to Fisheries and Oceans Canada’s NRKW data, a similar trend of declining fecundity is also present in that population). Though these fecundity rates are declining, average SRKW survival rates estimated by the NWFSC have been slowly increasing since the late 1990s. The population projection is most pessimistic if future fecundity rates are assumed to be similar to the last 5 years, and higher but still declining if average fecundity and survival rates over all years (1985-2021) is used for the projections (Figure 7-6). The projection using the highest fecundity and survival rates (1985-1989) shows some stability and even a slight increase over the next decade before severely declining. Only 25 years were selected for projections because as the model projects out over a longer time frame (e.g., 50 years), there is increased uncertainty around the estimates. This limitation is also discussed in Hilborn et al. (2012).



Source: NMFS, 2021b

Figure 7-6. SRKW population size projections from 2020 to 2045 using three scenarios: (1) projections using fecundity and survival rates estimated over the entire time series (1985-2021), (2) projections using rates estimated over the last 5 years (2017-2021), and (3) projections using the highest survival and fecundity rates estimated, during the period 1985-1989

7.1.3.3 Diversity

The SRKW population faces concerns related to low genetic diversity and potential fitness consequences due to its small size. Genetic analyses conducted by Ford et al. (2018) demonstrated a small effective population size and highlighted the likelihood of common inbreeding within the population, with recent offspring predominantly sired by only two males. Kardos et al. (2023) further emphasized the critical threat to SRKW, linking their small size, isolation, and resultant high levels of inbreeding to a decline in population. This research, integrating modern genomics with decades of field observations, revealed that inbreeding, coupled with historical human impacts such as marine park captures, contributes to the endangerment of this population. The newly sequenced genomes of the 73-whale population indicated that inbreeding significantly limits growth and recovery, reducing the lifespan of highly inbred individuals by almost half. The study highlights the need for genetic influx from other populations or substantial environmental improvements to prevent further decline. Additionally, a study by Weiss et al. (2023) explored the energetic cost of raising male offspring in SRKW, revealing a significant negative correlation between the number of surviving weaned sons and the annual probability of females producing viable calves. This suggests that caring for adult sons imposes reproductive costs on mothers, providing insight into a previously unknown life history strategy and emphasizing the challenges faced by the SRKW population that result from low extant diversity within the population.

7.1.3.4 Overall Status

The 2021 5-Year Review (NMFS, 2021b) presents findings indicating that, despite coordinated efforts over the long term and particularly during the last 5 years, the SRKW DPS has not grown. Although some downlisting and delisting criteria have been met, the overall status of the population is not consistent with a healthy, recovered population. Considering the current status and continuing threats, the SRKWs remain in danger of extinction. The recommended classification in the 2021 5-Year Review is for SRKW to remain listed as Endangered.

7.1.4 Limiting Factors, Threats, and Stressors

7.1.4.1 Historical and Current Limiting Factors and Stressors

Factors that have contributed to the decline of SRKW populations were documented at the time the species was listed (70 FR 69903 [2005]) and have been updated most recently in the 2021 status review (NMFS, 2021b). Specifically, NMFS evaluated the status of SRKW by analyzing the following five-factors, per guidelines in 50 CFR § 424 (1984) (see 70 FR 69903 (2005) for further details):

1. The present or threatened destruction, modification, or curtailment of its habitat or range
   Several factors have modified the Southern Residents' habitat, including contaminants, vessel traffic, and changes in prey availability…
2. Overutilization for commercial, recreational, scientific, or educational purposes
   [There] are still concerns regarding compliance with the guidelines and potential violations of the MMPA, increased numbers of vessels engaged in whale watching, and cumulative effects on the whales.
3. Disease or predation
   [High] contaminant levels may be affecting immune function in the whales, increasing their susceptibility to disease. The cohesive social structure and presence of all whales in a localized area at one time also has implications should a disease outbreak occur.
4. The inadequacy of existing regulatory mechanisms
   Current levels of contaminants in the environment indicate that previous regulatory mechanisms were not sufficient to protect killer whales…In addition, there are new emerging contaminants that may have similar negative effects that are not currently regulated.

5. Other natural or human-made factors affecting its continued existence
Puget Sound is one of the leading petroleum refining centers in the U.S. with about 15 billion gallons of crude oil and refined petroleum products transported through it annually (Puget Sound Action Team, 2005)…[There are] concerns about potential implications for Southern Residents, particularly if the entire population is together in the vicinity of a spill. In addition, there may be additional anthropogenic factors that have not yet been identified as threats for Southern Resident killer whales, particularly in their winter range which is not well known.

7.1.4.2 Updated Threats

Since listing, the primary threats to SRKW—prey availability, contaminants, vessel impacts and sound, and oil spills—are considered ongoing. This section summarizes these threats, as presented in NMFS' most recent status review (NMFS, 2021b) and elsewhere.

Prey Availability SRKWs consume a variety of fish species (22 species) and one species of squid (Ford et al., 1998, 2000, 2016; Ford and Ellis, 2006; Hanson et al., 2010) but salmon are identified as their primary prey. The best available information suggests an overall preference for Chinook Salmon during the summer and fall. Chum Salmon, Coho Salmon, and Steelhead (*O. mykiss*) may also be important in the SRKW diet at particular times and in specific locations. Several other fish species were also observed during predation events (Ford and Ellis, 2006); however, these data may underestimate the extent of feeding on bottom fish (Baird, 2000). A number of smaller fish and squid have been identified in stomach content analysis of resident whales (Ford et al., 1998).

SRKW diet studies are the subject of ongoing research, the majority of which has occurred during summer months in inland waters of Washington and British Columbia and have involved direct observation, scale and tissue sampling of prey remains, and fecal sampling. The diet data suggest that SRKWs are consuming mostly larger (i.e., generally age 3 and up) Chinook Salmon. Chinook Salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. Factors of potential importance include the Chinook Salmon's 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 (kilocalorie/kilogram [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 on average approximately 2.7 Coho, 3.1 Chum, 3.1 Sockeye, or 6.4 Pink Salmon (O'Neill et al., 2014). The degree to which killer whales are able to or willing to switch to non-preferred prey sources (i.e., prey other than Chinook Salmon) is also largely unknown, and likely variable depending on the time and location.

Recent stable isotope analyses of opportunistically collected fish scale samples (from prey remains and whale fecal samples (Warlick et al., 2020) continue to support and validate previous diet studies (Ford et al., 2016) and what is known of SRKW seasonal movements (Olson et al., 2018) but highlight temporal variability in isotopic values. Warlick et al. (2020) continued to find that Chinook Salmon is the primary prey for all pods in summer months followed by Coho

Salmon and then other salmonids. Carbon signatures in samples varied by month, which could indicate variation in Chinook and Coho salmon consumption between months and/or differences in carbon signatures across salmon runs and life histories. Peaks in carbon signatures in samples varied between K/L pod and J pod. Though Chinook Salmon was the primary prey across years, there was inter-annual variability in nitrogen signature in samples, which could indicate variation in Chinook Salmon nitrogen content from year to year or greater Chinook Salmon consumption in certain years versus others and/or nutritional stress in certain years, but this is difficult to determine.

Scale and tissue sampling from May to September in inland waters of Washington and British Columbia indicate that the SRKW's 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 from 2006-2010 indicate that when SRKWs are in inland waters from May to September, they primarily consume Chinook Salmon stocks that originate from the Fraser River, and to a lesser extent consume stocks from Puget Sound, the Central British Columbia Coast, and West and East Vancouver Island. Prey remains and fecal samples collected in inland Washington waters during October through December indicate Chinook and Chum salmon are primary contributors of the whales' diet (Hanson et al., 2021).

Collection of prey and fecal samples have also occurred in coastal waters in the winter and spring months, as well as observations of SRKWs overlapping with salmon runs (Wiles, 2004; Zamon et al., 2007; Krahn et al., 2009). Results indicate that, as is the case in inland waters, Chinook Salmon are the primary species detected in diet samples on the outer coast, although Steelhead, Chum Salmon, and Pacific Halibut (*Hippoglossus stenolepis*)were also detected in samples. Foraging on Chum and Coho salmon, Steelhead, Big Skate (*Rana binoculata*) and Lingcod (*Ophiodon elongatus*) was also detected in recent fecal samples (Hanson et al., 2021). 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 Salmon genetic stock identification from samples collected in winter and spring in coastal waters from California through Washington included 12 U.S. west coast stocks and showed that over half the Chinook Salmon consumed originated in the Columbia River (Hanson et al., 2021). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook Salmon collectively comprised over 90% of Chinook Salmon prey samples for which genetic stock origin was determined for SRKWs in coastal areas. As noted, most of the Chinook Salmon prey samples opportunistically collected in coastal waters were determined to have originated from the Columbia River Basin, including Lower Columbia Spring, Middle Columbia Tule, and Upper Columbia Summer/Fall. However, the Chinook Salmon stocks included fish from as far north as the Taku River (Alaska and British Columbia stocks) and as far south as the Central Valley California (Hanson et al., 2021).

Currently, there are over 300 hatchery programs in Oregon, Washington, Idaho, and California that release hundreds of millions of juvenile salmon annually. Hatchery production is a significant component of the salmon prey base returning to watersheds within the range of SRKWs (Barnett-Johnson et al., 2007; NMFS, 2008). The release of hatchery fish has not been identified as a threat to the survival or persistence of SRKWs, and there is no evidence to suggest the whales prefer wild salmon over hatchery salmon. Increased Chinook Salmon abundance, including hatchery fish, benefit this endangered population of whales by enhancing prey availability to SRKWs, and hatchery fish often contribute significantly to the salmon stocks consumed (Hanson et al., 2010). Currently, hatchery fish play a mitigation role of helping sustain Chinook Salmon numbers while other, longer term recovery actions for natural fish are underway. Although hatchery production has contributed to offset some 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).

Removal of the lower Klamath River dams is expected to alter Chinook Salmon availability differently over short- and long-term scales thereby affecting abundance, productivity, and diversity. Mortality due to reservoir drawdowns is expected to produce an ~12% decline in productivity of mainstem Klamath River Chinook, and high suspended sediment concentrations are expected to result in mortality of up to 17% of natural-origin juvenile Chinook Salmon in year 1 of lower Klamath dam removal (Renewal Corporation, 2021). This, combined with reductions in hatchery production, is likely to produce a temporary (i.e., 3- to 12-year) decline in Chinook production. However, modeling efforts predict a 35% increase (CDFW, 2018) in adult Chinook returns to the upper Klamath Basin (Dunsmoor and Huntington, 2006; Hendrix, 2011; Lindley and Davis, 2011) over the long term, potentially increasing ocean prey availability.

Contaminants Persistent organic pollutants remain a concern for SRKW. Interested readers are referred to NMFS' most recent SRKW 5-Year Status Review for details (NMFS, 2021b).

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; Subramanian et al., 1987; de Swart et al., 1996; Bonefeld-Jørgensen et al., 2001; Reddy et al., 2001; Schwacke et al., 2002; Darnerud, 2003, 2008; Legler and Brouwer, 2003; Viberg et al., 2003, 2006; Ylitalo et al., 2005; Fonnum et al., 2006; Legler 2008). SRKWs are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health and reproduction. Relatively high levels of these pollutants have been measured in blubber biopsy samples from SRKWs compared to other resident killer whales in the North Pacific (Ross et al., 2000; Krahn et al., 2004, 2007, 2009; Lawson et al., 2020). More recently, these pollutants were measured in fecal samples collected from SRKWs, and fecal toxicants matched those of blubber samples (Lundin et al., 2016a, 2016b).

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). The majority of growth in salmon occurs while feeding in saltwater (Quinn, 2005). Therefore, the majority (> 96%) of persistent pollutants in adult salmon are accumulated while feeding in the marine environment (Cullon et al., 2009; O'Neill and West, 2009). The marine distribution of salmon is an important factor affecting pollutant accumulation as is evident across the different salmon populations. For example, Chinook Salmon populations feeding in close proximity to land-based sources of contaminants have higher concentrations (O'Neill et al., 2006).

Recently, a toxic breakdown product derived from tire rubber (6PPD-quinone) was isolated and determined to cause acute Coho Salmon mortality (Tian et al., 2020). Environmental sampling revealed measurable concentrations of 6PPD-quinone in road runoff collected from Seattle, Los Angeles, and San Francisco, suggesting that this compound is essentially ubiquitous near urban roadways (Tian et al, 2020) and has lethal and sublethal physiological effects in Coho and other salmon species (French et al., 2022; Greer et al., 2023).

Upon consumption of prey species that contain these pollutants, these harmful pollutants are stored in the killer whale’s blubber and can later be released. 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 pollutants are redistributed to other tissues. The release of pollutants can also occur during gestation or lactation. Once the pollutants mobilize into 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 SRKWs and result in adverse health effects.

Vessel Impacts and Sound 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, SRKWs are a 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, 2010b, 2016a, 2018b). 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 and/or presence of motoring vessels up to 400 m away has the potential to affect the echolocation abilities of foraging whales and their foraging dives and success (Holt, 2008; Lusseau et al., 2009; Noren et al., 2009; Williams et al., 2010; Holt et al., 2021). Models of SRKW behavior states showed that both males and females spent less time in foraging states, with fewer prey-capture dives and shorter dives, when vessels were near (within 400 yards on average), but also that females were more likely to switch from deep and intermediate dive foraging behaviors to travel/respiration when vessels were near (Holt et al., 2021). 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., 2006b; Lusseau et al., 2009; Noren et al., 2009, 2012). Ayres et al. (2012) examined glucocorticoid and thyroid hormone levels in fecal samples collected from SRKWs in inland waters, and their results suggest that the impacts from vessel traffic on hormone levels are lower than the impacts from reduced prey availability.

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 December 2017, NMFS completed a technical memorandum evaluating the effectiveness of regulations that concluded some indicators suggested the regulations have benefited SRKWs by reducing impacts without causing economic harm to the commercial whale-watching industry or local communities, whereas some indicators suggested that vessel impacts continue and that some risks may have increased (Ferrara et al., 2017). In 2019, Washington State regulations were updated to increase vessel viewing distances from 200 to 300 yards to the side of the whales and reduce vessel speed within 0.5 nautical mile of the whales to 7 knots over ground (see Revised Code of Washington 77.15.740). In 2021, Washington implemented a Commercial Whale Watch Licensing Program requiring commercial operators to maintain a commercial whale watching license in order to view SRKWs in Washington waters.

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; NRC, 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).

Oil Spills In the Northwest, SRKWs are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their overall small population size, strong site fidelity to areas with high oil spill risk, large groups of individuals together, 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 SRKWs 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 SRKWs remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers.

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 Aubin, 1990; Schwacke et al., 2013; Venn-Watson et al., 2015; de Guise et al., 2017; Kellar et al., 2017), as well as potentially death and long-term effects on population viability (Matkin et al., 2008; Ziccardi et al., 2015). Previous polycyclic aromatic hydrocarbon (PAH) exposure estimates suggested SRKWs can be occasionally exposed to concerning levels (Lachmuth et al., 2011). More recently, Lundin et al. (2018) measured PAHs in whale fecal samples collected in inland waters of Washington between 2010 and 2013 and found low concentrations of the measured PAHs (<10 parts per billion [ppb], wet weight). However, PAHs were as high as 104 ppb in the first year of their study (2010) compared to the subsequent years. Although the cause of this trend is unclear, higher levels were observed prior to the 2011 vessel regulations that increased the distance vessels could approach the whales. In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect SRKWs by reducing food availability.

Scientific Research Potential impacts on SRKWs from permitted research include temporary disturbance and potential short-term disruptions or changes in behavior such as feeding or social interactions with researchers in close proximity, and any minor injuries that may be associated with sampling or attachment of tags for tracking movements and behavior.

Demographic Factors Because the SRKW population is already small and is forecast to continue shrinking, the potential for undesirable demographic risks increases. Currently, the following demographic factors have been identified as concerns for SRKW (NMFS, 2021b):

- Reduced fecundity
- Skewed sex ratio toward male births in recent years
- Lack of calf production from certain components of the population (e.g., L pod)
- Small number of adult males acting as sires
- Overall small number of individuals in the population.

The importance of these demographic factors is better recognized now, because of studies conducted after the species' ESA listing (e.g., Lacy et al., 2017; Ford et al., 2018) and knowledge synthesized in the status reviews (NMFS, 2021b).

7.1.5 Recovery Plan

In 2008 NMFS published the Recovery Plan for Southern Resident Killer Whales (Orcinus orca) (NMFS, 2008). The SRKW Recovery Plan aims to bring the SRKW DPS and its ecosystem to a level where they would no longer be listed as endangered under the ESA. The plan outlines actions to address threats such as reduced prey availability, vessel traffic, and environmental contaminants. It also sets criteria for delisting the SRKW DPS and emphasizes the importance of research and monitoring. In addition, the plan provides guidance for conservation efforts. Salient components are summarized below; interested readers are referred to the SRKW recovery plan (NMFS, 2008) for additional details.

7.1.5.1 Recovery Goals

The stated goal of the Recovery Plan is summarized below; interested readers are referred to the Recovery Plan for additional details (NMFS, 2008):

The ultimate goal of this recovery plan is to achieve the recovery of the Southern Resident killer whale distinct population segment (DPS) and its ecosystem to a level sufficient to warrant its removal from the Federal List of Endangered and Threatened Wildlife and Plants under the ESA. The intermediate goal is to reclassify the DPS from endangered to threatened.

7.1.5.2 Delisting Criteria and Recovery Metrics

The decision to list or delist SRKW is based on its biological performance and the threats to its existence. The Recovery Plan describes the approach to developing objective, measurable criteria that focus on two areas: 1) the performance of the population over a meaningful period of time (biological criteria), and 2) the reduction of threats that may have caused the population decline or limit recovery (threats criteria). The Recovery Plan outlines in detail the basis for the criteria and present objective, measurable criteria for delisting and downlisting the SRKW DPS.

7.1.5.3 Key Recovery Actions

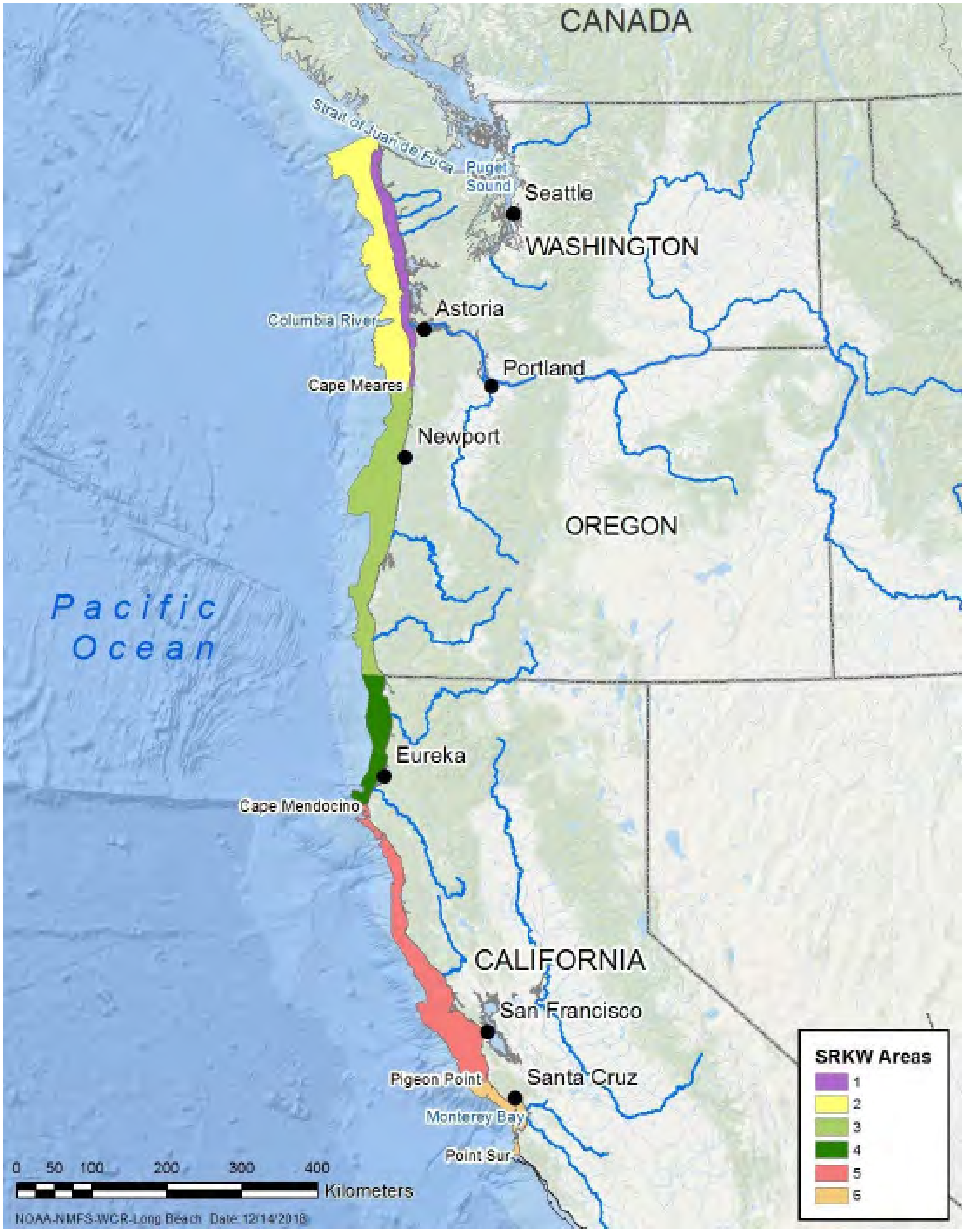
The Recovery Plan outlines recovery measures, research, and monitoring actions required to restore the SRKW population to long-term sustainability, including management, coordination, research, and monitoring actions to reduce threats and conserve SRKWs. The Implementation Schedule identifies parties responsible for specific actions, and priority, cost, and completion timeline are provided for each action. The Recovery Plan emphasizes that the ranking of activities does not imply an order of importance, and actions benefitting from additional research are referenced in the Research and Monitoring section.

7.1.6 Critical Habitat

NMFS issued a final rule designating Critical Habitat for the SRKW DPS in November 2006 (71 FR 69054 [2006]), which was later revised to include additional marine habitats in August 2021 (86 FR 41668 [2021]). The 2021 rule delineated six critical habitat areas (Figure 7-7) that provide essential features for SRKW (Table 7-1). The updated critical habitat designation also identified the following essential physical or biological features:

- Water quality to support growth and development
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth
- Passage conditions to allow for migration, resting, and foraging

The description and status of each physical or biological feature is summarized in Section 7.1.6.1 and is excerpted directly from 86 FR 41668 (2021).



Source: 86 FR 41668 (2021)

Figure 7-7. Specific areas containing essential habitat features for Southern Resident Killer Whales

Table 7-1. Southern Resident Killer Whale critical habitat specific area descriptions

Area	Size	Essential Feature
1 - Coastal Washington/Northern Oregon Inshore Area	1,437.9 mi^2; (3,724.2 km^2)	**Prey***, passage, water quality
2 - Coastal Washington/Northern Oregon Offshore Area	4,617.2 mi^2; (11,958.6 km^2)	**Prey***, passage, water quality
3 - Central/Southern Oregon Coast Area	4,962.6 mi^2; (12,853.1 km^2)	**Passage***, prey, water quality
4 - Northern California Coast Area	1,606.8 mi^2; (4,161.5 km^2)	**Prey***, passage, water quality
5 – North Central California Coast Area	3,976.2 mi^2 (10,298.4 km^2)	**Passage***, prey, water quality
6 - Monterey Bay Area	709.7 mi^2; (1,838.2 km^2)	**Prey***, passage, water quality

Notes: Asterisk and bolding indicate primary feature. Source: 86 FR 41668 (2021)

7.1.6.1 Physical and Biological Features

Water Quality to Support Growth and Development *Water quality supports Southern Resident killer whales' ability to forage, grow, and reproduce free from disease and impairment. Southern Resident killer whales are highly susceptible to biomagnification of pollutants, such that chemical pollution is considered one of the prime impediments to their recovery (NMFS 2008). Water quality is essential to the whales' conservation, given the whales' present contamination levels, small population numbers, increased extinction risk caused by any additional mortalities, and geographic range (and range of their primary prey) that includes highly populated and industrialized areas. Water quality is especially important in high-use areas where foraging behaviors occur and contaminants can enter the food chain. The absence of contaminants or other agents of a type and/or amount that would inhibit reproduction, impair immune function, result in mortalities, or otherwise impede the growth and recovery of the Southern Resident population is a habitat feature essential for the species' recovery. Exposure to oil spills also poses additional direct threats as well as longer-term population level impacts. Therefore, the absence of these chemicals is essential to Southern Resident conservation and survival.*

Prey Species of Sufficient Quantity, Quality and Availability to Support Individual Growth, Reproduction and Development, as Well as Overall Population Growth *Southern Resident killer whales need to maintain their energy balance all year long to support daily activities (foraging, traveling, resting, socializing) as well as gestation, lactation, and growth. Maintaining their energy balance and body condition is also important because when stored fat is metabolized, lipophilic contaminants may become more mobilized in the bloodstream, with potentially harmful health effects (Mongillo et al. 2016). Southern Resident killer whales are top predators that show a strong preference for salmonids in inland waters, particularly larger, older age class Chinook (age class of 3 years or older) (Ford & Ellis 2006, Hanson et al. 2010). Samples collected during observed feeding activities, as well as the timing and locations of killer whales' high-use areas that coincide with Chinook salmon runs, suggest the whales' preference for Chinook salmon extends to outer coastal habitat use as well (Hanson et al. 2017, Shelton et al. 2018, Hanson et al. 2021). At some low Chinook abundance level, the prey available to the whales will not be sufficient to forage successfully leading to adverse effects on body condition or fecundity (NMFS 2020). Habitat* *conditions should support the successful growth, recruitment, and sustainability of abundant prey to support the individual growth, reproduction, and development of Southern Resident killer whales.*

Age, size, and caloric content all affect the quality of prey, as do contaminants and pollution. The availability of key prey is also essential to the whales' conservation. Availability of prey along the coast is likely limited at particular times of year due to the small run sizes of some important *Chinook salmon stocks, as well as the distribution of preferred adult Chinook salmon that may be relatively spread out prior to their aggregation when returning to their natal rivers. Availability of Chinook salmon to the whales may also be impacted by sound from vessels or other sound sources if they raise average background noise within the animal's critical bandwidth to a level that is expected to chronically or regularly reduce echolocation space (Joy et al., 2019, Veirs et al., 2016), and by competition from other predators including other resident killer whales, pinnipeds, and fisheries (Chasco et al., 2017).*

Passage Conditions to Allow for Migration, Resting, and Foraging *Southern Resident killer whales are highly mobile, can cover large distances, and range over a variety of habitats, including inland waters and open ocean coastal areas from the Monterey Bay area in California north to Southeast Alaska. The whales' habitat utilization is dynamic. Analyses of Southern Resident killer whales' movement patterns on the outer coast from satellite tag data have revealed preferred depth bands and distances from shore that suggest potential travel corridors, and variations in travel speed or duration of occurrence that may indicate different behavioral states (Hanson et al., 2017).*

Southern Resident killer whales require open waterways that are free from obstruction (e.g., physical, acoustic) to move within and migrate between important habitat areas throughout their range, find prey, communicate, and fulfill other life history requirements. As an example of an "acoustic obstruction," killer whale occurrence in the Broughton Archipelago, Canada declined significantly when acoustic harassment devices were in use at a salmon farm, and returned to baseline levels once the devices were no longer used (Morton & Symonds 2002), indicating the introduction of this chronic noise source into the environment acted as an acoustic barrier and/or deterrent to the whales' use of the area. The passage feature may be less likely to be impacted in coastal ocean waters compared to the more geographically constricted inland waters because the whales may be able to more easily navigate around potential obstructions in the open ocean, but these passage conditions are still a feature essential to the whales' conservation and which may require special management considerations or protection.

7.2 Effects Analysis

The SRKWs are known to occur frequently in the outer coastal waters (within ~50 km of shore) and inland waters of Washington and British Columbia down the west coast of the United States to the coastal waters off California. SRKWs forage on fish. Chinook Salmon are their preferred prey; however, they will eat other salmonids, some groundfish, and, rarely, other types of fish and cephalopods (Hanson et al., 2021). They tend to diversify their diet more in the wintertime to include Steelhead, Chum, Lingcod, and Halibut, but Chinook Salmon remain their preferred prey when available (Hanson et al., 2021). Fall-run and spring-run Chinook Salmon that originate from the Klamath River make up about 2% of samples in the outer coast waters and no samples from Puget Sound were from the Klamath River watershed. This is consistent with studies that show Chinook Salmon of Klamath River watershed origin can occur as far north as the coastal waters off British Columbia during their ocean-going life-history phase. However, the majority of them do not travel further north than central Oregon (Weitkamp, 2009; Shelton et al., 2019).

The SRKW population comprises three pods (J, K, and L) which each contain several matrilines. J-pod matrilines are not documented in the coastal waters off California and Oregon and occur mostly in the Salish Sea and off the west coast of Vancouver Island. Photo-identification studies (CWR, 2024), satellite tagging studies (NOAA Fisheries and Cascadia Research unpublished data), prey studies (Hanson et al., 2021), contaminant studies (Krahn et al., 2007, 2009), passive acoustic monitoring (Hanson et al., 2013), as well as land-based and boat-based sighting networks indicate that J pod individuals rarely, if ever, travel beyond the coastal waters off Washington and British Columbia and rarely forage on salmon originating from the Klamath River watershed (NMFS, 2008, 2021b). K and L pods also occur frequently in the Salish Sea and off the west coast of Vancouver Island but also make frequent excursions to the coastal waters off Oregon and occasionally off the coast of California. K and L pods members have been observed as far south as the coastal waters off Monterey Bay (Monterey Bay Whale Watch, 2003; NMFS 2008, 2021b). Excursions to coastal California happen more often in February but have been documented, albeit rarely, in December, January, March, and April (Figure 7-8). The same group of studies listed above indicate that K and L pods forage more often on salmon originating from California than J pod. Therefore, Project operations are likely to have little to no effect on members of J pod but may affect members of K and L pod.

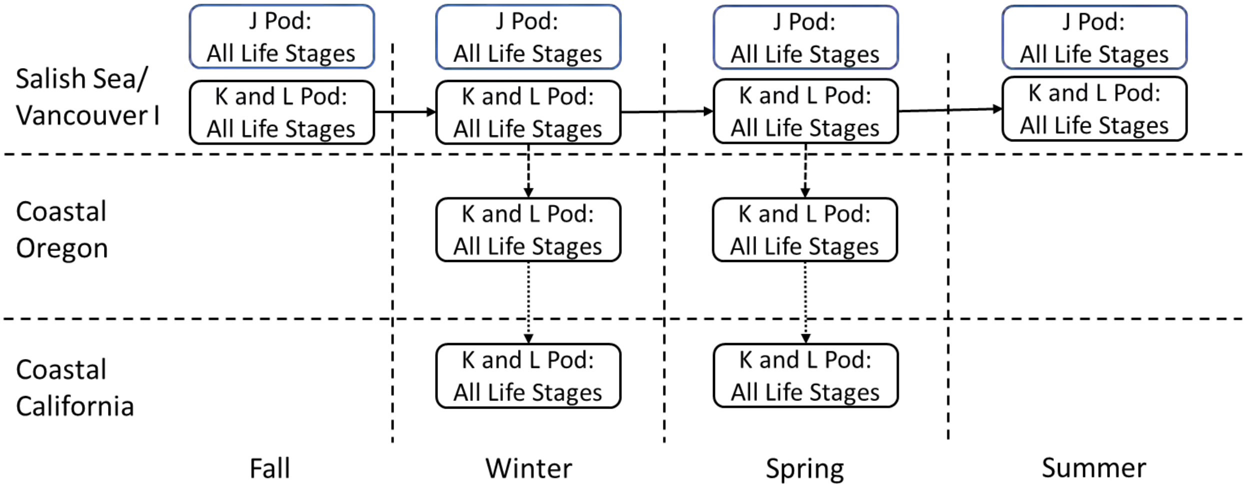


Figure 7-8. Geographic and temporal life stage domains for Southern Resident Killer Whales

The primary potential effect of the Proposed Action on SRKWs is through potential reductions in availability of preferred prey, Chinook Salmon, in the coastal waters where Chinook Salmon from the Klamath River may be encountered by SRKWs (Section 7.2.1). The most recent review (Lacy et al., 2017) indicates that non-prey factors in other parts of the range also impact SRKW population dynamics, so there is uncertainty in the extension of the statistical correlations to precise predictions of the effect of Chinook Salmon abundance on the SRKW population. To date there are no data or alternative explanations that contradict fundamental principles of ecology that wildlife populations respond to prey availability in a manner generally consistent with the analyses that link Chinook Salmon abundance and SRKWs. As a result, and based on evidence discussed in Section 7.1, the best available science suggests that relative changes in Chinook Salmon abundances are likely to influence the SRKW population.

7.2.1 Impacts to the Abundance of Chinook as a Result of the Proposed Action

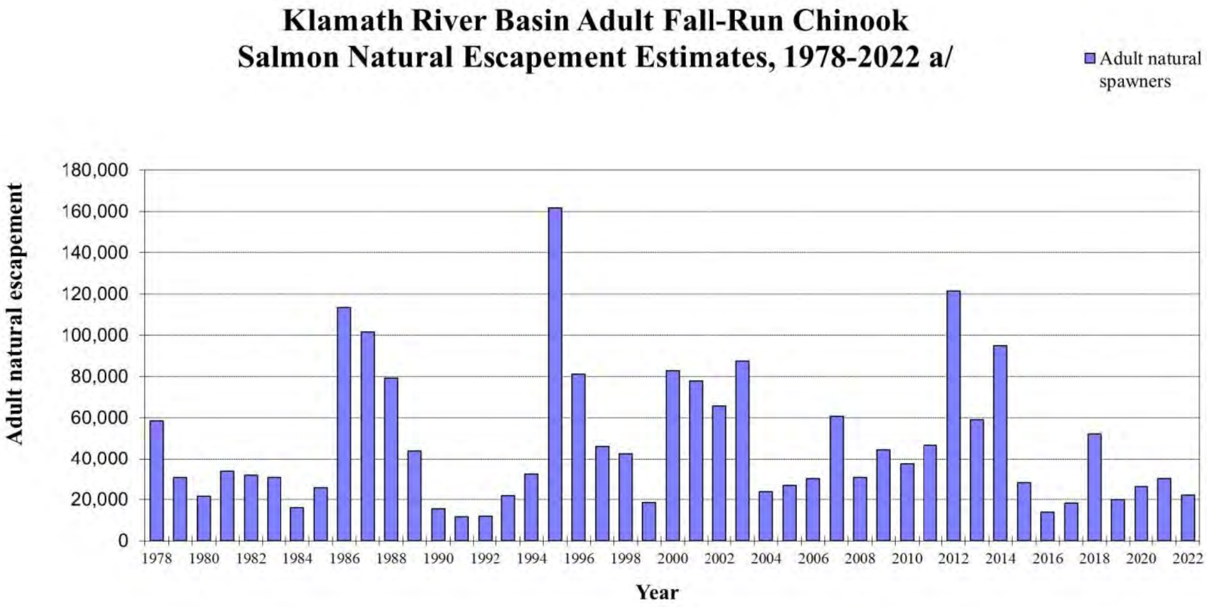
Chinook Salmon in the Klamath River are not listed under the ESA; however, the effects of the Proposed Action on Chinook Salmon are analyzed because they are a primary food source for SRKWs and Klamath River Chinook Salmon are potential prey for SRKWs along the coast. As described in Section 7.1, the best available science suggests that any effects of the Proposed Action that reduce Chinook Salmon production could negatively impact SRKWs. Likewise, actions that increase Chinook Salmon abundance could benefit SRKWs. Much like ESA-listed Coho Salmon, Chinook Salmon use the Klamath River during multiple life stages and the life history requirements of both Chinook and Coho salmon overlap. Therefore, the effects analysis conducted for Coho Salmon (Chapter 6) is referred to at times to inform the effects analysis of the Proposed Action on Chinook Salmon. However, there are life history strategies and habitat preferences of Chinook Salmon that do differ from Coho Salmon. Both Chinook Salmon specific information as well as relevant Coho Salmon information are summarized to help analyze the effects the Proposed Action may have on Chinook Salmon production. In turn, Chinook Salmon abundance at sea is an important driver of SRKW population dynamics (Ward et al., 2009; Ford et al., 2010; Hilborn et al., 2012; Velez-Espino et al., 2014; Lacy et al., 2017), and Coho Salmon have been shown to be an important part of the diet in times and places where more preferred species (Chinook and Chum) are not available.

7.2.1.1 Klamath River Chinook Salmon

Klamath River Chinook Salmon Life History Chinook Salmon display two types of life history strategies in the Klamath River, spring-run and fall-run, named for the season of adult freshwater entry and migration upstream. Unlike Coho Salmon, Chinook Salmon typically spawn in larger waterways such as the mainstem Klamath River and large tributaries including the Trinity, Salmon, Scott, and Shasta rivers. Fry emerge from redds between December and February. Juvenile Chinook Salmon can display either a “stream type” or “ocean type” life history strategy where the “stream type” rears for a greater length of time in freshwater than the “ocean type.” However, Williams et al. (2013) determined that juvenile Chinook Salmon in the Upper Klamath Trinity River ESU typically do not display the “stream type” strategy. Therefore, juveniles in the Klamath and Trinity rivers will usually outmigrate shortly after emergence between March and June. Chinook Salmon typically mature and return to freshwater between 3 and 6 years of age (Snyder, 1931).

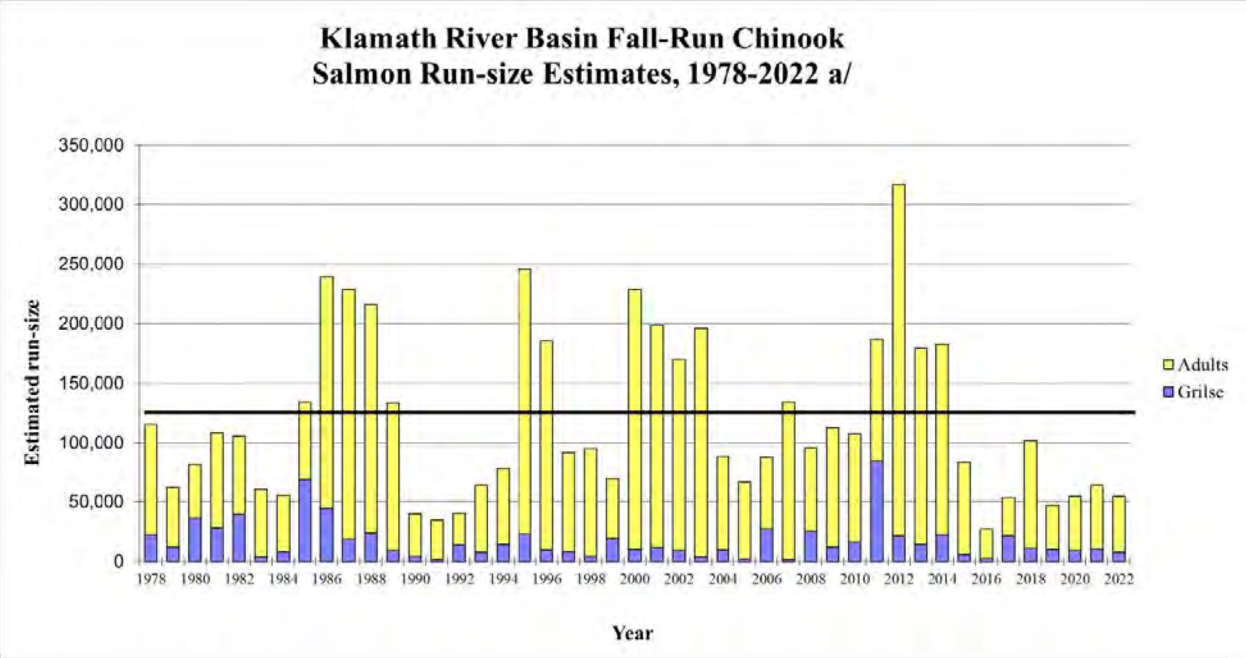
Chinook Salmon Spatial Structure/Distribution Chinook Salmon distribution has been greatly reduced in the Klamath Basin, first by the construction of Copco 1 Dam starting in 1912 (Hamilton et al., 2016). Currently, IGD, which was constructed in 1962, represents the upstream limit of anadromy in the Klamath River. Additionally, construction of Dwinnell Dam in the Shasta River blocked portions of habitat starting in 1928, while the Lewiston Dam built in 1963 on the Trinity River prevented access to many tributary habitats including East Fork, Stuart Fork, Upper Trinity River, and Coffee Creek (Campbell and Moyle, 1991). The significant loss of habitat because of dams has resulted in two mitigation hatcheries, Iron Gate and Trinity River hatcheries. Although both spring-run and fall-run Chinook Salmon are present in the Klamath Basin, no spring-run Chinook Salmon have been observed spawning in the mainstem Klamath River (Shaw et al., 1997). Instead, adult spring-run Chinook Salmon only use the mainstem as a migratory corridor to reach their spawning grounds in the tributaries. Currently, known distribution of spring-run Chinook Salmon are limited to the Salmon River and Trinity River sub-basins. As described in the analysis of effects of the Proposed Action on Coho Salmon, the effects of the Proposed Action are ameliorated substantially downstream as tributary accretions influence water quality, water quantity, and other physical and ecological factors. Because the Salmon River is approximately 125 RMs downstream of IGD with several large tributary influences upstream, only negligible effects on spring-run Chinook Salmon are anticipated. Conversely, a large portion of the fall-run Chinook Salmon population in the Klamath Basin are exposed to portions of the mainstem Klamath River that are impacted by the Proposed Action's modified flows, as described below.

Chinook Salmon Abundance and Productivity Natural-spawned Chinook Salmon abundance has declined dramatically since dams were constructed in the basin. CDFG (1965) estimated spawning escapement of Chinook Salmon at approximately 168,000 adults with the number split about evenly between Klamath and Trinity rivers. Hatchery production in the basin increases the overall abundance of Chinook Salmon in the Klamath. The Iron Gate Hatchery releases nearly 6 million fall-run Chinook Salmon juveniles each year, while Trinity River Hatchery releases 4.3 million juvenile spring-run and fall-run Chinook Salmon combined. Figure 7-9 shows the natural spawner abundance of fall-run Chinook Salmon in the Klamath Basin from 1978 to 2022 (CDFW, 2023a), and Figure 7-10 shows the entire escapement of fall-run Chinook Salmon during the same period but with hatchery fish included (CDFW, 2023b). Spring-run Chinook Salmon have a much lower abundance in the Klamath River. Figure 7-11 summarizes the escapement of hatchery and wild spawning adult spring-run Chinook Salmon (CDFW, 2021b).



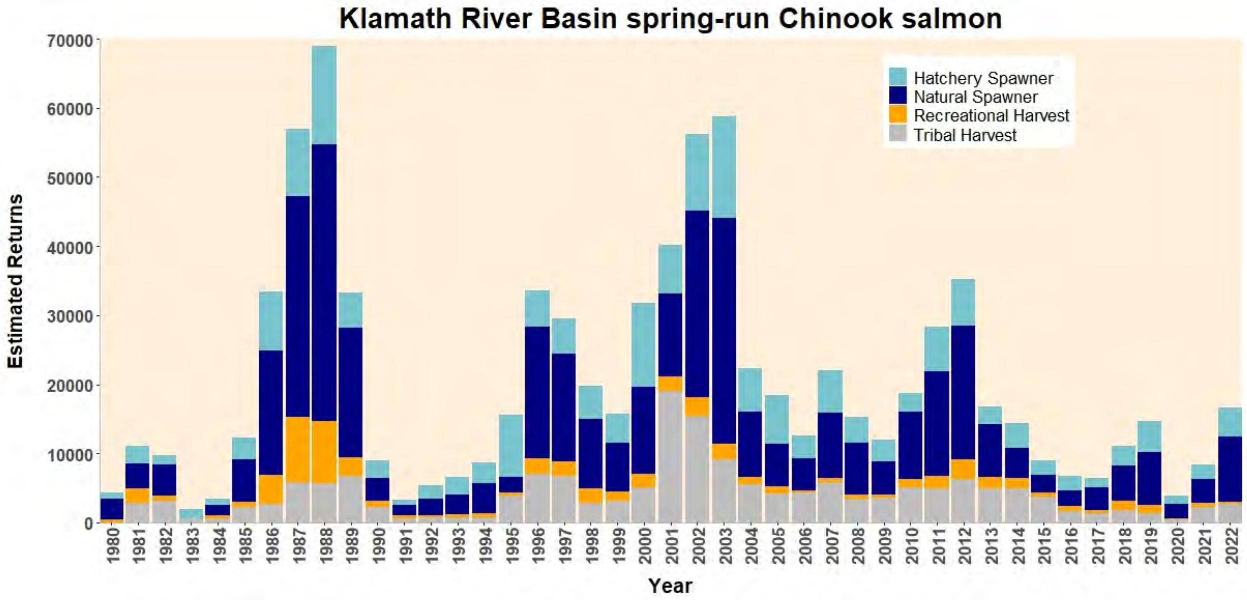
Note: Figure from CDFW (2023a). "a/" indicates that 2022 data are preliminary and subject to revision.

Figure 7-9. Adult natural escapement of fall-run Chinook Salmon in the Klamath Basin, including Trinity River fish



Notes: Figure from CDFW (2023b). "a/" indicates that 2022 data are preliminary and subject to revision.

Figure 7-10. Adult total in-river run of fall-run Chinook in the Klamath Basin, including in-river harvest and hatchery spawning, in the Trinity and Klamath rivers



Notes: Figure from CDFW (2021b). 2020 data is preliminary and subject to revision from NMFS (2021a).

Figure 7-11. Klamath Basin adult spring-run Chinook Salmon abundance estimates

Chinook Salmon Diversity Diversity within the Chinook Salmon population is represented by the differing life history strategies described above. These include spring and fall-run adult migration timing, different timing for freshwater rearing and smolt emigration, and different periods for adult maturation ranging from less than 1-year-old precocious males to 6-year-old adults.

Hatcheries can also play a role in shifting genetic diversity within populations. Releasing hatchery-origin fish can result in lower productivity of natural-origin salmonids. Between 1998 and 2016, Iron Gate and Trinity River hatcheries released roughly 9.8 million hatchery Chinook Salmon annually (CDFW, unpublished data). Hatchery-origin Chinook Salmon found in the wild are typically spawned adjacent to the two hatcheries and gene flow from hatchery-origin fish is mostly limited to those areas (Kinziger et al., 2013).

7.2.1.2 Effects of the Proposed Action on Chinook Salmon Individuals

As described in Chapter 6, the Proposed Action affects salmonid habitat in the Action Area through Project operations. The Proposed Action's greatest effects to Chinook Salmon production are associated with effects to the Klamath River hydrology. As a result of operating the Project, the Klamath River annual flow volume, spring peak magnitude and duration, deep flushing flows, and flow variability will be altered, relative to MS.

Based on the hydrological analysis of the period of record, naturally-driven flushing flows are less likely to occur under the Proposed Action (17% of years) than under the MS scenario (22% of years). Also, peak flows are higher under the MS scenario than under the Proposed Action. This is largely driven by flood control releases occurring in the fall under the MS scenario.

Minimum flows in summer are higher under the Proposed Action than they would be under the MS scenario in both wet and dry years. Similar to the anticipated effects described in Chapter 6, Chinook populations proximal to IGD (i.e., Klamath River mainstem, Iron Gate Hatchery, Bogus, Shasta, and Scott rivers) and upriver will experience the greatest effects of Project operations, whereas populations in the lower Klamath River (i.e., Salmon River) will be less likely to be affected.

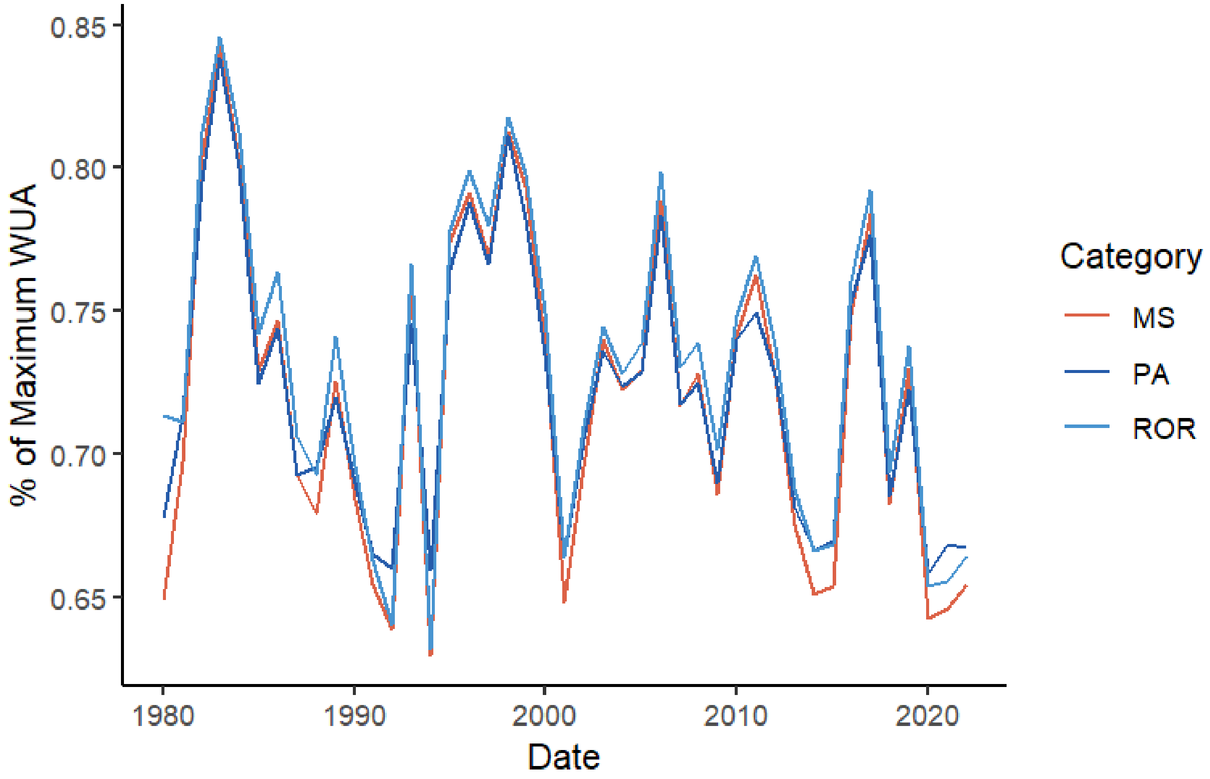
Exposure and Response

Adults Fall-run Chinook Salmon adults enter the Klamath River from July through September and may remain in the mainstem until spawning in late October and early November (Snyder, 1931). Adult Chinook Salmon can be susceptible to disease such as Ich (*Ichthyophthirius multifiliis*) and columnaris (caused by *Flavobacterium columnare*) when habitat conditions include exceptionally low flows, high water temperatures, and high densities of fish (such as adult salmon migrating upstream in the fall and holding at high densities in pools). In 2002, these habitat factors were present, and a disease outbreak occurred, killing more than 33,000 adult salmon and Steelhead (Guillen, 2003). July through September median daily flows supporting returning adults will be higher under the Proposed Action than under the baseline. Low flows at IGD and Keno Dam may contribute to conditions that increase risks of disease to adult Chinook Salmon that enter the Klamath River in late summer and early fall. Thus, by maintaining adequate median daily flows at both locations, adults are likely to do better under the Proposed Action than the baseline scenario.

Eggs The flows provided for in the Proposed Action increase (IGD) or remain relatively consistent (Keno) throughout the fall and winter. This, combined with cooler fall water temperatures should be sufficient to provide suitable conditions for egg incubation. Slightly warmer winter temperatures, on the order of 0.1°C, are well within Chinook Salmon egg thermal optima and present no risk of adverse effect. Therefore, fall-run Chinook Salmon eggs in the mainstem Klamath River are not expected to be adversely affected by the Proposed Action.

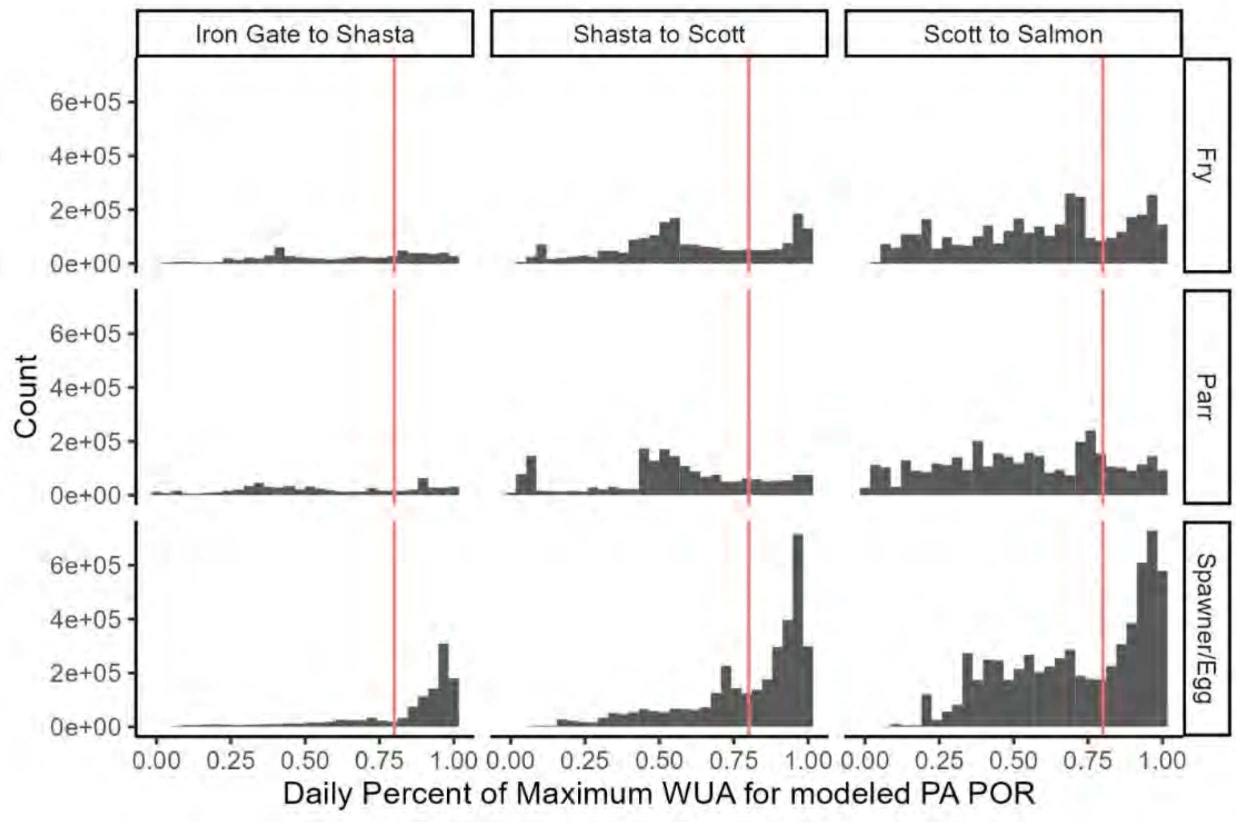
Juveniles Fall-run Chinook Salmon fry, parr, and smolt will experience modified flows resulting from the Proposed Action relative to the MS scenario. When fry emerge from their redds (December – February) they seek slow water habitat located on the channel fringes and in off-channel habitat features. The majority of juvenile Chinook Salmon rear as parr for a short period prior to outmigration in March to mid-June. During this spring freshwater rearing period, habitat availability will be reduced under some hydrological conditions relative to the MS scenario (Chapter 6), with a decreased amount of suitable habitat. However, in dry years, its habitat availability will be better under the Proposed Action than under the MS scenario.

Reclamation's habitat availability analysis uses a hydrodynamic model developed for the mainstem Klamath River (Perry et al., 2019) and WUA curves to simulate habitat availability for Chinook Salmon under the Proposed Action (Figure 7-12). Note that Figure 7-13 depicts the modeled daily frequency under the PA over the period of record without averaging across day (i.e., - time dimension) or reach (i.e., spatial dimension). This could be termed as "habitat-days greater than or equal to 80% WUA." Since each reach is made up of an aggregation of individual habitat units, aggregating data (i.e., mean, median, etc.) across days or reaches can obscure the availability of individual habitat within a reach if other habitat units within that reach have little to no habitat available. This gives the inaccurate impression that little/no habitat is available in that reach when in fact individual habitat units may have greater than 80% habitat available under those daily flows. Since individual fish do not experience their physical environment on a monthly, yearly or reach level scale, the finer scale of daily and individual habitat units represents the most biologically, as well as statistically, useful depiction of this data.



Note: In wet years, the area available under the Proposed Action would have been less than that under MS but in dry years, the area would have been greater.

Figure 7-12. The weighted usable area for Chinook for the Period of Record under the Proposed Action in blue and under the maximum storage and run-of-river scenarios



Note: Red vertical line denotes the 80%-of-maximum WUA threshold.

Figure 7-13. Daily frequency of Chinook Salmon fry, parr and spawner/egg habitat availability under the PA for the modeled period of record for three reaches downstream of Iron Gate Dam

Over the period of record, the PA generally has a higher or equal percent of maximum habitat (WUA) available than the MS scenario in winter, parts of spring and summer (See also 4.1.3.1, Figure 4-10). The frequency of Chinook salmon spawner/egg, fry and parr habitat under the PA over the modeled period of record is shown in Figure 7-13. All three reaches have substantial habitat (i.e., greater than or equal to 80% WUA threshold) available for all three life stages over the modeled period of record (Table 7-2). The apparent reduction in total available habitat from upstream to downstream is an artifact of the definition of reaches where IGD to the Shasta River has the fewest individual habitat units in it while the Scott River to Salmon River has the most. The Shasta River to Scott River Reach is intermediate. Generally, the IGD to Shasta River reach has the highest proportion of day/habitats with greater than or equal to 80% WUA while Shasta River to Scott River have the least. The spawner/egg life stage has the highest proportion of day/habitats with greater than or equal to 80% WUA across all reaches while the parr life stage has the least.

Table 7-2. Percent of days with greater than 80% habitat available for Chinook Salmon fry, parr, and spawner/egg under the Proposed Action for the modeled period of record (relative to mainstem flows for three reaches and four sites downstream of Iron Gate Dam

Stage	Reach	Percent of Days Greater Than or Equal to 80% WUA Threshold
Spawner/Egg	Iron Gate to Shasta River	73.5%
Spawner/Egg	Shasta River to Scott River	61.1%
Spawner/Egg	Scott River to Salmon River	46.3%
Fry	Iron Gate to Shasta River	36.1%
Fry	Shasta River to Scott River	29.1%
Fry	Scott River to Salmon River	27.8%
Parr	Iron Gate to Shasta River	28.9%
Parr	Shasta River to Scott River	20.2%
Parr	Scott River to Salmon River	19.4%

Habitat reduction increases competition with other salmonids and may force fish to relocate to less suitable habitat. These effects will likely result in reduced growth and survival of juvenile fall-run Chinook Salmon in the mainstem Klamath River between IGD and the Salmon River. In addition, the reduction in magnitude, frequency, and duration of sediment maintenance flows (specifically the frequency of immobile bed conditions; Figure 6-11) under the Proposed Action contributes to increased exposure to disease in the mainstem Klamath River. To offset some of the potential risks to juvenile salmonids during the outmigration period, the Proposed Action implements the FFA, such that volumes can be distributed to maximize ecological benefits (i.e., reduce disease risk and increase habitat availability). Established ramp down rates at IGD under the Proposed Action will minimize stranding risk of juvenile Chinook.

Summary of Effects on Chinook Salmon Individuals The effects analysis for SONCC Coho Salmon (Chapter 6) helps describes the effects to non-ESA-listed Chinook Salmon. Because Chinook Salmon occupy many of the same habitats at the same time as SRKWs, this analysis can inform effects of Reclamation's Proposed Action on the species.

Considering the analysis provided in the SONCC Coho Salmon effects section (Section 6.3) and the overlap of exposure to stressors that may occur, implementing the Proposed Action may affect and is likely to adversely affect fall-run Chinook Salmon juveniles and adults.

In terms of productivity and abundance, Klamath River Chinook Salmon are largely comprised of the fall-run and, to a much lesser degree, spring-run Chinook Salmon. This is reflected in annual spawning escapement estimates for the Klamath River and its associated tributaries; fall-run Chinook Salmon escapement estimates are typically on the order of 100,000 to 300,000 adults, although less in recent years, compared to less than 20,000 for spring-run Chinook Salmon on average during the period of record (Figure 7-9 and Figure 7-11).

Relative to the MS scenario, the Proposed Action increases the likelihood of ensuring adequate flows for spring-run Chinook during the summer, as well as reducing the concentration of pathogens faced by returning fall-run adults. Also, the Proposed Action would mitigate various stressors and increase the fitness and survival of fall-run Chinook Salmon relative to the MS scenario, primarily in drier water years when environmental stressors are heightened. Drier years are likely to occur during this consultation.

Negative effects in the mainstem Klamath River would be most acute during dry years and in periods of prolonged, elevated air temperatures. These adverse effects could include increased disease exposure during the juvenile rearing and outmigration period and reduced fry habitat availability leading to increased competition. These effects could reduce growth and survival of fry and juvenile Chinook Salmon. Adult Chinook Salmon could be exposed to lower flows in the mainstem Klamath River and, when combined with elevated water temperatures in late summer and early fall, may delay migration, which would reduce reproductive success. The Proposed Action is expected to contribute beneficially to reduced disease infection over the duration of the Proposed Action, due to the more natural flow regimes and flexible flow account augmentation.

This analysis of effects of the Proposed Action to Chinook Salmon generally describes and summarizes those effects in a qualitative manner based on the available information, since actual results will depend on unpredictable future natural conditions such as rainfall and temperature patterns, and policy decisions beyond the scope of this analysis. The effects of the underlying and ongoing impact of Project operations on juvenile survival under the Proposed Action cannot generally be quantified, with the notable exception of explicit quantification of the relative amount of adult spawning, egg incubation and juvenile rearing habitat anticipated to result from the Proposed Action.

The absolute magnitude of Klamath River Chinook Salmon prey that results from effects of the Proposed Action relative to MS conditions cannot be fully quantified at this time. This restricts the ability to provide specific quantifiable expectations for the increases in the abundance of fall-run Chinook Salmon in the ocean available as prey for SRKWs. Nevertheless, the analysis in this consultation indicates that prey availability will be lower under the Proposed Action. Reductions in the amount of habitat for spawner/egg, fry and parr life stages, though similar to past consultations (NMFS 2013, 2019), will nonetheless result in habitat availability less than 80% of maximum for 30-80% of days. This may adversely affect the overall abundance of Chinook salmon available as prey for SRKW.

General Effects of Reduced Prey Base for Southern Resident Killer Whales The information described above suggests that the population dynamics of SRKWs are related to the abundance of Chinook Salmon available as prey throughout their range. As a result, any changes in availability of preferred prey (Chinook Salmon) may affect the survival and reproductive success of SRKWs. As described in Section 7.1, SRKWs (particularly members of K and L pod) are likely to spend at least some time in coastal waters where they would be affected by any changes in Klamath River Chinook Salmon abundance due to the Proposed Action. Contaminant signatures confirm that SRKWs (particularly members of K and L pod) are likely to consume Chinook

Salmon from California (Krahn et al., 2007). As described in Section 7.1, Chinook Salmon from the Klamath River, especially fall-run Chinook Salmon, can constitute a proportion of the total abundance of Chinook Salmon that is available throughout the coastal range of SRKWs (approximately 4% on average, but varying substantially between 1 and 9% during any given year). Klamath River Chinook Salmon become a larger portion of the prey base during transits of SRKWs along the coast of Oregon and California that may occur during the winter and spring, and Klamath River Chinook Salmon may constitute as much as 45% of local abundance of Chinook Salmon in these areas when SRKWs are there.

SRKWs are believed to take advantage of local prey concentrations created by bathymetric features, upwelling, and returns to areas just offshore of river mouths. These concentrations are ephemeral in time and space. They may abandon areas with low prey concentration in search of more abundant prey or expend substantial effort to find prey resources in response to a decrease in the amount of available Chinook Salmon due to the Proposed Action. These changes in behavior can result in increased energy demands for foraging individuals as well as reductions in overall energy intake, increasing the risks of being unable to acquire adequate energy and nutrients from available prey resources (i.e., nutritional stress).

SRKWs are known to consume other species of fish, including other salmon, but the relative energetic value of these species is substantially less than that of Chinook Salmon (i.e., Chinook Salmon are larger, and adults have high fat content and thus have more energy value). Reduced availability of Chinook Salmon would likely increase predation activity on other species (and energy expenditures) and/or reduce energy intake.

Numerous studies have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) leading to reduced body size and condition and lower reproductive and survival rates for adults (e.g., Daan et al., 1996; Gamel et al., 2005) and juveniles (e.g., Trites and Donnelly, 2003; Noren et al., 2009). In the absence of sufficient food supply, adult females may not successfully become pregnant or give birth (Wasser et al., 2017) and juveniles may grow more slowly or die shortly after birth if the mother is unable to obtain the two to four times more food required to support lactation than what is required during pregnancy or after weaning. Any individual may lose vitality, succumb to disease or other factors as a result of decreased fitness, and subsequently die or not contribute effectively to future productivity of offspring necessary to avoid extinction and promote recovery of a population. Ultimately, the effect of reduced prey for SRKWs could lead to behavior changes and nutritional stress that could negatively affect the animal's growth, health, reproductive success, and/or ability to survive.

7.2.2 Project Operations Related Impacts of Reduced Prey Base for Southern Resident Killer Whales

Based on the analyses of expected effects of the Proposed Action to Chinook Salmon populations in the Klamath River, qualitative expectations can be established relative to other scenarios. The Proposed Action produces flushing flows almost every year, which should minimize juvenile salmon loss to *C. shasta*. Regulating spring flows is likely to make more habitat available to juveniles than the MS scenario. Maintaining adequate flows in the summer in most years to protect returning adults from high temperatures and pathogen exposure also means the Proposed Action is likely to perform better than the MS scenario.

Based on the analyses of expected effects of the Proposed Action to Klamath River Chinook Salmon, the impacts due to the operational effects of the Proposed Action on SRKWs cannot be precisely quantified. While on average, the Proposed Action is likely to be better for salmon than the MS scenario in terms of disease and temperature, the Proposed Action will result in habitat availability for spawner/egg, fry and parr life stages less than 80% of maximum WUA for 40-80% of days. This would likely reduce the number of adult Chinook Salmon available as prey for SRKWs in the Action Area especially after drier water years when potential stress on juvenile Chinook Salmon broods and their survival on the way to the ocean would be highest. Based on the general relative analyses that have been described above, all members of K and L pod may be affected by reduced fitness due to decreased Chinook Salmon abundance in the ocean resulting from the Proposed Action. Further, they may abandon the Pacific Coast and return to the Salish Sea briefly (see Shields et al., 2018) where they would compete with J Pod for prey there, resulting in potential harm to J Pod as well.

7.2.3 Overall Effects of Decreased Prey Base for Southern Resident Killer Whales as a Result of the Proposed Action

Based on the analysis above, the Proposed Action may decrease the amount of Klamath River fall-run Chinook Salmon available in the ocean for SRKWs to forage. The result of decreased ocean abundance of Klamath River Chinook Salmon over this period is that SRKWs, especially the K and L pod whales in the Action Area, may spend more time foraging. This would increase energy expenditures and increase the potential for nutritional stress, which could negatively affect the animal's growth, body condition, and health. It should be emphasized that the Proposed Action is expected to result in greater Chinook Salmon abundance than the MS scenario, so the reverse consequences would be expected under the MS scenario.

As described in Section 7.1, Chinook Salmon from the Klamath River are expected to constitute a portion of the diet of SRKWs in coastal waters within the Action Area where they overlap. SRKWs are expected to detect and respond to increased Klamath River Chinook Salmon abundance and an enhanced prey field during foraging. This will likely result in SRKWs spending less time searching for other Chinook Salmon and more abundant prey fields, either within the Action Area and/or other parts of their range. While Chinook Salmon are expected to be the preferred prey with high nutritional value, SRKWs are capable of taking advantage of other prey sources to supplement their nutritional needs and are known to do so in the immediate absence of sufficient Chinook Salmon resources. Any nutritional and energetic stress impacts prevented by the Proposed Action are most likely to occur in the more southerly range of SRKWs. Based on research and the known distribution of SRKWs described in Section 7.1, Reclamation concludes that while SRKWs are known to have used the southerly end of their range during all recent years, it is also likely that this population may limit or avoid use of this area altogether during some years.

Ford and Ellis (2006) report that SRKWs engage in prey sharing about 76% of the time during foraging activities. Prey sharing presumably would distribute more evenly any 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). While the overall absolute impact of the Proposed Action on the survival and abundance of Klamath River Chinook Salmon is not quantified, parts of the Proposed Action offer benefits in terms of reducing the potential impacts of disease that are expected to improve survival, especially for the Chinook populations most impacted by Project operations. Additionally, the benefits of reducing the potential impacts of disease that lead to improved survival is anticipated to be accrued during drier water years when the potential for the diminished survival of juvenile Chinook Salmon in the Klamath River would be expected to occur as described above. Based on the S3 model results, Reclamation concludes that Chinook Salmon habitat volume will likely increase for the mainstem Klamath River over the period of effects of the Proposed Action relative to the MS scenario but will still fall below 80% of maximum available habitat thresholds a substantial amount of the time. Based on: 1) conditions for Klamath River Chinook Salmon below the 80% habitat availability threshold; 2) the ability of SRKWs to take action to search out other areas with more abundant Chinook Salmon prey fields or take advantage of other prey sources to supplement their nutritional needs in the immediate absence of sufficient Chinook Salmon resources; 3) the variable contribution of Klamath Chinook to the available prey within the Action Area; 4) total abundance of Chinook available in the ocean for SRKWs across their range on an annual basis; and 5) the likelihood that SRKWs may avoid the southern end of their range, where Klamath Chinook can be an important food source, in some years, Reclamation concludes that the proposed action may adversely affect Chinook salmon prey availability which may adversely affect SRKWs. However, it is worth noting a previous population viability analysis (Reclamation, 2020a) indicates that random fluctuations in riparian and ocean conditions are more important in determining long-term population size than small but sustained differences in conditions. (NMFS, 2008, 2012).

7.3 Critical Habitat Effect Determination

The Project may affect but is not likely to adversely affect the prey species component of SRKW critical habitat. The Project’s effects on prey species, specifically Chinook Salmon is discussed in detail in Section 7.2 above.

8 Other Species

This chapter discusses the effects of implementing the Proposed Action on the southern DPS of North American Green Sturgeon, southern DPS of Pacific Eulachon, Bull Trout, Oregon Spotted Frog, Applegate's Milkvetch, Northwestern Pond Turtles, and Monarch Butterflies (*Danaus Plexippus*). Inclusion of proposed and candidate species, Northwestern Pond Turtle and Monarch Butterfly, in Reclamation's analysis here is relative to anticipated effects and final determination on species listing during the expected timeframe of this consultation (i.e., through fall of 2029). Reclamation seeks a conference with USFWS on these species.

8.1 Southern Distinct Population Segment Green Sturgeon

Green Sturgeon are members of the class of bony fishes, and the skeleton is composed mostly of cartilage. Sturgeon lack scales; however, they have five rows of characteristic bony plates on their body called scutes. The Green Sturgeon backbone curves upward into the caudal fin, forming their shark-like tail. On the ventral, or underside, of their flattened snouts are sensory barbels and a siphon-shaped, protrusible, toothless mouth. Recent genetic information suggests that Green Sturgeon in North America are taxonomically distinct from morphologically similar forms in Asia.

8.1.1 Legal Status

NMFS published a final rule listing the southern DPS Green Sturgeon as threatened (FR 71(67):17757–17766). NMFS (2018a) defined two DPSs for Green Sturgeon—a southern DPS that spawns in the Sacramento River and a northern DPS with spawning populations in the Klamath and Rogue rivers. The southern DPS includes all Green Sturgeon spawning populations south of the Eel River in California, of which only the Sacramento River currently contains a spawning population. NMFS (2018a) has declared the northern DPS a Species of Concern.

NMFS designated critical habitat for the southern DPS Green Sturgeon in 2009 (FR 74 52300). NMFS, in its critical habitat listing, designated the following specific primary constituent elements that are essential for the conservation of the southern DPS Green Sturgeon in freshwater river systems:

- Food resources: abundant prey items for larval, juvenile, sub-adult, and adult life stages.
- Substrate: substrates suitable for egg deposition and development, larval development, and sub-adults and adults. Spawning is believed to occur over substrates ranging from clean sand to bedrock, with preferences for cobble (Moyle et al., 1995).
- Water: a flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate of change of freshwater discharge over time) necessary for normal behavior, growth, and survival of all life stages.

- Water quality: suitable water quality for normal behavior, growth, and viability of life stages, including temperature, salinity, oxygen content, and other chemical characteristics.

8.1.2 Life History

Green Sturgeon are believed to spend the majority of their lives in nearshore oceanic waters, bays, and estuaries. Early life-history stages reside in freshwater, with adults returning to freshwater to spawn when they are more than 15 years of age and more than 4 ft (1.3 m) in size. Spawning is believed to occur every 2 to 5 years (Moyle, 2002). Adults typically migrate into freshwater beginning in late February; spawning occurs from March to July, with peak activity from April to June (Moyle et al., 1995). Females produce 60,000 to 140,000 eggs (Moyle et al., 1992). Juvenile Green Sturgeon individuals may enter the ocean and transition to the subadult life stage in their first year, but typical length of fish encountered in the ocean suggests ocean entry occurs at a later age (NMFS, 2018a). After their out-migration from freshwater, they disperse widely in the ocean (Moyle et al., 1992).

8.1.2.1 Spawning

The southern DPS Green Sturgeon typically spawn every 3 to 4 years (range 2 to 6 years) (NMFS, 2018a). Their spawning period is March to July, with a peak in mid-April to mid-June (Moyle et al., 1992). Preferred spawning areas are associated with deep pools in large, turbulent river mainstems (Moyle et al., 1992). Spawning habitat preferences are likely large cobble substrates but may range from clean sand to bedrock substrates. Green Sturgeon broadcast their eggs over the large cobble substrates where they settle into the interstitial spaces between cobbles. Green Sturgeon females produce 60,000 to 140,000 eggs (Moyle et al., 1992). NMFS (2018a) notes “the upper lethal temperature for developing embryos is 22-23°C, with sub-lethal effects occurring at 17.5 to 22.2°C.”

The southern DPS Green Sturgeon spawns in the Sacramento River Basin. The northern DPS Green Sturgeon spawns in the Rogue River in southern Oregon and the Klamath River in northern California (NMFS, 2018a). The Klamath Basin is thought to support the largest Green Sturgeon spawning population (Moyle et al., 1992). In the Klamath River, sturgeon courtship behaviors such as breaching have been observed in “The Sturgeon Hole” upstream of Orleans, CA (rkm 96). Larvae and juveniles have been caught in the Karuk Tribe’s Big Bar trap (rkm 80) on the Klamath and in the Willow Creek trap (rkm 40) on the Trinity River. In the Sacramento River, according to NMFS (2018a), southern DPS Green Sturgeon spawn in late spring and early summer from the Glenn Colusa Irrigation District area (rkm 332.5) to Cow Creek (rkm 451) based on adult distribution, with egg mat sampling confirming spawning between the Glenn Colusa Irrigation District area and Inks Creek (rkm 426).

8.1.2.2 Early Life History

Green Sturgeon larvae first feed at 10 days post-hatch, and metamorphosis to the juvenile stage is complete at 45 days. Larvae grow fast, reaching a length of 66 mm and a weight of 1.8 g in 3 weeks of exogenous feeding (Muir et al., 2000). Juveniles averaged 29 mm at the peak of occurrence in June/July at the Red Bluff Diversion Dam (California) fish trap and 36 mm at their peak abundance in July at the Glenn-Colusa Irrigation District trap (NMFS, 2005). These growth rates are consistent with rapid juvenile growth to 300 mm in 1 year and to over 600 mm within 2 to 3 years in the Klamath River (Nakamoto et al., 1995). Juvenile Green Sturgeon in the Klamath River appear to spend 1 to 3 years in freshwater before they enter the ocean (Nakamoto et al., 1995).

Green Sturgeon disperse widely in the ocean after out-migrating from fresh water (Moyle et al., 1992). The pattern of a northern migration is supported by the large concentration of Green Sturgeon in the Columbia River estuary, Willapa Bay, and Grays Harbor, which peaks in August. Genetic evidence suggests that Columbia River Green Sturgeon stocks are a mixture of fish from at least the Sacramento, Klamath, and Rogue rivers (Israel et al., 2004) although more recent evidence suggests at least sporadic spawning success in the Columbia River (Schreier and Stevens, 2020).

8.1.2.3 Age and Growth

Green Sturgeon are long-lived and slow-growing, similar to other sturgeon species (Nakamoto et al., 1995; Farr et al., 2002). Size-at-age is consistently smaller for fish from the Klamath River (Nakamoto et al., 1995) in comparison to fish from Oregon until around age 25, but thereafter the pattern is reversed. This could be the result of actual differences in growth or in ageing techniques. The asymptotic length for Klamath fish of 218 cm is close to the maximum observed size of 230 cm reported by Moyle et al. (1992) and substantially larger than other sturgeon species captured in Oregon (females 182 cm, males 168 cm).

