Appendix O, Tributary Habitat Restoration

Attachment O.1 Clear Creek Weighted Usable Area Analysis

O.1.1 Model Overview

Weighted usable area (WUA) analysis is a method for estimating the availability of suitable habitat in rivers, streams, and floodplains under different flow conditions (Bovee et al. 1998). It has been used primarily for estimating spawning and rearing habitat of fish species. WUA is computed as the surface area of physical habitat available for spawning or rearing, 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 in the stream or floodplain (Bovee et al. 1998). These data are used in hydraulic and habitat model simulations (e.g., PHABSIM or RIVER2D) that estimate the availability of suitable habitat in a portion of the stream at a given flow. WUA curves showing suitable habitat availability versus flow are generated from the simulations. These curves facilitate evaluating how different flow regimes affect spawning and rearing habitat of important fish species.

O.1.2 Model Development

O.1.2.1 Methods

For this analysis, spawning and rearing WUA were estimated for spring-run and fall-run Chinook salmon and California Central Valley steelhead in Clear Creek, Shasta County. Late fall-run Chinook also spawn in Clear Creek, but no studies have been conducted to estimate their spawning or rearing WUA in Clear Creek (USFWS 2007a). Spawning and rearing WUA were estimated for the scenarios and management alternatives from CalSim 3 flow data for each month of the 100-year period of record. The WUA analyses are based on a series of U.S. Fish Wildlife (USFWS) field studies conducted from 2004 through 2009 (USFWS 2007b, 2011a, 2011b, 2013a, 2015).

Modeling assumptions used to derive spawning WUA curves include that the suitability of physical habitat for salmon and steelhead spawning is largely a function of substrate particle size, water depth, and flow velocity. The race- or species-specific suitability of the habitat with respect to these physical habitat variables is determined by cataloguing conditions at active redds and is used to develop habitat suitability criteria (HSC) for each race or species of fish. Hydraulic modeling is then used to estimate the amount of habitat available for different HSC levels at different stream flow, and the results are combined to develop spawning habitat WUA curves and tables (Bovee et al. 1998). For the USFWS Clear Creek spawning WUA studies, the primary hydraulic model used was RIVER-2D (USFWS 2007b, 2011a). The WUA tables are used to look up the amount of spawning WUA available at different flows during the spawning period of the fish. The Clear Creek spawning WUA tables are provided in USFWS 2007b and 2011a.

For development of the rearing WUA curves, the modeling assumptions include that the suitability of physical habitat for salmon and steelhead rearing (fry and juveniles) is largely a function of water depth, flow velocity, adjacent velocity, and the availability of cover. Adjacent velocity is designed to account for microhabitats selected by juveniles in quiet water adjacent to more rapid flow, which provides higher rates of prey encounter. Such microhabitats include heads of pools, behind large boulders, riparian vegetation, and riverbanks (Naman et al. 2019). For the USFWS studies, adjacent velocity was measured within 2 feet on either side of the location where the velocity was the highest (USFWS 2011a, 2013a). The race- or species-specific suitability of the rearing habitat with respect to these physical variables is determined by observing the fish's behaviors and is used to develop HSC for each race or species and life stage. Hydraulic modeling is then used to estimate the amount of habitat available for different HSC levels at different river flows, and the results are combined to develop rearing habitat WUA curves and tables (Bovee et al. 1998). For USFWS's Clear Creek rearing WUA studies, the primary hydraulic model used was RIVER-2D (USFWS 2011b, 2013a). The WUA tables are used to look up the amount of rearing WUA available at different flows during the fry and juvenile rearing periods of the fish. The Clear Creek rearing WUA tables are provided in USFWS 2011b and 2013a.

The USFWS studies were conducted between Whiskeytown Reservoir and Clear Creek's confluence with the Sacramento River. For purposes of the studies, the creek was divided into three segments, designated from upstream to downstream as the Upper Alluvial segment, the Canyon segment, and the Lower Alluvial Segment (Figure O.1-1). Spring-run spawn primarily in the upper two segments, fall-run spawn only in the Lower Alluvial segment, and steelhead spawn in all three segments (USFWS 2015). The reports provide spawning WUA tables for spring-run and steelhead in the Upper Alluvial and Canyon segments (USFWS 2007b) and fall-run and steelhead in the Lower Alluvial segments (USFWS 2011a). The spawning WUA curves are provided below in Figure O.1-2, Figure O.1-3, and Figure O.1-4.

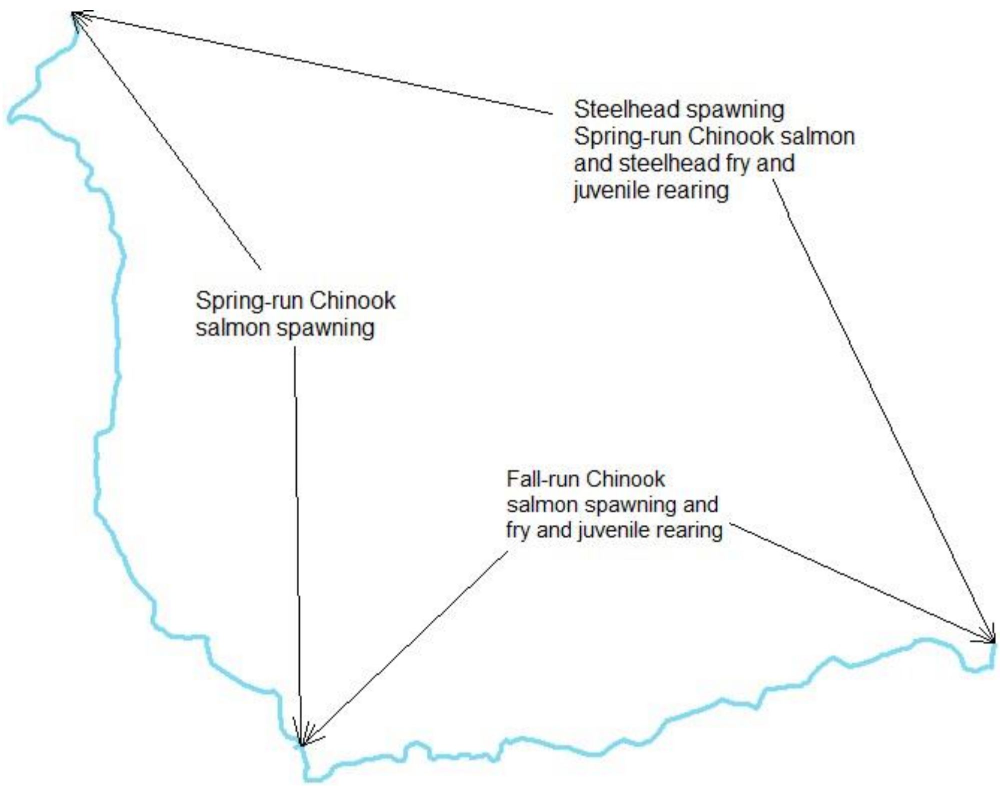

Figure O.1-1. Spatial Distribution of Adult and Juvenile Spring-run and Fall-run Chinook and Steelhead in Clear Creek.

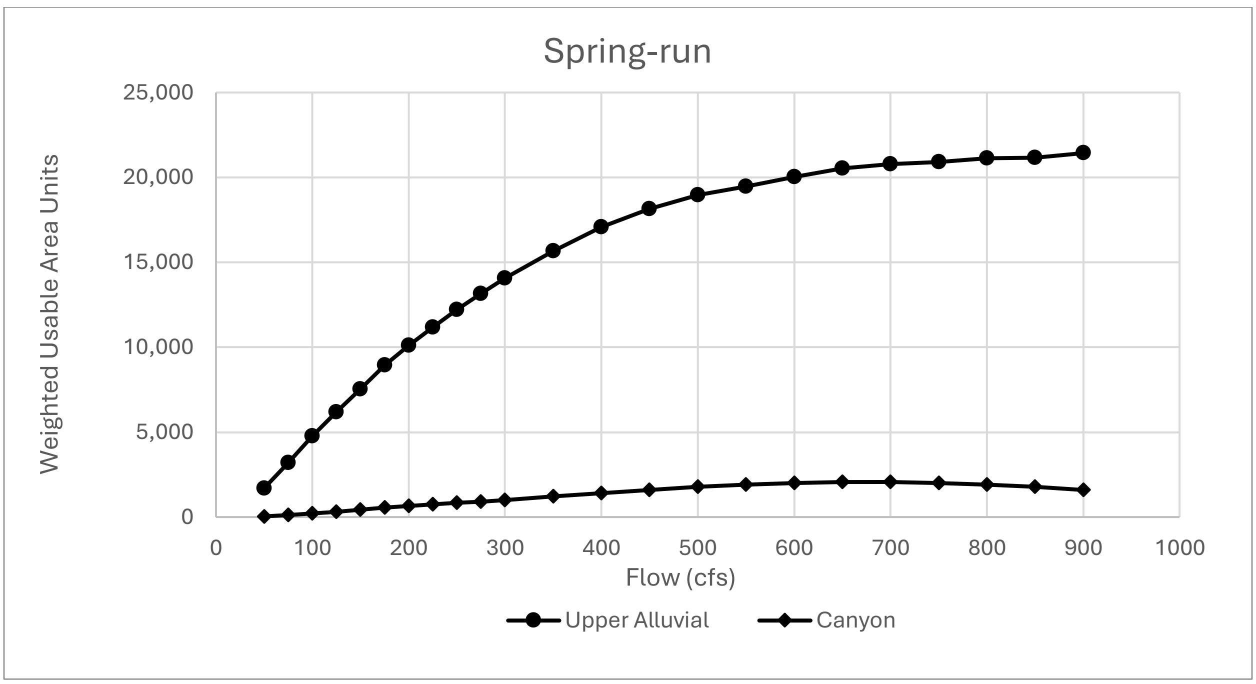

Figure O.1-2. Spawning WUA curves for Spring-Run Salmon in Clear Creek, Upper Alluvial and Canyon Segments.

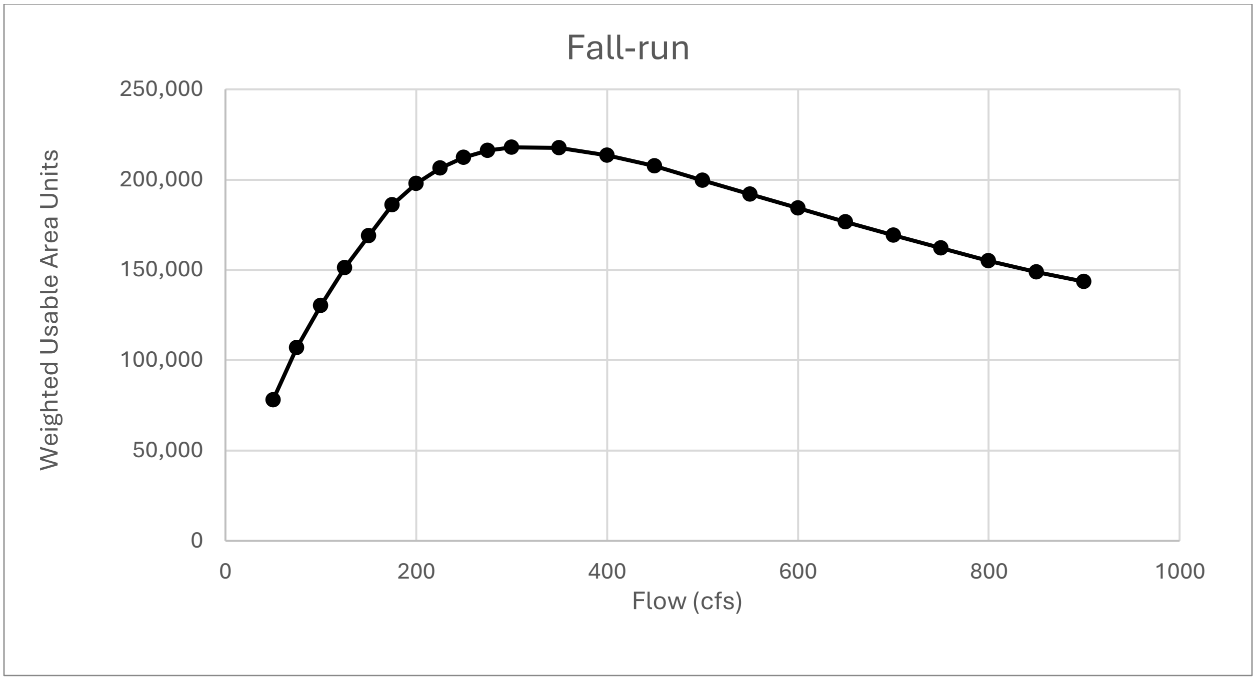

Figure O.1-3. Spawning WUA curve for Fall-Run Salmon in Clear Creek, Lower Alluvial Segment

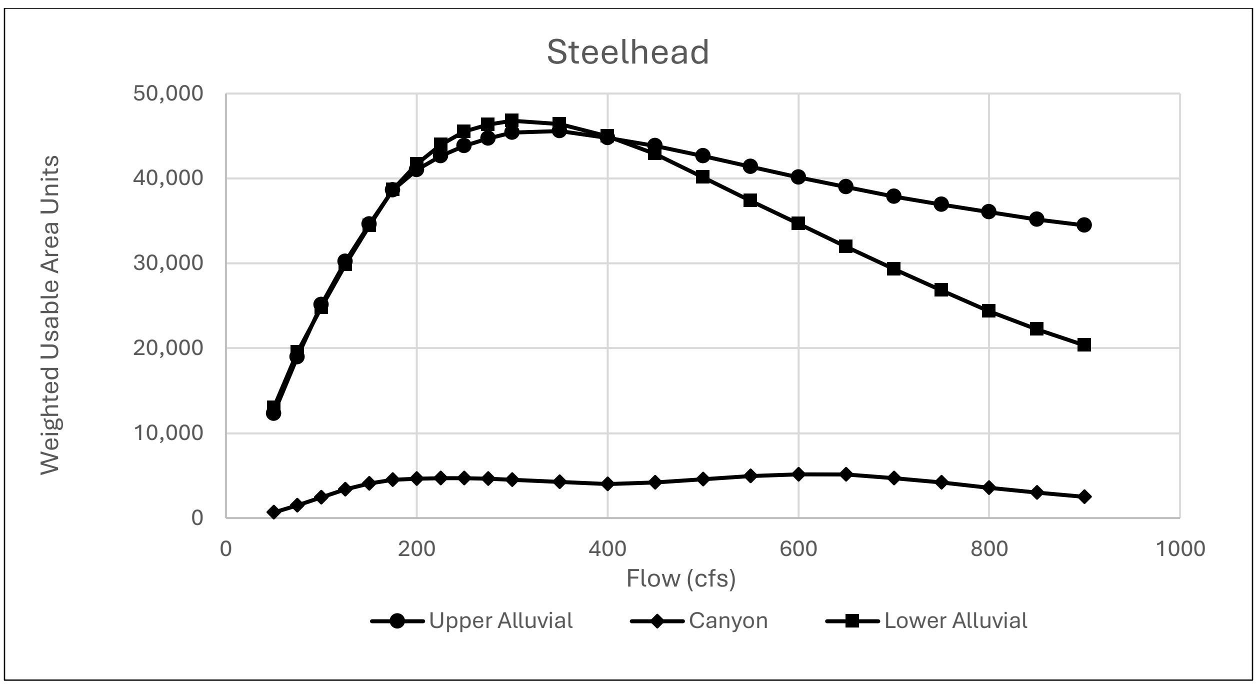

Figure O.1-4. Spawning WUA curves for Steelhead in Clear Creek, Upper Alluvial, Canyon, and Lower Alluvial Segments.

