Long-Term Operation – Biological Assessment

Appendix AB-O – Tributary Habitat Restoration

July 2024

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Appendix O Tributary Habitat Restoration

O.1 Introduction

Tributary habitat restoration appendix to the Public Draft Environmental Impact Statement (EIS) analyses addresses spawning and rearing habitat actions for the Sacramento River, American River, Stanislaus River, Clear Creek, and San Joaquin River. Project activities primarily include side channel and floodplain creation, expansion, and grading, spawning gravel and large cobble additions, and woody material additions.

Reclamation has authorities for habitat restoration, most specifically through the Central Valley Project Improvement Act (CVPIA), Public Law 102-575.

O.2 Initial Alternative Report

O.2.1 Management Questions

The United States Department of the Interior, Bureau of Reclamation's (Reclamation) management questions for the formulation of an alternative include the following.

- Where is habitat a primary factor influencing survival?
- Does habitat restoration increase primary and secondary productivity and improve growth?
- Does habitat restoration provide refuge habitat and improve survival?
- How does habitat restoration affect operations for flood conveyance, water supply, water quality, and/or hydropower?
- Where can connectivity be restored to provide fish access to suitable habitats and reduce potential habitat restoration needs downstream?

O.2.2 Initial Analyses

Reclamation solicited input for the knowledge base paper, *Tributary Habitat Restoration.*

Reclamation completed an exhaustive literature and data review to consider inclusion or exclusion of Sacramento–San Joaquin Delta (Delta) habitat restoration from consideration in alternatives.

O.2.3 Initial Findings

- Decision analyses suggest that tributary habitat-restoration actions, primarily focused on the addition of spawning or perennial rearing habitat in the mainstem Sacramento River and Clear Creek, can address habitat limitations and improve population productivity in these watersheds.

- Restoration of floodplain rearing habitat can result in increased prey resources and greater fish growth, compared to perennially inundated habitat, during periods of flooding. Restoration of perennially inundated habitat, including side-channel habitat, can provide similar prey abundances and fish growth rates to neighboring side channels and mainstem habitat and increase the total amount of suitable habitat available.
- Direct effects of tributary habitat restoration on rearing and migratory survival are poorly understood. However, high densities of fish in restored habitat sites suggest that restored habitat can provide quality rearing habitat for juvenile salmon and steelhead. Furthermore, increasing rearing habitat availability may decrease negative density-dependent effects on growth and outmigration timing.
- Habitat restoration projects that are designed to expand flood conveyance laterally and flood at lower-flow conditions can reduce the river flow required to inundate floodplains, maintain or increase flood conveyance, increase groundwater storage, and potentially increase settling of sediments and riparian vegetation recruitment.
- Expected effects of providing fish access to habitats upstream of existing barriers on reducing the need for downstream habitat restoration are unknown. Preliminary incubation and spawner translocation efforts have been conducted in Battle Creek and upstream of Shasta Reservoir. Temperature conditions for survival of eggs and alevins appear suitable above Shasta in the McCloud River but may be too high in Battle Creek.

O.2.4 Subsequent Consideration

O.3 Performance Metrics

Performance metrics describe criteria that can be measured, estimated, or calculated relevant to informing trade-offs for alternative management actions.

O.3.1 Habitat

- Suitable spawning habitat for salmonids and steelhead
- Suitable rearing habitat for salmonids and steelhead
- Suitable floodplain habitat for salmonids and steelhead

O.3.2 Biological

None.

O.3.3 Water Supply

Water supply metrics consider the possibility of multipurpose beneficial uses of tributary habitat restoration, including the following.

- South-of-Delta agricultural deliveries (average and critical/dry years)
- Sacramento river settlement contractor and CVPIA refuge deliveries
- *Bay-Delta Water Quality Control Plan* (Bay-Delta Plan) (D-1641) standards (State Water Resources Control Board 2000)

O.3.4 National Environmental Policy Act Resource Areas

Analysis of the rang**e** of alternatives**,** as required by the National Environmental Policy Act is anticipated to describe changes in multiple resource areas. Key resources are anticipated to include: surface water supply, water quality, air quality, aquatic resources, terrestrial biological resources, regional economics, land use and agricultural resources, recreation, cultural resources, hazards and hazardous material, and climate change.

O.4 Method Selection

In spring 2022, Reclamation solicited input for two knowledge base papers, Central Valley Tributary Habitat Restoration Effects on Salmonid Growth and Survival and Summer and Fall Habitat Management Actions on Delta Smelt Growth and Survival, included as attachments. Knowledge base papers compile potential datasets, literature, and models for analyzing potential effects from the operation of the Central Valley Project (CVP) and State Water Project (SWP) on species, water supply, and power generation.

O.4.1 Literature

O.4.1.1 History of Habitat Restoration Programs

History of Reclamation habitat restoration, description of CVPIA program, efforts, documents.

O.4.1.2 Habitat Restoration by Division

Table O-1 shows historical gravel inputs and percentage of target in tons on the Sacramento, Stanislaus, and American rivers between 1997 – 2022.

Table O-1. Historical gravel inputs and percentage of target in tons on the Sacramento, Stanislaus, and American rivers, 1997 – 2022

	Sacramento River (10,000 ton target)	% target	Stanislaus River (3,000 ton target)	% target	American River (7,000 ton target)	% target
1997	31,000	310%	2000	67%	-	0%
1998	23,000	230%	3000	100%	-	0%

	Sacramento River (10,000 ton target)	% target	Stanislaus River (3,000 ton target)	% target	American River (7,000 ton target)	% target
1999	25,000	250%	-	0%	6,000	86%
2000	32,000	320%	1,300	43%	-	0%
2001	0	0%	500	17%	-	0%
2002	15,000	150%	4,000	133%	-	0%
2003	8,800	88%	-	0%	-	0%
2004	8,500	85%	1,200	40%	-	0%
2005	7200	72%	2500	83%	-	0%
2006	6,000	60%	2,500	83%	-	0%
2007	6,000	60%	4,100	137%	0	0%
2008	8,300	83%	-	0%	7,000	100%
2009	9,900	99%	-	0%	10,600	151%
2010	5,500	55%	-	0%	16,000	229%
2011	5,000	50%	5000	167%	20,770	297%
2012	15,000	150%	3000	100%	24,510	350%
2013	14,000	140%	-	0%	6,000	86%
2014	0	0%	0	0%	10,000	143%
2015	0	0%	8,000	267%	0	0%
2016	32,000	320%	-	-	38,700	553%
2017	14,000	140%	-	-	-	-
2018	0	0%	0	-	0	-
2019	32,000	320%	-	-	22,000	314%
2020	2,000	20%	15,000	500%	-	-
2021	38,000	380%	8,000	267%	23,700	339%
2022	20,000	200%	-	-	-	-
TOTAL	**358,200**	**138%**	**60,100**	**95%**	**185,280**	**120%**

O.4.2 Stanislaus River

Table O-2. Historical gravel injection amounts (in tons and cubic yards) into the lower Stanislaus River

Year	Amount (Tons)	Amount (Cubic Yards)	Gravel Injection Location
1994	4605	3,070	-

Year	Amount (Tons)	Amount (Cubic Yards)	Gravel Injection Location
1995	0	0	-
1996	0	0	-
1997	19,772	13,181	Goodwin Cable Crossing area
1998	6,666	4,444	Goodwin Cable Crossing area
1999	13,000	7,647	18 riffles in lower Stanislaus River (Two-Mile Bar to city of Oakdale)
2000	2,148	1,432	Goodwin Cable Crossing area
2001	732	488	Goodwin Float Tube Pool - helicopter
2002	4,000	2,353	Goodwin Cable Crossing area
2003	0	0	-
2004	1,050	700	Goodwin Float Tube Pool - sluice
2005	2,500	1,471	-
2006	2,500	1,471	Goodwin Cable Crossing area
2007	17,118	11,412	Lover's Leap
2007	4,100	3,000	Goodwin Cable Crossing area
2008	0	0	Knights Ferry fire station
2009	0	0	-
2010	0	0	-
2011	5,000	2,941	Goodwin Cable Crossing area
2012	3,000	1,765	Goodwin Float Tube Pool - sluice
2012	13,600	8,000	Main channel and floodplain bench at Honolulu Bar
2013	0	0	-
2014	0	0	-
2015	7,059	4,706	Goodwin and cable crossing
2017	4,257	2,838	Buttonbush
2018	1,875	1,250	Rodden Road
2020	15,000	10,000	Goodwin Canyon (3000 tons in Float Tube Pool and 12000 tons at Cable Crossing)
TOTAL	112,982	82,169	-