8.1.2.4 Feeding

Little is known about Green Sturgeon feeding in the Klamath River as most feeding studies have occurred in other watersheds. Adults in the Sacramento-San Joaquin Delta feed on benthic invertebrates including shrimp, mollusks, amphipods, and even small fish (Moyle et al., 1992). Juveniles in the Sacramento River Delta feed on Opossum Shrimp (*Neomysis mercedis*) and Corophium amphipods (Radtke, 1966). Adams et al. (2002) reported Opisthobranch Mollusks (*Philline* sp.) were the most common prey for one 100 cm Green Sturgeon from the Sacramento-San Joaquin estuary.

8.1.3 Distribution

Green Sturgeon use riverine, estuarine, and marine habitats along the west coast of North America, spending substantial portions of their lives in marine waters (NMFS, 2018a). Southern DPS Green Sturgeon populations are known to congregate in coastal waters and estuaries, including non-natal estuaries, such as the Rogue River. Bemis and Kynard (1997) suggested that Green Sturgeon move into estuaries of non-natal rivers to feed. Information from fisheries-dependent sampling suggests that Green Sturgeon only occupy large estuaries during the summer and early fall in the northwestern United States.

Green Sturgeon are known to enter estuaries along the Washington coast during summer (Moser and Lindley, 2007). Commercial catches peak in October in the Columbia River estuary, and records from other estuarine fisheries (Willapa Bay and Grays Harbor, Washington) support the idea that sturgeon are only present in these estuaries from June until October (Moser and

Lindley, 2007). This information suggests that southern DPS Green Sturgeon are likely to use the Klamath River estuary only during the summer and fall months. Given that the majority of the southern DPS Green Sturgeon spend most of their life in the ocean and individuals frequent various estuaries along the West Coast during the summer and fall, only a small proportion of the southern DPS Green Sturgeon are expected to be present in the Klamath River estuary in any given year.

San Francisco Bay and its associated river systems contain the southernmost spawning population of Green Sturgeon. White Sturgeon (*Acipenser transmontanus*) supports a large fishery in this area, particularly in San Pablo Bay, which has been extensively studied by CDFW since the 1940s. While Green Sturgeon are not common in San Pablo Bay, they are collected incidentally in trammel net monitoring during most years in numbers ranging from 5 to 110 fish. Green Sturgeon juveniles are found throughout the Sacramento River Delta and San Francisco Bay.

The Columbia River has supported a large White Sturgeon fishery for many years in which Green Sturgeon are taken as bycatch. In the mid-1930s before Bonneville Dam was constructed, Green Sturgeon were found as far upstream as the Cascade Rapids. Green Sturgeon are presently found as far upstream as Bonneville Dam (rkm 235) but are predominately found in the lower 60 rkm. Willapa Bay, along with the Columbia River and Grays Harbor, is one of the estuaries where Green Sturgeon populations concentrate in summer. Generally, Green Sturgeon are more abundant than White Sturgeon in Willapa Bay (Emmett et al., 1991).

Grays Harbor in Washington is the northernmost estuary where Green Sturgeon populations concentrate in the summer months. NMFS (2018a) notes that adult and subadult southern DPS Green Sturgeon occur in relatively large concentrations from late spring to autumn within coastal bays and estuaries including the Columbia River estuary, Willapa Bay, Grays Harbor, and the Umpqua River estuary, with peaks in abundance in summer and autumn.

8.1.4 Species Current Condition

Population size and trends for Southern DPS Green Sturgeon have been estimated by comparing the relative size of the Sacramento-San Joaquin Green Sturgeon population (Southern DPS) with the Klamath River population (Northern DPS) (Beamesderfer et al., 2004). The Klamath River population (Northern DPS) is thought to be the largest spawning population of Green Sturgeon (Adams et al., 2007).

Based on Dual Frequency Identification Sonar surveys in the Sacramento River, which began in 2010, combined with a conceptual demographic structure applied to that adult population, NMFS (2018a) estimated a southern DPS Green Sturgeon subadult population estimate of 11,055 individuals and juvenile population estimate of 4,387 (95% CI = 2,595-6,179) (Mora et al., 2018).

8.1.5 Effects to Green Sturgeon

Due to the tributary accretions that contribute to flows in the lower Klamath River, it is difficult to wholly discern flow contributions from the upper basin (above IGD) during moderate to low flow periods. WOA, hydrological conditions in the lower Klamath River are likely to result in relatively high flows in the late winter and spring months and relatively low flows in the summer and fall months. Project operations under the Proposed Action, depending on hydrological conditions in a given year, may reduce the cumulative flow in the lower Klamath River during spring and summer when southern DPS Green Sturgeon are known to occupy the Klamath River estuary as compared to flows WOA. Variation in flows to the estuary resulting from the Proposed Action will not inhibit marine migration of southern DPS Green Sturgeon to the Klamath River estuary zone. Project operations are not expected to alter, reduce, or change the availability of food resources or meaningfully modify water temperature in the estuary zone during the summer months when Green Sturgeon can be expected to be in the estuary. Due to the relatively small contribution of upper basin to the overall flow in the lower Klamath River, no impacts to southern DPS Green Sturgeon are expected to be meaningfully measured, detected, or evaluated. Reclamation concludes that the Proposed Action may affect but is not likely to adversely affect the southern DPS Green Sturgeon.

8.2 Southern Distinct Population Segment Pacific Eulachon

Eulachon (commonly called smelt, candlefish, or hooligan) are a small, anadromous fish from the eastern Pacific Ocean that are a short-lived, highly fecund forage fish that tend to have extremely large population sizes. NMFS (2017) describes Eulachon as a slender-bodied fish with an average weight of 40 g and typically reaching 150 to 200 mm standard length, with compressed, elongated bodies and large mouths, the maxilla usually extending just past the middle of the eye. The opercula possess strong concentric striations and the pectoral fins, when pressed against the body, reach about two-thirds of the way to the bases of the pelvic fins. The jaws have small, pointed teeth which may be missing from spawning fish, especially males. The lining of the gut cavity is pale with dark speckles. Live fish are dark brown to dark blue on the back and head with a silvery white belly and unmarked fins. Spawning males develop a distinct mid-lateral ridge and numerous distinct tubercles on the head, body, and fins. Females may also have tubercles, but they are poorly developed. Eulachon feed on plankton only while at sea.

8.2.1 Legal Status

NMFS listed the southern DPS Pacific Eulachon as threatened under the ESA on March 18, 2010 (75 FR 13012). This DPS encompasses all populations within the states of Washington, Oregon, and California and extends from the Skeena River in British Columbia (inclusive) south to the Mad River in Northern California (inclusive). The DPS is divided into four sub-areas: Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers south of the Nass River.

NMFS designated approximately 539 km (335 miles) of freshwater creeks and rivers and their associated estuarine habitat in California, Oregon, and Washington within the geographical area occupied by the southern DPS Pacific Eulachon as critical habitat (76 FR 65324). NMFS designated critical habitat for Eulachon based upon areas that contain one or more physical or biological features essential to the conservation of the species that may require special management considerations or protection. NMFS designated critical habitat for 10.7 miles of the Klamath River from the mouth upstream to the confluence with Omogar Creek (76 FR 65324).

8.2.2 Life History

Eulachon typically spend 3 to 5 years in salt water before returning to fresh water to spawn. Eulachon generally spawn in rivers that are rain and snowmelt-dominated systems that experience spring freshets. Spawning grounds are typically in the lower reaches of larger rivers (Hay and McCarter, 2000). Spawning typically occurs at night. Spawning occurs between 4°C to 10°C throughout the range of the species and is largely limited to river reaches that are tidally influenced (NMFS, 2017).

Spawning cues and entry into rivers appear to be related to water temperature and the occurrence of high tides (Smith and Saalfeld, 1955; Spangler, 2002; NMFS, 2017) in January, February, and March in the northern part of the DPS, and later in the spring in the southern parts of the DPS. Most Eulachon adults die after spawning. Eulachon broadcast their eggs, which are fertilized in the water column, sink, and adhere to the river bottom typically in areas of gravel and coarse sand. It has been argued that because freshets rapidly move Eulachon eggs and larvae to estuaries, it is likely that Eulachon imprint and home to estuaries (Hay and McCarter, 2000). Eulachon eggs hatch in 20 to 40 days. Newly hatched young, transparent and 4 to 7 mm in length, are carried to the sea with the current (Hay and McCarter, 2000).

Juvenile Eulachon enter the ocean once they move from shallow nearshore areas to deeper areas over the continental shelf. Larvae and young juveniles become widely distributed in coastal waters, where they are typically found near the ocean bottom in waters 20- to 150-m deep (66 to 292 ft) (Hay and McCarter, 2000) and sometimes as deep as 182 m (597 ft) (Barraclough, 1964). There is currently little information available about Eulachon movements in nearshore marine areas and the open ocean. However, Eulachon occur as bycatch in the pink shrimp fishery (NMFS, 2017), which indicates that the distribution of these organisms overlaps in the ocean. Adult Pacific Eulachon have been recorded from several locations on the Washington and Oregon coasts and were previously common in Oregon’s Umpqua River and the Klamath River in northern California (Hay and McCarter, 2000; Willson et al., 2006; 75 FR 13012).

8.2.3 Species Current Condition

There are few direct estimates of abundance available for Eulachon, and there is an absence of monitoring programs in the United States. Most population data come from fishery catch and landing records, which, when combined with anecdotal information, indicate Eulachon historically were present in large annual runs and that significant declines in abundance have occurred (NMFS, 2017). Starting in 1994, the southern DPS of Eulachon experienced an abrupt decline in abundance throughout its range. Although Eulachon abundance in monitored rivers improved in the 2013 to 2015 return years, recent conditions in the northeast Pacific Ocean are likely linked to the sharp declines in Eulachon abundance in monitored rivers in 2016 and 2017. The likelihood that these poor ocean conditions will persist into the near future suggests that subpopulation declines may again be widespread in the upcoming return years (NMFS, 2017). The Columbia River, estimated to have historically represented half of the taxon’s abundance, experienced a sudden decline in its commercial Eulachon fishery landings in 1993 through 1994 (WDFW and ODFW, 2001; JCRMS, 2007). Similar declines in abundance have occurred in the Fraser River and other coastal British Columbia rivers (Hay and McCarter, 2000; Moody, 2008). In the Klamath River, Eulachon abundance has likely decreased below the minimum viable population size (75 FR 13012); NMFS (2017) has provided Yurok tribal fisheries seine/dip net survey data over a 4-year period showing a large variation, from seven Eulachon in 2011 to 1,000 in 2014.

There has been no long-term monitoring program targeting Eulachon in California, making estimates of historical abundance and abundance trends difficult to generate (Gustafson et al., 2008).

8.2.4 Effects to Pacific Eulachon

The southern DPS Pacific Eulachon are only known to occupy the Action Area in the lower Klamath River during the winter and spring for spawning, incubation, and early rearing. Under WOA, hydrological conditions in the lower Klamath River are likely to result in relatively high flows in the late winter and spring months and relatively low flows in the summer and fall months. Project operations under the Proposed Action, depending on hydrological conditions in a given year, reduce the cumulative flow in the lower Klamath River from late winter through spring in comparison to WOA hydrology. Thus, the Proposed Action could affect southern DPS Pacific Eulachon populations by impacting essential habitat features for spawning, incubation, and migration. Eulachon are documented to spawn in the lower Klamath River reach in association with spring freshets and rearing does occur in the estuarine and nearshore areas at the mouth of the Klamath River. Project operations, depending on hydrological conditions in a given year, could reduce the rate of flow in the Klamath River during times when southern DPS Pacific Eulachon are present. However, because the winter/springtime flows in the lower 10.7 miles of the Klamath River are largely driven by tributary accretions below IGD, Project operations and resultant effects to flow in the lower Klamath River are not expected to substantially alter habitat elements for the southern DPS Pacific Eulachon. Therefore, Reclamation concludes that the Proposed Action may affect, but is not likely to adversely affect the southern DPS Pacific Eulachon.

Critical habitat has been finalized in the lower Klamath River for the southern DPS Pacific Eulachon. Flows as a result of implementing the Proposed Action, when compared to WOA, may alter the physical or biological features for migration and spawning in the lower Klamath River that have been designated for the southern DPS Pacific Eulachon. However, due to the relatively small contribution of upper basin contributions to the overall flow in the lower Klamath River with either the Proposed Action or WOA, no impacts to southern DPS Pacific Eulachon are expected to be meaningfully measured, detected, or evaluated. Therefore, the Proposed Action may affect, but is not likely to adversely affect designated critical habitat of the southern DPS Pacific Eulachon.

8.3 Bull Trout

Bull Trout are members of the char sub-group (i.e., *Salvelinus*) of the family Salmonidae and are native to the western United States and western Canada. In the United States, Bull Trout are native to the Western United States and occurred historically throughout much of the Oregon portion of the Klamath Basin.

8.3.1 Legal Status

Bull Trout populations within the coterminous United States were listed under the ESA as threatened on November 1, 1999 (64 Fed. Reg. 58910). Critical habitat was designated for the Klamath River, Columbia River, Jarbidge River, Coastal-Puget Sound, and Saint Mary-Belly River populations of Bull Trout on September 26, 2005; revised Bull Trout October 18. 2010 (75 FR 63898).

The physical and biological features of Bull Trout critical habitat include: 1) springs, seeps, groundwater, and subsurface water connectivity; 2) migration habitats with minimal physical, biological, or water quality impediments; 3) abundant food base; 4) complex river, stream, lake, reservoir, and marine shoreline aquatic habitats; 5) water temperatures that range from 2°C to 15°C; 6) sufficient substrate amount and composition in spawning and rearing areas; 7) natural hydrograph; 8) sufficient water quality and quantity; and 9) sufficiently low levels of nonnative predatory, interbreeding, or competing species (75 FR 63898). The Klamath Recovery Unit Implementation Plan for Bull Trout identifies three core population areas in the Klamath Basin including the Upper Klamath Lake, Sycan River, and Upper Sprague River Core Areas.

8.3.2 Life History

Bull Trout adults typically range in size from an average of 200 to 305 mm for resident individuals, 405 to 610 mm in length for migratory river spawning individuals, and over 685 mm (27 inches) in length for adfluvial individuals (McPhail and Baxter, 1996).

Bull Trout exhibit four life history strategies: a non-migratory or resident form, a riverine or fluvial form, a lacustrine or adfluvial form, and a rare marine or amphidromous/anadromous form. Stream-resident Bull Trout complete their entire life cycle in the tributary streams where they spawn and rear. Most Bull Trout are migratory, spawning in tributary streams where juvenile fish usually rear from 1 to 4 years before migrating to either a larger river (fluvial) or lake (adfluvial), where they spend their adult life, returning to the tributary stream to spawn (Fraley and Shepard, 1989).

Bull Trout adults normally reach sexual maturity in 4 to 7 years and live as long as 12 years. Bull Trout typically spawn from August to November during periods of decreasing water temperatures. Spawning temperatures generally range from 4°C to 10°C (39°F to 51°F), with redds often constructed in stream reaches fed by springs or near other sources of cold groundwater (Pratt, 1992; Rieman and McIntyre, 1996). Bull Trout require spawning substrate consisting of loose, clean gravel relatively free of fine sediments (Fraley and Shepard, 1989). Egg incubation is normally 100 to 145 days (Pratt, 1992) and fry typically emerge from gravel early

April through May, depending upon water temperatures and increasing stream flows (Pratt, 1992; Ratliff and Howell, 1992).

Bull Trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre, 1993). Habitat components that influence Bull Trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard, 1989; Goetz, 1989; Hoelscher and Bjornn, 1989; Howell and Buchanan, 1992; Pratt, 1992; Rich, 1996; Rieman and McIntyre, 1993, 1995; Sedell and Everest, 1991; Watson and Hillman, 1997). Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for Bull Trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because Bull Trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre, 1996), Bull Trout should not be expected to simultaneously occupy all available habitats.

All life history stages of Bull Trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard, 1989; Goetz, 1989; Hoelscher and Bjornn, 1989; Pratt, 1992; Rich, 1996; Sedell and Everest, 1991; Sexauer and James, 1997; Thomas, 1992; Watson and Hillman, 1997). Maintaining Bull Trout habitat requires stable and complex stream channels and stable stream flows (Rieman and McIntyre, 1993). Juvenile and adult Bull Trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James, 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt Bull Trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard, 1989; Pratt, 1992; Pratt and Huston, 1993). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

Bull Trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. Fish growth depends on the quantity and quality of food that is eaten, and as fish grow their foraging strategy changes as their food changes in quantity, size, or other characteristics (Quinn, 2005). Resident and juvenile migratory Bull Trout prey on terrestrial and aquatic insects, macro-zooplankton, and small fish (Boag, 1987; Donald and Alger, 1993; Goetz, 1989). Subadult and adult migratory Bull Trout generally feed on various fish species (Donald and Alger, 1993; Fraley and Shepard, 1989; Leathe and Graham, 1982). Bull Trout are considered voracious nocturnal predators of Steelhead, redband, and Chinook Salmon eggs, fry, and juveniles (Lowery and Beauchamp, 2015; Thurow et al., 2020). Bull Trout of all sizes other than fry have been found to eat fish half their length (Beauchamp and VanTassell, 2001). In nearshore marine areas of western Washington, Bull Trout feed on Pacific Herring (*Clupea pallasi*), Pacific Sand Lance (*Ammodytes hexapterus*), and Surf Smelt (*Hypomesus pretiosus*) (Goetz et al., 2004; WDFW et al., 1997).

8.3.3 Species Current Conditions

8.3.3.1 Conditions Before Lower Klamath Dam Removal

Bull Trout in the Klamath Recovery Unit currently occur only as resident forms isolated and separated by long distances in higher elevation headwater streams within three core areas: 1) Sycan River core comprising Sycan Marsh, Sycan River, and their tributaries; 2) Upper Sprague River core comprising the North Fork and South Fork of the Sprague River upstream of their confluences, inclusive of Deming, Boulder, Dixon, Brownsworth, and Leonard creeks; and 3) UKL core comprising the northern portion of the lake and its immediate major and minor tributaries (USFWS, 2015). The Bootleg fire of 2021 is believed to have extirpated Bull Trout from Deming, Boulder, Dixon, Brownsworth, and Leonard (USFWS, 2021). Factors contributing to reduced distribution within this recovery unit are habitat degradation and fragmentation, past and present land use practices, water diversions, and past fisheries management practices (USFWS, 2015).

8.3.3.2 Anticipated Conditions Following Lower Klamath Dam Removal

The removal of the four dams in the lower Klamath River will create a new baseline within the Action Area that includes access to the Upper Klamath Basin for anadromous salmonids, specifically Chinook Salmon and Steelhead. Effects and stressors for Bull Trout under this new baseline include: 1) disease and pathogens from re-introduced Chinook Salmon and Steelhead; 2) competition with re-introduced Chinook Salmon and Steelhead for food; 3) competition with re-introduced Chinook Salmon and Steelhead for habitat; and 4) predation by Steelhead on various life stages of Bull Trout. Insignificant effects are expected from resource competition and diseases and pathogens. Predation may result in adverse effects to Bull Trout individuals over the long-term. Chinook Salmon and Steelhead are expected to provide beneficial effects over the short and long term from additional marine-derived nutrients and increased Bull Trout prey resources. Overall, the reintroduction of anadromous species associated with dam removal is anticipated to support Bull Trout recovery by increasing the prey base and providing marine-derived nutrients (Renewal Corporation, 2021; USFWS, 2015).

There is considerable uncertainty over how long it will take for anadromous salmonids to reach the areas where Bull Trout reside. After removal of the Elwha Dam, it took approximately 31 months for Chinook Salmon, Coho Salmon, Steelhead, Pacific Lamprey, and other anadromous species to move upstream and access portions of their historical reaches (Duda et al., 2021). The USFWS has stated they expect it will take longer than this for anadromous salmonids to reach the Upper Klamath Basin because of the further migration distances, number of potential barriers, poorer water quality, and increased water temperatures (USFWS, 2021).

Disease Section 2.4.3.3 discusses the presence and potential for multiple diseases and pathogens to affect multiple fish species. A common salmonid parasite, *Ceratonova shasta* (formerly *Ceratomyxa shasta*), is a significant source of salmonid mortality in the lower Klamath Basin (Stocking et al., 2011). However, the geographic distribution of C. *shasta* in the Klamath Basin already includes the headwaters of the Klamath River and is known to infect native

Klamath redband trout (*Oncorhynchus mykiss newberri*) (Stocking et al., 2011; Atkinson and Bartholomew, 2010).

Redband trout are known to exist in sympatry with Bull Trout in the Klamath Basin, and Bull Trout have likely been exposed to *C. shasta*. Based on the presence of the same diseases and pathogens upstream and downstream of IGD, and the evolution of Bull Trout in the presence of these pathogens, the potential for recolonizing Chinook Salmon and Steelhead to facilitate the reintroduction of new or unknown diseases and pathogens to Bull Trout is not meaningfully measurable or detectable and is therefore insignificant.

Competition for Food The recolonization by Chinook Salmon and Steelhead will increase the prey base for Bull Trout through salmon eggs, fry, juveniles, and carcasses. Another effect will be increased productivity from marine-derived nutrients (Section 8.3.4). These nutrients will lead to a greater abundance and richness of insects and aquatic macroinvertebrates (Cederholm et al., 1999) that also serve as food for Bull Trout. These effects will be beneficial to Bull Trout physical and biological feature 3 – Abundant Food Base.

Adult Chinook Salmon and Steelhead do not feed during their spawning migrations, and there will be no competition with Bull Trout for food resources during migration. Adult steelhead are known to resume feeding after their upstream migration, however, and there may be competition for food resources amongst juvenile Bull Trout and Steelhead. In most streams, juvenile Bull Trout generally do not occupy the same microhabitat as Chinook Salmon (Pearsons and Temple, 2007). Furthermore, the diets of juvenile Bull Trout and Chinook Salmon are not likely to overlap (Duda et al., 2011). Steelhead fry are associated with a benthic feeding strategy however, similar to Bull Trout (Johnson, 2007).

While Steelhead and Bull Trout rely on similar habitats to rear and feed, they primarily do so at different times of the day. Steelhead are sight feeders and therefore most active during daylight hours whereas Bull Trout are primarily nocturnal (Thurow et al., 2020). Because food resources are expected to be abundant for Bull Trout, Steelhead, and Chinook Salmon, any effects from competition for food resources are considered discountable.

Chinook Salmon migrate upstream in the spring and spawn in the fall like Bull Trout. However, Bull Trout spawn in colder headwater locations than Chinook Salmon and are known to use stream gradients greater than 4%, whereas Chinook Salmon prefer gradients less than 4% (Davies et al., 2007) and spawn in larger, deeper streams. Steelhead do not spawn at the same time as Bull Trout and therefore do not pose a risk of competition for available spawning grounds. Bull Trout juveniles also typically rear in colder streams compared to Chinook Salmon or Steelhead. Therefore, any effects from competition for spawning and rearing habitat between Bull Trout, Chinook Salmon, or Steelhead are expected to be insignificant and discountable.

Competition for Habitat If sub-adult and adult Bull Trout and anadromous salmonids do spatially overlap, it would most likely occur in habitats used by Bull Trout for feeding, migration, and overwintering, rather than spawning or rearing. Interspecific competition for space may occur between fall-run Chinook Salmon and Bull Trout fry (juveniles). This effect is likely discountable, as Bull Trout fry are cryptic, nocturnal, and associated with the interstitial (in-between) spaces of gravel and cobble more than other salmonids (Rieman and McIntyre, 1993; Goetz, 2006; Thurow et al., 2020). Bull Trout fry also stay in, or close to, the redd until they reach the juvenile stage. As described above, spawning habitats between fall-run Chinook Salmon and Bull Trout are not likely to overlap, and there will be no overlap between spawning Steelhead and Bull Trout fry, thereby limiting competitive interactions for space at the fry stage.

The spatial preference of both the fry and adult populations of Chinook Salmon and Bull Trout is such that the two species' foraging and spawning habitat should not substantially overlap. In addition, the microhabitat separation and different spawning timeframes would cause insignificant competition for space between Steelhead and Bull Trout.

Predation Juvenile Chinook Salmon begin to move downstream at small sizes (<150 mm) and appear to feed exclusively on aquatic and terrestrial insects (Healy, 1991). Therefore, if predation on Bull Trout eggs or fry were to occur, it would be from juvenile Steelhead. Adult Steelhead spawn in the spring and fry emerge from the substrate later that same year, after Bull Trout fry have emerged. As discussed above, Steelhead spawn in slightly different stream gradients than Bull Trout and feed during the day. Upon emergence, Steelhead fry are also too small to feed on small Bull Trout that emerged earlier in the year (i.e., they are gape-limited, or have too small a mouth).

Juvenile Steelhead can spend 1 to 3 years in freshwater prior to outmigrating to the ocean. Juvenile Steelhead distribute themselves widely, and many migrate into mainstem rivers as they rear and mature (NRC, 2004). This behavior limits the spatial overlap and potential for predation by Steelhead juveniles on small Bull Trout (NRC, 2004). However, 1 to 3-year-old juvenile Steelhead are likely to eat Bull Trout eggs and fry (subyearlings) to some degree. Bull Trout's coloration and cryptic behavior also make them difficult to detect, and they use areas with complex instream cover and coarse substrate (Pratt, 1984; Thurow and Schill, 1996; Thurow, 1997).

The magnitude of Steelhead predation on Bull Trout eggs and fry is difficult to estimate given their unknown future overlap in the Upper Klamath Basin. There is no available literature or local information regarding predation rates of juvenile Steelhead on Bull Trout sub-juveniles. However, an analysis of juvenile Steelhead predation on Chinook Salmon suggests approximately 0.6% of total subyearling Chinook Salmon were eaten (Sharpe et al., 2008). While Bull Trout were not among the species investigated in this study, the predation rate is likely an accurate description of will occur in areas where juvenile Steelhead overlap in Bull Trout spawning habitat. The uncertainty about the future extent of overlap and the lack of Bull Trout consideration in the predation study suggests that, while significant predation is highly unlikely, it is not entirely discountable.

Potential Beneficial Effects of Lower Klamath Dam Removal Beneficial effects for Bull Trout will primarily be the re-introduction of marine-derived nutrients that will increase food availability to juvenile and adult Bull Trout from Chinook Salmon and Steelhead eggs, fry, juvenile and adult spawner carcass flesh re-introduced to the Upper Klamath Basin. The Upper

Klamath watershed historically supported anadromous fish species, and it is believed the range of anadromy will be similar to the historical range (Fortune et al., 1966; Lane and Lane Associates, 1981; Nehlsen et al., 1991; Moyle, 2002; Hamilton et al., 2005).

The enrichment of the freshwater ecosystem from the input of salmon carcasses may have far reaching benefits throughout the food web by increasing primary productivity (Wipfli et al., 2003) and aquatic invertebrate biomass, thereby increasing the prey base for Bull Trout and other native fish. The primary benefit for Bull Trout will be increased food availability to juveniles and adults in the form of carcass flesh, eggs, fry, and juveniles of salmon and Steelhead reoccupying their historical habitats in the Upper Klamath Basin. Therefore, the indirect effect of restoring marine-derived nutrients into Bull Trout occupied streams is expected to be beneficial.

8.3.4 Effects to Bull Trout

The Proposed Action will result in both adverse and beneficial effects to Bull Trout in the Upper Klamath Basin. The Proposed Action, which includes the storage of water in UKL, will create seasonal fluctuations of lake surface elevation (and water depth) in UKL and Agency Lake. Agency Lake is identified as a foraging, migration, and overwintering habitat type for Bull Trout. For much of the year, occupancy of Bull Trout in Agency Lake is likely limited by water temperature or water quality. However, Bull Trout may migrate through this habitat during winter months. Reclamation anticipates the seasonal lake level fluctuations will have no effect on Bull Trout that may use Agency Lake as a migration corridor.

With WOA, lake surface elevations in UKL and Agency Lake are expected to be relatively low year-round, seasonally fluctuating from about 4,136 ft during late summer into winter and less than 4,142 ft during spring months. Reclamation anticipates that corresponding surface area and water depth will also fluctuate in a similar pattern. WOA results in low surface elevations of Agency Lake (the northern portion of UKL) from spring through winter resulting in limited habitat for Bull Trout to migrate or feed in this lake. The Proposed Action to store water in and divert water from UKL beneficially influences lake surface elevations in Agency Lake (northern portion of surface water considered part of UKL) and, to a lesser extent, the lowest reaches of tributaries to UKL and Agency Lake through maintaining surface elevations higher than the WOA scenario. These lake surface elevation changes are seasonal and temporary in nature and can be characterized as high elevations in late winter through early summer and low elevations in late summer through early winter. However, the Proposed Action has the beneficial result of higher surface elevations than the WOA scenario year-round.

Predation and competition on and with Steelhead, other salmonids, and Bull Trout is difficult to understand with the pending recolonization of anadromy in the Upper Klamath Basin. The impacts could be adverse and beneficial to Bull Trout individuals over the long term. Limited effects are expected from resource competition and diseases and pathogens. Reclamation concludes that the Proposed Action may affect but is not likely to adversely affect Bull Trout.

8.4 Oregon Spotted Frog

8.4.1 Legal Status

The Oregon Spotted Frog was listed as threatened under the Endangered Species Act in 2014 (79 FR 51658).

8.4.2 Life History

Historically, the Oregon Spotted Frog ranged from British Columbia to the Pit River drainage in northeastern California. Oregon Spotted Frog habitat in Oregon was historically found in Deschutes, Klamath, Lane, Wasco, and Jackson counties.

Oregon Spotted Frog is an aquatic frog that seldom strays from areas of standing water. Upland habitat is avoided by the Oregon Spotted Frog relative to wetland habitats. Oregon Spotted Frogs are generally found in slow-moving aquatic edge habitat along streams and marshes or beaver ponds. Oregon Spotted Frogs use shallow oviposition sites consistently across their range, with average depths per site ranging from 5.9 to 25.6 cm (Reclamation, 2018). This frog is often associated with submergent, floating, and low emergent vegetation, which it uses for basking sites and escape cover. Springs and spring-fed stream reaches are likely overwintering sites and may be a key habitat component.

During the breeding season (February through May), Oregon Spotted Frog prefer sedge-dominated and sedge/rush mix (*Carex* spp. and *Juncus* spp.) wetland vegetation for oviposition. During this season, Oregon Spotted Frog emerge from winter habitats and move into breeding areas of Hardhack (*Spiraea douglasii*) and sedge-dominated vegetation. Within wetlands, Oregon Spotted Frog select sedge and Hardhack-dominated vegetation and avoid dense stands of Reed Canarygrass (*Phalaris arundinacea*; cover greater than 50%) and areas of other grasses where closure is greater than 75% (Watson et al., 2003).

Oviposition sites tend to be above gently sloping substrates with herbaceous vegetation such as sedges, rushes, and grasses (McAllister and Leonard, 1997; Pearl and Hayes, 2004). Oviposition sites usually lack significant vertical vegetation comports and structures; however, taller vegetation (e.g., cattails, *Typha* spp.) can be nearby and used as cover.

Adults are thought to return to the same general breeding location across years, although actual locations of eggs shift within these regularly used areas based on water depth at the time of breeding. Eggs are generally laid in water less than 30 cm deep but can be laid in as little as 4 to 5 cm. However, it is not unusual for the tops of egg masses to be exposed above the water surface. Water-level fluctuations after oviposition can result in egg masses being stranded or inundated by deeper water (Pearl et al., 2010). In drought years, eggs laid on the margins of deeper, permanent waters may be the only source of population recruitment. Most Oregon Spotted Frogs avoid laying eggs in permanent waters, perhaps because eggs and hatching tadpoles are more vulnerable to predation at these locations, and water temperatures are colder compared to the temporary, shallow pools used in the floodplain wetlands (Watson et al., 2003).

After breeding, Oregon Spotted Frogs often redistribute themselves across a broader summer range. This summer range can include wetlands more than 0.3 km from the original breeding site (Watson et al., 2003; Pearl et al., 2010). Oregon Spotted Frogs inhabit relatively shallow water with cover from emergent or aquatic plants and will redistribute in response to changing water levels. During periods of prolonged and severe cold, they may become inactive, possibly burying themselves in silty substrates or clumps of emergent vegetation (McAllister and Leonard, 1997).

After relocating to summer habitat, adult Oregon Spotted Frogs often stay within a relatively small area until fall. In summer, adult Oregon Spotted Frogs bask and forage near moderate to dense vegetation; deeper pools or flocculant substrates are used by adults as retreats when disturbed (Watson et al., 2003). Summer is the season of maximum growth but also highest predation. Oregon Spotted Frog may balance basking and feeding opportunities against vulnerability of predators such as garter snakes (Pearl et al., 2010), herons, nonnative fish, and bullfrogs (McAllister and Leonard, 1997). The diet of Oregon Spotted Frogs at a site in British Columbia included slugs, snails, spiders, crickets, grasshoppers, dragonflies, damselflies, true bugs, beetles, butterflies, moths, bees, ants, and wasps (Pearl et al., 2010).

Oregon Spotted Frogs are generally inactive during the winter season, although some individuals may be observed at the water surface on warmer days (Hayes, 1994) and in lowland habitats that do not freeze. At higher elevations with harsher winters, Oregon Spotted Frogs appear to use nonfreezing aquatic environments such as springs, channels, beaver runs, and areas of deep water. Telemetry studies at montane sites in Washington and Oregon suggest that Oregon Spotted Frogs can be active under ice during portions of the winter (Pearl et al., 2010). In areas where snow and ice cover their habitat for months, Oregon Spotted Frogs are believed to retreat to springs where they spend the winter in a state of torpor in the highly oxygenated and ice-free water (McAllister and Leonard, 1997).

8.4.3 Species Current Conditions

Critical habitat for Oregon Spotted Frog was designated in 2016 and includes three occupied critical habitat units in the Klamath Basin (81 FR 29336). The Service has determined that the physical or biological features" (PBFs) for the Oregon spotted frog are: 1) non-breeding/breeding/rearing/overwintering habitat; 2) aquatic movement corridors; and 3) refugia habitat (81 FR 29336). The Williamson River unit (Unit 12) consists of the Williamson River (and a tributary, Jack Creek) and seasonally wetted areas along the river in Klamath Marsh NWR to the northeast of UKL. Upper Klamath Lake (Unit 13) includes the Wood River and its adjacent seasonally wetted areas from its headwaters downstream to the confluence with Agency Lake as well as the length of the Wood River Canal (81 FR 29336). The Upper Klamath unit (Unit 14) consists of lakes and creeks in Jackson and Klamath counties near Buck Lake, and Spencer Creek and Parsnip Lakes and seasonally wetted areas near Keene Creek (81 FR 29336). None of the three units are within the Klamath Project boundaries. Unit 13 could be impacted by Reclamation’s Proposed Action given its proximity to Agency Lake.

The UKL unit includes multiple areas in the Wood River and Sevenmile Creek areas north of UKL. The Wood River area is inclusive of the Wood River to the levee road near its confluence with Agency Lake and all of Fort Creek and Annie Creek downstream of the Annie Creek Sno-park to its confluence with the Wood River. This unit also includes portions of Sevenmile, Crane, and Fourmile creeks and associated wetted areas and springs that are located to the northwest of UKL (81 FR 29336).

The UKL unit has all the essential physical or biological features found within the unit but are impacted by invasive plants, woody vegetation plantings and succession, hydrological changes, and nonnative predators (81 FR 29336).

At the time of listing, the minimum population estimate for the Williamson River sub-basin, UKL sub-basin, and upper Klamath sub-basin were approximately 376 breeding individuals (male and female) based on 2011 and 2012 breeding data, approximately 374 based on 2011 breeding data and 112 breeding individuals based on an egg mass count, respectively (79 FR 51658). Jack Creek, within the Williamson River sub-basin, is the only area where breeding counts for Oregon Spotted Frog have been consistently conducted since the listing rule was published in 2014. Breeding counts since 2013 have ranged between 19 and 65 (USFWS, 2022). Surveys within the Klamath Marsh NWR between 2019 and 2021 suggest that breeding numbers at Klamath Marsh NWR have decreased (2019: 47 egg masses, 2020: 30 egg masses) and some of the historical sites have been dry in the past few years (USFWS, 2022). Recent breeding surveys from the four known Oregon Spotted Frog populations within the UKL sub-basin indicate that the minimum adult breeding population is higher than what was estimated for the listing (USFWS, 2022). Recent breeding surveys within the Upper Klamath sub-basin suggest a decline since listing with persistence at extremely low levels (Mean: 5, Range: 0 to 12; USFWS, 2022).

8.4.4 Effects to Oregon Spotted Frog

The Proposed Action, principally lake surface elevation fluctuation, is not anticipated to impact individual Oregon Spotted Frog populations that are north of UKL as populations in this area are at or behind levees (e.g., Wood River wetland area) that are higher than UKL surface elevations under the Proposed Action.

Implementation of the Proposed Action will result in a seasonal range of surface elevations in UKL, and the lowest portions of tributaries to UKL, such as the Williamson and Wood rivers, that can be generalized as relatively high-water surface elevations in late winter through early summer and low surface elevations from late summer through early winter. Both the Upper Klamath and the Williamson River critical habitat units, while in the Proposed Action area, are upstream from impacted areas relative to lake surface elevations in UKL or river flows in the Klamath River. The UKL critical habitat unit includes several tributaries to Agency Lake and includes an area along the Wood River adjacent to Agency Lake (i.e., UKL) that may be impacted during February through June by relatively high surface elevations in UKL and in the lower Wood River. The influence of UKL surface elevations could extend as far up the Wood River to the Bureau of Land Management south levee road but is expected to only reduce velocity of the Wood River in the area of the levee. The influence of lake surface elevations does not extend upstream to areas of Oregon Spotted Frog critical habitat on other tributaries to Agency Lake within the UKL critical habitat unit.

The Proposed Action may result in changes to Oregon Spotted Frog critical habitat nearest the south end of the Wood River wetland through reducing the Wood River currents and increasing river stage as water backs up due to high surface elevations in UKL and Agency Lake. These impacts, anticipated to occur in spring months, are small seasonal increases to habitat identified as primary constituent elements 1 and 2 for Oregon Spotted Frog (81 FR 29336). More specifically, increased river stage and slower currents could improve wetted movement corridors for Oregon Spotted Frog (primary constituent element 2) or increase the amount of seasonal non-breeding habitat if the river stage inundates adjacent depressions (primary constituent element 1). Reclamation concludes the Proposed Action will not destroy or adversely modify critical habitat in the Upper Klamath and Williamson River critical habitat units as these habitats are at elevations higher than the influence of the Proposed Action. The Proposed Action may have small benefits to critical habitat near the Wood River wetland as lake elevation management may increase the inundation of nearby areas.

Given the distribution of Oregon Spotted Frog populations at elevations higher than the water fluctuations anticipated under a WOA scenario or under the Proposed Action, Reclamation concludes the Proposed Action is not likely to adversely affect individual Oregon Spotted Frogs nor their critical habitat.

8.5 Applegate's Milkvetch

8.5.1 Legal Status

Applegate’s Milkvetch was federally listed as endangered without critical habitat in 1993 (58 FR 40547). The USFWS subsequently published a recovery plan for Applegate’s Milkvetch in 1998 (USFWS, 1998).

8.5.2 Life History

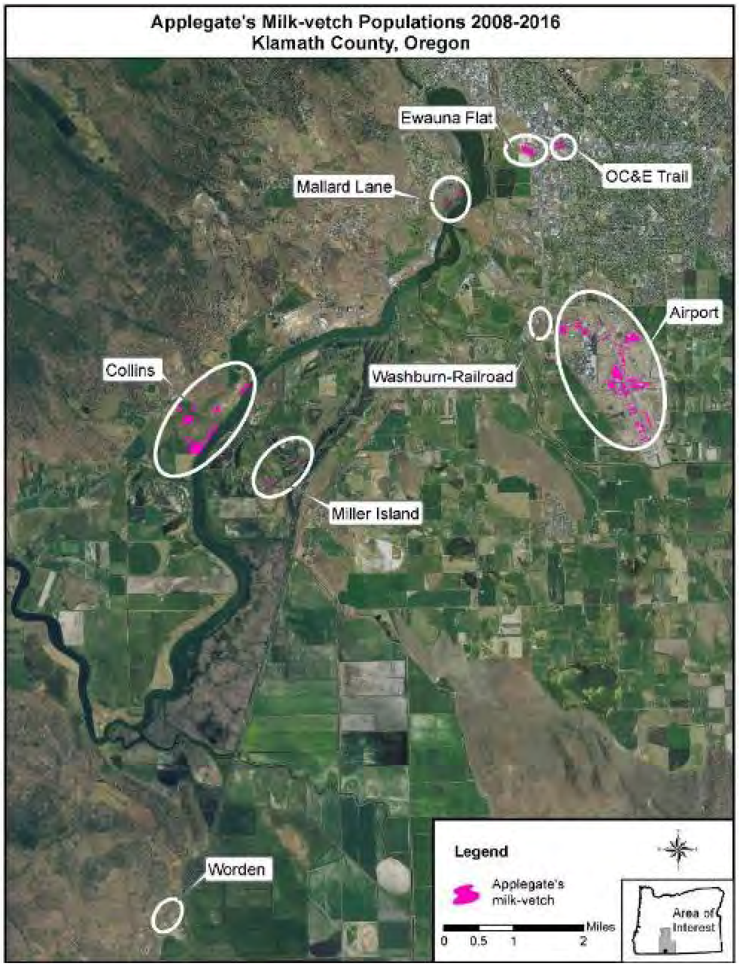
Applegate’s Milkvetch is a slender, low-growing, vine-like herbaceous perennial plant in the Fabaceae (pea) family. The plant’s physical appearance is characterized by multiple sprawling stems 12 to 36 inches long and small white to light pink to lavender pea-like flowers, measuring up to 7 mm (0.3 inch). The tip of the keel is faintly lilac tinged. Flowers are present from June to September. The anthers and stigma ripen simultaneously, enabling self-pollination. The leaves are typically 3.5 to 7 cm (1.4 to 2.8 inches) long with 7 to 11 leaflets, with stems 3 to 4 decimeters (12 to 16 inches) long. Plants produce 0.3- to 0.5-inch seed pods during June and July and are widely spreading or declined.

8.5.3 Current Conditions

Applegate’s Milkvetch is a narrowly distributed endemic plant known to occur only in southern Klamath County, Oregon, with currently eight occupied sites located within 13 miles of the city of Klamath Falls. Applegate’s Milkvetch was believed to be extinct up until its re-discovery in

1983. At the time of the Services listing decision, it was known from two extant sites and one historical site (USFWS, 2009). These extant sites were identified as Miller Island and Ewauna Flat Preserve, which supported an estimated 30 to 80 and 30,000 plants, respectively. The historical occurrence identified in the listing was the Keno site. Herbarium records indicate this site was last found in 1931 and was located approximately 2 miles east of the town of Keno, Oregon (USFWS, 2009).

Populations today are known to primarily colonize three large sites; however, presence has also been documented at several smaller sites south of Klamath Falls, Oregon. Sites where populations occur in highest numbers are OC&E Trail, Ewauna Flats Preserve, Collins Tract, and the Klamath Falls Airport (Figure 8-1). Based on habitat surveys, it is thought this species was historically more prevalent. Urban development, agriculture, weeds, fire suppression, flood control, and land reclamation have contributed to the decline of this species (USFWS, 2009).



Note: Source Spaur (2018)

Figure 8-1. Map of the area near Klamath Falls and the Keno Impoundment Oregon, showing both the known populations of Applegate's Milkvetch and locations of historic populations

Activities, characterized as routine maintenance activities such as weed control, roadbed improvement, and canal embankment would not be conducted WOA. WOA may prolong seasonal inundation of areas near known populations of Applegate’s Milkvetch, likely providing a slight benefit to the plant.

8.5.4 Effects to Applegate's Milkvetch

Each of the three sites of Applegate’s Milkvetch are within the Project boundaries. However, Reclamation does not anticipate effects to the sites or individual plants as a result of water storage and delivery within the Project. Routine O&M activities of the Proposed Action described in are also not expected to impact Applegate’s Milkvetch or habitats in the 13 sites where it is known to occur. Reclamation’s activities such as road maintenance, seasonal mowing, and weed abatement will not occur at occupied sites or near known plants; thus, the Proposed Action and WOA scenario will have no effect to designated critical habitat. The Proposed Action is anticipated to have no effect on Applegate’s Milkvetch.

8.6 Northwestern Pond Turtle

8.6.1 Legal Status

The USFWS has proposed listing the Northwestern Pond Turtle (*Actinemys marmorata*) as threatened (88 FR 68370). Critical habitat for Northwestern Pond Turtle is not proposed at this time.

8.6.2 Life History

Historically, the Northwestern Pond Turtle range extended into British Columbia. However, the current range extends from Puget Sound of western Washington through portions of Oregon, Nevada, and northern and central California (88 FR 68370). In Oregon, the species occupies areas along the Columbia River and west of the higher elevations of the Cascades Range, including portions of the Klamath Basin to the California border (88 FR 68370).

Northwestern Pond Turtles are medium in size (110 to 170 mm [4.33 to 7.05 inches] in length), with a color varying from olive to dark brown, occasionally without pattern but usually with a network of spots, lines, or dashes of brown or black (88 FR 68370). Northwestern pond turtles are semi-aquatic, having terrestrial and aquatic life history phases. Eggs are laid in upland terrestrial habitats, and hatchlings, juveniles, and adults use both terrestrial and aquatic habitats.

Northwestern Pond Turtles use both aquatic and terrestrial habitats at the hatchling, juvenile, and adult life history stages. The egg life history stage occurs only in terrestrial habitats. A Northwestern Pond Turtle will use aquatic and terrestrial habitats for different purposes throughout the individual's life.

Courtship and mating occur from spring through fall in the aquatic environment by adults. Nesting and egg depositing occur by females from late spring through mid-summer months in the terrestrial environment, usually within 3 to 100 m of water. Egg incubation is usually 3 to 4 months, and many hatchlings overwinter in the nest, although some may emerge as early as late summer or fall. Hatchlings migrate to aquatic environments upon emergence. Juvenile and adult turtles seasonally move between the aquatic and adjacent terrestrial environments.

Terrestrial environments are required for nesting, overwintering, aestivation, basking, and dispersal/seasonal movement. Terrestrial environments used by turtles are typically adjacent to aquatic environments; nesting habitats are usually with about 100m of water and overwintering areas are usually within 500 m of water. Home range of Northwestern Pond Turtles is small (average about 1 hectare) and can vary with turtle life history stage and sex.

Aquatic environments are required for breeding, feeding, overwintering and sheltering, basking, and movement/dispersal. Aquatic environments used can be both lentic and lotic and both permanent and ephemeral.

8.6.3 Species Current Conditions

Northwestern Pond Turtles have a historical range that stretches along the Pacific coast from British Columbia, Canada, to the northern part of Baja California, Mexico, primarily west of the Sierra Nevada and Cascade ranges (Ernst and Lovich, 2009; Stebbins and McGinnis, 2018). Northwestern Pond Turtle has been found at elevations ranging from brackish estuarine waters at sea level to 2,048 m (6,719 ft) (Ernst and Lovich, 2009; Stebbins and McGinnis, 2018).

Northwestern Pond Turtles have been observed in the Project from spring to fall, primarily at apparent basking sites in or near aquatic environments. However, knowledge of their distribution, population numbers, terrestrial habitat use, and population dynamics within the Project’s boundaries is limited.

8.6.4 Effects to Northwestern Pond Turtle

Little remains known of distribution, numbers, terrestrial habitat use, or population dynamics of Northwestern Pond Turtles within the Project’s boundaries. Observations made during spring through fall indicate that Northwestern Pond Turtles are present in the Project canals. Reclamation assumes that they are associated with adjacent terrestrial habitats based on the species life history descriptions.

Project water operations on individual turtles residing in and around the Project are largely unclear. These impacts could be potentially beneficial for Northwestern Pond Turtles as they may increase the availability of ephemeral and permanent aquatic habitats near beneficial terrestrial habitats (e.g., nesting and overwintering areas). However, water operation impacts might also have negative consequences for individuals in areas that are seasonally dewatered, leading to increased travel distances between aquatic and terrestrial habitats.

In addition to water operations, various routine maintenance activities in the Project, such as canal and levee maintenance, water control gate and structure maintenance, access road management, and weed abatement, may have seasonal effects that could potentially harm an unknown number of turtles. It is possible that adult and juvenile turtles could be harmed during mowing or driving equipment in occupied areas during terrestrial phases (i.e., migration to and from overwintering areas and nesting areas). Ground disturbing activities that occur in uplands adjacent to aquatic habitats have the potential to incidentally impact adults moving to and from their overwintering and/or nesting sites; dispersing individuals; eggs or hatchlings in nests; and hatchlings during their post-emergence migration to aquatic habitats. Activities in aquatic habitats can directly impact individuals occupying those habitats and/or important habitat components such as basking sites.

Although information is very limited on distribution and abundance of turtles in the Project, Reclamation concludes that the Proposed Action may adversely affect Northwestern Pond Turtle.

8.7 Monarch Butterfly

8.7.1 Legal Status

In December 2020, USFWS concluded that listing the Monarch Butterfly as an endangered or threatened species under the ESA is warranted but precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants. They stated that they will develop a proposed rule to list the Monarch Butterfly as their priorities allow. To date, the Monarch is a candidate for listing under the ESA, and its status is reviewed each year until it is no longer a candidate (USFWS, 2020a,b).

8.7.2 Life History

The Monarch is a species of butterfly in the order *Lepidoptera* (family *Nymphalidae*) that occurs in other parts of the world (e.g., Australia and Pacific Islands) but its ancestral origins and largest populations are in North America (USFWS, 2020b).

During the breeding season, Monarchs lay their eggs on their larval host plant, milkweed (primarily *Asclepias* spp.), and larvae emerge after two to five days (Zalucki, 1982; CEC, 2008). Larvae feed on the milkweed and develop over a period of 9 to 18 days, and then pupate into chrysalis before eclosing 6 to 14 days later as an adult butterfly (Parsons, 1965). Summer adult Monarch Butterflies live for approximately 2 to 5 weeks but in late summer and fall adults migrate and overwinter in dormancy living up to 10 months (Cockrell et al., 1993; Herman and Tatar, 2001; James and Kappen, 2021). The Monarch life cycle varies by geographic location. In temperate climates, such as eastern and western North America, Monarchs undergo long-distance migration, where the migratory generation of adults is in reproductive dormancy and lives for an extended period (Herman and Tatar, 2001; James and Kappen, 2021). In western North America, Monarchs begin migrating to overwintering sites in late summer and fall; individuals generally fly south and west to overwintering groves along the California coast into northern Baja California (Solensky, 2004; James and Kappen, 2021).

In early spring (February-March), surviving Monarchs break dormancy and mate at the overwintering sites before dispersing (Leong et al., 1995; van Hook, 1996). The same individuals that undertook the initial southward migration begin flying back through the breeding grounds and their offspring start the cycle of generational migration over again (Malcolm et al., 1993). In the spring in western North America, Monarchs migrate north and east over multiple generations from coastal California toward the Rockies and to the Pacific Northwest (Urquhart and Urquhart, 1977; Nagano et al., 1993; James and Kappen, 2021).

During migration to overwintering sites, most Monarchs are in reproductive dormancy, but continue to need blooming nectar plants throughout the migratory habitat to provide sugar that is eventually stored as lipid reserves (Brower et al., 2015). On their return, Monarchs are laying eggs, and thus need both nectar sources and milkweed. This habitat needs to be distributed throughout the landscape to ensure connectivity throughout their range and maximize lifetime fecundity (Zalucki and Lammers, 2010; Miller et al., 2012). In western North America, nectar and milkweed resources are often associated with riparian corridors, and milkweed may function as the principal nectar source for Monarchs in more arid regions (Dingle et al., 2005; Pelton et al., 2018; Waterbury and Potter, 2018; Dilts et al., 2018). However, the specific optimal amount of habitat and its spatial distribution are unknown; more research is needed on optimal distances between habitat patches, as well as optimal patch sizes and milkweed density and characteristics of patches selected for female oviposition (Kasten et al., 2016; Stenoien et al., 2016; Grant et al., 2018; Waterbury and Potter, 2018). Southern Oregon and Northern California (Klamath Project area) are important areas for monarch breeding in spring and summer. It is also an important part of the migration flying north in spring and south in the fall. Thus, nectar sources are very important at both times. A primary nectar source for fall migrants is Rabbitbrush.

8.7.3 Species Current Conditions

The western North American Monarch population has been censused annually since 1997, providing an estimate of annual population size; in 2022, the population estimate of overwintering Monarchs was 335,000 (USFWS, 2023d). This is a decline from the estimated 4.5 million Monarchs that overwintered on the California coast in the 1980s (USFWS, 2023d).

The population decline is likely due to multiple stressors across the Monarch’s range, including the loss and degradation of overwintering habitat; pesticide use, particularly insecticides; loss of breeding and migratory habitat; climate change; parasites and disease (James, 2024). Historically, the majority of western Monarchs spent the winter in forested groves near the coast from Mendocino County, California, south into northern Baja California, Mexico. In recent years, Monarchs have not clustered in the southern-most or northern-most parts of their overwintering range, and there are year-round residents in some areas of the coast (James et al., 2021). This resident phenomenon is likely due to a combination of climate change and an abundance of residential-planted non-native, tropical milkweed that is available for Monarchs year-round. Migratory western Monarchs depart overwintering sites in late-winter to early-spring. Throughout the spring and summer, Monarchs breed, lay their eggs on milkweed, and migrate across multiple generations until mid-June within California and other states west of the Rocky Mountains.

Data on Monarch populations in Klamath County, Oregon, are sparse, and their movement is variable and difficult to predict. Milkweed is a vital part of Monarch Butterfly’s life history, and thus the presence of milkweed is often used to map Monarch habitat. The Western Monarch Milkweed Mapper, a project that is part of a collaborative effort between several nonprofits and state and federal agencies, (The Xerces Society for Invertebrate Conservation, Idaho Department of Fish and Game, Washington Department of Fish and Wildlife, NFWF, and USFWS) to map Monarch Butterflies and their host plants, is one source of data on western Monarch and milkweed distribution and phenology. The data provided by this map indicate there have only been two recorded sightings of Monarchs (one of actively breeding Monarchs), and one sighting of milkweed, in Klamath County since 2020. Monarchs and Monarch habitat, i.e., milkweeds, have been observed in a few areas throughout the Project (monarch habitat is more than just milkweeds. They need other nectar sources and abundant shade). These Monarch and milkweed observations have been made during the summer months at what appear to be riparian areas. The Milkweed Mapper has data from the early 1900s to the present. From 1918 to the present, there have been 12 recorded sightings of milkweed and 20 recorded sightings of Monarchs (two of actively breeding Monarchs) in Klamath County, OR.

8.7.4 Effects to Monarch Butterfly

However, outside of the few observations detailed above, little is known of distribution, numbers, terrestrial habitat use, or population dynamics of Monarchs within the Project's boundaries. However, habitat use is likely to be similar to that reported for central Washington (James, 2016), with dense populations of milkweed, good nectar sources and tree/shrubs provide shade, best for supporting breeding monarch populations.

Project water operations on Monarchs residing in or traveling through the Project Area are largely unclear. These impacts could be potentially beneficial for Monarchs as they may increase the health of riparian habitats and vegetation. However, water operation impacts might also have negative consequences for individuals in areas that are seasonally dewatered in late fall, as this could negatively impact milkweed and blooming nectar plants and lead to increased travel distances between habitats.

In addition to water operations, various routine maintenance activities in the Project, such as road management, seasonal mowing, and weed/insect abatement, may have seasonal effects that could potentially harm an unknown number of Monarchs. Specifically, activities conducted during late spring and summer could impact milkweed and may pose a risk to Monarch Butterflies. Given the sparse sightings of Monarchs and milkweed in Klamath County, Reclamation determines we are not likely to adversely impact Monarch Butterflies.

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9 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). Such future state and private activities and their effects, to the extent they are reasonably certain to occur and can be ascertained, have been considered in conjunction with the above analysis of the WAO scenario. The effects of federal activities proposed to be undertaken pursuant to the Proposed Action have likewise been considered in the overall analysis. This consideration of both the cumulative effects of future state and private activities, and the anticipated effects of the federal action proposed under the Proposed Action, represents an overall framework for this impact analysis.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the Action Area. However, it is difficult if not impossible to distinguish between the Action Area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the Action Area are described earlier in the discussion of environmental baseline (Chapter 2).

Tribal lands are excluded from the designation of critical habitat for the SONCC Coho Salmon ESU, and Reclamation is unaware of Tribal actions that are reasonably certain to occur within the area of the action subject to ESA Section 7 consultation. Future federal actions will be subject to the consultation requirements established in Section 7 of the ESA, and therefore are not considered cumulative to the Proposed Action. Cumulative effects are discussed below.

9.1 Lost River and Shortnose Suckers

9.1.1 Water Quality – Total Maximum Daily Loads

The federal Clean Water Act (43 U.S.C. §§1251 to 1376) requires states to develop plans with goals and pollution targets for improving water quality in water bodies that are designated as impaired because of excessive quantities of various pollutants. This process includes establishing limits known as TMDLs for designated pollutants. Governmental entities (local, state, and federal) and/or private entities are responsible for addressing pollution under their control by developing management strategies, implementation plans, and schedules that are designed to collectively meet TMDL requirements. The Oregon Department of Environmental Quality released the *Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan* in 2002 (ODEQ, 2002). Implementation of the resultant water quality management plans will aid in improving water quality in UKL and its tributaries as well as the mainstem Klamath River in habitats occupied by listed suckers, which is beneficial to listed suckers and their habitats.

9.1.2 Ecosystem Restoration

Excerpt directly from the USFWS 2023 BiOp (USFWS, 2023a Page 173):

The non-Federal actions that are expected in the action area include habitat restoration, water quality improvements, and other actions that are regularly funded by the Oregon Watershed Enhancement Board, National Fish and Wildlife Foundation, as well as through other entities. For example, past work has been done by the Klamath Basin Rangeland Trust, Klamath Watershed Partnership, The Klamath Tribes, The Nature Conservancy, Trout Unlimited, Sustainable Northwest, Klamath Soil and Water Conservation District, and Klamath Water Users Association. Funding has been consistent through these entities for years, but uncertainty always remains. Much of the uncertainty surrounding progress in ecosystem restoration is the willingness of private land-owning entities and persons to participate in voluntary restoration actions. However, given the amount of focused effort and the involvement of several key organizations in the Upper Klamath Basin, progress is expected toward the groups' priorities over the next 2 years that will be measurable at some scales.

9.1.3 Rearing Programs

Excerpt directly from the USFWS 2023 BiOp (USFWS, 2023a Page 173):

The Klamath Tribes established a rearing program in 2018 for LRS and SNS at a facility near Chiloquin, Oregon. Sufficient data to analyze the total numbers and recruitment rates are currently unavailable because the first stocking occurred in 2021. In 2021, a total of 393suckers were released from the Klamath Tribes Hatchery, with approximately 700 suckers released in 2022, into UKL tributaries (Gonyaw pers. comm., 2022). The Klamath Tribes Hatchery will likely continue stocking suckers from the rearing program in future years. The rearing program is similar to the Service's program as described in environmental baseline (section 2.4.4.2) above and is expected to have similar results and result in an additive effect towards recovery of the species.

9.1.4 Agricultural Practices

Off-Project agricultural operations on Klamath River tributaries, if unaltered, will continue to reduce the quantity, and alter the timing, of water availability and may negatively affect water quality and instream habitats through upland modifications that lead to increased siltation, mobilization of phosphorous and other nutrients, or reductions in water flow in stream channels. Particularly, unscreened diversions can have a negative impact by increasing juvenile sucker entrainment into diversion canals. See Section 9.2.3 for additional details about environmental effects associated with off-Project agricultural practices that could affect suckers directly or indirectly through habitat degradation.

9.1.5 Cumulative Effects

Excerpt directly from the USFWS 2023 BiOp (USFWS, 2023a Page 174):

Most of the non-Federal actions listed above will improve water quantity, water quality, and habitat in areas that support listed suckers, including UKL and its tributaries and the Keno Reservoir. Screening will reduce entrainment of suckers and improve overall survival. Habitat restoration will increase the amount and quality of areas important to complete sucker life cycles.

Water quality improvement projects will work towards addressing a major factor limiting listed sucker recovery in the Upper Klamath Basin. If water quality is improved in Keno Reservoir, this area would likely support a substantial population of adult suckers and/or provide habitat to support larval and juvenile suckers that eventually will return to UKL as adults. Therefore, the effects of the proposed action, combined with future State, tribal, and private actions, will primarily result in beneficial cumulative effects to listed suckers over the life of the proposed action; however, none of the benefits can be quantified at this time because project details are limited and/or cannot currently be estimated.

9.2 Southern Oregon Northen California Coast Coho Salmon

9.2.1 Oregon Reintroduction Plan

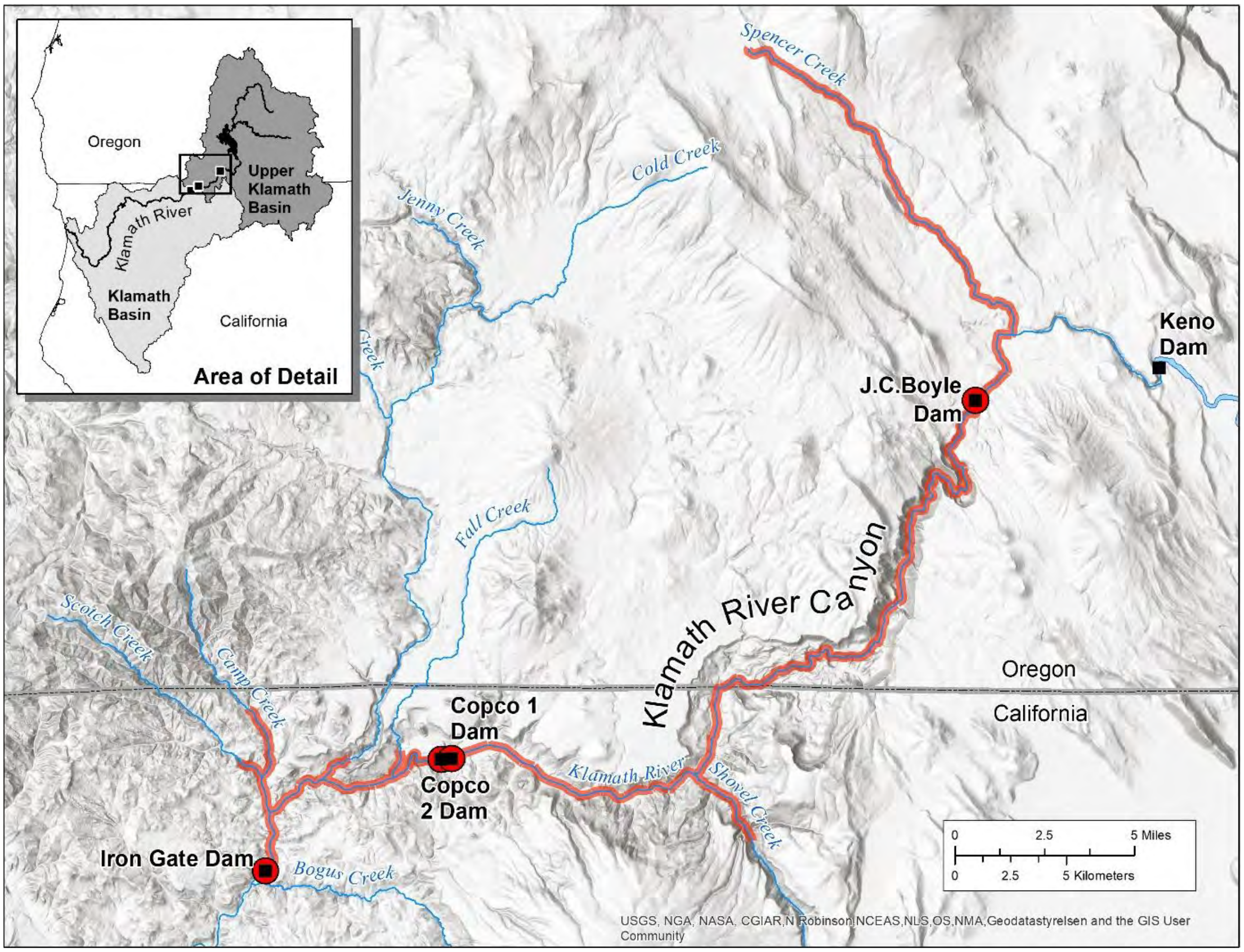
Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 251):

The ODFW and the Klamath Tribes of Oregon have prepared a draft Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin (Reintroduction Plan)(ODFW 2021). ODFW has made significant progress to secure funding and staff for purposes of implementing the Reintroduction Plan; thus, NMFS concludes that it is reasonably certain to occur. The Reintroduction Plan recommends species-specific approaches to guide the reintroduction of historically present anadromous fishes. When the dams are removed there is a high degree of confidence that coho salmon will repopulate newly available habitat as described in Section 2.5.1.2.5.8, Restored Access to Previously Blocked Habitat. This rapid repopulation response has been observed after barrier removal on the Elwha River (Liermann et al. 2017; Duda et al. 2021), White Salmon River (Allen et al. 2016; Hatten et al. 2016), Cedar River (Burton et al. 2013; Anderson et al. 2015), Rogue River (McDermott 2016), and the Penobscot River (Izzo et al. 2016). Therefore, this plan recommends a volitional approach to reintroduction of these fishes, in which no active measures will initially be taken to assist in repopulating habitat in the Upper Klamath Basin. The Reintroduction Plan includes a recommended strategy for monitoring reestablishment of coho salmon following the removal of the four Klamath Hydroelectric dams. The strategy for monitoring will be focused on fundamental questions. Immediately following the availability of passage, monitoring will focus on determining if coho salmon are migrating into habitat immediately above the dams. As fish populations become more widely established, monitoring will be more specific and focused on management objectives, such as determining adult escapement, juvenile productivity, and spatial distribution within each subbasin. Information gained through these Reintroduction Plan monitoring activities will advance and prioritize future restoration activities that promote improvements to fitness and survival of the Upper Klamath population of coho salmon.

Excerpt directly from the ODFW 2021 Re-introduction Plan (ODFW & The Klamath Tribes, 2021 Page 251):

While there are no historical records suggesting that Coho Salmon were present above Upper Klamath Lake, there is however, evidence that Coho Salmon spawned in tributaries to the Klamath

River above Iron Gate Dam prior to dam construction (Hamilton et al. 2005). It has been reported that Coho Salmon spawned in Fall Creek, which now flows into Iron Gate Reservoir, and the confluence of Jenny Creek was a popular fishing location for Coho Salmon (Coots 1957; Coots 1962; CDWR 1964; Hamilton et al. 2005). It is also thought that Coho Salmon historical distribution extended into Spencer Creek, the upper-most tributary to the mainstem Klamath River. Spencer Creek is a medium-sized, low-gradient tributary that contains the type of side-channel beaver ponds juvenile Coho Salmon prefer as rearing habitat (Hamilton 2005). Based on the available habitat and current use by resident salmonids, Spencer Creek has a very high potential for use by Coho Salmon (Ramos 2020). Fish passage through the Klamath Hydroelectric Project would open up over 59 miles of Coho Salmon habitat above Iron Gate Dam, 31 miles being in Oregon (18 miles of mainstem Klamath River and 13 miles of tributary habitat within Spencer Creek), and likely more non-natal, rearing habitat in some of the smaller tributaries within the Klamath River Canyon (Figure 9-1).

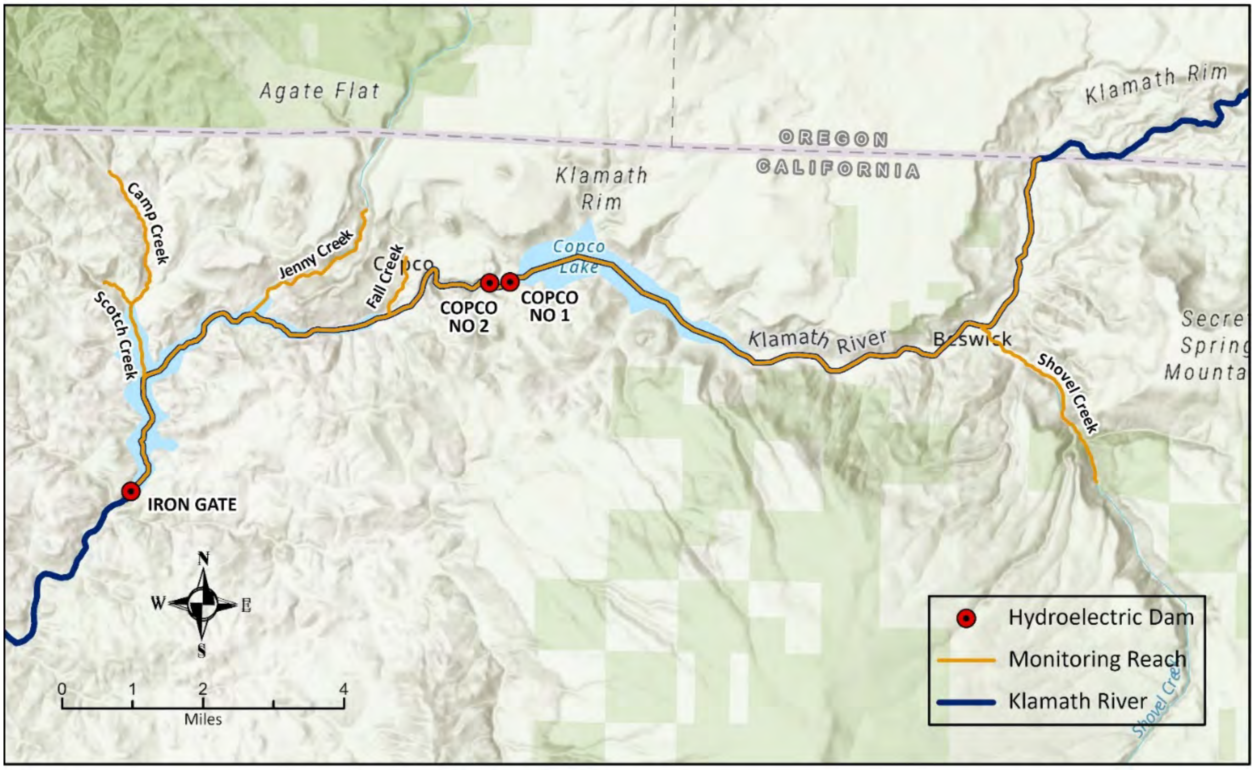


Source: Figure 1-4 in ODFW and the Klamath Tribes (2021)

Figure 9-1. Potential Coho Salmon habitat (highlighted with red) currently blocked by the Klamath Project (Iron Gate Dam, Copco 1 and 2 Dams, and J.C. Boyle Dam)

9.2.2 California Re-Introduction Plan

CDFW, with support from ODFW and other key partners including several Klamath Basin tribes, NOAA Fisheries, and USFWS have prepared a draft implementation plan for the re-introduction of anadromous fishes, including Coho Salmon, into the California portion of the Upper Klamath Basin. CDFW continues to work to finalize this plan and Reclamation believes that the plan is reasonably likely to be implemented. As with the Oregon plan, there is a high degree of confidence that Coho Salmon will re-populate newly available habitat (Figure 9-2); therefore, the focus is on increasing access to historical habitats to allow for volitional re-population of the Upper Klamath Basin. The plan includes a strategy for monitoring re-establishment of Coho Salmon in California waters following dam removal. The primary goal of monitoring is to track the rate of change in the number of fish per year and progress toward viable self-sustaining populations of anadromous fishes through 3 to 4 generations (12-15 years). The monitoring framework will have four-phases: Phase I – reintroduction, Phase II – establishment, Phase III – productivity and abundance, and Phase IV – spatial structure and diversity. The phases are intended to track the spatial-temporal phases of volitional reintroduction. However, monitoring will be implemented within an adaptive management framework and implementation of a particular phase will ultimately be driven by management information needs.



Source: Figure 3 in CDFW (2021)

Figure 9-2. Monitoring reach within California

9.2.3 Agricultural Practices

Off-Project agricultural operations on Klamath River tributaries, if unaltered, will continue to reduce the quantity, and alter the timing, of water availability and may negatively affect riparian and wetland habitats through upland modifications that lead to increased siltation or reductions in water flow in stream channels. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for ESA-listed Coho Salmon by increasing erosion and sedimentation, as well as introducing nitrogen, ammonia, and other nutrients into the watershed. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect salmonid reproductive success and survival rates. Furthermore, agricultural practices can alter the hydrograph (e.g., timing of peak runoff, base flows, return flows and contamination) and therefore impact salmonid habitats.

Also, with agricultural practices, the cultivation of marijuana, legal and illegal, can also impact salmonid habitats. Watersheds within the Action Area have been used to produce marijuana crops both legally and illegally. Illegal marijuana production within the Action Area can result in grow operations of over 100,000 plants; often these illegal grow operations occur on federal lands. These grow operations can adversely affect Coho Salmon habitat by diversion of water for irrigation, resulting in the drying of streams or draining of pools that provide rearing habitat for Coho Salmon juveniles. The operations can also contaminate nearby streams by the discharge of pesticides, rodenticides, and fertilizers to nearby streams. Such influx of contaminants can be lethal to exposed Coho Salmon or result in the alteration of stream habitats via eutrophication.

9.2.4 Timber Management on Private Lands

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 252):

Timber management, along with associated activities such as harvest, yarding, loading, log hauling, site preparation, slash burning, tree planting, thinning, and road construction occurs in the action area. Future private timber harvest levels in the action area cannot be precisely predicted; however, NMFS assumes that harvest levels on private lands within the action area in the foreseeable future will be similar to harvest levels that have occurred over the past 20 years.

Timber harvest is not regulated if the resulting timber is not sold. When timber is sold, timber harvest is regulated under the California Forest Practice Rules (CFPR). The CFPR has likely not consistently provided protection against an unknown amount or extent of unauthorized take of salmonids listed by NMFS under the ESA, such as listed SONCC ESU coho salmon. Timber harvest results in impairments in migration, shade, large woody debris, stream temperature, turbidity, and sediment levels (NMFS 2014a). These impacts will likely continue throughout the action area and for the duration of impacts resulting from the proposed action.

Reasonably foreseeable effects of timber harvest will likely continue to degrade conditions in designated SONCC coho salmon ESU critical habitat within the action area as described in the environmental baseline section of this Opinion.

9.2.5 Control of Wildland Fires on Non-Federal Lands

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 252):

Climate change is increasing the frequency and severity of wildfires not only in California [and Oregon] *but also all over the world. Since 1950, the area burned by California wildfires each year has been increasing, as spring and summer temperatures have warmed and spring snowmelt has occurred earlier (CARB 2021). During the recent drought, unusually warm temperatures intensified the effects of very low precipitation and snowpack, creating conditions for extreme, high severity wildfires that spread rapidly. Of the 20 largest fires in California's history, eight have occurred in the past three years (since 2017) (CalFire 2021).*

Control of wildland fires may include the removal or modification of vegetation due to the construction of firebreaks or setting of backfires to control the spread of fire. This removal of vegetation can trigger post-fire landslides as well as chronic sediment erosion that can negatively affect downstream coho salmon habitat. Also, the use of fire retardants may adversely affect salmonid habitat if used in a manner that does not sufficiently protect streams causing the potential for coho salmon to be exposed to lethal amounts of the retardant. This exposure is most likely to affect summer rearing juvenile coho salmon. State of California protective standards require 100-foot buffers reducing likelihood of fire retardants entering waterways. While we cannot predict precisely where and when wildfires will occur, we expect the rate and severity of wildland fires will increase. We expect degradation of coho salmon habitat from wildfires will occur during this action.

9.2.6 Construction, Reconstruction, Maintenance, and Use of Roads

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 253):

Adjacent to the action area are thousands of miles of surface roads used to provide access to timber or private residences. Erosion from unmaintained roads increases fine sediment concentrations to waterways and can suffocate redds, degrade pool quality, and decrease pool depth (Newcombe and Jensen 1996; Suttle et al. 2004). As the road networks in the action area are already fairly well established, NMFS does not anticipate significant new miles of roads to be built in the near future. However, NMFS does anticipate that restoration efforts will continue to upgrade and or decommission existing roads to make them less inclined to road failures (landslides) and/or be a chronic source of sediment discharge to adjacent stream networks. Improvement of environmental conditions on private and state lands related to roads adjacent to the action area is expected in the future due to an increasing emphasis on watershed-scale inventory, assessment and treatment of road networks as regulatory sediment reduction requirements are implemented in the action area (e.g., TMDLs). However, funding for such efforts is limited and the thousands of miles of existing roads in total is expected to continue to adversely affect coho salmon and their habitat.

Human population growth in the Action Area is expected to remain relatively stable and some development will continue to occur which, on a small-scale, can impact Coho Salmon habitat. Once development and associated infrastructure (e.g., roads, drainage, and water development) are established, the impacts to aquatic species are expected to be permanent. Anticipated impacts to aquatic resources include loss of riparian vegetation, changes to channel morphology and dynamics, altered hydrologic regimes (increased storm runoff), increased sediment loading, and elevated water temperatures where shade-providing canopy is removed. The infrastructure and roads waters may lead to the removal of large woody debris. There are also effects of home pesticide use, roadway runoff of automobile pollutants, introductions of invasive species to nearby streams and ponds, attraction of salmonid predators due to human occupation (e.g., raccoons), increased incidences of poaching, and loss of riparian habitat due to land clearing activities. These factors associated with residential development can have negative impacts on salmon populations.