Spring-run and steelhead juveniles rear in the Upper Alluvial, Canyon, and Lower Alluvial stream segments (USFWS 2011b and 2013a), whereas fall-run juveniles rear only in the Lower Alluvial segment (USFWS 2013a). For the rearing WUA analyses, juvenile steelhead and resident rainbow trout were combined because they could not be differentiated in the field studies. The USFWS reports provide separate WUA curves for fry and juvenile life stages. Based on statistical analyses of differences in habitat use by different sizes of the fish (USFWS 2011b, 2013a), a length of 80 mm was used to divide fry from juveniles in the upper two segments and 60 mm was used to divide the two life stages in the Lower Alluvial segment. Based on a lack of statistically significant differences in habitat use, results were lumped for juveniles of spring-run and steelhead (USFWS 2011b and 2013a). The reports provide rearing WUA tables for spring-run and steelhead in the Upper Alluvial and Canyon segments (USFWS 2011b) and for both salmon races and steelhead in the Lower Alluvial segment (USFWS 2013a). The rearing WUA curves are provided below in Figure O.1-5 through Figure O.1-9.

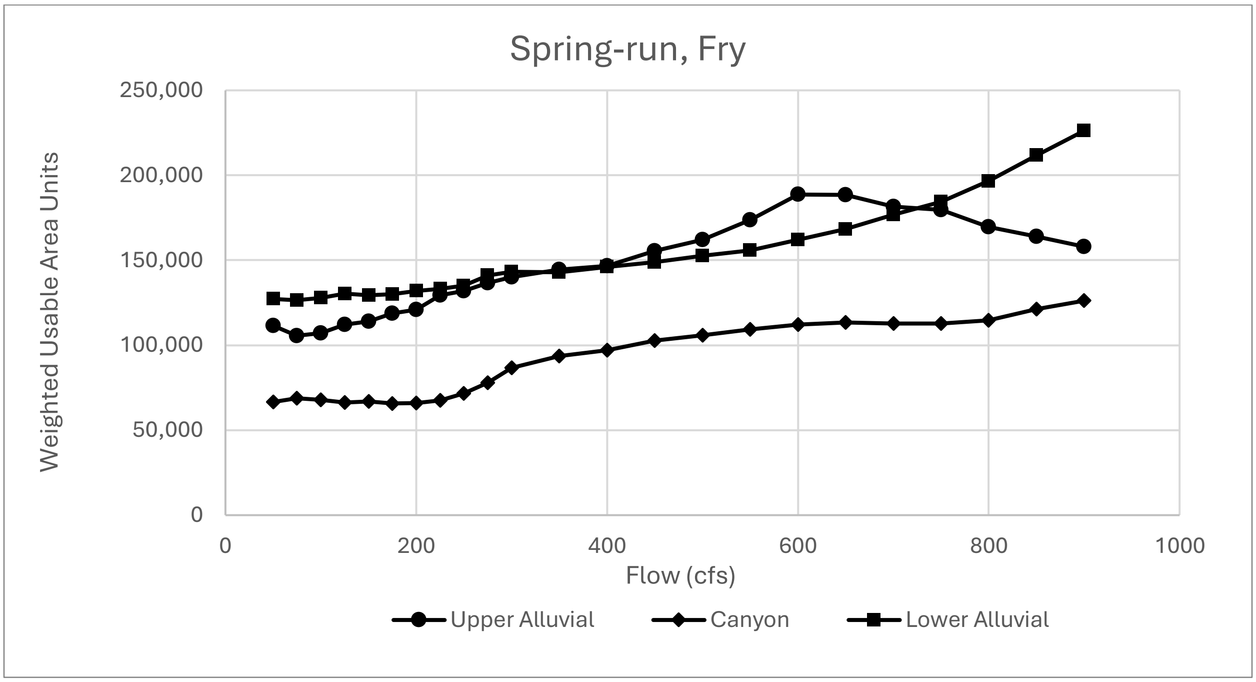

Figure O.1-5. Rearing WUA Curves for Spring-Run Salmon Fry in Clear Creek, Upper Alluvial, Canyon, and Lower Alluvial Segments.

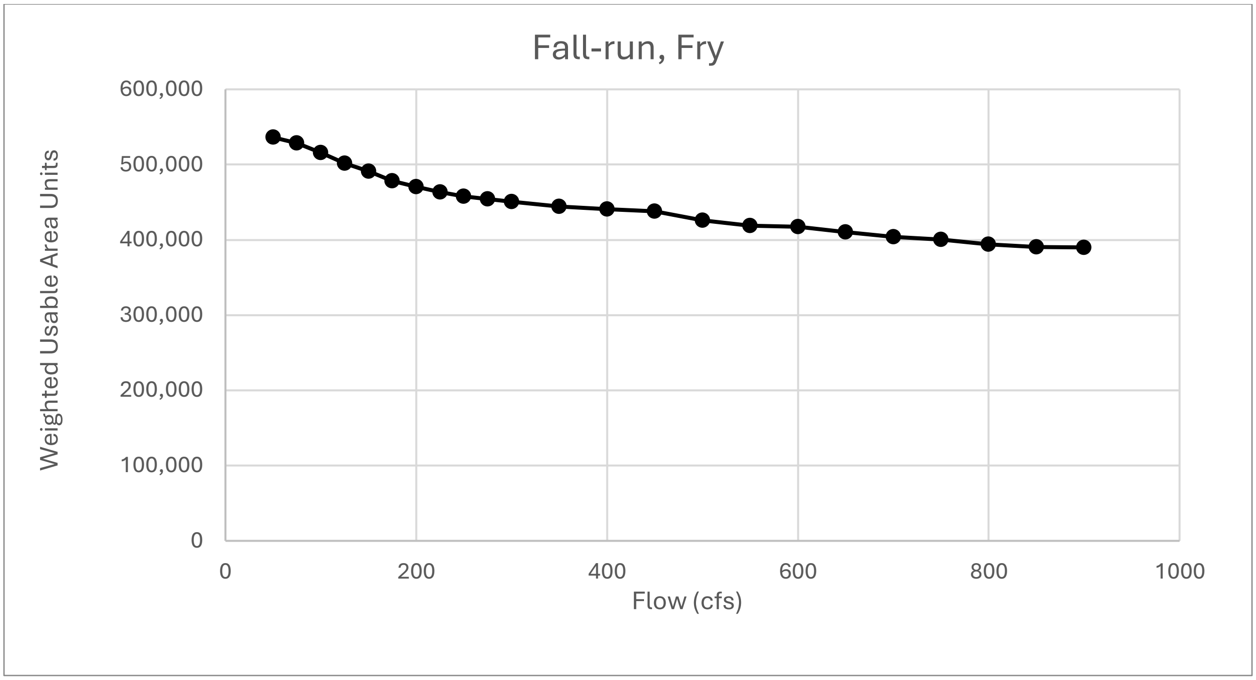

Figure O.1-6. Rearing WUA Curve for Fall-Run Salmon Fry in Clear Creek, Lower Alluvial Segment.

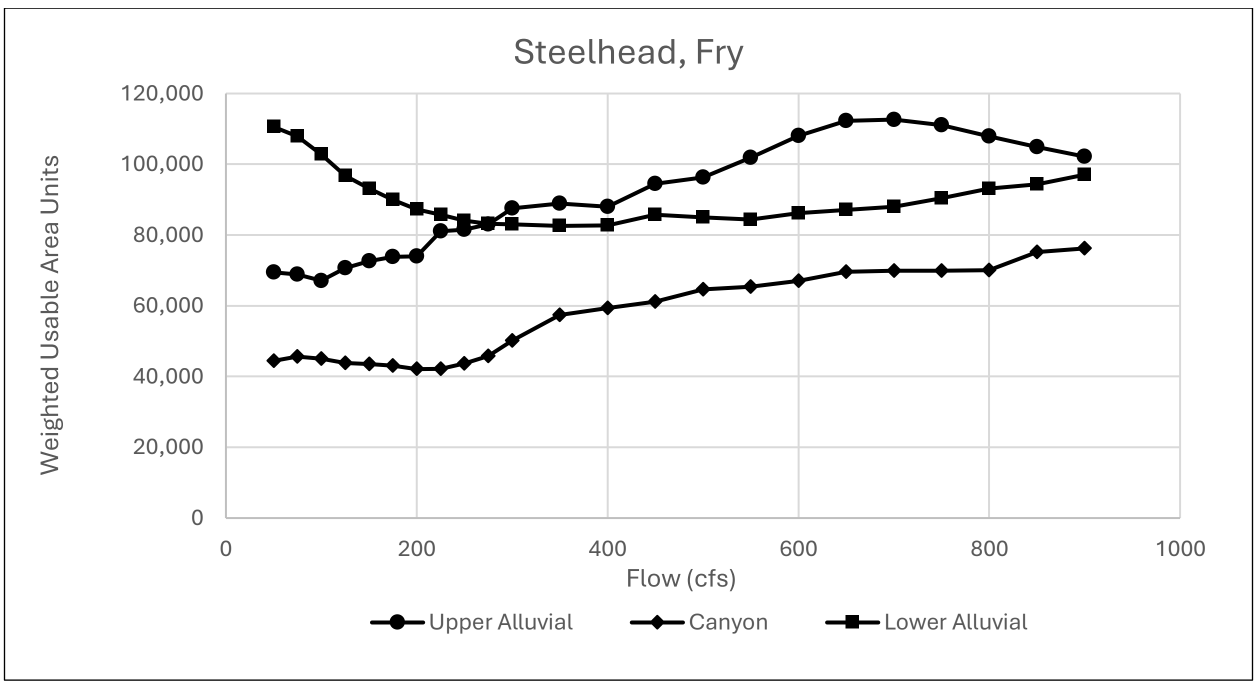

Figure O.1-7. Rearing WUA Curves for Steelhead Fry in Clear Creek, Upper Alluvial, Canyon, and Lower Alluvial Segments.

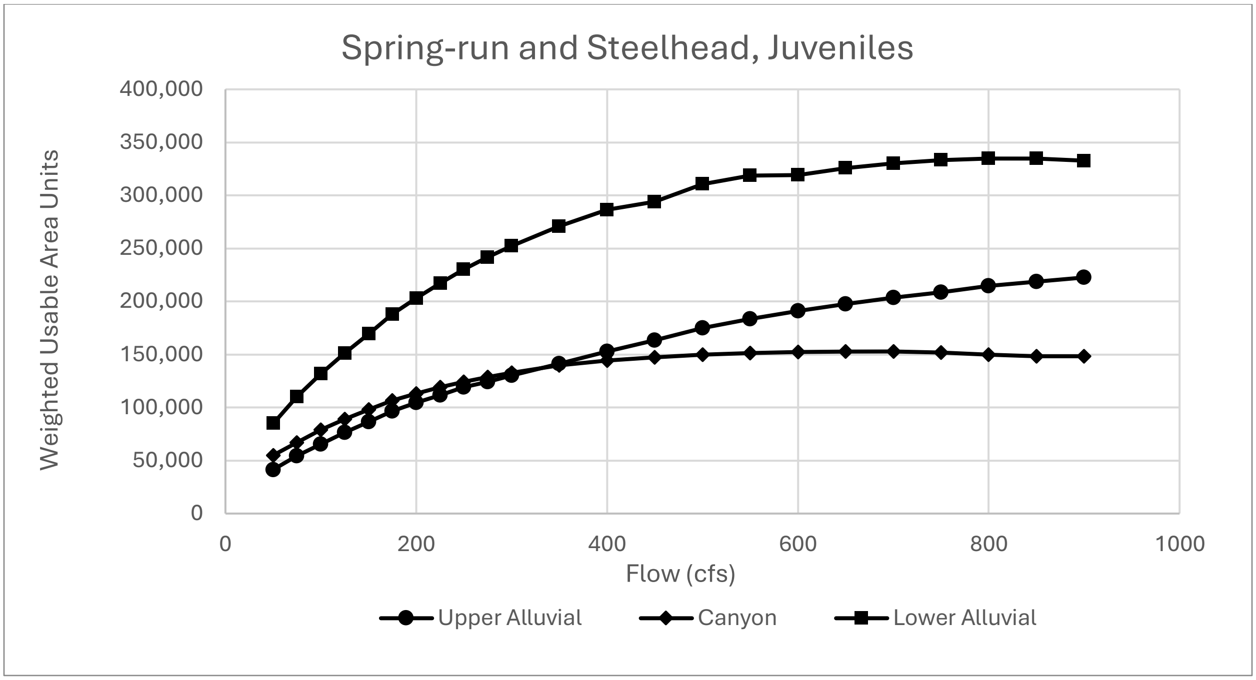

Figure O.1-8. Rearing WUA Curves for Spring-Run Salmon and Steelhead Juveniles in Clear Creek, Upper Alluvial, Canyon, and Lower Alluvial Segments.