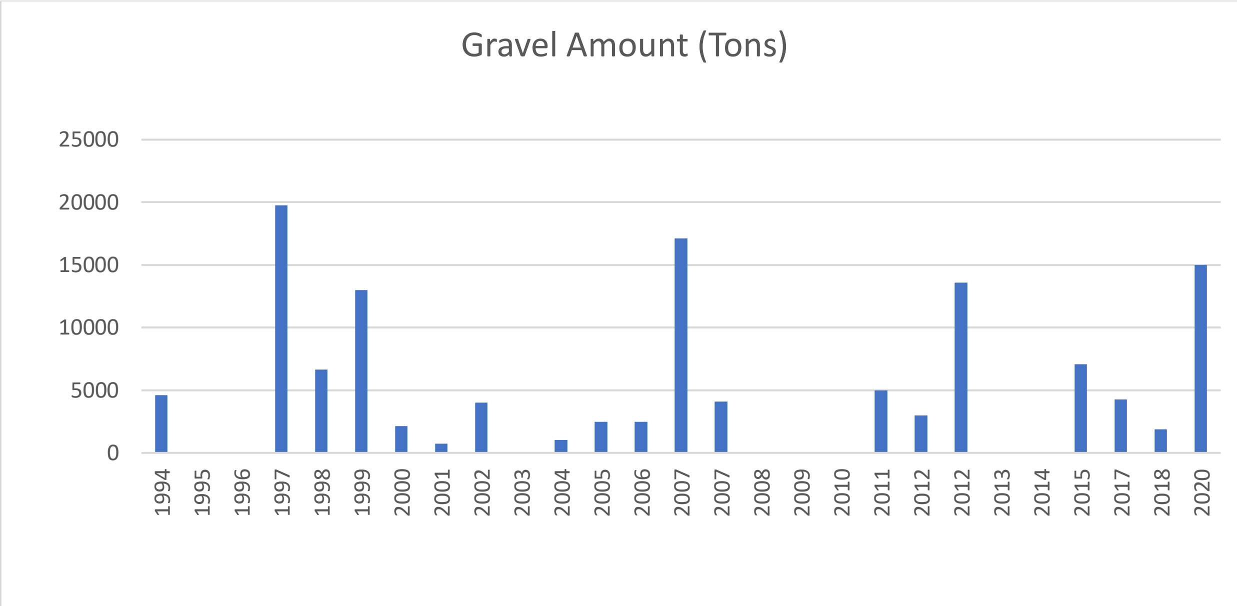


Figure O-1. Historical gravel amounts placed into the lower Stanislaus River (tons), 1994 – 2020

Figure O-1 shows historical gravel amounts placed into the lower Stanislaus River from 1994 to 2020 by ton.

O.4.3 Clear Creek

[PLACEHOLDERS:

- Historical gravel inputs
- Historical rearing habitat projects/acreage
- Pre/ post- project monitoring information]

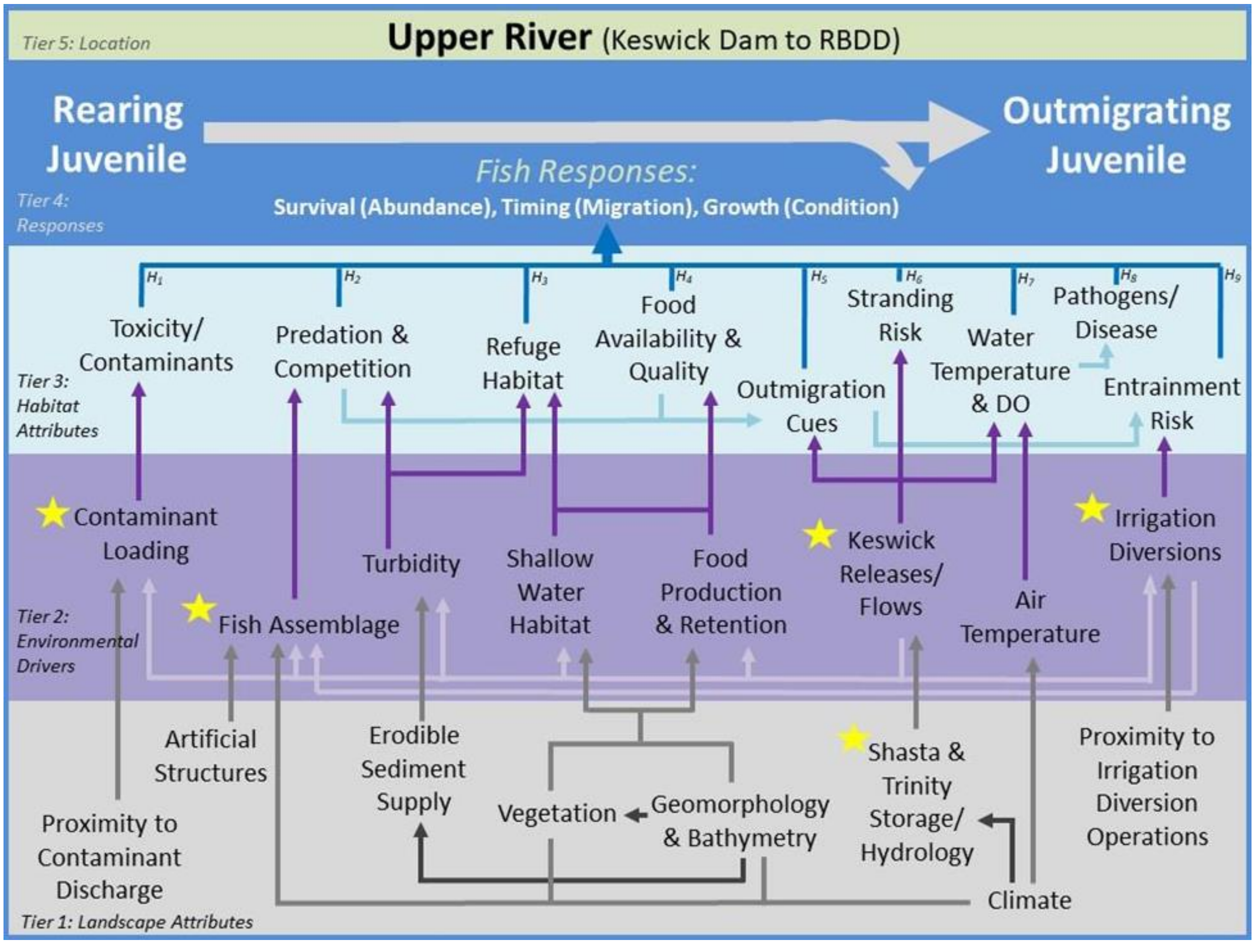
O.4.4 Sacramento River

Upper Sacramento River Anadromous Fish Habitat Restoration Program restoration and monitoring dataset has been used to evaluate the growth, survival, and life-history diversity of juvenile Chinook salmon and steelhead.

- Annual reports – summary of information on what information is in these reports. Fish counts by size comparing suitable and unsuitable habitats.
- There is spawning data but most gravel in placed in one location and the river moves it. Description of suitable habitat.
- Limited pre- project monitoring.
- Monitoring datasets can be found at the Red Bluff Fish and Wildlife Office, U.S. Fish and Wildlife Service website (doi.net).

O.4.4.1 Chinook Salmon and Steelhead

Tributary habitat restoration can affect the growth, survival, and life-history diversity of Central Valley (CV) Chinook salmon. Examples of tributary habitat restoration in the Sacramento River and San Joaquin River basins include creation of new habitat through excavation (e.g., creation of new side channels in the Sacramento River), adding more substrate to existing habitat (e.g., gravel augmentation), and increasing the frequency of floodplain inundation through hydrologic alterations (Bay-Delta Office, U.S. Bureau of Reclamation 2021). Figure O-2 (below) provides a conceptual model for effects of habitat conditions on fish responses during the transition from rearing to outmigrating in upper river systems. Tributary habitat restoration is expected to influence aspects of habitat conditions, including turbidity, shallow-water habitat, and food production and retention.



Source: Windell et al. 2017.

Figure O-2. Conceptual model of attributes affecting the transition of winter-run Chinook salmon from rearing in Upper River habitats (i.e., in this case, tributaries) to outmigration

Based on this conceptual model, increasing habitat availability and heterogeneity through restoration has the potential to increase salmon survival by providing refuge habitat from predators and adverse environmental conditions. Potential increases in food production and retention also can positively affect rearing survival.

Habitat restoration can affect juvenile salmon growth as well through effects on food production and retention. For example, creation of new floodplain habitat can increase local growth rates, given observed differences in food production and growth between floodplain and channel habitat (Jeffres et al. 2008). Gravel augmentations also can increase observed macroinvertebrate biomass (Merz and Chan 2005). Constructed side channels can create new food resources capable of being utilized by juvenile salmon (Heady and Merz 2007).

Habitat restoration also can support greater life-history diversity. For example, floodplain habitats have been observed to support greater life-history diversity, based on observations of size variability in the Yolo Bypass as a function of inundation period and temperature variability (Goertler et al. 2017). Habitat restoration can more broadly influence phenotypic and life-history expression by modifying the distribution of resources (Watters et al. 2003).

O.4.5 Datasets

Habitat restoration can have a positive impact on Federally listed native fish species, and its success is influenced by multiple factors, including hydrology, water quality, and fish population abundances and distribution. Monitoring of hydrodynamics, water quality, and fish populations has been ongoing for over forty years, for some datasets, and covers a large spatial extent of many of the Central Valley tributaries. These data and the following plots serve as the foundation and to illustrate patterns of interannual variability in historical hydrology and exports and trends in water quality. They also provide data and visualizations of trends in Federally listed native fish population abundances and distribution.

Presented in this section are three themes of empirical data: hydrodynamics, water quality parameters, and fish observations for Federally listed native fish species. Hydrodynamics datasets (Section 4.5.1, *Hydrodynamics*) include [Placeholder for datasets]. Water quality parameters (Section 4.5.2, *Water Quality Parameters*) include [Placeholder for datasets]. Fish observations (Section 4.5.3, *Fish Observations*) are separated into tributaries. The CVPIA Program has habitat restoration data for Stanislaus, American, Sacramento, and Clear Creek including spawning data (aerial, carcass), otolith and PBT genetics, and spawn weighted usable area (WUA) and redd dewatering.