9.2.7 Mining, Rock Quarrying, and Processing

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 253):

Although mining activity is a relatively minor land use within the action area as compared to timber management, NMFS anticipates that upland mining and quarrying will continue to be conducted by non-federal parties adjacent or upslope to and affecting the action area. The effects of upland mines and quarries on aquatic resources in the action area depend on the type of mining, the size of the quarry or mine, and distance from waters. Mining can cause increased sedimentation, accelerated erosion, increased streambank and streambed instability, and changes to substrate. Surface mining may result in soil compaction and loss of the vegetative cover and humic layer, thereby increasing surface runoff. Mining may also cause the loss of riparian vegetation. Chemicals used in mining can be toxic to aquatic species if transported to waters. Because the effects of mines and quarries depend on several variables, while NMFS cannot precisely determine the extent of the effects that mines and quarries and other commercial rock operations adjacent or upslope of the action area will have on coho salmon in the action area, we anticipate minor effects will continue into the future.

…in 2009 California suspended all instream mining using suction dredges (NMFS and USFWS 2013). The use of vacuum or suction dredge equipment, otherwise known as suction dredging, is currently prohibited and unlawful throughout California (https://wildlife.ca.gov/Licensing/Suction-Dredge-Permits, visited on November 29, 2021); see generally California Fish and Game Code 5653, 5653.1, 12000, subdivision (a)). Suction dredge mining in systems that support salmonids was known to cause locally significant adverse impacts on salmonids and their habitat. NMFS expects that the prohibition of suction dredging will allow for improved habitat conditions in the Klamath mainstem and larger tributaries, and will reduce the direct and indirect effects of this activity on SONCC ESU coho salmon in both the short and long term.

9.2.8 Water Withdrawals

Landowners with water rights independent of the Project and who are able to exercise such rights without the use of Project facilities, would reasonably be expected to continue to divert available supplies. Such diversions include approximately 17,000 acres irrigated by direct diversions from UKL, through private facilities over which Reclamation holds no discretionary control. There are also approximately 7,300 acres irrigated by direct diversions from the Keno Impoundment reach, again through private facilities that Reclamation has no control over. There are also landowners and entities along the Lost River with non-federal diversion works that would continue to operate. Among these are included Harpold Dam (owned and operated by HID) and the check dam at the Lost River Ranch (privately owned). HID serves approximately 10,000 acres of irrigable land around Bonanza, through district- and individually-owned pumps in the Lost River. HID has water rights independent of the Project that are recognized by the state of Oregon and that HID would presumably continue to exercise.

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 254):

An unknown number of permanent and temporary water withdrawal facilities exist within the action area. These include diversions for urban, agricultural, commercial, and residential use, along with temporary diversions, such as drafting for dust abatement. The nature of their impacts was discussed in the Environmental Baseline section. These and numerous other water diversions in the systems that feed the Klamath River decrease the quantity of mainstem flows on the Klamath River mostly during the summer months, when juvenile access to cooler tributaries and cooler mainstem water temperatures is essential. NMFS expects these activities to continue into the future with impacts similar to those described in the Environmental Baseline.

9.2.9 Recreation

Expected recreation impacts to salmonids include increased turbidity, impacts to water quality, barriers to movement, changes to habitat structures, and increased access for legal and illegal harvest (i.e., poaching). Streambanks, riparian vegetation, and spawning redds can be disturbed wherever human use is concentrated. Campgrounds can impair water quality by elevating nutrients in streams. Construction of summer dams to create swimming holes causes turbidity, destroys and degrades habitat, and blocks migration of juveniles between summer habitats. Impacts to salmonid habitat are expected to be localized, mild to moderate, and temporary. Fishing within the Action Area, typically for Steelhead or Chinook Salmon, is expected to continue subject to CDFW and ODFW regulations. Fishing for Coho Salmon directly is prohibited in the Klamath River. The level of impact to Coho Salmon within the Action Area from legal angling is unknown but is expected to remain at current levels (NMFS, 2010a). However, poaching may result from increased recreational access directly impacting salmonid abundance and spawning.

9.3 Southern Resident Killer Whales

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 254):

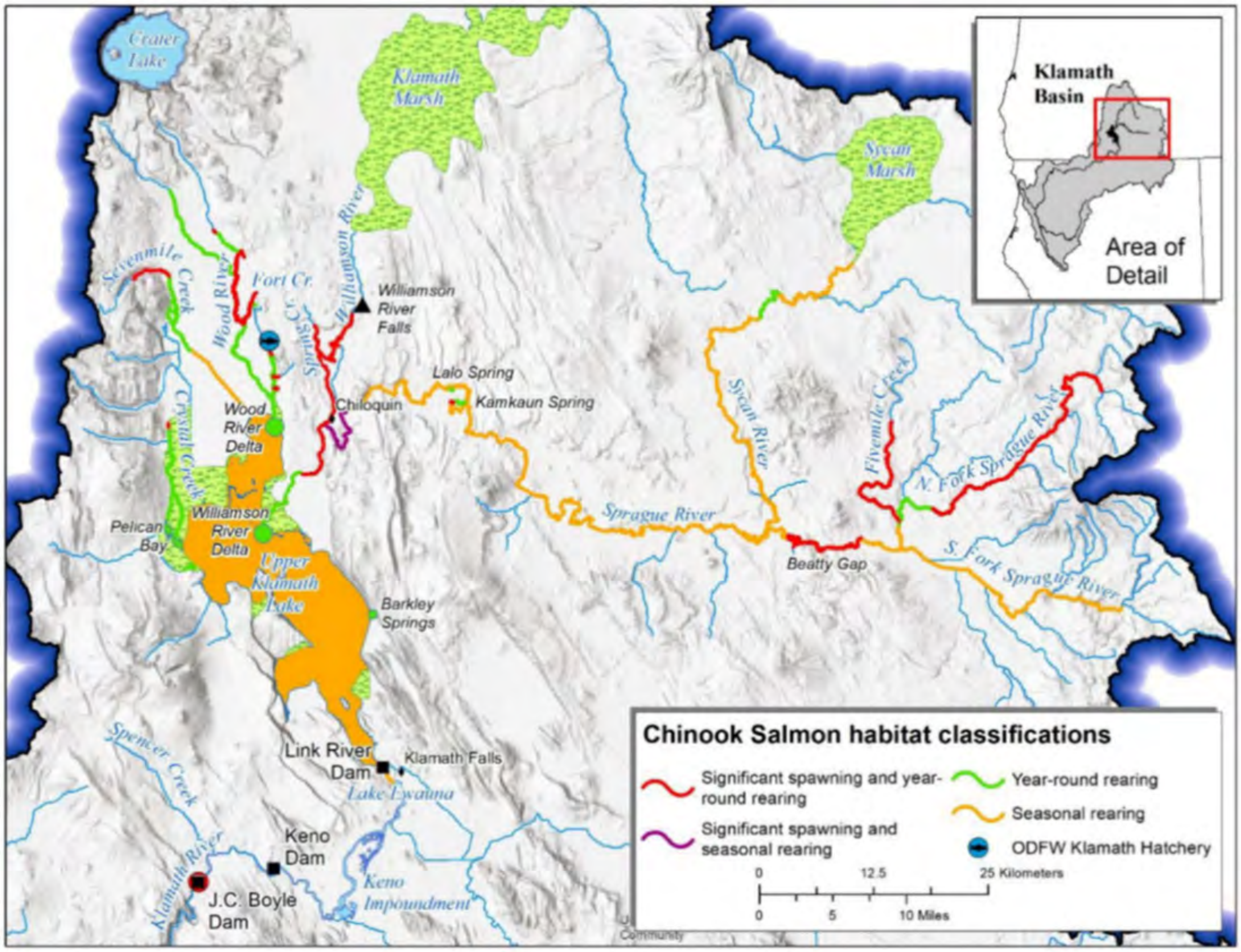
Cumulative effects on Klamath River basin Chinook salmon in the freshwater environment are likely to be similar to those described for SONCC coho salmon [Section 9.2 above] *because, as noted earlier, Chinook and coho share similar life histories and are thus likely to be affected by cumulative effects in similar ways. In turn, these result in effects to prey resources of SRKWs in the action area as described* [in Section 7.1]. *While many of the cumulative effects expected to affect coho salmon will also be relevant to Chinook salmon, there are some important differences between the species that need to be considered. First, Chinook salmon and coho salmon exhibit* *some differences in life history…The impact of these life history differences between Chinook and coho salmon is minor, as they have similar freshwater habitat requirements for spawning, egg incubation, and rearing, so threats for one species are generally likely to be threats for the other. However, one important difference between the two species that is relevant to the effects of the proposed action is that Chinook salmon are expected to migrate significantly farther upstream once the dams are removed than are coho salmon. Chinook salmon are expected to repopulate over 303 miles of habitat upstream of Iron Gate Dam…, while coho salmon are expected to repopulate up to 76 miles of habitat upstream of Iron Gate Dam…. NMFS coordinated with USFWS regarding activities that were reasonably certain to occur in the areas above Spencer Creek that would impact Chinook salmon future habitat, but not coho salmon, and did not identify activities that were likely to have an impact on Chinook salmon. There may be future activities authorized, funded, or carried out by Federal agencies in the area above Spencer Creek (e.g., restoration actions) that could impact Chinook salmon, but those would require additional ESA Section 7 consultation.*

9.3.1 Chinook Salmon Reintroduction

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 255):

[T]*hough not part of the proposed action, ODFW and Klamath Tribes (2021) have prepared a Draft Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin that includes active reintroduction (outplanting of hatchery juveniles into areas above the dams) of spring-run Chinook salmon into the Oregon portion of the basin, which would be expected to jumpstart repopulation by Chinook salmon. ODFW has made significant progress to secure funding and staff for purposes of implementing the Reintroduction Plan; thus, NMFS concludes that it is reasonably certain to occur. Therefore, NMFS expects that this active reintroduction as part of the reintroduction plan is reasonably certain to occur.*

This reintroduction effort is expected to result in Chinook Salmon occupying some or all of the potential habitat within the Upper Klamath Basin above Link River Dam that will become available (Figure 9-3).



Note: Figure and caption after ODFW and The Klamath Tribes (2021)

Figure 9-3. Potential Chinook Salmon habitat in the Upper Klamath Basin, above Link River Dam

[N]*atural (volitional) repopulation is generally considered the approach with the lowest risk of failure or unintended consequences because it minimizes the interruption or alteration of natural biological processes (George et al. 2009; Anderson et al. 2014). Active reintroduction by means of transplanting adults, juveniles, or fertilized gametes has the benefit of immediately placing fish in the reintroduction area, but has increased ecological risks relative to natural repopulation. The concern is that hatchery releases during active reintroduction may reduce the genetic fitness of wild fish (Araki et al. 2008) or induce density-dependent ecological processes affecting naturally spawning fish (Kostow 2009). When feasible, natural repopulation is considered most likely to maximize abundance and productivity in the long run. Fall-run Chinook salmon, coho salmon, steelhead trout, and Pacific lamprey are all found in habitat immediately downstream of Iron Gate Dam. When the dams are removed there is a high degree of confidence that individuals of these species will significantly repopulate newly available habitat on their own. However, because the timing and extent of volitional repopulation is uncertain, ODFW plans to allow three generations (estimated to be 9 years for coho salmon and 12 years for Chinook salmon) to pass following* *restored passage, after which an assessment will be conducted to determine if, where, and when active reintroduction is needed to help establish populations of these species. The only remaining populations of spring-run Chinook salmon in the Klamath Basin are located in the Trinity River and Salmon River sub-basins (150 and 128 miles downstream of Iron Gate Dam, respectively). Because of the long distance from Iron Gate Dam, and even further distance to newly available habitat, to the source populations of spring-run Chinook salmon (Trinity River and Salmon River sub-basins), these fish are unlikely to repopulate habitat in the upper basin on their own. The addition of new spring-run Chinook salmon populations in the Klamath Basin would represent an improvement in the availability of Chinook salmon prey resources for SRKWs. In addition to the general increase in the abundance of Chinook salmon that new populations could bring, we recognize the spring-run Chinook salmon that are aggregating to return or distributed along the coast during the winter and spring could provide enhanced resources of prey when SRKWs are most likely to be within the action area. This also coincides with the time of year that prey resources are believed to be most limited (NMFS and WDFW 2018).*

9.3.2 California Re-introduction Plan

CDFW, with support from the ODFW and other key partners including several Klamath Basin Tribes, NOAA Fisheries, and USFWS have prepared a draft implementation plan for the re-introduction of anadromous fishes, including Chinook Salmon, into the California portion of the Upper Klamath Basin. CDFW continues to work to finalize this plan and Reclamation believes that the plan is reasonably likely to be implemented.

Excerpt directly from the CDFW 2021 Draft Re-introduction Plan (CDFW, 2021 Page 28):

CDFW is not considering actively reintroducing spring-run Chinook Salmon; however, the ODFW and The Klamath Tribes are evaluating the potential to actively reintroduce spring-run Chinook Salmon to historical spawning and over-summering habitats in Oregon. As identified by Anderson et al. (2014), active reintroduction is often best suited for areas that are distant from extant populations, where long distance dispersal may be unlikely. In this case, transplanting can ensure an adequate number of individuals reach the reintroduction site (Anderson et al. 2014) with the expectation that lineages will continue to breed naturally at the site. It is anticipated that any reintroduction effort by the ODFW and The Klamath Tribes would be coordinated with NOAA Fisheries, CDFW and others. If active reintroduction of spring-run Chinook Salmon does occur, it will be critical to monitor these reintroduced fish in Oregon and California, and to the extent possible offshore oceanic waters, including distinguishing them from fish that reestablish through volitional migration.

As with Coho Salmon, there is a high degree of confidence that Chinook Salmon will re-populate newly available habitat (Figure 9-2) therefore the focus is on increasing access to historical habitats to allow for volitional re-population of the Upper Klamath Basin. The plan for both species is functionally identical in spatial and temporal extent, Phases, and structure. An adaptive management approach will be taken in both cases.

The addition of new spring-run Chinook Salmon populations and the bolstering of fall-run Chinook Salmon populations would improve the availability of Chinook Salmon prey resources for SRKWs. The increase in the abundance of Chinook Salmon that new or improved populations could bring could provide enhanced resources of prey during winter and spring when SRKWs are most likely to be within the Action Area and prey resources are likely to be most limited (NMFS and WDFW, 2018).

9.3.3 Dam Removal

9.3.3.1 Hatchery Production

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 256):

CDFW, ODFW and the Klamath Tribes (2021)[5] *are drafting anadromous species reintroduction plans that discuss the potential for modified hatchery operations in the Klamath River to continue beyond the length of time proposed (eight years). Hatchery operations beyond eight years (or potentially cessation of hatchery operations earlier than eight years if warranted) will depend on the level of natural production that is occurring throughout the Klamath River (including newly available upstream habitat) as indicated by monitoring efforts. The response to what is observed following dam removal and commencement of restoration activities, and any potential changes in the timeline and/or extent of hatchery production that occurs will be decided in coordination with Klamath Basin fisheries managers including State regulatory agencies and Tribal partners. […] we are reasonably certain that hatchery production would continue to occur at some level beyond eight years if expectations for repopulation of newly available spawning habitat and improved productivity throughout the Klamath River system are not being met. We base this assumption on the expectation, based on past investment of resources State regulatory agencies and Tribal partners, that their investment of resources through staff and infrastructure will continue in place over the eight year period following dam removal. Also, Klamath River Chinook salmon are an important federally managed and tribal trust species that affects west coast fisheries opportunities. Klamath River Chinook salmon production has and will remain a priority for restorative actions by these agencies, and if natural production is deemed to be insufficient, continued hatchery production may be warranted despite the recognized potential negative impacts of hatchery releases on natural production. The result of this action would be the likely extension of the duration associated with the anticipated mid-term effects for SRKWs for some time period until the benefits of long-term restoration are being more fully realized.*

9.3.3.2 Natural Production

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 257):

Although it is not possible to precisely predict the timeline for the increase in natural production in the Klamath River, NMFS and other agencies will monitor progress and NMFS expects significant progress by the time the long-term effects period begins. General plans at this point are to allow for three generations (estimated to be 12 years for Chinook salmon) to pass following dam

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[5] Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin (ODFW, 2021) was completed in 2021 after the BiOp quoted here was issued. The Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the CDFW is anticipated to be completed in late-winter/early-spring of 2024. However, the content of this quote remains consistent with the final and most current draft of each plan, respectively.

removal and restored access to the Upper Klamath River, after which an assessment will be conducted to determine if, where, and when active reintroduction may be needed to help establish populations of these species.

9.3.4 Marine Policy and Conditions

Excerpt directly from the NMFS 2021 BiOp (NMFS, 2021a Page 257):

Numerous non-federal NMFS partners will continue to implement targeted management actions identified in the SRKW recovery plan (NMFS 2008) informed by research. Future projects funded by the Pacific Coastal Salmon Recovery Fund (PCSRF) and conducted by states and tribes that will be implemented throughout the region will make important contributions to improve the status of ESA-listed salmon and protect currently healthy populations, which will help support the prey needs of SRKW in the action area. Additional actions by non-federal activities surrounding implementation of the SRKW recovery plan that are ongoing or expected to occur are described in the most recent 5-year review (NMFS 2016e).

Additional activities that may occur in the coastal waters off Oregon and California will likely consist of state or local government actions related to ocean use policy and management of public resources, such as changes to or additional fishing or energy development projects. Changes in ocean use policies as a result of non-federal government action are highly uncertain and may be subject to sudden changes as political and financial situations develop. Examples of changes to or additional actions that may occur include: development of aquaculture projects; changes to state fisheries which may alter fishing patterns; installation of hydrokinetic projects near areas where SRKWs are known to occur; designation or modification of marine protected areas that include habitat or resources that are known to affect marine mammals in general; and coastal development which may alter patterns of shipping or boating traffic. However, none of these potential state, local, or private actions, can be anticipated with any reasonable certainty in the action area at this time, and most of those described as examples would likely involve federal involvement of some type given the federal government's role in regulating activity in the ocean across numerous agencies and activities.

In summary, most of the potential factors affecting Chinook salmon and SRKWs are ongoing and expected to continue in the future. However, the precise level of their future impacts is uncertain. …One cumulative effect (Section 2.6.2) that we find reasonably certain to occur is that, if sufficient natural production that is not occurring throughout the Klamath River as described above, hatchery operations would continue beyond eight years in some capacity based on investment of resources by state regulatory agencies and Tribal partners to help offset any delay in the realization of long term benefits associated with the proposed action.

10 Conclusions

The determination of effects for listed species and their designated critical habitat in this Biological Assessment considers direct and indirect effects of the Proposed Action together with the effect of other activities that are interrelated or dependent on the Proposed Action. The Biological Assessment further considers the effects of the Proposed Action as measured in relation to the maximum storage (MS) scenario. This chapter presents a summary of the effects for listed species and their designated critical habitat.

10.1 Analytical Approach

Population and critical habitat analyses are included in this Biological Assessment to assist the fishery agencies in making the determination of whether the Proposed Action would reasonably be expected to “directly or indirectly, 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). Three possible determinations exist regarding a Proposed Action’s effects on listed species:

- No effect - “No effect” is the appropriate conclusion when it is determined that the Proposed Action will not affect a listed species or designated critical habitat.
- “May affect but is not likely to adversely affect” is the appropriate conclusion when effects to listed species or critical habitat are expected to be discountable (extremely unlikely to occur), insignificant (never resulting in take), or completely beneficial (positive effects without adverse effects).
- May affect, likely to adversely affect is the appropriate conclusion if any adverse effect may occur to listed species or critical habitat as a direct result of the Proposed Action, and the effect is not discountable, insignificant, or beneficial. If incidental take is anticipated to occur as a result of the Proposed Action, an “is likely to adversely affect” determination is made.

The ongoing stressors associated with existing dams and other structures are part of the environmental baseline. Reclamation does not currently have the authority or discretion to remove these structures and alter these baseline conditions. The Proposed Action includes storing, diverting, and conveying water in accordance with existing water contracts and agreements, including NWR deliveries, consistent with water rights and applicable laws and regulations. The Proposed Action also includes other actions to benefit species.

In consideration of the foregoing effects assessments, incidental take could potentially occur as a result of the Proposed Action. The main objective in this consultation is to operate the Klamath Project while meeting our obligations under the Endangered Species Act. A result of meeting our obligations is receipt of incidental take coverage of ESA-listed species for the operation of the Project. Incidental take is the taking of listed fish or wildlife species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by a federal agency or applicant (50 CFR § 402.02). The definition of take is to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a listed species or attempt to engage in any such conduct (ESA §3(19)). Harm means an act that actually kills or injures wildlife. Harm is further defined by USFWS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harass is defined by USFWS as encompassing actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR § 17.3).

Although the effects analysis describes effects to listed species in a holistic, species-level manner throughout the Action Area, Reclamation also considered whether the effects analysis indicated effects to listed species at the individual level to determine whether incidental take coverage for the Proposed Action would be necessary. Reclamation provides this Biological Assessment to help the Services develop their BiOps. The determination of jeopardy or adverse modification by the Services is based on the effects of the Proposed Action on the continued existence of the entire population of the listed species or on a listed population, and/or the effect on critical habitat. An action that does not result in jeopardy or adverse modification can nevertheless result in incidental take.

Table 10-1. Determination of effects

Species	Scientific Name	Status	Effect of the Proposed Action
SONCC Coho Salmon	*Oncorhynchus kisutch*	Threatened	May affect, likely to adversely affect
Lost River Sucker	*Deltistes luxatus*	Endangered	May affect, likely to adversely affect
Shortnose Sucker	*Chasmistes brevirostris*	Endangered	May affect, likely to adversely affect
Southern Resident DPS Killer Whale	*Orcinus orca*	Endangered	May affect, not likely to adversely affect
Southern DPS North American Green Sturgeon	*Acipenser medirostris*	Threatened	May affect, not likely to adversely affect
Southern DPS Pacific Eulachon	*Thaleichthys Pacificus*	Threatened	May affect, not likely to adversely affect
Bull Trout	*Salvelinus confluentus*	Threatened	May affect, not likely to adversely affect
Oregon Spotted Frog	*Rana pretiosa*	Threatened	No effect
Applegate's Milk-Vetch	*Astragalus applegatei*	Endangered	No effect
Monarch Butterfly	*Danaus plexippus*	Candidate	No effect
Northwestern Pond Turtle	*Actinemys marmorata*	Under Review, proposed Threatened	May affect, likely to adversely affect

Species	Scientific Name	Status	Effect of the Proposed Action
SONCC Coho Salmon Critical Habitat	*Oncorhynchus kisutch*	Designated	May affect, likely to adversely affect
Lost River Sucker Critical Habitat	*Deltistes luxatus*	Designated	May affect, likely to adversely affect
Shortnose Sucker Critical Habitat	*Chasmistes brevirostris*	Designated	May affect, likely to adversely affect
Southern DPS Pacific Eulachon Critical Habitat	*Thaleichthys Pacificus*	Designated	May affect, not likely to adversely affect
Southern DPS North American Green Sturgeon Critical Habitat	*Acipenser medirostris*	Designated	Not in Proposed Action Area and not analyzed
Bull Trout Critical Habitat	*Salvelinus confluentus*	Designated	Not likely to adversely affect
Oregon Spotted Frog Critical Habitat	*Rana pretiosa*	Designated	Not likely to adversely affect

10.2 Summary and Determination of Effects of the Proposed Action on Lost River and Shortnose Sucker and Designated Critical Habitat

10.2.1 Determination of Effects on Lost River and Shortnose Sucker

The Proposed Action results in beneficial effects for suckers through surface elevation management during water storing operations at each of the reservoirs. Management of UKL results in lower, but still adequate, elevations from late winter into fall and improves the amount of habitat at multiple life history stages by extending the periodicity and amount of shoreline spawning area, emergent vegetation habitat for larvae, and habitat diversity, water depth, and surface area for YOY juveniles, older juveniles, and adults of both sucker species. Higher lake elevations in Clear Lake and Gerber Reservoirs also increase diversity of prey base for feeding suckers, at each life history stage, with the benefit of improving individual fitness.

It is anticipated that results of dry hydrologic conditions from the environmental baseline can diminish the beneficial outcome for suckers by precluding Reclamation from managing surface elevations in a manner that maximizes habitat access for all life history stages throughout seasons when these habitats are beneficial. However, impacts from low surface elevations during important life history stages at each reservoir are expected to be less frequent and less extreme in the Proposed Action than under the MS scenario. Several factors influencing suckers from the baseline carry forward largely without influence from the Proposed Action, such as wetland/habitat loss, stressful water quality conditions, and predation.

An action carried forward in the Proposed Action from the baseline is entrainment. Sucker entrainment, while it continues to occur, is expected to be less at both Clear Lake and A Canal due to a fish screen and changes in sucker abundance over the last several decades. Sucker entrainment at other reservoirs, and at subsequent other diversion points, also carries forward from the baseline to the future conditions for suckers. Sucker entrainment at other reservoirs, and at subsequent diversion points, also carries forward from the baseline to the future conditions for suckers but entrainment may be less in the future under this Proposed Action based on diversion volumes from and recent declines in sucker abundance.

The Proposed Action provides numerous benefits for suckers through surface elevation management that provides available habitat for each life history stage (Section 5.2). The Proposed Action also may affect and is likely to adversely affect individual suckers from UKL at each life history stage through entrainment of larvae at A Canal, and multiple life history stages at LRD, LRDC (Keno), and Ady Canal (Keno). The Proposed Action also may affect and is likely to adversely affect individuals at Clear Lake and Gerber reservoirs through continued entrainment and reduced spawning access in dry years.

After considering the best available scientific and commercial information, the analysis indicates that LRS and SNS are likely to be exposed to environmental consequences and will respond in a negative manner to the exposure to adverse stressors. Thus, Reclamation concludes that implementing the Proposed Action, including the beneficial measures intended to offset adverse impacts, may affect, and is likely to adversely affect the LRS and SNS.

10.2.2 Determination of Effects on Designated Lost River and Shortnose Sucker Critical Habitat

The Proposed Action is not anticipated to influence water quality at UKL, Clear Lake Reservoir, and Gerber Reservoir. The Proposed Action is anticipated to provide relatively high surface elevations in lakes and reservoirs, which is anticipated to provide habitat for each life history stage (described above in individual impacts) within the context of the baseline.

The Proposed Action is anticipated to increase access to spawning habitats in each reservoir within the context of the baseline, except in dry hydrologic years. Periodic, though infrequent and temporary, low surface elevations as a result of low inflows may impact proposed critical habitat through limiting sucker access to spawning habitat at shoreline spawning areas in UKL, tributaries to Tule Lake Sump 1A, as well as Clear Lake and Gerber reservoirs. Reclamation anticipates habitat impacts to be seasonal and temporary with surface elevation fluctuations within the Proposed Action. Reclamation anticipates that the Proposed Action may affect, and is likely to adversely affect, designated critical habitats for LRS and SNS.

10.3 Summary and Determination of Effects of the Proposed Action on Coho Salmon and Designated Critical Habitat

10.3.1 Determination of Effects on Coho Salmon

After considering the best available scientific information, implementing the Proposed Action may affect, and is likely to adversely affect Coho Salmon survival, growth, and reproduction. The Proposed Action has beneficial impacts of providing a volume of water as the Flexible Flow Account to shape flow events to affect fish disease cycles in the river and shape river hydrograph to provide Coho Salmon habitat. Furthermore, river flows into the late summer and fall months, as a result of the Proposed Action, increase some available habitats and tributary connectivity for juveniles and for adult migration.

Factors that can affect juvenile salmon survival include disease exposure, temperature, and available habitat. The Proposed Action provides a Flexible Flow Account to simulate a natural flow regime that can address some seasonal habitat and disease issues in the Klamath River. Projects previously funded by the Klamath Coho Restoration Program and consulted on in previous consultations (NMFS, 2019) are expected to be completed during the period covered by this consultation. These efforts are likely to result in improvements and increases in Coho Salmon habitat through aquatic and riparian habitat restoration. This restoration is designed to improve conditions for adult and juvenile Coho Salmon in the areas most likely to result in improved survival, growth, and reproduction. Even with the several benefits of the Proposed Action, Reclamation concludes that the Proposed Action may affect, and is likely to adversely affect Coho Salmon survival, growth, and reproduction in the Klamath River through the act of storing and diverting water.

Reclamation anticipates both some improvements and some adverse effects to SONCC Coho with the Proposed Action. However, the Proposed Action is also likely to result in some incidental take as a result of reduced fry and juvenile habitats, particularly during dry hydrologic conditions in the spring months. Incidental take of SONCC Coho Salmon is also likely through disease-related infection and mortality.

After considering the best available scientific information, Reclamation concludes that implementing the Proposed Action may affect, and is likely to adversely affect Coho Salmon survival, growth, and reproduction. However, more natural flow regimes, through use of the Flexible Flow Account under the Proposed Action, paired with previously funded and consulted on projects through the Klamath Coho Restoration Program will help address habitat and disease issues in the Klamath River. These are expected to result in aquatic habitat restoration designed to improve conditions for adult and juvenile Coho Salmon in the areas most likely to result in improved survival, growth, and reproduction will minimize the effects of implementation of the Proposed Action.

10.3.2 Determination of Effects on Designated Coho Salmon Critical Habitat

The Proposed Action likely reduces the quantity of juvenile Coho rearing habitat in the mainstem Klamath River between IGD and the Salmon River. While there will be reductions in rearing habitat availability, particularly during spring and early summer, the Proposed Action does have flexibility to provide habitat, such as ensuring a minimum flow in critically dry years and a minimum summer flow in all years. The adverse effects to Coho Salmon juvenile habitat in the Klamath River are likely to be somewhat moderated by flow variability provided through the Proposed Action when hydrological conditions in the upper Klamath Basin allow. Effects to designated critical habitat are seasonal and temporary in nature. Previously funded and consulted projects implemented during the period of coverage for this consultation under the Klamath River Coho Restoration Program could result in improvements and increases in Coho habitat but have the potential to cause temporary adverse conditions to critical habitat. After considering the best available scientific information, Reclamation concludes that implementing the Proposed Action may affect, and is likely to adversely affect designated Coho Salmon critical habitat. However, the Proposed Action provides for more natural flow regimes and flexibility to address quantity of habitat in the Klamath River. Flexible flow accounting is anticipated to provide additional habitat in dry and critically dry years.

10.4 Summary and Determination on Effects of the Proposed Action on Southern Resident Killer Whale and Designated Critical Habitat

10.4.1 Determination of Effects on Southern Resident Killer Whale Distinct Population Segment

The Proposed Action contains components that benefit to Chinook Salmon relative to MS conditions. It provides for more natural flow regimes to address habitat and disease issues in the Klamath River. Minimum flows into the late summer and fall months increase available habitat and tributary connectivity for adult migration. The Proposed Action maintains higher flows in dry and critically dry years to increase habitat availability and respond to disease concerns. The Proposed Action likely increases the quantity of habitat for juvenile Chinook rearing habitat in the mainstem Klamath River between IGD and the Salmon River during the spring outmigration relative to the MS Scenario.

The impact on competition for available habitat is less clear. Lowered spawner/egg, fry and juvenile habitat availability leads to increased competition, which could reduce growth and survival of spawner/egg, fry, and juvenile Chinook Salmon. The Proposed Action is likely to reduce the quantity of Chinook spawner/egg, fry, and juvenile rearing habitat. The adverse effects to Chinook Salmon spawner/egg, fry and juvenile habitat in the Klamath River are likely to be somewhat moderated by flow variability provided through the Proposed Action when hydrological conditions in the Upper Klamath Basin result in additional releases and enhanced flow variability. Further, consistent ramping rates will reduce stranding risk after high flow events. The Proposed Action also emphasizes the storage of water in UKL in early spring, such that the volume is sufficient to meet the needs of Chinook over the summer. In dry years, this will help by decreasing temperatures and diluting pathogens to improve adult survival as they move upstream to spawn.

Previously funded and consulted restoration activities implemented during the period of coverage for this consultation will increase the availability of high-quality habitat that will improve survival of all life stages. Reclamation's previous funding for restoration activities, while likely to result in minor and short-term adverse effects during implementation, are anticipated to will result in longer term improvements to the function and role of instream habitat in the Action Area, and thus improve conditions for Chinook Salmon.

These actions under the Proposed Action may decrease salmon abundance within the SRKW range. SRKWs feed preferentially on Chinook but will eat Coho when Chinook and Chum salmon are not available. While it is not possible to precisely quantify the impacts to SRKWs, numerous studies have shown correlation between prey availability and population growth rate. Although the Klamath River Basin is currently a small part of the overall prey base, the range of Klamath River Chinook overlaps with the part of the range where females are often nursing calves, so abundant salmon there is especially important to SRKWs, and Klamath River Chinook are a large percentage of the available salmon within that part of the SRKW range.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the Action Area, the effects of the Proposed Action, and cumulative effects, Reclamation concludes that the Proposed Action may affect and is likely to adversely affect the SRKW DPS.

10.4.2 Determination of Effects on Southern Resident Killer Whale Critical Habitat

Reclamation's Proposed Action does not impact SRKW DPS designated critical habitat, defined as inland marine waters of Washington, except for Hood Canal and areas excluded for military exercises. NMFS revised critical habitat in August 2021 to include Pacific coastal waters from Washington through Central California, with exclusions for military exercises off the Washington Coast.

Klamath River Chinook pass through the proposed critical habitat during their time at sea. A primary constituent element of critical habitat is prey availability, and Klamath River Chinook will contribute to this. The Proposed Action is expected to increase prey availability relative to the MS scenario. Thus, the Proposed Action will provide net benefits to SRKW critical habitat relative to the MS scenario.

After considering the best available scientific information, Reclamation concludes that implementing the Proposed Action will have no effect on designated critical habitat for SRKW. The Proposed Action may affect but is not likely to adversely affect proposed SRKW critical habitat.

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64 FR 58910. U.S. Fish and Wildlife Service. Rules and Regulations Department Of The Interior Fish and Wildlife Service 50 CFR Part 17 Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States. November 1, 1999.

68 FR 31980. National Oceanic and Atmospheric Administration. Regulations Governing the Taking and Importing of Marine Mammals; Eastern North Pacific Southern Resident Killer Whales. May 28, 2003.

70 FR 37160. National Marine Fisheries Service. Final Rule. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. June 28, 2005.

70 FR 69903. National Oceanic and Atmospheric Administration. Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales. November 18, 2005.

71 FR 17757–17766. National Marine Fisheries Service. Endangered and threatened wildlife and plants: threatened status for southern distinct population segment of North American green sturgeon.

71 FR 69054. National Oceanic and Atmospheric Administration. Endangered and Threatened Species; Designation of Critical Habitat for Southern Resident Killer Whale. November 29, 2006.

74 FR 52300. National Marine Fisheries Service. Endangered and threatened wildlife and plants: final rulemaking to designate critical habitat for the threatened southern distinct population segment of North American Green Sturgeon. October 9, 2009.

75 FR 13012–13024. National Marine Fisheries Service. Endangered and threatened wildlife and plants: threatened status for southern distinct population segment of eulachon. Federal Register. March 18, 2010.

75 FR 63898. U.S. Fish and Wildlife Service. Revised designation of critical habitat for bull trout in the coterminous United States; final rule. October 18, 2010.

76 FR 20870. National Marine Fisheries Service. Protective Regulations for Killer Whales in the Northwest Region Under the Endangered Species Act and Marine Mammal Protection Act. April 14, 2011.

76 FR 65324. (2011). National Marine Fisheries Service. Endangered and threatened species; designation of critical habitat for the southern distinct population segment of eulachon. October 20, 2011.

77 FR 73739-73768. U.S. Fish and Wildlife Service. Final Rule. Designation of Critical Habitat for Lost River Sucker and Shortnose Sucker. December 11, 2012.

77 FR 73740-73768. U.S. Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Lost River Sucker and Shortnose Sucker. December 11, 2012.

78 FR 6298. National Marine Fisheries Service. Endangered and Threatened Species; Take of Anadromous Fish; Correction. January 30, 2013.

79 FR 20802. National Oceanic and Atmospheric Administration. Endangered and Threatened Wildlife; Final Rule To Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service. April 14, 2014.

79 FR 51658. U.S. Fish and Wildlife Service. Threatened status for Oregon spotted frog. Final rule. August 29, 2014.

79 FR 69428–69429. National Marine Fisheries Service. Endangered and threatened species; take of anadromous fish: issuance of a scientific purposes and enhancement of survival permit for a hatchery and genetic management plan (HGMP). November 21, 2014.

81 FR 29336. U.S. Fish and Wildlife Service. Endangered and threatened wildlife and plants; designation of critical habitat for the Oregon spotted frog. June 10, 2016.

86 FR 41668. National Oceanic and Atmospheric Administration. Endangered and Threatened Wildlife and Plants; Revision of Critical Habitat for the Southern Resident Killer Whale Distinct Population Segment. August 2, 2021.

88 FR 68370-68399. U.S. Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; Threatened Species Status With Section 4(d) Rule for the Northwestern Pond Turtle and Southwestern Pond Turtle. October 3, 2023.

California Code of Regulations 2050 (1974). Fish and Game Code 1.5 § 2050-2115.5 California Endangered Species Act, Pub. L. No. 1.5.

Executive Order 4851 April 3, 1029.

Oregon Revised Statutes (ORS). 496.171-496.192. Oregon Endangered Species Act.

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APPENDIX A Species List Correspondence

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United States Department of the Interior

BUREAU OF RECLAMATION
Klamath Basin Area Office
6600 Washburn Way
Klamath Falls, OR 97603-9365

IN REPLY REFER TO:

KO-320
2.2.2.12

VIA ELECTRONIC MAIL AND USPS

Jim Simondet, Klamath Branch Supervisor
California Coastal Area Office
National Marine Fisheries Service
1655 Herndon Road
Arcata, California 95521

Subject: Request for National Marine Fisheries Service (NMFS) Concurrence Regarding Listed Species and Critical Habitat Designations Within the Action Area of the 2024-2029 Reinitiation of Consultation Biological Assessment (BA) on the Ongoing Operations of the Klamath Project (Project)

Dear Mr. Simondet:

The Bureau of Reclamation (Reclamation) is in the process of preparing a BA to evaluate the potential effects of and determine if the Project operations may affect the Endangered Species Act (ESA) listed species and/or their designated critical habitats. Specifically, Reclamation proposes to store, divert, and convey Project water to meet authorized Project purposes and contractual obligations in compliance with applicable federal and state law.

Current analysis indicates that the action area associated with Reclamation's proposed action includes the area within the boundaries of the Project located in southern Oregon and northern California, and the Klamath River from Upper Klamath Lake to the mouth of the river at Klamath, California.

To appropriately evaluate and determine if the proposed action has the potential to affect threatened and/or endangered species, Reclamation is requesting your review and concurrence on the following ESA listed species and their respective critical habitats (50 CFR 402.12(c)) to be included in the BA for the proposed action. Our data indicates that these species are under the jurisdiction of NMFS and are documented to be present or potentially present within the action area.

NMFS Jurisdictional ESA-listed Species and their Critical Habitats (50 CFR 402.12(c)) to be included in the Reclamation 2024-2029 BA for the Proposed Action on the Ongoing Operations of the Project.

Species	Scientific Name	Status	Critical Habitat
Southern Oregon/Northern California Coast Coho Salmon	*Oncorhynchus kisutch*	Threatened	Designated
Southern Resident DPS Killer Whale	*Orcinus orca*	Endangered	Designated
Southern DPS North American Green sturgeon	*Acipenser medirostris*	Threatened	Designated
Southern DPS Pacific eulachon	*Thaleichthys pacificus*	Threatened	Designated

Please respond at your earliest convenience, with your concurrence or provide an updated species list and critical habitat designations. You can contact me at (541) 880-2561 or cashley@usbr.gov.

We look forward to hearing from you as soon as possible. Thank you for your prompt attention to this matter.

Sincerely,

CHRISTINA ASHLEY
Digitally signed by CHRISTINA ASHLEY
Date: 2024.02.12 08:27:19 -08'00'

Christina Ashley
Chief, Environmental Compliance Branch

cc: Jenny Land, Field Supervisor
U.S. Fish and Wildlife Service
1936 California Ave
Klamath Falls, OR 97601

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1655 Heindon Road
Arcata, California 95521-4573

May 29, 2024 **Refer to NMFS No: 10012WCR2024AR00028**

Christina Ashley
Chief, Environmental Compliance Branch
United States Department of the Interior, Bureau of Reclamation
Klamath Basin Area Office
6600 Washburn Way
Klamath Falls, OR 97603-9365

Dear Ms. Ashley:

Thank you for your February 12, 2024 letter requesting NOAA Fisheries National Marine Fisheries Service concurrence regarding listed species and critical habitat designations within the action area of the 2024-2029 reinitiation of consultation biological assessment on the ongoing operations of the Klamath Project. We concur with the list of ESA-listed species and their critical habitats that you provided in that letter.

If additional action is needed, we would be happy to schedule a phone call or meeting with you. If interested, please contact me at (707) 825-5171 or jim.simondet@noaa.gov.

Sincerely,

Jim Simondet
Klamath Branch Supervisor
California Coastal Office

Cc: Jenny Land, Field Supervisor, U.S. Fish and Wildlife Service

Appendix Table A-1. Federally-listed endangered, threatened, proposed, and candidate species and designated critical habitats under the jurisdiction of the U.S. Fish and Wildlife Service that may be present or potentially present in the Action Area

Species	Scientific Name	Status	Critical Habitat Status
Lost River Sucker	*Deltistes luxatus*	Endangered	Designated
Shortnose Sucker	*Chasmistes brevirostris*	Endangered	Designated
Bull Trout	*Salvelinus confluentus*	Threatened	Designated
Oregon spotted frog	*Rana pretiosa*	Threatened	Designated
Gray wolf	*Canis lupus*	Endangered	Designated
North American wolverine (DPS)	*Gulo gulo luscus*	Threatened	None
Northern spotted owl	*Strix occidentalis caurina*	Threatened	Designated
Yellow-billed cuckoo	*Coccyzus americanus*	Threatened	Designated
Applegate's milk-vetch	*Astragalus applegatei*	Endangered	None
Greene's tuctoria	*Tuctoria greenei*	Endangered	Designated
Slender Orcutt grass	*Orcuttia tenuis*	Threatened	Designated
Whitebark pine	*Pinus albicaulis*	Threatened	None
Northwestern Pond Turtle	*Actinemys marmorata*	Proposed Threatened	None
Monarch Butterfly	*Danaus plexippus*	Candidate	None
Canada lynx (DPS)	*Lynx canadensis*	Threatened	Designated
Pacific marten (Coastal DPS)	*Martes caurina*	Threatened	Proposed
Hawaiian petrel	*Pterodroma sandwichensis*	Endangered	None
Marbled murrelet	*Brachyramphus marmoratus*	Threatened	Designated
Short-tailed albatross	*Phoebastria albatrus*	Endangered	None
Tidewater goby	*Eucyclogobius newberryi*	Endangered	Designated
Western snowy plover	*Charadrius nivosus nivosus*	Threatened	Designated
Franklin's bumble bee	*Bombus franklini*	Endangered	None
Conservancy fairy shrimp	*Branchinecta conservatio*	Endangered	Designated
Shasta crayfish	*Pacifastacus fortis*	Endangered	None
Vernal pool fairy shrimp	*Branchinecta lynchi*	Threatened	Designated
Vernal pool tadpole shrimp	*Lepidurus packardi*	Endangered	Designated
Beach layia	*Layia carnosa*	Threatened	None
Gentner's fritillary	*Fritillaria gentneri*	Endangered	None
Lassics lupine	*Lupinus constancei*	Endangered	Designated
Mcdonald's rock-cress	*Arabis macdonaldiana*	Endangered	None
Yreka phlox	*Phlox hirsuta*	Endangered	None

Note: The polygon used to generate this species list in IPaC was much broader than the actual Action Area for the Klamath Project.

Appendix Table A-2. Federally-listed endangered, threatened, proposed, and candidate species and designated critical habitats under the jurisdiction of the U.S. Fish and Wildlife Service within the Action Area that U.S. Bureau of Reclamation is conducting Section 7 consultation with the U.S. Fish and Wildlife Service and is represented in the body of the 2024 Biological Assessment

Species	Scientific Name	Status	Critical Habitat Status
Lost River Sucker	*Deltistes luxatus*	Endangered	Designated
Shortnose Sucker	*Chasmistes brevirostris*	Endangered	Designated
Bull Trout	*Salvelinus confluentus*	Threatened	Designated
Oregon spotted frog	*Rana pretiosa*	Threatened	Designated
Applegate's milk-vetch	*Astragalus applegatei*	Endangered	None
Northwestern Pond Turtle	*Actinemys marmorata*	Proposed: Threatened	None
Monarch Butterfly	*Danaus plexippus*	Candidate	None

Notes: The Klamath Basin Area Office acknowledges that the Bald Eagle (*Haliaeetus leucocephalus*) and Golden Eagle (*Aquila chrysaetos*) are no longer protected under the Endangered Species Act; however, both species are still protected under the Bald and Golden Eagle Protection Act (BGEPA) and the Migratory Bird Treaty Act (MBTA). The Klamath Basin Area Office understands that the BGEPA and MBTA prohibits the taking, killing, possession, and transportation among other actions related to migratory birds, their eggs, parts, and nests, except when specifically permitted by regulations.

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APPENDIX B Species Spatial and Temporal Domains

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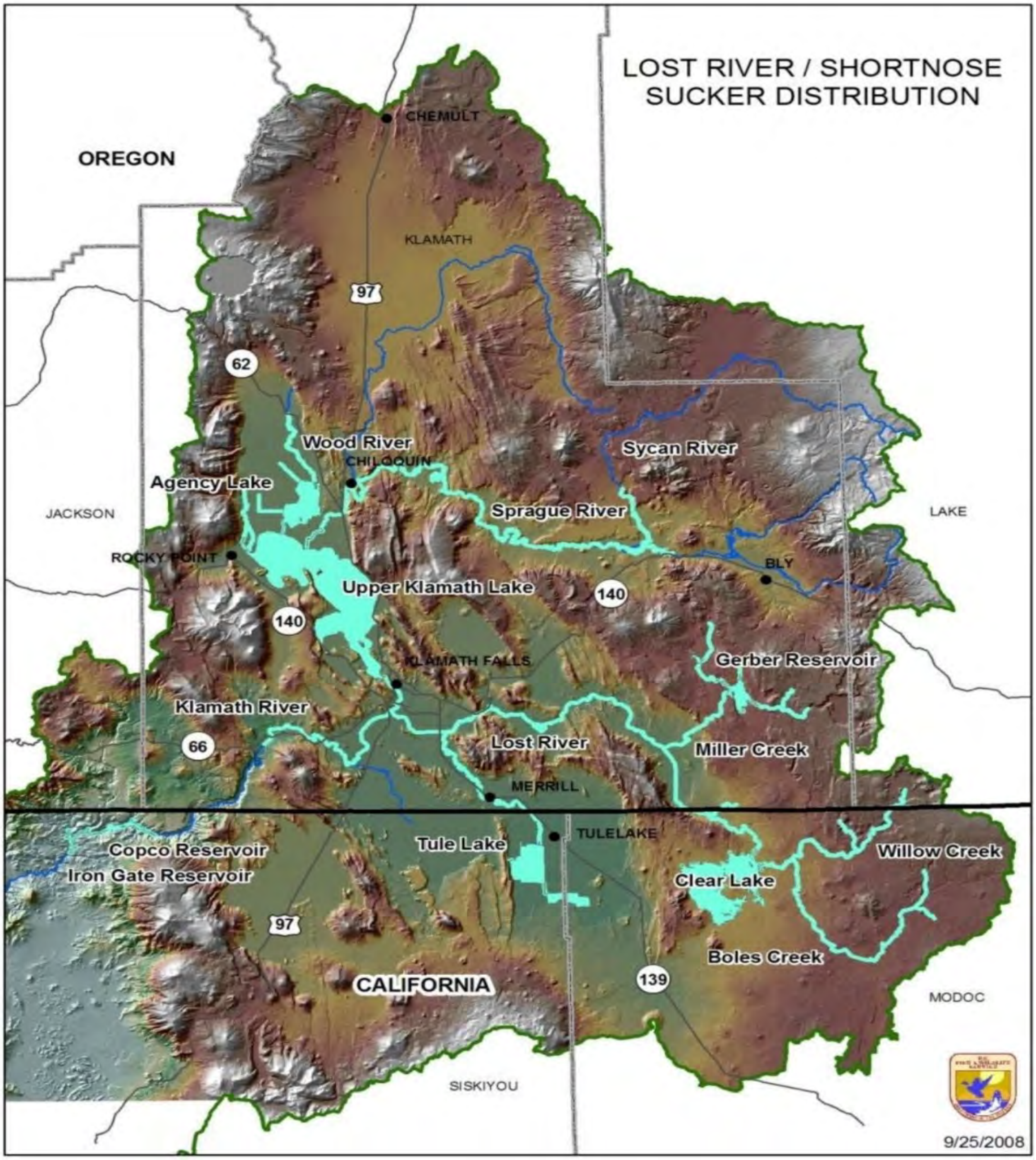
Introduction

This document describes the presence of listed species by life stage and geographic region to inform whether individuals may experience stressors that require evaluation due to operation of the Klamath Project. Sources of data in existing species timing tables were reviewed or aggregated to evaluate each species in different locations.

Variability in the timing of species present requires consideration of a broader window than conditions on average or in any single year. For example, if fish may start migrating as early as November or as late as January, then the analyses considered the migration as potentially starting in November so that the potential stressors would be evaluated. Differences in abundance were categorized, as the following describes , with approximate percentages Additionally, this document describes the observed demographics of listed species by life stage and geographic region to inform life cycle analyses completed during the evaluations of the operation of the Klamath Project. Sources of species data were reviewed and aggregated to assess long-term status and trend and inform comparisons with evaluations under alternatives.

Lost River and Shortnose Suckers

Lost River Suckers *Deltistes luxatus* (LRS*)* and Shortnose Suckers *Chasmistes brevirostris* (SNS) are endemic to the lakes and tributaries in the Upper Klamath Basin (Moyle, 2002; Appendix Figure B-1). These species are present in Upper Klamath Lake (UKL) and its tributaries, Clear Lake Reservoir and tributaries, Lake Ewauna, the Klamath River downstream to Keno Dam, the Lost River, and Gerber Reservoir (USFWS, 2002). Until recently, suckers were also present in the Klamath River impoundments (which are now part of the Klamath River since dam-removal) and, until 2023 when they went dry or only partially filled, in the Tule Lake Sumps. As of 2024, the Tule Lake Sumps have re-filled, and it is anticipated that suckers already have or will re-populated during the period of this consultation.



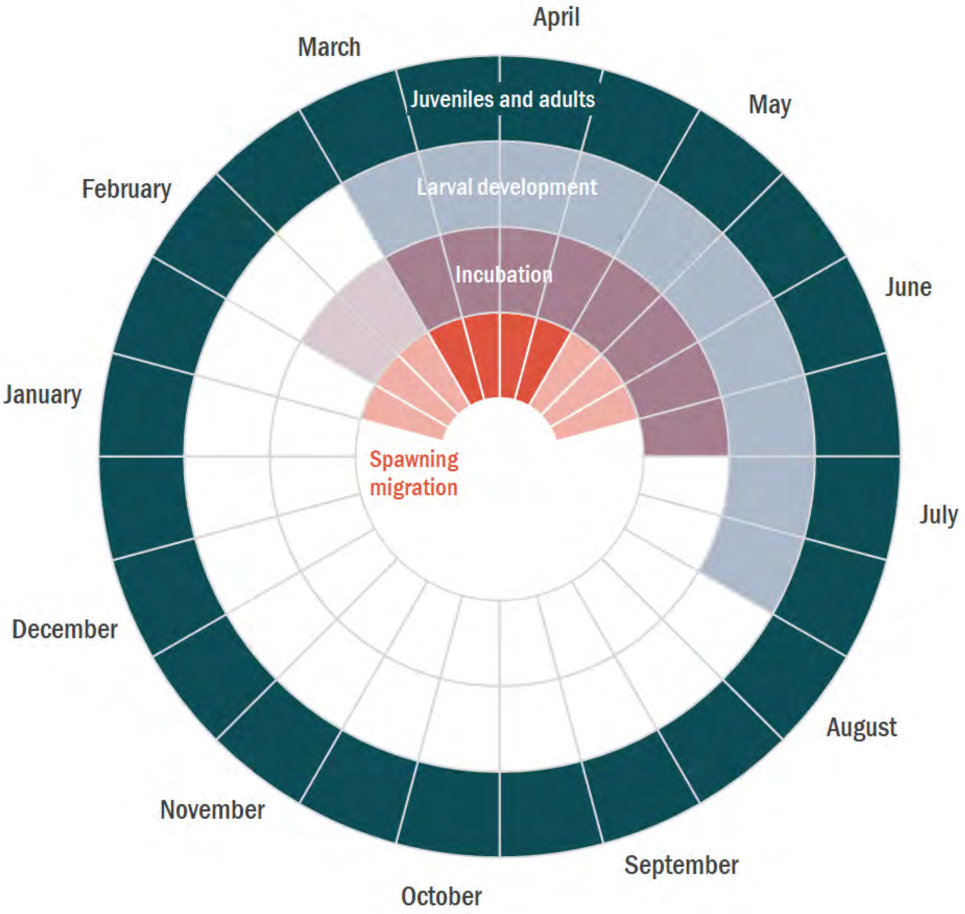
Notes: Lower Klamath Lake and Sheepy Lake populations are extirpated and therefore not shown. Source: USFWS (2019)

Appendix Figure B-1. Population distribution of Lost River and Shortnose Suckers in the upper Klamath Basin

Adult Migration

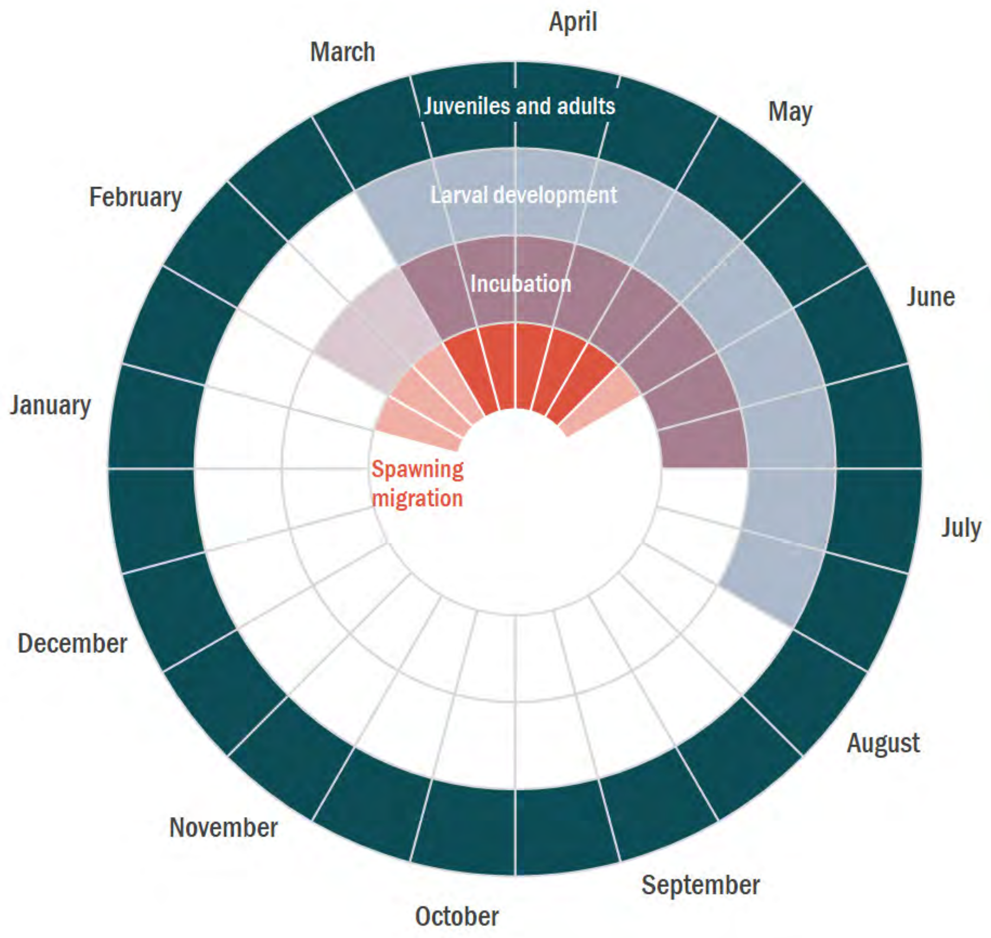
Rising water temperatures are a critical cue for initiation of migration (Hewitt et al., 2017; Hewitt and Hayes, 2013) and hydrologic conditions such as low lake elevations and low tributary flows can restrict access to shoreline (Burdick et al., 2015) and tributary spawning grounds (Hewitt and Hayes, 2013). Suckers also have a high degree of breeding site fidelity (Hewitt et al., 2018).

Adult LRS and SNS in Clear Lake Reservoir begin migrating from open water lake habitats to spawning grounds in tributary streams and rivers as early as February when water temperatures are at least 6°C, reservoir surface elevations are adequate for access to Willow Creek, and when Willow Creek has adequate flows (Hewitt et al., 2021). Adult LRS and SNS in UKL begin spawning migrations as early as March when water temperatures are 10°C for LRS, and 12°C for SNS (Hewitt et al., 2018; Appendix Figure B-2, Appendix Figure B-3).



Note: Within a ring, darker colors indicate peak periods. Data Source: Reiser et al. (2001); Hewitt et al., (2012, 2021); Hewitt and Hayes (2013)

Appendix Figure B-2. Summary of temporal life stage domains for Lost River Suckers



Note: Within a ring, darker colors indicate peak periods. Data Source: Reiser et al. (2001); Hewitt et al., (2012, 2021); Hewitt and Hayes (2013)

Appendix Figure B-3. Summary of temporal life stage domains for Shortnose Suckers

Adult Spawning

Spawning occurs from February through May in Clear Lake and March through May in UKL (Appendix Figure B-2, Appendix Figure B-3) over gravel substrates in rivers and shoreline spring habitats less than 1.3 meters (4.3 feet) deep (Buettner and Scoppettone, 1990). Both species are broadcast spawners (Buettner and Scoppettone, 1990), and fertilized eggs settle within the top few inches of the substrate until hatching (Coleman et al., 1988). In UKL there are two main spawning aggregations of LRS; those that spawn in the Williamson and Sprague rivers (tributary spawners) and those that spawn at springs along the eastern shoreline of UKL (Barry et al., 2007a). Both populations of LRS show a high degree of site fidelity, returning year after year to the same locations, with little interbreeding (Hewitt et al., 2018). SNS in UKL only spawn in the Williamson and Sprague rivers (Hewitt et al., 2018). Both species of suckers in Clear Lake Reservoir and SNS in Gerber Reservoir spawn primarily in tributary streams (Barry et al., 2007b; Banet et al., 2021).

Egg Incubation and Larval Emergence

Sucker eggs require flowing water and relatively porous substrate to allow gas exchange, waste removal, and protection from predators (Coleman et al., 1988). Eggs hatch approximately 8 days after fertilization, depending on temperature (Coleman et al., 1988). Larvae emerge from the gravel approximately 10 days after hatching, when about 7 to 10 millimeters (0.2 inches to 0.6 inches) total length and mostly transparent with a small yolk sac (Coleman et al., 1988; Buettner and Scoppettone, 1990).

Larvae

After emerging from gravel, larvae transition rapidly from tributaries to lakes (Buettner and Scoppettone, 1990; Cooperman and Markle, 2003; Ellsworth and Martin, 2012). Peak larval drift occurs in mid-May (Scoppettone et al., 1995). Most larvae from tributary populations drift from the river toward the lake during dark hours (Cooperman and Markle, 2003; Ellsworth and Martin, 2012), then exit the river current during daylight hours and move to nearshore shallow habitat (Cooperman and Markle, 2003). Little is known about the drift dynamics of LRS larvae from UKL shoreline springs.

Once in lakes, larvae generally inhabit nearshore areas (Cooperman and Markle, 2004, Erdman et al., 2011), particularly those with emergent vegetation (Cooperman and Markle, 2004). Emergent vegetation provides protection from non-native predators (e.g., fathead minnows *Pimephales promelas*), currents, and turbulence, while providing access to prey (Cooperman and Markle, 2004; Crandall et al., 2008, Markle and Dunsmoor, 2007) and warmer temperatures, which may promote growth (Crandall et al., 2008; Cooperman et al., 2010). Emergent wetland habitat also provides habitat for piscivorous predators (e.g., fathead minnows, yellow perch, and avian predators).

Differences do exist between LRS and SNS larval habitat use. SNS larvae predominantly use nearshore areas adjacent to and within emergent vegetation, and LRS larvae tend to occur more often in open-water habitat than near vegetated areas (Burdick and Brown, 2010). Additionally, habitat use differs among locations, based on local habitat availability. For example, compared to UKL, emergent vegetation is generally scarce or absent along the shorelines of Clear Lake and Gerber reservoirs (Reclamation, 2020).

Juveniles

When larvae are approximately 20–30 millimeters (0.8 to 1.2 inches), they develop into juveniles and transition from predominantly feeding at the surface to feeding near the lake bottom (Markle and Clauson, 2006). Few diet studies have been conducted, but identifiable prey include chironomid larvae and pupae, chydorids, ostracods, and harpacticoid copepods (Markle and Clauson, 2006). In UKL, juveniles are generally found in a wide variety of habitats including deeper, unvegetated offshore habitat (Buettner and Scoppettone, 1990; Burdick et al., 2008; Burdick and Brown, 2010), though some juvenile suckers continue to use relatively shallow (less than 1.2 meters [3.9 feet]) vegetated areas, and habitat use varies by species. One-year-old juveniles occupy shallow habitats during April and May, then appear to seek deeper waters along the western shore of UKL during early summer (Bottcher and Burdick, 2010; Burdick and Vanderkooi, 2010). As summer progresses and dissolved oxygen levels are reduced in this deeper part of UKL, juveniles appear to move back into shallower areas throughout the rest of the lake (Bottcher and Burdick, 2010).

Catches of age-0 suckers in UKL are typically highest in August and decline through October until very few juveniles are observed (Burdick and Martin, 2017). Previously some of the reduced abundance was thought to be associated with both emigration and entrainment from UKL (Markle et al., 2009). Age-0 suckers were thought to move from UKL into the Link River primarily between July and October, generally peaking in August (Markle et al., 2009). However, sampling efforts in Lake Ewauna catch relatively low numbers of juvenile suckers (Phillips et al., 2011; Simon et al., 2013) suggesting mechanisms other than emigration or entrainment from UKL may be involved.

Little is known about juvenile habitat use in Clear Lake Reservoir. Unlike UKL, Clear Lake Reservoir has no surrounding wetlands and only limited submerged or emergent vegetation. Some juvenile suckers in Clear Lake Reservoir may spend one or more years in the Willow Creek drainage prior to migrating into Clear Lake Reservoir (Bart et al., 2021). Juvenile suckers are found throughout Clear Lake Reservoir; for unknown reasons, juvenile suckers survive better in Clear Lake Reservoir than in UKL (Bart et al., 2021). Less is known about juvenile sucker survival in Gerber Reservoir, but it is assumed to be like Clear Lake Reservoir due to similar physical habitat characteristics.

Adult Resident

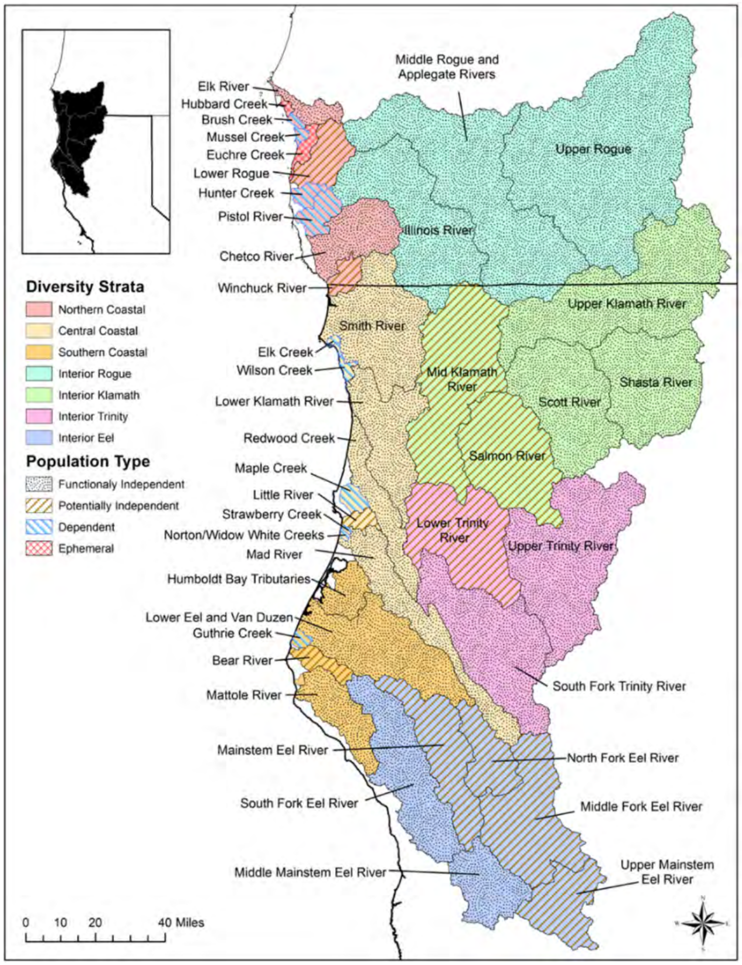
After spawning, adult LRS and SNS are distributed throughout UKL, including in Pelican Bay, typically at depths greater than 2 meters, which provides protection from avian predators and access to food resources (Banish et al., 2007, 2009). Pelican Bay has clear, cool water that was thought to be used by suckers primarily when water quality conditions are poor; however, submersible antennas deployed in May through September 2023, detected thousands of suckers in Pelican Bay in June, July, and August, suggesting some suckers use Pelican Bay throughout the summer (Krause 2023, pers. comm. 12/21/23). Previous studies have found that when water quality declines in summer, adults congregate in the northern portion of UKL (Reiser et al., 2001; Banish et al., 2009). During periods of extremely poor water quality, adult suckers seek refuge near cool-water springs with higher dissolved oxygen concentrations, and by mid-September, many suckers can be found in the northern portion of UKL and demonstrate depth preference (Banish et al., 2007, 2009). When surface elevations are low in water bodies other than UKL (e.g., Tule Lake, Clear Lake Reservoir, Gerber Reservoir), suckers do not always have access to deeper water or cool-water refuges.

Relatively little is known about the diets of adult LRS and SNS. Limited data from Clear Lake Reservoir suggest that adult LRS tend to feed directly near the lake bottom, whereas adult SNS primarily consume zooplankton from the water column (Scoppettone et al., 1995).

Coho Salmon

Coho Salmon *Oncorhynchus kisutch* within the Klamath River basins are included within the Southern Oregon/Northern California Coast (SONCC) Coho Salmon evolutionarily significant unit (ESU), which is listed as federally threatened (NMFS, 1997). This ESU includes all naturally spawning populations between Punta Gorda, California, and Cape Blanco, Oregon, which includes the Trinity and Klamath basins (NMFS, 1997).

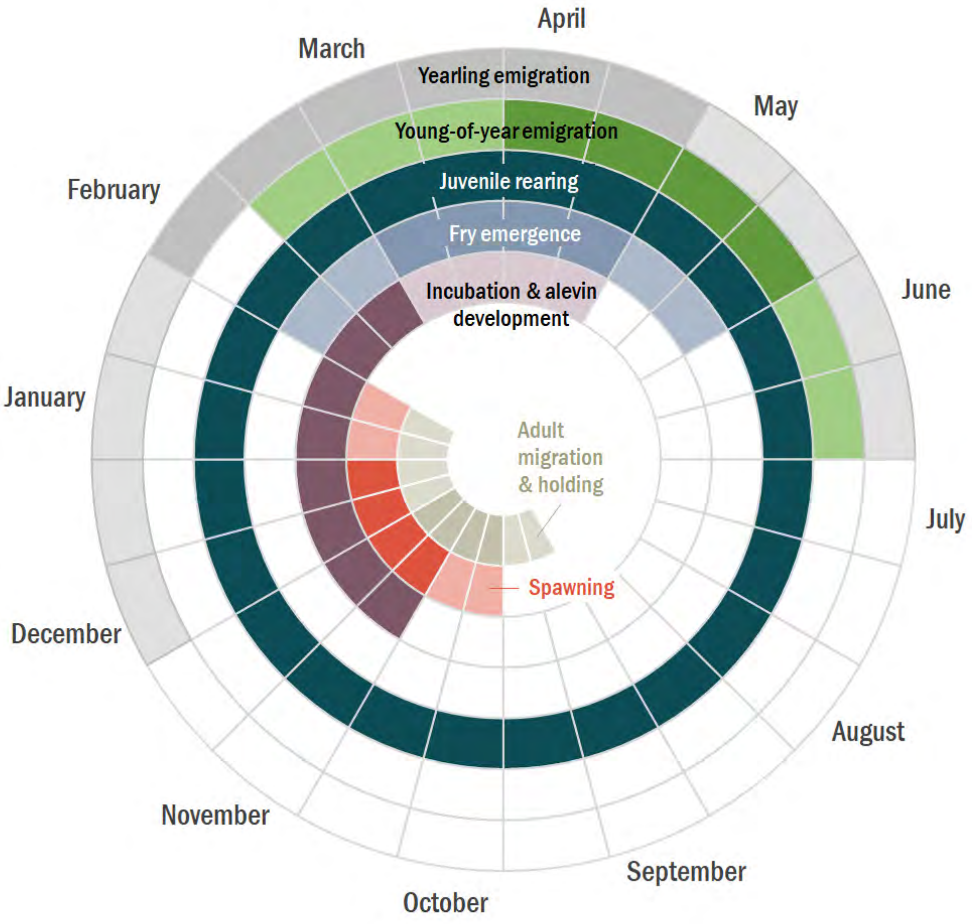
Coho Salmon are native to the Klamath Basin. Williams et al. (2006) describes nine historical Coho Salmon populations within the Klamath Basin: the Upper Klamath River, Shasta River, Scott River, Salmon River, Middle Klamath River, and Lower Klamath River (Appendix Figure B-4). The long-term operations of the Klamath Project have the potential to affect the Upper Klamath River, Shasta River, Scott River, Salmon River, Middle Klamath River, and Lower Klamath River population units.



Source: NMFS (2014)

Appendix Figure B-4. Population units within the Southern Oregon Northern California Coast Coho Salmon Evolutionary Significant Unit

Summaries of the temporal life-history domains for Klamath River Coho Salmon are shown in Appendix Figure B-5.



Note: Within a ring, darker colors indicate peak periods. Data sources: NRC (2004); FERC (2022)

Appendix Figure B-5. Summary of temporal life stage domains for Klamath River Coho Salmon

Adult Migration and Holding

From late summer through fall, Coho Salmon return from the ocean through the Klamath River Estuary, moving upstream toward spawning habitat. The Coho Salmon run in California consists mostly of 3-year-old adults that have spent about 18 months in the ocean, but a small and variable proportion of the run consists of “jacks,” sexually mature males that have reared in the ocean for less than 1 year (Sandercock, 1991; Weitkamp et al., 1995; Waples et al., 2001).

Timing of river entry by mature Coho Salmon typically corresponds with rain-driven flow increases (Moyle, 2002) and may also be related to the distance that must be traveled to reach natal spawning streams (NMFS, 2014), so the timing of fall rains and the geographic location of the population unit to which a fish belongs are believed to dictate migration onset. After completing their upstream migration, mature Coho Salmon may hold for days, weeks, or sometimes months before spawning, and for many Coho Salmon populations there is no correlation between timing of river entry and spawning date (Sandercock, 1991).

Spawning and Egg Incubation

Coho Salmon spawn primarily in tributaries rather than large mainstem rivers (Sandercock, 1991; Moyle, 2002). After arriving on the spawning ground, female Coho Salmon select a nest site and defend the area against other females (Sandercock, 1991). Spawning occurs in riffles with suitable gravel and hydraulic characteristics, where the female excavates a series of redds and deposits several hundred eggs in each (Shapovalov and Taft, 1954; Sandercock, 1991). Spawning may take about a week to complete, and the female may guard a nest for up to 2 weeks (Hassler, 1987). Both males and females die after spawning. Leidy and Leidy (1984) characterized the spawning period for Coho Salmon in tributaries of the Klamath River as extending from November through January and possibly into February (Appendix Figure B-5).

Following deposition in the gravel, Coho Salmon eggs incubate for 35–50 days (Shapovalov and Taft, 1954), with the duration of incubation inversely related to water temperature. The typical egg incubation period for Coho Salmon in the Klamath Basin is November through March, with emergence of alevins occurring from February through mid-May (Leidy and Leidy, 1984).

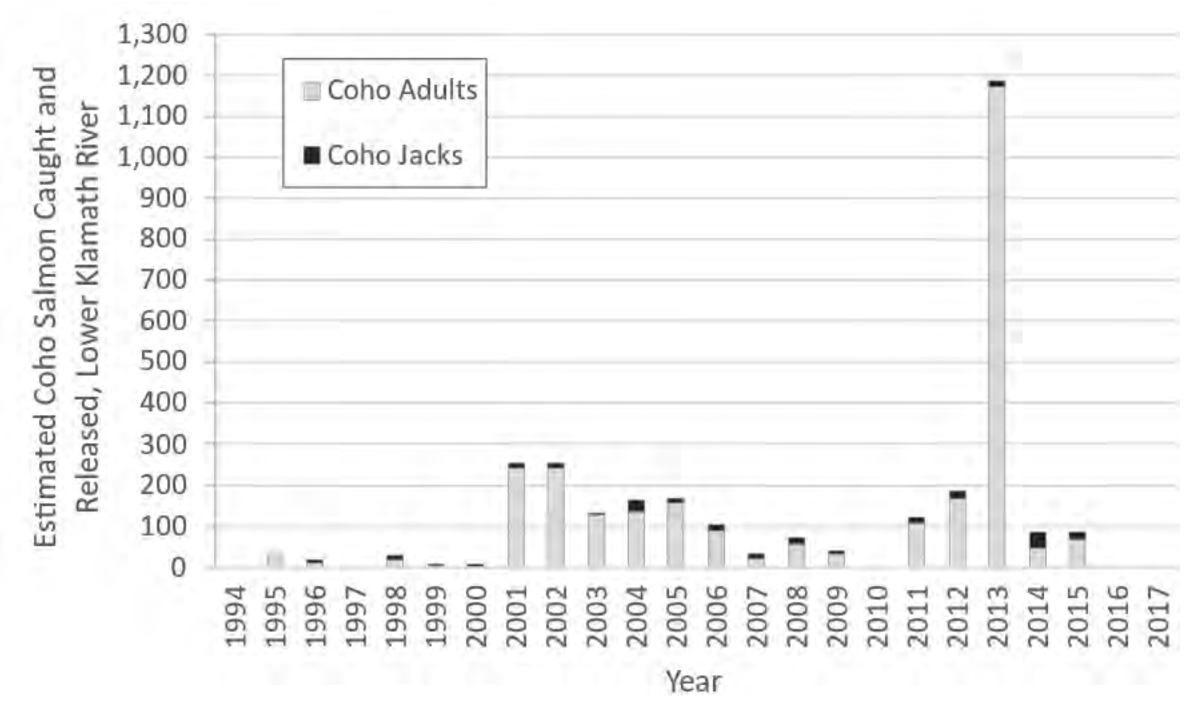
Juvenile Rearing and Migration

Juvenile Coho Salmon in California typically rear in freshwater for about 12–15 months and migrate to the ocean as yearling smolts (Leidy and Leidy, 1984; Sandercock, 1991, Moyle, 2002), but in some populations—including Prairie Creek in Humboldt County, California, part of the SONCC ESU—a portion of the out-migrating smolts may be 2-year-olds (Bell et al., 2001; Bell and Duffy, 2007). The time spent rearing in freshwater may be related to winter growth rate, with juveniles that experience slower winter growth in their first year remaining to rear a second year before out-migrating as 2-year-olds (Bell and Duffy, 2007).

Research in the SONCC ESU and elsewhere has shown that juvenile Coho Salmon in freshwater may exhibit multiple life history strategies that include rearing in estuaries, lower mainstem river reaches, and the river-estuary transition zone before entering the ocean (Tschaplinski, 1988; Pinnix et al., 2013; Jones et al., 2014).

Spawner Adult Abundance

Harvest (retention) of Coho Salmon in ocean commercial and recreational fisheries has been prohibited from Cape Falcon, Oregon (south of the Columbia River) to the United States/Mexico border since 1994, and in California waters—including rivers and streams—since 1998 (14 CCR § 7.00). As a result, NMFS (2016b) characterized freshwater recreational fishery impacts on SONCC Coho Salmon as relatively low. Creel surveys conducted in the lower Klamath River provide rough estimates of annual catch-and-release numbers for Coho Salmon. From 1994–2017, an average of 10 Coho Salmon jacks (range 0–38) and 114 adults (range 0–1,173) were estimated to have been caught and released annually (Appendix Figure B-6; Troxel and Lindke, 2018).