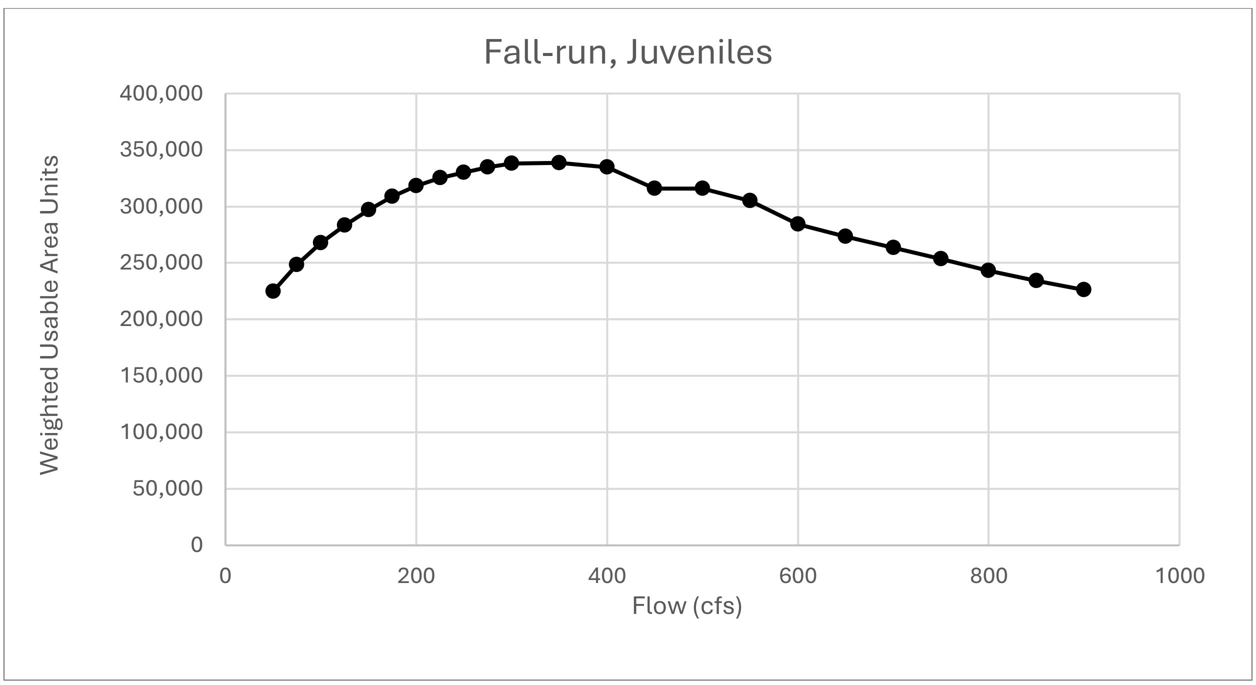

Figure O.1-9. Rearing WUA Curve for Fall-Run Salmon Juveniles in Clear Creek, Lower Alluvial Segment.

In this analysis, spawning and rearing WUA tables in the USFWS reports (USFWS 2007b, 2011a, 2011b, and 2013a) were used with CalSim 3 flow data for Whiskeytown Lake releases to Clear Creek to estimate spring-run, fall-run, and steelhead spawning and rearing WUA under the BA and EIS modeled scenarios for each month of the 100-year CalSim 3 period of record. Lower Clear Creek has only minor tributaries, so except under high runoff conditions, flow at Whiskeytown Lake is expected to adequately represents flow throughout the stream..

Spawning and rearing WUAs were determined using flows for the spawning and rearing periods of each run or species (Table O.1-1) under each water year type and all water year types combined. The spawning and rearing periods in Table O.1-1 were adopted from Table 1 in USFWS 2015, except that October was added for the Spring-run spawning period based on redd survey results from USFWS (2004, 2005, 2008, 2013b) . Total weighted mean spawning WUA was computed for the two Chinook races and steelhead by weighting the results of the WUA analyses by the month and segment weighting factors in Table O.1-2 and Table O.1-3. The monthly weighting factors for spring-run and fall-run spawning are from observations and redd survey results in USFWS 2015, 2013b, and 2008, while the monthly weighting factors for steelhead spawning are from Figure 35 and Figure 36 in Appendix C. The segment distribution weightings were determined from spawning habitat use data in USFWS 2007b and 2011. For fry and juvenile rearing, mean total WUAs were computed for the months given in Table O.1-1. No weighting factors were applied in computing the rearing WUAs because information on temporal and spatial distributions of the fry and juveniles was often inconsistent or ambiguous. For instance, data from RST surveys conducted at the mouth of Clear Creek were useful for monitoring emigration from the creek, but not for estimating temporal and spatial distribution of fry and juveniles within the creek. The means were computed for each water year type and all water year types combined.

Table O.1-1. Monthly Distributions of Spring-run, Fall-run and Steelhead Spawning in Clear Creek.

Life Stage	**Fall-run**	**Spring-run**	**Steelhead**
Spawning	October-December	September-October	December-April
Fry	January-April	November-March	February-June
Juvenile	May-September	April-August	July-December

Table O.1-2. Monthly Weighting Factors for Spring-run, Fall-run Chinook, and Steelhead Spawning in Clear Creek.

Month	**Spring-run Chinook**	**Steelhead**	**Fall-run Chinook**
January	0	0.35	0
February	0	0.4	0
March	0	0.05	0
April	0	0	0
May	0	0	0

Month	Spring-run Chinook	Steelhead	Fall-run Chinook
June	0	0	0
July	0	0	0
August	0	0	0
September	0.8	0	0
October	0.2	0	0.3
November	0	0	0.4
December	0	0.2	0.3

Table O.1-3. Spawning Distributions Factors of Spring-run, Fall-run and Steelhead for Three Major Segments of Spawning Habitat in Clear Creek.

Segment Description	Spring-run	Fall-run	Steelhead
Upper Alluvial	0.7	0	0.9
Canyon	0.3	0	0.02
Lower Alluvial Canyon	0	1.0	0.08

O.1.2.2 Assumptions / Uncertainty

This section includes two subsections. The first subsection provides a list of some important uncertainties and assumptions of the WUA analyses used for this effects analysis. The second subsection provides a more general discussion of the validity of WUA analysis, responding to concerns that have been raised in the scientific literature.

O.1.2.2.1 Important Uncertainties and Assumptions of the WUA Analyses Conducted for this Analysis

1. The CalSim 3 operations model used to estimate spawning and rearing WUA under the scenarios and the alternatives uses a monthly timestep. Therefore, the WUA results should be treated as monthly averages. Using monthly averages to compare spawning and rearing WUA results is suitable for showing differences in effects of the different flow regimes under scenarios and alternatives conditions. Monthly average WUA results faithfully represent the average conditions affecting the fish.

2. The suitability of physical habitat for salmon and steelhead spawning is largely a function of substrate particle size, water depth, and flow velocity. Other unmeasured factors (e.g., flow vortices, competition, water quality, etc.) could influence habitat suitability, contributing to uncertainty in the results.

3. The suitability of physical habitat for salmon and steelhead fry and juvenile rearing is largely a function of availability of cover, water depth, and flow velocity. Other unmeasured factors (e.g., flow vortices, complex feeding behaviors, competition, water quality, etc.) could influence habitat suitability, contributing to uncertainty in the results.

4. The output of the WUA analysis, is an index of habitat suitability, not an absolute measure of habitat surface area. In the literature, including in the USFWS reports on which this analysis is based (USFWS 2007b, 2011a, 2011b, 2013a), Weighted Usable Area may be expressed as square feet, square meters, or acres for a given linear distance of stream, which is misleading and can result in unsupported conclusions (Payne 2003; Railsback 2016; Reiser and Hilgert 2018).

5. Fixed spawning periods were used in this analysis for determining effects of changes in flow on spawning WUA (Table O.1-1). These periods are provided by USFWS (2015), which has collected data on spawning of salmonids in Clear Creek over many years. They are expected to represent the primary spawning periods of the fish. However, the timing of spawning by salmon and steelhead may vary somewhat among years depending on flows (Quinn 2005). The timing of spawning may be directly affected by flow volume in spawning habitats or indirectly affected via flow effects on upstream migration timing or water temperatures (Sullivan and Hileman 2019; Jennings and Hendrix 2020). The use of fixed spawning periods for this analysis does not account for these potential variations either in flow from year to year nor for differences in flow regimes between the alternative scenarios, which potentially increases uncertainty in the results. However, variations from the primary spawning periods are likely to be small, because spawn timing is a conservative, genetically controlled trait in anadromous fish (Quinn 2005).

6. WUA analyses assume that the channel characteristics of the river, such as proportions of mesohabitat types, during the time of field data collection by USFWS (2004-2009) have remained in dynamic equilibrium to the present time and will continue to do so through the life of the Project. If the channel characteristics substantially changed, the shape of the curves might no longer be applicable.

O.1.2.2.2 Discussion Regarding Validity of Weighted Usable Area Analysis

WUA analysis is among the most widely used and recognized analytical tools for assessing effects of flow on fish populations (Reiser and Hilgert 2018). Procedures for quantifying WUA were developed and standardized by USFWS in the 1970s and they have since been widely adopted by researchers (e.g., Bourgeois et al. 1996; Beecher et al. 2010; Railsback 2016; Naman et al. 2020). However, WUA analysis has received some criticism from instream flow analysis practitioners, especially in recent years. Many conclusions in this analysis regarding effects on fish of changes in flow resulting from operations are based on WUA analyses. Therefore, it is important to understand and evaluate the criticisms of WUA analysis and consider any potential limitations for assessing flow-related effects.

Two frequent criticisms of the WUA analysis that are most potentially relevant with regard to the results and conclusions of the analysis are: (1) WUA analysis fails to directly evaluate many factors that are known to be important to fish population production, including water quality (especially temperature), predation, competition, and food supply (Beecher et al. 2010; Railsback 2016; Naman et al. 2019, 2020). Effects of flows on critical processes such channel maintenance, floodplain inundation, and riparian regeneration are also beyond the scope of WUA analyses (Poff et al. 1997; Petts 2009), and (2) the models employed to develop the WUA curves (especially PHABSIM) are antiquated, the field observations and measurements used to run the models are not sufficiently fine-grained to capture important highly localized factors, and the models do not adequately capture many dynamic properties of fish habitat use (Railsback 2016; Reiser and Hilgert 2018).

Regarding the first criticism, PHABSIM and the WUA curves they produce were never meant to address all factors affecting fish populations. As noted in a recent paper rebutting many of the criticisms of PHABSIM (Stalnaker et al. 2017): "PHABSIM is a component of instream flow incremental methodology (IFIM), which is a multifaceted decision support system that looks at riverine ecology for the purpose of making water management decisions." The IFIM uses a suite of evaluation tools (including PHABSIM) and investigates water quality factors and other factors that affect fish in addition to the hydraulic-related habitat conditions analyzed using PHABSIM or related hydraulic habitat models such as RIVER-2D (Beecher 2017). Analysis methods other than PHABSIM are used to evaluate the other factors, which may or may not be affected by flow. These methods typically include evaluation tools for assessing effects on water temperatures, redd dewatering, adult migration passage, emigrating juvenile salmonid survival, water diversion entrainment, and other factors. Conclusions regarding effects of the Project on a species are based on evaluations of the results for all the factors analyzed.

The second criticism is more specific to the modeling tools used for WUA analyses. Many of the limitations of PHABSIM cited by critics are acknowledged by its defenders (Beecher 2017; Stalnaker et al. 2017; Reiser and Hilgert 2018). Some of the cited shortcomings are common to any model that attempts to simulate complex ecological systems. Others reflect that PHABSIM is antiquated; newer, more powerful procedures have been incorporated into newer models. In fact, many studies have replaced or combined PHABSIM with more powerful tools in recent years, including the RIVER2D hydraulic and habitat model, which was the principal hydraulic habitat model used in the USFWS analyses (USFWS 2007b, 2011a, 2011b, 2013a) to develop the Clear Creek WUA curves used in this analysis. The habitat variables included in the hydraulic/habitat modeling have also been expanded and improved (Li et al. 2019). For instance, improvements have been made in the flow velocity data used to represent the full range of flow velocity conditions affecting drift-feeding juvenile salmonids (Naman et al. 2019). Many of these improvements were incorporated in the USFWS Clear Creek WUA analyses (USFWS 2007b, 2011a, 2011b, 2013a). In addition, improvements have been developed to include a broader range of factors in the modeling, including some of those mentioned in the previous paragraph. One of these includes modeling of bioenergetic factors (Naman et al. 2020). Such methods are promising, but they are not currently available for use in analyzing flow effects on fish populations in Clear Creek.

Some shortcomings of WUA analysis are more difficult to remedy. For instance, competition within a cohort of juvenile salmonids may affect habitat use such that dominant fish exclude sub-dominants from optimal habitat locations, resulting in the highest densities of fish occupying sub-optimal habitat (Beecher et al. 2010; Beecher 2017). Some such biases are inevitable in any effort to model fish populations, but improvements in sampling and modeling techniques can be expected to lead to more accurate models in the future. PHABSIM and similar models, despite their shortcomings, continue to be among the most used and useful analytical tools for assessing instream-flow-related issues (Reiser and Hilgert 2018).

O.1.2.3 Code and Data Repository

Code, input, and output files for this analysis are available upon request.

O.1.3 Results

The following results provide the estimates of spawning and rearing WUA for spring-run and fall-run Chinook salmon and steelhead. For each race and species, the spawning and rearing WUA results are provided separately, with tables and figures for the BA and EIS modeled scenarios included in each section.