While some datasets include data gaps or shorter sampling efforts than others, overall, a large body of historic monitoring data within many of the Central Valley tributaries is available. These data sets, in conjunction with modeled data (i.e., CalSim 3, DSM2, USRDOM), serve as inputs for models that can be used to understand and predict the effects of CVP and SWP operations on environmental conditions and fish distributions and loss. Each data set is incorporated into one or multiple lines of evidence used to inform conclusions about both the magnitude and direction of differences among alternatives regarding habitat restoration and listed native fish populations abundance.

O.4.5.1 Hydrodynamics

[Placeholder for datasets]

O.4.5.2 Water Quality Parameters

[Placeholder for datasets]

O.4.5.3 Fish Observations

[Placeholder CVPIA NMFS Report]

O.4.6 American River

Table O-3 shows the annual river-wide Chinook red counts between 204 and 2020 from aerial spawning surveys.

Table O-3. Annual river-wide Chinook redd counts 2004-2020 in the American River from aerial spawning surveys.

Water Year	Count
2004	5,309
2005	4,874
2006	2,459
2007	1,206
2008	551
2009	267
2010	526
2011	4,037
2012	5,832
2013	2,840
2014	5,393
2015	2,462
2016	2,463
2017	1,755
2018	3,233
2019	5,644
2020	4,791

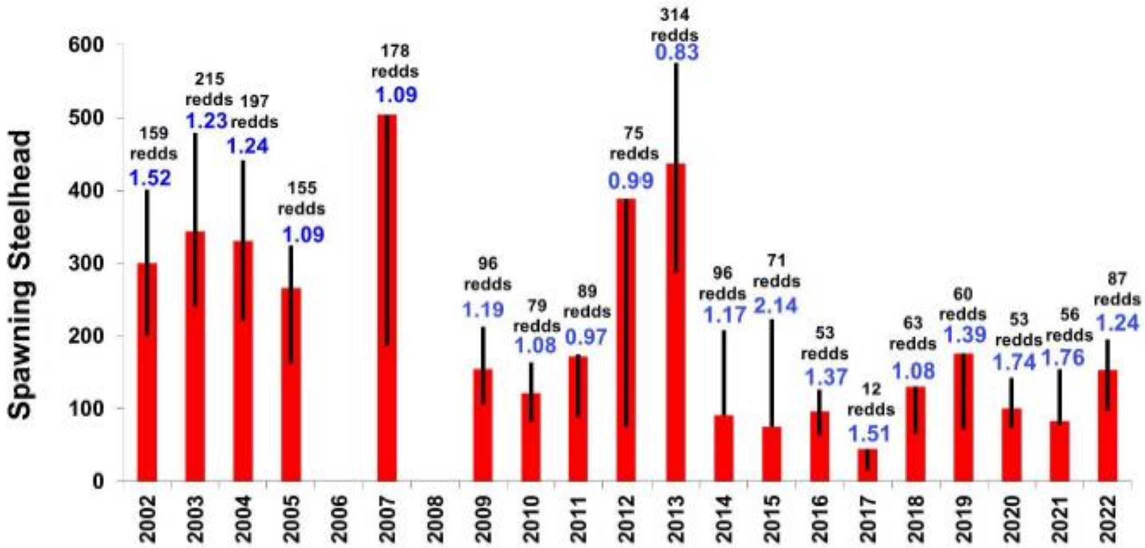
Table O-4 shows Chinook redd data in the American River by location and river mile for 2020.

Table O-4. Chinook redd data for 2020 in the American River by location and river mile. Description of 2nd half of table

Location	**River Mile**		**# Redds**
Nimbus Basin	23		1592
Upper Sailor Bar	23/ 22		1168
Lower Sailor Bar	22		662
Upper Sunrise	21		215
Sunrise	20		495
Lower Sunrise	20		438
Sacramento Bar	19		49
El Manto	19		5
El Manto	18		0
Rossmoor Bar	17		42
Ancil Hoffman	17		64
Upper River Bend	15		39
River Bend	14		4
Lower River Bend	13		13
Gristmill	12		3
Sara Park	11		1
Watt Ave	10		1
TOTAL 2020 REDD COUNT			4791
Gravel Project Sites:		**# Redds**	
Nimbus Basin - main channel	-		926
Nimbus Basin - SC	-		529
Upper Sailor Bar - 2019 -Upper Pad	-		390
Upper Sailor Bar - 2019 -Lower Pad	-		521
Upper Sailor Bar - 2019 - SC	-		257
Lower Sailor Bar - 2012	-		87
Upper Sunrise - 2010	-		0
Upper Sunrise - 2011	-		21
Sacramento Bar - main channel	-		48
River Bend Park - main channel	-		1
River Bend Park SC	-		0
2008 Lower Sunrise Side Channel - WF			14
-	-		-
Fry production at 5,000 eggs/female and 30% egg to fry survival			
		Fry	7,186,500

Table O-5. American River steelhead redd counts and distribution 2003-2022

Year	Location (river mile in parenthesis)															Total
	Nimbus to Upper Sailor	Lower Sailor Bar (22)	Bar to Upper Upper Sunrise Sunrise (21)	to Sunrise Sunrise Bridge Bridge (20)	to Lower Sacramento Bar Sunrise (19)	to San Juan San Juan Rapids (18)	Rapids to Lower Rossmoor (17)	Rossmoor to SMUD Cables to Ancil Hoffman	Upper (16) Riverbend Side Riverbend (15)	Channel (14) Lower River	Bend to Arden Below River Rapids (13)	Bend to Gristmill (12) Gristmill (12)	Gristmill to Watt (10)	Watt (9)	Paradise Beach (5)	
2003	28	46	11	21	16	11	4	22	15	15	5	7	5	9	0	215
2004	31	45	-	21	8	10	-	20	13	6	17	-	0	9	1	187
2005	40	27	6	10	3	0	3	11	5	3	-	-	-	3	14	131
2006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2007	-	25	9	21	13	18	18	7	3	-	9	-	12	-	0	172
2008	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	72	13	5	0	0	0	0	0	0	0	3	0	0	3	0	96
2010	59	0	0	13	0	0	0	0	0	4	-	0	0	-	0	79
2011	32	17	0	-	-	3	9	10	4	0	9	0	0	0	1	88
2012	38	17	6	10	-	-	-	0	0	0	0	0	0	0	1	75
2013	65	118	19	-	11	4	28	-	-	-	21	0	0	12	0	316
2014	21	3	12	4	2	7		0	0	21	12	0	-	0	0	84
2015	27	-	5	9	0	19	8	-	0	8	3	-	0	0	0	83
2016	12	8	-	6	-	0	-	-	10	0	4	0	-	-	0	52
2017	0	0	0	-	-	0	-	3	0	4	0	0	0	0	0	10
2018	5	14	6	5	5		5	-	5	5	7	-	0	6	0	6 7
2019	4	25	6	4	0	4	0	0	-	0	5	0	-	4	5	60
2020	14	4	11	5	5	2	3	-	0	-	0	0	0	4	2	53
2021	3	0	14	-	4	2	6	-	0	8	13	0	0	-	11	56
2022	30	-	13	0	3	0	24	-	6	-	4	0	0	0	3	87



Error estimates are a range of population estimates using either 1 or 2 redds per female. Male to female ratio displayed in blue text above bars. Observed redds displayed in black text ab bottom of bars. 2009 and 2010 estimates based on redd counts only.

Figure O-3. In-river spawning steelhead population estimates in the American River 2002-2022

O.4.7 Models

O.4.7.1 Weighted Usable Area (spawning and rearing)

WUA analysis provides estimates of the amount of suitable spawning and rearing habitat of fishes available in rivers and streams at various levels of flow (Bovee et al. 1998). WUA is computed as the surface area of physical habitat available weighted by its suitability. Habitat suitability is determined from field studies of the distributions of redds or rearing juveniles with respect to flow velocities, depths, and substrate or cover characteristics in the river (Bovee et al. 1998). These data are used in hydraulic and habitat model simulations (PHABSIM and/or RIVER2D) that estimate the availability of suitable habitat in a portion of the river at a given flow. WUA curves showing suitable habitat availability versus flow are generated from the simulations. These curves are typically used to evaluate effects of proposed changes in a river's flow regime on the river's spawning and rearing habitat availability. The results of the WUA curves can be expressed as the surface area of suitable habitat per unit distance of stream, which can be multiplied by length of habitat in the stream to estimate the total area of suitable habitat.

Stanislaus (spawning)

The U.S. Fish and Wildlife Service (USFWS) (Aceituno 1993) provides spawning WUA curves for fall-run Chinook salmon in the Stanislaus River, for spawning habitat from Goodwin Dam downstream about 23 miles.

Upper Sacramento (spawning and rearing))

Several Weighted Usable Area studies were conducted by USFWS personnel in the upper Sacramento River from 2003 through 2006 (USFWS 2003a, 2005a, 2006). The reports of these studies provide spawning and rearing WUA curves for winter-run, fall-run, and late fall–run Chinook salmon and steelhead but not spring-run. The fall-run WUA curves were used to estimate spring-run spawning and rearing WUA. The WUA curves were developed for three reaches from Keswick Dam to the Battle Creek (and a reach to Deer Creek for fall-run spawning).