Source: Troxel and Lindke (2018)

Appendix Figure B-6. Estimated number of Coho Salmon caught and released in the Lower Klamath River, 1994–2017

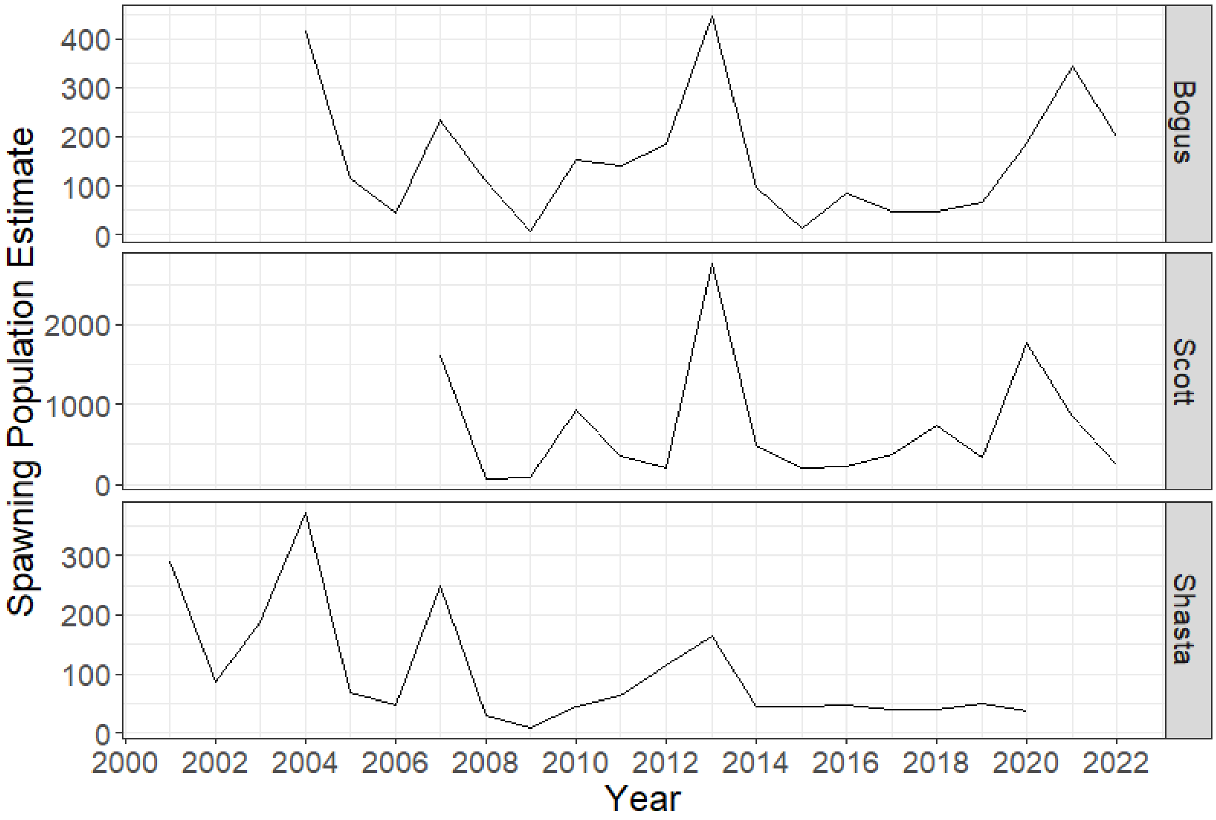
In the Klamath-Trinity basin, the Yurok, Hoopa, and Karuk tribes harvest a relatively small number of Coho Salmon for subsistence and ceremonial purposes. Harvest data are available from the Yurok and Hoopa tribes. The estimated annual Yurok harvest from 1997–2022, based on expansions of Klamath River harvest monitoring data from the Klamath River Estuary, Middle Klamath, and Upper Klamath areas of the Yurok Indian Reservation (all of which are downstream of the Klamath-Trinity confluence), ranged from 8–2,455 adult Coho Salmon, with an estimated average annual harvest of 425 over this period (Appendix Table B-1). Coho Salmon harvest estimates are differentiated by origin based on presence/absence and location of a maxillary bone clip (left or right side), providing an estimate of the number of adult Coho Salmon of natural origin and those originating from the Trinity River Hatchery on the upper Trinity River or Iron Gate Hatchery on the Klamath River. From 1997–2022, the percentage of Trinity River Hatchery-origin Coho Salmon in the Yurok harvest averaged 39% (range: 7%–66%) (Appendix Table B-1).

Appendix Table B-1. Estimated Yurok Tribe Coho Salmon harvest from the Klamath River Estuary, Middle Klamath, and Upper Klamath areas of the Yurok Indian Reservation

Year	Total Harvest	Natural Origin (Unclipped)	Iron Gate Hatchery Origin (Left Maxillary Clip)	Trinity River Hatchery Origin (Right Maxillary Clip)	Percent Trinity River Hatchery Origin
1997	71	14	22	21	30%
1998	176	55	7	117	66%
1999	238	83	1	120	50%
2000	113	37	0	70	62%
2001	2,455	974	146	1,214	49%
2002	493	130	18	327	66%
2003	352	124	78	121	34%
2004	1,569	952	14	553	35%
2005	990	275	69	640	65%
2006	592	255	2	241	41%
2007	174	95	9	61	35%
2008	819	192	134	472	58%
2009	206	69	3	132	64%
2010	416	174	24	211	51%
2011	178	131	2	19	11%
2012	287	113	10	102	36%
2013	1,244	639	154	445	36%
2014	21	14	0	7	33%
2015	165	130	0	35	21%
2016	105	77	5	23	22%
2017	8	4	0	4	50%
2018	82	76	0	6	7%
2019	34	28	2	4	12%
2020	110	77	16	17	15%
2021	89	50	11	28	31%
2022	59	25	13	21	36%
Average	425	184	28	193	39%

Sources: 1997–2013 data from Williams (2015); 2014–2022 data (unpublished) provided by C. Laskodi, Yurok Tribe.

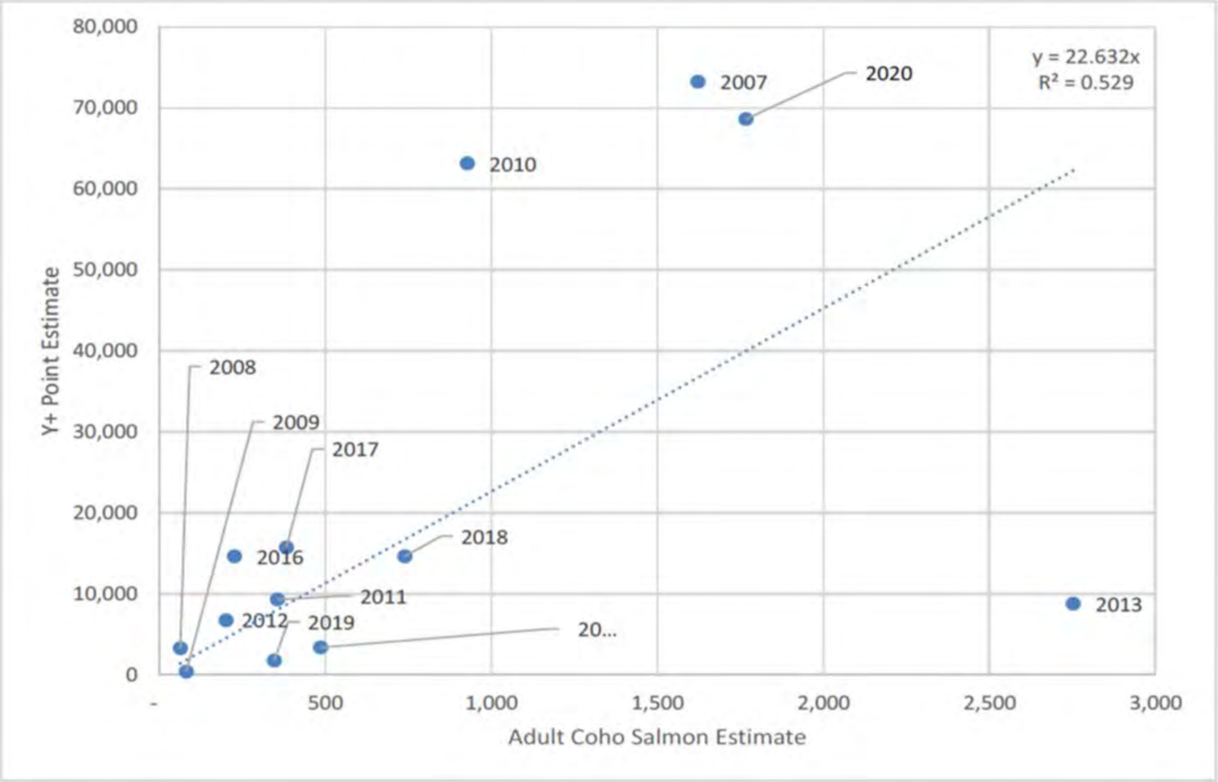
The Shasta and Scott River and Bogus Creek adult video weir monitoring projects provide two spawner abundance estimates for Klamath SONCC Coho Salmon (Appendix Figure B-7). The Shasta River has an average spawner abundance of 102 (range: 9–373). The Scott River has an average spanner abundance of 645 (range: 63–2752), and Bogus Creek has an average spawner abundance of 138 (range: 7–446) over the period of record.



Source: Data from Knechtle and Giudice (2023a,b); Giudice and Knechtle (2023)

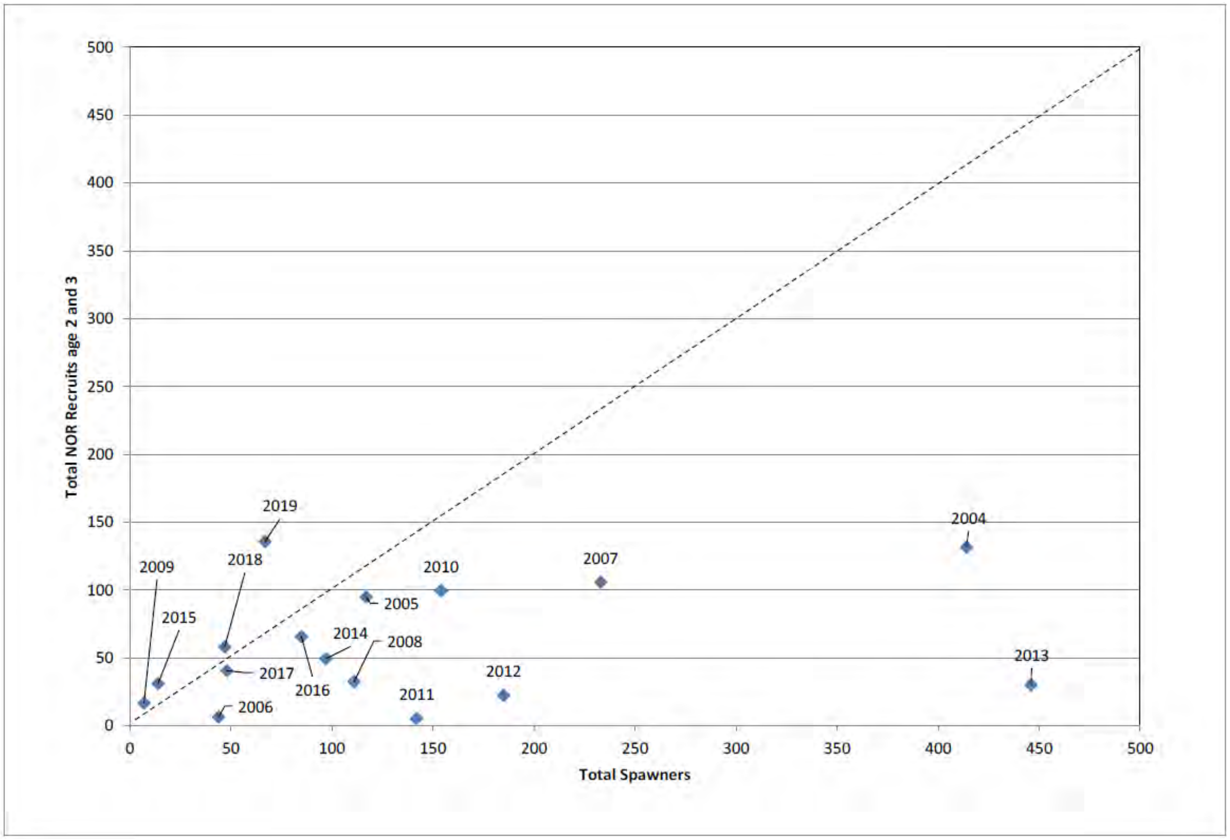
Appendix Figure B-7. Spawning population abundance for Bogus Creek, Scott River, and Shasta River populations of Southern Oregon Northern California Coast Coho Salmon

Productivity



Source: Knechtle and Giudice (2023a)

Appendix Figure B-8. Number of returning adults and corresponding number of Y+ Coho Salmon produced by brood year in the Scott River, for Brood Years 2007-2014 and 2016-2020



Source: Knechtle and Giudice (2023b)

Appendix Figure B-9. Total Spawner (natural plus hatchery origin) to natural origin recruit analysis for Bogus Creek Coho Salmon for spawner Brood Years 2004, 2005, and 2007-2016

Fecundity

Fecundity data for Klamath River Coho Salmon is available only for hatchery-origin Coho returning to the Iron Gate Hatchery (Appendix Table B-2). For the period encompassing brood years 1993-2018, average fecundity of hatchery origin Coho Salmon was 2,563 eggs per female and ranged from 1,711 to 3,258 (CDFW, 2019, Table 7).

Appendix Table B-2. Fecundity (eggs per female) of Coho Salmon returning to the Iron Gate Hatchery 1993–2018

Brood Year	Eggs/Female
1993	2,298
1994	2,481
1995	2,660
1996	2,736
1997	2,418

Brood Year	Eggs/Female
1998	2,446
1999	2,472
2000	2,844
2001	3,209
2002	3,258
2003	2,548
2004	2,897
2005	2,865
2006	2,781
2007	2,550
2008	3,078
2009	2,672
2010	3,244
2011	2,653
2012	2,479
2013	2,801
2014	1,936
2015	1,711
2016	1,900
2017	1,922
2018	1,787
Average	2,563

Source: Data from Table 7 in CDFW (2019)

Redds

Salmonid spawning surveys in the Shasta and Scott rivers as well as Bogus Creek are primarily focused on Chinook Salmon *Oncorhynchus tshawytscha* and do not span the entire Coho Salmon spawning period. Coho Salmon redd and carcass counts are therefore considered incomplete and do not provide accurate estimates of Coho Salmon spawner abundance in the Klamath River.

Survival of Eggs

Egg survival data for Klamath River Coho Salmon is available only for hatchery-origin Coho returning to the Iron Gate Hatchery and only for egg to smolt survival (Appendix Table B-3). For the period encompassing brood years 1993-2017, average egg to smolt of hatchery origin Coho Salmon was 37% and ranged from 10% to 79% (CDFW, 2019, Table 7).

Appendix Table B-3. Egg Survival (egg to smolt percentage) of Coho Salmon returning to the Iron Gate Hatchery 1993–2017

Brood Year	Egg to Smolt Survival (%)
1993	16
1994	53
1995	10
1996	15
1997	25
1998	26
1999	53
2000	25
2001	18
2002	18
2003	15
2004	11
2005	40
2006	23
2007	37
2008	27
2009	42
2010	60
2011	26
2012	49
2013	40
2014	74
2015	77
2016	79
2017	76
Average	37

Source: Data from Table 7 in CDFW (2019)

Survival of Fry

Estimates of survival of SONCC Coho Salmon fry in the Klamath River are not available.

Fry Abundance

Estimates of SONCC Coho Salmon fry abundance in the Klamath River are not available.

Survival of Parr

Estimates of SONCC Coho Salmon parr survival in the Klamath River are not available.

Parr Abundance

Parr abundance estimates are available for SONCC Coho Slamon in the Shasta River (Appendix Table B-4). These estimates average 2,594 parr (range: 19–11052) over the period of record (2003–2020).

Appendix Table B-4. Parr Abundance estimates for Southern Oregon Northern California Coast Coho Salmon Coho Salmon in the Shasta River

Yearling Year	Natural Origin Yearling Point Estimate
2003	11,052
2004	1,799
2005	2,054
2006	10,833
2007	1,178
2008	208
2009	5,396
2010	169
2011	19
2012	2,049
2013	494
2014	850
2015	6,279
2016	229
2017	28
2018	3,697
2019	69
2020	291
2021	Not Available

Source: Massie and Morrow (2020), as reported in Giudice and Knechtle (2020)

Survival of Smolts

Estimates of SONCC Coho Salmon smolt survival are available for the Shasta and Scott rivers (Appendix Table B-5). The estimates average 26.2% (range: 0.34%–255.6%) and 7.9% (range: 1.25%–55.81%) for the Shasta and Scott rivers, respectively, over the period of record.

Appendix Table B-5. Southern Oregon Northern California Coast Coho Salmon Coho Salmon smolt survival estimates for Shasta and Scott rivers

Smolt Year	Natural Origin Smolt Survival Point Estimate Shasta River	Natural Origin Smolt Survival Point Estimate Scott River
2003	2.93%	--
2004	3.30%	--

Smolt Year	Natural Origin Smolt Survival Point Estimate Shasta River	Natural Origin Smolt Survival Point Estimate Scott River
2005	1.84%	--
2006	2.20%	1.69%
2007	0.58%	1.48%
2008	3.37%	7.01%
2009	0.52%	1.25%
2010	7.91%	10.99%
2011	255.56%	55.81%
2012	3.51%	4.19%
2013	0.34%	5.43%
2014	4.54%	4.31%
2015	0.66%	2.85%
2016	14.93%	10.79%
2017	118.18%	Not Available
2018	1.25%	2.5%
2019	52.17%	10.64%
2020	17.87%	6.47%
2021	6.46%	13.51%

Source: Massie and Morrow (2020), as reported in Giudice and Knechtle (2020); Romero and Robinson (2023a,b).

Smolt Abundance

Estimates of Coho Salmon smolt abundance are available for the Shasta and Scott rivers (Appendix Table B-6). The estimates average 2,672 (range: 9–12,735) and 22,866 (range: 353–95815) for the Shasta and Scott rivers, respectively, over the period of record.

Appendix Table B-6. Southern Oregon Northern California Coast Coho Salmon Coho Salmon smolt abundance estimates for Shasta and Scott rivers

Smolt Year	Natural Origin Smolt Abundance Point Estimate Shasta River	Natural Origin Smolt Abundance Point Estimate Scott River
2003	12,735	--
2004	2,090	--
2005	2,554	--
2006	11,077	95,815
2007	1,374	3,931
2008	208	1,142
2009	6,295	73,232
2010	215	3,257
2011	9	353
2012	2,049	63,135
2013	586	9,283
2014	991	6,734

Smolt Year	Natural Origin Smolt Abundance Point Estimate Shasta River	Natural Origin Smolt Abundance Point Estimate Scott River
2015	7,326	8,758
2016	268	3,372
2017	33	Not Available
2018	4,236	14,628
2019	69	15,707
2020	291	14,628
2021	728	1,762
2022	1,950	68,966
2023	1,029	4,014

Source: Massie and Morrow (2020), as reported in Giudice and Knechtle (2020); Romero and Robinson (2023a,b).

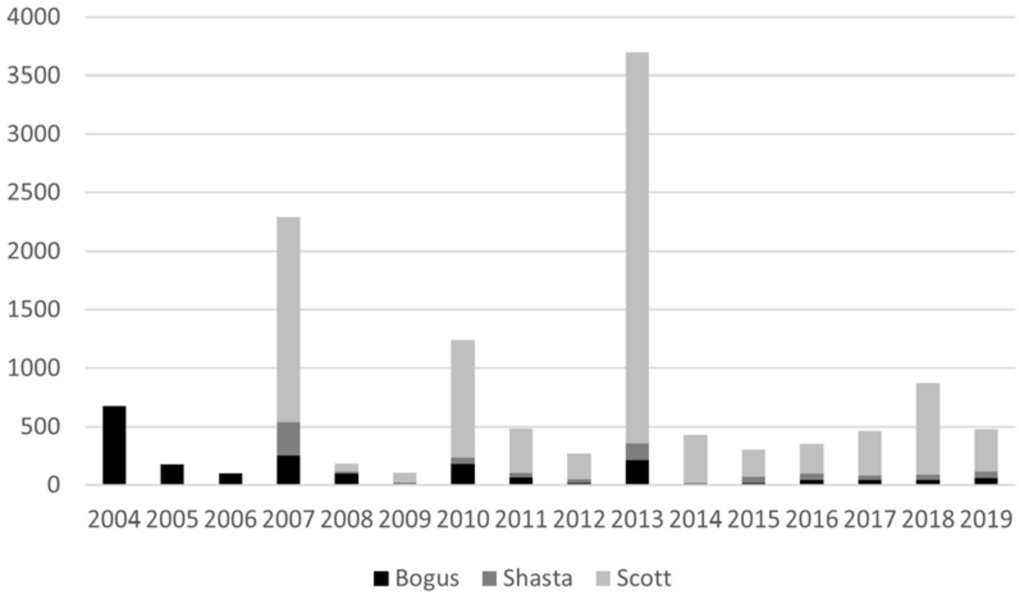
Survival of Juveniles in Ocean

Estimates of SONCC Coho Salmon juvenile ocean survival for the Klamath River are not available.

Ocean Abundance

Wild SONCC Coho Salmon are not tagged or monitored in ocean fisheries and there is no ocean abundance forecast for natural-origin SONCC Coho Salmon (PFMC, 2021).

Annual forecasts of ocean abundance for hatchery-origin SONCC Coho Salmon are produced as part of the Oregon Production Index public hatchery forecast process (PFMC, 2021). The Oregon Production Index Technical Team generates a forecast of aggregate hatchery-origin Coho Salmon abundance from northern California to the Columbia River, and a subset of this aggregate forecast is apportioned to the Rogue-Klamath basins based on the total number of smolts released from three hatcheries, one of which is Iron Gate Hatchery. Annual estimates of pre-fishery ocean abundance of Klamath River Coho Salmon of Iron Gate Hatchery origin are available from 1997–2019 (PFMC, 2021). During this period, estimated ocean abundance ranged from a low of 59 in 2017 to a high of 10,261 in 2004 (Appendix Figure B-10).



Source: PFMC (2021)

Appendix Figure B-10. Estimated pre-fishery ocean abundance of Klamath River (Iron Gate Hatchery-origin) Coho Salmon, 1997–2019

Subadult Ocean Survival

Cochran (2015) studied the effects of outmigrant size on marine survival of Coho Salmon from several northern California watersheds, including some within the SONCC Coho Salmon ESU. Estimated marine survival of Coho Salmon out-migrating from 2000–2012 ranged from <1%–22%, with survival ≤12% in most years and from most watersheds. Cochran (2015) found considerable variability in ocean survival among and between Cohorts, among watersheds, and between analysis techniques, with little evidence that size at outmigration was a reliable determinant of marine survival for Coho Salmon in the northern California study streams.

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APPENDIX C Description of the Klamath Basin Planning Model, Keno Release Version

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As in the previous Section 7 Endangered Species Act (ESA) consultations on U.S. Bureau of Reclamation (Reclamation) Project operations, the Klamath Basin Planning Model (KBPM) was used to simulate operations under the Proposed Action. Various versions of the KBPM have been used since 2009, each based in the Water Resources Integrated Modeling System (WRIMS). This highly flexible modeling system enables implementation of operational alternatives in simulations. In the current re-consultation effort, removal of dams in the Klamath Hydroelectric Project required that the downstream-most compliance point be moved from the U.S. Geological Survey (USGS) gage below Iron Gate Dam to the USGS gage below Keno Dam. As a result, the version of the KBPM developed in support of this re-consultation has been named the Keno Release Model (KRM). The operational strategy embodied in the Proposed Action as simulated by the KRM is described in this Appendix.

Some aspects of the KRM that were described previously are not discussed in detail herein. Agricultural deliveries in the KRM are simulated using the Agricultural Water Delivery Sub-model described in Section A.4.4.4 of Appendix A to Reclamation’s 2018 Biological Assessment (Reclamation, 2018), which is fully incorporated into the KRM. Also, the modifications to the KBPM used in the KRM to simulate reconnection to Upper Klamath Lake (UKL) of the reclaimed former wetland area within the Upper Klamath National Wildlife Refuge were documented in Dunsmoor (2022).

Key Structural Variables

The KRM implements a consistent year-round operational strategy for making water management decisions focused on continuous tracking of the hydrologic conditions in the Upper Klamath Basin using the Normalized Wetness Index (NWI) and water storage conditions in UKL using the UKL Status Index (UKL Status). These two indices are combined into a single Operations Index (Ops Index) that is used to distribute water among the various uses relative to conditions of basin hydrology and UKL storage.

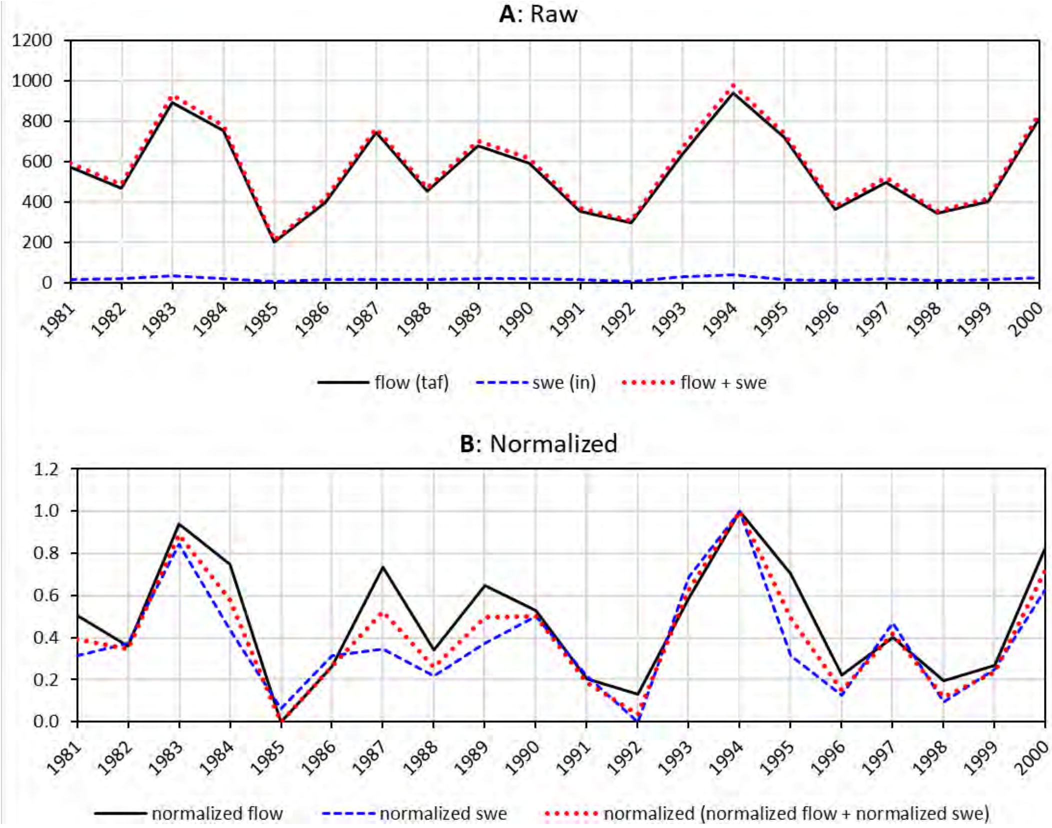
Normalizing Variables

All three indices use normalized variables. Normalized variables are rescaled to the minimum and maximum values for water years 1991-2022 using this equation:

$$Normalized_i = \left(\frac{X_i - X_{min}}{X_{max} - X_{min}}\right) \quad (1)$$

Where i is day (or month for climate index variables) and min/max are the daily (monthly) minima/maxima over the 1991-2022 period. This simple rescaling of variables with different units retains the relative patterns within each variable while ensuring that the normalized variable is zero when the raw variable is at the minimum, and 1 when the raw variable is at the maximum. When applying this formula to time frames outside of the 1991-2022 period that may contain more extreme minima or maxima, the calculation is constrained to a minimum of 0 and a maximum of 1.

In addition, normalized variables can be meaningfully combined in ways that the raw variables cannot. To illustrate, consider two made-up time series consisting of flow volumes measured in thousands of acre-feet (TAF) and snowpack water content measured in inches of snow-water equivalents (SWE) on Appendix Figure C-1A. Because the units of the two raw variables are so different, combining them as a sum retains nearly all the information from the variable with the largest units (flow, TAF) and nearly none of the information from the variable with the smallest units (SWE, inches). However, if the two variables are normalized to their respective maxima and minima (Appendix Figure C-1B) the scale difference is eliminated because each is now unitless, scaled from 0 (when at the raw minimum) to 1 (when at the raw maximum). Rescaling the variables in this way also retains the patterns within each variable in that the relative position of each normalized data point is unchanged from the raw data. If the two normalized variables are summed, and the sum is subsequently normalized, then the information from each variable is retained equally despite the different units of the raw variables.



Notes: In A, raw variables with different units (TAF of flow, and inches of SWE of the snowpack) do not retain equivalent information from each variable when summed because of the large difference in magnitudes of the units. In B, the normalized variables are now on the same scale (0 to 1), each retains the relative patterns of the raw variables, and the normalized sum retains equal amounts of information from each variable.

Appendix Figure C-1. An illustrative example of normalization using made-up variables

Normalized Wetness Index

Within the KRM, the hydrologic status of the Upper Klamath Basin is estimated using two versions of the NWI. The daily version of the NWI tracks hydrologic conditions throughout the year, and as a component of the Ops Index is a key variable governing the distribution of water. The seasonal version of the NWI generates seasonal forecasts of UKL net inflow that are used by the KRM to determine water allocations from UKL to the Project irrigators.

Daily Version of the Normalized Wetness Index

The NWI is a daily index expressing the hydrologic status of the Upper Klamath Basin that is used by the KRM in two ways. The continuous daily NWI is one component of the Ops Index, the main structural variable governing the movement of water in the KRM. Because the NWI was designed to track with UKL net inflow, with some modification from its daily form, it can be used to forecast seasonal UKL net inflow volumes that are used in the KRM to allocate water to Project irrigation. This seasonal forecasting application of the NWI is described in the *Seasonal Version of the Normalized Wetness Index* section below.

The daily version of the NWI is a daily index expressing the hydrologic status of the Upper Klamath Basin, calculated as:

$$WI_d = q_dQ_d + s_dS_d + pn_dPN_d + pl_dPL_d + c_dC \tag{2}$$

where:

q_d is the daily weight for UKL net inflow.

Q_d is the normalized 30-day trailing sum of UKL net inflow volume.

s_d is the overall daily weight for the SWE of the snowpack.

S_d is the normalized weighted mean SWE of the three 8-digit hydrologic unit code (HUC8) catchments upstream of Link River Dam, where the weights are the proportion of each catchment area exceeding 1,500 m (4,839 ft) in elevation to the total area exceeding 1,500 m in all three catchments. Mean SWE of each HUC8 catchment is computed using the Natural Resources Conservation Service (NRCS) Snow Telemetry (SNOTEL) stations listed in Appendix Table C-1 and mapped on Appendix Figure C-2.

pn_d is the overall daily weight for the 30-day trailing sum of precipitation.

PN_d is the normalized weighted mean 30-day trailing sum of precipitation of the three HUC8 catchments upstream of Link River Dam, where the weights are the proportion of each catchment area to the total area of all three catchments. Daily precipitation time series were acquired from Parameter-elevation Regressions on Independent Slopes Model (PRISM) outputs for ten randomly selected 4-km grids within each HUC8 catchment, from which a daily mean was calculated for each HUC8 catchment. PRISM precipitation data were obtained July 6, 2023, from the PRISM Climate Group at Oregon State University.

pl_d is the overall daily weight for the 31- (1 month) to 1,095-day (36 months or 3 years) trailing sum of precipitation.

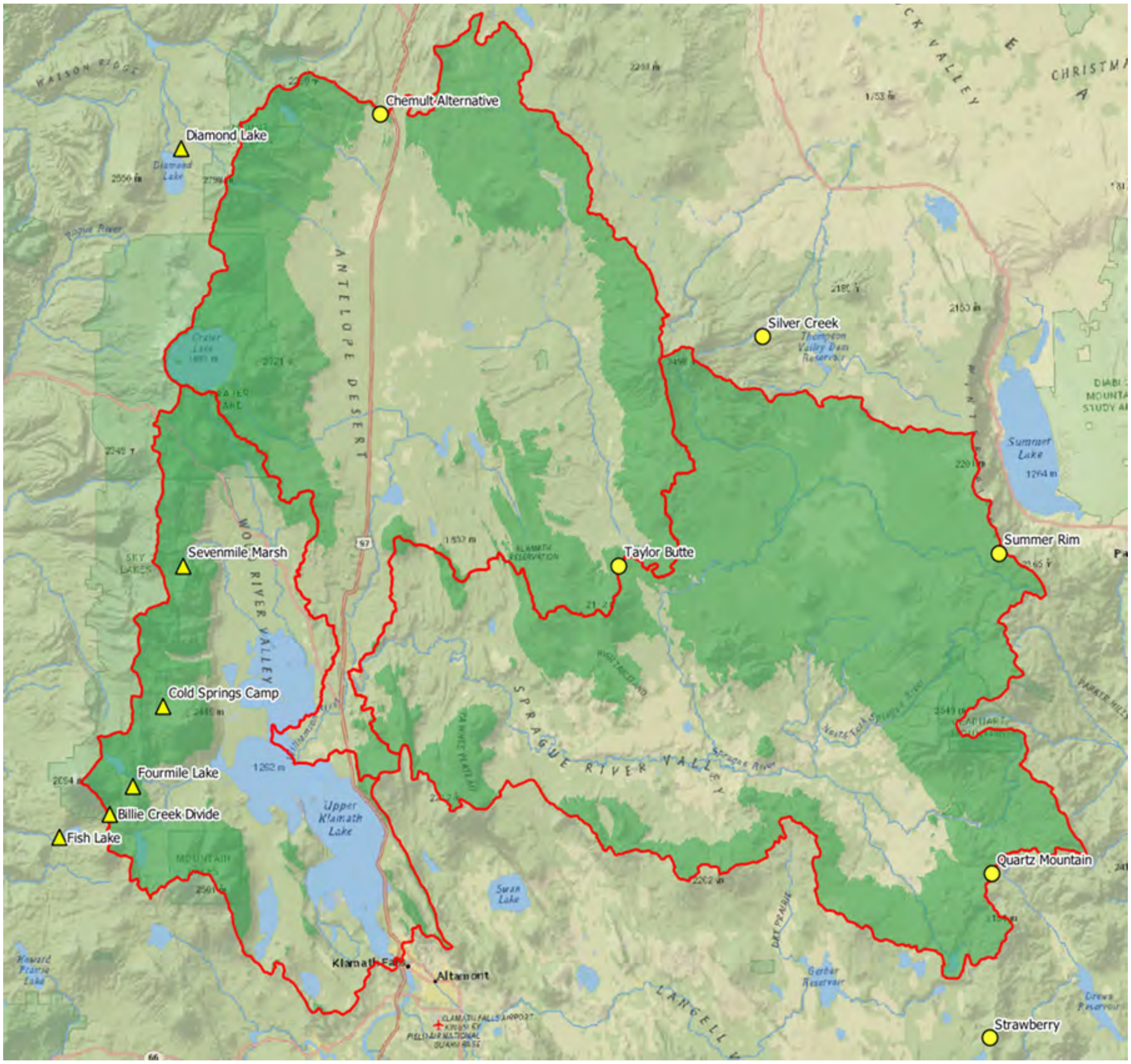
PL_d is the normalized weighted mean 31- to 1,095-day trailing sum of precipitation of the three HUC8 catchments upstream of Link River Dam, otherwise computed similarly to PN_d. Precipitation conditions over the prior 3 years is intended to capture effects, for example, of extended periods of dry or wet conditions on processes that may influence inflow (e.g., soil moisture conditions, flow of springs from responsive aquifers, etc.).

c_d is the daily weight for the climate index.

C is, from December 1 to April 14, the 3-month trailing mean of the normalized Pacific Decadal Oscillation index (PDO; Mantua et al., 1997) for the prior month. From April 15 to November 30, C captures the interaction of the monthly PDO index and the monthly Niño 3.4 sea surface temperature anomalies index (N34), computed as follows. First, the complement of the normalized N34 is calculated (1 – normalized N34). Second, the normalized PDO and the complement of the normalized N34 are summed by month and normalized again. Finally, the 3-month trailing mean is computed, and the value from the prior month is used. Each index is computed from the Extended Reconstructed Sea Surface Temperature (ERSST) version 5 data set (Huang et al., 2017).

Appendix Table C-1. Natural Resources Conservation Service Snow Telemetry sites used to calculate mean snow-water equivalents for the 8-digit hydrologic unit code catchments above Link River Dam

Upper Klamath Lake HUC8 18010203	**Williamson HUC8 18010201**	**Sprague HUC8 18010202**
Fish Lake	Diamond Lake	Silver Creek
Billie Creek Divide	Chemult Alternate	Taylor Butte
Fourmile Lake	Silver Creek	Summer Rim
Cold Springs Camp	Taylor Butte	Quartz Mountain
Sevenmile Marsh	-	Strawberry



Notes: HUC8 catchments are outlined in red. Yellow symbols denote SNOTEL sites in the Cascade Mountains (triangles) and east of the Cascade Mountains (circles). Green-shaded areas are above 1,500 m in elevation.

Appendix Figure C-2. Natural Resources Conservation Service Snow Telemetry sites used to calculate mean snow-water equivalents for the daily and seasonal versions of the Normalized Wetness Index

Variables were normalized to the period-of-record for water years 1991-2022 using Equation 1. The last step in computing the NWI is to normalize the WI_d values so that the driest condition yields an NWI of zero, and the wettest condition an NWI of 1. The daily NWI time series is smoothed using a 14-day trailing mean for use in the KRM.

On the first and fifteenth day of each month (or the day before in leap years), an iterative process was used to assign values to the daily weights q_d, s_d, pn_d, pl_d, and c_d. For each of these days, 7,776 combinations of weights (0-1 by 0.2 increments) were used to compute 7,776 versions of the NWI, each of which was then regressed on the square root of the 91-day forward sum of UKL net inflow volume. Mean absolute error (MAE) was computed for each regression. For each variable, the weight to be used in the final NWI calculation was then calculated as the mean weight of the 10 weight combinations yielding the lowest regression MAE, and this mean was weighted by the MAE values reflected on the mean MAE (that is, the smallest MAE values are assigned the largest weights, and the largest MAE values are assigned the lowest weights). Using these daily weights (Appendix Table C-1) to compute the NWI produces the relationships between NWI and future UKL net inflows on Appendix Figure C-3. After the daily weights were established by this iterative process, the weights for the remaining days were linearly interpolated. The daily NWI relationship to UKL net inflows holds up over longer periods as compared to the 91-day forward sum of UKL net inflow used to optimize the NWI. For example, means of the NWI and UKL net inflow volumes by water year for October through March and April through September retain clear relationships (Appendix Figure C-4).

Singh et. al (2021) found streamflow changes were responsive to interactions among the ENSO (N34) and PDO climate indices in the Pacific Northwest but not in the West (California and Nevada). Because the Klamath Basin is in the transition area between these two regions and may respond differently than the much larger regions used in that study, interactions among the PDO and N34 indices were explored. These indices were normalized and considered separately and combined in various ways. Because the NWI is formulated to have a positive correlation with future UKL net inflow, and at times climate indices may be negatively correlated with future inflows, the complement of the normalized index was calculated as 1 - normalized index. If the climate index was negatively correlated with inflow, then it would be positively correlated with its complement, which could then be used in the NWI.

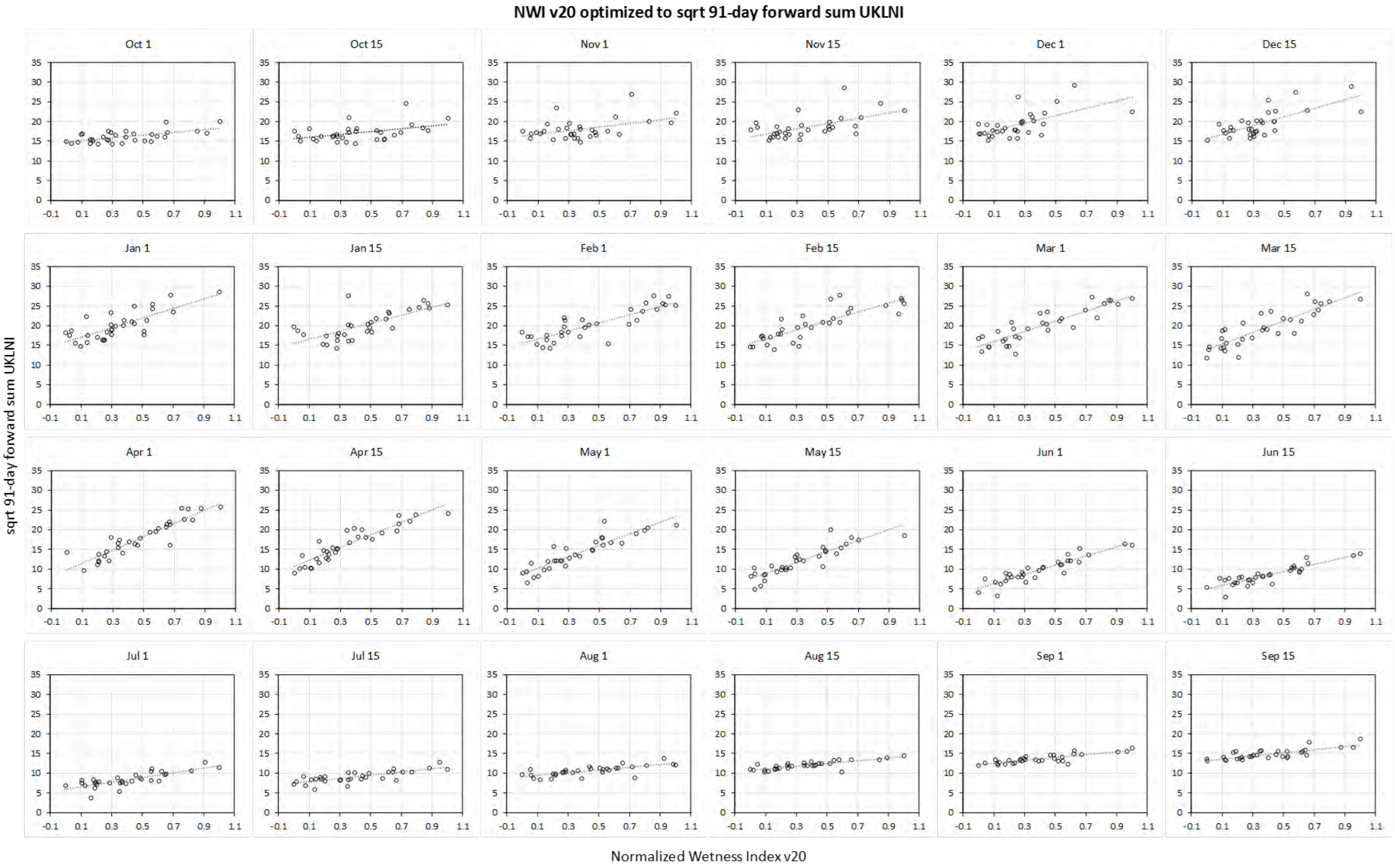
Eight potential formulations were considered for incorporating normalized climate indices into the daily NWI: PDO, N34, CPDO, CN34, PDO_N34, PDO_CN34, CPDO_N34, and CPDO_CN34 (C indicates use of the complement of the normalized index). Combined indices were produced by first normalizing each individual index and computing its complement, if necessary, adding them together, and normalizing again. A version of the NWI without a climate index variable was also evaluated.

In each of these cases, the iterative process for determining optimal weights for variables was completed, the optimal weights were used to compute the NWI, and errors from the regression of NWI on the square root of the 91-day forward sum of UKL net inflow were calculated. For each NWI associated with the alternative formulations of the climate indices, these errors were compared to those for the NWI without a climate index variable (base case) and the best performing (largest error reduction from the base case) formulations over contiguous periods of time were selected. In the end, two formulations of the climate indices were chosen for use in the daily NWI: the PDO for December 1 to April 1, and the PDO_CN34 for the rest of the year.

Appendix Table C-2. Daily weights for computing the daily Normalized Wetness Index

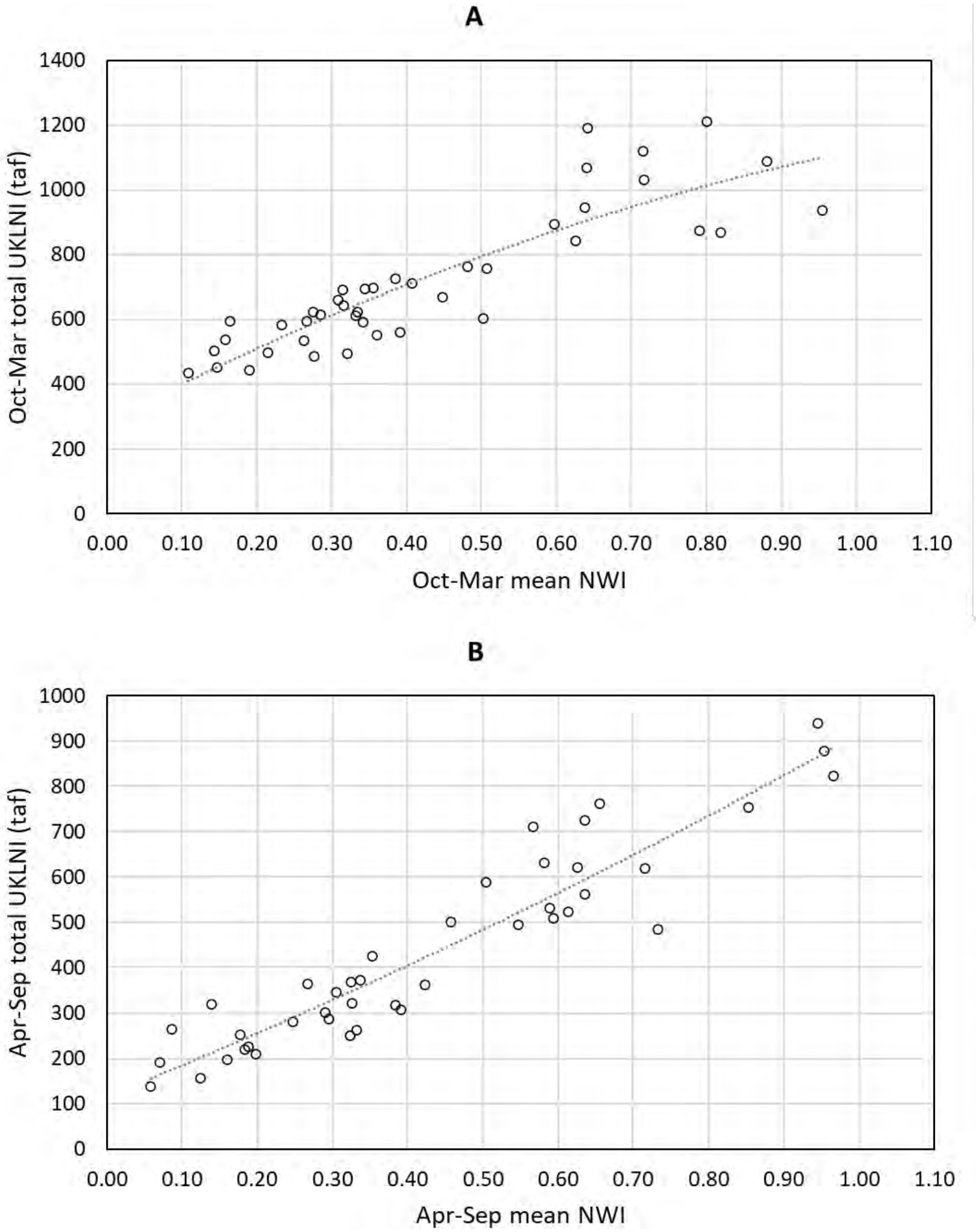
Day of Water Year	Date	q_d	s_d	pn_d	pl_d	c_d	Climate Index Used	MAE	MSE	MAPE
1	Oct 1	0.06	-	0.00	0.86	0.51	3 mta PDO_CN34	0.92	1.26	5.6%
15	Oct 15	0.10	-	0.00	0.76	0.78	3 mta PDO_CN34	1.27	3.19	7.2%
32	Nov 1	0.00	0.22	0.00	0.71	0.21	3 mta PDO_CN34	1.50	4.76	8.0%
46	Nov 15	0.32	0.96	0.50	0.90	0.34	3 mta PDO_CN34	1.58	5.12	8.1%
62	Dec 1	0.94	0.12	0.56	0.06	0.46	3 mta PDO	1.65	5.85	8.3%
76	Dec 15	0.76	0.16	0.76	0.74	0.40	3 mta PDO	1.78	5.16	9.0%
93	Jan 1	0.56	0.28	0.82	0.88	0.42	3 mta PDO	1.75	4.74	8.9%
107	Jan 15	0.12	0.84	0.22	0.74	0.24	3 mta PDO	1.68	5.30	8.6%
124	Feb 1	0.12	0.94	0.88	0.50	0.16	3 mta PDO	1.55	3.91	8.2%
138	Feb 15	0.88	0.55	0.65	0.02	0.00	3 mta PDO	1.52	4.47	7.9%
152	Mar 1	0.65	0.88	0.08	0.02	0.00	3 mta PDO	1.55	3.85	8.5%
166	Mar 15	0.41	0.86	0.00	0.08	0.04	3 mta PDO	1.75	5.04	9.6%
183	Apr 1	0.44	0.92	0.20	0.24	0.18	3 mta PDO	1.36	3.19	8.6%
197	Apr 15	0.52	0.94	0.14	0.22	0.02	3 mta PDO_CN34	1.19	2.40	7.7%
213	May 1	0.44	0.92	0.20	0.26	0.06	3 mta PDO_CN34	1.23	2.65	9.7%
227	May 15	0.98	0.88	0.20	0.06	0.16	3 mta PDO_CN34	1.17	2.66	11.6%
244	Jun 1	0.80	0.76	0.31	0.41	0.00	3 mta PDO_CN34	0.89	1.53	11.9%
258	Jun 15	0.70	0.80	0.00	0.49	0.00	3 mta PDO_CN34	0.77	1.20	12.1%
274	Jul 1	0.52	-	0.00	0.94	0.20	3 mta PDO_CN34	0.78	1.14	11.0%
288	Jul 15	0.41	-	0.00	0.82	0.43	3 mta PDO_CN34	0.73	0.86	8.6%
305	Aug 1	0.22	-	0.00	0.88	0.49	3 mta PDO_CN34	0.59	0.75	5.9%
319	Aug 15	0.06	-	0.33	0.84	0.39	3 mta PDO_CN34	0.44	0.43	3.7%
336	Sep 1	0.08	-	0.00	0.80	0.23	3 mta PDO_CN34	0.47	0.40	3.5%
350	Sep 15	0.00	-	0.06	0.86	0.45	3 mta PDO_CN34	0.62	0.62	4.1%

Notes: Date is the day corresponding to the specified day of water year in non-leap years. q_d is the weight for the normalized 30-day trailing sum of UKL net inflow volume. s_d is the weight for normalized weighted mean SWE. pn_d is the weight for the normalized weighted mean 30-day trailing sum of precipitation. pl_d is the weight for the normalized weighted mean 31- to 1,095-day trailing sum of precipitation. c_d is the weight for the 3-month trailing mean of the normalized climate index. PDO_CN34 indicates use of the PDO combined with the complement of the N34 as described in the text, and 3-month trailing average is denoted by 3 mta. For each date, errors from the best performing (lowest MAE) NWI regression on the square root of the 91-day forward sum of the UKL net inflow volume are summarized as MAE, mean squared error (MSE), and mean absolute percentage error (MAPE).



Notes: The regression with the lowest MAE is shown for each date.

Appendix Figure C-3. Normalized Wetness Index regressed on the square root of the 91-day forward sum of Upper Klamath Lake net inflow volume on the days for which daily weights were iterated for use in the Normalized Wetness Index



Note: Fitted lines are included to help visualize the relationships.

Appendix Figure C-4. Daily Normalized Wetness Index averaged over fall-winter (A) and spring-summer (B) periods relative to the actual Upper Klamath Lake net inflow volumes for the same periods (TAF)

Seasonal Version of the Normalized Wetness Index

The seasonal version of the NWI relies upon the same variables as the daily version except for the treatment of climate indices. However, the process used to determine the weights for each variable regressed each of the date-specific 7,776 iterations of the NWI (calculated using each unique combination of weights) on the square root of the seasonal UKL net inflow volume being forecasted instead of the square root of the 91-day forward sum of the UKL net inflow volume that was used for the daily NWI. Quantile regression models (Koenker et al., 2018) for seasonal forecasts were developed for each of the forecast periods listed in Appendix Table C-3 from the specified day of the water year through September, which resulted in leap years including one more day in each forecast period than in non-leap years. Future revisions of the NWI-based forecasts should ensure that the number of days in each forecast period is consistent across years.

Appendix Table C-3. Date-specific weights for computing the seasonal Normalized Wetness Index

Day of Water Year	Date	Forecast Period	q_d	s_d	pn_d	pl_d	c_d	MAPE
152	Mar 1	Apr-Sep	0.33	0.84	0.00	0.10	0.04	10.0%
183	Apr 1	Apr-Sep	0.50	0.92	0.24	0.40	0.00	7.6%
197	Apr 15	Apr 15-Sep	0.52	0.90	0.20	0.30	0.00	7.1%
213	May 1	May-Sep	0.54	0.96	0.26	0.48	0.00	7.8%
227	May 15	May 15-Sep	0.98	0.68	0.18	0.32	0.08	8.7%
244	Jun 1	Jun-Sep	0.92	0.68	0.36	0.84	0.20	7.7%

Notes: Date is the day when a forecast will be issued in non-leap years. q_d is the weight for the normalized 30-day trailing sum of UKL net inflow volume. s_d is the weight for normalized weighted mean SWE. pn_d is the weight for the normalized weighted mean 30-day trailing sum of precipitation. pl_d is the weight for the normalized weighted mean 31- to 1,095-day trailing sum of precipitation. c_d is the weight for the 3-month trailing mean of the normalized climate index. For each date, errors from the best performing (lowest MAE) NWI regression on the square root of the forecast period sum of the UKL net inflow volume are summarized as MAPE.

Climate variables were evaluated for use in the seasonal NWI in the same manner as for the daily NWI. The complement of the normalized PDO is the only climate index used in the seasonal NWI. The influence of the climate index variable is considerably less on the seasonal NWI than on the daily NWI (compare c_d values in Appendix Table C-2 to those in Appendix Table C-3), presumably because of the longer period over which UKL net inflow is accumulated in the seasonal NWI. Note that the climate index variable has a substantial effect for only the June 1 forecast date (Appendix Table C-3).

A leave-one-out cross-validation approach (James et al., 2021) was used to select the final forecasting model from among four candidate forms: $y = b_1x + \varepsilon$, $y = b_1x^2 + b_2x + \varepsilon$, $\sqrt{y} = b_1x + \varepsilon$, or or $\sqrt{y} = b_1x^2 + b_2x + \varepsilon$, where x is the seasonal NWI, y is the seasonal volume of UKL net inflow being forecasted, and ε is error. This process involved omitting 1 year, fitting each candidate quantile regression model and then using it to forecast the year that was omitted, and then computing the cross-validation forecast error for that year. After repeating this process until all the years (1991-2022) had been omitted and forecasted with attendant errors computed, the forecast model with the lowest MAE was used to directly estimate the 50% and

95% exceedance forecasts for each of the forecast dates (Appendix Table C-4 through Appendix Table C-9, and Appendix Figure C-5). Forecasts were made for the period-of-record used to calibrate the forecast models (1991-2022), but also for the years not involved in the calibration (1981-1990). The KRM uses all the 50% exceedance forecasts, and the 95% exceedance forecasts for Apr 1 and 15, to compute the water allocations for Project irrigation (see the *Project Irrigation Allocation* section below).

Appendix Table C-4. March 1 percent-exceedance forecasts of April through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%	Year	95%	70%	50%	30%	5%
1981	117	179	238	266	345	2002	253	382	429	463	575
1982	357	538	569	605	739	2003	139	211	270	299	383
1983	482	724	729	768	926	2004	314	474	512	547	672
1984	385	579	605	642	781	2005	140	214	272	302	386
1985	313	472	510	545	670	2006	434	653	668	707	856
1986	349	526	557	594	726	2007	228	345	395	428	535
1987	228	344	395	428	534	2008	308	465	504	539	663
1988	174	265	321	352	445	2009	211	320	372	405	507
1989	301	454	494	529	652	2010	180	273	329	360	455
1990	161	245	302	332	422	2011	234	354	404	437	545
1991	98	150	209	236	308	2012	170	258	315	346	438
1992	101	155	214	241	315	2013	190	287	342	374	471
1993	414	622	642	679	824	2014	115	175	234	262	340
1994	161	245	302	333	423	2015	90	138	197	224	294
1995	219	332	383	416	520	2016	239	361	410	443	552
1996	371	559	587	624	760	2017	396	595	618	656	797
1997	365	549	578	615	751	2018	111	169	228	256	332
1998	401	603	625	663	806	2019	283	427	470	505	623
1999	552	829	819	859	1030	2020	162	246	303	333	424
2000	354	534	564	601	734	2021	173	263	319	350	443
2001	151	229	287	317	405	2022	131	199	258	287	369

Appendix Table C-5. April 1 percent-exceedance forecasts of April through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%	Year	95%	70%	50%	30%	5%
1981	196	232	260	282	400	2002	254	325	351	386	501
1982	455	663	678	760	843	2003	193	228	256	277	395
1983	551	829	836	942	1002	2004	258	331	358	393	508
1984	503	745	757	850	922	2005	187	219	247	267	385
1985	409	583	602	672	765	2006	441	639	655	734	820

Year	95%	70%	50%	30%	5%	Year	95%	70%	50%	30%	5%
1986	368	513	534	595	696	2007	255	326	353	387	503
1987	275	359	385	424	538	2008	363	505	527	586	687
1988	193	227	255	276	394	2009	285	376	402	443	556
1989	461	673	688	771	853	2010	206	249	276	300	419
1990	209	252	280	304	422	2011	410	585	603	674	767
1991	236	296	323	353	470	2012	314	423	448	495	605
1992	132	135	161	171	285	2013	204	245	272	296	414
1993	376	528	549	611	710	2014	194	230	257	279	397
1994	161	179	207	222	339	2015	155	170	197	211	328
1995	346	477	500	555	659	2016	335	458	482	534	640
1996	346	476	499	554	659	2017	436	629	646	723	810
1997	326	444	467	518	626	2018	222	273	300	328	446
1998	411	587	606	677	769	2019	319	432	456	505	613
1999	551	829	836	942	1002	2020	180	208	236	255	373
2000	379	532	553	616	715	2021	170	193	220	237	355
2001	183	212	240	259	377	2022	118	116	142	149	261

Appendix Table C-6. April 15 percent-exceedance forecasts of April 15 through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%	Year	95%	70%	50%	30%	5%
1981	171	208	226	265	338	2002	168	204	223	261	334
1982	481	556	575	643	779	2003	206	247	266	308	388
1983	604	694	712	792	952	2004	178	216	235	274	349
1984	556	641	659	735	885	2005	159	194	213	250	321
1985	333	390	409	463	569	2006	484	559	577	646	782
1986	313	367	385	438	539	2007	225	269	287	331	415
1987	199	239	258	299	377	2008	375	437	455	513	627
1988	120	151	170	204	266	2009	264	312	330	378	470
1989	376	438	456	515	629	2010	222	265	284	327	411
1990	129	161	180	215	279	2011	436	506	524	588	714
1991	187	226	244	285	361	2012	354	413	431	488	597
1992	71	96	115	144	197	2013	197	237	255	296	374
1993	473	547	565	633	766	2014	133	165	183	218	284
1994	124	155	174	208	272	2015	109	139	157	190	250
1995	316	371	390	442	544	2016	217	259	278	321	403
1996	280	331	349	398	493	2017	443	513	531	596	723
1997	302	355	373	425	524	2018	203	244	263	305	384
1998	454	526	544	610	740	2019	329	386	404	458	562
1999	604	694	712	792	952	2020	150	185	203	240	309
2000	259	307	326	373	464	2021	83	109	128	158	213
2001	160	196	214	252	323	2022	95	122	141	172	230

Appendix Table C-7. May 1 percent-exceedance forecasts of May 1 through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%	Year	95%	70%	50%	30%	5%
1981	106	146	159	187	244	2002	129	169	183	212	284
1982	317	348	362	394	593	2003	175	214	228	259	362
1983	560	564	576	606	970	2004	137	177	191	220	298
1984	480	493	507	538	847	2005	120	160	174	202	269
1985	297	329	343	375	561	2006	415	436	450	481	747
1986	214	252	266	297	426	2007	172	211	226	256	357
1987	96	136	149	176	226	2008	287	320	334	366	545
1988	104	144	157	185	240	2009	153	193	207	237	325
1989	267	301	316	347	513	2010	177	216	231	261	365
1990	94	134	147	174	223	2011	397	419	433	465	718
1991	154	194	208	238	327	2012	235	271	285	316	460
1992	72	110	122	148	182	2013	123	163	177	205	274
1993	372	397	411	443	679	2014	90	130	143	170	216
1994	81	120	133	160	200	2015	69	107	120	145	177
1995	264	299	313	344	508	2016	132	172	186	215	289
1996	259	294	308	340	500	2017	342	370	384	416	631
1997	289	322	336	368	548	2018	155	195	209	238	328
1998	297	329	343	375	561	2019	248	283	298	329	481
1999	563	566	579	609	974	2020	82	122	134	161	202
2000	254	289	303	335	491	2021	61	98	110	135	162
2001	105	145	159	186	243	2022	105	145	158	186	242

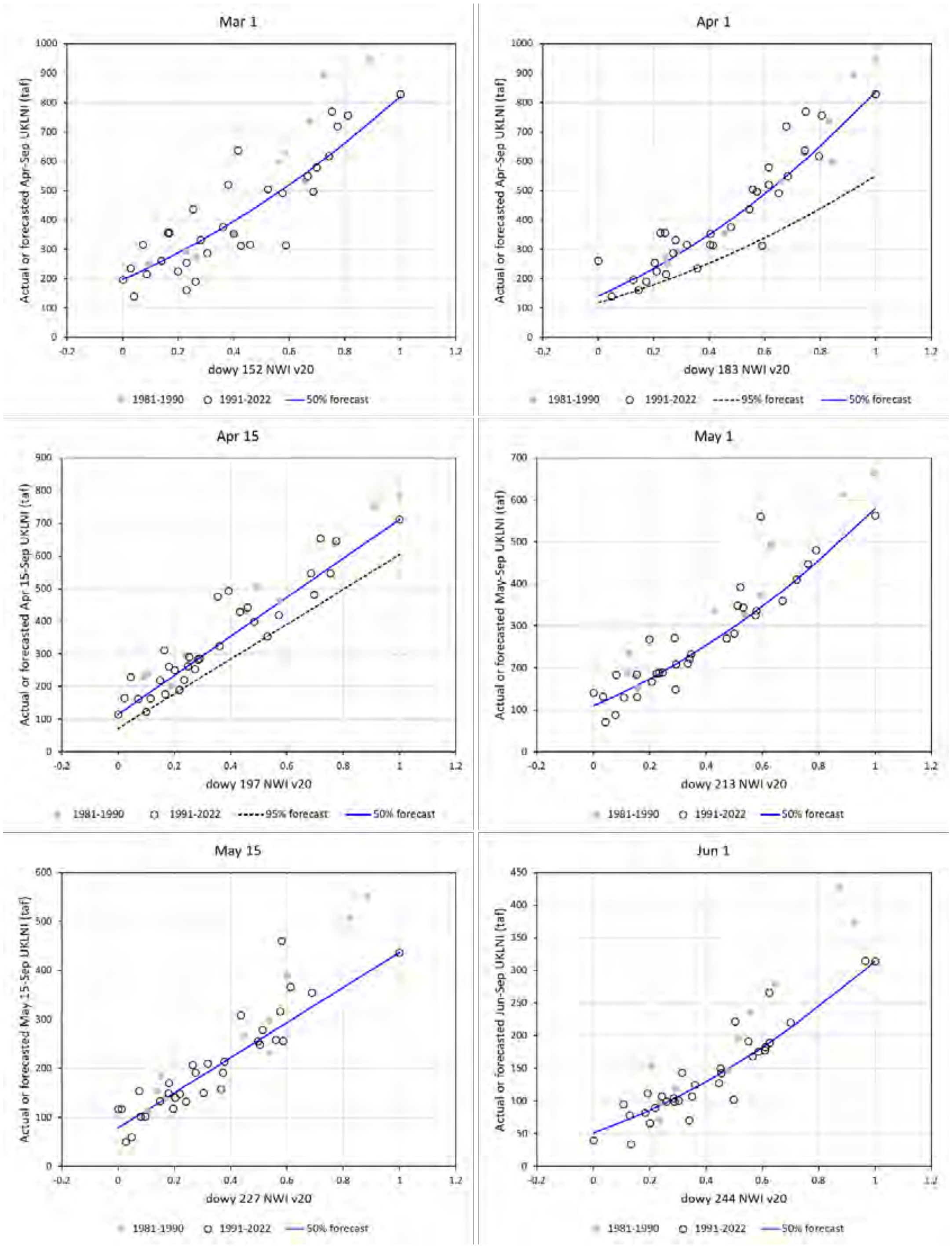
Appendix Table C-8. May 15 percent-exceedance forecasts of May 15 through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%	Year	95%	70%	50%	30%	5%
1981	77	98	115	142	178	2002	127	150	165	192	260
1982	256	285	293	322	472	2003	172	197	209	237	333
1983	358	393	395	426	640	2004	119	141	157	184	247
1984	336	369	373	403	603	2005	135	158	173	200	273
1985	233	262	271	299	435	2006	288	319	325	355	524
1986	201	228	238	267	381	2007	150	174	187	215	297
1987	95	116	133	159	207	2008	219	246	256	284	410
1988	100	121	137	164	215	2009	155	179	193	220	306
1989	234	262	271	300	435	2010	139	162	176	204	279
1990	91	112	128	155	200	2011	260	290	298	327	479
1991	111	132	148	175	233	2012	174	200	212	240	338
1992	50	69	88	114	133	2013	94	115	132	158	205

Year	95%	70%	50%	30%	5%	Year	95%	70%	50%	30%	5%
1993	247	276	285	314	458	2014	69	89	107	133	164
1994	58	77	95	122	146	2015	40	59	78	104	117
1995	242	270	279	308	448	2016	113	135	151	178	237
1996	197	224	235	263	375	2017	225	253	262	291	420
1997	221	249	259	287	414	2018	105	127	143	170	224
1998	249	278	286	315	461	2019	176	202	214	242	341
1999	400	437	437	468	708	2020	67	87	105	131	161
2000	251	280	288	317	463	2021	45	64	83	109	125
2001	75	95	113	139	175	2022	104	126	142	169	223

Appendix Table C-9. June 1 percent-exceedance forecasts of June 1 through September U Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%	Year	95%	70%	50%	30%	5%
1981	50	82	92	99	129	2002	48	79	90	96	125
1982	147	194	195	204	274	2003	63	98	107	115	150
1983	222	275	268	278	378	2004	60	94	104	111	145
1984	242	298	288	298	406	2005	107	148	154	162	216
1985	122	166	170	178	239	2006	163	212	212	221	298
1986	111	154	159	167	223	2007	73	109	118	125	165
1987	46	77	87	94	122	2008	137	182	185	194	260
1988	52	84	94	101	131	2009	96	136	143	151	200
1989	102	143	149	157	209	2010	66	101	110	117	154
1990	61	95	105	112	146	2011	141	187	189	198	266
1991	71	107	116	123	162	2012	94	134	141	149	198
1992	18	40	51	57	71	2013	60	94	103	110	144
1993	108	150	155	164	218	2014	34	61	72	79	100
1994	35	62	73	79	102	2015	42	72	83	89	115
1995	124	169	173	181	242	2016	55	88	98	105	136
1996	141	188	190	199	267	2017	120	164	168	176	236
1997	137	183	186	194	261	2018	75	112	120	128	168
1998	257	313	301	311	426	2019	95	135	142	150	199
1999	271	328	314	324	444	2020	52	84	95	101	132
2000	130	175	178	187	250	2021	31	57	68	74	95
2001	45	76	86	93	120	2022	44	74	84	91	117



Notes: 50% (blue solid lines) and 95% (black dashed lines) exceedance forecasts were directly estimated using quantile regression for the 1991-2022 period of record (open circles). The same equations were used to forecast net inflows over the 1981-1990 period (solid grey circles). Note that the KRM uses the 95% exceedance forecasts only for April 1 and 15.

Appendix Figure C-5. Seasonal Upper Klamath Lake net inflow forecasts based on the seasonal Normalized Wetness Index that are used in the Keno Release Model

In the Proposed Action, seasonal forecasts of net inflow into UKL are used only to determine allocations to Project irrigation. Because of the very recent change in the UKL net inflow time series, the seasonal NWI-based forecast models are the only available models that have been calibrated using the new net inflow time series. Therefore, the KRM presently uses only the seasonal NWI to forecast UKL net inflows and calculate the seasonal progression of water volumes available for irrigation use. However, the KRM is structured to use the NRCS, California Nevade River Forecast Center (CNRFC), and NWI models for forecasting either individually or in combination. Combined forecasts consist of an average weighted by the reflection of the MAE associated with each forecast model. The reflection is a simple transformation that flips the model-specific MAE relative to the mean of all the models so that the reflected MAE for the best performing model (i.e., the smallest MAE) will be the largest weight when combining the forecasts. Combined forecasts among some or all of the three main forecasting models frequently outperformed the individual models when this KRM component was built prior to the change in the UKL net inflow time series, and this will likely also be true using the recalibrated models.

Appendix Table C-10 and Appendix Table C-11 compare the absolute values of the errors (actual - forecast) from the three forecast models. This is not yet an “apples-to-apples" comparison because the NRCS and CNRFC forecasts are made for, and errors are computed from, the UKL net inflow time series used before the recent revision, whereas the seasonal NWI-based forecasts and errors use the revised UKL net inflow time series. Nonetheless these comparisons illustrate the kind of evaluation that should be performed before finalizing the selection of forecast model products for use in the Proposed Action. Note that in this imperfect comparison, the NWI-based forecasts out-perform the other two models for the May 1 and June 1 forecasts and are intermediate for the April 1 forecast (Appendix Table C-10 and Appendix Table C-11), but on each date a combination of forecasts performs the best.

Appendix Table C-10. Mean absolute errors of seasonal 50% exceedance forecasts of Upper Klamath Lake net inflow among the three forecast models and the best performing combination of the three models

Source	**Mar 1 Apr-Sep**	**Apr 1 Apr-Sep**	**Apr 15 Apr 15-Sep**	**May 1 May-Sep**	**May 15 May 15-Sep**	**Jun 1 Jun-Sep**
NRCS	-	47	-	38	-	20
CNRFC	-	54	-	41	-	27
NWI	72	50	40	32	31	16
Best combined	-	39	-	30	-	15

Appendix Table C-11. Mean absolute percentage errors of seasonal 50% exceedance forecasts of Upper Klamath Lake net inflow among the three forecast models and the best performing combination of the three models

Source	Mar 1 Apr-Sep	Apr 1 Apr-Sep	Apr 15 Apr 15-Sep	May 1 May-Sep	May 15 May 15-Sep	Jun 1 Jun-Sep
NRCS	-	12.0%	-	15.7%	-	15.6%
CNRFC	-	14.1%	-	16.3%	-	19.9%
NWI	21.7%	13.3%	12.4%	14.4%	17.9%	15.7%
Best combined	-	10.6%	-	12.2%	-	12.3%

When the NRCS and CNRFC have finished reconstructing their forecasts, Reclamation and U.S. Fish and Wildlife Service and National Marine Fisheries Service (Services) will evaluate the forecast characteristics and the effects on the Proposed Action outcomes of using the best performing model or combination of models in the KRM. Reclamation and the Services will seek agreement on the specific forecast model or combination of models to be used for updating forecasts every 2 weeks from April 1 to June 1. Until then the Proposed Action will use the seasonal NWI-based forecasts.

Upper Klamath Lake Status

In addition to tracking the hydrologic condition of the Upper Klamath Basin using the NWI, the storage condition of UKL is another important consideration for water management. Before describing it, however, it is important to understand the use of shadow UKL levels in the KRM. As will be described later in this document, the KRM implements a deferred use operation (Flexible Flow Account) for river flow releases from Keno Dam in which a specified proportion of calculated releases during October through March 1 is stored in UKL for use during March 2 through June. A similar deferred use operation is employed for Project irrigation (deferred Project Supply Account) in which inflows or return flows from the Lost River and F/FF pumps that are allowed to move out of the Project to contribute to targeted releases from Keno Dam (when neither Link River Dam nor Keno Dam is spilling) are accounted for as an accrual to the deferred Project Supply Account in UKL that can be used by irrigators during the irrigation season. Deferred Project Supply Account accruals also occur when UKL water that is set aside for maintaining Sump 1A in Tule Lake National Wildlife Refuge (TLNWR) and Unit 2 in Lower Klamath National Wildlife Refuge (LKNWR) is replaced by inflows or return flows from the Lost River and F/FF pumps when neither dam is spilling.

Each of these deferred use operations is intended to provide flexibility to those using the water and is designed to have no or minimal impact on how water is used by other system components at any point in time. To achieve that end, a water accounting structure keeps daily track of what UKL levels would be if the deferred use operations were not occurring—this is called the UKL shadow level. By using the UKL shadow level to determine the UKL Status (and hence the Ops Index), the deferred use operations can proceed in a flexible manner without affecting the Ops Index, which is a key component in the computation of River releases, Project irrigation allocation, and other variables. UKL shadow levels on day d are determined from UKL shadow storage (SS) computed as:

$$S_d = S1_{d-1} - FFA_d - DPSA_d \tag{3}$$

where $S1$ is UKL storage volume, FFA is the Flexible Flow Account volume, and $DPSA$ is the accumulated deferred Project Supply Account volume. Both FFA and $DPSA$ are described in the *Releases from Keno Dam to the Klamath River* and *Deferred Project Supply Accounting* sections of this Appendix, respectively. UKL shadow storage is translated into UKL shadow level using the elevation-capacity relationship for Upper Klamath Lake that includes the Upper Klamath National Wildlife Refuge (UKNWR) wetland reconnection via interpolation when needed (Appendix Table C-12).

Appendix Table C-12. Elevation-capacity relationship for Upper Klamath Lake including the Upper Klamath National Wildlife Refuge wetland reconnection

Elevation **(ft, Reclamation datum)**	**Active Storage** **(TAF)**	**Elevation** **(ft, Reclamation datum)**	**Active Storage** **(TAF)**
4,136	0.000	4,139.8	294.841
4,136.1	6.557	4,139.9	303.924
4,136.2	13.220	4,140	313.118
4,136.3	19.983	4,140.1	322.432
4,136.4	26.843	4,140.2	331.839
4,136.5	33.797	4,140.3	341.326
4,136.6	40.841	4,140.4	350.886
4,136.7	47.970	4,140.5	360.513
4,136.8	55.180	4,140.6	370.206
4,136.9	62.464	4,140.7	379.960
4,137	69.817	4,140.8	389.775
4,137.1	77.226	4,140.9	399.649
4,137.2	84.678	4,141	409.581
4,137.3	92.165	4,141.1	419.582
4,137.4	99.687	4,141.2	429.623
4,137.5	107.242	4,141.3	439.696
4,137.6	114.831	4,141.4	449.798
4,137.7	122.454	4,141.5	459.928
4,137.8	130.112	4,141.6	470.083
4,137.9	137.802	4,141.7	480.264
4,138	145.526	4,141.8	490.470
4,138.1	153.283	4,141.9	500.699
4,138.2	161.083	4,142	510.949
4,138.3	168.935	4,142.1	521.221
4,138.4	176.843	4,142.2	531.509
4,138.5	184.812	4,142.3	541.813

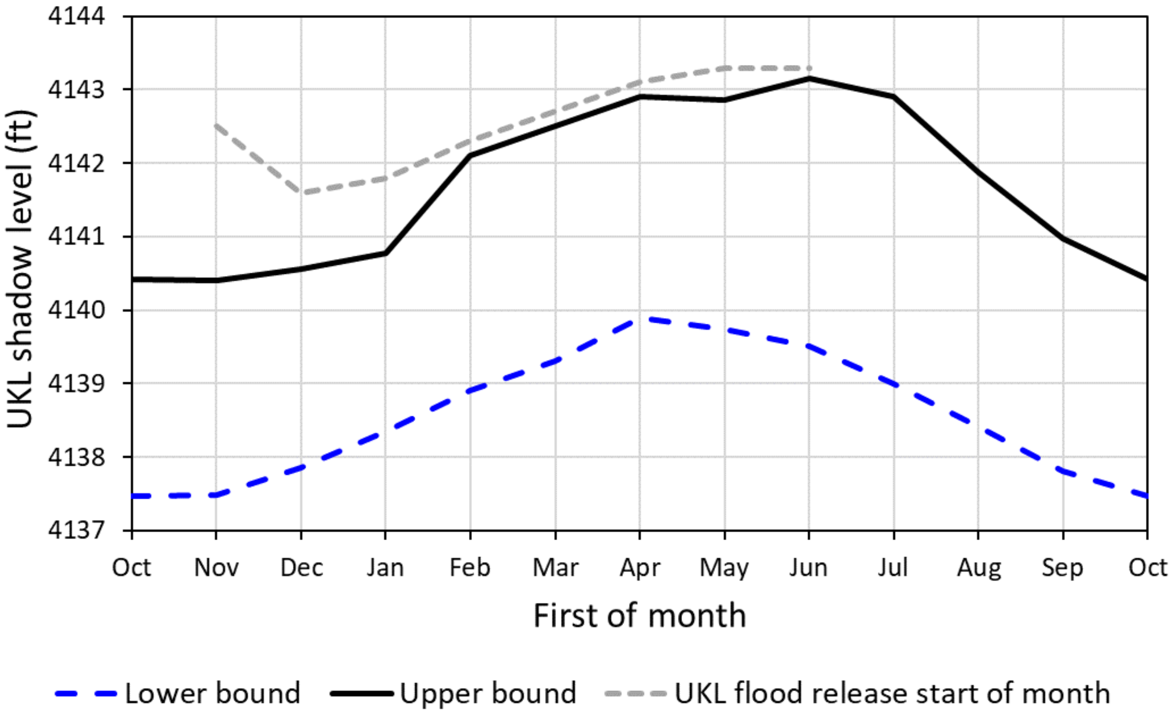
Elevation (ft, Reclamation datum)	**Active Storage** (TAF)	**Elevation** (ft, Reclamation datum)	**Active Storage** (TAF)
4,138.6	192.845	4,142.4	552.132
4,138.7	200.944	4,142.5	562.465
4,138.8	209.111	4,142.6	572.812
4,138.9	217.347	4,142.7	583.175
4,139	225.651	4,142.8	593.552
4,139.1	234.014	4,142.9	603.943
4,139.2	242.443	4,143	614.345
4,139.3	250.949	4,143.1	624.761
4,139.4	259.539	4,143.2	635.189
4,139.5	268.218	4,143.3	645.627
4,139.6	276.991	4,143.4	656.076
4,139.7	285.864	4,143.5	666.535

In the KRM, lower and upper bounds are set on UKL shadow levels, and daily UKL Status is calculated as the relative position of UKL shadow level (L) on day d between the specified lower (low) and upper (up) bounds for water years 1991-2022:

$$UKLStatus_d = \min\left(1, \left(\max\left(0, \frac{L_d - L_{low}}{L_{up} - L_{low}}\right)\right)\right) \qquad (4)$$

When L_d is at or above the upper bound, UKL Status will be 1; UKL Status will be zero when L_d is at or below the lower bound. The lower bound is established as the 95% exceedance UKL shadow level on the first day of each month (interpolated for other days) as computed from the output of a particular simulation. Similarly, on the first day of each month (interpolated for other days), the upper bound is the flood release curve minus 0.2 ft during December through March but is otherwise the highest simulated UKL shadow level. The upper and lower bounds are determined iteratively by repeatedly running the KRM, recalculating the lower and upper bounds for each iteration using the results from the prior simulation. After several iterations, the upper and lower bounds stop changing significantly and the bounds are finalized.