O.1.3.1 Spring-run Chinook Salmon

O.1.3.1.1 Spawning Weighted Usable Area

Table O.1-4 and Table O.1-5 provide the spawning WUA results for spring-run Chinook salmon under the BA modeled scenarios and EIS modeled scenarios, respectively. The results are the means for all years analyzed, weighted by their expected distributions among months (Table O.1-2) and creek segments (Table O.1-3). The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table O.1-5).

The results for both the BA and EIS modeled scenarios mostly show modest and inconsistent variation in mean spawning WUA with water year type for EXP1, EXP3, the NAA, and the BA and EIS modeled scenarios for alternatives, although WUA is generally lowest in critical water years and increases in wetter year types (Table O.1-4). This pattern of variation is consistent with the spring-run spawning WUA curves, which show increased WUA with increased flow (Figure O.1-2). Alt 1 and the EXP1 have relatively low spring-run spawning WUA for all water year types (Table O.1-4) because September and October flows are relatively low for these scenarios. For the EIS modeled scenarios, all of the scenarios had much lower spring-run spawning WUA values than the NAA (Table O.1-5). Much the largest reductions were for Alt 1, which had nearly 80% lower WUA values under all water year types.

Table O.1-4. Expected WUA for Spring-run Chinook Spawning in Clear Creek for EXP1, EXP3, the NAA, and Four Alt 2 Management Scenarios.

Water Year Type	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	1,270	2,857	2,876	2,532	2,532	2,532	2,532
AN	1,247	2,938	2,822	2,524	2,524	2,524	2,524
BN	382	2,085	2,729	2,497	2,270	2,281	2,265
Dry	387	1,644	2,859	2,525	2,525	2,525	2,525
Critical	281	1,463	2,535	2,289	2,071	2,108	2,061
All	737	2,215	2,783	2,484	2,408	2,416	2,406

Table O.1-5. Expected WUA for Spring-run Chinook Spawning in Clear Creek Confluence for the NAA and Alternatives 1-4.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	2,876	600	2,532	2,532	2,532	2,532	2,266	2,523
AN	2,822	596	2,524	2,524	2,524	2,524	2,263	2,515
BN	2,729	567	2,497	2,270	2,281	2,265	2,228	2,383
Dry	2,859	600	2,525	2,525	2,525	2,525	2,263	2,516
Critical	2,535	509	2,289	2,071	2,108	2,061	2,092	2,258
All	2,783	579	2,484	2,408	2,416	2,406	2,230	2,453
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	2,876	-79.13	-11.96	-11.96	-11.96	-11.96	-21.21	-12.28
AN	2,822	-78.89	-10.54	-10.54	-10.54	-10.54	-19.81	-10.87
BN	2,729	-79.23	-8.53	-16.84	-16.44	-17.02	-18.35	-12.68
Dry	2,859	-79.01	-11.68	-11.68	-11.68	-11.68	-20.85	-12.00
Critical	2,535	-79.93	-9.71	-18.30	-16.85	-18.67	-17.46	-10.91
All	2,783	-79.20	-10.75	-13.47	-13.19	-13.56	-19.87	-11.88

Figure O.1-10 and Figure O.1-11 show the differences in estimated mean spawning WUA for spring-run under the BA and EIS modeled scenarios, respectively, for spawning in September and October. These spawning WUA results were not computed with the monthly weighting factors in Table O.1-2 (0.8 for September and 0.2 for October). Eliminating the weighting factors facilitates comparisons of spawning habitat between months irrespective of the seasonal use patterns. The patterns of variation in spawning WUA among the different BA and EIS alternatives are quite similar for the two months, but spawning WUA is consistently greater for October than September. Spawning WUA is consistently higher under the NAA than under the four phases of Alternative 2 and differences among the Alternative 2 phases are small. For the BA alternatives (Figure O.1-10), WUA is much lower under EXP1 and moderately lower under EXP3 than under the four phases of Alternative 2 or the NAA. For the EIS alternatives (Figure O.1-11), spawning WUA is much lower under Alternative 1 than under the other alternatives in both months. Other than Alternative 1, the differences among the alternatives are minor, although Alternative 3 is consistently lower than Alternative 2 or Alternative 4. These results are consistent with the results for "All" water year types in Tables O.1-4 and O.1-5.

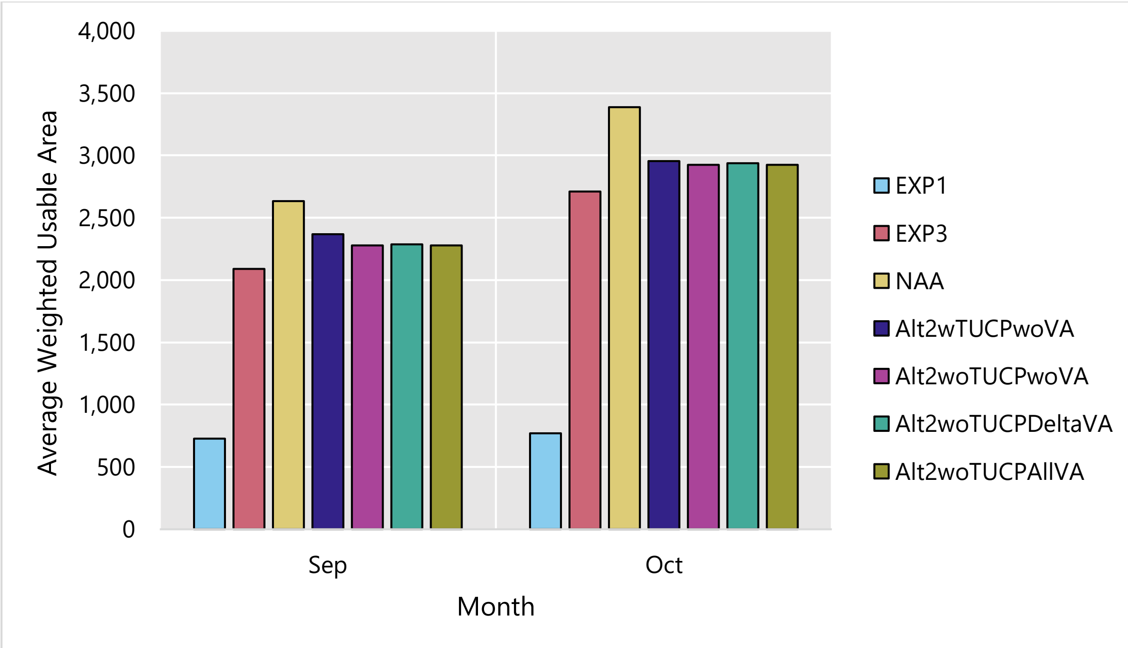

Figure O.1-10. Expected Average WUA for Spring-run Chinook Spawning in Clear Creek for EXP1, EXP3, NAA, and four phases of Alternative 2, by Month with the Two Spawning Segments Combined

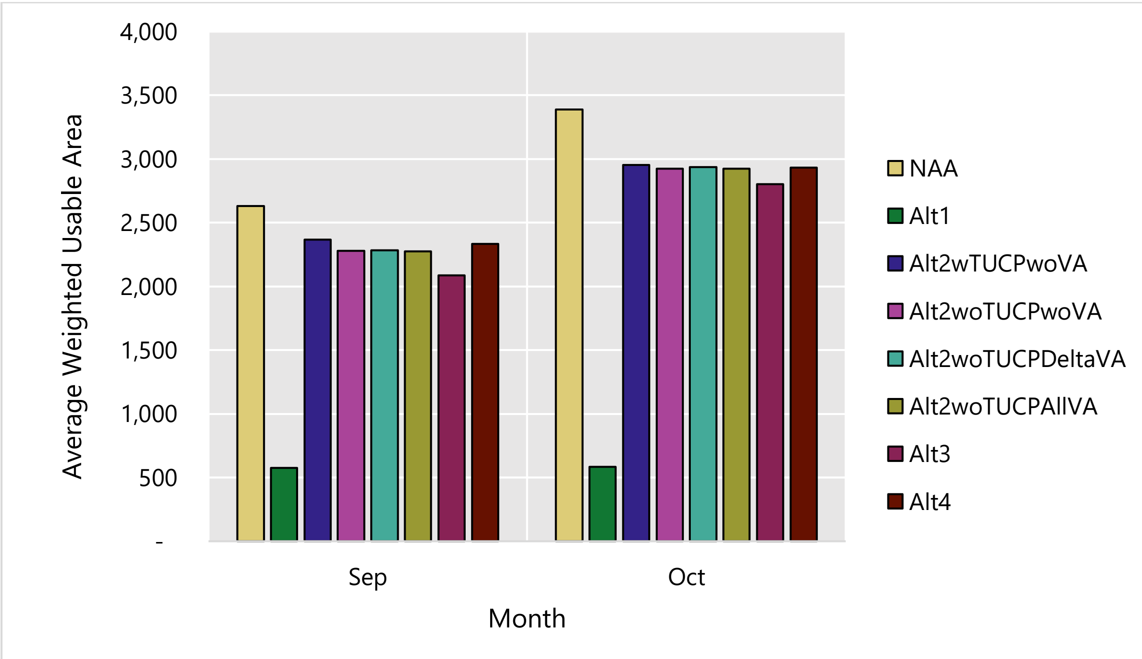

Figure O.1-11. Expected Average WUA for Spring-run Chinook Spawning in Clear Creek for the NAA and Alternatives 1-4, by Month with the Two Spawning Segments Combined

O.1.3.1.2 Rearing Weighted Usable Area

Table O.1-6 through Table O.1-9 provide the rearing WUA results for fry and juveniles of Clear Creek spring-run under the BA and EIS modeled scenarios, respectively. The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table O.1-7 and Table O.1-9).

The results for both the BA and EIS modeled scenarios mostly show modest variation in mean fry rearing WUA among water year types for EXP 1, EXP 3, the NAA, and the BA and EIS modeled scenarios for alternatives, with generally small increases from drier to wetter water year types (Table O.1-6 and Table O.1-7). This reflects the shape of the spring-run fry rearing WUA curves, which monotonically increase with flow in the Canyon and Lower Alluvial segments and increase with flow in the Upper Alluvial segment until peaking at about 600 cfs (Figure O.1-5). For the EIS modeled scenarios, all the scenarios have higher fry rearing WUA values than the NAA, except Alt 1 which has values for all water year types (Table O.1-7). Differences are consistently large for all scenarios, exceeding 5% except for Alt 1 under critical water years, for which the difference is a 3.6% reduction in WUA.

Table O.1-6. Expected WUA for Spring-run Chinook Fry Rearing in Clear Creek for EXP1, EXP3, the NAA, and Four Alt 2 Management Scenarios.

Water Year Type	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	89,129	87,750	67,499	71,419	71,406	71,404	71,404
AN	86,895	85,024	66,091	69,859	69,859	69,859	69,859
BN	69,829	70,347	64,684	69,313	69,163	69,128	69,133
Dry	69,618	68,570	64,168	69,141	69,141	69,141	69,141
Critical	54,122	58,434	61,003	64,628	64,607	64,602	64,595
All	75,058	74,942	64,956	69,188	69,154	69,147	69,146

Table O.1-7. Expected WUA for Spring-run Chinook Fry Rearing in Clear Creek Confluence for the NAA and Alternatives 1-4.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	67,499	62,303	71,419	71,406	71,404	71,404	71,319	71,611
AN	66,091	60,831	69,859	69,859	69,859	69,859	69,816	70,100
BN	64,684	59,861	69,313	69,163	69,128	69,133	69,221	69,531
Dry	64,168	60,832	69,141	69,141	69,141	69,141	69,033	69,298
Critical	61,003	58,801	64,628	64,607	64,602	64,595	65,079	64,816
All	64,956	60,744	69,188	69,154	69,147	69,146	69,184	69,383
WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	67,499	-7.70	5.81	5.79	5.79	5.79	5.66	6.09
AN	66,091	-7.96	5.70	5.70	5.70	5.70	5.64	6.07
BN	64,684	-7.46	7.16	6.92	6.87	6.88	7.01	7.49
Dry	64,168	-5.20	7.75	7.75	7.75	7.75	7.58	8.00
Critical	61,003	-3.61	5.94	5.91	5.90	5.89	6.68	6.25
All	64,956	-6.48	6.51	6.46	6.45	6.45	6.51	6.81

Figure O.1-10 and Figure O.1-11 show the differences in estimated mean fry rearing WUA for spring-run under the BA and EIS modeled scenarios, respectively, for each month of the November through March fry rearing period. Rearing WUA among the four phases of Alternative 2 is nearly identical for the four phases of Alternative 2 and shows increases with respect to the NAA in all months except February, for which NAA has a slightly higher value. For the BA scenarios (Figure O.1-12), EXP1 and EXP3 vary among the months of the rearing period much more than the NAA or the four phases of Alternative 2, steadily increasing from relatively low values in November to their maximum values in February or March. For the EIS alternatives (Figure O.1-13), fry rearing WUA is lower under Alternative 1 than the NAA in every month. WUA under Alternatives 3 and 4 is similar to that of the four phases of Alternative 2. All the alternatives have their lowest values in November and highest in January and February, but the range is not large. These results are consistent with the results for “All” water year types in Tables O.1-6 and O.1-7.