American (spawning)

The USFWS (2003b) developed spawning WUA curves for American River fall-run Chinook salmon and steelhead. More recently, Bratovich et al. (2017) conducted studies related to the lower American River Modified Flow Management Standard that prepared spawning WUA curves for fall-run Chinook and steelhead. Both studies evaluated spawning habitat from Nimbus Dam up to about 10 miles downstream.

Clear Creek (spawning and rearing)

The USFWS conducted a series of spawning and rearing WUA studies in Clear Creek from 2003 through 2013 for fall-run and spring-run Chinook salmon and steelhead. The reports of these studies (USFWS 2007, 2011a, 2011b, 2013, 2015) provide WUA curves for spring-run and steelhead spawning between Whiskeytown Dam and Clear Creek Road (USFWS 2007); for fall-run and steelhead spawning between Clear Creek Road and the Sacramento River (USFWS 2011a); for spring-run and steelhead rearing between Whiskeytown Dam and Clear Creek Road (USFWS 2011b); and for spring-run, fall-run and steelhead rearing between Clear Creek Road and the Sacramento River (USFWS 2013).

O.4.7.2 Redd Dewatering Analysis

The redd dewatering analyses for the American River are based on the maximum reduction in flow from the initial flow, or *spawning flow*, that occurs during the incubation period of embryos (fertilized egg and alevin) to fry emergence. This period may vary from about two to three months, depending primarily on water temperature (Bratovitch et al. 2017). The minimum flow of the incubation period is referred to herein as the *dewatering flow*. If all flows during the incubation/development period are greater than or equal to the spawning flow, no dewatering is assumed to occur.

American River

Bratovich et al. (2017) developed redd dewatering analyses for fall-run Chinook salmon and steelhead in the American River. These analyses use the depth distributions of redds at different spawning locations in the river, as determined from field studies, with the stage (water elevation) versus flow relationships at different river locations to estimate the percentage of fall-run and steelhead redds dewatered at different river flows. The redd dewatering was determined for the same river reach that was included in the spawning WUA study described above.

O.4.7.3 CVPIA SIT DSM Habitat Modeling

The SIT DSM models can be used to estimate Chinook salmon spawning and rearing habitat in all CVP tributaries. These estimates are based on flow to suitable habitat area relationships and are largely reported as WUA in square feet per 1000 feet as a function of flow in cubic feet per second. For some combinations of watershed and run type, estimates of habitat are estimated through varying other means.

For the Clear Creek tributary in-stream spawning, fry, and juvenile habitats of spring-run Chinook salmon are based on relationships determined through four USFWS instream flow evaluations (USFWS 2007, 2011a, 2011b, 2013). For Clear Creek floodplain habitat, hydraulic modeling was not available for spring-run Chinook salmon. Instead, floodplain habitat was estimated using a flow to floodplain habitat relationship scaled from the Cottonwood Creek watershed. Based on hydrologic and geomorphic analyses, the floodplain areas for Clear Creek were calculated as 0.21 percent of Cottonwood Creek values. A 0.1 scaling factor was then applied to the high gradient (but not low gradient) extents of the tributary.

For the Upper Sacramento River, in-stream spawning habitats of winter-run Chinook salmon are based on data from a U.S. Fish and Wildlife Service report on flow-spawning habitat relationships in the Sacramento River (USFWS 2003). Winter-run WUAs are based on spawning that occurs between Keswick Dam and Battle Creek and consider conditions with and without the Anderson Cottonwood Irrigation District (ACID) diversion dam. Instream and floodplain rearing habitats are based on data from the Central Valley Floodplain Evaluation and Delineation (CVFED) HEC-RAS hydraulic model refined for use in the NOAA-NMFS Winter Run Chinook Salmon life cycle model. High quality rearing habitats were defined as areas with channel depth >0.2 m and <1.5 m and velocity ≤ 0.15m/s. These suitable areas are quantified by the CVPIA SIT DSMs for four segments along the Sacramento River, with the Upper Sacramento defined as Keswick to Red Bluff, which falls within Sections 1 and 2 of the NOAA-NMFS modeling.

The SIT DSMs use these watershed-specific habitat values in combination with redd and juvenile territory sizes to determine carrying capacity for spawning and rearing. The expected redd size is 9.29 m^2 based on expert opinion from SIT members. Territory sizes of small (<42 mm, medium (42-72 mm) and large (72-110 mm) are specified as 0.04999, 0.13894, and 0.47108 m^2, respectively, based on analyses in Grant and Kramer (1990).

These models can use CalSim data as inputs for estimates of flow, but not all habitat estimates in the SIT DSMs are solely responsive to flow. Model outputs include estimated habitat areas for spawning and rearing, in which rearing habitat is broken into in-channel and floodplain, as well as spawning and rearing capacity. Detailed model documentation is available at Home - CVPIA Science Integration Team (gitbook.io). The model was previously used in a published decision analysis (Peterson and Duarte 2020). The model development is open and participatory.

O.5 Lines of Evidence

O.5.1 Weighted Usable Area (spawning and juvenile rearing)

This section will summarize results from Attachment L.X Sacramento Weighted Usable Area and Attachment O.1 *Clear Creek Weighted Usable Area*. This line of evidence was used in the Initial Alternative Report. Results will provide an evaluation of the change in the suitable acres for adults spawning and juvenile rearing between the NAA and each alternative.

Spawning habitat weighted usable area analysis in the upper Sacramento for winter-run Chinook salmon shows that for spawning flows below approximately 10,000 cfs, spawning habitat weighted usable area value peaks for Section 6 (Keswick- ACID (dam board in) and Section 5 (ACID to Cow Creek). For segment 4 (Cow Creek to Battle Creek and), spawning habitat decreases with flows below 5,000 cfs. The greatest weighted usable area for spawning habitat value is during Dry water years under EXP 3 and the lowest weighted usable area habitat value is during critical years under EXP1. Releases during the summer of dry and critically dry years are quite different for these two scenarios (Figure O-4). EXP1 is the lowest during the winter-run Chinook spawning month, which results in a low WUA habitat value, while EXP3 is closest to the peak of the WUA curve, which is at 10,000 cfs.

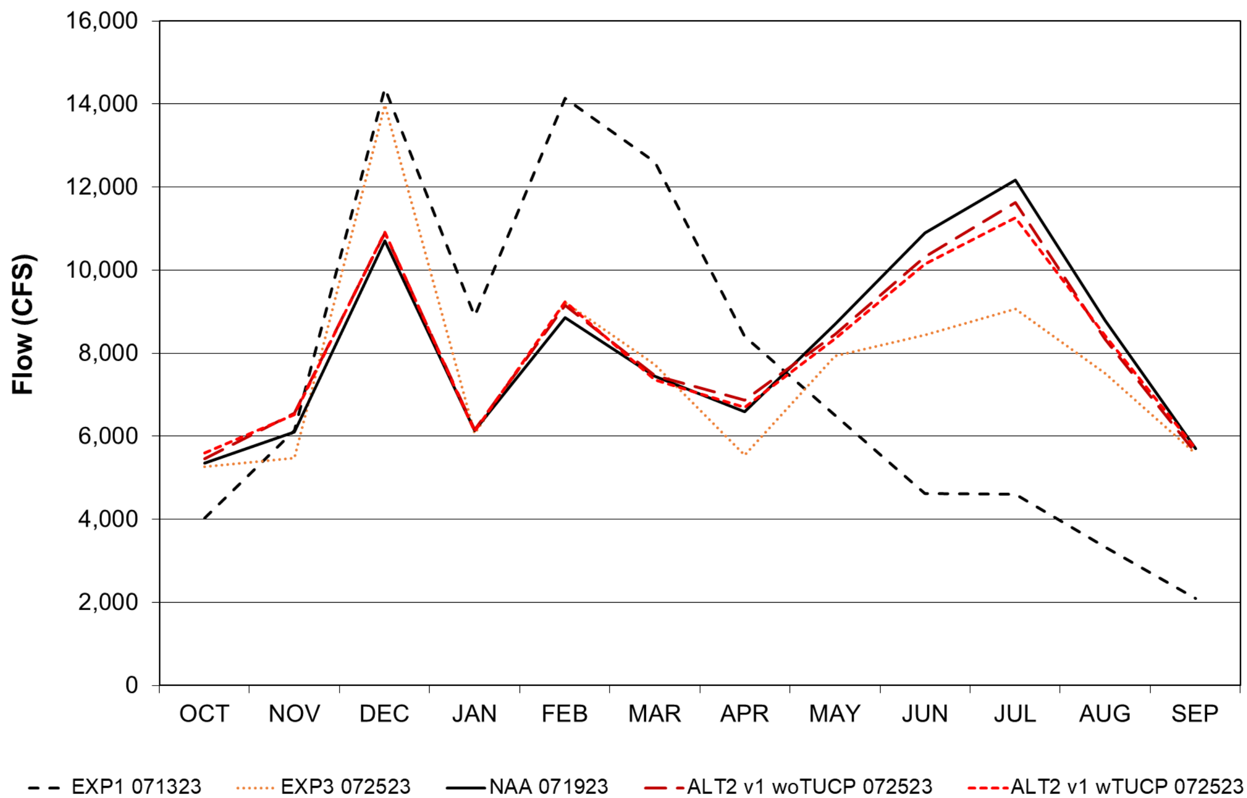


Figure O-4. Sacramento River Flow at Bend Bridge Dry and Critically Dry Years (40-30-30)