UKL bounds do not prevent UKL levels from moving above or below them; they are not lake level requirements. Rather, they specify the UKL shadow level at which and below the UKL Status will be zero, or at which and above the UKL Status will be 1. The upper and lower bounds used in the KRM for the Proposed Action are shown on Appendix Figure C-6.

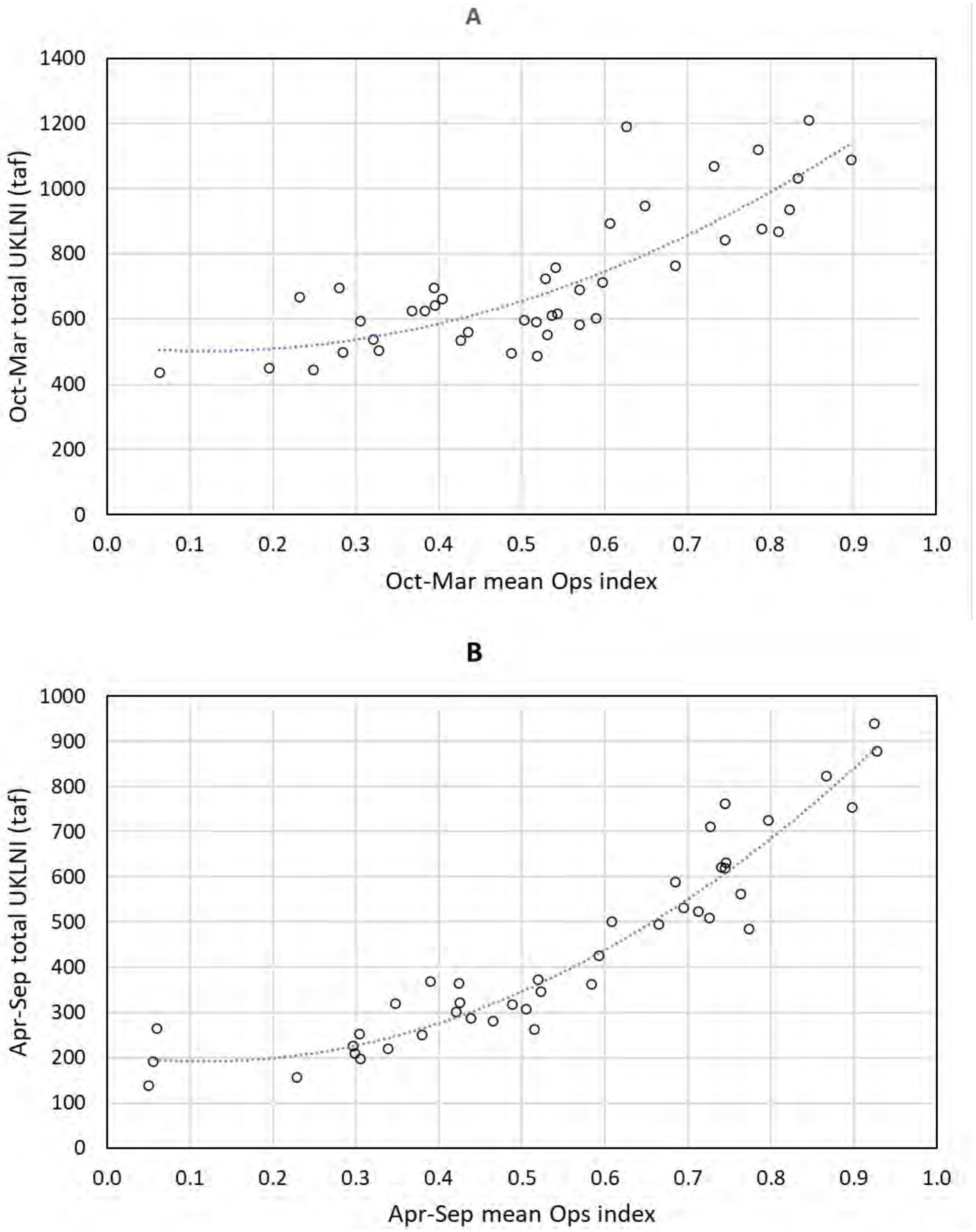


Appendix Figure C-6. Lower and upper bounds for Upper Klamath Lake shadow levels used for computing UKL Status and the winter/spring flood release curve for Upper Klamath Lake

Operations Index

The Ops Index is the main structural variable governing the movement of water in the KRM. It is calculated as the average of the 14-day trailing mean of the daily NWI and the UKL Status, thereby including measurement of the basin hydrologic status and the storage status of UKL. Ops Index values range from 0 (driest, lowest storage) to 1 (wettest, highest storage).

The Ops Index tracks consistently with UKL net inflow. For example, October to March and April to September average Ops Index values show clear relationships to similarly averaged UKL net inflow volumes (Appendix Figure C-7).



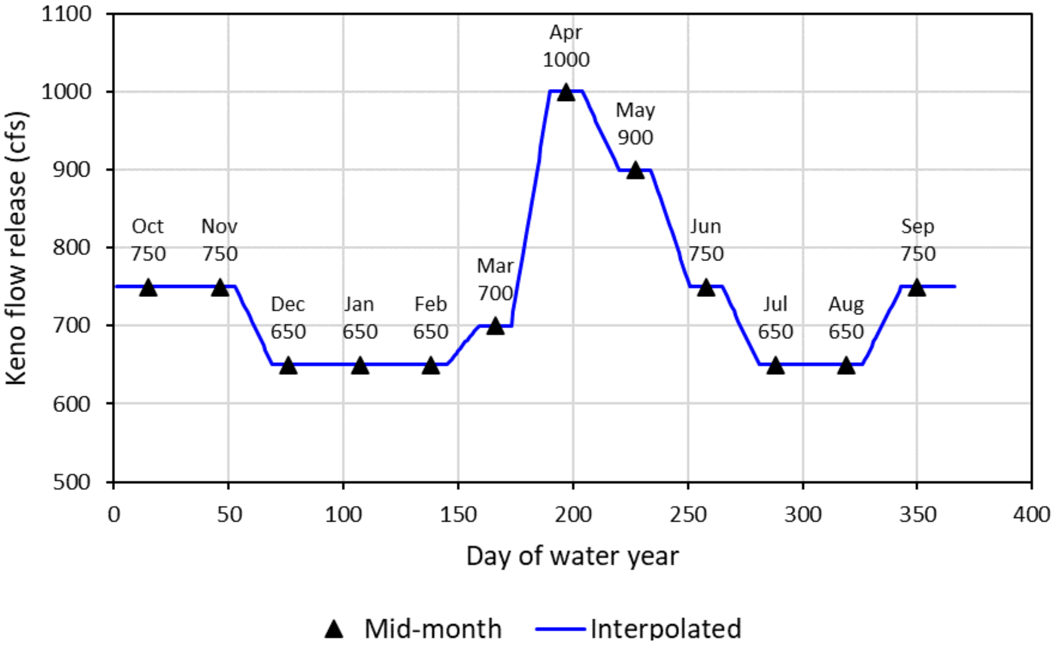
Note: Fitted lines are included to help visualize the relationships.

Appendix Figure C-7 Seasonal relationship between the mean Ops Index and Upper Klamath Lake net inflow volume for October through March (A), and April through September (B) in the Proposed Action

Releases from Keno Dam to the Klamath River

A daily River Base Flow regime for Keno Dam releases was established by specifying base flows for the center 15 days of each month and interpolating flows for the remaining days (Appendix Figure C-8). The River Base Flow (*RBF*) is the lowest flow that will ever be targeted for release from Keno Dam on a specific day of the year, which would occur only when the Ops Index or the Keno Release Multiplier (*KRmult*) is 0. On each day (*d*), a *KRmult* is selected based on the Ops Index and the current month (Appendix Table C-13), and the targeted release (in cfs) from Keno Dam (*KRT*) is computed:

$$KRT_d = max(RBF_d, RBF_d + (RBF_d \times KRmult_d) - FFAinc_d + FFAuse_d) \qquad (5)$$



Appendix Figure C-8. River Base Flows specified for 15 days centered on the fifteenth day of each month, with daily flows interpolated between these periods

Appendix Table C-13. Keno Release Multiplier lookup table used by the Keno Release Model

Ops Index	Oct	Nov	Dec-Feb	Mar	Apr	May	Jun	Jul-Sep
0	0	0	0	0	0	0	0	0
0.2	0.06	0.06	0.07	0.17	0.14	0.11	0.14	0
0.4	0.09	0.09	0.16	0.35	0.27	0.4	0.17	0.01
0.6	0.14	0.16	0.6	0.93	0.62	0.74	0.33	0.05
0.8	0.34	0.6	2.05	2.49	2.19	1.73	0.72	0.23
1	1.08	2.43	4.78	6.28	5.3	4.18	2.5	0.68

Note: Each day the Ops Index is computed and used to look up the associated multiplier values (interpolated as necessary).

A Flexible Flow Account (FFA) operation is used in the KRM that defers use of some water targeted for release to the river during fall-winter ($FFAinc_d$), storing the accumulating volume in UKL during the October to March 1 accrual period. During March 2 through June, the stored FFA water ($FFAuse_d$) is used in a manner that can vary each year.

Key elements of this operation include the FFA reserve proportion (RP_d) determined by the value of the Ops Index (Appendix Table C-14), and the expectation that the river will fully use the FFA volume each year. Computation of the daily addition of deferred volume to the FFA begins with:

$$FFAinc_d = (RBF_d \times KRmult_d) \times RP_d \tag{6}$$

As the Ops Index approaches 0.7, the FFA reserve proportion declines to zero because with wetter conditions comes less need to augment flows or to shape a discrete event like a pulse flow.

Appendix Table C-14. Flexible Flow Account reserve proportion lookup table for the Keno Release Model

Ops Index	FFA Reserve Proportion
0	0.9
0.6	0.7
0.7	0
1	0

Note: Reserve proportions are interpolated to correspond with the computed Ops Index.

However, the full amount of the *FFAinc*$_d$ is not always stored for later use (i.e., added to the FFA) because of interactions with spill and ramping operations. The amount of yesterday's daily accrual volume (TAF) to the FFA is calculated as:

$$\begin{aligned} Yest_{FFA_{savings}}{}_d = \max(0, FFAinc_{d-1} - \max(0, C13_{exc}{}_{d-1} - Yest_{DPS_{spill}}{}_d \\ - I91\_IG_{d-1} - C13\_ramp_{d-1})) \end{aligned} \tag{7}$$

Where *C13_exc*$_{d-1}$ is yesterday's spill from Keno Dam, *I91_IG*$_{d-1}$ and *C131_IG*$_{d-1}$ are yesterday's flows from the Lost River and returns from KDD, respectively, that contributed to Klamath River flows below Keno Dam, and *C13_ramp*$_{d-1}$ is yesterday's down-ramping flow at Keno Dam. Yesterday's spill of the deferred Project Supply volume ($Yest\_DPS\_spill_d$) is explained later in the *Deferred Project Supply Accounting* section below.

Spills from Link River or Keno dams will stop the accrual of FFA volume. Spills from Link River Dam will spill the stored FFA volume after the accumulated deferred Project Supply volume has been spilled.

Use of the FFA volume ($FFAuse_d$) may take different forms year to year. Pulse flows may be implemented from the FFA volume, or the volume may be used to augment flows, or both. Two simulations of the Proposed Action have been prepared to illustrate the flexibility intended for the use of the FFA. In one (run name MST11b_DraftPA_Jan26) a Pulse Flow operation is implemented annually based upon a set of criteria intended to provide a realistic (but not prescriptive) representation of how Pulse Flows could be implemented. In the other (run name MST11b_DraftPA_PFoff_Jan26) no Pulse Flows are implemented and the FFA volume is added to the Keno Release Targets according to one of many possible distribution shapes.

The conditions governing Pulse Flow operations in the KRM were not intended to constrain real-time operations. Operationally, sizing the peak release based on ramping rates (which typically govern the recession limb of the Pulse Flow) and release targets immediately before the Pulse Flow must be done in a manner that prevents using more volume for the Pulse Flow event than is available in the FFA. The KRM determined the magnitude of the first day's Pulse Flow release to be 30% of the FFA volume, a conservative approach that ensured subsequent ramping did not overspend the FFA in the period of record simulated. In addition, the KRM limited the size of the FFA to approximately 35 TAF, which appeared to adequately balance the cost of deferrals to winter flows with the benefit of providing sufficient pulse flows and/or augmented flows in the spring. Finally, the KRM did not simulate a Pulse Flow if a daily release from Keno Dam exceeded 4,500 cfs after January.

The variable $Yest\_FFA\_use_d$ (TAF) is used to account for the interaction of yesterday's *FFAuse* and yesterday's spill from Link River Dam ($C1\_exc_{d-1}$):

$$Yest\_FFA\_use_d = \min(FFAuse_{d-1}, C1\_exc_{d-1}). \tag{8}$$

Spills from the FFA can occur after all of the accumulated deferred Project Supply volume has been spilled and are quantified by:

$$\begin{aligned} Yest_{FFA_{spill}}{}_d = \max\big(0, (\min(C1_{exc_{d-1}}, C13_{exc_{d-1}} - I91_{IG_{d-1}} - C131_{IG_{d-1}})) \\ - Yest\_DPS\_spill_d\big) \end{aligned} \tag{9}$$

The FFA (FFA_d) tracks the accrual, storage, and use of deferred flow volumes as of day (*d*) using:

$$FFA_d = max(0, FFA_{d-1} + Yest\_FFA\_savings_d - Yest\_FFA\_use_d - Yest\_FFA\_spill_d) \tag{10}$$

Down-ramping rates used in the KRM have been translated from those used for Iron Gate Dam releases to approximate ramp rates for releases from Keno Dam that would produce flow changes at the Iron Gate gage like those required under previous Biological Opinions (Appendix Table C-15).

Simulated Proposed Action outcomes for the river expressed as percent exceedance, maximum and minimum of daily flows computed by month for water years 1991-2022 are in Appendix Table C-16 and Appendix Table C-17 for the Keno gage, and Appendix Table C-18 and Appendix Table C-19 for the Iron Gate gage. Note that tables are provided for each of the Proposed

Action simulations (Pulse Flows on and off). Simulated flow at the Iron Gate gage is the sum of the Keno Release Target, Keno ramping and spills, and the Keno to Iron Gate accretions.

Appendix Table C-15. Ramp rates for releases from Keno Dam under the Proposed Action compared to those for releases from Iron Gate Dam under the Interim Operations Plan

Keno Release Threshold (cfs)	Keno Ramp Rate (cfs/day)	IGD Release Threshold from IOP (cfs)	IGD Ramp Rate (cfs/day)
<1,400	150	<1,900	150
<2,800	300	<3,300	300
<3,100	600	<3,600	600
<3,500	$C13_{-1}$ - 2,500	<4,000	$C15_{-1}$ - 3,000
<4,100	1,000	<4,600	1,000
≥4,100	min(2,000, $C13_{-1}$ - 3,100)	≥4,100	min(2,000, $C15_{-1}$ - 3,600)

Note: $C13_{-1}$ and $C15_{-1}$ are the prior day releases from Keno and Iron Gate dams, respectively.

Appendix Table C-16. Simulated Proposed Action outcomes (cfs) for the river at the Keno gage with Pulse Flows on

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,418	2,281	3,335	6,705	7,772	6,046	6,878	5,759	4,654	1,658	1,370	1,189
5%	1,161	1,475	2,088	2,164	3,381	3,978	4,612	3,307	1,851	893	1,220	1,072
10%	975	1,104	1,428	1,628	2,510	2,877	3,796	2,549	1,368	839	1,034	897
15%	948	1,041	1,165	1,271	1,787	2,604	3,128	2,264	1,294	797	920	872
20%	937	907	785	992	1,224	2,427	2,855	2,141	1,219	776	846	848
25%	869	860	758	764	1,074	2,233	2,500	2,039	1,176	757	790	831
30%	840	803	746	751	909	1,717	2,237	1,932	1,148	748	768	823
35%	794	784	736	737	758	1,470	2,070	1,714	1,098	737	745	815
40%	779	777	726	725	735	1,375	1,947	1,563	1,052	698	727	791
45%	773	773	719	717	713	1,224	1,841	1,484	1,026	681	708	777
50%	771	770	710	708	699	1,182	1,651	1,446	1,001	677	690	771
55%	770	765	701	697	691	1,123	1,545	1,405	990	673	678	766
60%	767	763	689	687	686	1,049	1,472	1,345	978	669	673	757
65%	764	760	679	679	681	982	1,417	1,304	969	665	666	755
70%	762	759	673	674	677	943	1,363	1,235	956	659	662	754
75%	762	758	669	671	673	921	1,300	1,188	930	655	656	753
80%	760	755	665	665	669	904	1,260	1,140	913	654	654	751
85%	758	752	663	660	662	881	1,210	1,107	874	653	653	750
90%	757	742	661	658	658	821	1,138	1,030	831	651	651	745
95%	752	726	656	656	655	756	1,043	948	783	650	650	730
Min	751	706	650	650	650	675	877	840	708	650	650	709

Notes: Statistics (minimum, maximum, and percent exceedance) are computed from daily flows for water years 1991-2022 for the specified months.

Appendix Table C-17. Simulated Proposed Action outcomes (cfs) for the river at the Keno gage with Pulse Flows off

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,418	2,281	3,335	6,705	7,772	6,046	6,878	5,759	4,654	1,658	1,370	1,189
5%	1,161	1,475	2,087	2,164	3,381	3,656	4,504	3,307	1,851	893	1,220	1,072
10%	976	1,104	1,429	1,626	2,510	2,712	3,531	2,672	1,366	839	1,034	897
15%	948	1,045	1,165	1,271	1,787	2,474	3,141	2,366	1,297	797	920	872
20%	937	910	785	993	1,227	2,313	2,728	2,250	1,231	776	846	849
25%	869	861	759	764	1,079	1,531	2,378	2,140	1,183	758	790	832
30%	842	804	747	751	908	1,362	2,202	2,037	1,150	748	768	823
35%	796	784	736	737	754	1,281	2,044	1,913	1,111	737	745	816
40%	779	777	726	725	734	1,202	1,900	1,784	1,068	698	727	791
45%	773	773	720	717	712	1,171	1,774	1,698	1,043	681	708	777
50%	771	770	710	708	699	1,119	1,638	1,649	1,009	677	689	771
55%	770	765	701	697	691	1,066	1,571	1,593	985	673	678	766
60%	767	763	689	687	685	996	1,522	1,527	967	669	673	757
65%	764	760	679	679	681	952	1,490	1,463	957	665	666	755
70%	762	759	673	674	677	930	1,434	1,407	943	659	662	754
75%	762	758	669	671	673	915	1,370	1,343	926	655	656	753
80%	760	755	665	665	669	897	1,317	1,287	906	654	654	751
85%	758	752	663	660	662	869	1,237	1,239	879	653	653	750
90%	757	741	661	658	658	821	1,148	1,115	825	651	651	745
95%	752	726	656	656	655	755	1,097	1,015	798	650	650	730
Min	751	706	650	650	650	675	877	884	703	650	650	709

Notes: Statistics (minimum, maximum, and percent exceedance) are computed from daily flows for water years 1991-2022 for the specified months.

Appendix Table C-18. Simulated Proposed Action outcomes (cfs) for the river at the Iron Gate gage with Pulse Flows on

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,902	3,231	6,609	12,735	10,344	8,341	7,855	6,251	5,406	2,163	1,768	1,555
5%	1,549	1,887	3,043	3,799	4,721	5,042	5,546	4,235	2,449	1,336	1,568	1,444
10%	1,446	1,553	1,981	2,338	3,329	3,977	4,718	3,330	1,981	1,254	1,363	1,291
15%	1,333	1,450	1,756	1,997	2,692	3,509	4,120	3,000	1,803	1,200	1,306	1,233
20%	1,301	1,339	1,527	1,783	2,243	3,295	3,591	2,762	1,669	1,160	1,230	1,204
25%	1,259	1,281	1,351	1,541	1,797	3,079	3,251	2,642	1,608	1,134	1,166	1,182
30%	1,207	1,227	1,262	1,406	1,557	2,895	3,005	2,527	1,572	1,096	1,115	1,166
35%	1,171	1,191	1,205	1,317	1,472	2,559	2,864	2,306	1,502	1,077	1,080	1,146
40%	1,152	1,167	1,172	1,258	1,374	2,307	2,691	2,141	1,442	1,040	1,062	1,133
45%	1,140	1,147	1,143	1,223	1,292	2,050	2,524	2,027	1,398	1,023	1,041	1,122
50%	1,133	1,134	1,119	1,187	1,230	1,866	2,296	1,932	1,360	1,009	1,019	1,109
55%	1,122	1,125	1,100	1,151	1,195	1,724	2,203	1,877	1,338	999	1,005	1,096
60%	1,110	1,117	1,079	1,121	1,160	1,584	2,090	1,815	1,319	990	988	1,081

Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
65%	1,096	1,109	1,065	1,097	1,131	1,503	1,980	1,754	1,301	980	975	1,069
70%	1,084	1,100	1,052	1,081	1,105	1,424	1,881	1,675	1,275	972	967	1,059
75%	1,072	1,088	1,039	1,061	1,087	1,361	1,741	1,612	1,259	958	955	1,049
80%	1,054	1,078	1,022	1,041	1,069	1,310	1,669	1,532	1,235	948	945	1,038
85%	1,036	1,066	1,003	1,021	1,048	1,276	1,637	1,483	1,207	940	934	1,027
90%	1,024	1,051	984	992	1,019	1,236	1,564	1,369	1,149	927	924	1,010
95%	1,015	1,026	961	969	996	1,129	1,421	1,264	1,070	917	913	998
Min	986	978	918	912	930	1,024	1,250	1,102	1,001	898	883	958

Notes: Statistics (minimum, maximum, and percent exceedance) are computed from daily flows for water years 1991-2022 for the specified months.

Appendix Table C-19. Simulated Proposed Action outcomes (cfs) for the river at the Iron Gate gage with Pulse Flows off

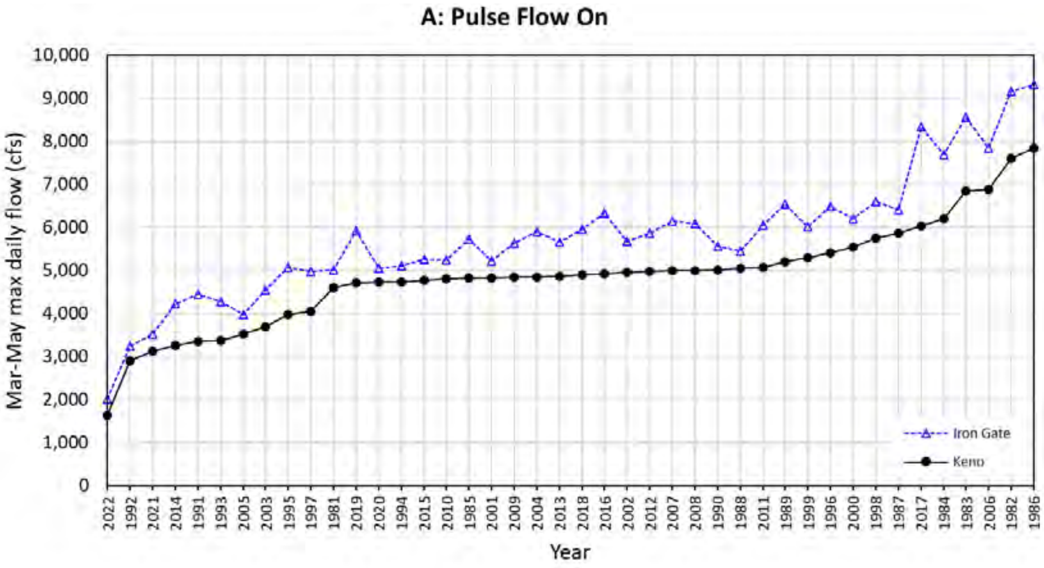
Stat.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,902	3,231	6,609	12,735	10,344	8,341	7,855	6,251	5,406	2,163	1,768	1,555
5%	1,549	1,887	3,043	3,799	4,721	4,719	5,517	4,235	2,465	1,337	1,568	1,444
10%	1,446	1,553	1,980	2,338	3,329	3,693	4,555	3,423	1,997	1,254	1,363	1,291
15%	1,333	1,455	1,750	2,002	2,692	3,347	4,105	3,167	1,794	1,200	1,306	1,233
20%	1,301	1,343	1,530	1,783	2,243	3,094	3,534	2,852	1,674	1,160	1,230	1,204
25%	1,260	1,281	1,346	1,541	1,798	2,848	3,166	2,757	1,616	1,134	1,166	1,182
30%	1,209	1,228	1,262	1,406	1,556	2,478	3,009	2,634	1,569	1,096	1,115	1,166
35%	1,171	1,192	1,205	1,317	1,475	2,272	2,867	2,499	1,519	1,077	1,080	1,147
40%	1,152	1,168	1,172	1,260	1,373	2,069	2,576	2,332	1,456	1,040	1,062	1,133
45%	1,140	1,147	1,143	1,225	1,290	1,946	2,434	2,217	1,409	1,023	1,041	1,122
50%	1,133	1,134	1,118	1,187	1,230	1,779	2,265	2,134	1,371	1,009	1,019	1,109
55%	1,123	1,125	1,100	1,151	1,196	1,703	2,191	2,058	1,351	999	1,005	1,096
60%	1,110	1,117	1,079	1,121	1,160	1,565	2,124	1,993	1,320	990	988	1,081
65%	1,096	1,109	1,065	1,097	1,131	1,494	2,029	1,911	1,292	980	975	1,069
70%	1,084	1,100	1,052	1,080	1,105	1,417	1,853	1,842	1,267	972	967	1,059
75%	1,072	1,088	1,039	1,061	1,087	1,358	1,800	1,768	1,247	958	955	1,049
80%	1,054	1,078	1,022	1,041	1,069	1,310	1,758	1,706	1,223	948	945	1,038
85%	1,036	1,066	1,003	1,021	1,048	1,275	1,667	1,629	1,190	940	934	1,027
90%	1,024	1,051	984	992	1,019	1,236	1,562	1,447	1,139	927	924	1,010
95%	1,015	1,026	961	969	996	1,128	1,472	1,360	1,081	917	913	998
Min	986	978	918	912	930	1,024	1,250	1,159	993	898	883	958

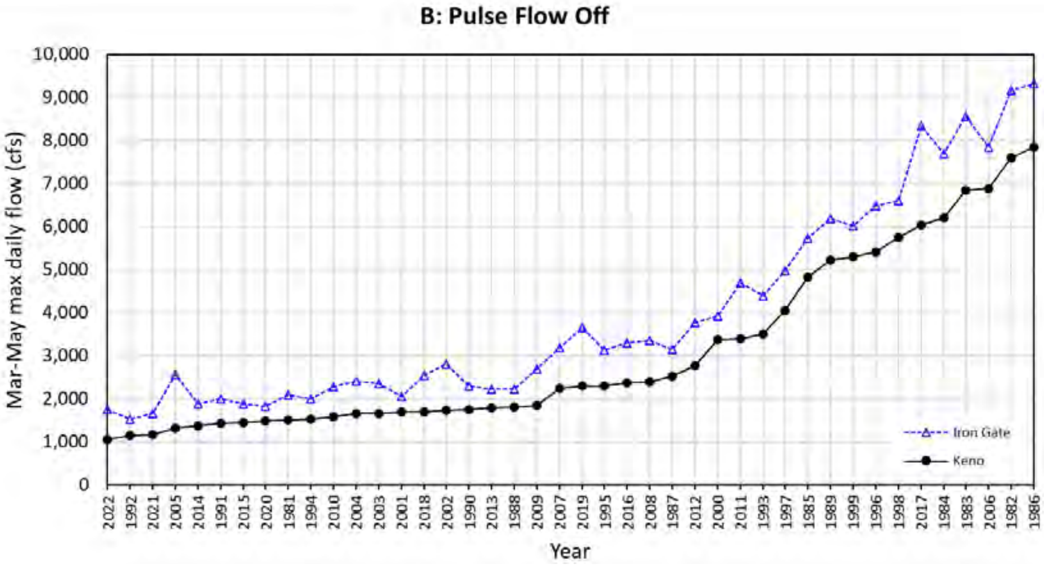
Notes: Statistics (minimum, maximum, and percent exceedance) are computed from daily flows for water years 1991-2022 for the specified months.

The volume used from the FFA each year for each of the Proposed Action simulations is almost always very similar (Appendix Table C-20). In 1989, less FFA water was used when the Pulse Flow was off because in that scenario some of the FFA volume spilled (after all the accumulated deferred Project Supply volume spilled). Maximum daily flows at Keno and Iron Gate with Pulse Flows on and off are shown on Appendix Figure C-9.

Appendix Table C-20. Flexible Flow Account volumes used by the river each year for each of the Proposed Action simulations (Pulse Flows on and off)

Year	FFA Used with PF On (TAF)	FFA Used with PF Off (TAF)	Year	FFA Used with PF On (TAF)	FFA Used with PF Off (TAF)
1981	22	22	2002	34	34
1982	0	0	2003	18	18
1983	0	0	2004	24	25
1984	7	7	2005	16	16
1985	15	15	2006	22	22
1986	0	0	2007	35	35
1987	35	35	2008	36	36
1988	36	36	2009	36	36
1989	36	30	2010	25	25
1990	36	36	2011	36	36
1991	17	17	2012	36	36
1992	12	12	2013	35	35
1993	12	12	2014	16	16
1994	34	34	2015	25	25
1995	20	20	2016	34	34
1996	0	0	2017	11	11
1997	0	0	2018	27	27
1998	8	8	2019	24	24
1999	5	5	2020	34	34
2000	20	20	2021	14	14
2001	35	35	2022	4	4





Note: Years are sorted based on the magnitude of the March through May max daily flow at Keno.

Appendix Figure C-9. Maximum daily flow for March through May in each year for the Pulse Flow on (A) and Pulse Flow off (B) scenarios of the Proposed Action

Project Irrigation Allocation

In past operations of the Project, allocations from UKL were made to various uses based on the volume of UKL net inflow forecasted to appear from some specified date in the spring through September. The only forecast-based allocation in the current Proposed Action is made for Project irrigation. Portions of this allocation can change when the net inflow forecasts change (see Appendix Table C-3 for the forecast dates), but the allocation is firm and unchanging from

June 1 through the rest of the year. Water available for irrigation use from UKL during the spring-summer period is divided into forecast-based firm and variable components from UKL storage and inflow.

The process for allocating water for irrigation begins with looking up the Project Share (PS) of storage or inflow components, which is determined by the Ops Index (Appendix Table C-21). On March 1 and then again on April 1, a Project Supply from Storage (PSS, in TAF) is computed as:

$$PSS_d = (SS_d - 209.111\ taf) \times PS_d, \tag{11}$$

where *d* is either March 1 or April 1, SS_d is UKL Shadow Storage, and 209.111 TAF is the UKL active storage at an elevation of 4,138.8 ft (Reclamation datum, see Appendix Table C-21). The PSS_{Apr1} is the Firm Project Supply from Storage, which does not change again that year.

Appendix Table C-21. Project Share of storage and inflow components of the Klamath Project allocation

Ops Index	Project Share
0	0.12
0.2	0.17
0.4	0.26
0.6	0.26
0.8	0.25
1	0.24

Note: Project Share values are interpolated based on the value of the Ops Index.

Estimates of UKL net inflow volume for April through September are made on each forecast date and are used to calculate the Project Supply from inflow (*PSI*). Such estimates are comprised of the actual UKL net inflow volume since April 1 plus the forecasted UKL net inflow volume from the forecast date through September. On April 1, the variable Apr95vol is the 95% exceedance forecast on April 1 of April-September UKL net inflow. On April 15, Apr95vol is the actual UKL net inflow from April 1-14 plus the 95% exceedance forecast of April 15-September UKL net inflow. Apr50vol is computed in the same manner as Apr95vol using the 50% exceedance forecast instead of the 95% exceedance forecast. So, for example, the Apr50vol on March 1 and April 1 is the 50% exceedance forecast of April-September UKL net inflow, and on May 15 is the actual UKL net inflow from April 1-May 14 plus the 50% exceedance forecast of May 15-September UKL net inflow.

In March there is no distinction between firm and variable allocations from UKL net inflow for irrigation, so on March 1 the Project Supply from inflow (*PSI*, in TAF) is calculated as:

$$PSI_{Mar\ 1} = Apr50vol_{Mar\ 1} \times PS_{Mar\ 1} \tag{12}$$

Starting on April 1, the Project Supply from inflow is divided into firm and variable components. The Firm Project Supply from inflow (*FPSI*, in TAF) is computed provisionally on April 1 and then finally on April 15 as:

$$FPSI_d = \min\left(350\ taf - PSS_{Apr1}, Apr95vol_d \times PS_d\right) \tag{13}$$

Where *d* is either April 1 or 15, and 350 TAF is the maximum Project Supply from UKL. $FPSI_d$ is constrained so that when added to the Project Supply from Storage the sum does not exceed the maximum Project Supply from UKL. The $FPSI_{Apr15}$ remains constant through the rest of the year.

By April 15, the firm supplies from storage and inflow are known, and the Firm Project Supply (*FPS*, in TAF) is calculated as:

$$FPS_{Apr\ 15} = \min\left(350\ \text{taf}, PSS_{Apr1}\ + FPSI_{Apr15}\right) \tag{14}$$

but note that this is also computed provisionally on Apr 1 using the provisional $FPSI_{Apr1}$.

On April 1, the variable component (which can increase or decrease) of Project Supply from inflow (VPSI, in TAF) is computed for the first time, and then is recomputed on every subsequent forecast date until becoming firm on June 1. On forecast date *d* this supply is computed as:

$$VPSI_d = \min\left(350\ taf - FPS_d, (Apr50vol_d \times PS_d - FPSI_d)\right) \times PSM_d \tag{15}$$

Where FPS_d is held constant at FPS_{Apr15} for forecast dates later than April 15, and PSM_d is the Project Supply Multiplier that is determined by the exceedance quantile of the cumulative actual UKL net inflow volume since April 1 (Appendix Table C-22). As actual UKL net inflow after April 1 increases above the median (the exceedance quantile declines from 0.5), the Project Supply Multiplier increases above 1 and increases the Variable Project Supply. The opposite occurs when the inflows decline below the median (the exceedance quantile increases from 0.5). The annual progression of the Variable Project Supply from inflow is shown in Appendix Table C-23 for the Proposed Action run with Pulse Flows on.

Appendix Table C-22. The Project Supply Multiplier is determined by the exceedance quantile for cumulative Upper Klamath Lake net inflow volume since Apr 1

Inflow Exceedance Since Apr 1	Project Supply Multiplier
0.05	1.5
0.5	1
0.95	0.5

Note: Exceedance is computed for water years 1991-2022.

Appendix Table C-23. Keno Release Model output showing the various computed components of Project Supply from Upper Klamath Lake (TAF) for the Proposed Action run with Pulse Flows on

Year	Storage Mar 1	Provisional Inflow Mar 1	Firm Storage Apr 1	Provisional Inflow Apr 1	Firm Inflow Apr 15	Variable Apr 1	Variable Apr 15	Variable May 1	Variable May 15	Firm Variable Jun 1	Firm Supply Apr 15	Firm Supply Jun 1
1981	48	120	63	49	58	13	12	6	2	6	121	127
1982	88	142	95	112	143	76	31	10	26	29	238	267
1983	81	178	89	134	185	103	40	37	14	14	274	288
1984	73	153	96	122	167	91	37	37	25	45	263	307
1985	60	133	76	105	115	69	28	51	53	41	191	232
1986	92	137	101	91	103	58	24	19	31	29	204	232
1987	79	101	93	70	67	27	15	3	12	7	160	167
1988	78	83	93	50	41	10	9	17	22	20	134	155
1989	51	128	92	114	126	83	29	32	50	36	218	255
1990	70	79	87	54	46	15	10	16	17	19	133	152
1991	31	39	53	56	58	14	10	9	1	5	111	116
1992	15	32	18	19	14	3	3	7	6	3	32	35
1993	11	139	58	98	162	68	35	26	15	7	220	227
1994	52	73	59	38	38	6	8	3	0	0	97	97
1995	44	100	76	90	102	54	23	29	44	38	177	216
1996	90	142	95	86	91	41	22	41	44	71	186	257
1997	87	140	89	83	95	40	20	37	40	39	183	222
1998	75	155	90	103	141	70	32	0	11	62	231	293
1999	57	204	70	137	179	101	39	43	37	39	248	287
2000	79	142	87	95	84	53	20	57	83	70	171	241
2001	55	71	72	48	54	14	10	9	2	1	126	127
2002	55	112	69	66	58	23	13	24	33	25	127	152
2003	54	70	68	50	71	19	16	24	37	25	139	164
2004	52	133	72	67	61	33	14	19	21	20	133	153
2005	21	46	26	31	38	8	7	7	25	73	63	136
2006	68	166	72	111	149	68	32	45	49	58	221	279
2007	68	103	90	66	76	30	17	21	28	19	165	185

Year	Storage Mar 1	Provisional Inflow Mar 1	Firm Storage Apr 1	Provisional Inflow Apr 1	Firm Inflow Apr 15	Variable Apr 1	Variable Apr 15	Variable May 1	Variable May 15	Firm Variable Jun 1	Firm Supply Apr 15	Firm Supply Jun 1
2008	55	131	72	94	114	56	24	15	13	16	186	202
2009	60	97	79	74	83	27	14	0	11	15	161	177
2010	53	86	60	52	70	15	13	12	9	5	130	135
2011	71	105	89	104	131	68	29	30	13	13	220	233
2012	75	82	89	81	110	35	25	4	6	5	199	203
2013	60	89	73	53	68	14	15	9	5	1	141	143
2014	44	58	56	45	47	9	10	3	0	0	104	104
2015	59	51	66	37	36	7	7	2	0	2	102	104
2016	52	107	82	86	70	37	15	9	12	8	152	161
2017	73	156	97	108	143	77	32	24	14	15	240	255
2018	48	50	71	58	67	15	14	14	7	12	138	150
2019	49	122	63	83	112	38	26	29	25	21	175	196
2020	54	79	50	40	42	7	7	0	0	4	92	96
2021	20	58	20	28	16	4	3	2	2	2	36	39
2022	3	31	5	14	15	1	3	10	14	12	20	32

The Project Supply from UKL ($PSup$) sums the storage and inflow components and becomes firm on June 1, after which it does not change. On March 1, it is calculated as:

$$PSup_{Mar\ 1} = min(350\ taf, PSS_{Mar\ 1} + PSI_{Mar\ 1}). \tag{16}$$

On and after April 1 it is calculated as:

$$PSup_d = min(350\ taf, FPS_d + VPSI_d), \tag{17}$$

Note that *d* is either April 1 or 15 for *FPS*. At the end of this process, $PSup_{Jun1}$ is the final, firm Project Supply from UKL for the rest of the year. Appendix Table C-23 reports the values computed for each component of Project Supply for the Proposed Action run with Pulse Flows on, and the temporal sequence of computed Project Supply from UKL within each year is in Appendix Table C-24.

Appendix Table C-24. Keno Release Model output showing the computed values of Project Supply from Upper Klamath Lake (TAF) within each year for the Proposed Action run with Pulse Flows on

Year	Mar 1	Apr 1	Apr 15	May 1	May 15	Jun 1	Year	Mar 1	Apr 1	Apr 15	May 1	May 15	Jun 1
1981	168	125	132	127	122	127	2002	167	158	140	150	160	152
1982	230	282	269	247	263	267	2003	124	137	155	163	176	164
1983	258	325	313	311	288	288	2004	185	172	147	152	153	153
1984	226	310	300	299	287	307	2005	67	65	70	71	89	136
1985	192	250	219	242	244	232	2006	234	251	254	266	270	279
1986	228	249	228	223	235	232	2007	170	186	183	187	193	185
1987	180	191	175	163	172	167	2008	186	223	210	201	199	202
1988	162	153	143	151	156	155	2009	157	179	176	161	172	177
1989	180	289	248	250	268	255	2010	138	127	143	142	139	135
1990	149	156	143	149	150	152	2011	176	261	249	250	233	233
1991	69	122	121	120	111	116	2012	157	205	223	203	205	203
1992	47	40	35	39	38	35	2013	149	140	157	150	146	143
1993	150	224	255	246	235	227	2014	101	111	114	107	104	104
1994	124	103	105	100	97	97	2015	110	111	109	104	102	104
1995	143	219	201	207	221	216	2016	159	205	167	162	165	161
1996	231	222	208	227	230	257	2017	229	282	272	264	254	255
1997	227	211	204	220	224	222	2018	98	144	151	152	145	150
1998	230	263	263	231	243	293	2019	171	183	201	205	200	196
1999	262	308	287	291	285	287	2020	133	97	99	92	92	96
2000	221	236	191	228	254	241	2021	78	52	40	39	39	39
2001	126	133	136	135	127	127	2022	34	21	23	30	34	32

Project Irrigation Diversions

The KRM represents Klamath Project Ag diversions at A Canal (D1), Station 48 and Miller Hill (aggregated into D91), North Canal (D11), and Ady Canal (D12A). In the KRM accounting, three sources of water are tracked for Project Ag diversions: UKL, Lost River water diverted into the LRDC (LRDC accretions), and F/FF pumping. During the irrigation season, UKL source diversions are divided into a Project Supply component (described above) and a Deferred Project Supply component (described in the *Deferred Project Supply Accounting* section). Ag diversion accounting rules vary by point of diversion, season of diversion, and the flood control status of UKL. The following priority schedule is used to determine how much Project Supply and deferred Project Supply were diverted the previous day.

1. A Canal
    - Irrigation season (March-October)
        - No flood control.
            - All diversions are from UKL.
                - Division between Project Supply and Deferred Project Supply is described below.
        - Flood control operations declared (imminent or occurring).
            - All diversions are from UKL.
                - Divert Deferred Project Supply first.
                - Divert Project Supply second.
    - Winter season (November-February).
        - No A Canal Ag diversions.
2. Station 48 and Miller Hill.
    - Irrigation season (March – November 15).
        - No flood control.
            - Divert LRDC accretions first.
            - Divert from UKL second.
                - Division between Project Supply and Deferred Project Supply is described below.
            - Divert from F/FF pumping last.

- Flood control operations declared (imminent or occurring).
    - Divert LRDC accretions first.
    - Divert F/FF pumping second.
    - Divert UKL last.
        - Divert Deferred Project Supply first.
        - Divert Project Supply second.
- Winter season (November 16 – February).
    - No Station 48 or Miller Hill Ag diversions.

3. North and Ady Canals (Ag).
    - Irrigation season (March-September).
        - No flood control.
            - Divert from UKL first.
                - Division between Project Supply and Deferred Project Supply is described below.
            - Divert LRDC accretions second.
            - Divert F/FF pumping last.
        - Flood control operations declared (imminent or occurring).
            - Divert LRDC accretions first.
            - Divert F/FF pumping second.
            - Divert UKL last.
                - Divert Deferred Project Supply first.
                - Divert Project Supply second.
    - Winter Season (October-February).
        - Flood control or No Flood Control.
            - KDD winter water right diversions are from UKL.
                - None are from Deferred Project Supply.
                - Winter water right is limited to 28,910 acre-feet.

Note that when there are no flood control operations during the irrigation season, Station 48 diverts LRDC accretions first when available, whereas North and Ady Canals divert water from

UKL. The purpose of this is to keep as much Lost River water in the Lost River basin as possible. Beyond that, if flood control is not imminent or occurring, the LRDC accretions are allowed to support river flows and accumulate as Deferred Project Supply in UKL (accounting described in next section). The UKL water then being diverted by North and Ady Canals is a combination of Project Supply and Deferred Project Supply. Similarly, diversion of F/FF pumping occurs last during the irrigation season when there is no flood control. It is not lost to the Project. The F/FF pumping supports Keno flows and generates deferred Project Supply in UKL as described in the *Deferred Project Supply Accounting* section of this Appendix.

In the Proposed Action simulation, Project diversions during the irrigation season (SS for Spring-Summer) by source and year are listed in Appendix Table C-25. The diversion from UKL includes both Project Supply and Deferred Project Supply. As indicated in the priority diversion outline above, the A Canal irrigation season is March through October, Station 48 and Miller Hill is March through November 15, and North and Ady Canals is March through September.

Appendix Table C-25. Simulated irrigation season (SS) Klamath Project diversions (TAF) by year and source

Year	From UKL	From LRDC Accretions	From F/FF Pumping	SS Total	Year	From UKL	From LRDC Accretions	From F/FF Pumping	SS Total
1981	176	10	0	187	2002	199	26	0	226
1982	297	41	1	339	2003	200	26	0	226
1983	292	47	2	341	2004	230	28	0	258
1984	315	51	2	368	2005	181	17	0	198
1985	315	46	2	362	2006	355	48	2	405
1986	274	35	4	313	2007	264	21	1	285
1987	206	19	1	226	2008	248	18	0	266
1988	191	13	2	205	2009	220	11	0	231
1989	282	27	2	311	2010	160	15	0	175
1990	212	15	0	227	2011	274	17	0	291
1991	156	5	0	161	2012	238	14	0	252
1992	56	0	0	56	2013	176	10	0	186
1993	293	15	0	308	2014	127	3	0	130
1994	129	3	0	132	2015	129	5	0	134
1995	293	19	0	313	2016	193	10	0	203
1996	315	21	2	338	2017	290	29	4	323
1997	288	23	0	311	2018	190	19	0	209
1998	313	35	5	353	2019	275	25	0	300
1999	380	52	5	437	2020	133	20	0	152
2000	309	42	4	355	2021	63	10	0	72
2001	203	27	0	230	2022	49	4	0	53

Deferred Project Supply Accounting

Deferred Project Supply accumulates in UKL through two accounting mechanisms. The first is Project contributions to targeted flows at Keno Dam that replaces river releases at Link River Dam, and the second is Project contributions to TLNWR and LKNWR that replace refuge supply from UKL.

The amount of Lost River water or F/FF pumping that goes to Keno Releases can be calculated using the diversion priority schedule outlined in the previous section. First, determine the amount of Lost River accretions and/or F/FF pumping that is diverted at Station 48, Miller Hill, and North or Ady Canals using the diversion priorities. The remainder is the Project contribution to flows at Keno.

Project contributions to targeted flows at Keno Dam must occur under the following conditions to result in an increase in the Deferred Project Supply Account (DPSA).

1. The Keno impoundment is balanced.
    a. Releases at Link Dam are in balance with Project deliveries out of the Keno impoundment, targeted flow releases from Keno Dam, and operational storage levels within the Keno impoundment.
    b. Keno impoundment is not in flood control operations.
2. UKL is not in flood control operations.
3. The date is on or between November 1 and September 30. No Deferred Project Supply is accumulated in October.

If these three conditions are met while Lost River accretions or F/FF pumping are contributing to Keno flows, there will be an equivalent decrease in Link Dam releases and increase in the DPSA. If there is flow exceeding the targeted flow due to a Keno impoundment imbalance, the increase in DPSA is the Project contribution to Keno flows minus the Keno excess flow:

$$Yest\_Flow\_Savings_d = max(0, Yest\_Prj\_Keno\_Contribution_d - C13\_exc_{d-1}), \qquad (18)$$

where, $Yest\_flow\_savings_d$ is the amount (TAF) Link release was reduced due to Project contributions to Keno flow, $Yest\_Prj\_Keno\_Contribution_d$ is yesterday's LRDC accretion and F/FF pumping contribution to flow at Keno (TAF), and $C13\_exc_{d-1}$ is flow (TAF) at Keno in excess of targeted and ramping flows (i.e., spill).

On April 1, it is assumed that Reclamation and FWS will formulate a plan for meeting LKNWR and TLNWR needs over the irrigation season. Needs will be met through a combination of water already in the refuges, water provided by the Project through reuse of Ag drainage, and, finally, the 43,000 acre-feet dedicated supply from UKL. If it is determined that none or part of the UKL refuge supply is needed, it will be added to the DPSA uniformly from April 2 to October 31.

Yest_Ref_Savings is the variable name for the daily uniform distribution of foregone UKL refuge supply to the DPSA in acre-feet. It is assumed that if the quantity of foregone UKL refuge supply is adjusted over the course of the irrigation season that the *Yest_Ref_Savings* calculation will be adjusted such that the cumulative savings to the DPSA is the correct amount by the end of October.

Project use of Deferred Project Supply is calculated based on the Ag diversion priorities set in the previous section. First, the quantity of UKL Ag diversion is calculated. These diversions only occur during the irrigation season. If flood control operations were not imminent or occurring yesterday, the Project diversion of DSP is calculated as:

$$Yest\_Prj\_Div\_DPS_d = Frac\_Div\_DPS_d \times Yest\_Prj\_Div\_UKL_d, \tag{19}$$

where, $Yest\_Prj\_Div\_DPS_d$ is yesterday's Project diversion of deferred Project Supply (TAF), $Frac\_Div\_DPS_d$ is the proportion of Deferred Project Supply diversion to the total Project diversion from UKL (Equation 20), and $Yest\_Prj\_Div\_UKL_d$ is the total Project diversion from UKL (TAF) as of yesterday.

When UKL is not in flood control, the variable $Frac\_Div\_DPS_d$ is calculated as:

$$Frac\_Div\_DPS_d = \frac{DPSA_{d-1}}{\max(0, PSup_d - PSup\_used_{d-1}) + DPSA_{d-1}}, \tag{20}$$

where, $DPSA_{d-1}$ is the deferred Project Supply Account balance at the beginning of yesterday, $PSup_d$ is the Project Supply, and $PSup\_used_{d-1}$ is the total quantity of Project Supply used at the beginning of yesterday.

If flood control operations are occurring or declared to be imminent, the fraction of the UKL diversion that comes from Deferred Project Supply is 1 and any remaining UKL diversion after Deferred Project Supply is exhausted comes from Project Supply.

In the event of flood control releases (actual or imminent), Deferred Project Supply can be diverted by the TLNWR and LKNWR. For Deferred Project Supply accounting, the refuge diversion variable is $Yest\_Ref\_Div\_DPS_d$ and is an aggregate account of yesterday's refuge diversion of Deferred Project Supply in acre-feet.

During UKL flood control operations, Deferred Project Supply spills before the Flexible Flow Account. The calculation of yesterday's Deferred Project Supply spill to the river is:

$$\begin{aligned} Yest\_DPS\_Spill_d &= \\ max(0, min(C1\_exc_{d-1}, C13\_exc_{d-1} &- Yest\_Prj\_Keno\_Contribution_d, \\ DPSA_{d-1} - Yest\_Prj\_Div\_DPS_d &- Yest\_Ref\_Div\_DPS_d)), \end{aligned} \tag{21}$$

Where, $Yest\_DPS\_Spill_d$ is the UKL flood control spill of Deferred Project Supply that is not diverted by the Project or Refuge (TAF), and $C1\_exc_{d-1}$ is flow at Link River Dam that exceeds the minimum required Link release (TAF).

Now that the mechanisms for accumulating, diverting, and spilling Deferred Project Supply have been defined, the final calculation is the balance of the deferred Project Supply Account (DPSA) for the end of yesterday:

$$\begin{aligned} DPSA_d = \max\,(0, DPSA_{d-1} + Yest\_Flow\_Savings_d + Yest\_Ref\_Savings_d \\ - Yest\_Prj\_Div\_DPS_d - Yest\_Ref\_Div\_DPS_d - Yest\_DPS\_Spill_d), \end{aligned} \quad (22)$$

where, $DPSA_d$ is the deferred Project Supply account in UKL at the end of yesterday. The *DPSA* is reset to zero on November 1 (there is no carryover into the next year), and accumulation of water in the account begins on the same day.

Table E-26 reports cumulative values by water year for key parameters in Equation 22. Column Flow/Ref Savings is the combined accumulation of variables $Yest\_Flow\_Savings_d$ and $Yest\_Ref\_Savings_d$. DPS Prj Delivery reports the cumulative $Yest\_Prj\_Div\_DPS_d$. DPS Ref Delivery column reports the cumulative $Yest\_Ref\_Div\_DPS_d$, and Deferred Project Supply Spill to the River reports the cumulative $Yest\_DPS\_Spill_d$. When savings is greater than the sum of the expenditures, the remainder is converted to general UKL storage on November 1.

Appendix Table C-26. Simulated accumulation of Deferred Project Supply through Flow and Refuge Savings and expenditure of Deferred Project Supply through Project Delivery, Refuge Delivery, and Spill to River (TAF)

Year	Flow/Ref Savings	DPS Prj Delivery	DPS Ref Delivery	DPS Spill to River	Year	Flow/Ref Savings	DPS Prj Delivery	DPS Ref Delivery	DPS Spill to River
1981	52	52	0	0	2002	53	53	0	0
1982	165	91	5	69	2003	39	39	0	0
1983	222	92	21	90	2004	83	83	0	0
1984	216	77	24	111	2005	52	52	0	0
1985	124	87	0	37	2006	185	108	17	60
1986	88	54	3	31	2007	92	89	4	0
1987	61	46	15	0	2008	51	51	0	0
1988	60	43	17	0	2009	45	45	0	0
1989	75	31	4	40	2010	26	26	0	0
1990	71	66	4	0	2011	44	44	0	0
1991	42	42	0	0	2012	37	37	0	0
1992	22	22	0	0	2013	35	35	0	0
1993	81	70	0	11	2014	24	24	0	0
1994	34	34	0	0	2015	25	25	0	0
1995	89	89	0	0	2016	33	33	0	0
1996	127	71	15	41	2017	71	45	10	16
1997	103	77	5	20	2018	45	45	0	0
1998	214	27	10	171	2019	96	96	0	0
1999	262	133	9	102	2020	39	39	0	0
2000	101	77	18	5	2021	25	25	0	0
2001	84	84	0	0	2022	18	18	0	0

Refuge Diversions

TLNWR and LKNWR have four sources of water: dedicated UKL storage, Lost River water, Deferred Project Supply flood spill, and UKL flood spill. Refuges cannot divert flood-released FFA.

Each irrigation season, 43,000 acre-feet of UKL water was modeled as diversions to the LKNWR and TLNWR. This water is delivered over the April through October period. The point of diversion for the LKNWR is Ady Canal. The modeled point of diversion for TLNWR is Station 48. To the extent that the Project can maintain the needed elevations of Sump 1A and Unit 2 by other means, the dedicated UKL refuge supply can be accrued to the Deferred Project Supply for delivery to the Project.

Lost River water, if allowed, will flow directly to the TLNWR. If the TLNWR reaches capacity, Lost River water can also be pumped from the Tule Basin to LKNWR through D Plant. When the Tule Basin is at capacity and UKL is approaching flood control, Lost River water can be diverted into the LRDC and re-diverted to the LKNWR through Ady Canal.

If the Deferred Project Supply spills, the refuges can divert the spilled water at Station 48 or Ady Canal before it flows over Keno Dam. During the irrigation season, Project Ag diversions of spilled Deferred Project Supply take priority over refuge diversions. If UKL continues to spill in flood control operations after the DPSA and FFA are empty, the LKNWR can divert flood waters from UKL at Ady Canal.

Appendix Table C-27 lists simulated deliveries to TLNWR and LKNWR combined by source and water year. In years when the diversion of dedicated UKL supply does not equal 43,000 acre-feet, the remainder was credited to Deferred Project Supply and delivered to the Project. This was accounted for in the Flow/Ref Savings column of Appendix Table C-26. The quantity of Lost River water delivered to TLNWR and LKNWR listed in Appendix Table C-27 includes Lost River water that flows directly to TLNWR, D Plant diversion out of the Tule Basin to LKNWR, and Ady diversion to LKNWR of LRDC accretions.

Appendix Table C-27. Combined Tule Lake National Wildlife Refuge and Lower Klamath National Wildlife Refuge deliveries (TAF) by source and water year

Year	Dedicated UKL	Lost River	DPS Spill	UKL Spill	Year	Dedicated UKL	Lost River	DPS Spill	UKL Spill
1981	31	46	0	0	2002	20	58	0	0
1982	2	117	5	11	2003	26	71	0	0
1983	0	95	21	0	2004	19	56	0	0
1984	0	109	24	0	2005	22	64	0	0
1985	0	62	0	0	2006	0	114	17	0
1986	0	94	3	4	2007	4	55	4	0
1987	6	52	15	0	2008	17	68	0	0

Year	Dedicated UKL	Lost River	DPS Spill	UKL Spill	Year	Dedicated UKL	Lost River	DPS Spill	UKL Spill
1988	12	52	17	0	2009	29	36	0	0
1989	15	77	4	0	2010	38	25	0	0
1990	17	56	4	0	2011	26	72	0	0
1991	32	31	0	0	2012	27	42	0	0
1992	41	15	0	0	2013	30	42	0	0
1993	21	71	0	0	2014	39	18	0	0
1994	30	28	0	0	2015	40	20	0	0
1995	22	72	0	0	2016	31	42	0	0
1996	0	102	15	3	2017	11	82	10	0
1997	0	97	5	2	2018	22	57	0	0
1998	0	131	10	2	2019	21	68	0	0
1999	0	98	9	0	2020	26	38	0	0
2000	0	97	18	0	2021	37	27	0	0
2001	6	28	0	0	2022	43	12	0	0

Inflow and Accretion Inputs to the Keno Release Model

The KRM inputs some inflow and accretion time series. Details of their development are provided in this section. An inflow/accretion time series representing the historic inputs from the Lost River (*I91hist*) was not filtered or smoothed. It is, however, dynamically adjusted within the KRM either up or down depending on the difference in simulated daily A Canal deliveries from the historic deliveries as documented in Section A.4.4.5 of Appendix 4 to the 2018 Biological Assessment (Reclamation, 2018).

Upper Klamath Lake Net Inflow

Daily UKL net inflow accounts for the net amount of water entering or leaving UKL above Link River Dam. There is no reliable measurement of actual daily inflow into UKL because of the many ungaged surface water and groundwater inflows. In addition, the ungaged activities of agricultural operations around the periphery of the lake, many of which are within the footprint of diked and drained wetlands that were once part of UKL, frequently pump water that accumulated behind dikes over the winter back into UKL during the spring and divert water for irrigation during the summer. Evaporation from open-water areas, and evapotranspiration from wetland areas, are continuous phenomena that vary with meteorological conditions and the areal extent of inundation.

Despite these conditions, it is essential to estimate the balance of water for each day in the period of record to be simulated (water years 1981-2022) entering or leaving the primary storage reservoir for the Klamath Reclamation Project, and this is done by measuring the daily net inflow to UKL. This is a two-step process. In the first step, the daily (*d*) raw UKL net inflow (*I1raw*, in TAF) is calculated as:

$$I1raw_d = \Delta\, storage_d + outflow_d, \tag{23}$$

Where $\Delta storage_d$ is the change in UKL storage from the previous day, and $outflow_d$ is the sum gaged diversions (and at times inflows, which enter the summation as negative numbers). A more detailed depiction of this calculation is:

$$I1raw_d = (UKLS_d - UKLS_{d-1}) + (Link\ River_d + ACan_d + PStor_d + Cal_d), \tag{24}$$

where $UKLS_d$ is the volume held in active storage within UKL, $Link\ River_d$, is the gaged flow of the Link River below Link River Dam adjusted for diversions at the dam into the Westside (Keno) Canal, and $ACan_d$ is the diversion into the A Canal. $PStor_d$ accounts for the pumped-storage operations using the Agency Lake Ranch lands on the west side of Agency Lake that occurred from 1998 through 2013 and occasional short-term actions by the UKNWR after 2013. $PStor_d$ is the daily net movement of water into or out of this area (diversion minus return), which will be negative when returns exceed diversions. Finally, Cal_d accounts for the breached dike that inundated the former Caledonia Marsh area from July 8 through December 31, 2006, and the subsequent pump-off that lasted until April 30, 2008. More detailed information is available from Dunsmoor (2017), although after that report the bathymetry of UKL was re-measured and the relationship between storage and lake surface elevation was re-defined (Hollenback et al., 2023). This revised elevation-capacity relationship (Table E-12) was used to compute daily UKL storage from the weighted mean elevation (Reclamation datum) of multiple gages reported by USGS gage 11507001.

This measurement of the raw UKL net inflow is affected by windy conditions and associated seiches in UKL that affect lake level measurements. Therefore, a smoothed UKL net inflow time series (*I1*) is used both operationally and for the KRM simulations. A single exponential smoother (alpha = 0.182) was applied to generate *I1*.

Keno Impoundment Accretions

In the reach between the USGS gage Link River at Klamath Falls, Oregon (11507500) and the USGS gage Klamath River at Keno, Oregon (11509500) there are many diversions from and inputs to the Keno impoundment from domestic, industrial, municipal, agricultural, and other sources. Over the 1981-2022 period of record, daily accretions (which can be, and frequently are, negative) have been highly variable, reflecting the many uncoordinated inputs and outputs to this reach, a few of which are gaged.

The first step in calculating the Keno impoundment accretions (*I10*, in TAF) involves calculating what the flow would be at the Keno gage based on the daily (*d*) gaged inputs to and outputs from the Keno impoundment:

$$\begin{aligned} Computed\ Keno\ flow_d = {} & Link\ River_d + LRDC\ input_d + FFF_d - LRDC\ diversion_d - \\ & North\ Canal_d - Ady\ Canal_d, \end{aligned} \tag{25}$$

where Link River$_d$ is the same combination of gaged Link River flow and Westside Canal diversion as that used in the UKL net inflow calculation, $LRDC\ input_d$ is inflow from the Lost River Diversion Channel, FFF_d is inflow from the F and FF pumps, and $LRDC\ diversion_d$, $North\ Canal_d$, and $Ady\ Canal_d$ are diversions from the Keno impoundment into the LRDC or into the footprint of the former Lower Klamath Lake for irrigation or refuge uses.

Next, the raw Keno impoundment accretion (*I10raw*, in TAF) is calculated as:

$$I10raw_d = Measured\ Keno\ flow_d + Computed\ Keno\ flow_d, \tag{26}$$

where $Measured\ Keno\ flow_d$ is the mean daily flow for the Klamath River at Keno gage reported by USGS. $I10raw_d$ may be positive or negative.

Intermittent (once every few years) signatures of the PacifiCorp hydropower operation are present in this time series in the form of very large, sudden positive $I10raw_d$ values on one day followed by very large negative $I10raw_d$ values on the next day. According to PacifiCorp, these result from maintenance activities within the hydropower project. Daily accretions associated with these events have been identified and replaced by the 5-day trailing average of $I10raw_d$. Finally, the *I10* time series used in operations and modeling is produced by applying a single exponential smoother (alpha = 0.3) to the $I10raw_d$ time series.

Keno to Iron Gate Accretions

Estimating daily accretions into the Keno-to-Iron Gate (KIG) reach between the USGS gage Klamath River at Keno, Oregon (11509500) and the USGS gage Klamath River below Iron Gate Dam, California (11516530) has long been difficult because of the operations of PacifiCorp's hydroelectric project. To optimize the power peaking operations at this series of facilities, PacifiCorp required frequent, rapid changes in releases from the dams above Iron Gate. Details and data for these operations have always been confidential, making it very difficult to estimate daily accretions.

PacifiCorp and Reclamation entered into a non-disclosure agreement allowing the use of daily time-step reservoir storage data, which resulted in improved KIG accretion estimates in the last consultation. Nonetheless, issues remained with the accretion time series. For instance, operations within the hydropower project can result in lower releases from Iron Gate Dam than are occurring from Keno Dam, causing accretion estimates to be erroneously negative. For the current consultation, the KIG accretion time series was revisited to remove artifacts of the hydropower operations and improve the accuracy of the daily accretion estimates.

Step one of this process was the calculation of the daily raw accretion, I15hist_raw$_d$ (TAF):

$$I15hist\_raw_d = (avgIGQ_d - avgKQ_d) + (avgTS_d - avgTS_{d-1}), \tag{27}$$

where $avgIGQ_d$ and $avgKQ_d$ are the average flow volumes for days *d* and *d-1* at the Iron Gate and Keno gages, respectively, $avgTS_d$ is the average combined storage of JC Boyle, Copco, and

Iron Gate reservoirs for days *d* and *d-1,* and $avgTS_{d-1}$ is the average combined reservoir storage for days *d-1* and *d-2*. Averaging the flow and storage components of the accretion calculation in this way reduces the incidence of wild swings in the time series but does not eliminate them.

Step two begins the first filtering pass by computing the daily accretion change ($\Delta I15hist\_raw_d$) as a proportion of the 7-day trailing median accretion ($7dtmI15hist\_raw_d$, median of *d-1* through *d-7*) accretion:

$$\Delta I15hist\_raw_d = \frac{I15hist\_raw_d - I15hist\_raw_{d-1}}{\mathrm{7dtmI15hist\_raw}_d}. \tag{28}$$

Then $I15hist\_raw_d$ values are evaluated by a first-pass filter for the following conditions:

1. $\Delta I15hist\_raw_d < -0.25$;
2. $|\Delta I15hist\_raw_d| \leq 0.25$;
3. $|\Delta I15hist\_raw_d| > 0.25$ and air temperature exceeds 34° F on day d or $d-1$ and SWE at the Fish Lake SNOTEL exceeds 0.2 inches;
4. $|\Delta I15hist\_raw_d| > 0.25$ and precipitation over days d through $d-6$ equals or exceeds 0.4 inches.

If condition 1 is true, or if none of the conditions are true, then the raw accretion for that day is flagged as an operational outlier. If condition 2, 3, or 4 is true then the raw accretion for that day is not flagged. Values flagged as operational outliers are replaced by the 5-day trailing median (median of days *d-1* through *d-5*) in the new variable $I15hist\_p1_d$.

Step three applies the second-pass filter, which repeats step two using $I15hist\_p1_d$ instead of $I15hist\_raw_d$. After the operational outliers have been replaced by the 5-day trailing median (median of days *d-1* through *d-5*), any value less than 225 cfs is replaced by the 70% exceedance flow of the prior 30 days in the new variable $I15hist\_p2_d$.

Step four applies the third-pass filter, which repeats step three using $I15hist\_p2_d$ instead of $I15hist\_p1_d$. After the operational outliers have been replaced by the 5-day trailing median (median of days *d-1* through *d-5*), any value less than 225 cfs is replaced by the 70% exceedance flow of the prior 30 days. The last step in the filtering process was manually identifying any remaining operational outliers (20 were found), and then replacing them with the 70% exceedance flow of the prior 30 days in the new variable $I15hist\_p3_d$.

After the filtering steps were completed, *I15hist_p3* was smoothed with a single exponential smoother (alpha = 0.5) to produce the *I15hist* daily time series that is a direct input into the KRM. This time series represents the accretions estimated with all the hydropower dams in place and operating normally.

The KRM ingests as input the $I15hist$ time series as well as another, *I15evap*, that estimates the daily evaporative losses from the reservoirs above JC Boyle, Copco 1, and Iron Gate dams.

Evaporation estimates were generated using the Daily Lake Evaporation Model by Reclamation Technical Service Center scientists for use in the Natural Flow Study and were graciously shared for use in the KRM. An earlier version of these estimates was documented in a draft report on open-water evaporation for the Natural Flow Study that was released for comment in late 2023 (Mikkelson, 2023). The data shared for use in KRM included some changes that were made in response to reviewer comments since the release of Mikkelson (2023), and it is possible that additional changes may be made to the evaporation estimates before they are finalized (Kristin Mikkelson, personal communication, January 3, 2024). Because the dams downstream from Keno Dam have been removed, the KRM uses the daily sum of *I15hist* and *I15evap* to generate *I15*, the accretions to the KIG reach of the Klamath River.

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Appendix C Addendum 1: Key KRM Outcomes

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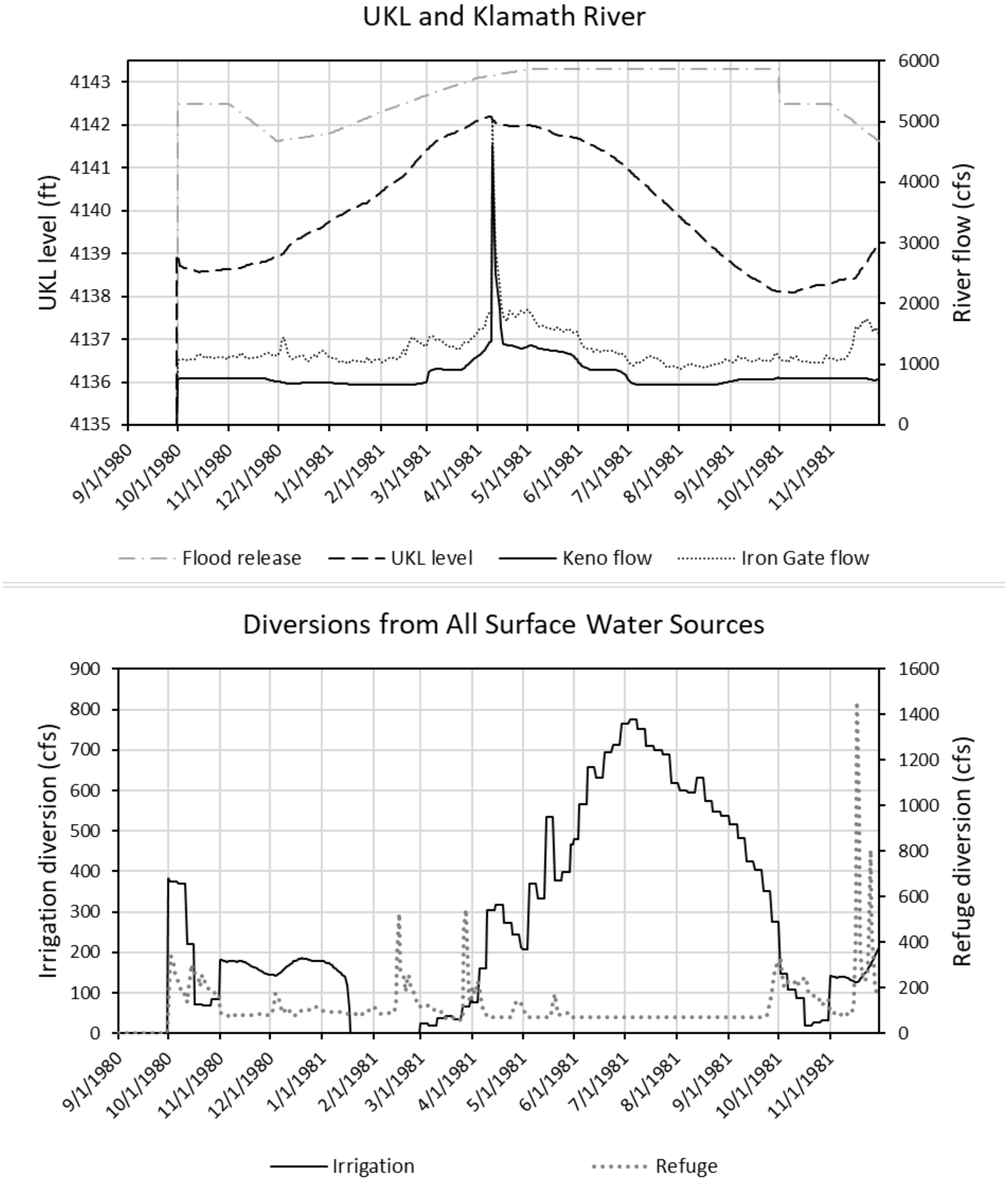
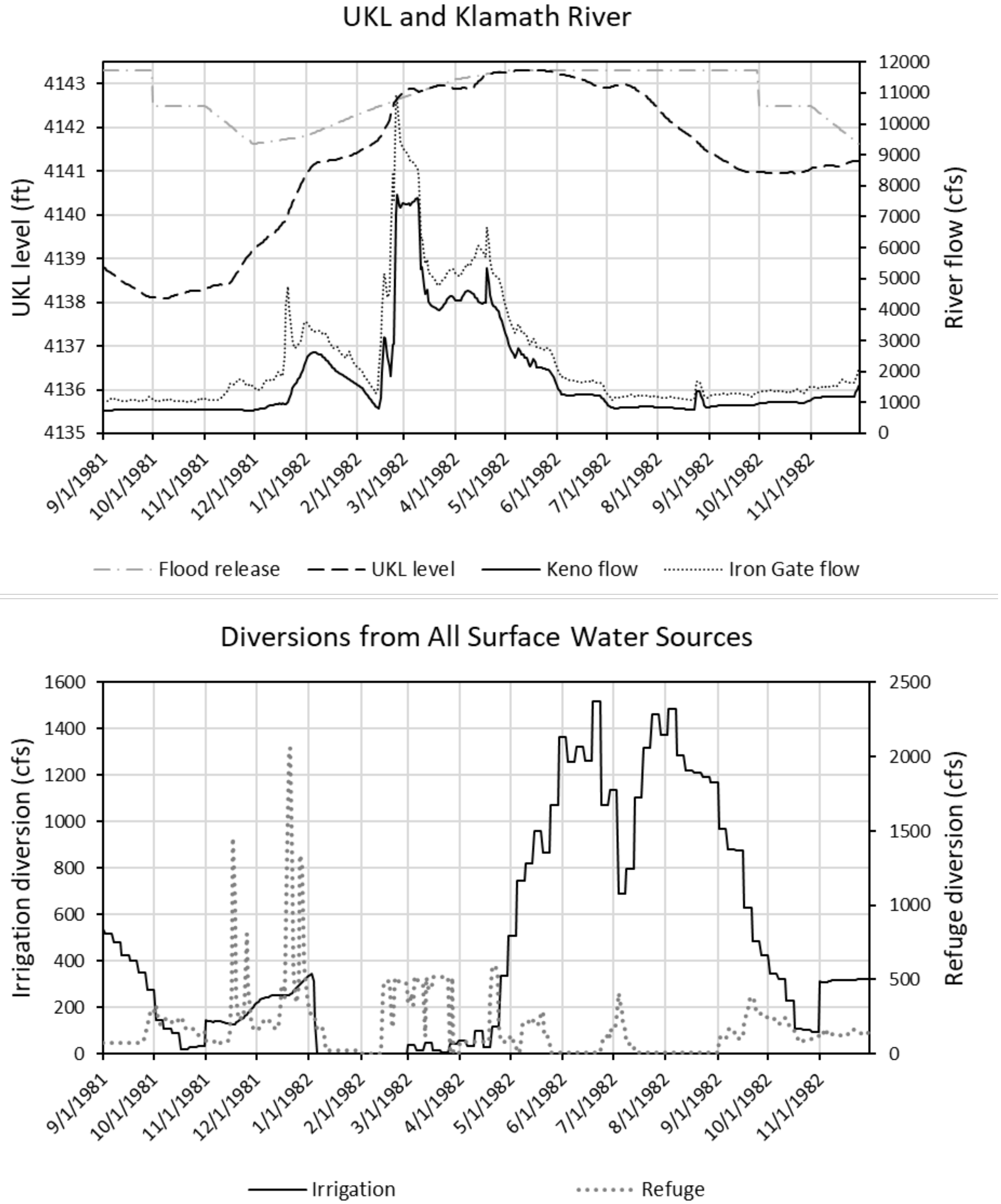


Note: The y-axis scales in the figures in this addendum may differ year to year.