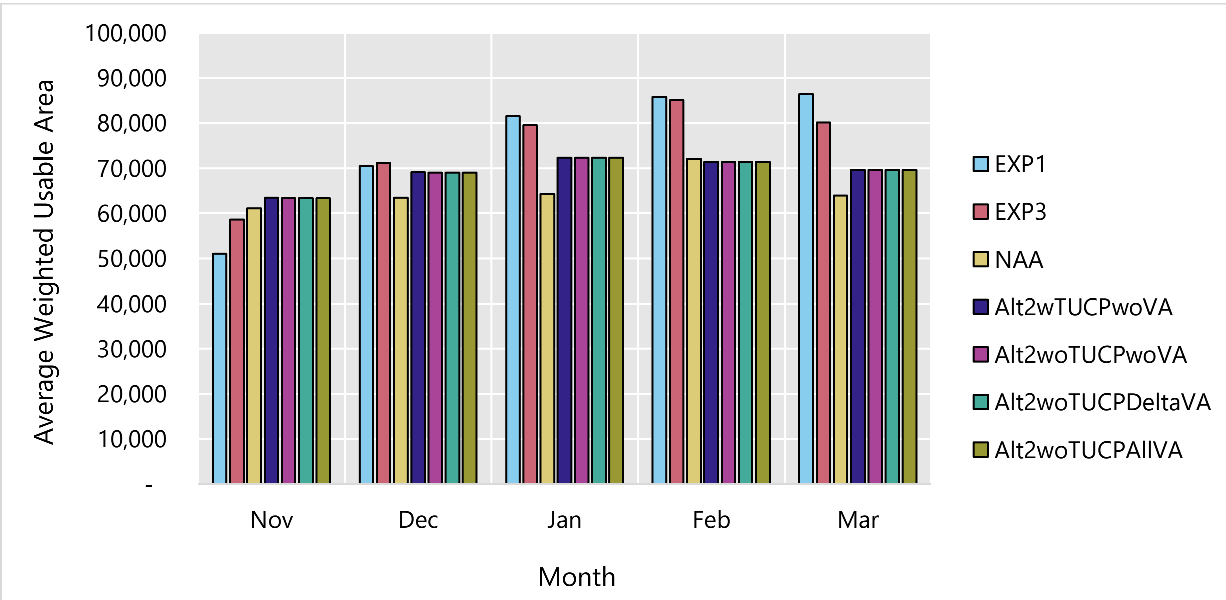

Figure O.1-12. Expected Average WUA for Spring-run Chinook Fry Rearing in Clear Creek for EXP1, EXP3, NAA, and four phases of Alternative 2, by Month with All Three Segments Combined.

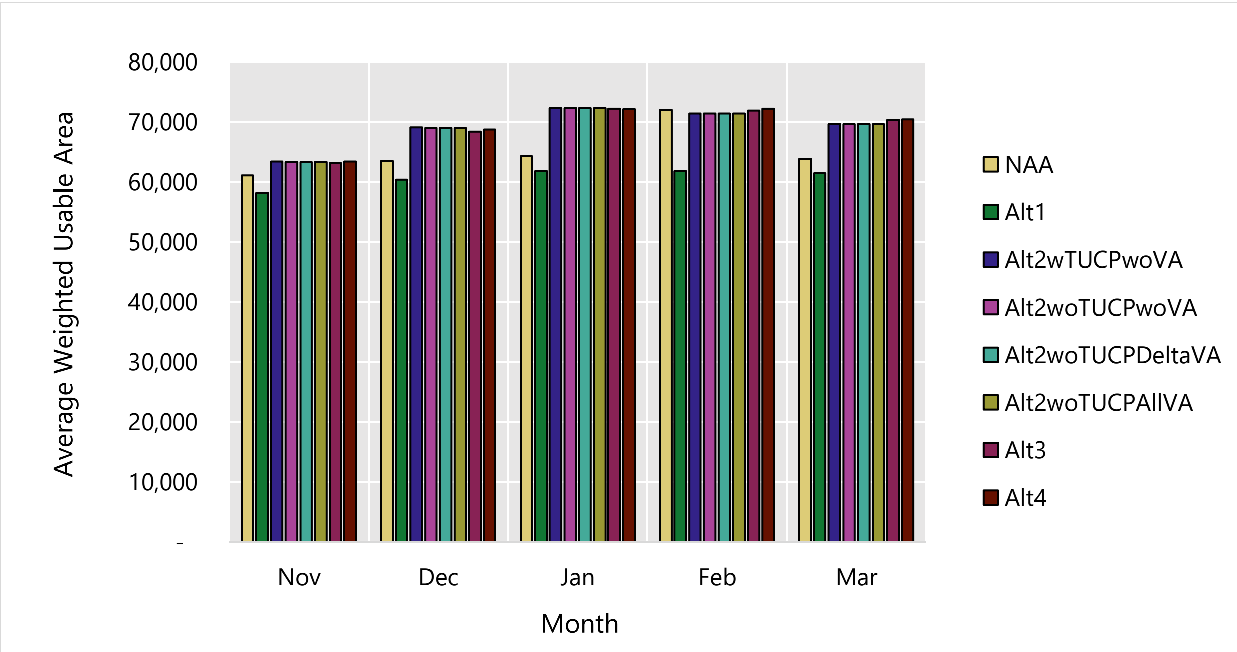

Figure O.1-13. Expected Average WUA for Spring-run Chinook Fry Rearing in Clear Creek for the NAA and Alternatives 1-4 by Month with All Three Segments Combined.

The results for both the BA and EIS modeled scenarios mostly show modest variation in mean spring-run juvenile rearing WUA among water year types for EXP1, EXP3, the NAA, and the BA and EIS modeled scenarios for alternatives, with generally small increases from drier to wetter water year types (Table O.1-8 and Table O.1-9). This reflects the shape of the spring-run juvenile rearing WUA curves, which increase with flow in the Upper and Lower Alluvial segments and increase in the Canyon segment for flows below about 500 cfs then plateau at higher flows (Figure O.1-8). For the EIS modeled scenarios, all the scenarios except Alt 1 have consistently lower juvenile rearing WUA than the NAA (Table O.1-7). Reductions range from 4.1% to 7.7% for these scenarios. Alt 1 has much lower juvenile rearing values than the NAA or any of the other EIS modeled scenarios for all water year types, ranging up to 56.4% lower (Table O.1-9). As previously noted, Alt 1 has consistently much lower flows than all other scenarios.

Table O.1-8. Expected WUA for Spring-run Chinook Juvenile Rearing in Clear Creek for EXP1, EXP3, the NAA, and Four Phases of Alternative 2.

Water Year Type	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	84,580	96,306	83,160	78,986	78,986	78,986	78,986
AN	83,572	91,815	83,160	78,986	78,986	78,986	78,986
BN	69,670	79,876	83,160	78,986	78,986	78,986	78,986
Dry	64,056	71,479	82,935	78,639	78,639	78,639	78,639
Critical	57,322	58,347	73,473	69,071	68,673	69,153	69,398
All	72,468	80,688	81,556	77,316	77,253	77,330	77,369

Table O.1-9. Expected WUA for Spring-run Juvenile Rearing in Clear Creek Confluence for the NAA and Alternatives 1-4.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	83,160	36,217	78,986	78,986	78,986	78,986	79,682	79,134
AN	83,160	36,217	78,986	78,986	78,986	78,986	79,682	79,134
BN	83,160	36,217	78,986	78,986	78,986	78,986	79,682	79,134
Dry	82,935	36,217	78,639	78,639	78,639	78,639	79,302	78,779
Critical	73,473	35,540	69,071	68,673	69,153	69,398	67,826	69,265
All	81,556	36,109	77,316	77,253	77,330	77,369	77,694	77,470
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	83,160	-56.45	-5.02	-5.02	-5.02	-5.02	-4.18	-4.84
AN	83,160	-56.45	-5.02	-5.02	-5.02	-5.02	-4.18	-4.84
BN	83,160	-56.45	-5.02	-5.02	-5.02	-5.02	-4.18	-4.84
Dry	82,935	-56.33	-5.18	-5.18	-5.18	-5.18	-4.38	-5.01
Critical	73,473	-51.63	-5.99	-6.53	-5.88	-5.55	-7.69	-5.73
All	81,556	-55.73	-5.20	-5.28	-5.18	-5.13	-4.74	-5.01

Figure O.1-14 and Figure O.1-15 show the differences in estimated rearing WUA for spring-run juveniles under the BA and EIS modeled scenarios, respectively, for each month of the April through August juvenile rearing period. The four phases of Alternative 2 have largely similar rearing WUA values, ranging in parallel from relatively high values in April through June to lower values in July and August. Rearing WUA for the four phases of Alternative 2 are higher than the NAA in all April and May and lower than the NAA in June through August. For the BA alternatives (Figure O.1-14), EXP1 varies much more than the NAA or the four phases of Alternative 2, steadily falling from relatively high values in April to increasingly lower in the later months. Rearing WUA under EXP3 varies from similar, relatively high values in April through June and substantially lower values in July and August. For the EIS alternatives (Figure O.1-15), juvenile rearing WUA is consistently much lower under Alternative 1 than under the NAA or any of the other alternatives. Alternatives 3 and 4 are largely similar to the four phases of Alternative 2. These results are generally consistent with those for "All" water year types in Tables O.1-8 and O.1-9.

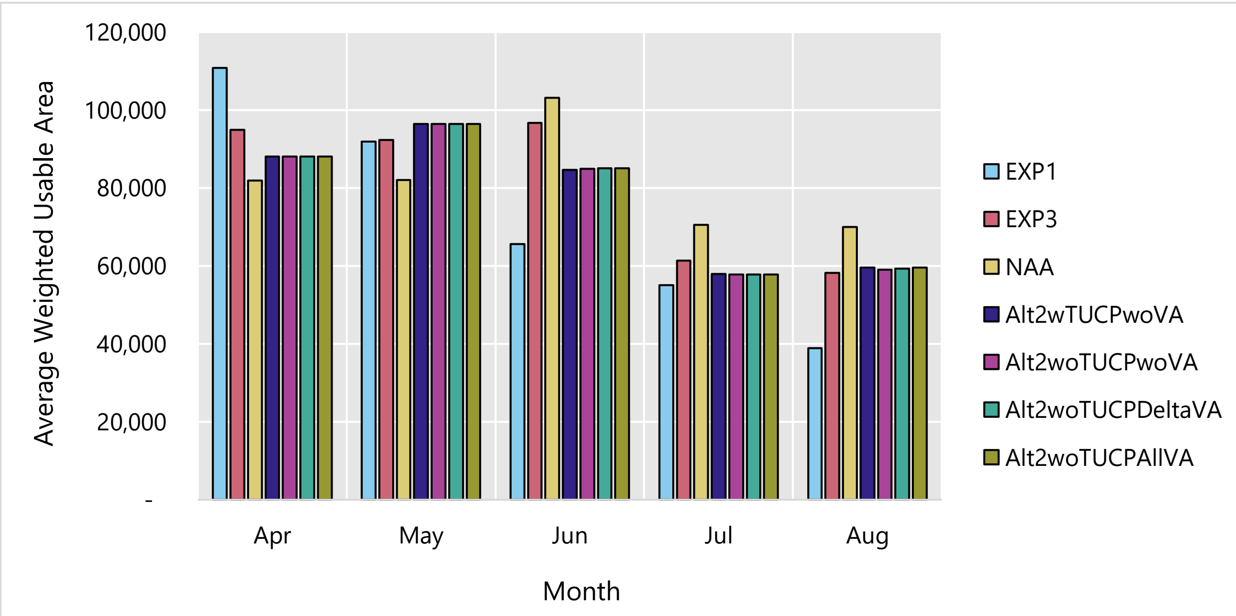

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Figure O.1-14. Expected Average WUA for Spring-run Chinook Juvenile Rearing in Clear Creek for EXP1, EXP3, NAA, and four phases of Alternative, by Month with All Three Segments Combined

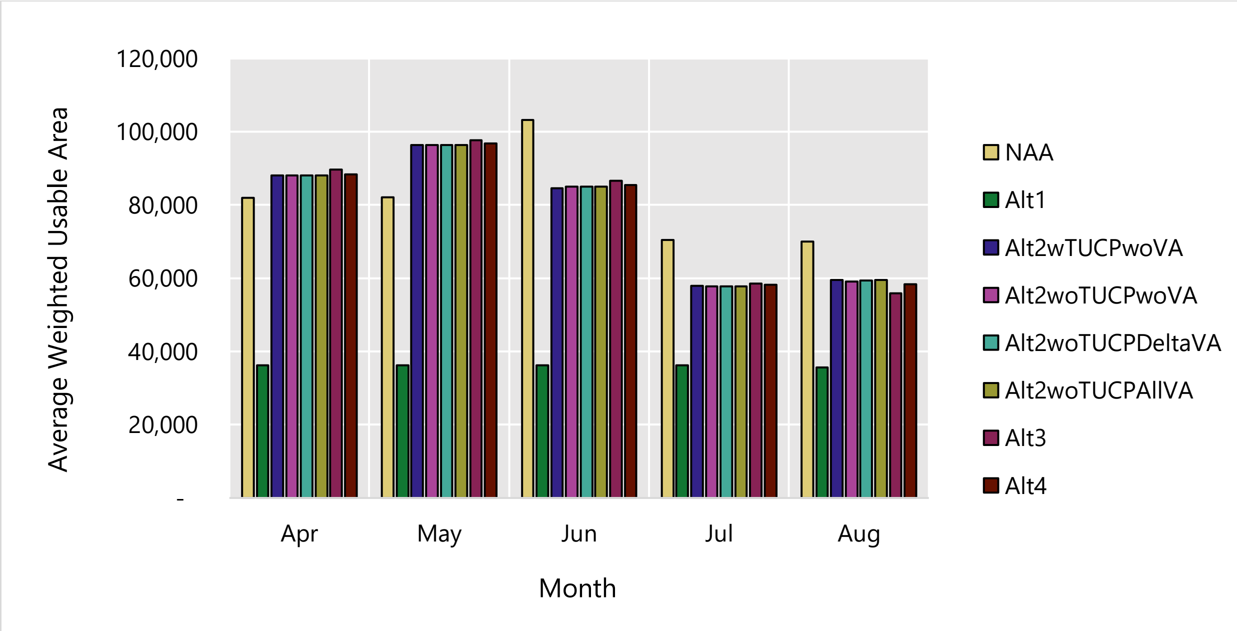

Figure O.1-15. Expected Average WUA for Spring-run Chinook Juvenile Rearing in Clear Creek for the NAA, and Alternative 1, Alternative 3, Alternative 4, and four phases of Alternative 2, by Month with All Three Segments Combined

O.1.3.2 Steelhead

O.1.3.2.1 Spawning Weighted Usable Area

Table O.1-10 and Table O.1-11 provide the spawning WUA results for steelhead under the BA modeled scenarios and EIS modeled scenarios, respectively. The results are the means for all years analyzed, weighted by their expected distributions among months (Table O.1-2) and creek segments (Table O.1-3). The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table O.1-11).