Table O-6. Winter-run Spawning WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	503,647	576,192	545,135	548,494	548,607	548,848
AN	477,951	594,047	518,502	522,694	523,507	530,681
BN	469,563	599,138	532,471	538,253	538,289	546,497

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
D	468,443	601,967	547,915	560,634	557,712	564,350
C	421,055	598,986	582,871	583,645	578,943	580,022
All	472,251	592,655	545,832	551,576	550,275	554,590

Table O-7. Winter-run Spawning WUA combined means weighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	545,135	547,715	548,572	548,494	548,607	548,848	543,711	548,569
AN	518,502	511,277	522,731	522,694	523,507	530,681	547,419	522,906
BN	532,471	527,984	538,123	538,253	538,289	546,497	554,780	534,410
D	547,915	549,027	561,083	560,634	557,712	564,350	552,224	558,365
C	582,871	578,374	582,443	583,645	578,943	580,022	581,003	585,336
All	545,832	544,283	551,495	551,576	550,275	554,590	554,232	550,661

Table O-8. Winter-run Spawning WUA combined mean percent differences between the EIS alternatives and the NAA, weighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	545,135	0.47	0.63	0.62	0.64	0.68	-0.26	0.63
AN	518,502	-1.39	0.82	0.81	0.97	2.35	5.58	0.85
BN	532,471	-0.84	1.06	1.09	1.09	2.63	4.19	0.36
D	547,915	0.20	2.40	2.32	1.79	3.00	0.79	1.91
C	582,871	-0.77	-0.07	0.13	-0.67	-0.49	-0.32	0.42
All	545,832	-0.28	1.04	1.05	0.81	1.60	1.54	0.88

[Placeholder narrative text for spring-run spawning]

Table O-9. Spring-run Spawning WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	439,130	451,262	340,515	343,070	342,592	342,214
AN	401,963	453,809	359,947	352,226	350,776	352,152

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
BN	330,606	451,585	429,354	428,824	431,627	430,136
D	273,640	452,989	440,725	440,399	441,154	440,956
C	247,091	459,597	443,545	448,282	435,218	435,186
All	344,395	453,360	399,692	399,840	398,123	397,909

Table O-10. Spring-run Spawning WUA combined means weighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
W	340,515	359,262	343,188	343,070	342,592	342,214	355,495	343,198
AN	359,947	415,812	352,157	352,226	350,776	352,152	380,542	352,056
BN	429,354	424,073	427,272	428,824	431,627	430,136	418,510	427,753
D	440,725	439,070	440,393	440,399	441,154	440,956	434,659	440,213
C	443,545	431,449	456,308	448,282	435,218	435,186	451,937	457,579
All	399,692	409,562	400,832	399,840	398,123	397,909	404,640	401,066

Table O-11. Spring-run Spawning WUA combined mean percent differences between the EIS alternatives and the NAA, weighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2v1 wTUCP	Alt2v1 woTUCP	Alt2Delta	Alt2All Watershed	Alt 3	Alt 4
W	340,515	5.51	0.78	0.75	0.61	0.50	4.40	0.79
AN	359,947	15.52	-2.16	-2.14	-2.55	-2.17	5.72	-2.19
BN	429,354	-1.23	-0.48	-0.12	0.53	0.18	-2.53	-0.37
D	440,725	-0.38	-0.08	-0.07	0.10	0.05	-1.38	-0.12
C	443,545	-2.73	2.88	1.07	-1.88	-1.88	1.89	3.16
All	399,692	2.47	0.29	0.04	-0.39	-0.45	1.24	0.34

[Placeholder narrative text for steelhead spawning in the Sac]

Table O-12. Steelhead Spawning WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	41,897	68,022	68,940	68,889	68,907	68,835

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
AN	53,504	82,616	85,350	86,419	86,071	85,715
BN	89,406	112,719	115,190	114,543	114,585	114,042
D	98,693	115,715	118,718	118,798	118,827	118,828
C	117,244	120,505	120,314	120,229	120,958	120,945
All	77,760	97,954	99,729	99,753	99,841	99,671

Table O-13. Steelhead Spawning WUA combined means weighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
W	68,940	68,257	68,872	68,889	68,907	68,835	68,905	68,974
AN	85,350	83,628	85,338	86,419	86,071	85,715	85,383	85,113
BN	115,190	113,671	114,540	114,543	114,585	114,042	115,340	114,529
D	118,718	118,760	118,804	118,798	118,827	118,828	119,787	118,762
C	120,314	121,510	119,788	120,229	120,958	120,945	121,177	120,064
All	99,729	99,225	99,528	99,753	99,841	99,671	100,145	99,557

Table O-14. Steelhead Spawning WUA combined mean percent differences between the EIS alternatives and the NAA, weighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
W	68,940	-0.99	-0.10	-0.07	-0.05	-0.15	-0.05	0.05
AN	85,350	-2.02	-0.01	1.25	0.85	0.43	0.04	-0.28
BN	115,190	-1.32	-0.56	-0.56	-0.53	-1.00	0.13	-0.57
D	118,718	0.04	0.07	0.07	0.09	0.09	0.90	0.04
C	120,314	0.99	-0.44	-0.07	0.54	0.52	0.72	-0.21
All	99,729	-0.51	-0.20	0.02	0.11	-0.06	0.42	-0.17

[Placeholder narrative text for fall-run spawning in the Sac]

Table O-15. Fall-run Spawning WUA combined means weighted by month and Sacramento River segment, including segment 3, for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	270,962	255,464	248,609	247,665	246,597	246,813
AN	271,725	265,598	260,323	257,011	254,853	255,899
BN	246,291	277,176	279,409	277,477	275,880	274,523
D	240,802	280,288	282,535	281,218	281,931	279,807
C	241,628	306,968	295,535	295,655	293,366	293,615
All	254,885	274,575	271,162	269,760	268,670	268,172

Table O-16. Fall-run Spawning WUA combined means weighted by month and Sacramento River segment, including segment 3, for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	248,609	251,195	247,735	247,665	246,597	246,813	253,861	248,051
AN	260,323	271,327	257,015	257,011	254,853	255,899	266,848	257,479
BN	279,409	278,724	277,187	277,477	275,880	274,523	272,376	275,650
D	282,535	282,309	281,169	281,218	281,931	279,807	281,449	281,806
C	295,535	293,889	299,876	295,655	293,366	293,615	300,890	298,829
All	271,162	273,059	270,353	269,760	268,670	268,172	272,874	270,231

Table O-17. Fall-run Spawning WUA combined mean percent differences between the EIS alternatives and the NAA, weighted by month and Sacramento River segment, including segment 3, for all water year types

WYT	NAA	Alt 1	Alt2v1 wTUCP	Alt2v1 woTUCP	Alt2Delta	Alt2All Watershed	Alt 3	Alt 4
W	248,609	1.04	-0.35	-0.38	-0.81	-0.72	2.11	-0.22
AN	260,323	4.23	-1.27	-1.27	-2.10	-1.70	2.51	-1.09
BN	279,409	-0.25	-0.79	-0.69	-1.26	-1.75	-2.52	-1.35
D	282,535	-0.08	-0.48	-0.47	-0.21	-0.97	-0.38	-0.26
C	295,535	-0.56	1.47	0.04	-0.73	-0.65	1.81	1.11
All	271,162	0.70	-0.30	-0.52	-0.92	-1.10	0.63	-0.34

[Placeholder narrative text for late fall-run spawning in the Sac]

Table O-18. Late Fall-run Spawning WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	128,356	116,362	173,702	172,176	172,601	172,584
AN	137,779	159,340	226,884	226,599	226,173	225,212
BN	165,162	227,012	257,048	255,026	254,051	253,848
D	200,893	253,854	280,192	274,857	276,405	275,625
C	242,151	312,104	308,625	304,394	308,616	309,708
All	171,781	205,891	243,156	240,372	241,296	241,106

Table O-19. Late Fall-run Spawning WUA combined means weighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	173,702	170,866	171,746	172,176	172,601	172,584	170,001	174,201
AN	226,884	210,084	223,076	226,599	226,173	225,212	213,486	226,719
BN	257,048	253,693	255,025	255,026	254,051	253,848	249,880	254,618
D	280,192	277,702	274,627	274,857	276,405	275,625	276,762	277,845
C	308,625	306,270	304,982	304,394	308,616	309,708	302,470	304,190
All	243,156	238,310	239,795	240,372	241,296	241,106	237,085	241,600

Table O-20. Late Fall-run Spawning WUA combined mean percent differences between the EIS alternatives and the NAA, weighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2v1 wTUCP	Alt2v1 woTUCP	Alt2Delta	Alt2All Watershed	Alt 3	Alt 4
W	173,702	-1.63	-1.13	-0.88	-0.63	-0.64	-2.13	0.29
AN	226,884	-7.40	-1.68	-0.13	-0.31	-0.74	-5.91	-0.07
BN	257,048	-1.31	-0.79	-0.79	-1.17	-1.24	-2.79	-0.95
D	280,192	-0.89	-1.99	-1.90	-1.35	-1.63	-1.22	-0.84
C	308,625	-0.76	-1.18	-1.37	0.00	0.35	-1.99	-1.44
All	243,156	-1.99	-1.38	-1.14	-0.76	-0.84	-2.50	-0.64