Addendum Figure CA-1. Simulated daily outcomes in 1981 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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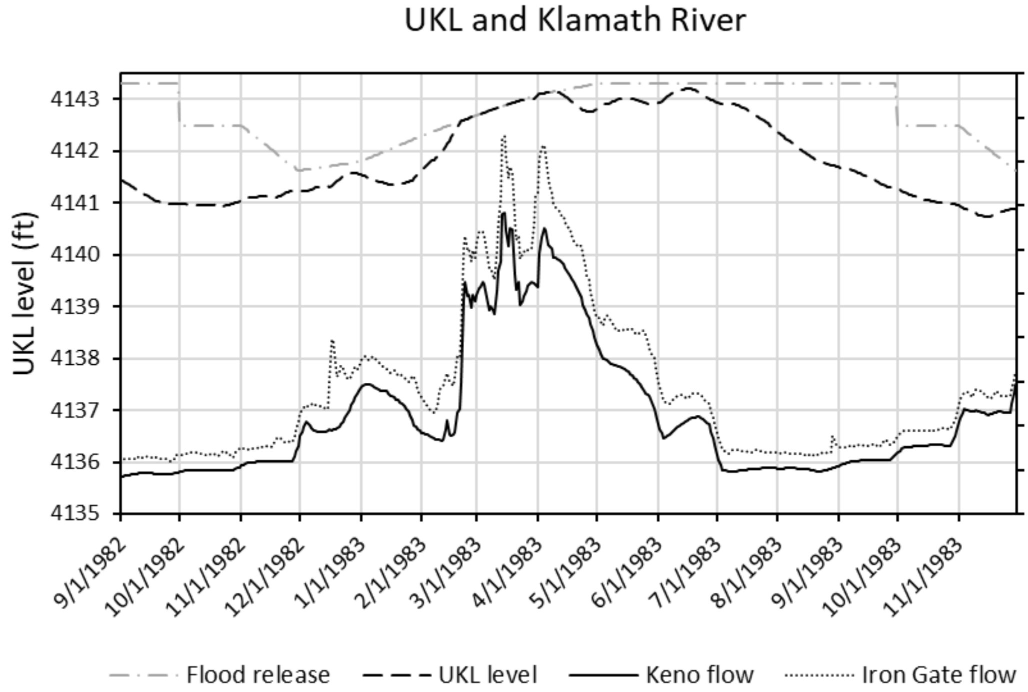
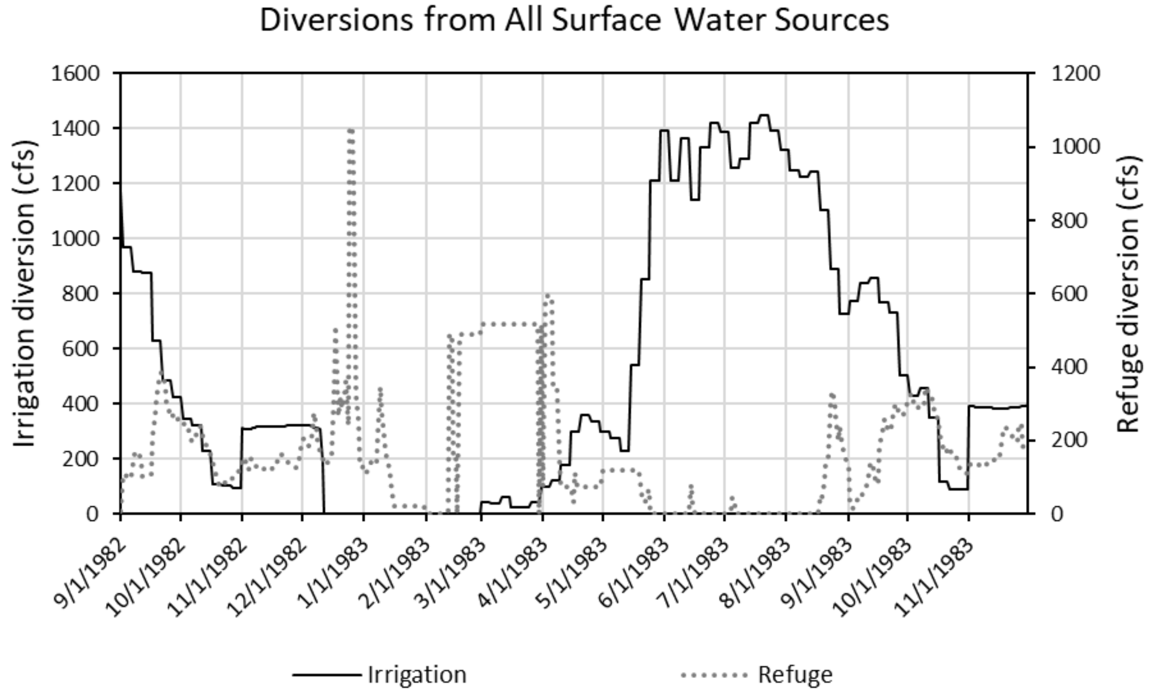
Addendum Figure CA-2. Simulated daily outcomes in 1982 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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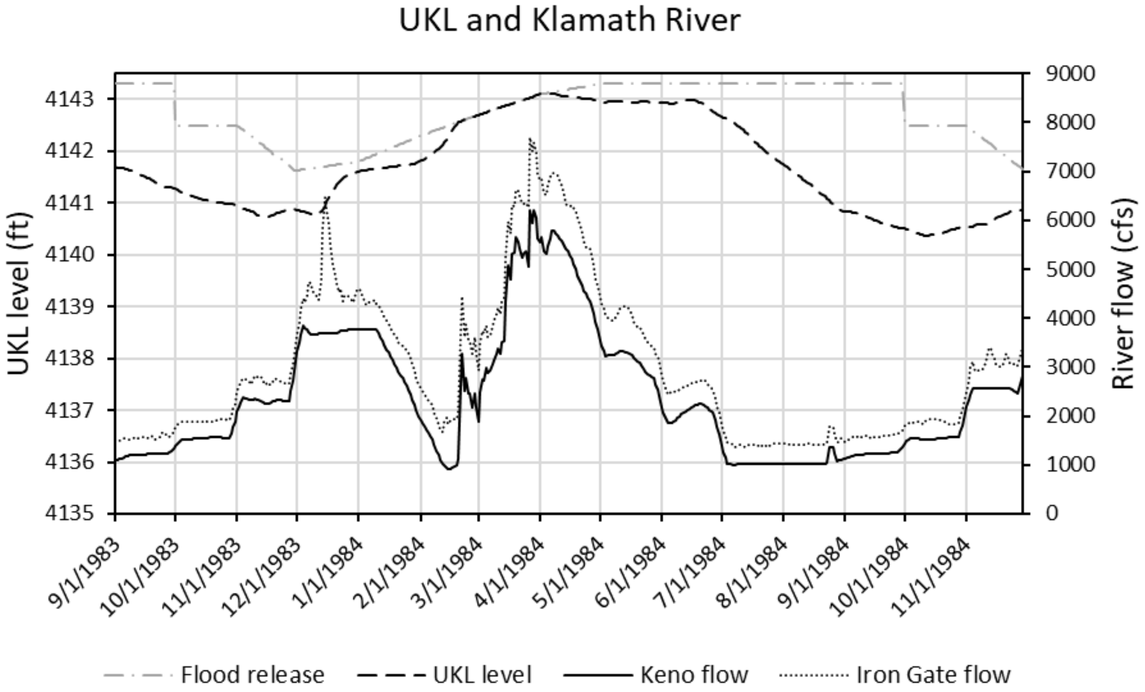
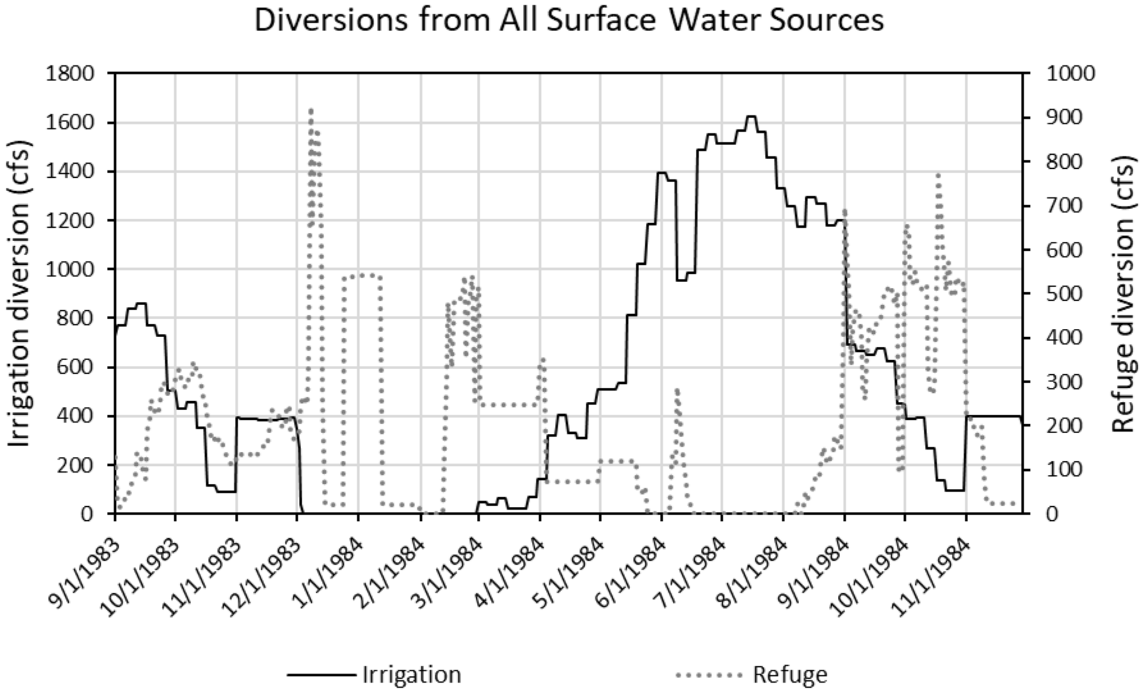
Addendum Figure CA-3. Simulated daily outcomes in 1983 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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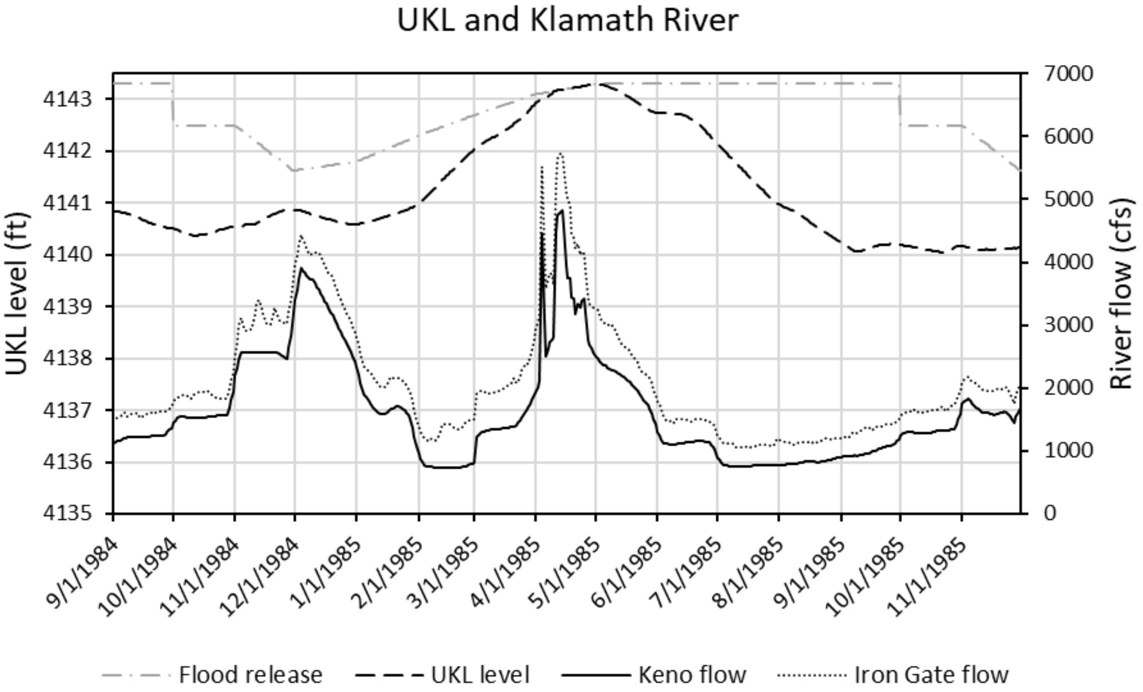
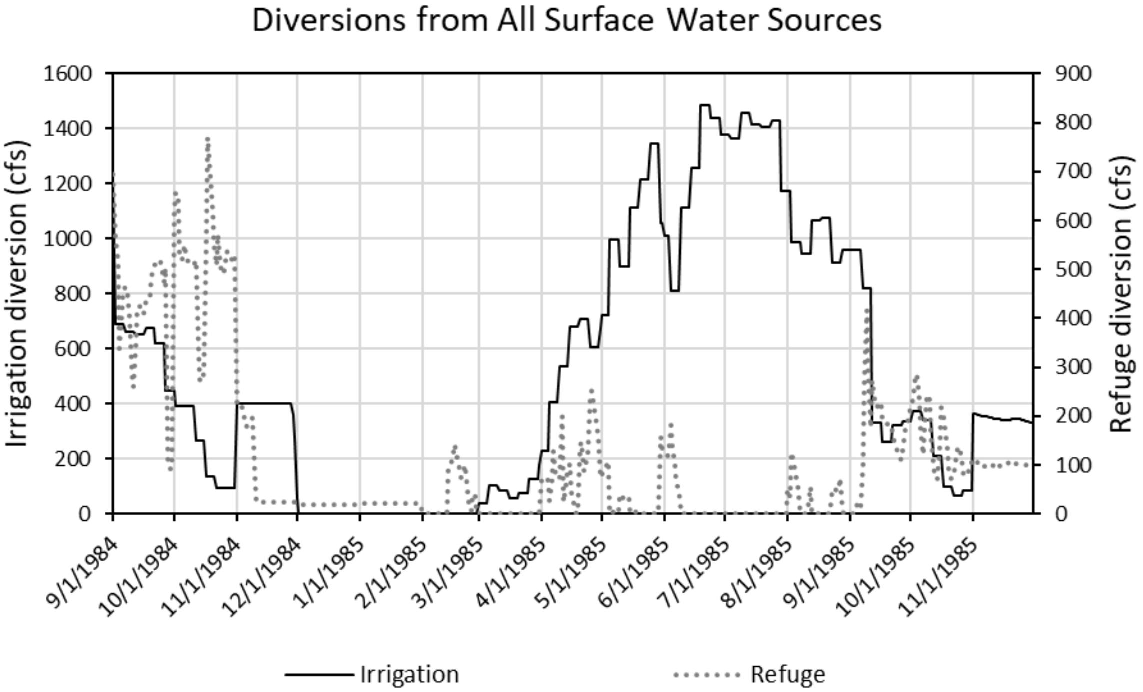
Addendum Figure CA-4. Simulated daily outcomes in 1984 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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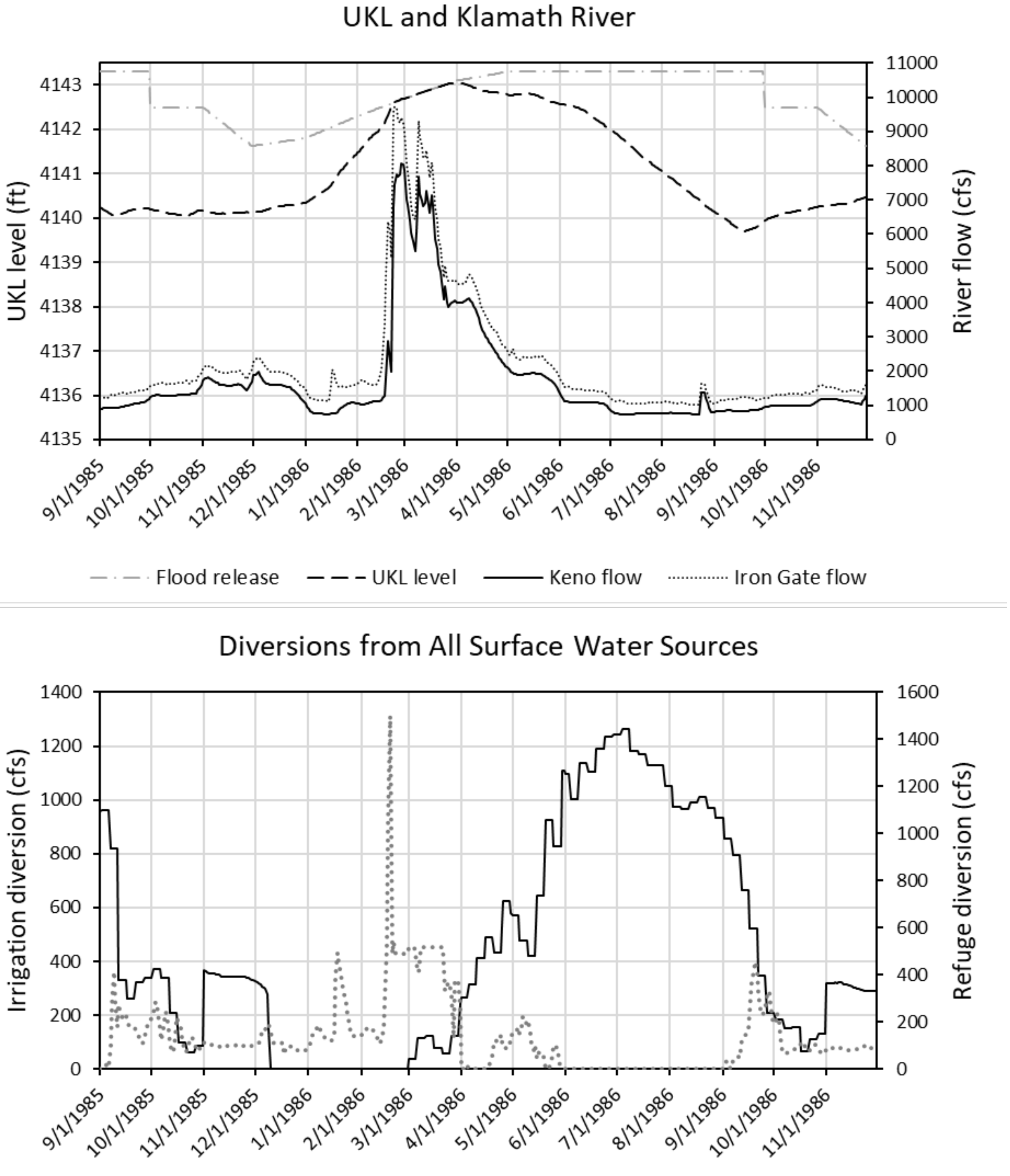
Addendum Figure CA-5. Simulated daily outcomes in 1985 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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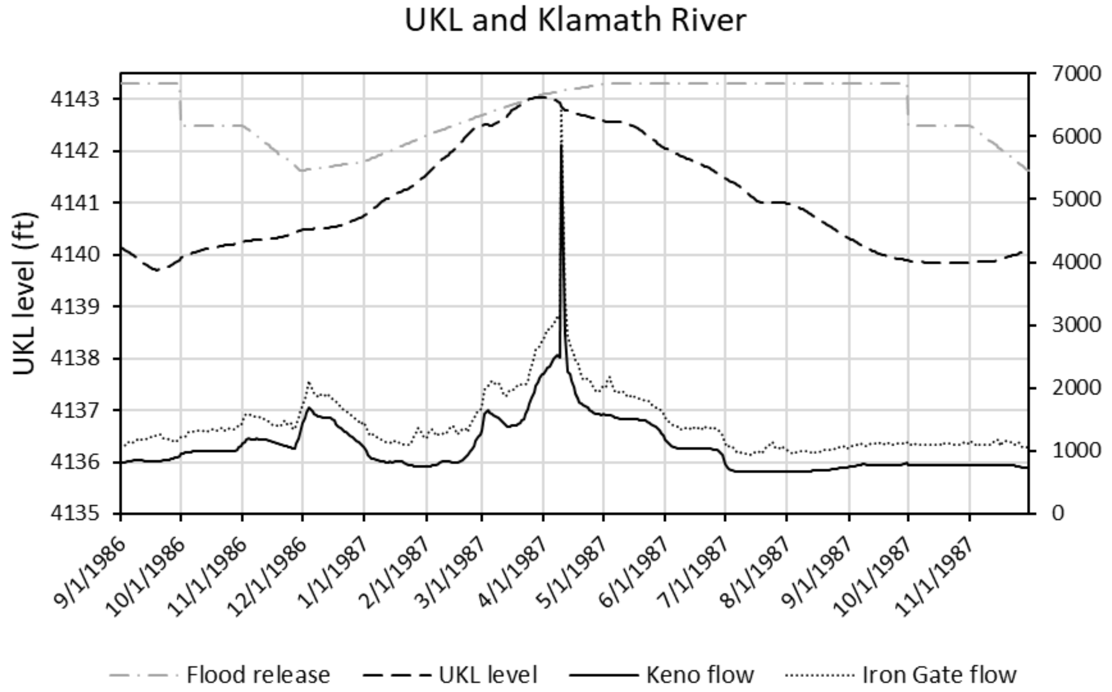
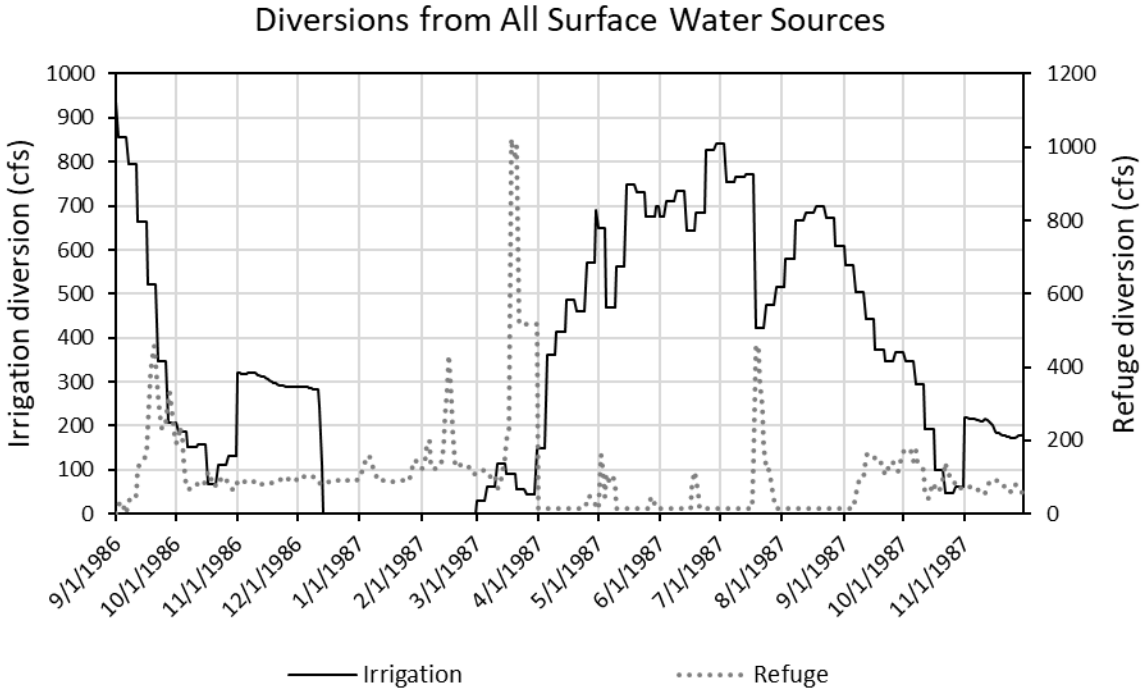
Addendum Figure CA-6. Simulated daily outcomes in 1986 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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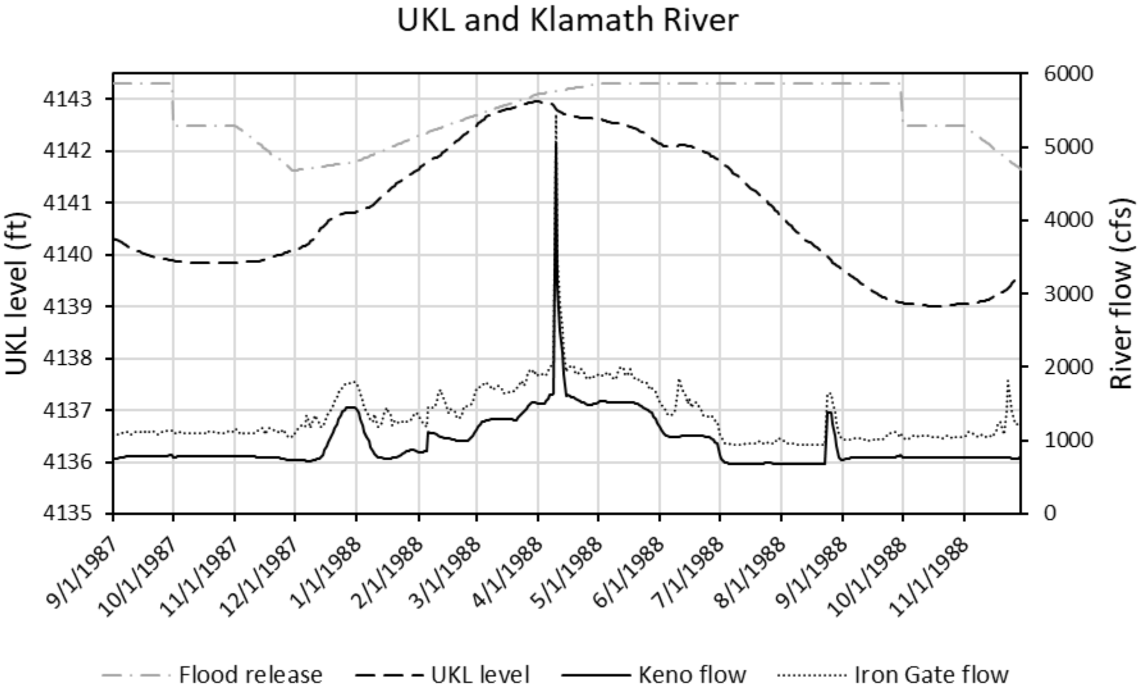
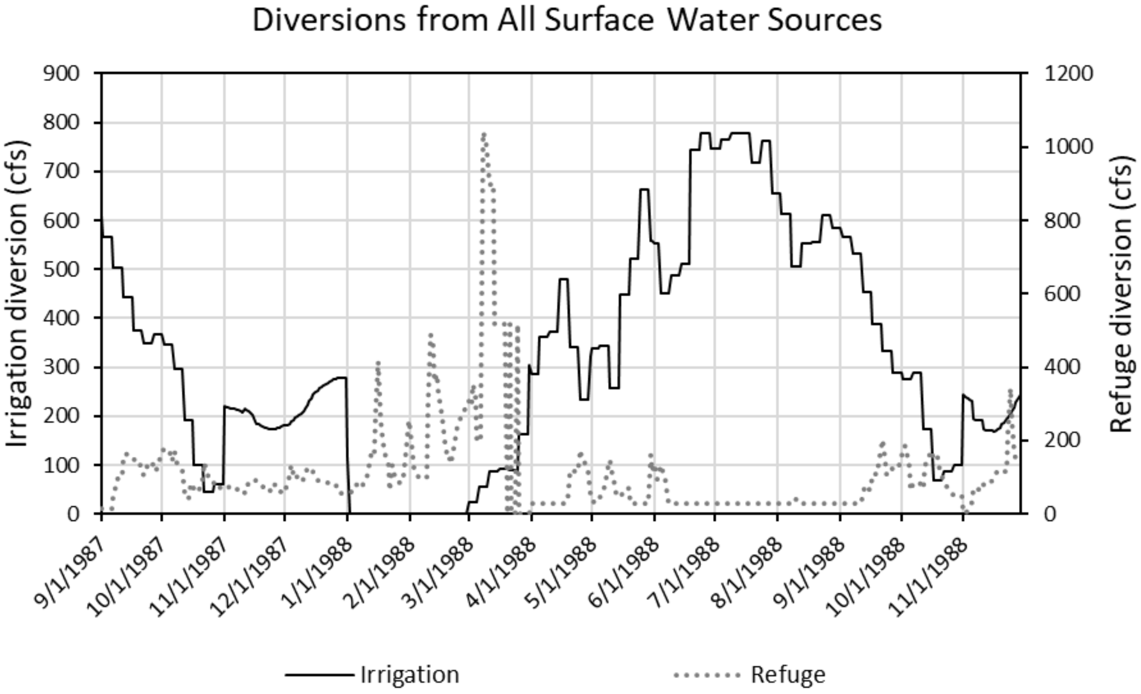
Addendum Figure CA-7. Simulated daily outcomes in 1987 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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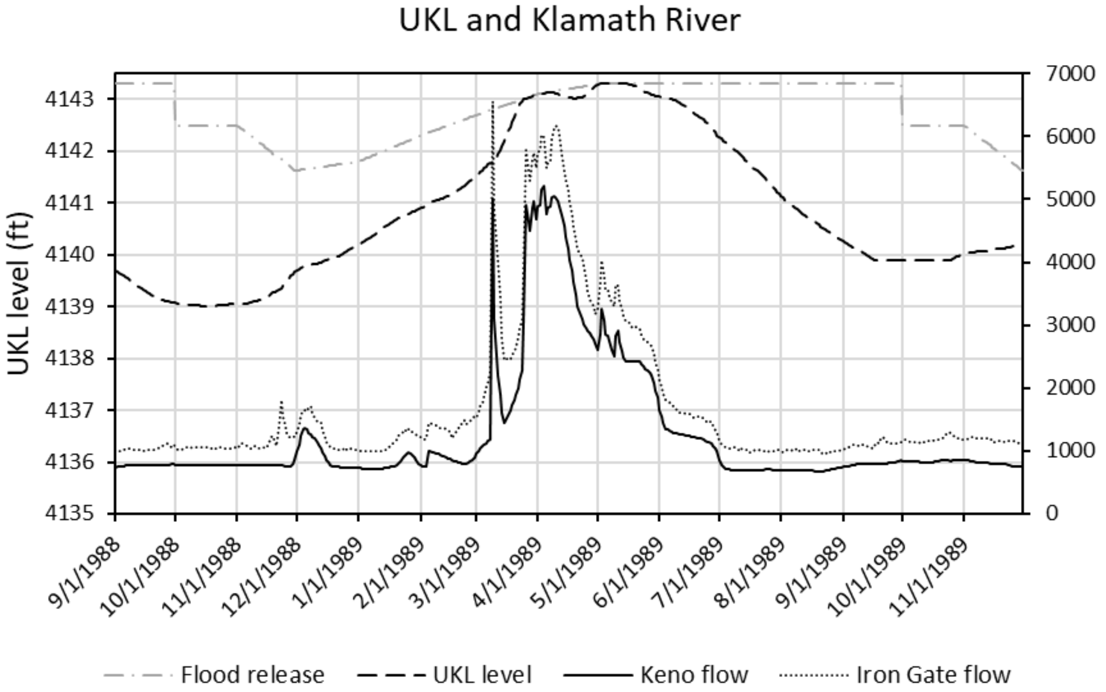
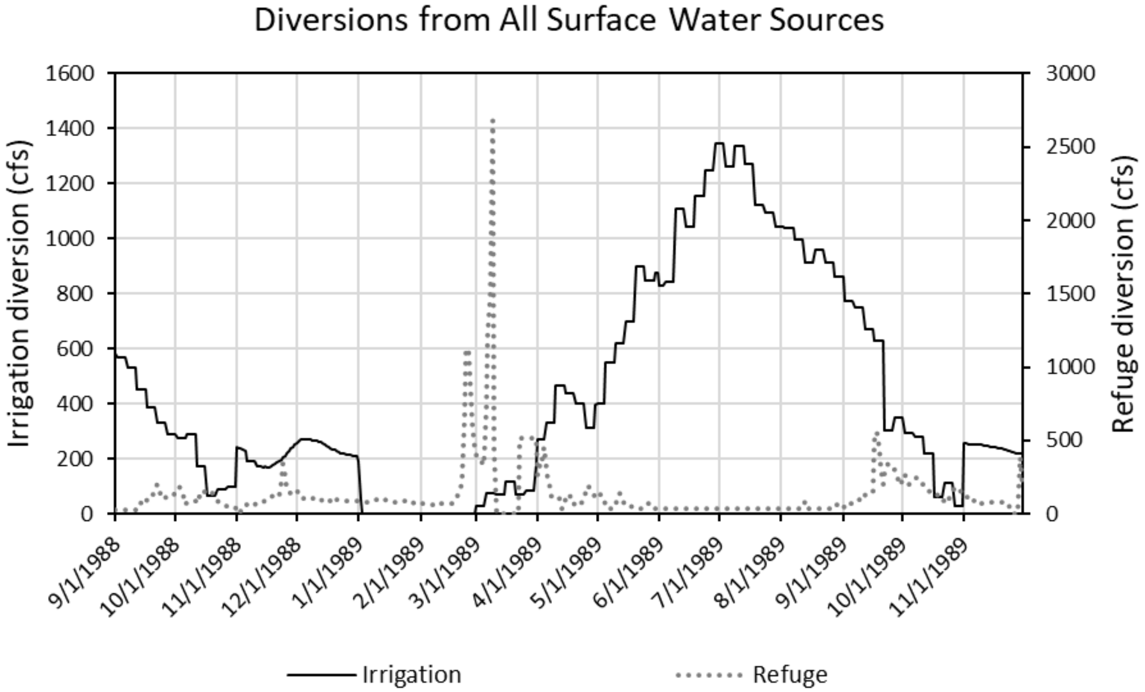
Addendum Figure CA-8. Simulated daily outcomes in 1988 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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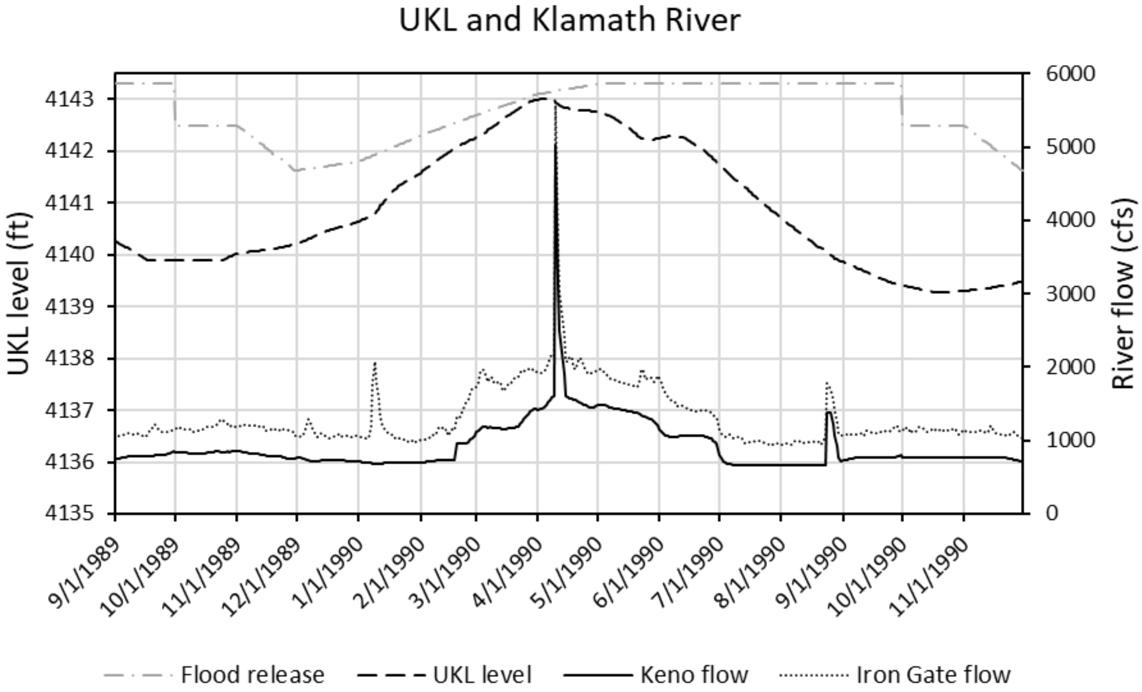
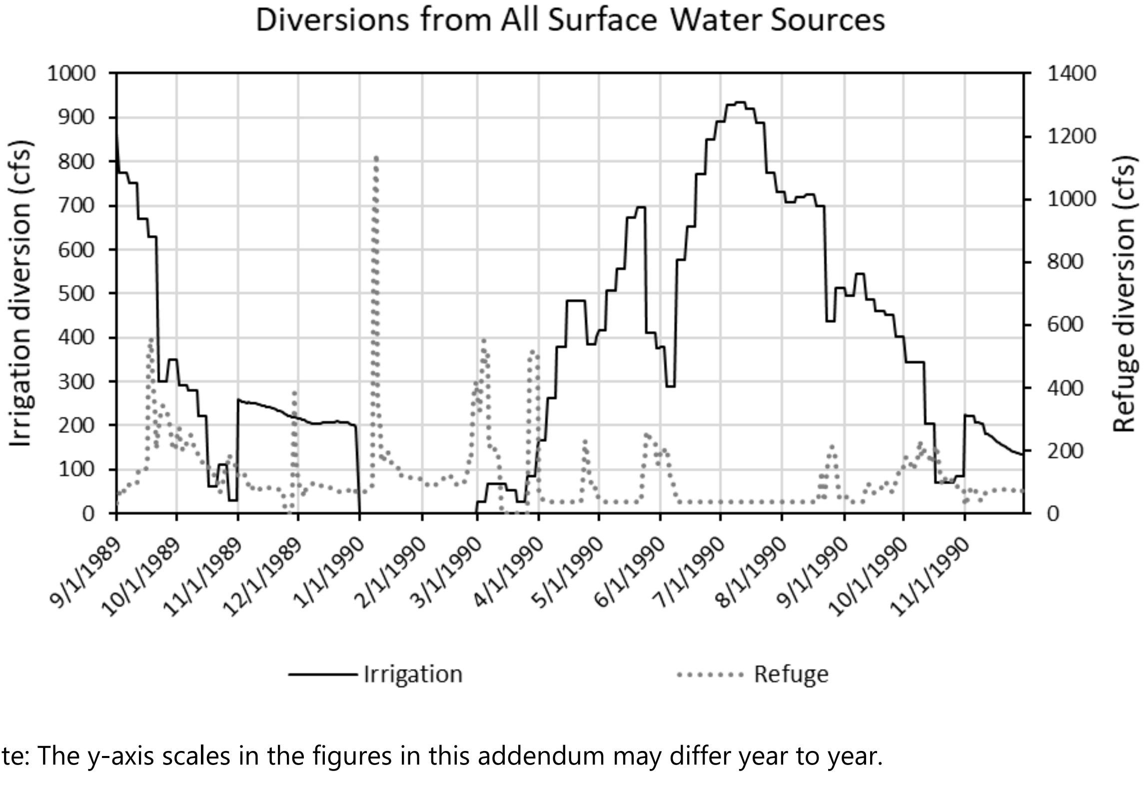
Addendum Figure CA-9. Simulated daily outcomes in 1989 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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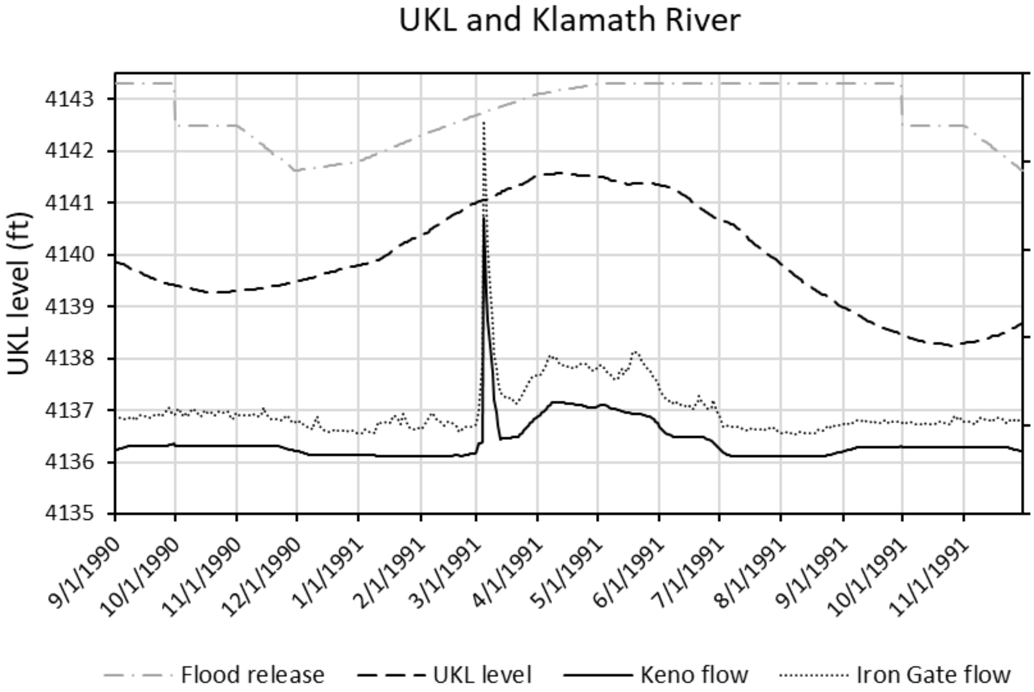
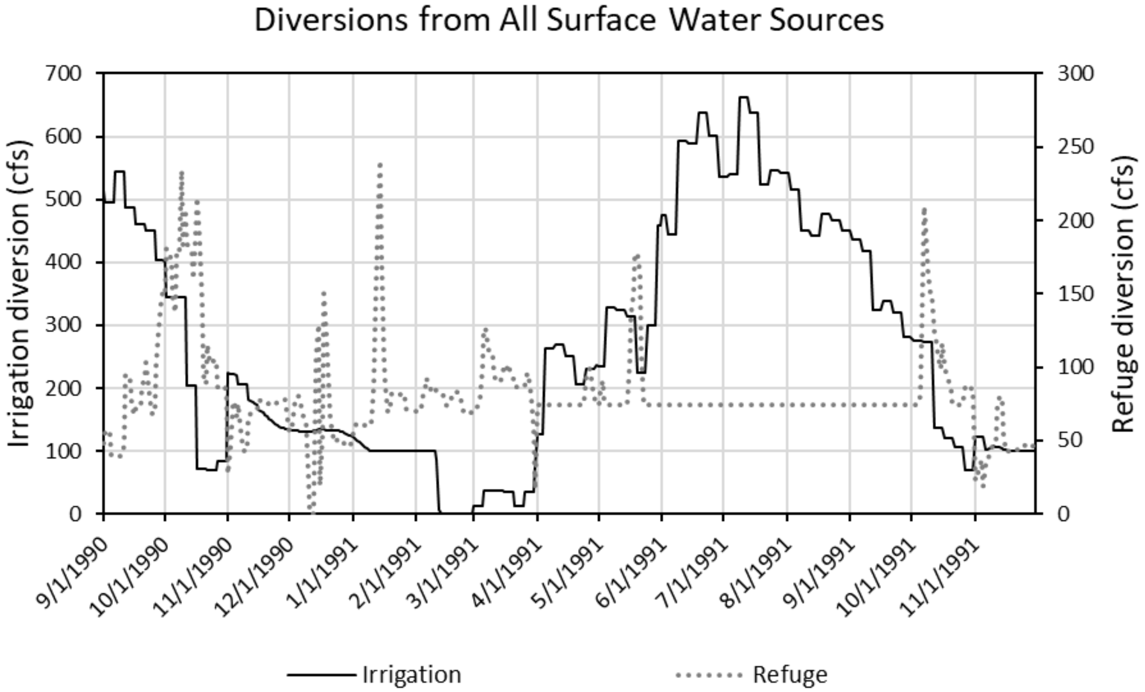
Addendum Figure CA-10. Simulated daily outcomes in 1990 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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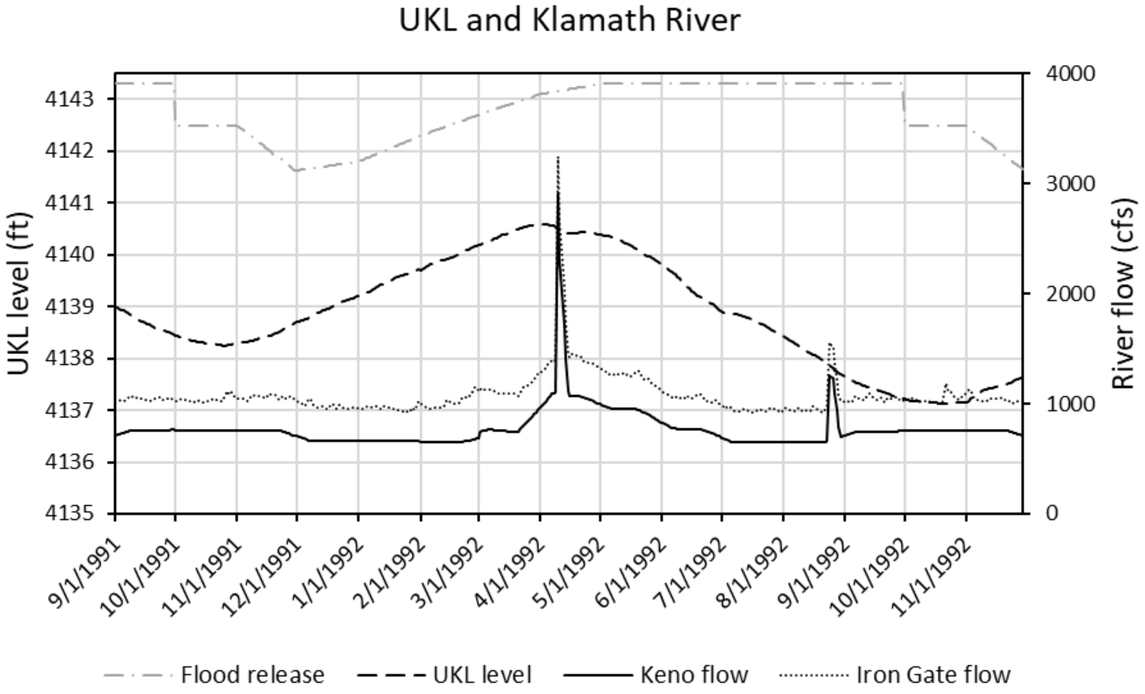
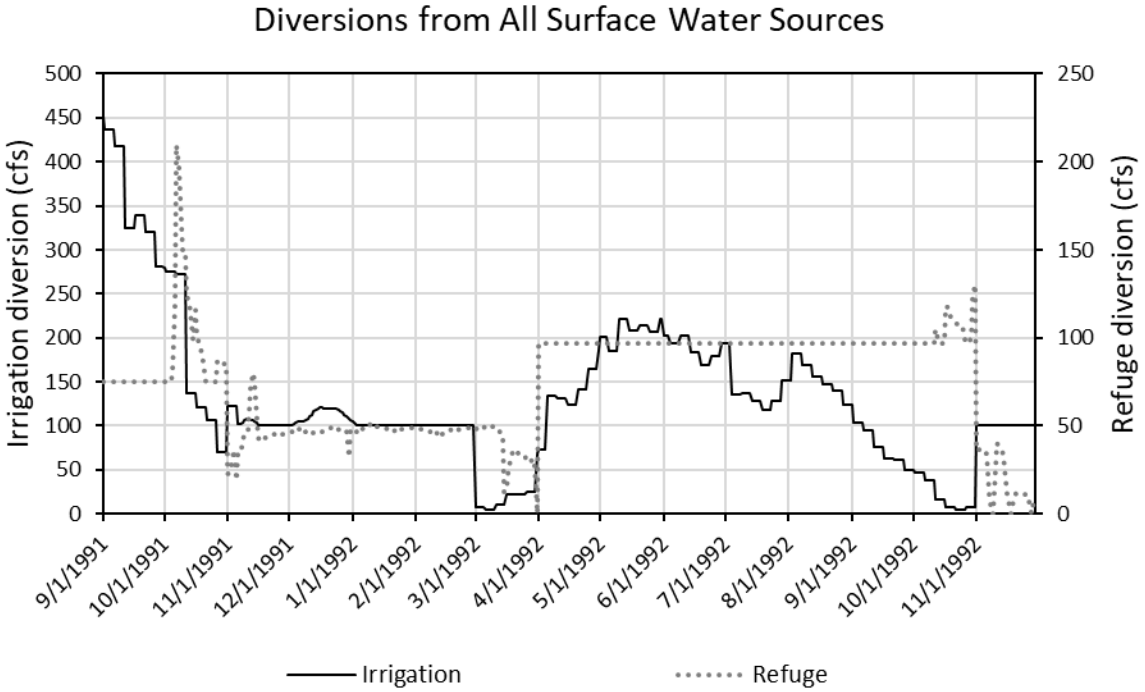
Addendum Figure CA-11. Simulated daily outcomes in 1991 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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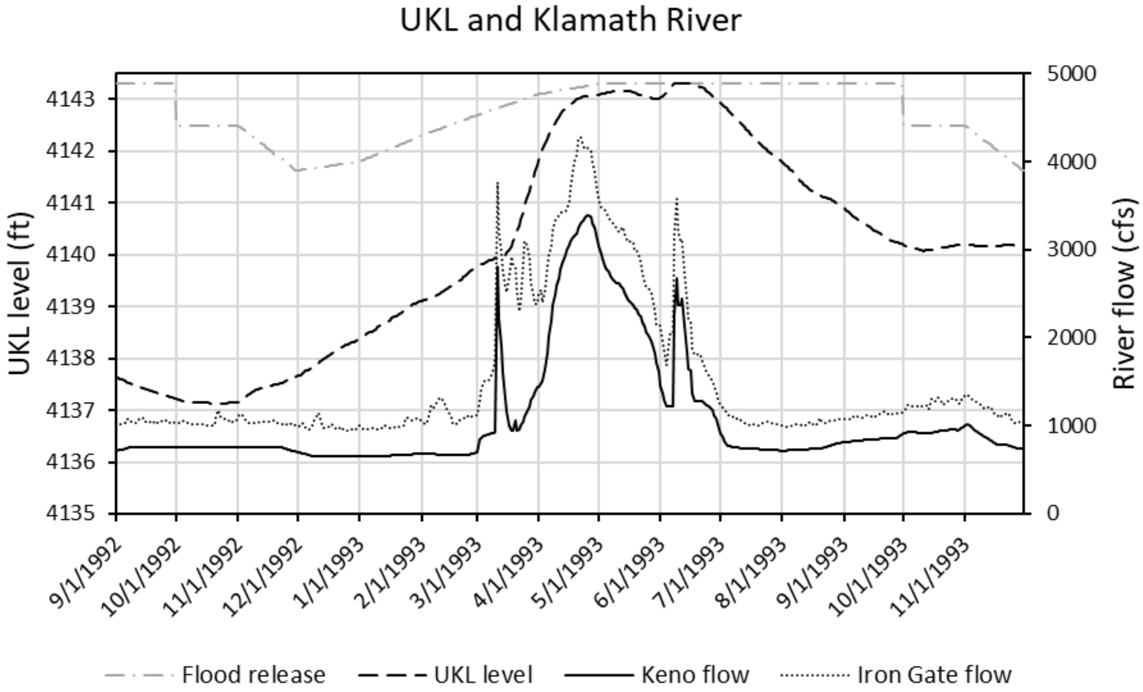
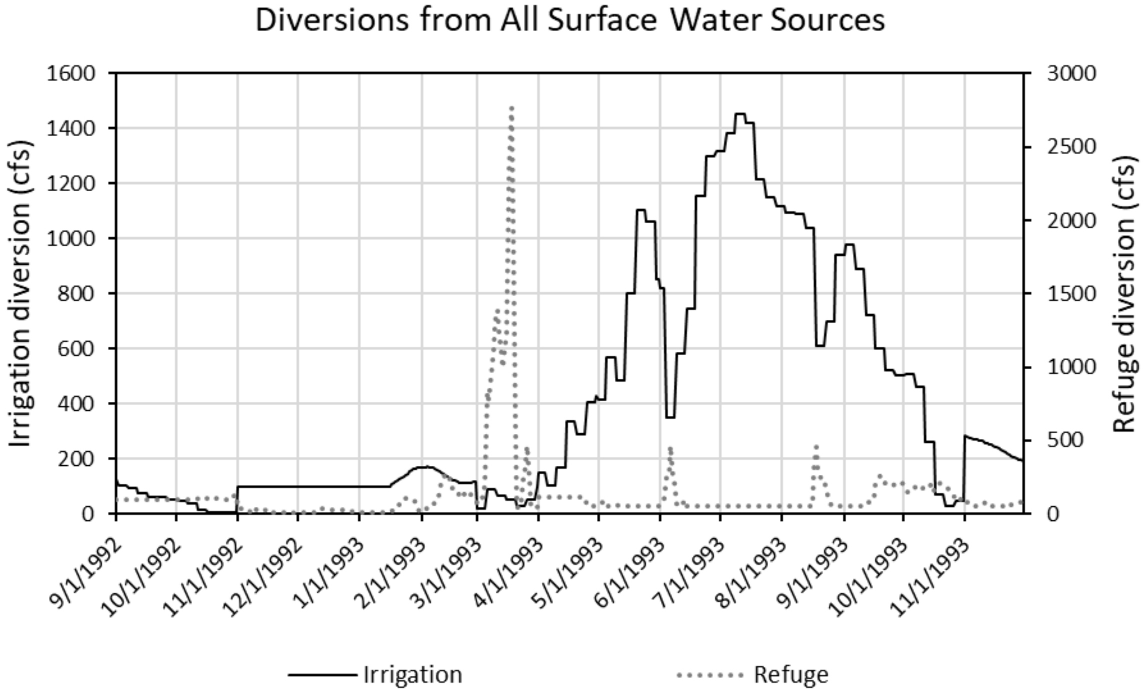
Addendum Figure CA-12. Simulated daily outcomes in 1992 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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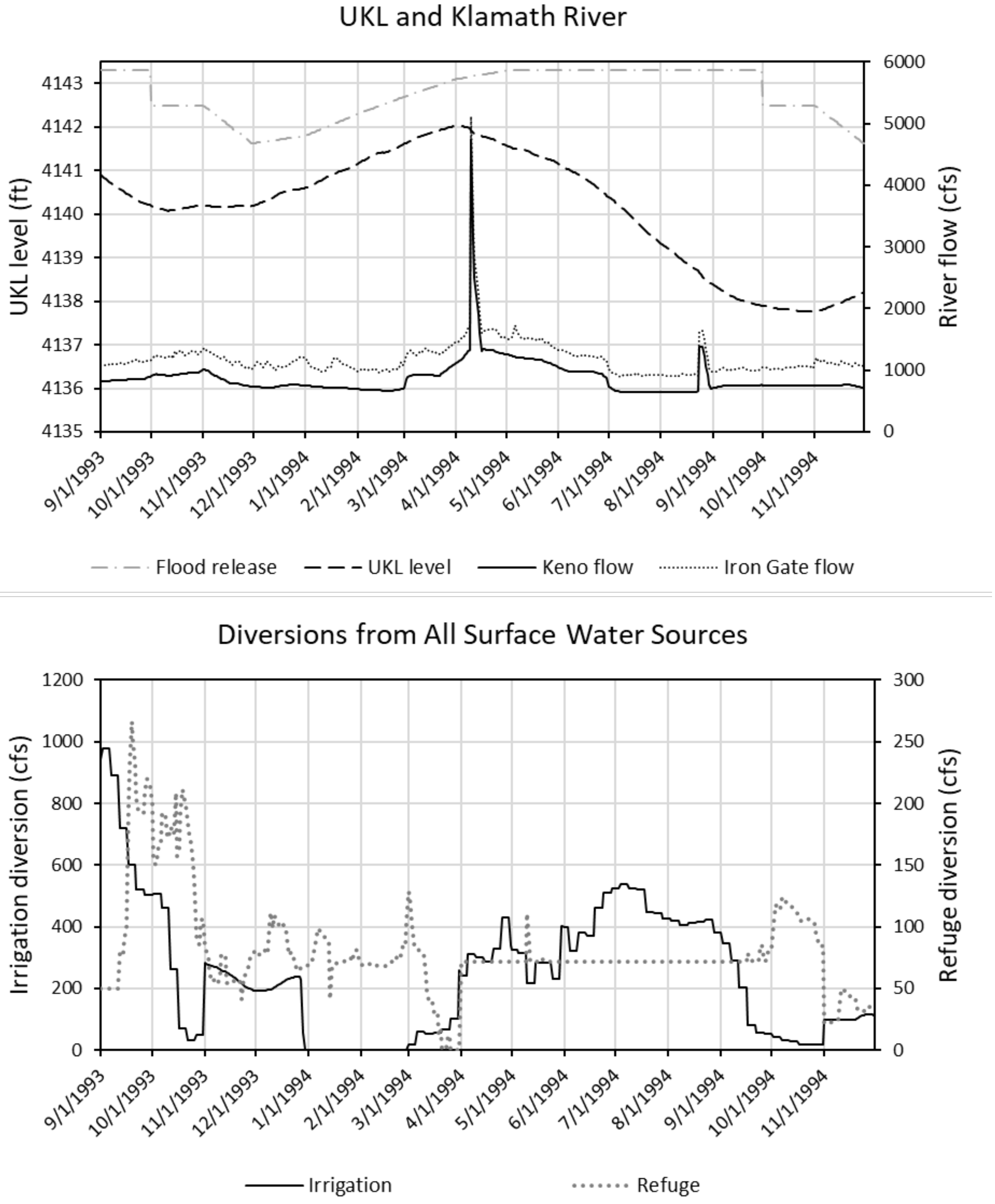
Addendum Figure CA-13. Simulated daily outcomes in 1993 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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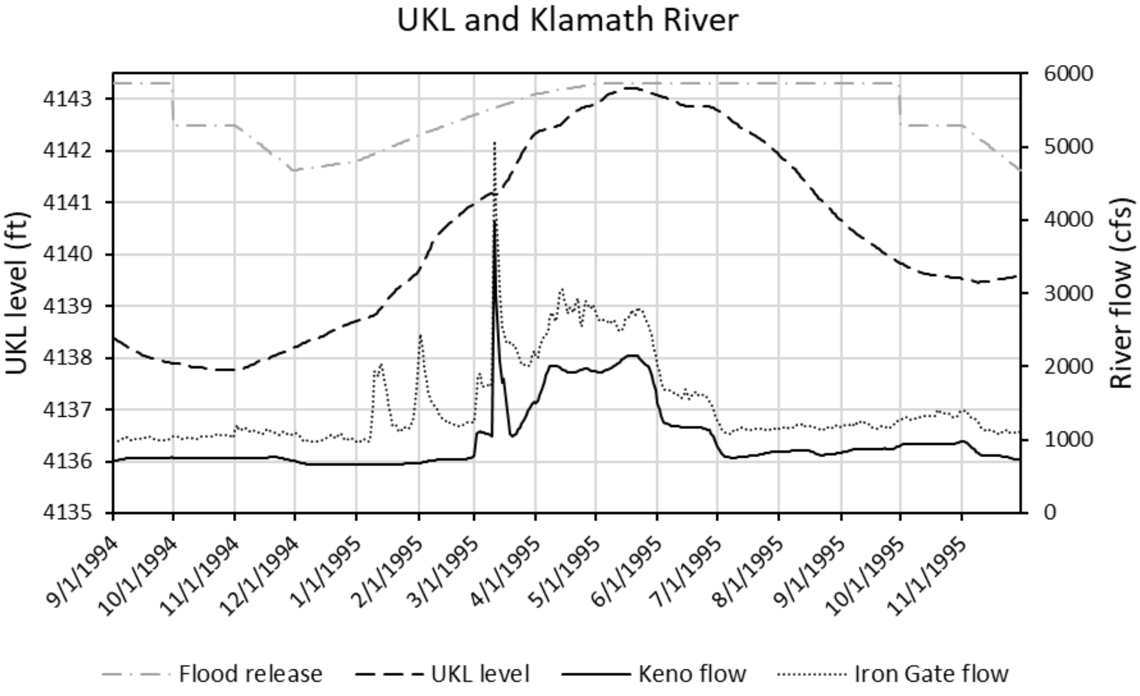
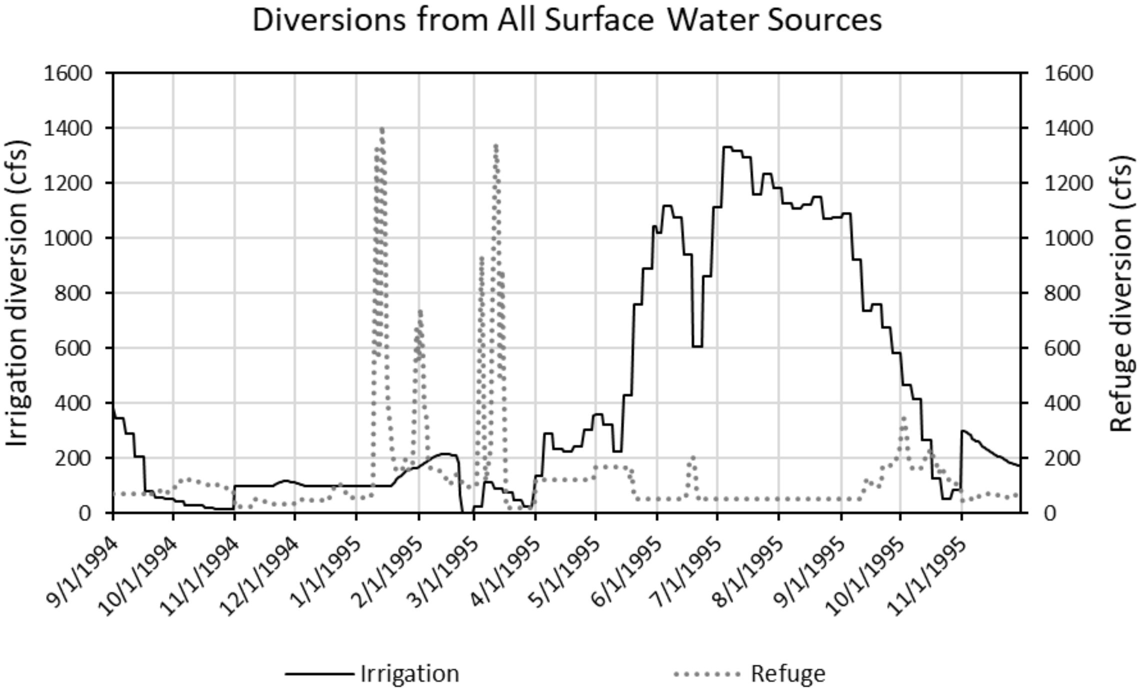
Addendum Figure CA-14. Simulated daily outcomes in 1994 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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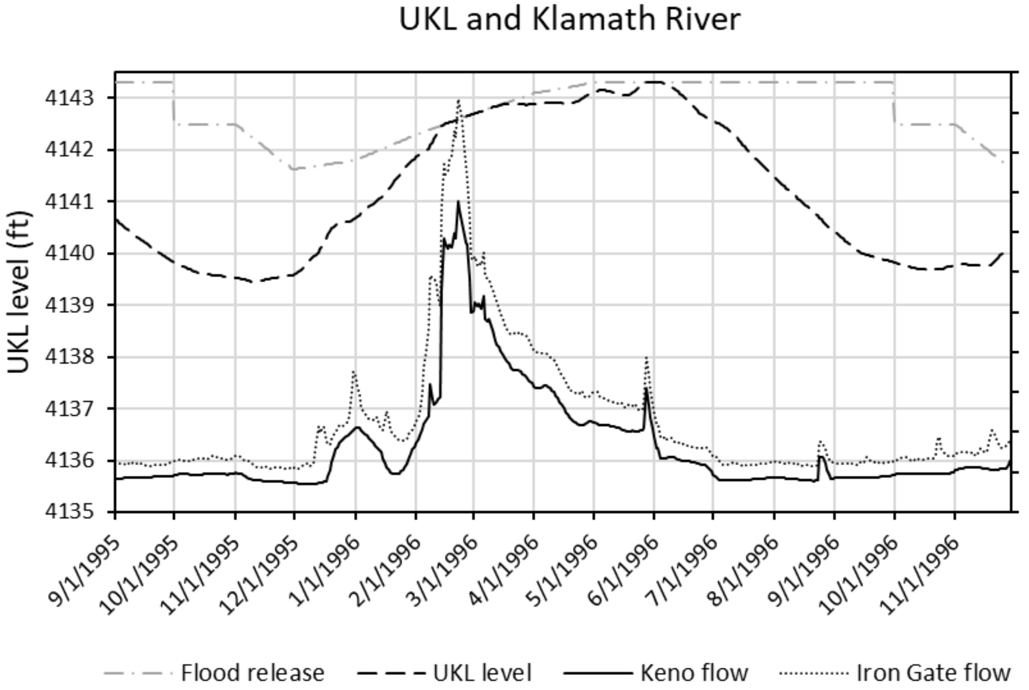
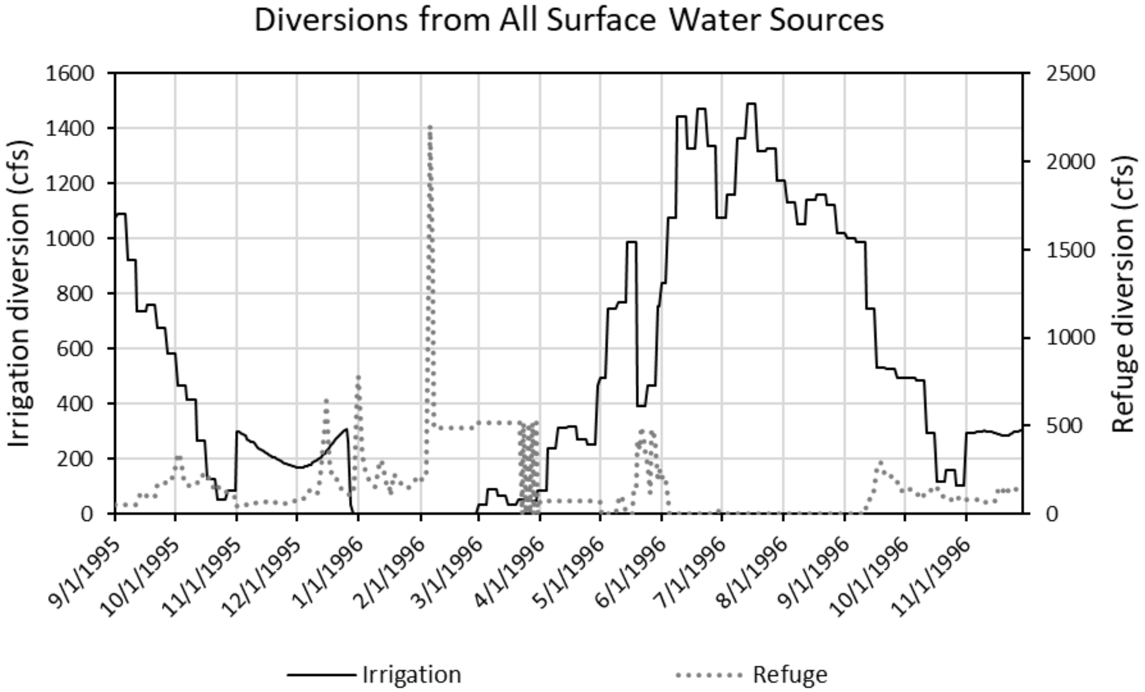
Addendum Figure CA-15. Simulated daily outcomes in 1995 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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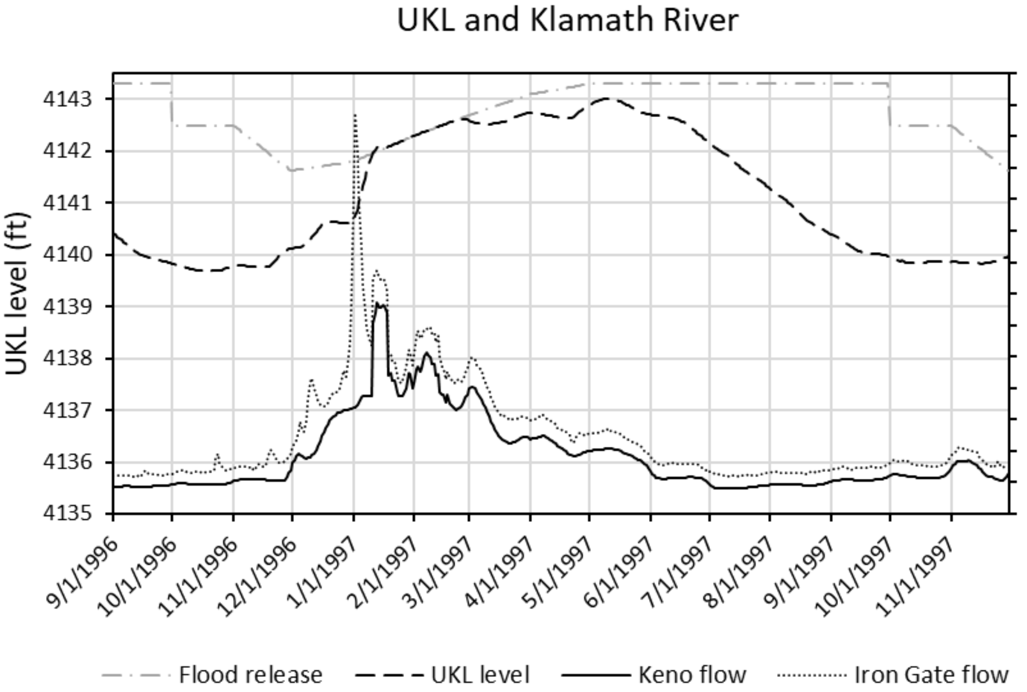
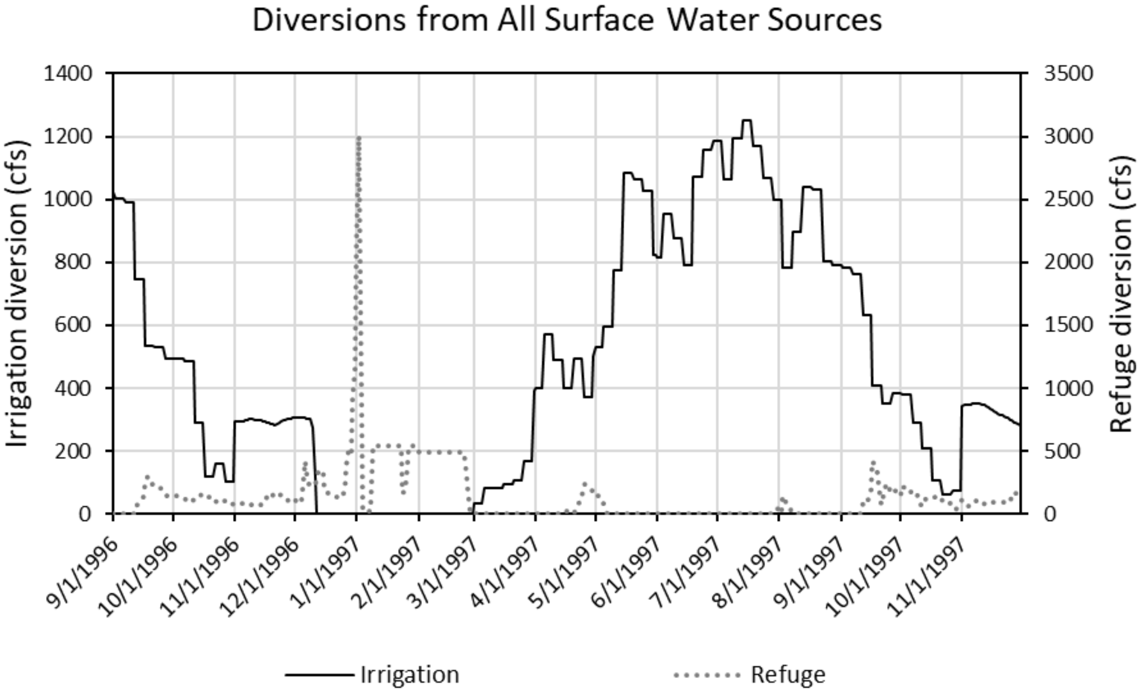
Addendum Figure CA-16. Simulated daily outcomes in 1996 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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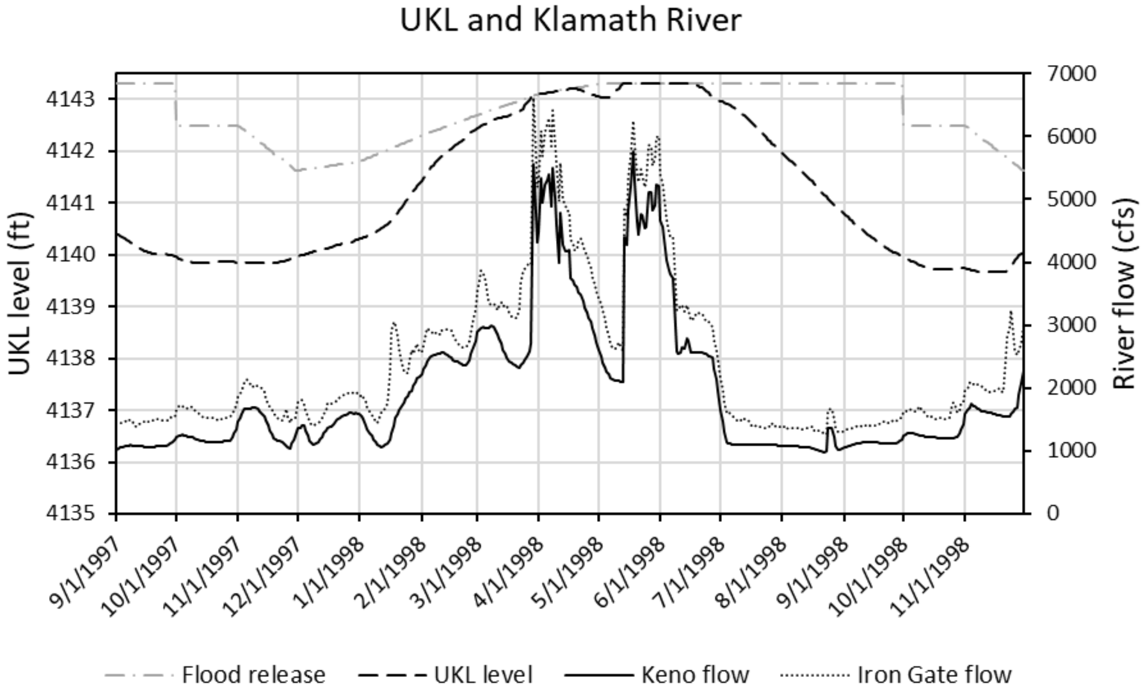
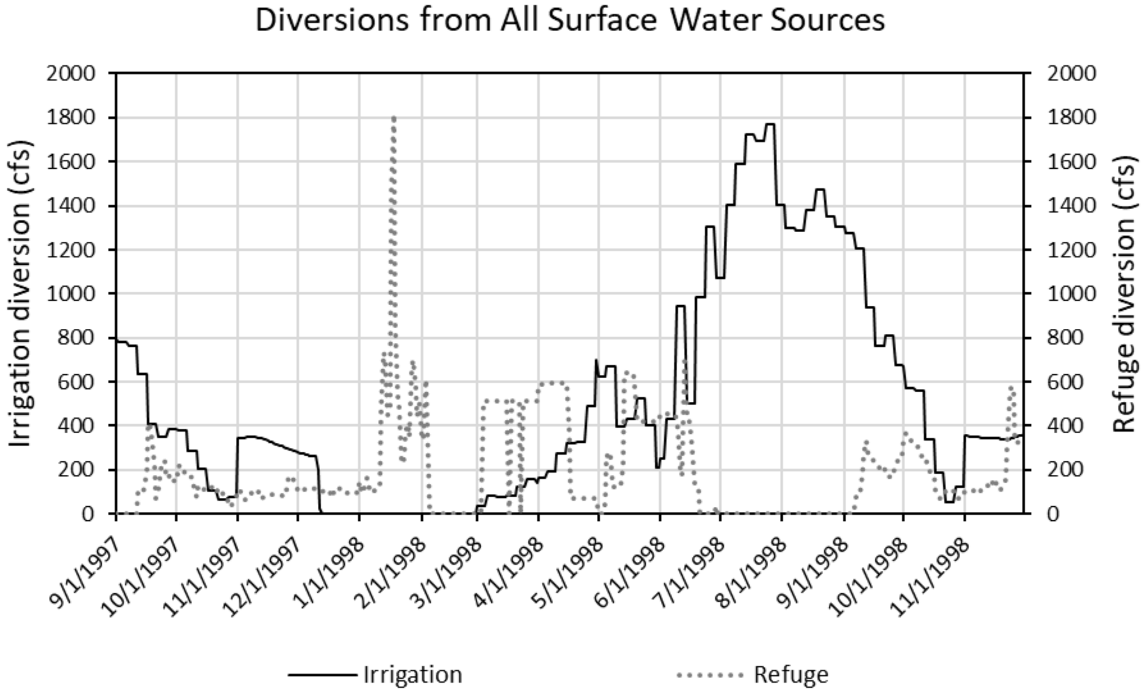
Addendum Figure CA-17. Simulated daily outcomes in 1997 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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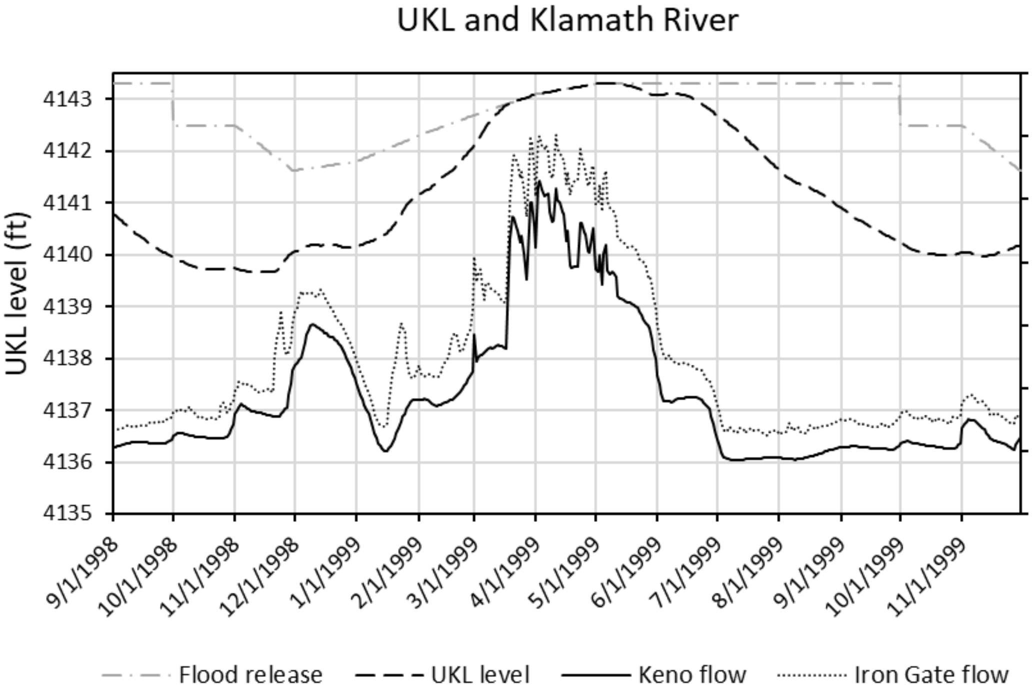
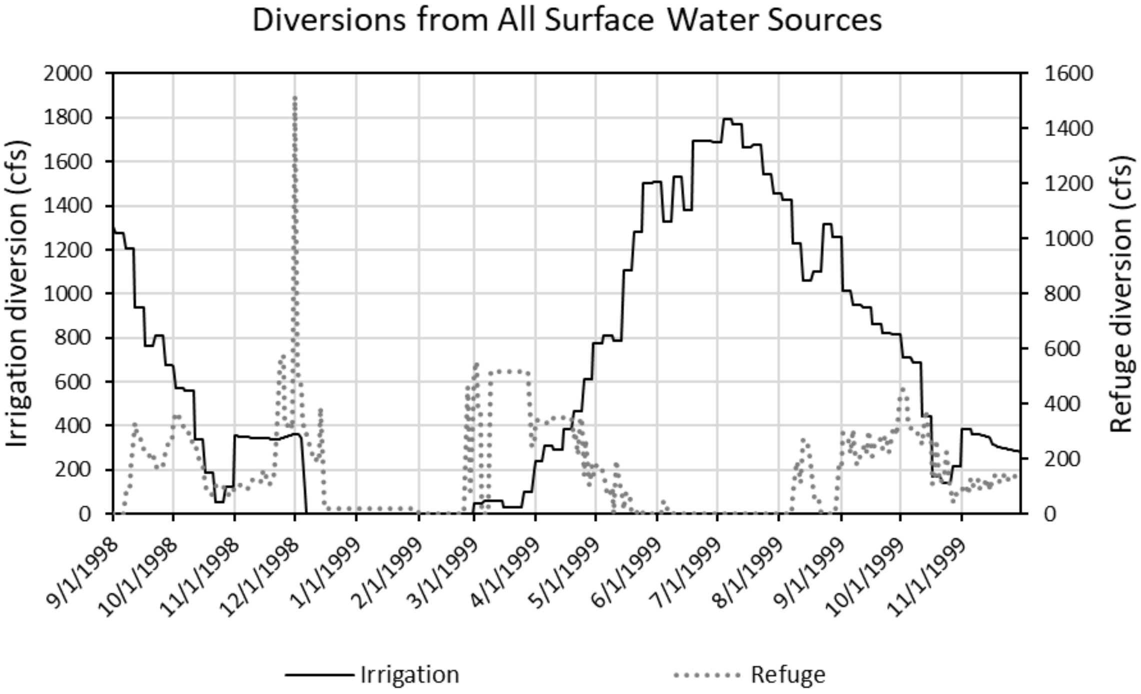
Addendum Figure CA-18. Simulated daily outcomes in 1998 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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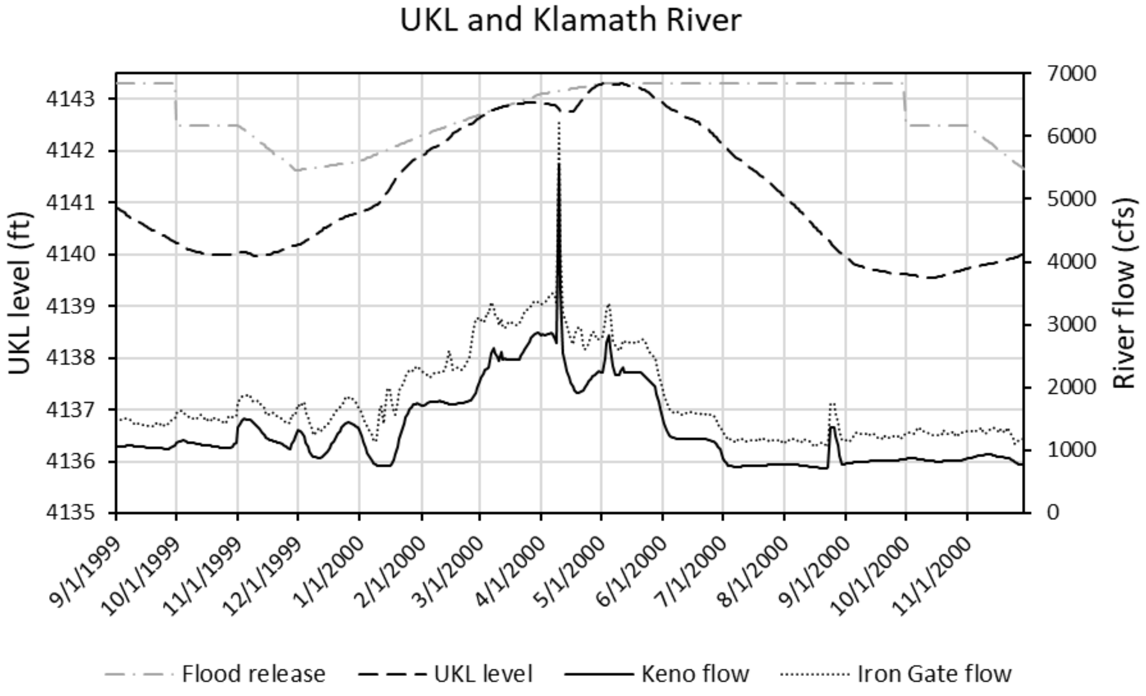
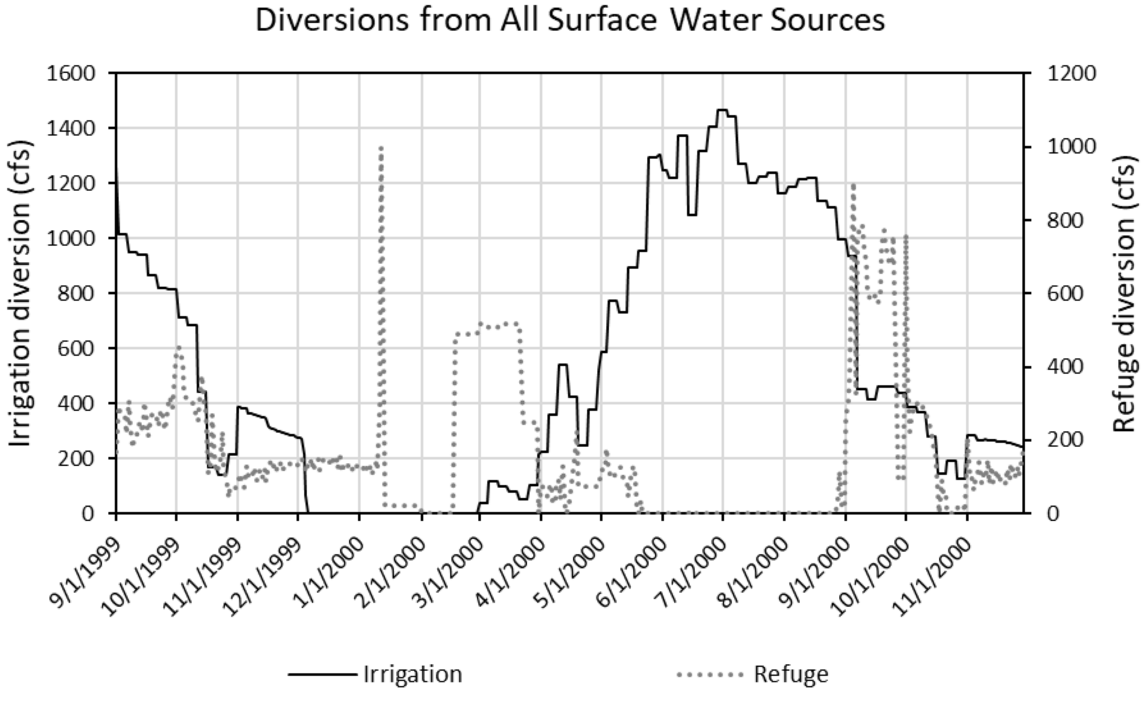
Addendum Figure CA-19. Simulated daily outcomes in 1999 for UKL levels, Klamath River flows, and diversions for irrigation and refuges