The results for both the BA and EIS modeled scenarios show modest increases in mean spawning WUA from dry to wet water year types (Table O.1-10). This pattern of variation reflects the steelhead spawning WUA curves for the Upper and Lower Alluvial segments, which vary widely with flow, increasing from very low values at the lowest flows, peaking at about 300cfs, and then dropping off at higher flows show (Table O.1-4). Therefore, a wide range of flows, including low flows in dry years and high flows in wet years, can depress the spawning WUA values. Alternative 1 has especially low steelhead spawning WUA for all water year types (Table O.1-11) because winter flows are relatively low under this scenario (mean flow <100 cfs). For the EIS modeled scenarios, all of the scenarios have higher steelhead spawning WUA values than the NAA except Alt 1, for which the values are much lower (ranging from 61.9% to 65.2% lower) (Table O.1-11). The increases in spawning WUA for the other scenarios range from 5.3% to 7.4%.

Table O.1-10. Expected WUA for Steelhead Spawning in Clear Creek for EXP1, EXP3, the NAA, and Four Phases of Alternative 2.

WYT	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	8,818	8,915	10,299	10,863	10,863	10,863	10,863
AN	8,879	9,066	10,326	10,872	10,872	10,872	10,872
BN	8,191	8,792	10,223	10,903	10,822	10,824	10,822
Dry	8,669	9,297	9,897	10,617	10,617	10,617	10,617
Critical	7,057	7,733	9,152	9,653	9,654	9,654	9,654
All	8,396	8,817	10,009	10,619	10,605	10,605	10,605

Table O.1-11. Expected WUA for Steelhead Spawning in Clear Creek Confluence for the NAA and Alternatives 1-4.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	10,299	3,922	10,863	10,863	10,863	10,863	10,879	10,863
AN	10,326	3,598	10,872	10,872	10,872	10,872	10,893	10,872
BN	10,223	3,585	10,903	10,822	10,824	10,822	10,922	10,897
Dry	9,897	3,620	10,617	10,617	10,617	10,617	10,628	10,617
Critical	9,152	3,489	9,653	9,654	9,654	9,654	9,649	9,653
All	10,009	3,674	10,619	10,605	10,605	10,605	10,632	10,618
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	10,299	-61.91	5.48	5.48	5.48	5.48	5.63	5.47
AN	10,326	-65.16	5.29	5.29	5.29	5.29	5.49	5.29
BN	10,223	-64.94	6.65	5.86	5.88	5.86	6.84	6.60
Dry	9,897	-63.43	7.28	7.28	7.28	7.28	7.39	7.28
Critical	9,152	-61.88	5.46	5.48	5.48	5.48	5.42	5.46
All	10,009	-63.29	6.09	5.95	5.95	5.95	6.22	6.08

Figure O.1-10 and Figure O.1-11 show the differences in estimated mean spawning WUA for steelhead under the BA and EIS modeled scenarios, respectively, for spawning in December through March.

These spawning WUA results were not computed with the monthly weighting factors in Table O.1-2. Eliminating the weighting factors facilitates comparisons of spawning habitat between months irrespective of the seasonal use patterns. The patterns of variation in spawning WUA among the different BA and EIS alternatives are quite similar for all four months. Spawning WUA varies little among the four phases of Alternative 2 and is consistently greater under the four phases than under the NAA. For the BA alternatives (Figure O.1-16), spawning WUA is consistently lower under EXP1 and EXP3 than under the NAA or the four phases of Alternative 2. For the EIS alternatives (Figure O.1-17), spawning WUA is much lower under Alternative 1 than that under the other alternatives or the NAA in all four months. These results are consistent with the results for "All" water year types in Tables O.1-10 and O.1-11.

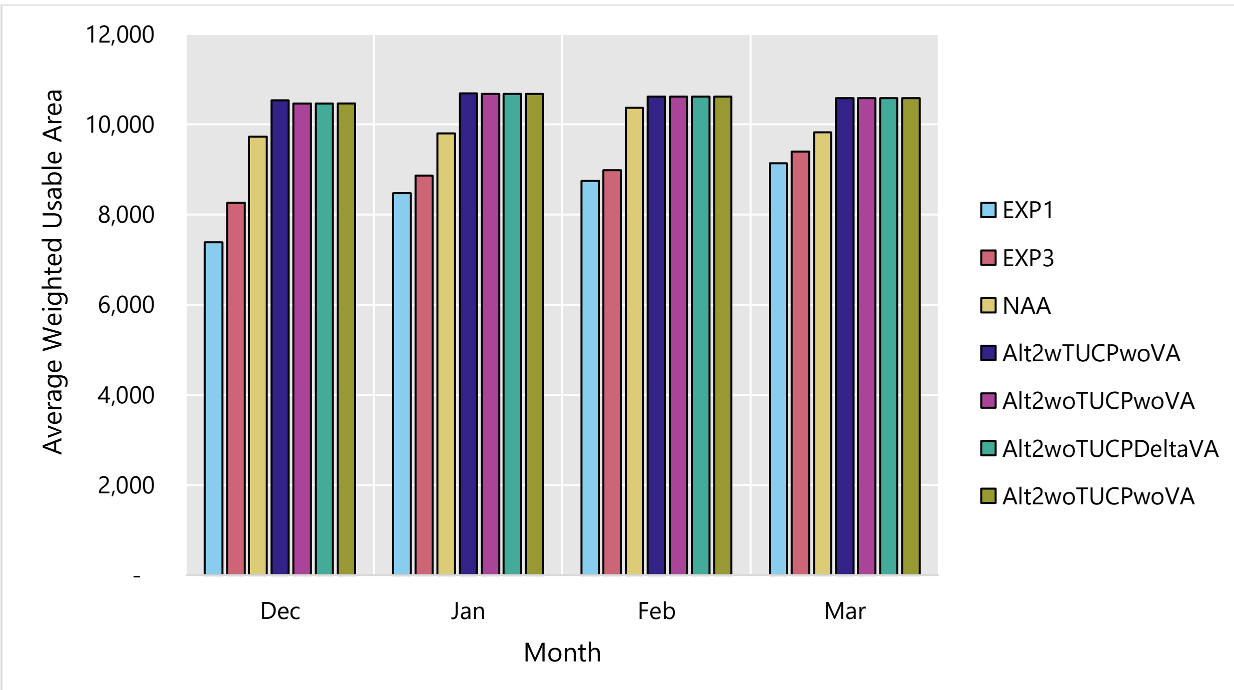

Figure O.1-16. Expected Average WUA for Steelhead Spawning in Clear Creek for EXP1, EXP3, NAA, and Four Phases of Alternative 2, by Month

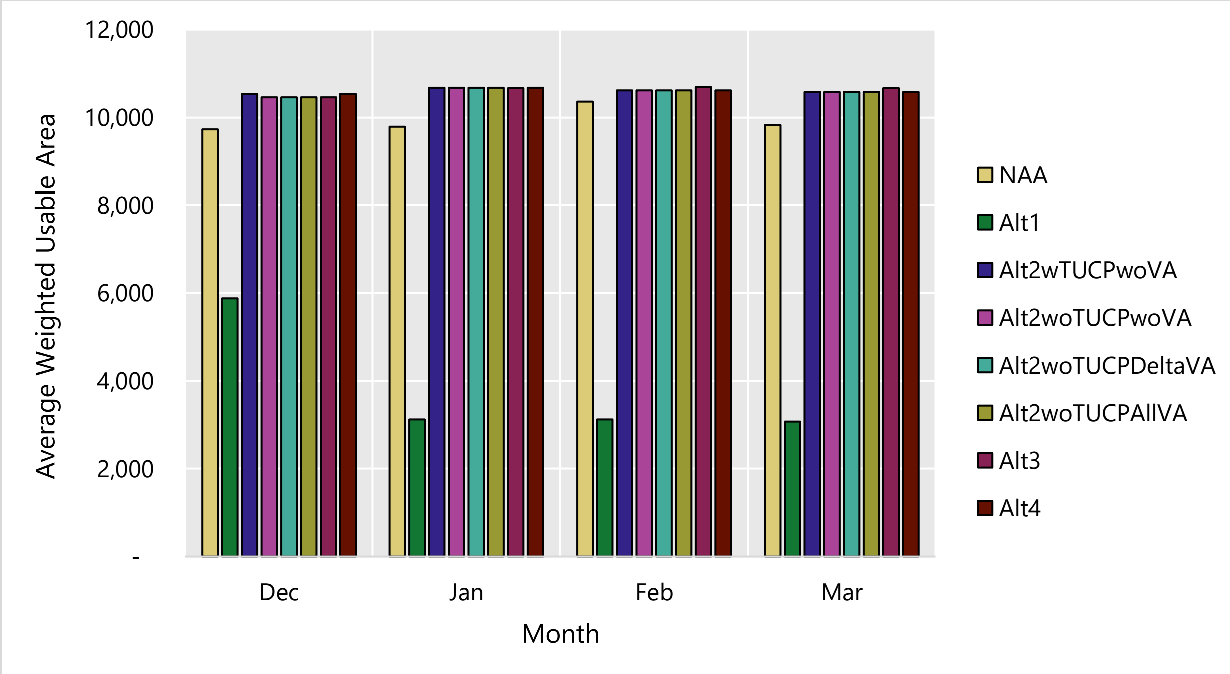

Figure O.1-17. Expected Average WUA for Steelhead Spawning in Clear Creek for the NAA and Alternatives 1-4, by Month

O.1.3.2.2 Rearing Weighted Usable Area

Table O.1-12 through Table O.1-15 provide the rearing WUA results for fry and juveniles of Clear Creek steelhead under the BA and EIS modeled scenarios, respectively. The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table O.1-13 and Table O.1-15).

The results for both the BA and EIS modeled scenarios mostly show modest variation in mean fry rearing WUA among water year types for EXP1, EXP3, the NAA, and the BA and EIS modeled scenarios for alternatives, with generally small increases from drier to wetter water year types (Table O.1-6 and Table O.1-7). This reflects the inconsistent variations in the shapes of the steelhead fry rearing WUA curves (Figure O.1-7). For the EIS modeled scenarios, most differences from the NAA are small (≤1%), except for Alt 1 (Table O.1-13). Under Alt 1, fry rearing WUA ranges from 5.6% to 7.7% higher than under the NAA (Table O.1-13).

Table O.1-12. Expected WUA for Steelhead Fry Rearing in Clear Creek for EXP1, EXP3, the NAA, and Four Alt 2 Management Scenarios.

Water Year Type	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	49,478	48,718	42,717	42,498	42,498	42,498	42,498
AN	49,418	48,014	42,444	42,237	42,237	42,237	42,237
BN	45,185	43,191	42,286	42,237	42,237	42,237	42,237

Water Year Type	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Dry	44,835	43,662	41,849	42,152	42,152	42,152	42,152
Critical	41,374	40,602	41,648	41,376	41,442	41,460	41,460
All	46,286	45,113	42,222	42,152	42,163	42,166	42,166

Table O.1-13. Expected WUA for Steelhead Fry Rearing in Clear Creek Confluence for the NAA and Alternatives 1-4.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	42,717	45,090	42,498	42,498	42,498	42,498	42,706	42,773
AN	42,444	44,871	42,237	42,237	42,237	42,237	42,455	42,522
BN	42,286	44,871	42,237	42,237	42,237	42,237	42,455	42,522
Dry	41,849	44,871	42,152	42,152	42,152	42,152	42,333	42,395
Critical	41,648	44,871	41,376	41,442	41,460	41,460	41,717	41,580
All	42,222	44,933	42,152	42,163	42,166	42,166	42,378	42,411
WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	42,717	5.56	-0.51	-0.51	-0.51	-0.51	-0.03	0.13
AN	42,444	5.72	-0.49	-0.49	-0.49	-0.49	0.03	0.18
BN	42,286	6.11	-0.11	-0.11	-0.11	-0.11	0.40	0.56
Dry	41,849	7.22	0.73	0.73	0.73	0.73	1.16	1.31
Critical	41,648	7.74	-0.65	-0.49	-0.45	-0.45	0.17	-0.16
All	42,222	6.42	-0.16	-0.14	-0.13	-0.13	0.37	0.45

Figure O.1-10 and Figure O.1-11 show the differences in estimated mean fry rearing WUA for steelhead under the BA and EIS modeled scenarios, respectively, for each month of the February through June fry rearing period. Both figures show rearing WUA values for the four phases of Alternative 2, which are almost identical and vary little among months. The rearing WUA values under the NAA are more variable and are higher than the values for the four phases of Alternative 2 in February and June and lower than those values in March through May, although all differences are small. For the BA scenarios (Figure O.1-18), rearing WUA under EXP1 and EXP3 declines modestly from February and March through June. Both have higher WUA than the NAA in all months except in June, when WUA values are higher for the NAA. For the EIS alternatives (Figure O.1-19), fry rearing WUA is modestly higher under Alternative 1 than under the NAA, the four phases of Alternative 2, or Alternatives 3 and 4. These results are consistent with the results for “All” water year types in Tables O.1-12 and O.1-13.