[placeholder narrative text winter-run fry and juvenile rearing, spring-run fry and juvenile rearing, and steelhead fry and juvenile rearing]

Table O-21. Winter-run Fry-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	266,854	268,280	235,210	234,984	234,656	234,938
AN	257,580	266,879	237,840	236,715	236,564	236,501
BN	228,209	265,673	254,387	253,464	253,344	252,334
D	210,866	264,051	257,409	256,880	257,399	257,864
C	188,143	262,792	257,398	259,957	255,456	255,519
All	232,888	265,748	247,838	247,705	246,996	247,008

Table O-22. Winter-run Fry-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	235,210	237,442	234,968	234,984	234,656	234,938	240,093	234,997
AN	237,840	245,321	236,761	236,715	236,564	236,501	242,387	236,813
BN	254,387	251,034	253,021	253,464	253,344	252,334	257,933	252,214
D	257,409	256,959	256,873	256,880	257,399	257,864	259,847	257,277
C	257,398	253,475	263,028	259,957	255,456	255,519	262,727	262,259
All	247,838	248,220	248,095	247,705	246,996	247,008	251,909	247,946

Table O-23. Winter-run Fry-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, weighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	235,210	0.95	-0.10	-0.10	-0.24	-0.12	2.08	-0.09
AN	237,840	3.15	-0.45	-0.47	-0.54	-0.56	1.91	-0.43
BN	254,387	-1.32	-0.54	-0.36	-0.41	-0.81	1.39	-0.85
D	257,409	-0.17	-0.21	-0.21	0.00	0.18	0.95	-0.05
C	257,398	-1.52	2.19	0.99	-0.75	-0.73	2.07	1.89
All	247,838	0.15	0.10	-0.05	-0.34	-0.33	1.64	0.04

Table O-24. Winter-run Juvenile-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	137,825	141,579	136,563	136,574	136,480	136,502
AN	136,925	136,994	134,859	134,439	134,260	134,429
BN	128,529	136,520	133,640	133,246	133,121	132,936
D	129,802	136,889	136,003	135,658	135,872	135,853
C	123,629	137,292	135,317	135,360	135,209	135,298
All	131,931	138,215	135,453	135,245	135,200	135,208

Table O-25. Winter-run Juvenile-rearing WUA combined means unweighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	136,563	136,945	136,582	136,574	136,480	136,502	137,149	136,587
AN	134,859	135,568	134,399	134,439	134,260	134,429	135,149	134,599
BN	133,640	133,516	133,217	133,246	133,121	132,936	133,037	133,030
D	136,003	136,234	135,643	135,658	135,872	135,853	135,789	135,874
C	135,317	135,259	136,207	135,360	135,209	135,298	136,203	136,324
All	135,453	135,691	135,360	135,245	135,200	135,208	135,635	135,431

Table O-26. Winter-run Juvenile-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, unweighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	136,563	0.28	0.01	0.01	-0.06	-0.04	0.43	0.02
AN	134,859	0.53	-0.34	-0.31	-0.44	-0.32	0.21	-0.19
BN	133,640	-0.09	-0.32	-0.29	-0.39	-0.53	-0.45	-0.46
D	136,003	0.17	-0.26	-0.25	-0.10	-0.11	-0.16	-0.09
C	135,317	-0.04	0.66	0.03	-0.08	-0.01	0.66	0.74
All	135,453	0.18	-0.07	-0.15	-0.19	-0.18	0.13	-0.02

Table O-27. Spring-run Fry-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	416,795	457,583	455,508	453,691	454,147	453,937
AN	413,508	480,525	491,821	489,252	489,809	485,585
BN	416,041	537,650	528,229	523,994	524,594	520,618
D	431,463	554,191	549,399	542,669	546,266	544,527
C	484,777	595,099	580,491	567,869	565,212	565,304
All	430,544	520,166	516,082	510,841	511,587	509,814

Table O-28. Spring-run Fry-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	455,508	459,294	453,553	453,691	454,147	453,937	451,157	455,905
AN	491,821	489,832	488,294	489,252	489,809	485,585	484,558	492,029
BN	528,229	519,813	523,923	523,994	524,594	520,618	530,257	523,900
D	549,399	542,581	541,788	542,669	546,266	544,527	553,984	545,807
C	580,491	568,482	579,203	567,869	565,212	565,304	577,040	576,456
All	516,082	511,765	512,255	510,841	511,587	509,814	514,811	513,976

Table O-29. Spring-run Fry-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, weighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	455,508	0.83	-0.43	-0.40	-0.30	-0.34	-0.96	0.09
AN	491,821	-0.40	-0.72	-0.52	-0.41	-1.27	-1.48	0.04
BN	528,229	-1.59	-0.82	-0.80	-0.69	-1.44	0.38	-0.82
D	549,399	-1.24	-1.39	-1.23	-0.57	-0.89	0.83	-0.65
C	580,491	-2.07	-0.22	-2.17	-2.63	-2.62	-0.59	-0.70
All	516,082	-0.84	-0.74	-1.02	-0.87	-1.21	-0.25	-0.41

Table O-30. Spring-run Juvenile-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	182,154	183,641	176,621	175,478	175,359	175,491
AN	187,247	192,085	191,772	189,570	188,849	189,116
BN	182,973	209,016	205,613	203,723	203,074	202,858
D	192,028	216,519	217,257	214,433	215,220	214,642
C	193,690	229,142	226,675	223,881	224,132	224,786
All	187,336	204,369	201,520	199,430	199,407	199,410

Table O-31. Spring-run Juvenile-rearing WUA combined means unweighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	176,621	177,085	175,420	175,478	175,359	175,491	178,542	176,308
AN	191,772	193,605	188,962	189,570	188,849	189,116	191,760	190,139
BN	205,613	205,328	203,557	203,723	203,074	202,858	203,781	202,808
D	217,257	217,108	214,448	214,433	215,220	214,642	214,799	215,985
C	226,675	225,580	225,044	223,881	224,132	224,786	222,811	224,606
All	201,520	201,681	199,471	199,430	199,407	199,410	200,552	200,065

Table O-32. Spring-run Juvenile-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, unweighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	176,621	0.26	-0.68	-0.65	-0.71	-0.64	1.09	-0.18
AN	191,772	0.96	-1.47	-1.15	-1.52	-1.38	-0.01	-0.85
BN	205,613	-0.14	-1.00	-0.92	-1.23	-1.34	-0.89	-1.36
D	217,257	-0.07	-1.29	-1.30	-0.94	-1.20	-1.13	-0.59
C	226,675	-0.48	-0.72	-1.23	-1.12	-0.83	-1.70	-0.91
All	201,520	0.08	-1.02	-1.04	-1.05	-1.05	-0.48	-0.72

Table O-33. Steelhead Fry-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	517,053	429,915	369,731	369,270	369,217	369,514
AN	532,254	412,169	370,176	370,052	369,569	368,182
BN	524,923	399,469	379,819	377,485	378,388	375,573
D	506,445	397,856	383,413	381,072	382,286	383,068
C	500,494	400,888	395,872	415,011	412,754	411,061
All	515,476	409,637	379,021	380,946	380,961	380,262

Table O-34. Steelhead Fry-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	369,731	369,951	369,257	369,270	369,217	369,514	376,385	369,261
AN	370,176	377,065	370,059	370,052	369,569	368,182	371,535	370,069
BN	379,819	375,275	376,446	377,485	378,388	375,573	382,589	376,785
D	383,413	380,264	380,896	381,072	382,286	383,068	388,407	380,574
C	395,872	395,783	418,908	415,011	412,754	411,061	418,050	411,478
All	379,021	378,472	381,336	380,946	380,961	380,262	386,317	380,136

Table O-35. Steelhead Fry-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, weighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	369,731	0.06	-0.13	-0.12	-0.14	-0.06	1.80	-0.13
AN	370,176	1.86	-0.03	-0.03	-0.16	-0.54	0.37	-0.03
BN	379,819	-1.20	-0.89	-0.61	-0.38	-1.12	0.73	-0.80
D	383,413	-0.82	-0.66	-0.61	-0.29	-0.09	1.30	-0.74
C	395,872	-0.02	5.82	4.83	4.26	3.84	5.60	3.94
All	379,021	-0.14	0.61	0.51	0.51	0.33	1.92	0.29

Table O-36. Steelhead Juvenile-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	169,059	170,656	164,114	163,190	163,063	163,166
AN	173,183	176,981	176,458	174,604	174,015	174,225
BN	168,711	191,453	188,133	186,665	186,134	185,880
D	176,487	197,392	197,910	195,623	196,298	195,845
C	176,722	207,617	205,617	203,335	203,506	204,054
All	172,688	187,459	184,750	183,055	183,030	183,024

Table O-37. Steelhead Juvenile-rearing WUA combined means unweighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	164,114	164,551	163,146	163,190	163,063	163,166	165,783	163,881
AN	176,458	177,999	174,141	174,604	174,015	174,225	176,511	175,097
BN	188,133	188,009	186,549	186,665	186,134	185,880	186,435	185,951
D	197,910	197,849	195,606	195,623	196,298	195,845	195,894	196,900
C	205,617	204,775	204,251	203,335	203,506	204,054	202,427	204,063
All	184,750	184,946	183,086	183,055	183,030	183,024	183,952	183,610