UKL and Klamath River


Diversions from All Surface Water Sources

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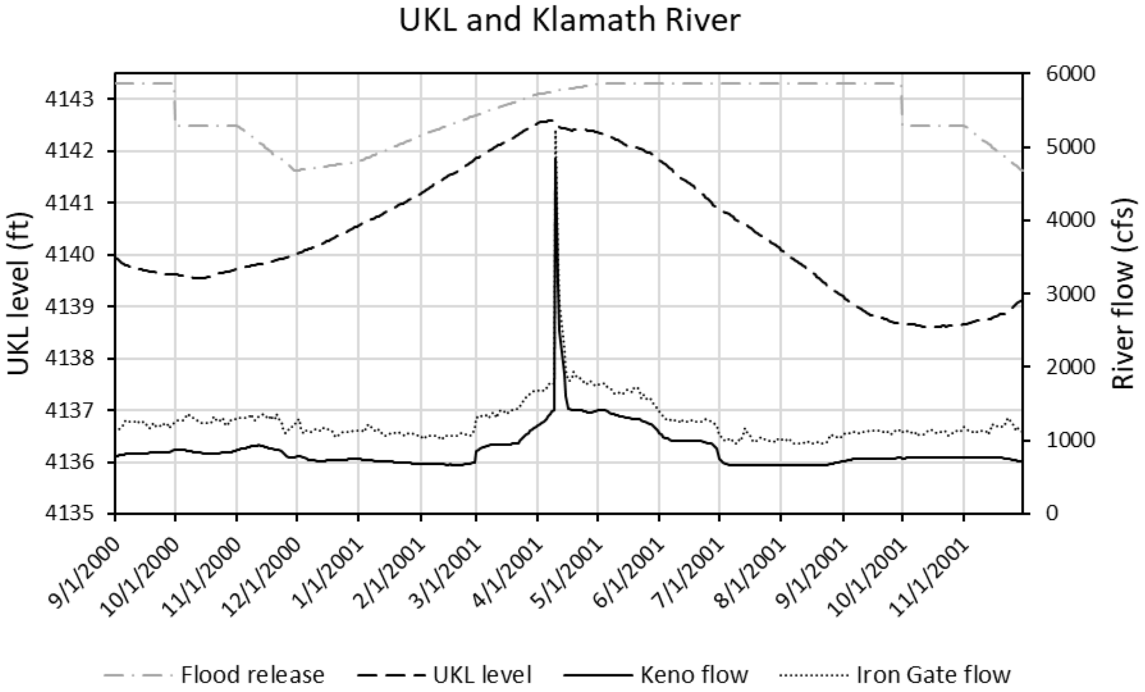
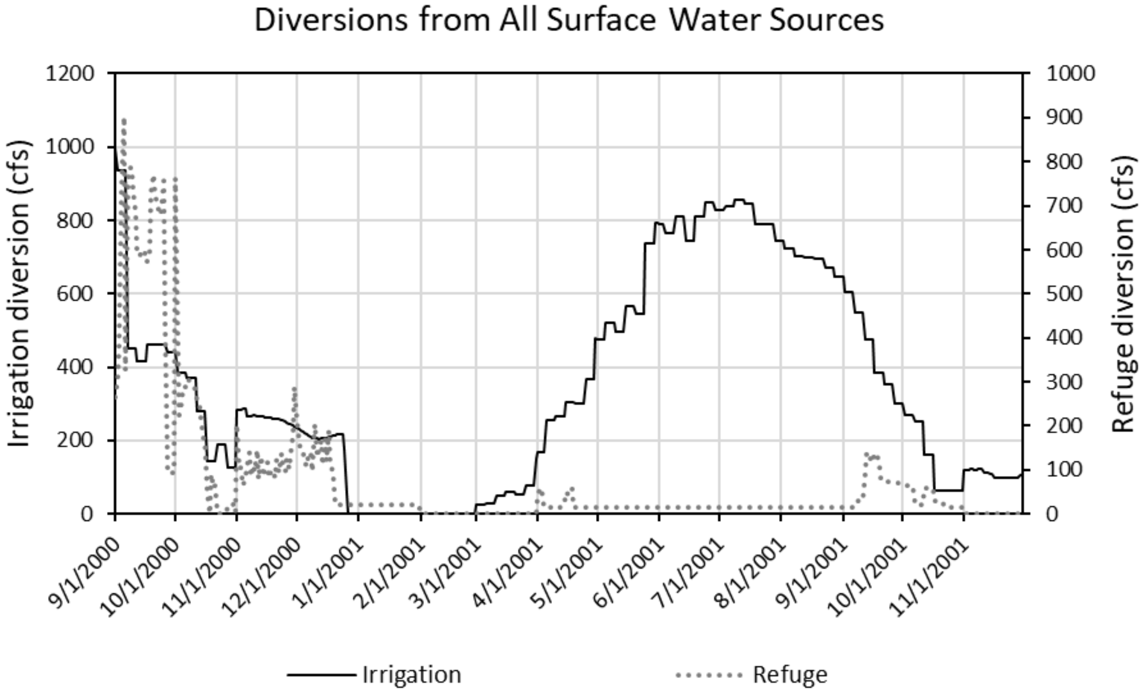
Addendum Figure CA-20. Simulated daily outcomes in 2000 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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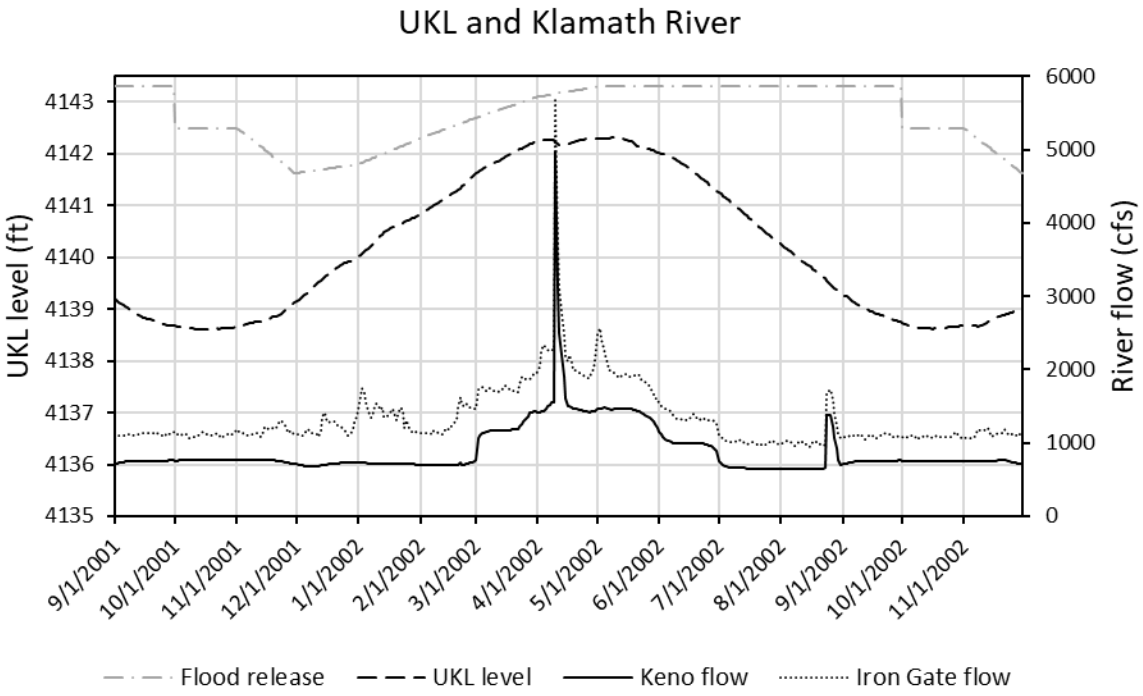
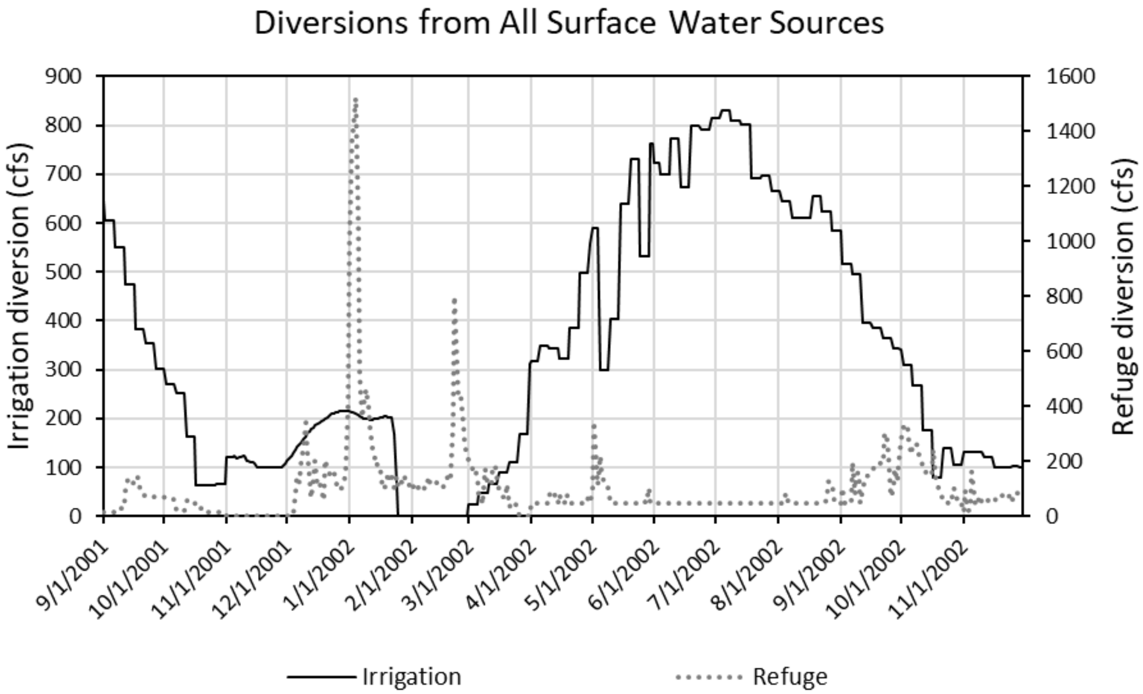
Addendum Figure CA-21. Simulated daily outcomes in 2001 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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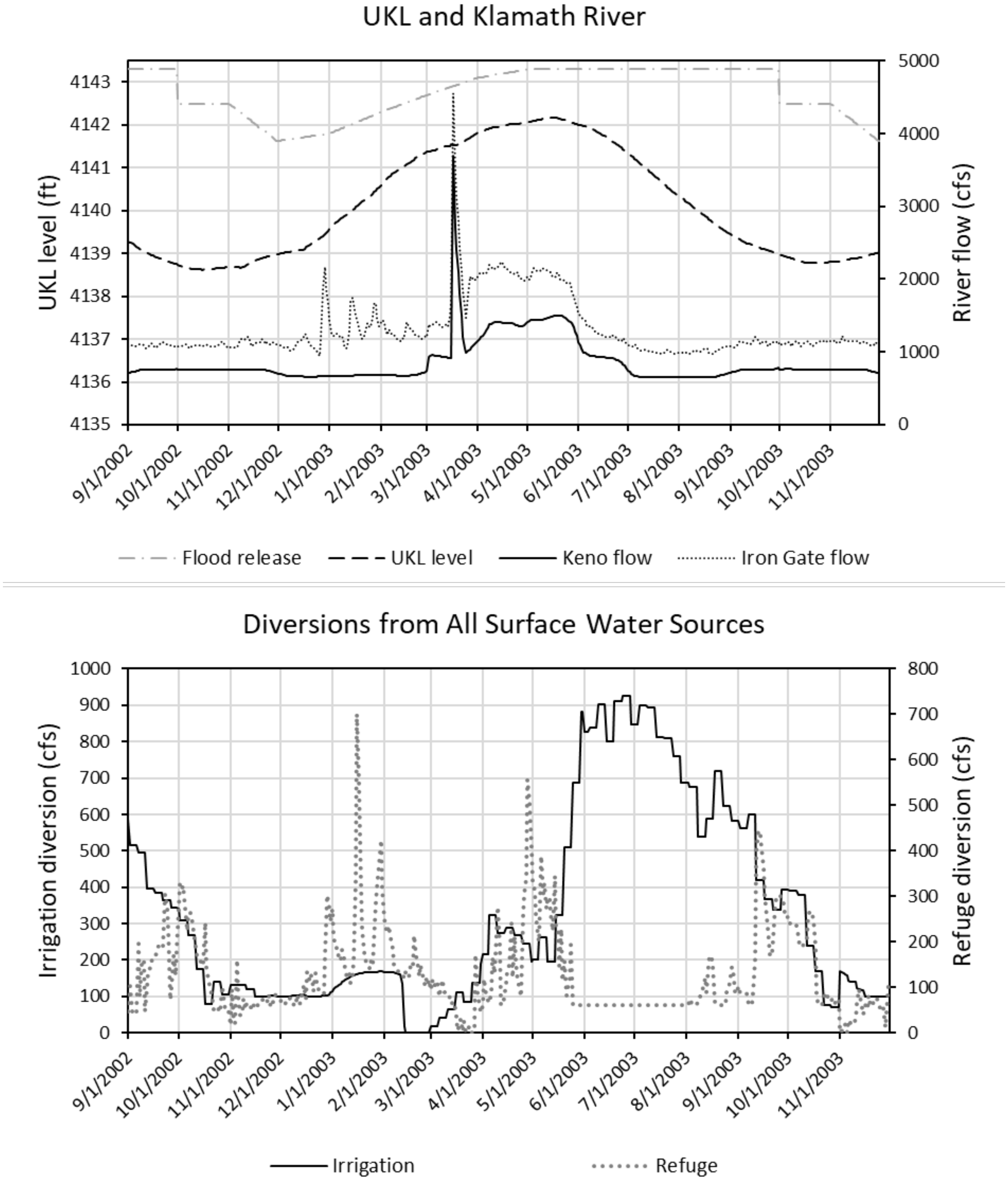
Addendum Figure CA-22. Simulated daily outcomes in 2002 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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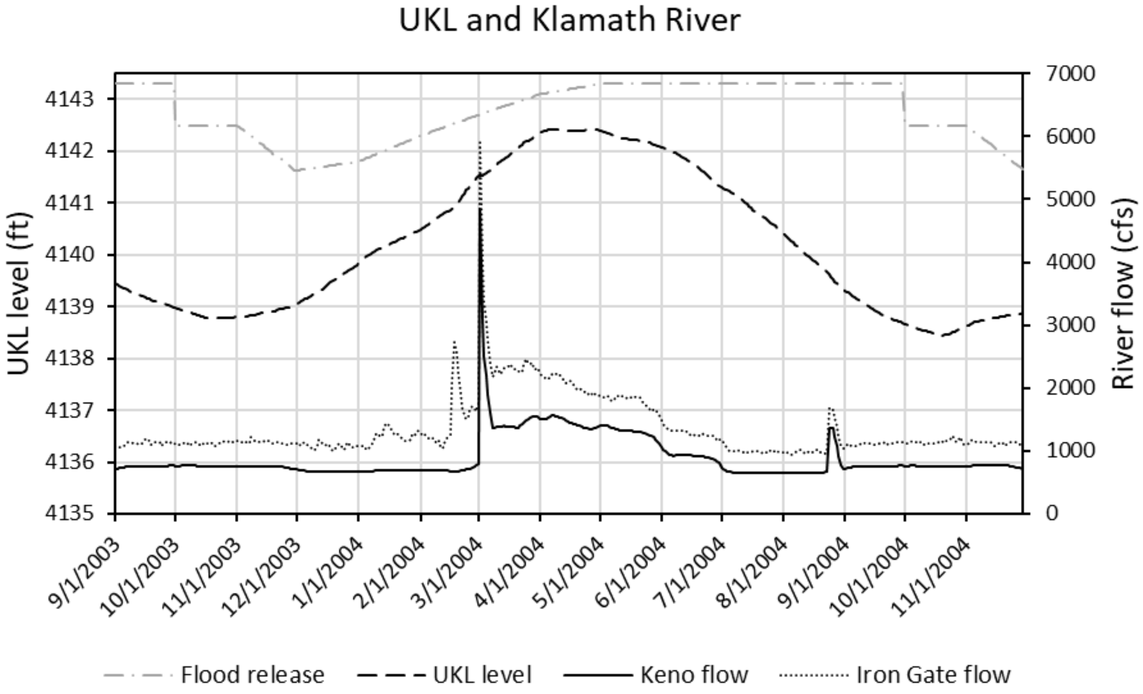
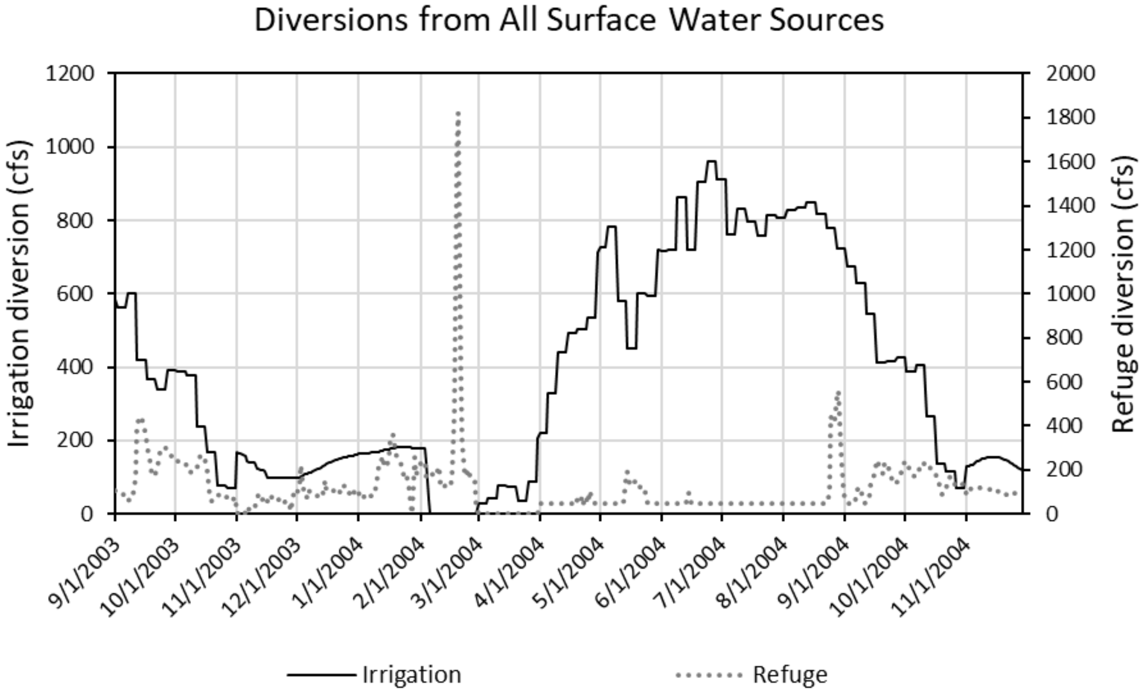
Addendum Figure CA-23. Simulated daily outcomes in 2003 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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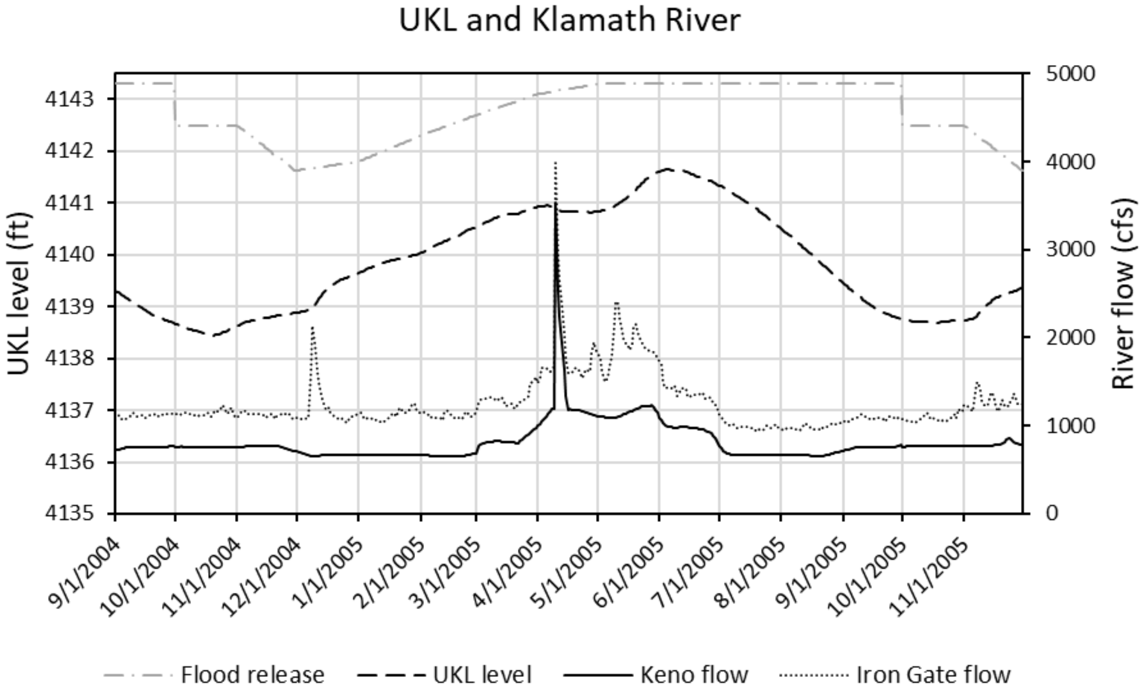
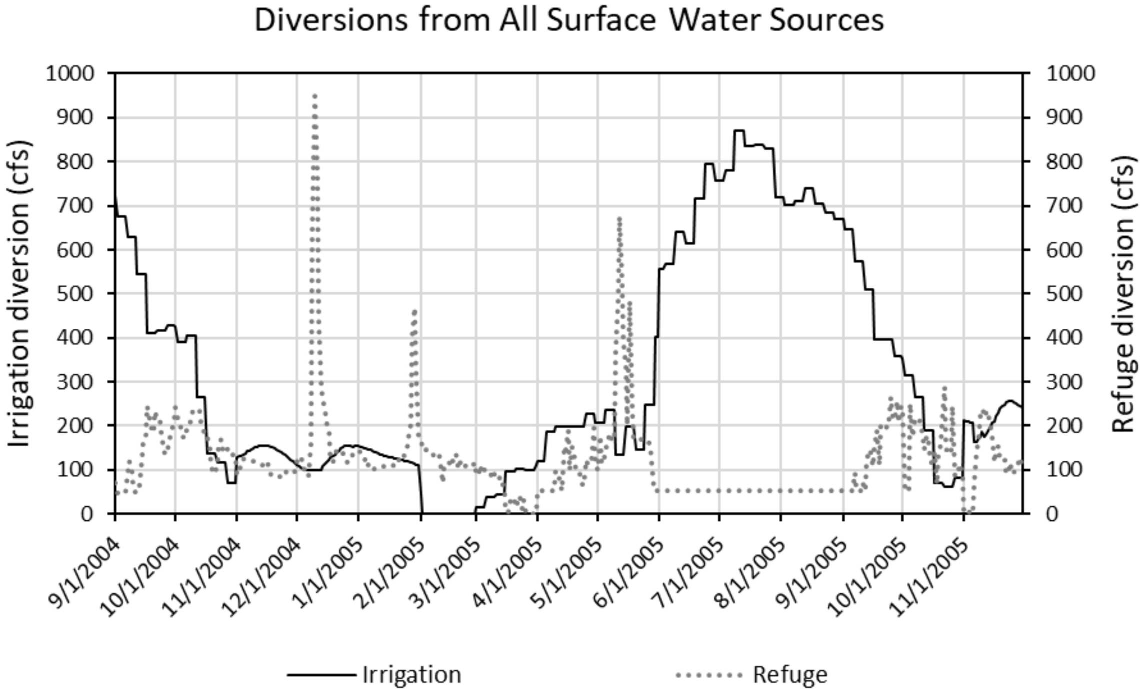
Addendum Figure CA-24. Simulated daily outcomes in 2004 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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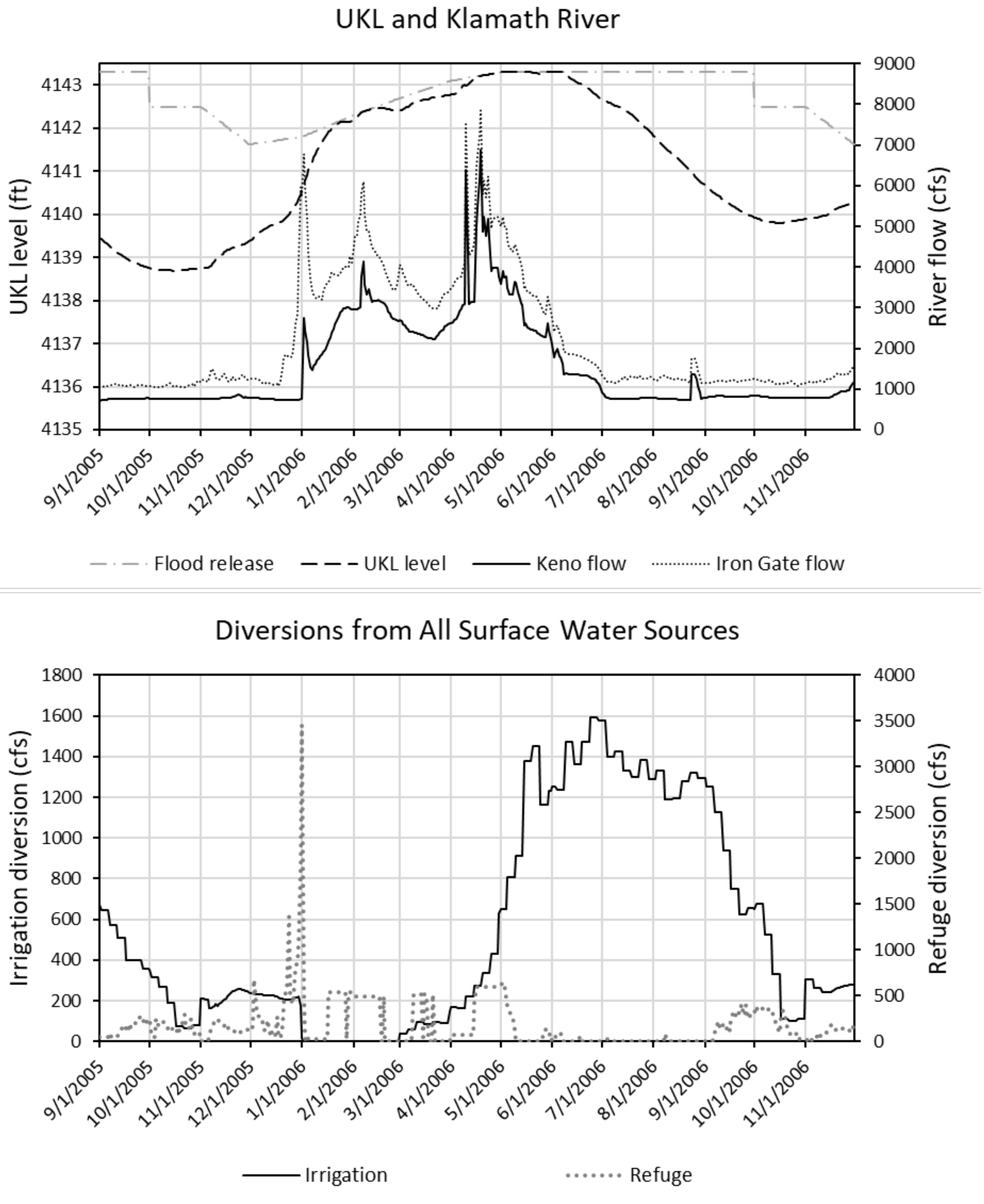
Addendum Figure CA-25. Simulated daily outcomes in 2005 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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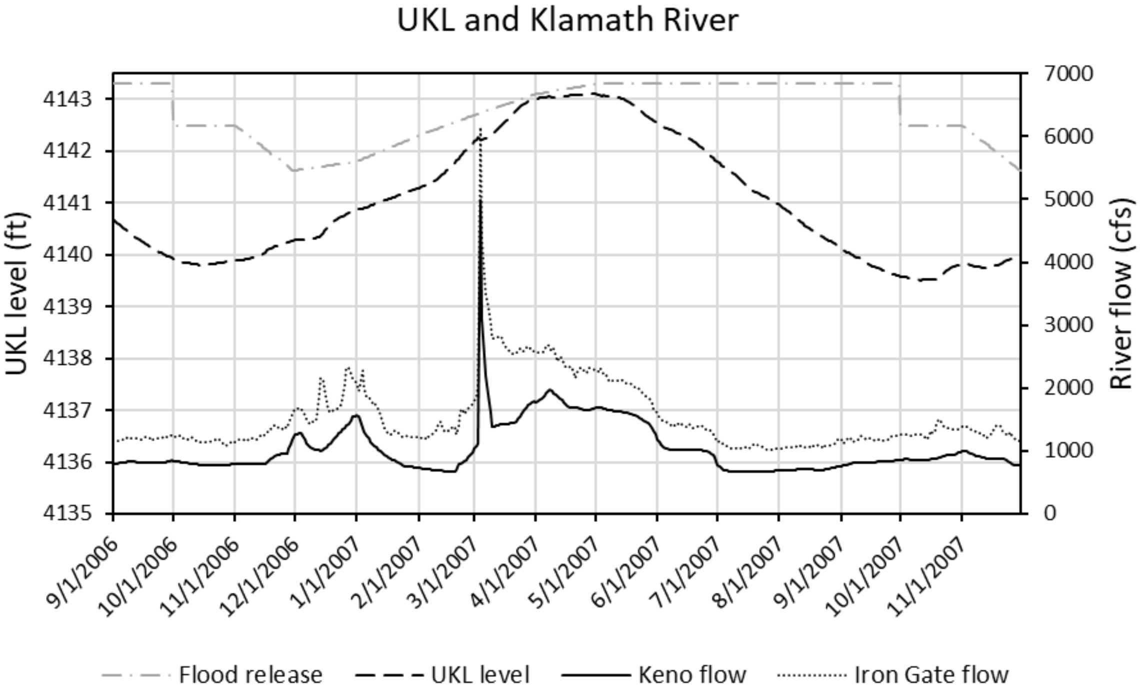
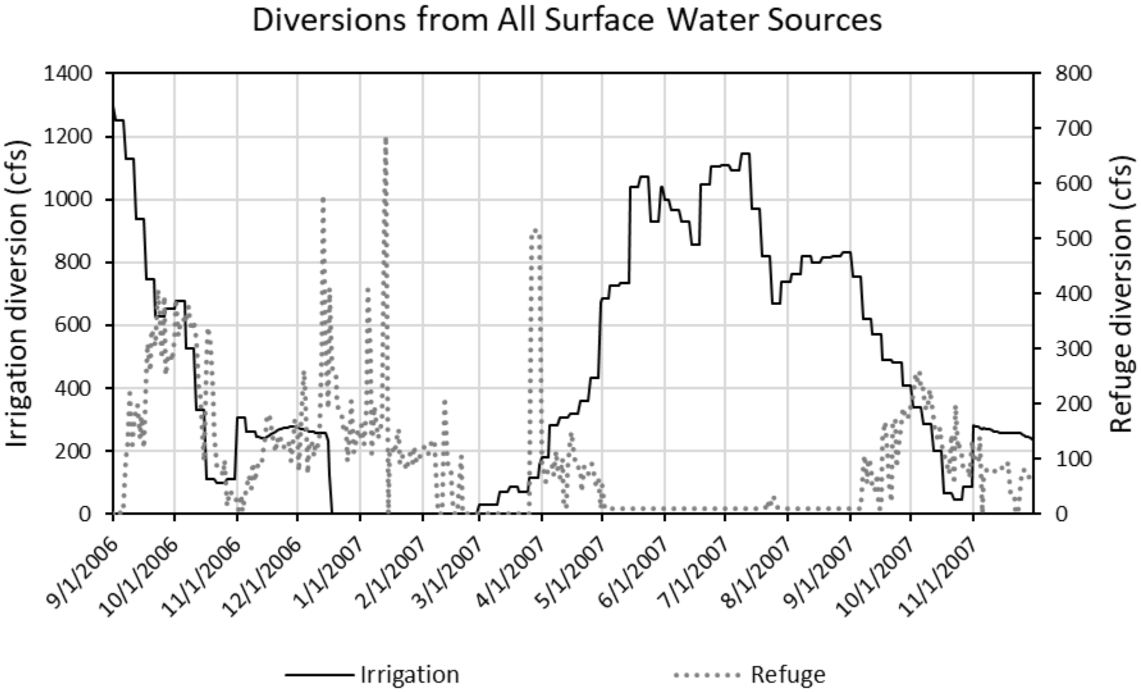
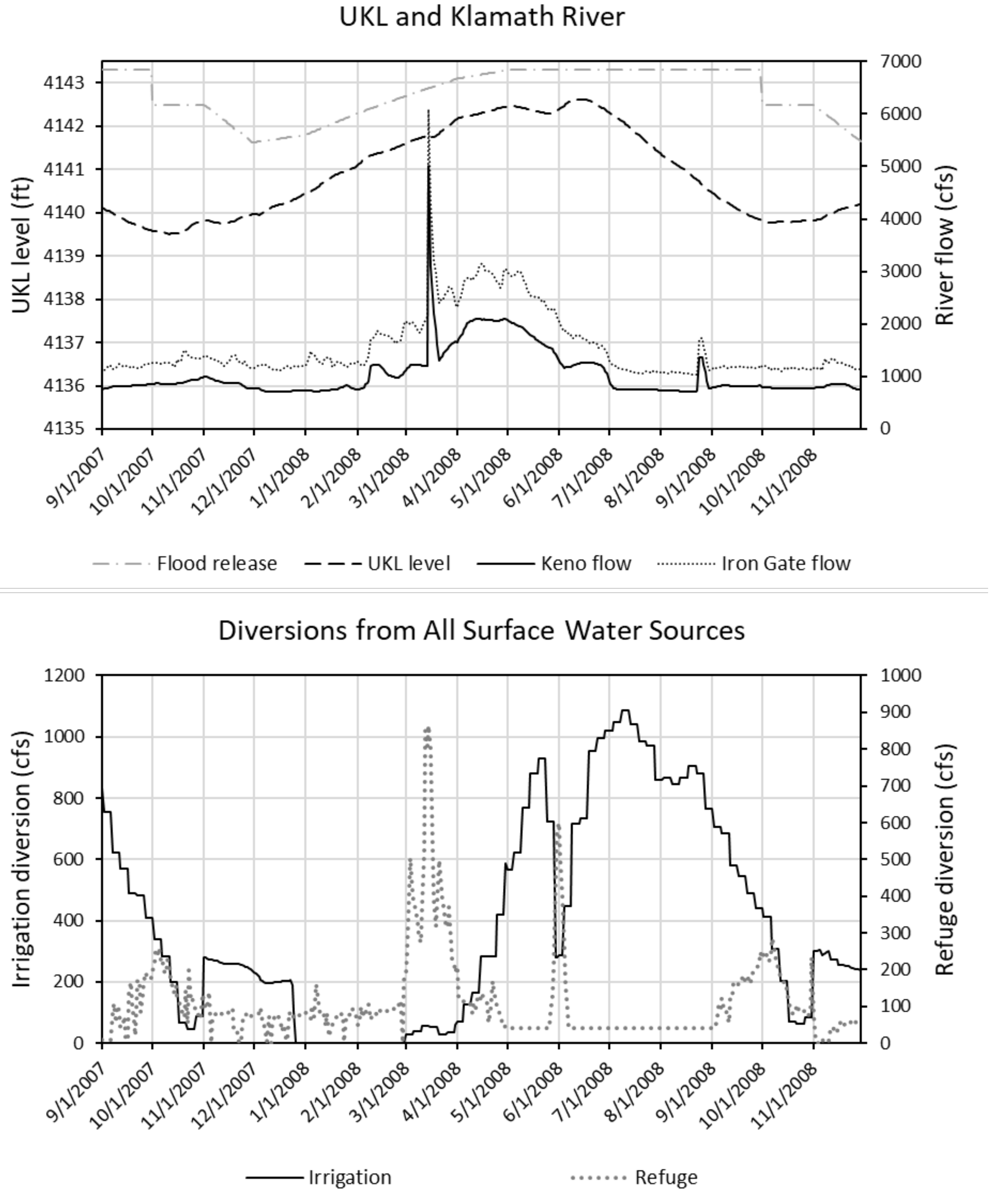
Addendum Figure CA-26. Simulated daily outcomes in 2006 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





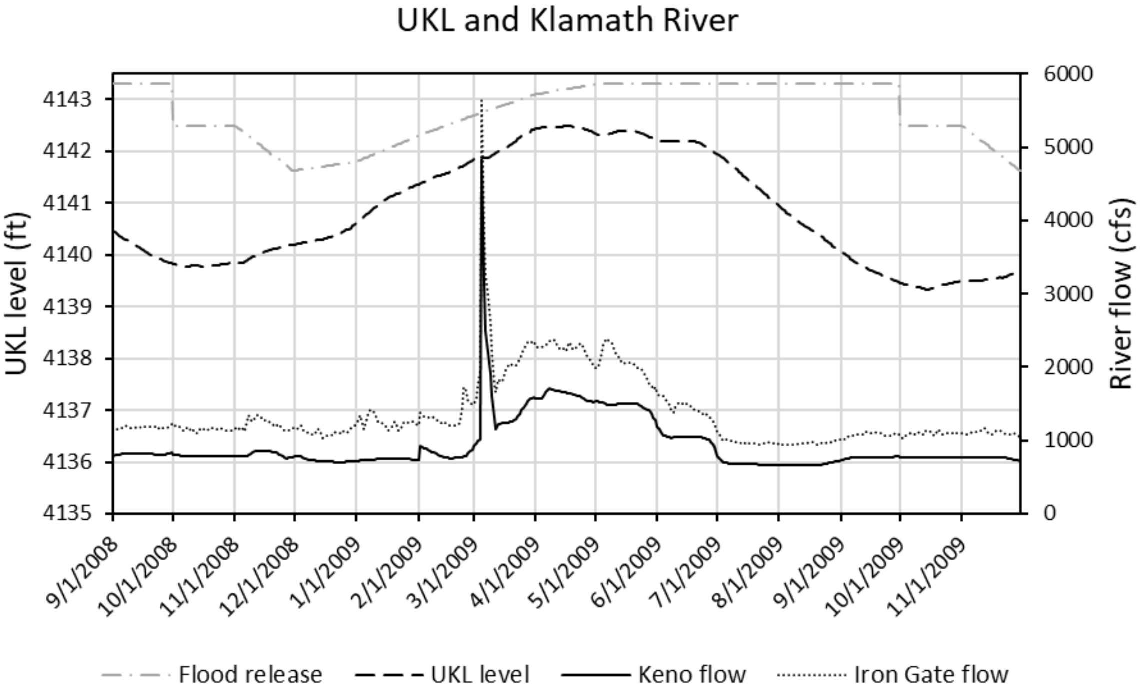
Note: The y-axis scales in the figures in this addendum may differ year to year.

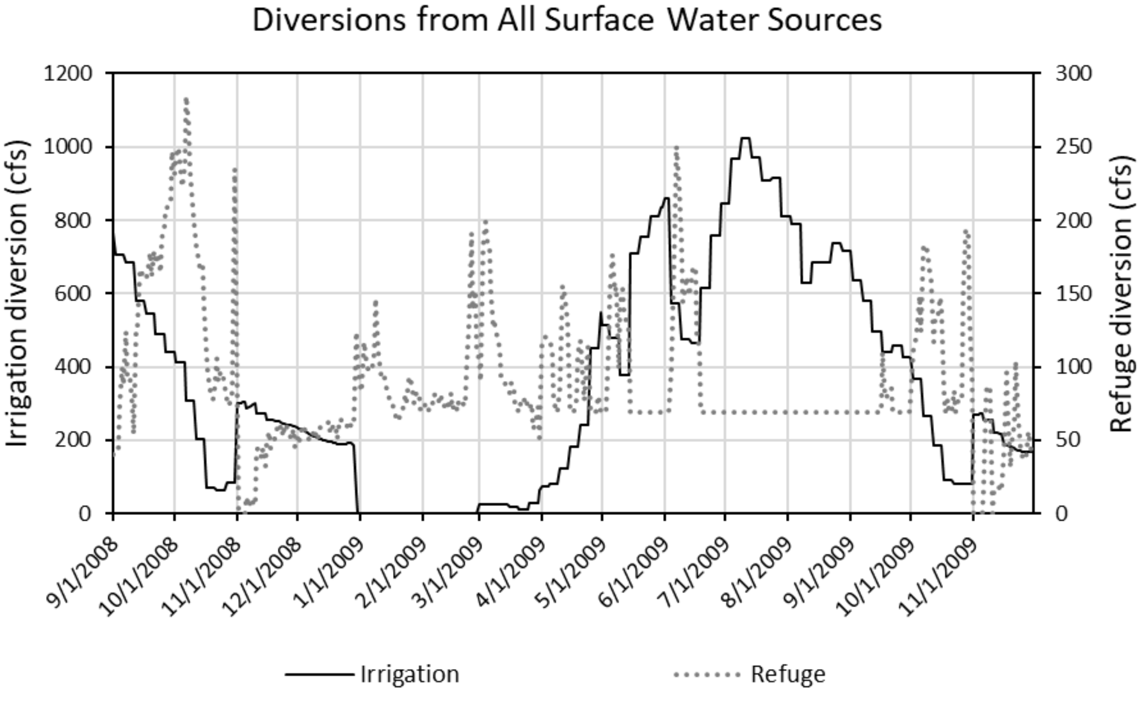
Addendum Figure CA-27. Simulated daily outcomes in 2007 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



Note: The y-axis scales in the figures in this addendum may differ year to year.

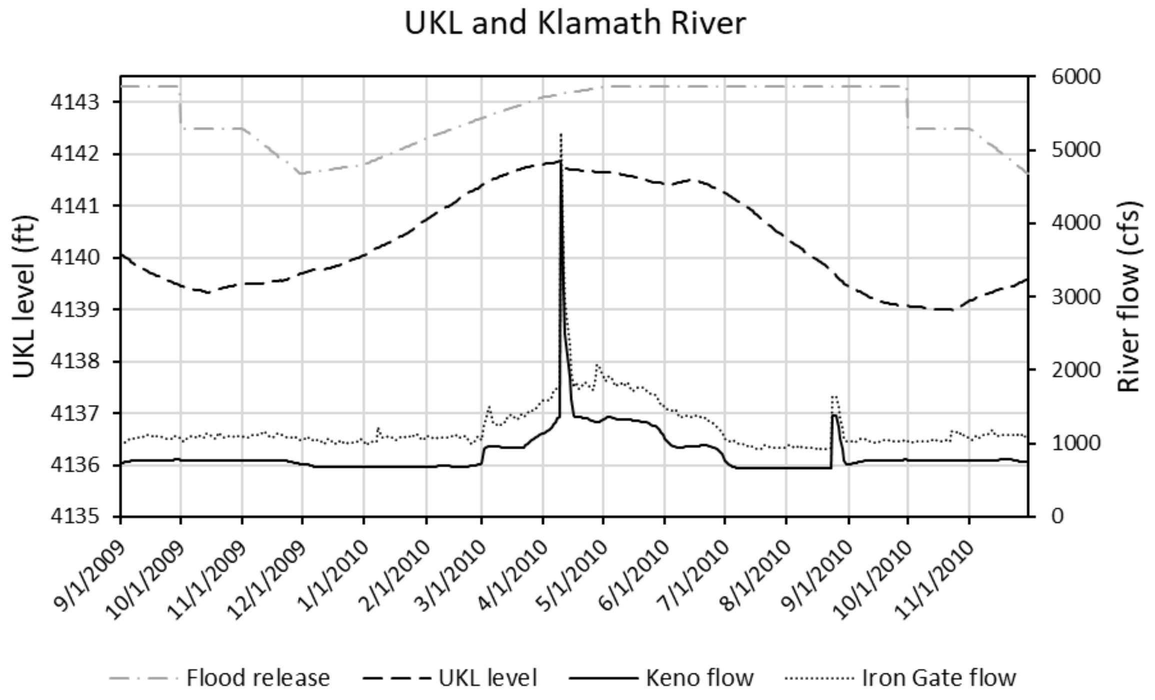
Addendum Figure CA-28. Simulated daily outcomes in 2008 for UKL levels, Klamath River flows, and diversions for irrigation and refuges

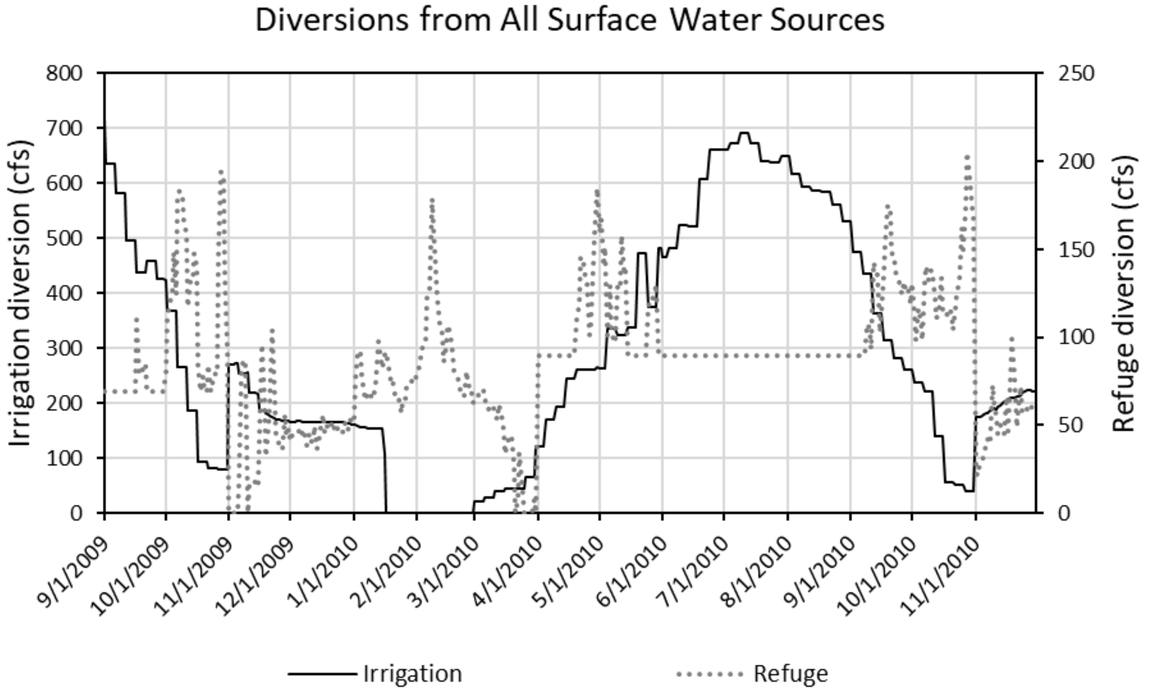




Note: The y-axis scales in the figures in this addendum may differ year to year.

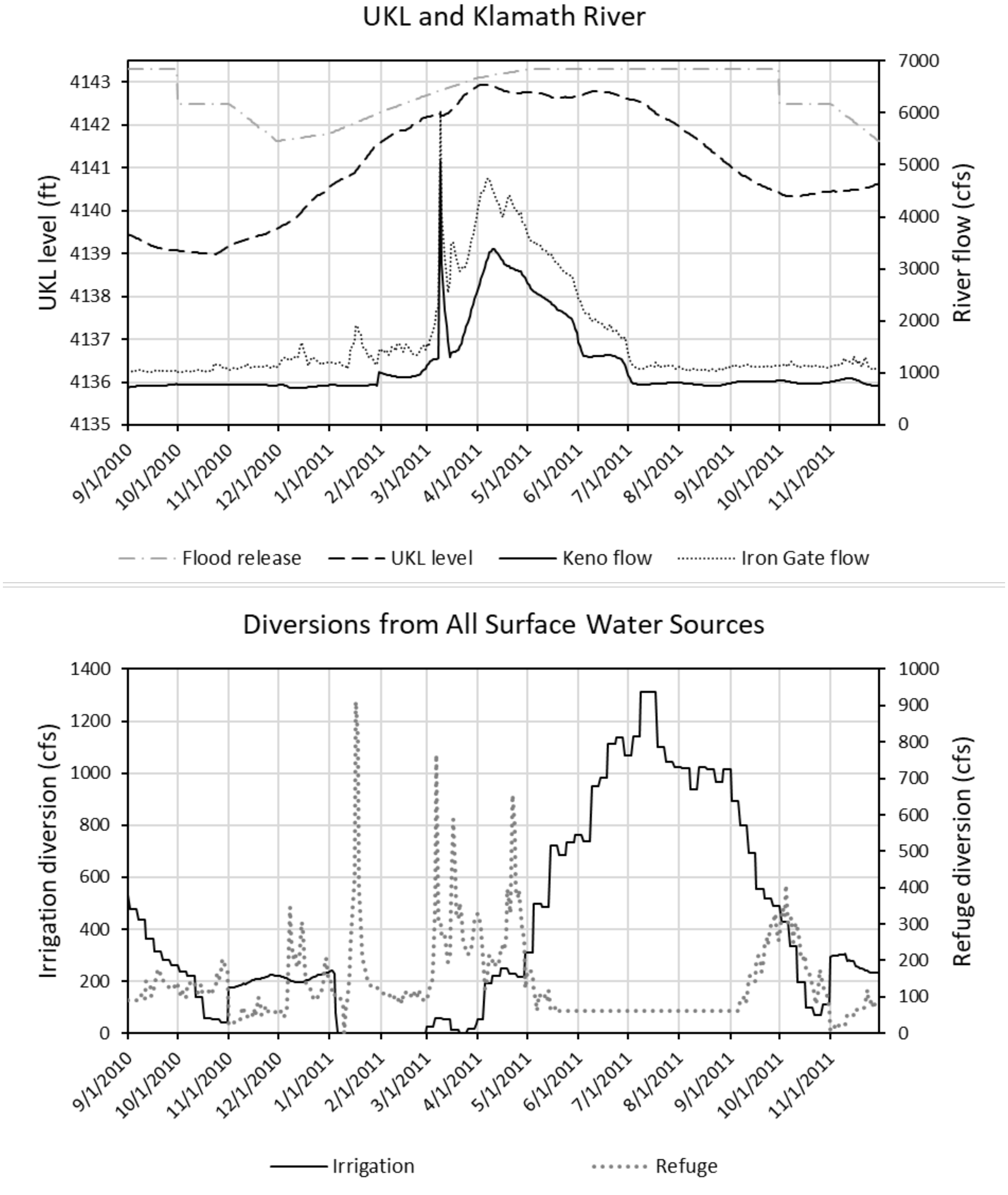
Addendum Figure CA-29. Simulated daily outcomes in 2009 for UKL levels, Klamath River flows, and diversions for irrigation and refuges


UKL and Klamath River


Diversions from All Surface Water Sources

Note: The y-axis scales in the figures in this addendum may differ year to year.

Addendum Figure CA-30. Simulated daily outcomes in 2010 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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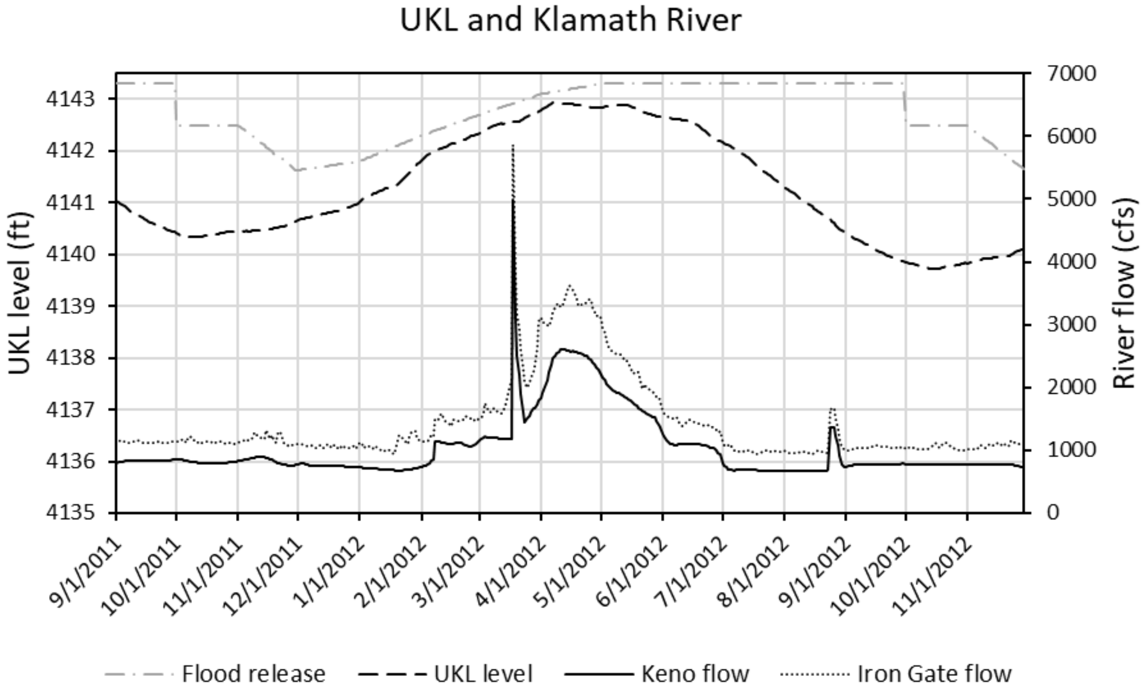
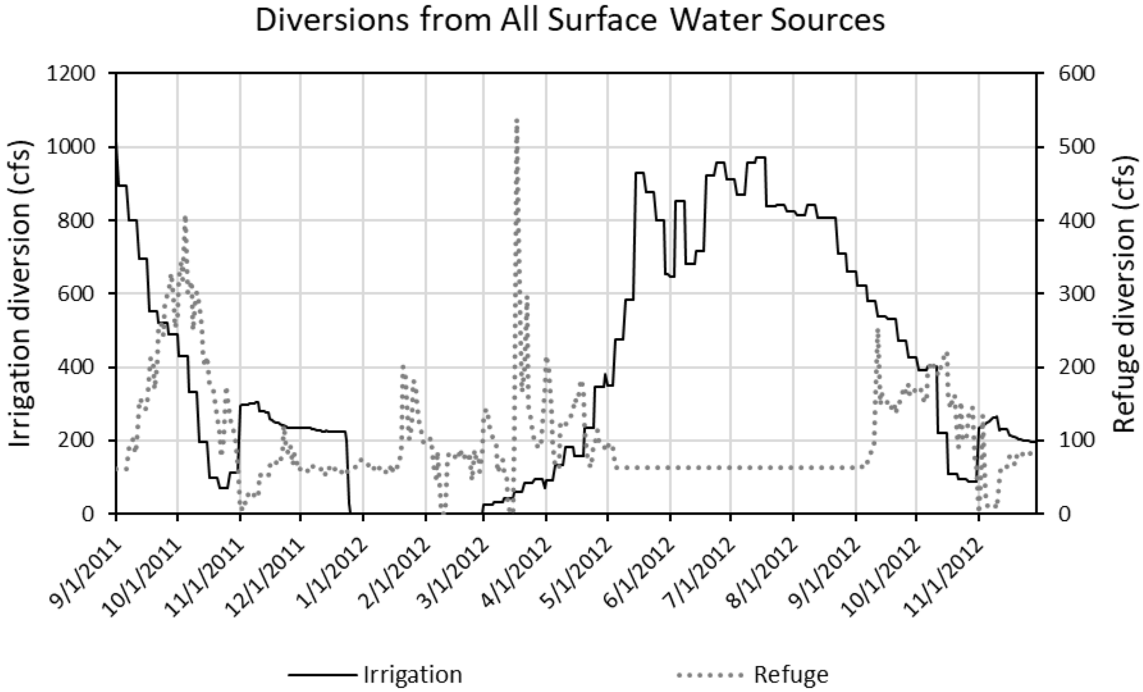
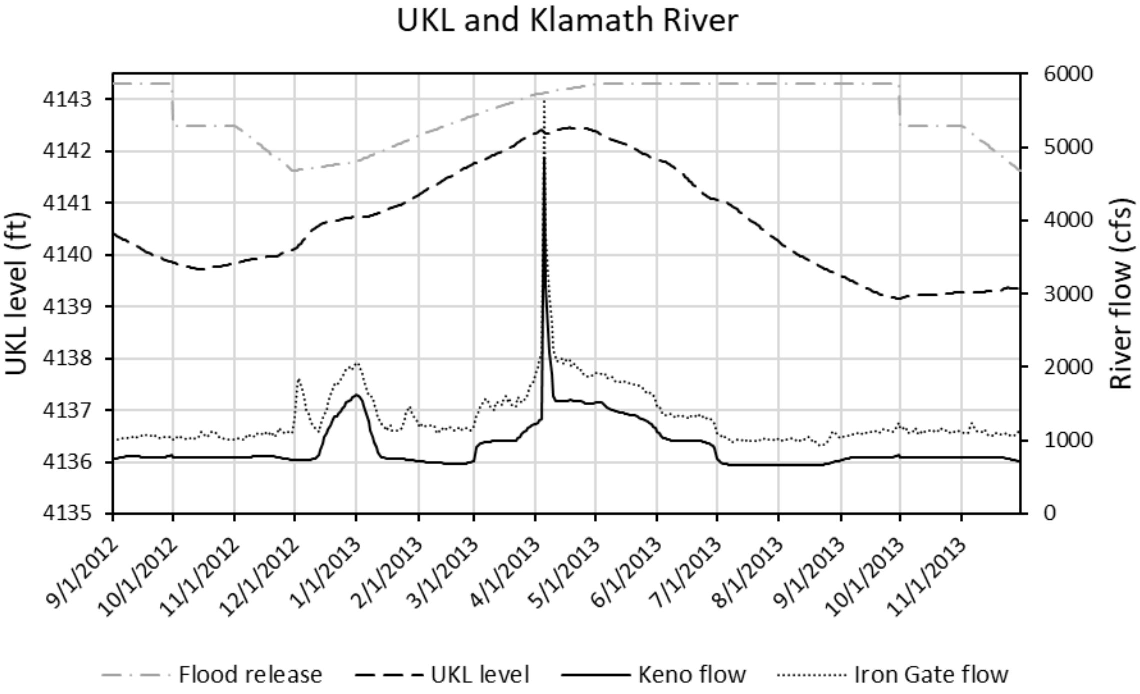
Addendum Figure CA-31. Simulated daily outcomes in 2011 for UKL levels, Klamath River flows, and diversions for irrigation and refuges

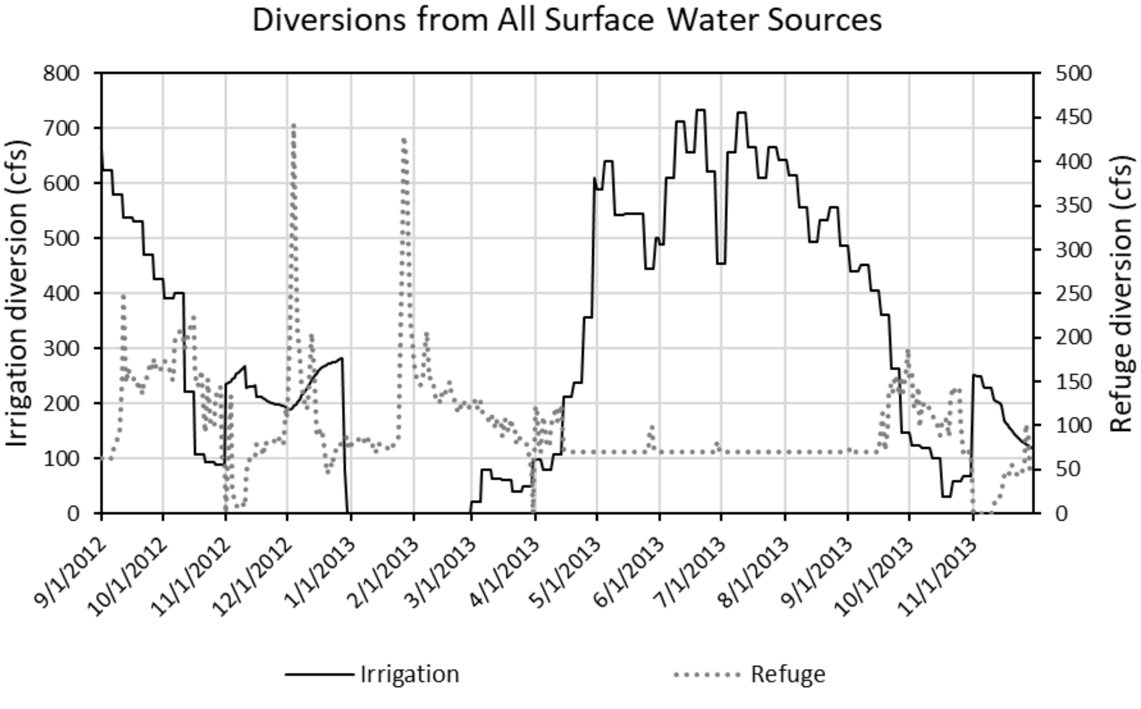




Note: The y-axis scales in the figures in this addendum may differ year to year.

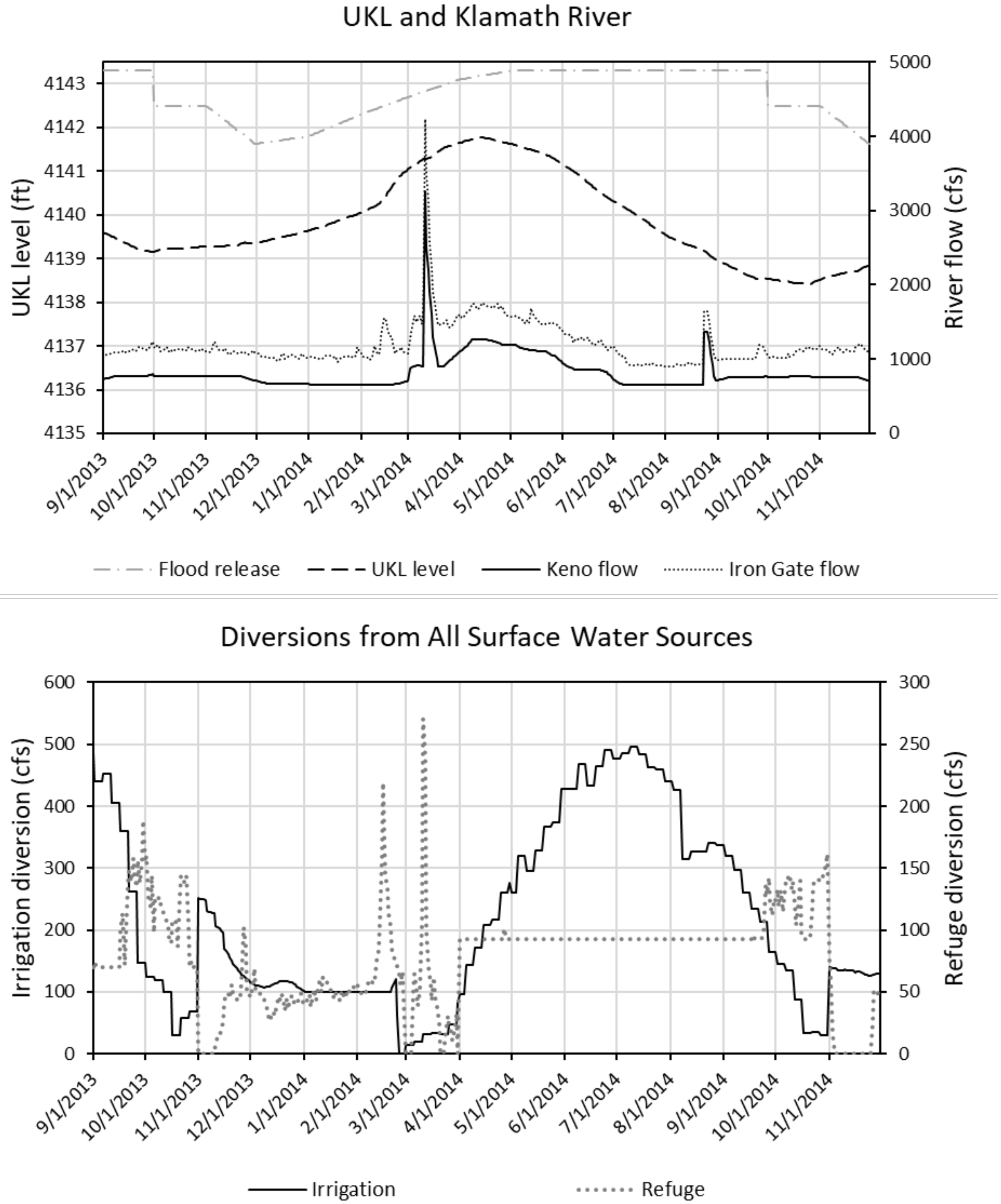
Addendum Figure CA-32. Simulated daily outcomes in 2012 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





Note: The y-axis scales in the figures in this addendum may differ year to year.