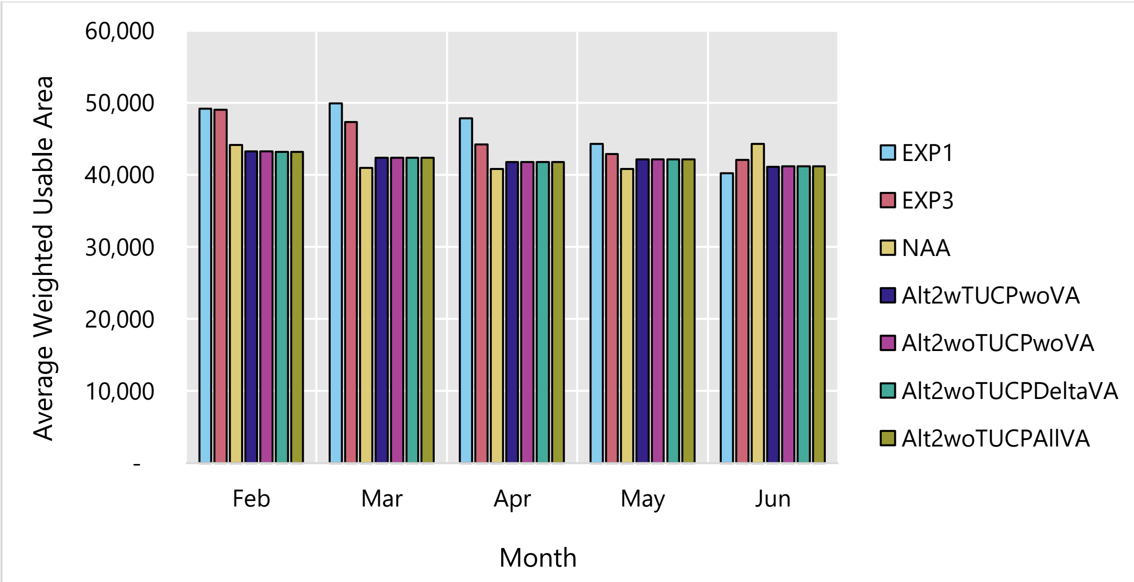

Figure O.1-18. Expected Average WUA for Steelhead Fry Rearing in Clear Creek for EXP1, EXP3, NAA, and Four Phases of Alternative 2, by Month for Three Segments Combined.

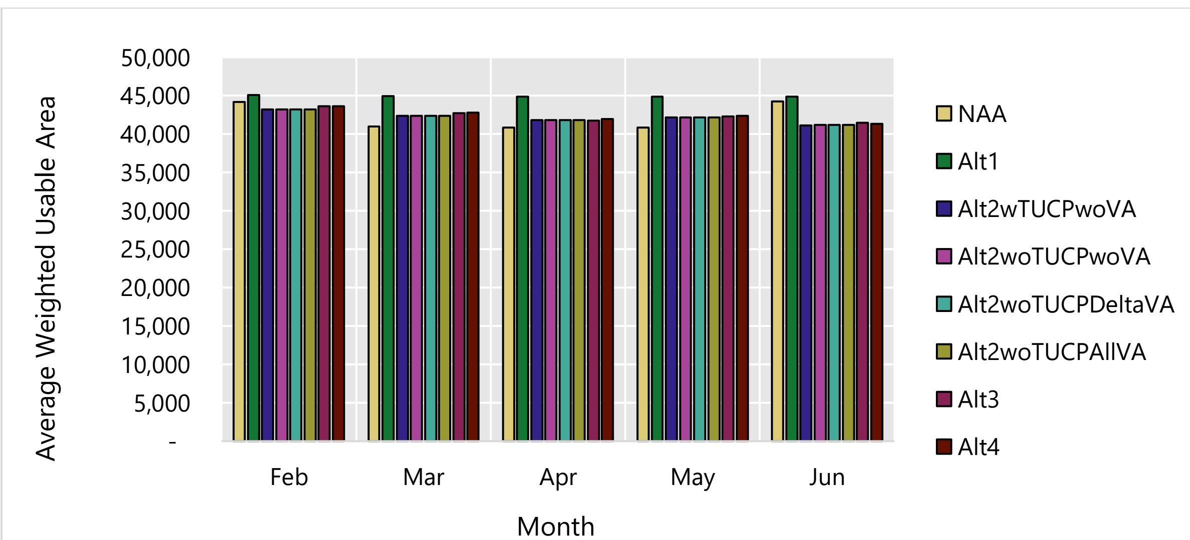

Figure O.1-19. Expected Average WUA for Steelhead Fry Rearing in Clear Creek for the NAA, and Alternative 1, Alternative 3, Alternative 4, and four phases of Alternative 2, by Month for Three Segments Combined

The results for both the BA and EIS modeled scenarios mostly show little variation in mean steelhead juvenile rearing WUA among water year types for EXP1, EXP3, the NAA, and the BA and EIS modeled scenarios for alternatives, except that critical water years consistently have the lowest WUA values. (Table O.1-14 and Table O.1-15). This reflects the shape of the steelhead juvenile rearing WUA curves (which are the same curves as those used for spring-run juveniles), which increase with flow in the Upper and Lower Alluvial segments and increase in the Canyon segment for flows below about 500 cfs then plateau at higher flows (Table O.1-8). For the EIS modeled scenarios, all the scenarios have much lower juvenile rearing WUA than the NAA, ranging from 2.8% to 6.5% lower for the EIS modeled scenarios other than Alt 1, and ranging from 44.7% to 45.3% lower for Alt 1 (Table O.1-15). As previously noted, Alt 1 has consistently much lower flows than all other scenarios.

Table O.1-14. Expected WUA for Steelhead Juvenile Rearing in Clear Creek for EXP1, EXP3, the NAA, and Four Alt 2 Management Scenarios.

Water Year Type	**EXP1**	**EXP3**	**NAA**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**
Wet	45,237	59,998	55,303	53,073	53,057	53,052	53,052
AN	42,210	57,391	54,073	52,421	52,421	52,421	52,421
BN	29,388	46,759	53,169	51,617	50,440	50,168	50,115
Dry	28,421	39,131	54,872	52,529	52,529	52,529	52,529
Critical	22,245	33,079	49,221	47,854	46,632	46,655	46,697
All	34,245	47,935	53,670	51,754	51,342	51,296	51,293

Table O.1-15. Expected WUA for Steelhead Juvenile Rearing in Clear Creek Confluence for the NAA and Alternatives 1-4

WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	55,303	30,373	53,073	53,057	53,052	53,052	51,765	52,653
AN	54,073	29,899	52,421	52,421	52,421	52,421	51,192	52,039
BN	53,169	29,077	51,617	50,440	50,168	50,115	49,963	50,906
Dry	54,872	30,248	52,529	52,529	52,529	52,529	51,289	52,144
Critical	49,221	26,976	47,854	46,632	46,655	46,697	46,821	47,563
All	53,670	29,500	51,754	51,342	51,296	51,293	50,455	51,316

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	55,303	-45.08	-4.03	-4.06	-4.07	-4.07	-6.40	-4.79
AN	54,073	-44.71	-3.05	-3.05	-3.05	-3.05	-5.33	-3.76
BN	53,169	-45.31	-2.92	-5.13	-5.64	-5.74	-6.03	-4.26
Dry	54,872	-44.88	-4.27	-4.27	-4.27	-4.27	-6.53	-4.97
Critical	49,221	-45.19	-2.78	-5.26	-5.21	-5.13	-4.88	-3.37
All	53,670	-45.03	-3.57	-4.34	-4.42	-4.43	-5.99	-4.39

Figure O.1-10 and Figure O.1-11 show the differences in estimated mean juvenile rearing WUA for steelhead under the BA and EIS modeled scenarios, respectively, for each month of the July through December juvenile rearing period. Both figures show rearing WUA values for the four phases of Alternative 2, which are almost identical and increase substantially from July and August through December. The rearing WUA values under the NAA are higher than those of the four phases of Alternative 2 and Alternatives 3 and 4 for July through October and are lower than the WUA values for these alternatives in November and December. For the BA scenarios (Figure O.1-20), juvenile rearing WUA under EXP1 declines sharply from July through September and then increases through December. EXP1 has much lower WUA than the NAA in all months except December. EXP3 varies from little from July through September and then increases through December. Like EXP1, EXP3 has lower WUA than the NAA in all months except December. For the EIS alternatives (Figure O.1-21), juvenile rearing WUA is much lower under Alternative 1 than under the NAA, the four phases of Alternative 2, or Alternatives 3 and 4. These results are consistent with the results for “All” water year types in Tables O.1-14 and O.1-15.

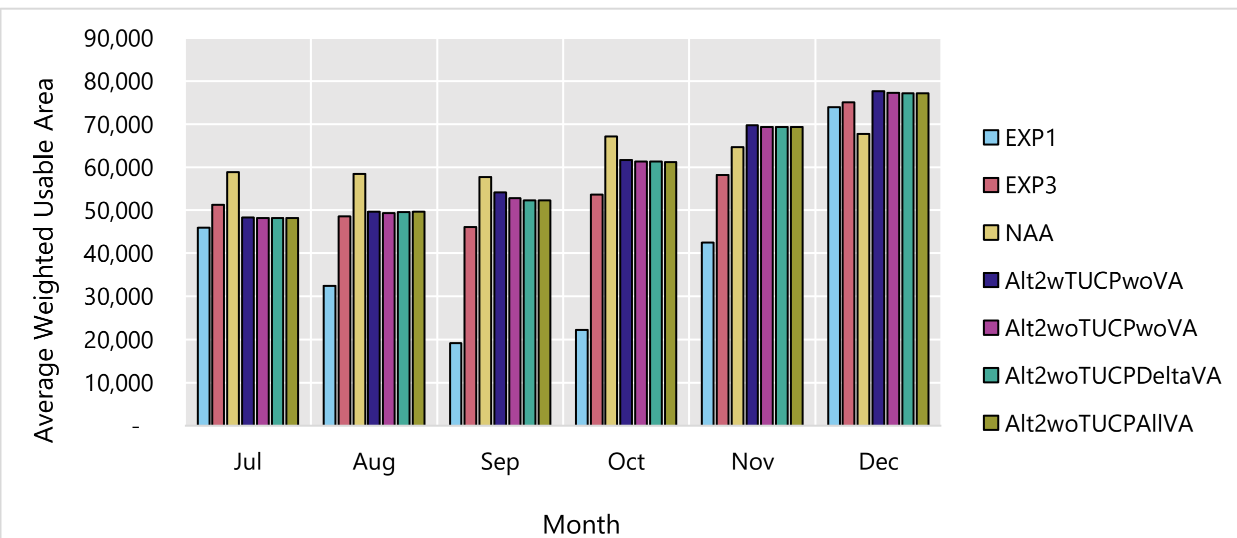

Figure O.1-20. Expected Average WUA for Steelhead Juvenile Rearing in Clear Creek for EXP1, EXP3, NAA, and Four Phases of Alternative 2, by Month for Three Segments Combined

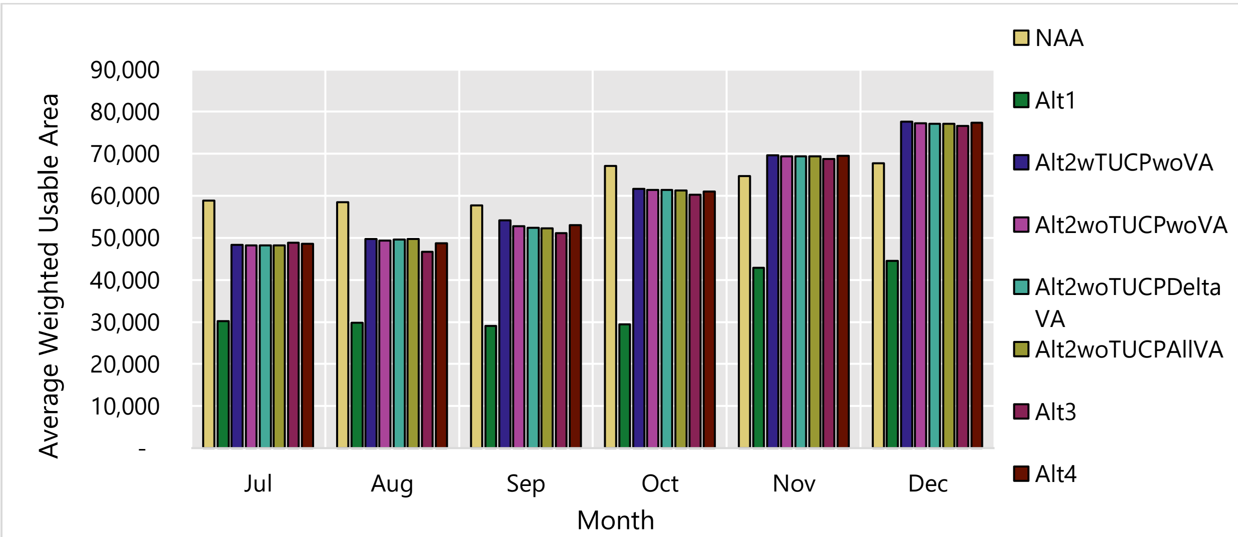

Figure O.1-21. Expected Average WUA for Steelhead Juvenile Rearing in Clear Creek for the NAA and Alternatives 1-4, by Month for Three Segments Combined

O.1.3.3 Fall-run Chinook Salmon

O.1.3.3.1 Spawning Weighted Usable Area

Table O.1-16 provides the spawning WUA results for fall-run Chinook salmon under the EIS modeled scenarios. The results are the means for all years analyzed, weighted by their expected distributions among months (Table O.1-2) and creek segments (Table O.1-3). Table O.1-16 includes the percent differences between the results of the NAA and the alternatives (Table O.1-16).

Most results for the EIS modeled scenarios show little variation in mean spawning WUA for dry through wet water year types, but WUA is consistently substantially lower under critical years (Table O.1-16). Most scenarios other than Alt 1 have higher spawning WUA than the NAA, ranging from 0.5% lower for Alt 3 in wet and above normal years to 13.3% higher for Alt 3 under critical year types (Table O.1-16). For Alt 1, spawning WUA ranges from 40.5% to 42.0% lower than the NAA. As previously noted, Alt 1 has consistently much lower flows than all other scenarios.