Table O-38. Steelhead Juvenile-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, unweighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	164,114	0.27	-0.59	-0.56	-0.64	-0.58	1.02	-0.14
AN	176,458	0.87	-1.31	-1.05	-1.38	-1.27	0.03	-0.77
BN	188,133	-0.07	-0.84	-0.78	-1.06	-1.20	-0.90	-1.16
D	197,910	-0.03	-1.16	-1.16	-0.81	-1.04	-1.02	-0.51
C	205,617	-0.41	-0.66	-1.11	-1.03	-0.76	-1.55	-0.76
All	184,750	0.11	-0.90	-0.92	-0.93	-0.93	-0.43	-0.62

Table O-39. Fall-run Fry-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	116,325	132,264	177,821	176,841	177,013	176,998
AN	128,166	176,574	229,007	229,343	228,862	228,191
BN	181,832	268,021	295,355	291,907	290,983	290,331
D	216,169	292,780	317,204	313,867	314,902	313,433
C	281,564	351,518	344,867	339,484	344,537	345,060
All	180,081	235,993	266,237	263,724	264,592	264,108

Table O-40. Fall-run Fry-rearing WUA combined means unweighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	177,821	175,517	176,638	176,841	177,013	176,998	174,415	177,805
AN	229,007	217,392	226,428	229,343	228,862	228,191	219,760	228,283
BN	295,355	289,712	291,889	291,907	290,983	290,331	287,489	291,396
D	317,204	316,040	313,453	313,867	314,902	313,433	317,316	315,155
C	344,867	345,067	343,041	339,484	344,537	345,060	344,619	341,795
All	266,237	262,621	263,725	263,724	264,592	264,108	262,503	264,457

Table O-41. Fall-run Fry-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, unweighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	177,821	-1.30	-0.67	-0.55	-0.45	-0.46	-1.92	-0.01
AN	229,007	-5.07	-1.13	0.15	-0.06	-0.36	-4.04	-0.32
BN	295,355	-1.91	-1.17	-1.17	-1.48	-1.70	-2.66	-1.34
D	317,204	-0.37	-1.18	-1.05	-0.73	-1.19	0.04	-0.65
C	344,867	0.06	-0.53	-1.56	-0.10	0.06	-0.07	-0.89
All	266,237	-1.36	-0.94	-0.94	-0.62	-0.80	-1.40	-0.67

Table O-42. Fall-run Juvenile-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	149,520	177,624	167,061	166,986	167,013	167,070
AN	158,113	184,813	173,315	173,471	173,501	172,640
BN	176,455	201,053	188,565	187,747	188,449	187,141
D	184,222	203,830	192,553	193,236	193,811	194,576
C	207,643	215,987	207,891	209,372	207,499	206,366
All	173,199	195,275	184,459	184,713	184,689	184,351

Table O-43. Fall-run Juvenile-rearing WUA combined means unweighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	167,061	165,808	166,997	166,986	167,013	167,070	164,405	166,980
AN	173,315	171,758	173,451	173,471	173,501	172,640	171,616	173,477
BN	188,565	185,016	187,349	187,747	188,449	187,141	192,391	187,171
D	192,553	190,916	192,941	193,236	193,811	194,576	197,892	192,681
C	207,891	203,702	213,653	209,372	207,499	206,366	215,240	211,970
All	184,459	182,188	185,256	184,713	184,689	184,351	186,623	184,891

Table O-44. Fall-run Juvenile-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, unweighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	167,061	-0.75	-0.04	-0.05	-0.03	0.00	-1.59	-0.05
AN	173,315	-0.90	0.08	0.09	0.11	-0.39	-0.98	0.09
BN	188,565	-1.88	-0.64	-0.43	-0.06	-0.76	2.03	-0.74
D	192,553	-0.85	0.20	0.35	0.65	1.05	2.77	0.07
C	207,891	-2.02	2.77	0.71	-0.19	-0.73	3.54	1.96
All	184,459	-1.23	0.43	0.14	0.13	-0.06	1.17	0.23

Table O-45. Late Fall-run Fry-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	398,085	443,727	408,175	407,907	407,868	407,993
AN	417,558	446,301	413,558	413,850	414,305	409,047
BN	441,256	454,261	424,557	424,582	426,992	419,988
D	450,014	459,884	432,209	432,163	433,380	435,731
C	503,760	476,380	466,993	472,641	463,016	458,930
All	437,953	455,086	427,057	427,919	427,158	425,107

Table O-46. Late Fall-run Fry-rearing WUA combined means unweighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	408,175	409,503	407,911	407,907	407,868	407,993	404,002	407,950
AN	413,558	418,974	414,442	413,850	414,305	409,047	413,311	414,684
BN	424,557	423,266	423,934	424,582	426,992	419,988	438,344	423,485
D	432,209	425,394	431,906	432,163	433,380	435,731	448,418	431,687
C	466,993	450,647	483,744	472,641	463,016	458,930	493,127	475,630
All	427,057	423,703	429,602	427,919	427,158	425,107	436,407	428,215

Table O-47. Late Fall-run Fry-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, unweighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	408,175	0.33	-0.06	-0.07	-0.08	-0.04	-1.02	-0.06
AN	413,558	1.31	0.21	0.07	0.18	-1.09	-0.06	0.27
BN	424,557	-0.30	-0.15	0.01	0.57	-1.08	3.25	-0.25
D	432,209	-1.58	-0.07	-0.01	0.27	0.81	3.75	-0.12
C	466,993	-3.50	3.59	1.21	-0.85	-1.73	5.60	1.85
All	427,057	-0.79	0.60	0.20	0.02	-0.46	2.19	0.27

Table O-48. Late Fall-run Juvenile-rearing WUA combined means weighted by month and Sacramento River segment for all water year types (Biological Assessment Results)

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	190,694	175,454	146,115	146,382	146,289	146,525
AN	199,677	169,711	138,604	139,000	138,957	140,412
BN	203,839	164,775	136,531	137,706	138,187	139,757
D	200,968	164,733	141,755	143,664	143,393	145,519
C	196,226	168,088	158,342	165,568	164,259	163,625
All	197,669	168,976	144,248	146,204	145,984	146,945

Table O-49. Late Fall-run Juvenile-rearing WUA combined means unweighted by month and Sacramento River segment for all water year types (EIS Results)

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	146,115	145,066	146,404	146,382	146,289	146,525	146,985	146,362
AN	138,604	138,055	138,927	139,000	138,957	140,412	140,532	139,121
BN	136,531	137,398	136,858	137,706	138,187	139,757	139,595	136,582
D	141,755	141,398	143,677	143,664	143,393	145,519	140,093	142,919
C	158,342	154,956	168,956	165,568	164,259	163,625	165,254	167,397
All	144,248	143,406	146,593	146,204	145,984	146,945	146,020	146,127

Table O-50. Late Fall-run Juvenile-rearing WUA combined mean percent differences between the EIS alternatives and the NAA, unweighted by month and Sacramento River segment for all water year types

WYT	NAA	Alt 1	Alt2wTUCPwoVA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA	Alt 3	Alt 4
W	146,115	-0.72	0.20	0.18	0.12	0.28	0.60	0.17
AN	138,604	-0.40	0.23	0.29	0.25	1.30	1.39	0.37
BN	136,531	0.63	0.24	0.86	1.21	2.36	2.24	0.04
D	141,755	-0.25	1.36	1.35	1.16	2.65	-1.17	0.82
C	158,342	-2.14	6.70	4.56	3.74	3.34	4.37	5.72
All	144,248	-0.58	1.63	1.36	1.20	1.87	1.23	1.30

[Placeholder for text for Spring run Chinook and steelhead in Clear Creek. Include tables of average WUA for spawning habitat for different WYTs]

Table O-51. Mean Weighted Usable Area for Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type, Steelhead Spawning in Clear Creek

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	35,270	35,662	41,196	43,452	43,452	43,452
AN	35,517	36,262	41,305	43,489	43,489	43,489
BN	32,763	35,167	40,891	43,288	43,295	43,289
D	34,675	37,190	39,588	42,470	42,470	42,470
C	28,227	30,931	36,610	38,618	38,618	38,618
All	33,584	35,267	40,037	42,418	42,420	42,419

Table O-52. Mean Weighted Usable Area for Combined Upper Alluvial and Canyon Segments by Water Year Type, Spring-run Spawning in Clear Creek

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	2,540	5,714	5,752	5,064	5,064	5,064
AN	2,494	5,875	5,643	5,048	5,048	5,048
BN	764	4,170	5,459	4,540	4,561	4,530
D	773	3,287	5,719	5,051	5,051	5,051
C	563	2,926	5,069	4,141	4,215	4,123
All	1,473	4,430	5,567	4,817	4,832	4,812

Table O-53. Mean Weighted Usable Area for Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type, Steelhead Fry Rearing in Clear Creek

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	103,078	101,495	88,993	88,538	88,538	88,538
AN	102,954	100,028	88,425	87,994	87,994	87,994
BN	94,135	89,982	88,095	87,994	87,994	87,994
D	93,406	90,963	87,185	87,818	87,818	87,818
C	86,196	84,587	86,766	86,337	86,375	86,375
All	96,429	93,985	87,962	87,839	87,845	87,845

Table O-54. Mean Weighted Usable Area for Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type, Steelhead Juvenile Rearing in Clear Creek