Addendum Figure CA-33. Simulated daily outcomes in 2013 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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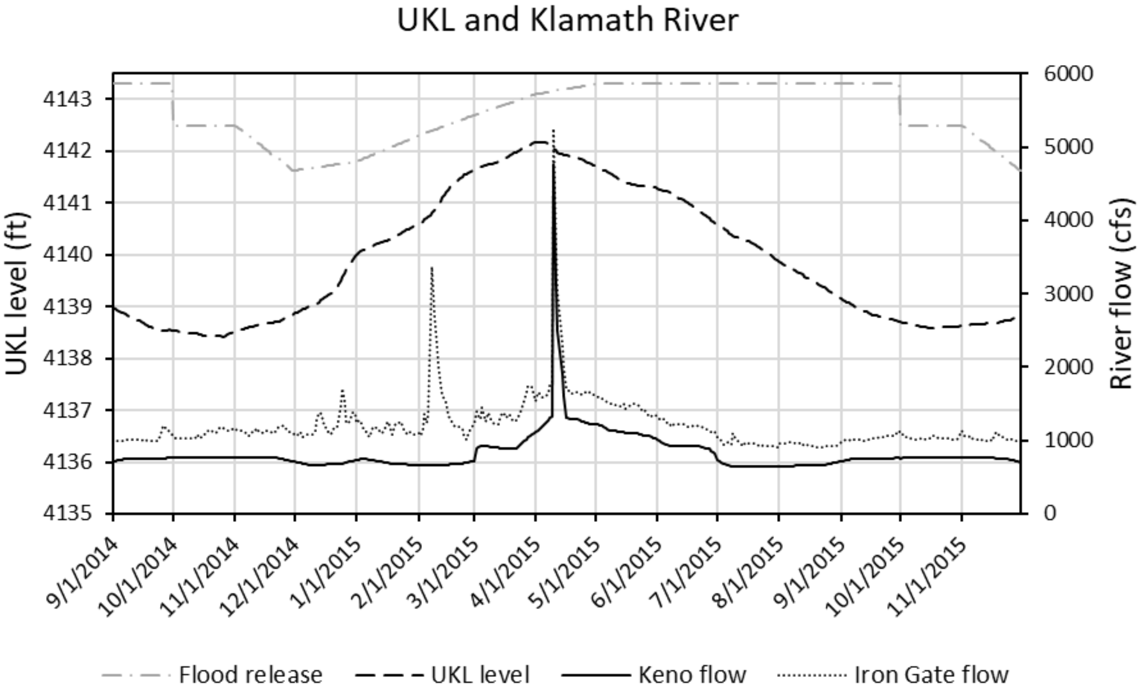
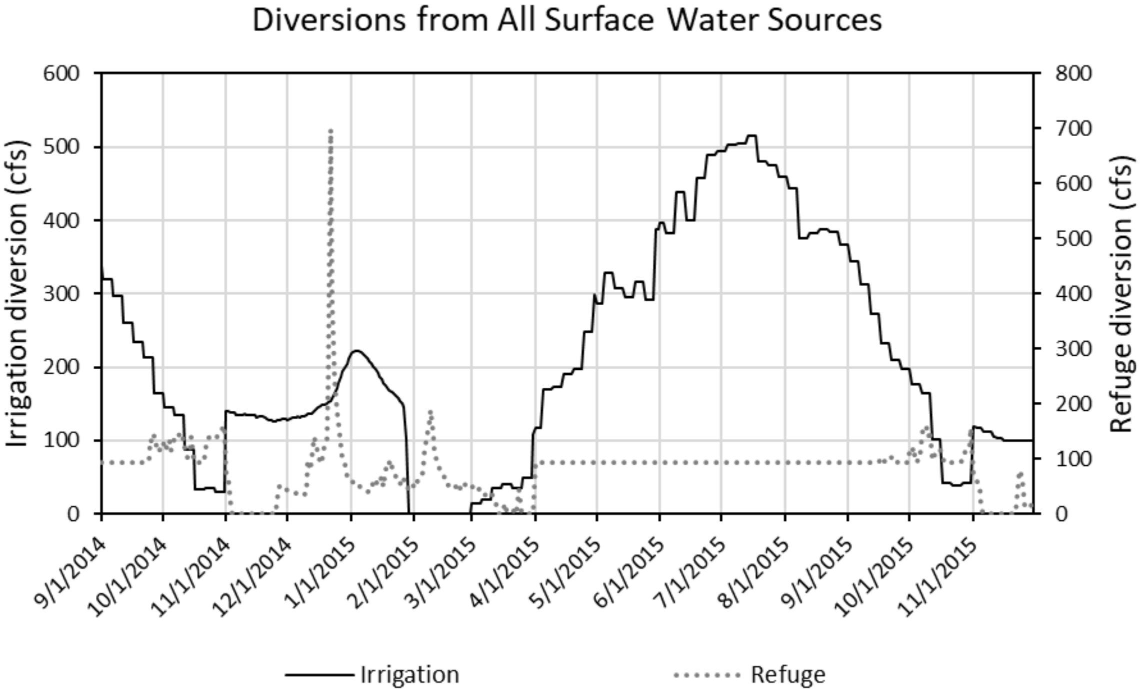
Addendum Figure CA-34. Simulated daily outcomes in 2014 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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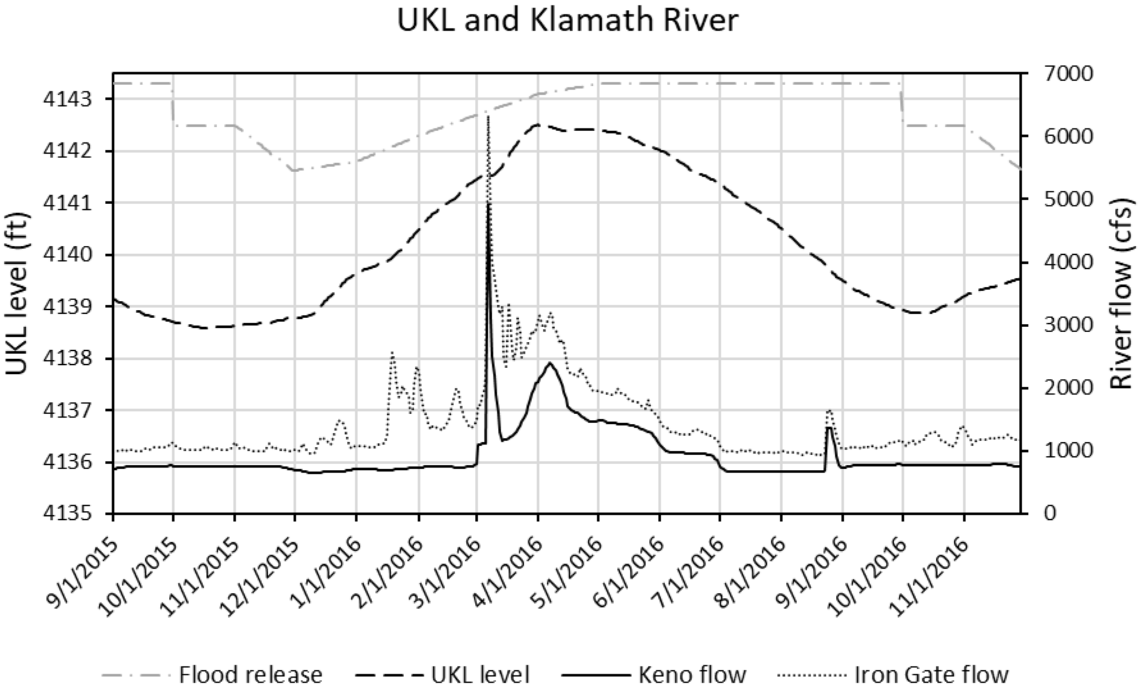
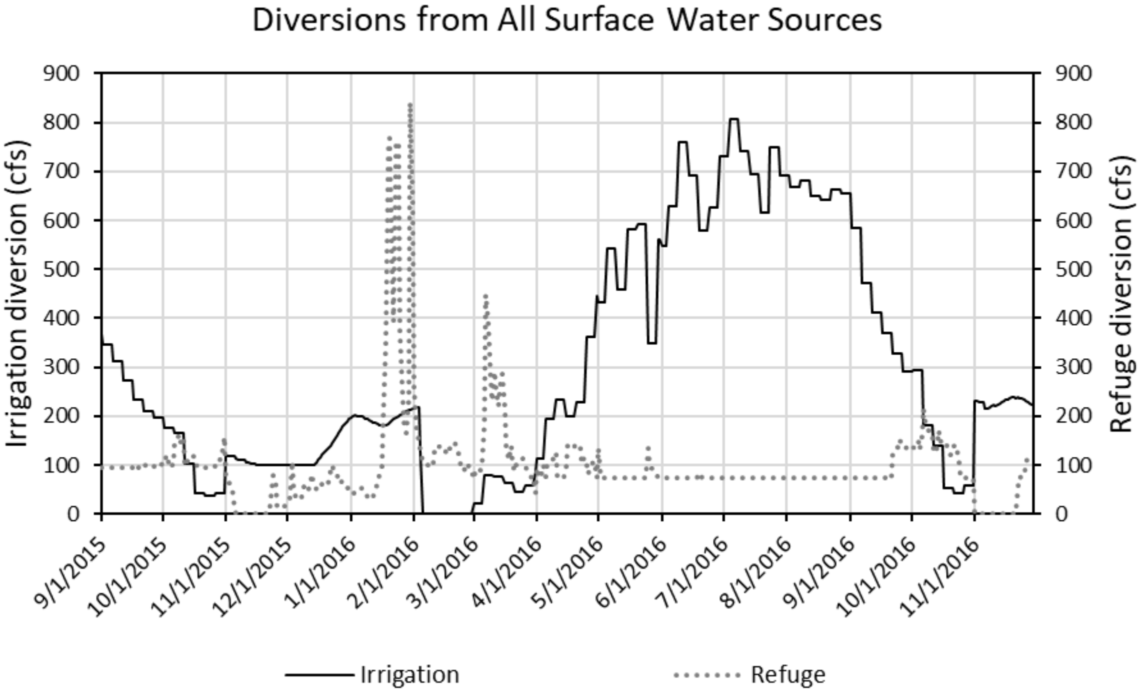
Addendum Figure CA-35. Simulated daily outcomes in 2015 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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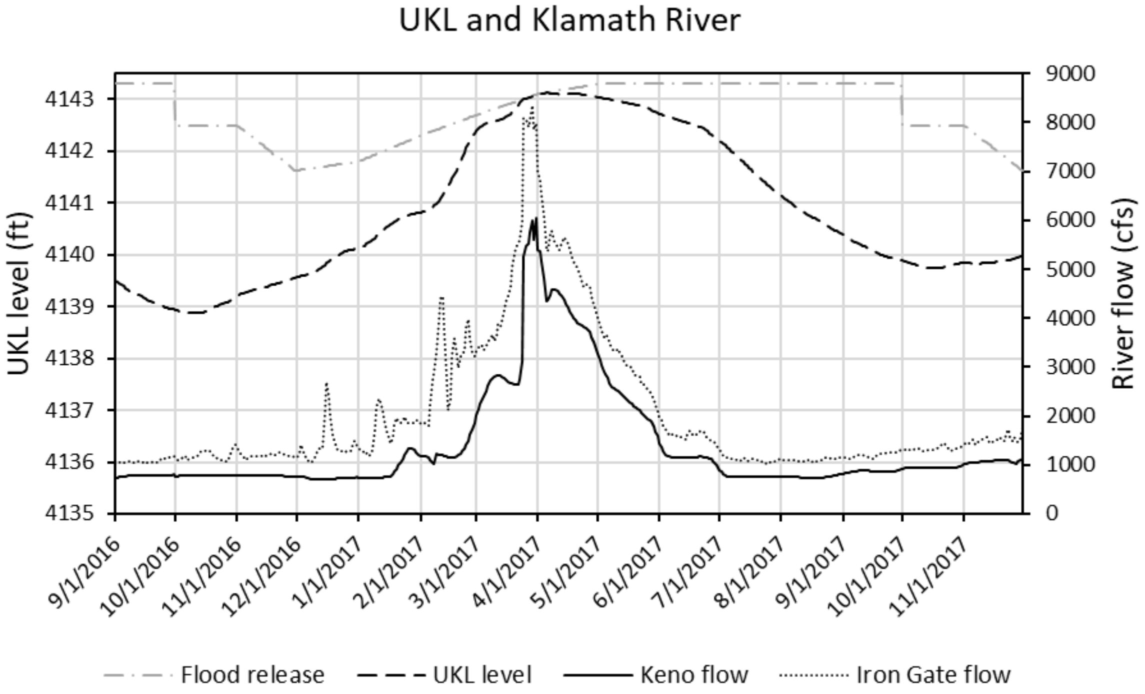
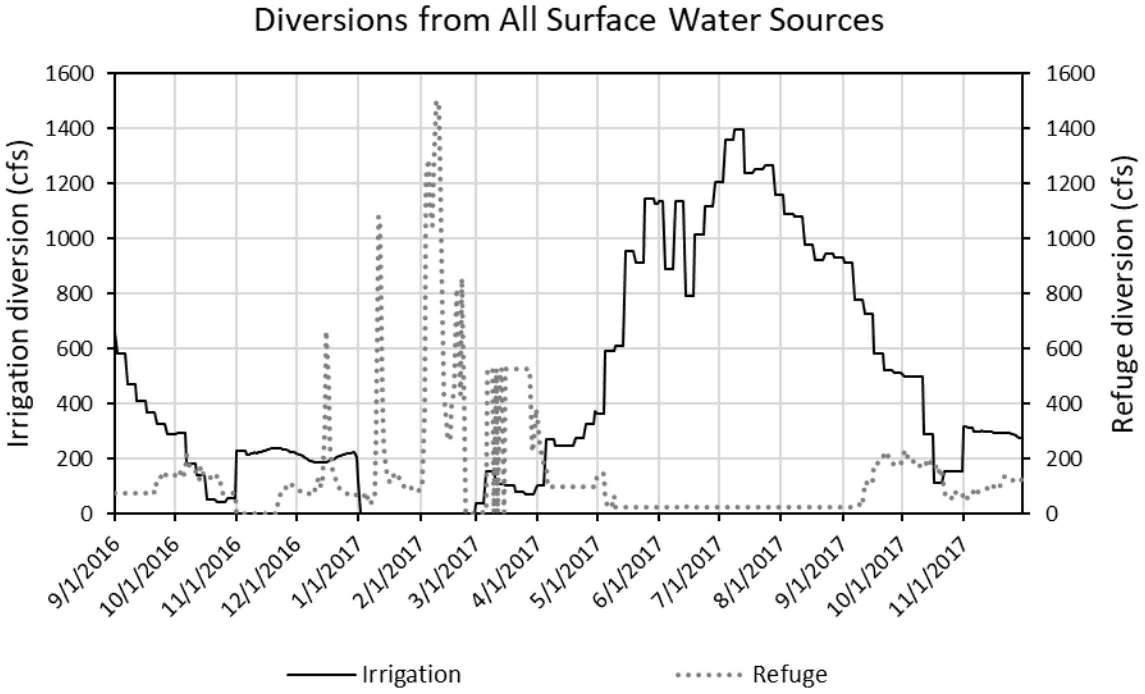
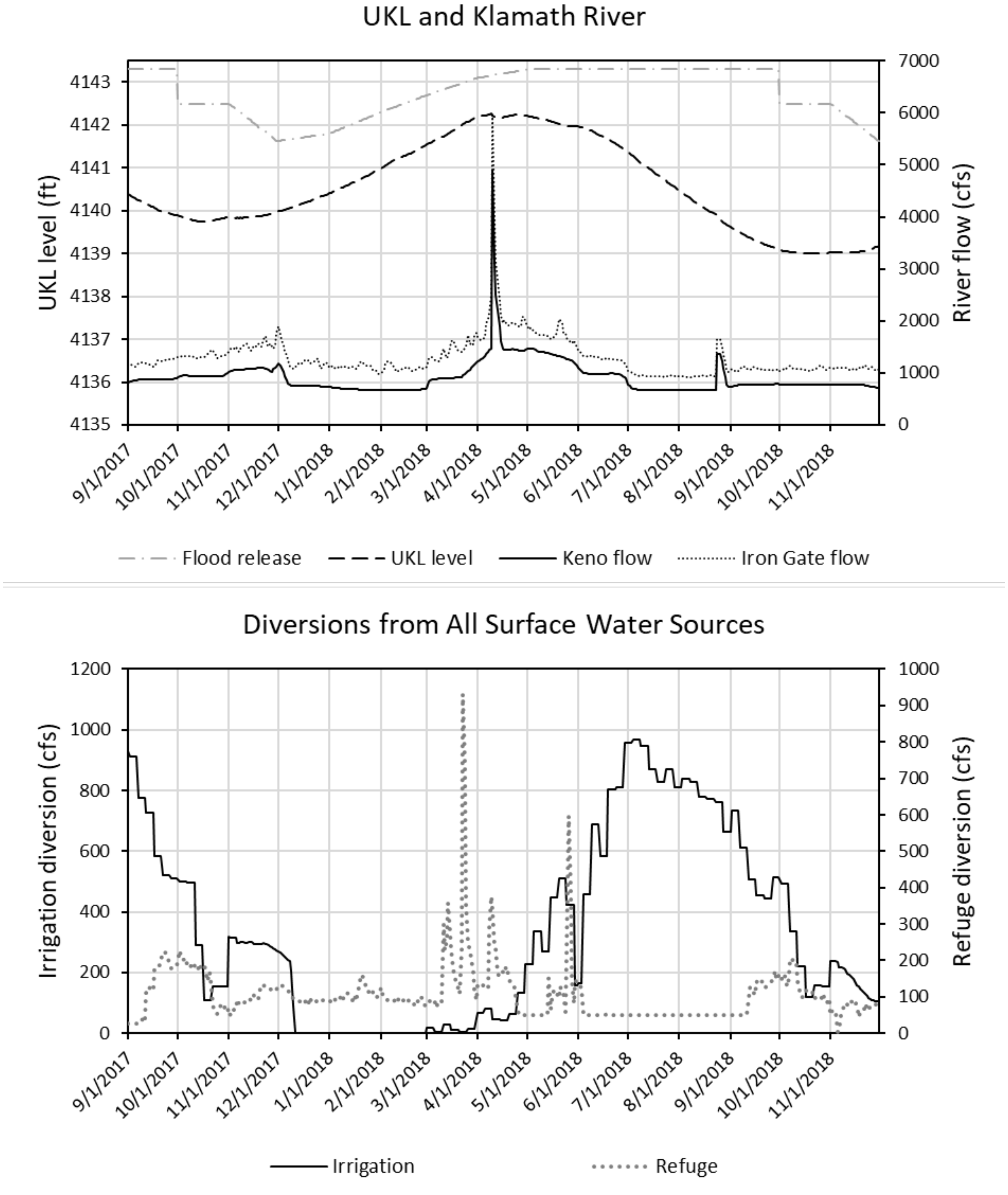
Addendum Figure CA-36. Simulated daily outcomes in 2016 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





Note: The y-axis scales in the figures in this addendum may differ year to year.

Addendum Figure CA-37. Simulated daily outcomes in 2017 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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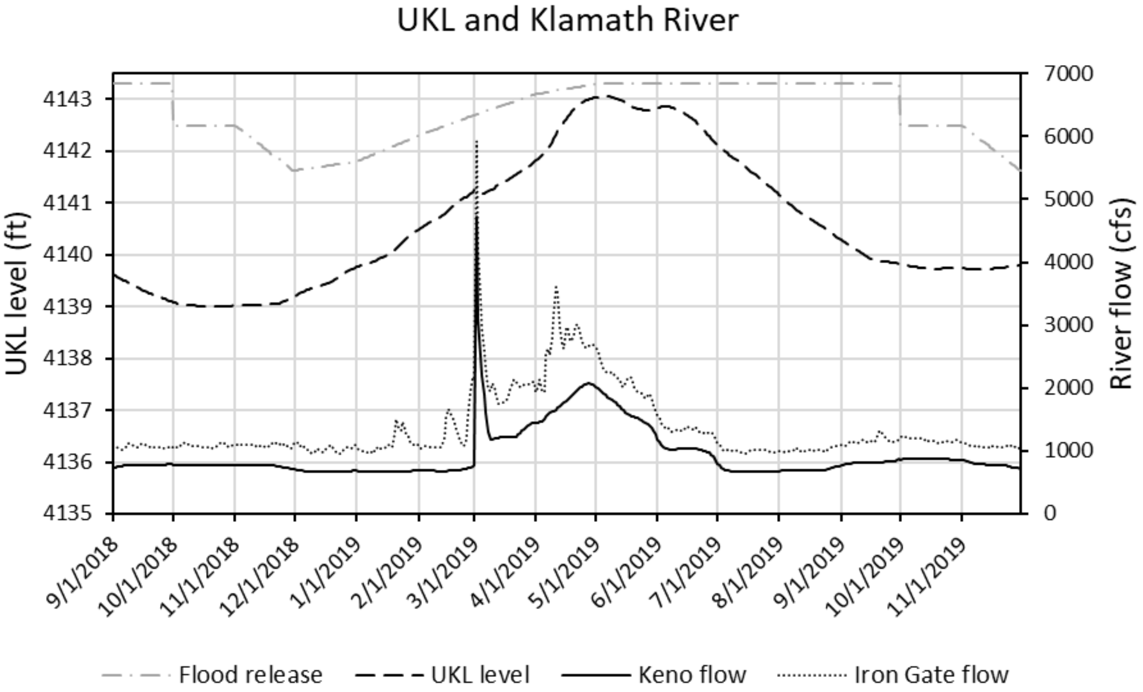
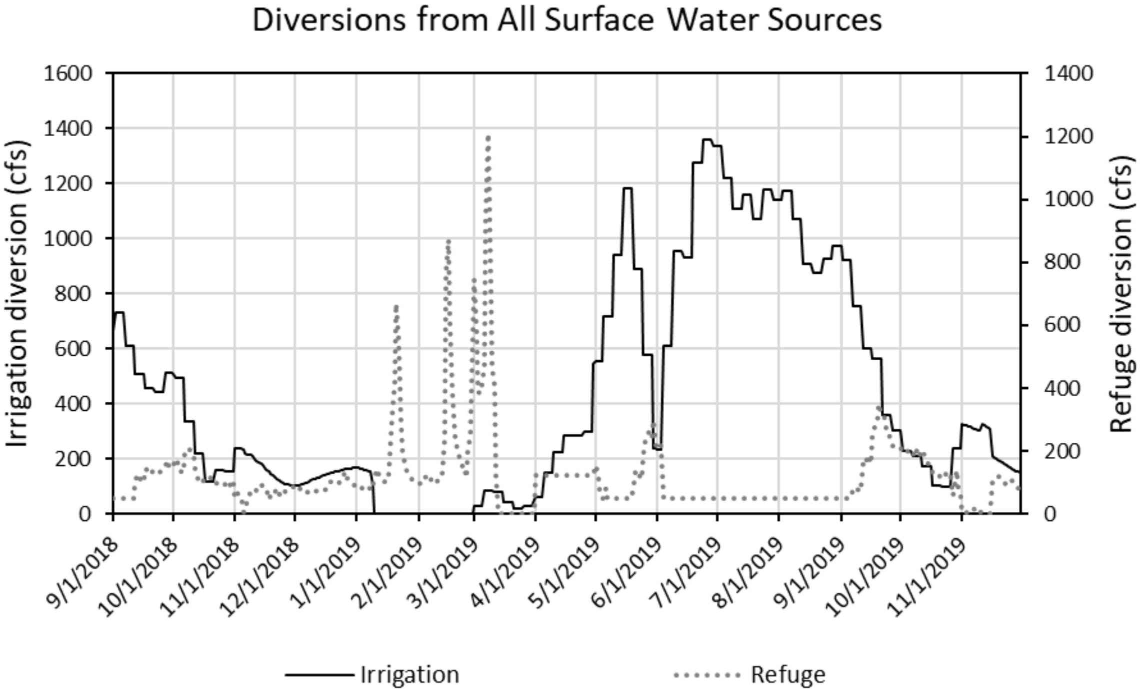
Addendum Figure CA-38. Simulated daily outcomes in 2018 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





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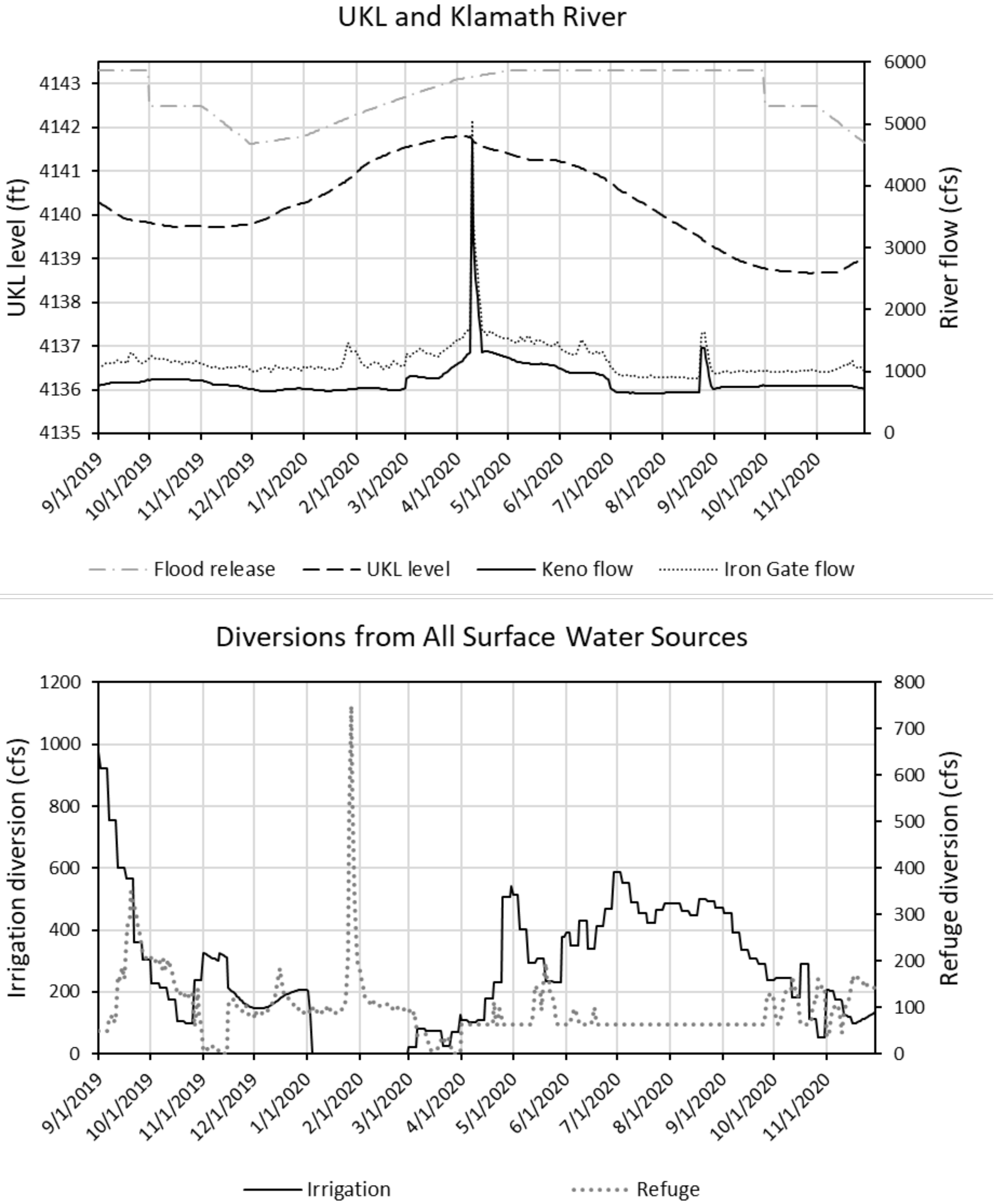
Addendum Figure CA-39. Simulated daily outcomes in 2019 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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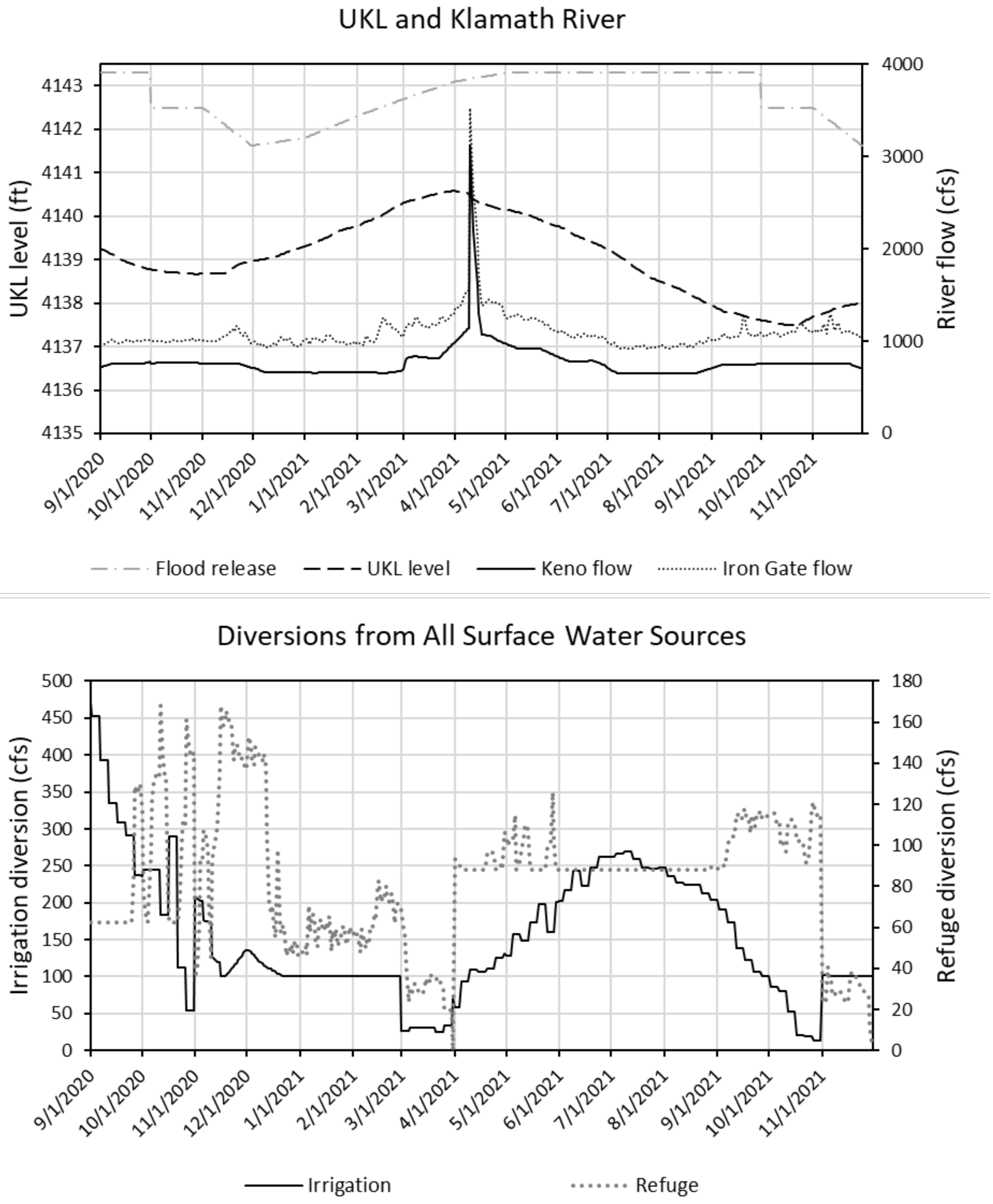
Addendum Figure CA-40. Simulated daily outcomes in 2020 for UKL levels, Klamath River flows, and diversions for irrigation and refuges



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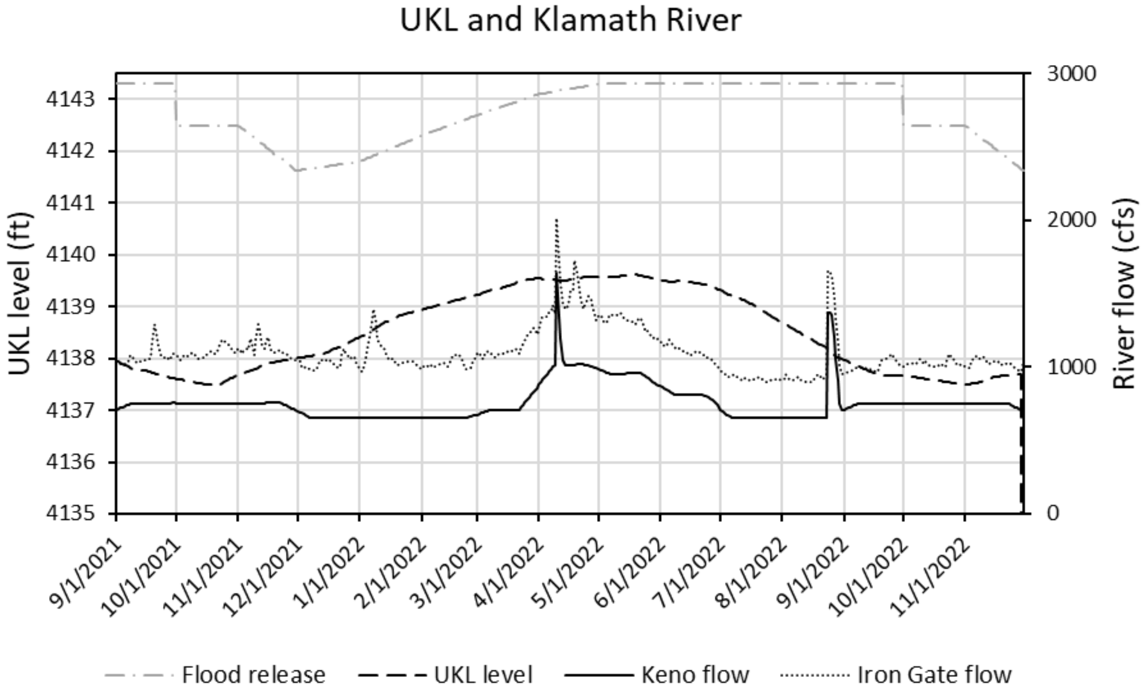
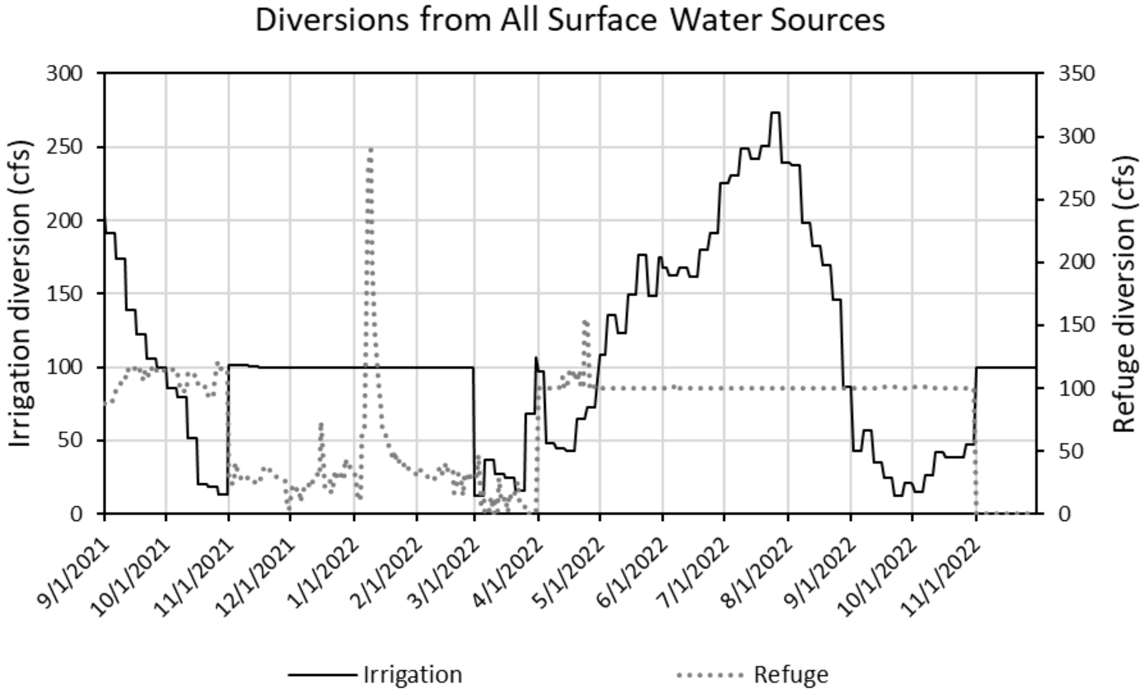
Addendum Figure CA-41. Simulated daily outcomes in 2021 for UKL levels, Klamath River flows, and diversions for irrigation and refuges





Note: The y-axis scales in the figures in this addendum may differ year to year.

Addendum Figure CA-42. Simulated daily outcomes in 2022 for UKL levels, Klamath River flows, and diversions for irrigation and refuges

APPENDIX D Essential Fish Habitat Assessment

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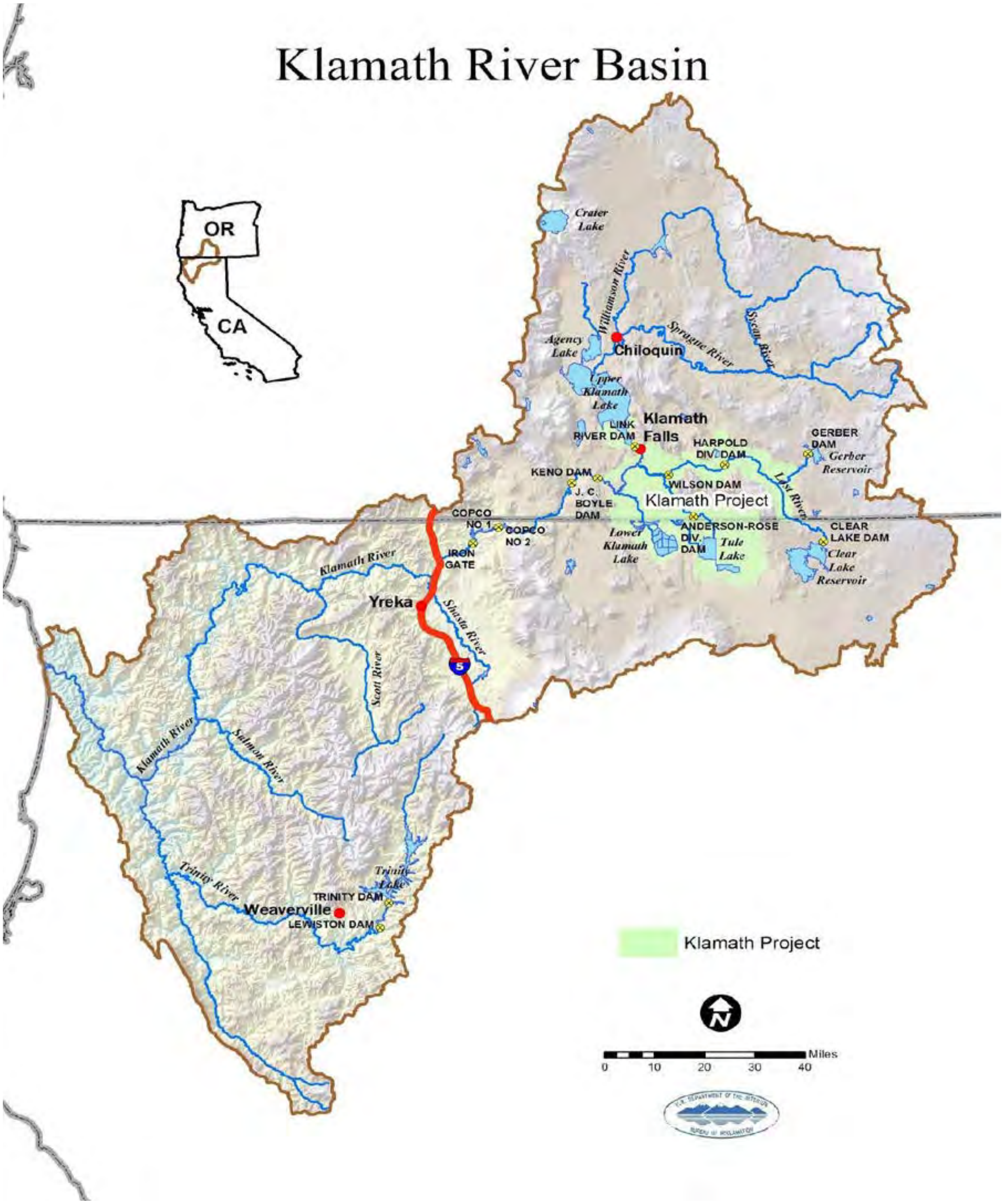
Introduction and Background

Essential Fish Habitat (EFH) is designated for commercially fished species under the Magnuson-Stevens Fishery Conservation and Management Act Public Law 94-265 as amended by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (P.L. 109-479) (Magnuson-Stevens Act). The Magnuson-Stevens Act requires federal fishery management plans, developed by National Oceanic Atmospheric Administration's National Marine Fisheries Service (NMFS) and the Pacific Southwest Fisheries Management Council, to describe the habitat essential to the fish being managed and to describe threats to that habitat from both fishing and non-fishing activities. Pursuant to Section 305(b) of the Magnuson-Stevens Act (16 U.S.C. 1855(b)), federal agencies are required to consult with NMFS on actions that may adversely affect EFH for species managed under the Pacific Coast Salmon Fishery Management Plan. This section also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

The Magnuson-Stevens Act clarifies that EFH "means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 USC § 1802 (10)) The following clarifications are important for the purpose of interpreting the definition of EFH: 1) "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include areas historically used by fish where appropriate; 2) "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; 3) "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and 4) "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

Managed Pacific salmon species (including Chinook Salmon *Oncorhynchus tshawytscha* and Coho Salmon *O. kisutch*) EFH and life histories are discussed in Appendix A to the Pacific Coast Salmon Fishery Management Plan (PFMP) as modified by Amendment 18 to the PFMP (PFMC, 2024), which is summarized here for Chinook and Coho Salmon with specific life history information for the Klamath River. Habitat Areas of Particular Concern have also been identified in Appendix A of the PFMP. Habitat Areas of Particular Concern for salmon are complex channel and floodplain habitat, spawning habitat, thermal refugia, estuaries, and submerged vegetation.

This EFH analysis covers Chinook Salmon and Southern Oregon Northern California Coast Coho Salmon (herein referred to as Coho Salmon). Chinook and Coho Salmon are managed under the Magnuson-Stevens Act, under the authority of which EFH for Coho and Chinook Salmon is described in Amendment 14 to the PFMP (50 CFR § 660.412). Freshwater EFH for Coho and Chinook Salmon in the Klamath Basin has been designated for the mainstem Klamath River and its tributaries from its mouth to the former Iron Gate Dam (IGD) site and upstream to Lewiston Dam on the Trinity River (Figure D-1). Freshwater EFH includes the water quality and quantity necessary for successful spawning, fry, and parr habitat for Soho Salmon and Chinook Salmon. Estuarine and marine EFH contains habitat elements for juvenile, smolt, and adult life histories. It covers an extensive area that varies seasonally and interannually.



Appendix Figure D-1. The Klamath River Basin, including the action area for Reclamation’s modified Proposed Action. EFH, for Chinook and Coho Salmon, includes all waterways accessible to anadromous fish.

The objective of this EFH assessment is to determine whether the operations of Reclamation's Project under the Proposed Action may adversely affect designated EFH for Chinook and Coho Salmon. Adverse effect means any impact that reduces quality and/or quantity of EFH. Adverse effects may include 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 and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR § 600.810).

The EFH determinations for Chinook and Coho Salmon within the action area will include the mainstem Klamath River from the former IGD site (river mile [RM] 190) to the Klamath River mouth and all accessible tributaries (excluding the Trinity River to Lewiston Dam).

Chinook and Coho Salmon Habitat Requirements for EFH

The diversity of freshwater, estuarine, and marine habitats utilized by Chinook and Coho Salmon is complex. Therefore, it is difficult to specify all stream reaches, wetlands, and water bodies essential for the species survival. Given the importance of tributaries for spawning, rearing, and habitat needs, evaluating specific reaches of a tributary, not the entire tributary, may exclude important tributaries or tributary reaches from designation as EFH. The low densities of juvenile salmonids and lack of thorough understanding of the species' current and historical freshwater distribution and habitat requirements in the Klamath River Basin make defining specific river reaches complicated. Adopting a watershed-based approach to EFH is appropriate, because it

- recognizes the species' use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas;
- takes into account the natural variability in habitat quality and use (e.g., some streams may have fish present only in years with plentiful rainfall) that makes precise mapping difficult; and
- reinforces the important linkage between aquatic areas and adjacent upslope areas.

A detailed discussion of Coho Salmon life cycle and habitat requirements can be found in Section 6.1 and Appendix B of the 2024 BA. A detailed discussion of Chinook Salmon life cycle and habitat requirements can be found in Section 7.2.1.1 of the 2024 BA.

Chinook and Coho Salmon EFH Requirements

Chinook and Coho Salmon EFH for freshwater habitats consists of four major components: 1) spawning and incubation; 2) juvenile rearing; 3) juvenile migration corridors; and 4) adult migration corridors and holding habitat. The freshwater EFH for both species depends on lateral (e.g., floodplain, riparian), vertical (e.g., hyporheic), and longitudinal connectivity to create habitat conditions for spawning, rearing, and migration. These habitat conditions include the following:

- Water quality (e.g., dissolved oxygen [DO], nutrients, temperature)
- Water quantity, depth, and velocity
- Riparian-stream-marine energy exchanges
- Channel gradient and stability
- Prey availability
- Cover and habitat complexity (e.g., large woody debris and aquatic and terrestrial vegetation)
- Space
- Habitat connectivity from headwaters to the ocean (e.g., dispersal corridors, floodplain connectivity)
- Groundwater-stream interactions
- Substrate composition

The Chinook and Coho Salmon EFH for estuarine and marine habitats are estuarine rearing, ocean rearing, and juvenile and adult migration. Chinook and Coho Salmon share most of the critical features of these habitats including good water quality, cool water temperatures, abundant prey species and forage base (food), and adequate depth, cover, and marine vegetation in estuarine and nearshore habitats. Coho Salmon critical features also include connectivity with terrestrial ecosystems. Overall, Chinook and Coho Salmon marine distributions are extensive, vary seasonally and interannually, and can be identified in general terms only.

EFH Affected by the Project

The existing condition of freshwater EFH within the action area and variables that may influence Chinook or Coho Salmon habitats are flow (discharge, velocity, and depth), water temperature, and important habitat parameters. These variables and their relationship to EFH are discussed in detail below. The four major components of EFH and associated habitat conditions are covered by the following variables:

- Water Quality – water quality (nutrients, DO, temperature), prey availability, and riparian-stream-marine energy exchanges
- Flow Variables – water quality, water quantity, depth, and velocity, riparian-stream-marine energy exchanges, channel gradient and stability, cover and habitat complexity, habitat connectivity, groundwater-stream interactions, and substrate composition
- Habitat Parameters – channel gradient and stability; prey availability; cover and habitat complexity; and substrate composition

Water Temperature

Water temperatures in the Klamath Basin vary seasonally and by location. Downstream from the former IGD site, water released from Iron Gate Reservoir was 2.5°C (range 1 to 4.5°C) cooler in the spring but was 2 to 10°C (range 3.6 to 18°C) warmer in the summer and fall, as compared with modeled conditions without the hydroelectric dams (PacifiCorp, 2004; Dunsmoor and Huntington, 2006; NCRWQCB, 2010; Risley et al., 2012). Immediately downstream from the former IGD site (RM 190.1) water temperatures are also less variable than those documented farther downstream in the Klamath River (Karuk Tribe of California, 2009, 2010). While these conditions may be expected to change following dam removal, the exact magnitude and direction of that change is currently unknown. It is reasonable to assume Keno Dam may continue to have thermal effects similar to those seen downstream of IGD prior to its removal.

Downstream of the Shasta River, water temperatures are more influenced by solar energy, the natural heating and cooling regime of ambient air temperatures, and tributary inputs of surface water. Meteorological control of water temperatures resulted in increasing temperature with distance downstream from IGD. For example, daily average water temperatures between June and September were approximately 1 to 4°C higher near Seiad Valley (RM 129) than temperatures just downstream from the IGD (Karuk Tribe of California, 2009, 2010).

Downstream from the Salmon River (Klamath RM 66), summer water temperatures decrease slightly with distance as coastal meteorology (i.e., fog and lower air temperatures) reduces longitudinal warming (Scheiff and Zedonis, 2011) and cool-water tributary inputs increase the overall flow volume in the river. However, the slight decrease in water temperatures in this reach is generally not sufficient to support cold-water fish habitat during summer months. Daily maximum summer water temperatures have been measured at values greater than 26°C just upstream from the confluence with the Trinity River (Weitchpec at RM 43.5), decreasing to 24.5°C near Turwar Creek (RM 5.8; Yurok Tribe Environmental Program, 2005).

Juvenile salmonids cope with high mainstem Klamath River temperatures by moving to pockets of thermal refugia such as confluences of cold-water tributaries, off-channel habitats, and beaver ponds. The mainstem Klamath River regularly exceeds 24 °C during the summer (NRC, 2004), which can limit juvenile rearing due to these temperatures being above thermal stress tolerances. Moyle (2002) found upper thermal limits for juvenile Chinook Salmon of 22 to 23°C, a point at which extensive mortality occurs. Sutton and Soto (2012) found that when water temperatures in the mainstem Klamath River approach approximately 19°C, juvenile Coho Salmon begin to use thermal refugia. These authors also noted that use of refugia declined as water temperatures exceeded 22 to 23°C, an indicator of unsuitable habitats. Thermal refugia are spatially and temporally variable with many factors impacting the size, shape, and function of the refugia habitat (Deas et al., 2006). In the mainstem Klamath River, changes in flow at the former IGD site, meteorological conditions, and tributary contributions influence both the amount and extent of available refugia (Deas et al., 2006). Although the mainstem Klamath River offers only limited and patchy rearing habitats during the summer due to higher water temperatures, it provides a corridor for redistribution to refugia in tributaries. As tributary conditions continue to improve from previously completed restoration programs, thermal refugia in the mainstem Klamath River could provide more habitat.

Flow Variables (Discharge, Water Velocity, and Water Depth)

Chinook and Coho Salmon require spawning sites within the stream or river where water velocity, depth, and gravel size are optimal for the incubation of developing eggs (gravel sizes are discussed in Section 6.1.2.3 of the 2024 BA). Successful incubation requires stable flow rates that are adequate to supply the required level of DO but not high enough to cause gravel movement and streambed scour that could expose eggs to predators or wash them downstream.

Areas with uniform water velocity are often preferred and fine sediments are avoided because the incubating eggs require a steady supply of cool (4 to 14°C), oxygenated water, and fine sediments restrict hyporheic flow (i.e., suffocate eggs). Velocity is also important in redd construction because the water carries dislodged substrate materials from the nesting site (Reiser and Bjornn, 1979). Spawning/redd water depths were greater than or equal to 18 cm with velocities ranging from 0.30 to 0.91 meters per second (m/s) for Chinook and Coho Salmon (Thompson, 1972). Chinook Salmon prefer redd sites with subsurface flow that are 25 to 100 cm deep with velocities ranging from 0.3 to 0.8 m/s (Moyle, 2002). However, Coho Salmon optimal spawning grounds are sites that are groundwater influenced with depths ranging from 10.2 to 20.1 cm (Bjornn and Reiser, 1991), and velocities of 0.3 to 0.5 m/s (CDFG, 2004). These differences could be related to differences in spawning locations. Chinook Salmon primarily spawn in mainstem rivers (NMFS 2021), while Coho Salmon primarily are tributary spawners (Sandercock, 1991; Moyle, 2002).

Water depth and associated velocities are critical for growth and survival and vary by life history stages of Chinook and Coho salmon. Thompson (1972) indicated that adult Pacific Northwest Chinook Salmon require a minimum depth of 0.24 m with velocities less than 2.44 m/sec for migration, while Coho Salmon require a minimum depth of 0.18 m, with velocities less than 2.44 m/s for migration (CDFG, 2004). Water depth criteria for salmon in spawning areas are estimated to be 24 to 30 cm for Chinook Salmon, and approximately 18 cm for Coho Salmon (Bjornn and Reiser, 1991). Juvenile Chinook Salmon use depths up to 3 m when water velocities are not limiting and avoid depths less than 6.0 cm during their free-swimming stage. Chinook Salmon juveniles are associated with low velocities 0.3 to 6.0 m/s, depending on fish size, and are typically found in pools along the margins of riffles or current eddies. Juvenile Coho Salmon use habitat with shallower water depths ranging from 0.06 to 0.88 m, favoring depths between 0.21 to 0.4 m (Hardy et al., 2006). Coho Salmon fry also prefer slower velocities, favoring velocities between 0.1 to 0.5 m/s (Hardy et al., 2006). Juvenile Coho Salmon remain closely associated with slow velocity, low-gradient habitats (Lestelle, 2007; Quinn, 2005) for feeding, cover, and predator avoidance. Excessive velocities and shallow water may impede migrating adult fish or re-distribution of juvenile fish for both species.

The magnitude of flow events (discharge) and their recurrence interval, timing, and duration contributes to the complexity of channel form, instream habitat (depth and velocity), and substrate composition, which impacts salmon disease such as the myxozoan parasite, *Certanova* *shasta*. Altered flow regimes due to dam construction and/or irrigation withdrawals will affect physical and ecological responses of a river (Rathburn et al., 2009, *in* Som et al. 2016), leading to changes in aquatic fauna and myxozoan life cycles. Fine sediment accumulation on the channel bed and margins are of concern because high densities of the polychaete invertebrate host for *C. shasta* (*Manayunkia speciosa*) have been observed in these habitats in the Klamath River (Conor et al., 2016). Suitable polychaete habitat (e.g., weighted usable area [WUA]) deceases with increasing flows (Som et al., 2016a), and evidence suggests that the prevalence of *C. shasta* infection in polychaetes is negatively correlated with the peak flow regime (Som et al., 2016b). Increases in flow (discharge) may also reduce spore concentrations (myxospores and actinospores); however, additional studies are required to determine effectiveness at reducing *C. shasta* infection rates (Som and Hetrick, 2016).

High water or flushing flows increase water velocities and decrease substrate stability, dislodging the polychaetes, which could directly influence the distribution of polychaetes by restricting habitat use to stable substrates (Malakauskas et al., 2013, *in* Som et al., 2016). Alexander et al. (2016) found that increasing peak discharge is associated with decreases in predicted WUA for polychaetes. Infected polychaetes were more associated with deeper and lower-velocity depositional habitats (Shea et al. 2016), and these habitat conditions can be attributed to alterations in the natural flow regime (e.g., reduced frequency of flushing flows). These disease prevalence and flow altering factors contributed to Hillemeier et al. (2017) recommending sediment flushing and/or geomorphic flows to control infected polychaete populations and promote a more functional hydrologic and geomorphic regime in the Klamath River. Restoring the variability of the flow regime will also enable the sediment mobilization that is required to maintain spawning areas and gravels.

Habitat Parameters

River discharge influences the channel’s planform, cross-sectional area, and riparian attributes, as well as sediment transport and substrate composition (Leopold, 1994). Changing a river’s natural flow regime (via magnitude, frequency, duration, timing, and/or sequencing of both high and low flow events) can alter sediment transport and change substrate composition, all of which affects aquatic species (Poff et al., 1997). On the Klamath River, natural flow regimes have been altered by water storage, power-generating dams, and extensive irrigation water withdrawals. The altered flows have limited sediment mobilization as well as channel maintenance flows, which can enable sediment accumulation, alter invertebrate composition and densities, and impact spawning gravels (Shea et al., 2016).

Chinook and Coho Salmon have different life histories regarding spawning locations but similar redd and substrate habitat requirements. In the Klamath River Basin, Chinook Salmon primarily spawn in the mainstem Klamath River and large tributaries such as the Trinity, Salmon, Scott and Shasta rivers (NMFS 2021). Coho Salmon primarily spawn in tributaries (Sandercock, 1991; Moyle, 2002) with some overlap for both species. Most of the Coho Salmon mainstem spawning in the Klamath River occurs within 12 river miles of the former IGD site (Magneson and Gough, 2006), and it is speculated that these fish could have originated from Iron Gate Hatchery (NMFS, 2010). Chinook and Coho Salmon redds are predominantly constructed in areas with subsurface flow, with loose gravel and/or cobble substrates that are small enough to be moved by the fish and large enough to allow good intra-gravel water flow to the incubating eggs and developing alevins. Chinook Salmon redds tend to be in areas of coarser gravel and are often characterized by having a few large cobbles in the bottom of the nest. Since Chinook Salmon eggs are the largest of all the Pacific Salmon and therefore have a small surface-to-volume ratio, adequate subgravel flow is vital to egg survival. Spawning areas with slightly larger gravel size and low rates of sedimentation consistently generate higher survival rates; however, in cases where large amounts of silt build up in spawning beds, survival rates for both species are greatly reduced.

Adult Chinook and Coho Salmon substrate requirements and sediment interactions are dynamic, variable, and interact with river flow; a brief discussion is included here (for detailed descriptions refer to Reclamation [2011]). Chinook Salmon require about 13.4 to 20.1 square meters (m^2) gravel per spawning pair, and Coho Salmon require 11.7 m^2 (Bjornn and Reiser, 1991), but other studies have found greater variabilities in the area required for pairs of spawning Chinook (2.0 to 44.8 m^2) (numerous authors *in* CDWR, 2003) and Coho Salmon (up to 38.4 m^2) for redd and inter-redd space (CDFG, 2004). Individual redds encompass 3.3 to 10.0 m^2 for Chinook and 2.8 m^2 for Coho Salmon (Chinook: Neilson and Banford, 1983; Burner, 1951; Reiser and White, 1981 *all in* Bjornn and Reiser 1991) (Coho: Burner, 1951, *in* Bjornn and Reiser, 1991). However, Hassel (CDFG, 2004) found that Coho Salmon redds could vary from 1.7 to 5.2 m^2. Thompson (1972) found that Chinook and Coho Salmon spawn in substrates sized 13 to 102 millimeters (mm) (Medium Gravel – Medium Cobble; Wentworth Size Classes for Wolman Pebble Counts: Wolman, 1954; Bevenger and King, 1995). Chinook Salmon have been recorded spawning in substrates ranging from 30 to 150 mm (Raleigh et al., 1986, *in* CDWR, 2003); however, a review of several studies found Coho Salmon preferences ranged from 13 to 152 mm (CDFG, 2004). While most Coho Salmon redds (approximately 85%) were found in areas with substrate 150 mm or smaller (CDFG, 2004), Coho Salmon preferred substrates 75 to 150 mm in diameter in the Trinity River (CDFG 2004). Suitable substrate for Chinook Salmon embryos is a gravel/cobble mixture with a mean diameter of 25.4 to 101.6 mm and a composition including less than 5% fines (particles less than 7.6 mm) (CDWR et al., 2000, *in* CDWR, 2003). The differences in redd and substrate sizes may be attributable to the species' spawning locations.

Based on a review of the scientific literature, the following are the most commonly observed effects of suspended sediment on fish:

- Avoidance of turbid waters in homing adult anadromous salmonids
- Avoidance or alarm reactions by juvenile salmonids
- Displacement of juvenile salmonids
- Reduced feeding and growth
- Physiological stress and respiratory impairment
- Damage to gills
- Reduced tolerance to disease and toxicants

- Reduced survival
- Direct mortality

Information on both concentration and duration of suspended sediment is necessary for understanding the potential severity of its effects on salmonids (Reclamation, 2011).

Effects of Modified Proposed Action on Chinook Salmon and Coho Salmon EFH

Flow variability is important for providing EFH for salmonids. The Proposed Action accumulates a flow volume over the winter months into a Flex Flow account. During spring or summer, this account may be used for flushing flows, flow augmentation, or other purposes deemed necessary for fish health. The volume that accumulates in the Flex Flow account may vary year-to-year depending on hydrologic conditions.

Proposed Action

The Action Area and Proposed Action (Sections 3.2 and 3, respectively, of the 2024 BA), are described in detail in the main body of the BA above. The Proposed Action is Reclamation's continued operation of the Project. Reclamation's Proposed Action consists of three major elements to meet authorized Project purposes, satisfy contractual obligations, and address protections for listed species and certainty for Project irrigators. The period covered by this BA is 5 years, from 2024 to 2029.

The Proposed Action contains three elements that pertain to EFH:

1. Store waters of the Upper Klamath Basin and Lost River (Section 3.3.1 of the 2024 BA).
2. Operate the Project, or direct the operation of Project facilities, for the delivery of water for irrigation purposes subject to water availability, while maintaining conditions in Upper Klamath Lake (UKL) and the Klamath River that meet the legal requirements under Section 7 of the Endangered Species Act (Section 3.3.2 of the 2024 BA).
3. Perform operation and maintenance activities necessary to maintain Project facilities (Section 3.3.3 of the 2024 BA).

Water Quality Effects to EFH

The Proposed Action may affect Chinook and Coho Salmon EFH through water quality parameters, including nutrients, DO, and temperature. Water quality parameters and their effects on adult salmon are described in Section 6.3.1.1, Section 6.3.1.3, Section 6.3.1.4, and Section 6.3.1.5 of the 2024 BA. These sections contain the main analyses and results for water quality parameters in general. Subsequent life stage specific sections (e.g., Sections 6.3.2.1 and

6.3.3.1 of the 2024 BA) may refer to these analyses and discuss them in reference to a specific life stage.

Nutrient Loading

The contribution of nutrients from the Project relative to the Proposed Action is described in Section 6.3.1.4 of the 2024 BA. UKL is considered the source of greatest nutrient and biological oxygen demand (BOD) loads during the summer months (ODEQ, 2017; Schenk et al., 2018) and the Project may act as a nutrient sink, reducing nutrient load from UKL, but any negative effect of these loads on water quality parameters is shrouded by algal biomass from UKL and the reservoirs, dams, and meteorological and hydrologic conditions downstream of the Project.

Dissolved Oxygen

DO concentrations in the Klamath River downstream of the former IGD site are not a concern in the late fall, winter, and early spring given relatively cold-water temperatures and increased discharge due to changing weather conditions and increased precipitation. Klamath River DO concentrations are inversely correlated with water temperature during the summer season (Asarian and Kann, 2013) and can be affected by periphyton dynamics (Asarian et al., 2015). Fluctuations in discharge below Keno affects DO concentrations and is influenced by Project operations. In June through September, the Proposed Action results in an average increase in daily Klamath River discharge at Keno Dam relative to the maximum storage (MS) scenario (Figure 4-3 of 2024 BA). These increased flows should improve DO concentrations in the Klamath River.

Temperature

Klamath River water temperatures are largely correlated with air temperature but may also be affected by discharge (see Water Temperature section above). Water temperatures in the fall and winter are not a concern to salmonids and no additional effects are anticipated from the Proposed Action on Klamath River during these seasons. However, Asarian and Kann (2013) found statistically significant negative relationships between mean monthly flow and mean water temperature for June and July (2001 to 2011) in lower Klamath River reaches (Orleans, Weitchpec, Tully Creek, and Turwar) but not in the upper reaches. Historically, there were no significant relationships between flow and water temperature at the sites most affected by IGD releases (i.e., immediately below IGD and in Seiad Valley), suggesting that IGD flow releases influence water temperature less than factors affecting flow below Seiad Valley, such as tributary inflow. With the removal of IGD, this pattern may reasonably be expected to continue below Keno Dam. The Proposed Action, through the use of the Flex Flow account, provides the opportunity for augmented flows in spring and summer, which could decrease water temperatures, especially in the lower reaches.

As described in Section 6.3.1.5 of the 2024 BA, Reclamation analyzed RBM10 output from March to October for 1991 to 2021 (Figures 6-11 to 6-13 of the 2024 BA). These analyses suggest an overall decrease in water temperatures in most years due to implementation of the Proposed Action. However, in some sites and years temperature increases. The greatest increases in water temperatures were ~0.6°C and occurred during October 1994 (RM62.5 just below the confluence with the Salmon River, Table 6-13), but increases are also predicted for other flow years, months, and sites, most of which were ≤ 0.5°C. Consequently, implementation of the Proposed Action will reduce overall water temperatures but may increase average monthly water temperatures in a few years (for about a month) in the Klamath River below the confluence of the Shasta River.

Flow Effects to EFH

Flow Variables

The flow variables include discharge, water velocity, and depth, all of which are interrelated. Discharge was assessed using subsistence flow, base flow, high-flow pulses, overbank flow, and flow variability (Table D-1) and these flows are defined below. The effects of altering discharge are apparent in sediment mobilization, maintenance of channel form, riparian health, and disease (*M. speciosa* and *C. shasta*). Water velocity and depth are part of the WUA analyses (see Habitat Parameters (WUA) Effects to EFH section below). For Coho Salmon, the graphs and tables are displayed in Section 6.5.3 of the 2024 BA (Figures 6-11 and 6-12 and Tables 6-15 to 6-18), and for Chinook Salmon, the graphs and tables are displayed in Section 7.2.1.2 of the 2024 BA (Figures 7-12 and 7-13 and Table 7-2).

Previous studies have examined flow requirements for salmon habitat in the Klamath River. Many of these studies included the effects that the hydropower dams had on recruitment and mobilization of river substrate. There is a need to update studies post-dam removal, which may affect the flow analyses cited below.

Subsistence flow was set at 1,000 cfs to provide sufficient flow to maintain connectivity to tributaries for re-distributing juvenile Coho Salmon (NMFS and USFWS, 2013), which is separate from base flows. Approximately 30.8% of the daily average flows are below 1,000 cfs, and implementation of the Proposed Action will result in an increase in the frequency and decrease in magnitude of daily average flows below 1,000 cfs when compared to the Period of Record (POR) (Table D-1), which will adversely affect EFH for both species. Base flows (1,000 cfs to 6,000 cfs) accounted for 66.8% of Proposed Action flows during the POR and implementation of the Proposed Action would decrease the frequency but increase the magnitude of these flows. These flows will be most critical for temperature, DO, nutrient, and periphyton affects and may adversely affect EFH for both species.

High-flow pulses (6,000 cfs to 12,000 cfs) are needed to maintain channel form, transport sediments (including spawning gravels), and rejuvenate riparian health. Fewer high-flow pulses may stabilize gravel bars, promote thick riparian vegetation at the river edges, and cause alluvial barriers to seasonally form at the mouth’s mainstem tributaries (NMFS, 2012). High-pulse flows accounted for 2.4% of flows under the Proposed Action, and implementation of the Proposed Action increased both the frequency and magnitude of these flows (Table D-1). These high-pulse flows may beneficially affect EFH for both species.

Overbank flows, or geomorphically effective flows, are defined by this BA as flows greater than 12,000 cfs, even though other studies set this level higher, for example at 13,000 cfs (Hardy et al.,

2006) and 15,000 cfs (Shea et al., 2016). These flows are needed to maintain channel form and reduce riparian encroachment. Implementation of the Proposed Action would result in infrequent occurrences of overbank flows (Table D-1). However, overbank flows would occur with greater frequency and magnitude under the Proposed Action than they have previously over the POR. Shea et al. (2016) analyzed the flood frequency analysis for Klamath River below IGD and found that at a 10-year return period the discharge should be 15,610 cfs. Under the Proposed Action, there are no 3-day periods with flows exceeding 15,610 cfs. However, there are 2 years with flows greater than 12,000 cfs (1996, and 1997; n=6 days and 0.05% of flows), but only one of those periods lasts for at least 3 days (Table D-1). These overbank flows may beneficially affect EFH for both species.

The Proposed Action provides flow variability during precipitation and snowmelt events in the mainstem Klamath River that is reflective of actual hydrologic conditions above UKL and in the tributaries of the reservoir reach. Without a forced flushing flow every year, there may be opportunities to redistribute flow from large discharge events later into the spring months. Also, despite not including managed flushing flows as it did under the Services' 2019 BiOp, the Proposed Action includes natural flushing flows and the flexibility to deviate from the formulaic approach. This would allow for flexible flow accounting that can address disease (see Disease section below) as well as other potential factors (see Habitat Parameters (WUA) Effects to EFH section below). These flow measures may beneficially affect salmon EFH including juvenile summer and winter rearing habitat as well as juvenile and adult migration corridors in the mainstem Klamath River.

Disease

The altered hydrology will lead to changes in the river's channel form or fluvial processes over time, which can influence the life cycle of *M. speciosa*. High velocities can disrupt the parasite's life cycle by disrupting and constraining suitable polychaete habitat and thereby limiting effective parasite transmission (Bjork and Bartholomew, 2009; Malakauskas et al., 2013; Alexander et al., 2016). Decreases in *M. speciosa* density can lead to diminished *C. shasta* actinospore production and decreased disease incidence in salmonids (Hillemeier et al., 2017; Reclamation, 2018).

The Proposed Action seldom results in annelid-disrupting flows in excess of 6,000 cfs at the former IGD site. Under the Proposed Action, annelid-disrupting flows do not occur until approximately the 10% exceedance level (Figure 6-6, Table 6-14). While annelid-disrupting flows may occur above the 10% exceedance level, this is unlikely to regularly result in appreciable disruption of annelids under the Proposed Action. However, the magnitude of peak flows during spring and summer are higher under the Proposed Action compared to the MS scenario (Figure 6-10). Therefore, the Proposed Action may reduce disease severity as a result of these higher magnitude flow events in the spring. However, the differences are so slight and so rarely reach the level of an annelid-disrupting event that it seems unlikely that there would be any appreciable effect. Annelid-disrupting flows would likely only be reached during wet years (i.e., 1997; Figure 6-10 of the 2024 BA) and even then, rarely. Given the limited data available on flow effects on parasites, spore concentrations, and infection rates for flows between 2,500 and 5,000 cfs, it is unclear how elevated flows under the Proposed Action would affect disease conditions.

Manipulating flows may be effective at reducing *M. speciosa* distribution (Bartholomew et al., 2018). However, reducing *M. speciosa* densities and/or preferred habitat in the Klamath River requires additional research and modeling (Bartholomew et al., 2018). IGD flows between 8,700 and 11,250 cfs were critical in removing fine sediment deposited within the armored layer of the riverbed (i.e., large boulders, bedrock), which is something that cannot be accomplished with surface-flushing flows alone (Shea et al., 2016). Reclamation's deep flushing flows (11,250 cfs for 24 hours) would occur in 2 years (1996 and 1997) of the 31-year modeled POR, which is less than the approximately 5-year recurrence interval for this discharge below the former IGD site (Shea et al., 2016). Water availability will determine the timing and frequency Reclamation is able to implement a deep flushing flow; as such, Reclamation is unable to "guarantee" a managed deep flushing flow but will attempt to do so as hydrologic conditions and public safety allow. If implemented, deep flushing flows could reduce *M. speciosa* distribution, densities, and habitat, which would benefit Chinook and Coho Salmon EFH.

Habitat Parameters (WUA) Effects to EFH

The Proposed Action is expected to reduce discharge below Keno in spring and produce roughly equivalent discharge throughout the rest of the year, relative to recent operations. The effects of reduced flows on habitat availability for Chinook and Coho Salmon fry and parr depends on the flow volume and habitat area at each site. Coho Salmon habitat models are discussed in Section 6.5.2 of the 2024 BA. Coho salmon habitat area model results including WUA habitat curves (Figure 6-11), 80% exceedance results (Figure 6-12, Table 6-15), and exceedance tables (Tables 6-16 to 6-18) were included in Section 6.5.3 of the 2024 BA. Chinook Salmon habitat models are discussed in Section 7.2.1.2 of the 2024 BA. Chinook Salmon habitat area model results including WUA comparisons (Figure 7-12), and 80% exceedance results (Figure 7-13, Table 7-2) were included in Section 7.2.1.2 of the 2024 BA.

Keno flow releases are not the only driver of Coho Salmon habitat availability due to flow accretions and habitat/flow relationships. Flow accretions, as affected by meteorological and hydrologic conditions as well as the trans-basin diversions on some of the tributaries, play a major role. Consequently, Reclamation cannot feasibly optimize flows at Keno to maximize WUA without considering the influence of tributary inputs. The relationship between flow and habitat area is nonlinear as suitable Chinook and Coho Salmon habitat includes variables such as velocity and depth preferences of fish. There are times and locations where greater flow releases at Keno may increase suitable habitat area, but other instances where less water released from Keno increases suitable habitat area. Consequently, there is no single Keno release that maximizes average percent maximum WUA for Chinook or Coho Salmon fry or parr across all stream reaches.

Habitat (WUA) – Coho Salmon

Coho Salmon juveniles during the spring months (March through June) will see a reduction of habitat at a variety of flows for specific stream reaches (Figure 6-11 of the 2024 BA):

- Trees of Heaven flows roughly less than 1,200 cfs or greater than 6,500 cfs
- Beaver Creek flows roughly less than 4,000 cfs
- Community Center flows roughly less than 1,200 cfs

Under the Proposed Action, the Trees of Heaven and Klamath Community Center reached 80% of the maximum WUA on 90% and 81% of days, respectively, over the period of record (Figure 6-12; Table 6-15). Beaver Creek was the most impacted under the Proposed Action, reaching the 80% threshold on only 10% of days over the POR. Also, the three sites responded very differently to the Proposed Action across a broad range of exceedance values (Table 6-16 through Table 6-18). Trees of Heaven and Klamath Community Center were relatively unaffected across a broad range of exceedances while the effects of the Proposed Action are predicted to occur most frequently and substantially at the Beaver Creek site.

The Proposed Action is expected to increase exceedance flows at all levels in April. Also, exceedance flows in July, August, and September are expected to increase (Tables 6-8 to 6-10), relative to the MS scenario, which may result in increased juvenile summer rearing habitat and migration corridors during critical low flow periods. However, the Proposed Action may adversely affect Coho Salmon EFH, as evidenced by substantial reductions at specific locations such as Beaver Creek.

Habitat (WUA) – Chinook Salmon

The Proposed Action generally has a higher or equal percent of maximum habitat (WUA) available than the MS scenario in winter and parts of spring and summer (see also Section 4.1.3.1 of the 2024 BA, Figure 4-10). All three reaches (i.e., the former IGD site to Shasta, Shasta to Scott, and Scott to Salmon) have substantial habitat (i.e., greater than or equal to 80% WUA threshold) available for all three life stages (spawner/egg, fry, and parr) over the modeled period of record (Table 7-2, Figure 7-13). Generally, the former IGD site to Shasta River reach has the highest proportion of day/habitats with greater than or equal to 80% WUA while Shasta River to Scott River have the least. The spawner/egg life stage has the highest proportion of day/habitats with greater than or equal to 80% WUA across all reaches while the parr life stage has the least. However, the proportion of habitat greater than or equal to 80% WUA is low for some life stages and reaches and therefore the Proposed Action is likely to adversely affect EFH for Chinook Salmon.

Determination of Effects on Chinook Salmon and Coho Salmon EFH

The Proposed Action includes opportunity for natural flushing flows and flow re-distribution for disease and habitat/substrate maintenance, protective ramping rates for transitions between flow regimes and slightly decreases summer water temperatures due to increased flows. The Proposed Action will provide an overall decrease in summer water temperatures during critical migration and rearing periods for Chinook and Coho Salmon. However, during some years there will be an increase in water temperatures up to 0.6°C for short periods of time, and some months may experience reduced flow. The Proposed Action also includes minimum flows in the Klamath River that should ensure adequate passage into tributary habitats where restoration projects have occurred under previous consultations and where restoration projects authorized under previous consultations will continue to occur. Adequate flows to allow fish to access current and ongoing restored habitat will mitigate some of the adverse effects of the Proposed Action.

Reclamation's analysis included both a qualitative and quantitative assessment of Project effects, which resulted in a determination that implementation of the Proposed Action is expected to result in both beneficial and adverse effects to Chinook and Coho Salmon EFH (Table D-2). With respect to adverse effects, the minimum flow component of the Proposed Action described in the 2024 BA is considered useful to minimize adverse effects on the water quality, cover, access and passage, disease, and habitat connectivity components of Chinook and Coho Salmon EFH. While adverse effects to habitat suitability components of EFH will remain, Reclamation believes the adverse effects have been sufficiently reduced due to the net effect of both negative and positive impacts of the Proposed Action paired with mitigating factors such as the flow components.

Appendix Table D-1. Summary of the Iron Gate Dam historical (actual) average daily flows during the Period of Record (WY 1991 to 2022), and for the modeled average daily flows with the implementation of the modified Proposed Action when applied to the same period.

Flows	Criteria	Modeled Proposed Action	Period of Record	Difference
Daily Flows (Total Daily Flows)	Count	11,749	11,749	0
Daily Flows (Total Daily Flows)	Average Daily Flow (cfs)	1,613	1,604	9
Below Subsistence Flows (Flows < 1,000 cfs)	Count	3,615	1,255	2,360
Below Subsistence Flows (Flows < 1,000 cfs)	Percent of Total Count	30.8%	10.7%	20.1%
Below Subsistence Flows (Flows < 1,000 cfs)	Average Daily Flow (cfs)	860	958	-98
Base Flows (Flows ≥ 1,000 cfs but < 6,000 cfs)	Count	7,848	10,421	-2,573
Base Flows (Flows ≥ 1,000 cfs but < 6,000 cfs)	Percent of Total Count	66.8%	88.7%	-21.9%
Base Flows (Flows ≥ 1,000 cfs but < 6,000 cfs)	Average Daily Flow (cfs)	1,733	1,640	92
High-Flow Pulses (≥ 6,000 cfs but < 12,000 cfs)	Count	280	72	208
High-Flow Pulses (≥ 6,000 cfs but < 12,000 cfs)	Percent of Total Count	2.4%	0.6%	1.8%

Flows	Criteria	Modeled Proposed Action	Period of Record	Difference
High-Flow Pulses (≥ 6,000 cfs but < 12,000 cfs)	Average Daily Flow (cfs)	7,702	7,435	266
Overbank Flow (≥ 12,000 cfs)	Count	6	1	5
Overbank Flow (≥ 12,000 cfs)	Percent of Total Count	0.05%	0.01%	0.04%
Overbank Flow (≥ 12,000 cfs)	Average Daily Flow (cfs)	14,367	12,735	1,632

Appendix Table D-2. Summary of predicted effects of the modified Proposed Action on Chinook and Coho Salmon habitat conditions in the mainstem Klamath River.

EFH Feature	Chinook Salmon	Coho Salmon
Substrate Composition	The natural surface and opportunistic deep flushing flows may improve substrate composition by mobilizing fine sediments, which will disrupt (*M. speciosa*) habitats and could lead to decreased densities and reduced *C. shasta* infections. This effect, particularly from natural surface flows, is expected to be minor.	The natural surface and opportunistic deep flushing flows may improve substrate composition by mobilizing fine sediments, which will disrupt (*M. speciosa*) habitats and which could lead to decreased densities and reduced *C. shasta* infections. This effect, particularly from natural surface flows, is expected to be minor.
Water Quality	Water quality should improve for both temperature and DO. Cooler water temperatures are expected to provide the most benefit in the summer when water temperatures exceed optimum thresholds for salmon growth and survival.	Water quality should improve for both temperature and DO. Cooler water temperatures are expected to provide the most benefit in the summer when water temperatures exceed optimum thresholds for salmon growth and survival.
Habitat Suitability	Habitat suitability is expected to decrease for juvenile parr and fry during certain flow events.	Habitat suitability will decrease for parr and fry during certain flow events.
Channel Gradient and Stability	Channel stability will decrease slightly due to the reduced geomorphically effective flows to maintain channel form and riparian habitats as well as the reduction in overbank flows. This reduction may be due to over-stabilization of the streambanks from riparian vegetation encroachment.	Channel stability will decrease slightly due to the reduced geomorphically effective flows to maintain channel form and riparian habitats as well as the reduction in overbank flows. This reduction may be due to over-stabilization of the streambanks from riparian vegetation encroachment.
Access and Passage	Increased discharge and decreased water temperatures during summer are expected to improve adult Chinook Salmon migration and holding conditions.	Increased discharge and decreased water temperatures during summer are expected to improve adult Coho Salmon migration and holding conditions.

EFH Feature	Chinook Salmon	Coho Salmon
Floodplain Connectivity	Floodplain connectivity will decrease slightly due to the reduced geomorphically effective flows to maintain channel form and riparian habitats as well as the reduction in overbank flows.	Floodplain connectivity will decrease slightly due to the reduced geomorphically effective flows to maintain channel form and riparian habitats as well as the reduction in overbank flows.

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