Table O.1-16. Expected WUA for Fall-run Chinook Spawning in Clear Creek Confluence for the NAA and Alternatives 1-4.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	65,902	38,193	67,040	67,040	67,040	67,040	65,594	67,040
AN	65,902	38,193	67,040	67,040	67,040	67,040	65,594	67,040
BN	64,175	37,344	67,040	65,944	66,008	66,096	65,594	66,980
Dry	65,902	38,193	67,040	67,040	67,040	67,040	65,594	67,040
Critical	45,509	27,097	48,644	47,365	47,867	47,260	51,486	47,782
All	62,532	36,376	64,280	63,891	63,978	63,903	63,477	64,141
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	65,902	-42.05	1.73	1.73	1.73	1.73	-0.47	1.73
AN	65,902	-42.05	1.73	1.73	1.73	1.73	-0.47	1.73
BN	64,175	-41.81	4.46	2.76	2.86	2.99	2.21	4.37
Dry	65,902	-42.05	1.73	1.73	1.73	1.73	-0.47	1.73
Critical	45,509	-40.46	6.89	4.08	5.18	3.85	13.13	5.00
All	62,532	-41.83	2.80	2.17	2.31	2.19	1.51	2.57

Figure O.1-10 shows the differences in estimated mean spawning WUA for fall-run under the EIS modeled scenarios for spawning in October, November, and December. These spawning WUA results were not computed with the monthly weighting factors in Table O.1-2. Eliminating the weighting factors facilitates comparisons of spawning habitat between months irrespective of the seasonal use patterns. The patterns of variation in spawning WUA among the different BA and EIS alternatives are quite similar for the three months, but spawning WUA consistently increases from October through December. WUA varies little among the four phases of Alternative 4 and Alternatives 3 and 4, but is consistently much lower under Alternative 1. Spawning WUA under the NAA is similar among the months and is higher than the alternatives in October, but lower in November and December. These results are consistent with the results for "All" water year types in Tables O.1-16.

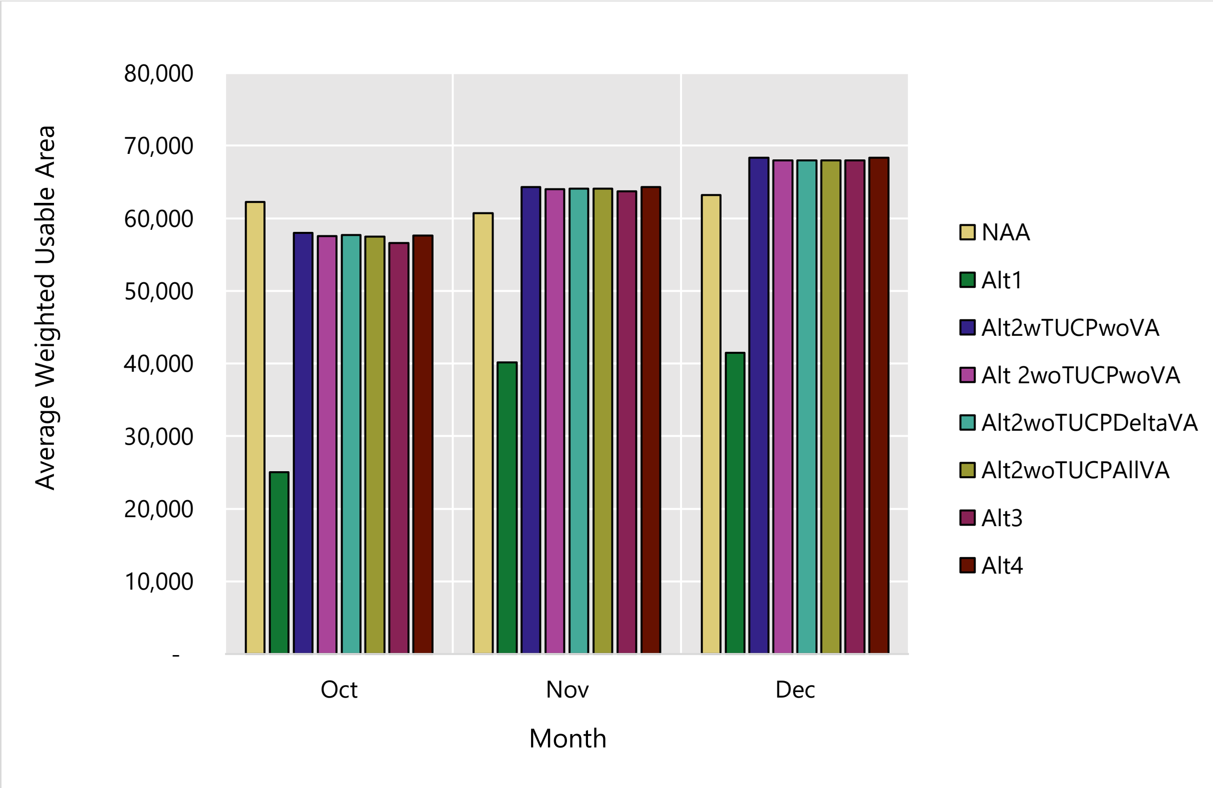

Figure O.1-22. Expected Average WUA for Fall-run Chinook Salmon Spawning in Clear Creek the NAA and Alternatives 1-4, by Month

O.1.3.3.2 Rearing Weighted Usable Area

Table O.1-17 and Table O.1-18 provide the rearing WUA results for fry and juveniles of Clear Creek steelhead under the EIS modeled scenarios. The tables include the percent differences between the results of the NAA and the alternatives.

The results for mean fry rearing WUA show little variation among water year types for the EIS modeled scenarios, although there are small reductions from drier to wetter water year types for most scenarios (Table O.1-17). This reflects the shallow, negative slope of the fall fry rearing WUA curves (Figure O.1-6). For all the EIS modeled scenarios except Alt 1, all differences from the NAA are negative, ranging between 1.2% lower to 2.3% lower (Table O.1-17). For Alt 1, fry rearing WUA greatly increases under all water year types, ranging from 10.7% to 15.4% higher than under the NAA (Table O.1-13). As noted previously, Alt 1 has consistently lower flows than the other scenarios. The fall-run fry WUA rearing curve declines with flow, so the lower flows for Alt 1 result in increased fry rearing WUA.

Table O.1-17. Expected WUA for Fall-run Chinook Fry Rearing in Clear Creek Confluence for the NAA and Alternatives 1-4.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	115,197	132,409	113,192	113,192	113,192	113,192	112,811	113,192
AN	116,173	134,042	114,155	114,155	114,155	114,155	113,760	114,155
BN	116,394	134,042	114,078	114,089	114,089	114,088	113,683	114,090
Dry	117,970	134,042	115,228	115,228	115,228	115,228	114,898	115,228
Critical	121,046	134,041	119,566	119,566	119,566	119,566	119,495	119,566
All	117,151	133,585	114,995	114,997	114,997	114,997	114,671	114,997
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	115,197	14.94	-1.74	-1.74	-1.74	-1.74	-2.07	-1.74
AN	116,173	15.38	-1.74	-1.74	-1.74	-1.74	-2.08	-1.74
BN	116,394	15.16	-1.99	-1.98	-1.98	-1.98	-2.33	-1.98
Dry	117,970	13.62	-2.32	-2.32	-2.32	-2.32	-2.60	-2.32
Critical	121,046	10.74	-1.22	-1.22	-1.22	-1.22	-1.28	-1.22
All	117,151	14.03	-1.84	-1.84	-1.84	-1.84	-2.12	-1.84

Figure O.1-10 shows the differences in estimated mean fry rearing WUA for fall-run under the EIS modeled scenarios for each month of the January through April fry rearing period. The four phases of Alternative 2 and Alternatives 3 and 4 have nearly identical fry rearing WUA values and show little variation among months. Their values are slightly lower than the rearing WUA values under the NAA, except in February, for which the values are about the same. Fry rearing WUA is consistently higher under Alternative 1 than under the NAA and all other scenarios. These results are consistent with the results for “All” water year types in Tables O.1-17.

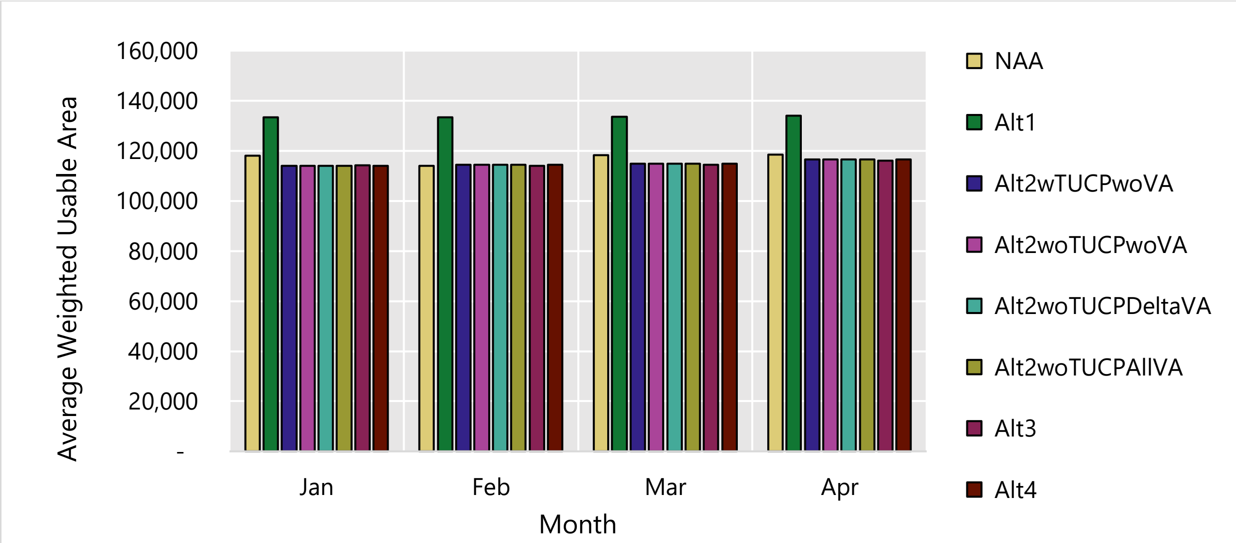

Figure O.1-23. Expected Average WUA for Fall-run Chinook Salmon Fry Rearing in Clear Creek for the NAA and Alternatives 1-4 by Month for Three Segments Combined

The results for the EIS modeled scenarios mostly show little variation in mean fall-run juvenile rearing WUA among water year types for the EIS modeled scenarios for alternatives, except that critical water years consistently have the lowest WUA values (Table O.1-18). All the scenarios have lower juvenile rearing WUA than the NAA, ranging from 2.4% to 11.3% lower for the EIS modeled scenarios other than Alt 1, and ranging from 27.3% to 27.6 % lower for Alt 1 (Table O.1-18). As previously noted, Alt 1 has consistently much lower flows than all other scenarios.

Table O.1-18. Expected WUA for Fall-run Juvenile Rearing in Clear Creek Confluence for the NAA and Alternatives 1-4.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	61,877	44,983	59,760	59,760	59,760	59,760	59,412	59,760
AN	61,877	44,983	59,760	59,760	59,760	59,760	59,412	59,760
BN	61,217	44,483	59,760	58,478	58,478	58,478	59,412	59,119
Dry	61,877	44,983	59,760	59,760	59,760	59,760	59,412	59,760
Critical	58,826	42,607	53,525	52,154	52,967	52,891	55,177	53,884
All	61,270	44,513	58,763	58,313	58,443	58,430	58,735	58,705

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	61,877	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
AN	61,877	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
BN	61,217	-27.34	-2.38	-4.47	-4.47	-4.47	-2.95	-3.43
Dry	61,877	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
Critical	58,826	-27.57	-9.01	-11.34	-9.96	-10.09	-6.20	-8.40
All	61,270	-27.35	-4.09	-4.83	-4.61	-4.63	-4.14	-4.19

Figure O.1-10 shows the differences in estimated mean juvenile rearing WUA for fall-run under the EIS modeled scenarios for each month of the May through September fry rearing period. The four phases of Alternative 2 and Alternatives 3 and 4 have similar juvenile rearing WUA values and vary in parallel with highest values in May and lowest in July and August. Their values are lower than the WUA values under the NAA except in May, when their values are higher. Juvenile rearing WUA is consistently much lower under Alternative 1 than under the NAA and all other scenarios. These results are consistent with the results for "All" water year types in Tables O.1-18.

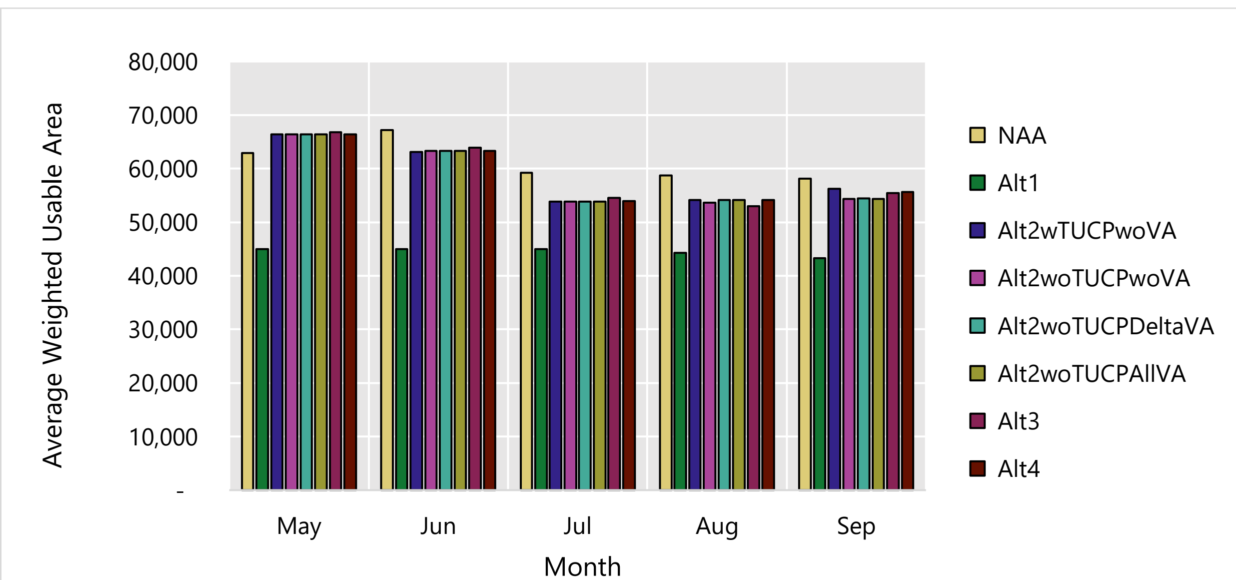

Figure O.1-24. Expected Average WUA for Fall-run Chinook Salmon Juvenile Rearing in Clear Creek for the NAA and Alternatives 1-4 by Month for Three Segments Combined

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