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	192,931	254,577	237,237	222,263	222,247	222,247

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
AN	181,198	245,210	232,940	220,041	220,041	220,041
BN	127,122	202,905	229,783	213,121	212,171	211,988
D	119,511	176,737	235,731	220,420	220,420	220,420
C	100,134	144,778	209,260	190,231	190,605	190,750
All	146,974	207,715	230,456	214,739	214,623	214,613

Table O-55. Mean Weighted Usable Area for Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type, Spring-run Fry Rearing in Clear Creek

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	185,685	182,813	140,622	148,763	148,758	148,758
AN	181,031	177,134	137,690	145,540	145,540	145,540
BN	145,477	146,556	134,759	144,090	144,017	144,028
D	145,037	142,854	133,683	144,044	144,044	144,044
C	112,753	121,738	127,090	134,599	134,589	134,573
All	156,372	156,130	135,326	144,072	144,056	144,055

Table O-56. Mean Weighted Usable Area for Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type, Spring-run Juvenile Rearing in Clear Creek

WYT	EXP 1	EXP 3	NAA	Alt2woTUCPwoVA	Alt2woTUCPDeltaVA	Alt2woTUCPAllVA
W	231,315	252,978	209,203	206,168	206,168	206,168
AN	230,519	244,602	208,363	205,538	205,538	205,538
BN	194,655	208,445	208,363	205,538	205,538	205,538
D	181,157	193,208	206,955	202,898	202,898	202,898
C	157,449	155,298	184,309	176,143	177,144	177,655
All	200,748	213,816	204,411	200,378	200,538	200,619

O.5.2 CVPIA DSMs

This section will summarize results from Attachment O.2 *CVPIA SIT DSM Habitat Modeling*. This line of evidence was used in the Initial Alternative Report. Results will provide an evaluation of the change in the suitable acres for adults spawning and juvenile rearing.

O.6 Uncertainty

Hydrodynamic and water quality effects of tributary restoration on refuge habitat and food quantity and quality stressors are well documented. Habitat restoration monitoring lacks mechanistic models to explain individual effects on fish from these restoration actions. Uncertainty remains around how individual effects on survival and growth, from tributary habitat restoration, may affect Endangered Species Act (ESA) listed species populations.

Special studies of high value that may reduce uncertainty about the effectiveness of tributary habitat restoration for ESA listed salmonids include:

Tributary Habitat Restoration Effectiveness for salmonid fishes

O.7 References

Aceituno, M. E. 1993. The Relationship Between Instream Flow and Physical Habitat Availability for Chinook Salmon in the Stanislaus River, California. U.S. Fish and Wildlife Service, Ecological Services, Sacramento Field Office, Sacramento, California.

Anderson, J. J., Beer, W. N., Israel, J. A., and Greene, S. 2022. Targeting river operations to the critical thermal window of fish incubation: Model and case study on Sacramento River winter-run Chinook salmon. River Research and Applications 38: 895-905.

Banet, A., Tussing, S., Roualdes, E., Doolittle, G. And Nielsen, D. 2021. The Upper Sacramento River Anadromous Fish Habitat Restoration Project: Monitoring of Habitat Restoration Sites in the Upper Sacramento River in 2019-2020. Chico State University.

———. 2022. The Upper Sacramento River Anadromous Fish Habitat Restoration Project: Monitoring of Habitat Restoration Sites in the Upper Sacramento River in 2020–2021. Chico State University. 60 p + App.

Bay-Delta Office, U.S. Bureau of Reclamation. 2021. 2021 Long-Term Operations Habitat Restoration Report. Central Valley Project, California.

Bovee, K. D., B. L. Lamb, J. M. Bartholow, C. B. Stalnaker, J. Taylor, and J. Henriksen. 1998. *Stream Habitat Analysis Using the Instream Flow Incremental Methodology.* USGS/BRD-1998-0004. Fort Collins, CO.

Bratovich, P., J. Weaver, C. Addley, and C. Hammersmark. 2017. *Lower American River: Biological Rationale, Development and Performance of the Modified Flow Management Standard*. Exhibit ARWA-702. Prepared for Water Forum. Sacramento, CA.

-Goertler, P. A. L., Sommer, T. R., Satterthwaite, W. H., and Schreier, B. M. 2018. Seasonal floodplain-tidal slough complex supports size variation for juvenile Chinook salmon (Oncorhynchus tshawytscha). Ecol Freshw Fish.: 27:580–593. https://doi.org/10.1111/eff.12372

Grant, J.W.A., and Kramer, D.L. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences 47: 1724-1737.

Heady, W., and Merz, J. 2007. Lower Mokelumne River Salmonid Rearing Habitat Restoration Project Summary Report, Santa Cruz, CA.

Jeffres, C. A., Opperman, J. J., and Moyle, P. B. 2008. Ephemeral Floodplain Habitats Provide Best Growth Conditions for Juvenile Chinook Salmon in a California River. Environmental Biology of Fishes 83:449–458.

Martin, B. T., Pike, A., John, S. N., Hamda, N., Roberts, J., Lindley, S. T., and Danner, E. M. 2017. Phenomenological vs. biophysical models of thermal stress in aquatic eggs. Ecology Letters 20:50–59.

Matella, M. K., and Merenlender, A. M. 2015. Scenarios for restoring floodplain ecology given changes to river flows under climate change: case form the San Joaquin River, California. River Research and Applications 31:280–290.

Merz, J. E., and Ochikubo Chan, L. K. 2005. Effects of gravel augmentation on macroinvertebrate assemblages in a regulated California river. River Research and Applications, 21(1):61–74.

Peterson, J. T., and Duarte, A. 2020. Decision analysis for greater insights into the development and evaluation of Chinook salmon restoration strategies in California's Central Valley. Restoration Ecology 28(6): 1,596–1,609.

Plumb, J., Hansen, A., Adams, N., Evans, S., and Hannon, J. (2019). Movement and Apparent Survival of Acoustically Tagged Juvenile Late-Fall Run Chinook Salmon Released Upstream of Shasta Reservoir, California. San Francisco Estuary and Watershed Science, 17(3).

Poytress, W.R. 2016. Brood-year 2014 winter Chinook juvenile production indices with comparisons to juvenile production estimates derived from adult escapement. Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Sacramento, CA.

Roni, P. 2019. Does river restoration increase fish abundance and survival or concentrate fish? The effects of project scale, location, and fish life history. Fisheries, 44, 1, 7–19.

Sommer T, Nobriga M, Harrell W, Batham W, Kimmer W. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58: 325–333.

State Water Resource Control Board. 2000. Revised Water Rights Decision 1641. https://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1600_d1649/wrd1641_1999dec29.pdf.

U.S. Fish and Wildlife Service (USFWS). 2003a. *Flow-Habitat Relationships for steelhead and fall, late-fall, and winter-run Chinook salmon spawning in the Sacramento River between Keswick Dam and Battle Cree*k. February 4, 2003. Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2003b. *Comparison of PHABSIM and 2-D Modeling of Habitat for Steelhead and Fall-run Chinook Salmon Spawning in the Lower American River*. February 4, 2003. Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2005a. *Flow-Habitat Relationships for Chinook Salmon Rearing in the Sacramento River between Keswick Dam and Battle Creek*. August 2, 2005. Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2005b. *Flow-Habitat Relationships for Fall-run Chinook Salmon Spawning in the Sacramento River between Battle Creek and Deer Creek.* August 10, 2005. Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2006. *Sacramento River (Keswick Dam to Battle Creek) Redd Dewatering and Juvenile Stranding Final Report.* June 22, 2006. Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2007. *Flow-habitat Relationships for Spring Chinook Salmon and steelhead/Rainbow Trout Spawning in Clear Creek between Whiskeytown Dam and Clear Creek Road*.

U.S. Fish and Wildlife Service (USFWS). 2011a. Flow-habitat Relationships for fall-run Chinook Salmon and steelhead/Rainbow Trout Spawning in Clear Creek between Clear Creek Road and the Sacramento River.

U.S. Fish and Wildlife Service (USFWS). 2011b. Flow-habitat Relationships for Spring-Run Chinook Salmon and steelhead/Rainbow Trout Rearing in Clear Creek between Whiskeytown Dam and Clear Creek Road.

U.S. Fish and Wildlife Service (USFWS). 2013. Flow-habitat Relationships for Spring-Run and fall-run Chinook Salmon and steelhead/Rainbow Trout Rearing in Clear Creek Clear Creek Road and the Sacramento River.

U.S. Fish and Wildlife Service (USFWS). 2015. Clear Creek Habitat Synthesis Report.

Watters, J. V., Lema, S. C., and Nevitt, G. A. 2003. Phenotype management: a new approach to habitat restoration. Biological Conservation, 112(3): 435–445.

Windell, S., Brandes, P. L., Conrad, J.L., et al. 2017. Scientific Framework for Assessing Factors Influencing Endangered Sacramento River Winter-Run Chinook Salmon (Oncorhynchus tshawytscha) Across the Life Cycle. NOAA Technical Memorandum NMFS NOAA-TM-NMFS-SWFSC-586.

Zeug, S. C., Wiesenfeld, J., Sellheim, K., Brodsky, A., and Merz, J. E. 2019. Assessment of juvenile Chinook salmon rearing habitat potential prior to species reintroduction. North American Journal of Fisheries Management 39:762–777.