Appendix AB-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, 2013, 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, 2013). 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, 2013). 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 2013.

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.

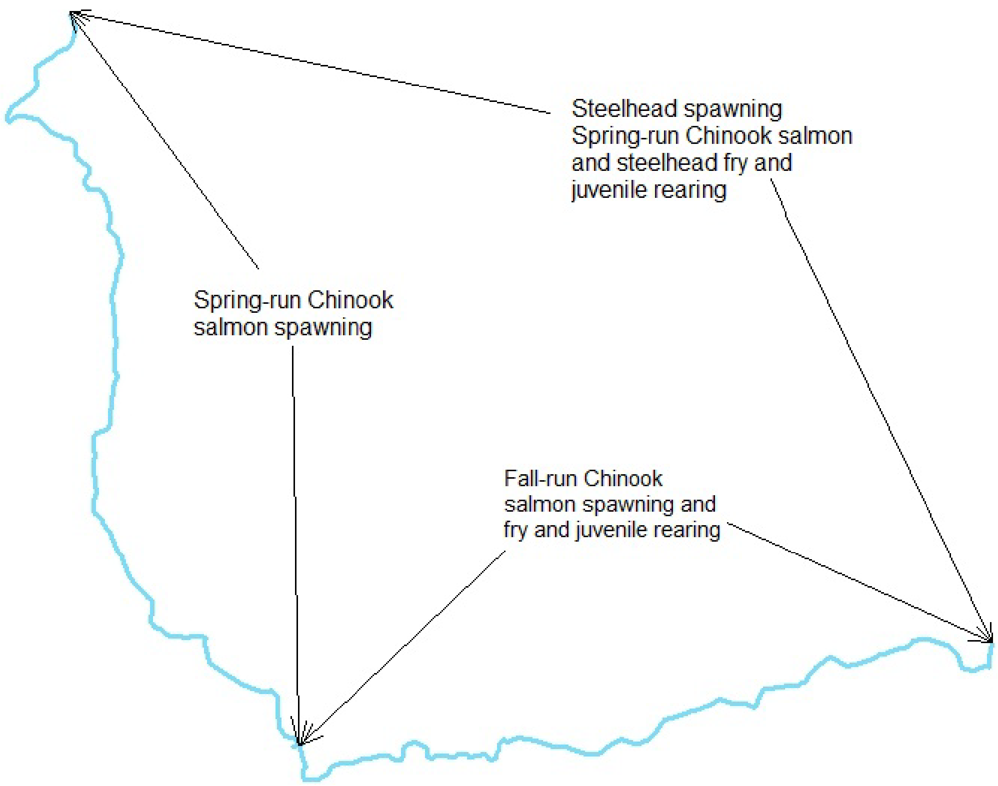

Figure O.1-1. Spatial Distribution of Adult and Juvenile Spring-run and Fall-run Chinook and Steelhead in Clear Creek.

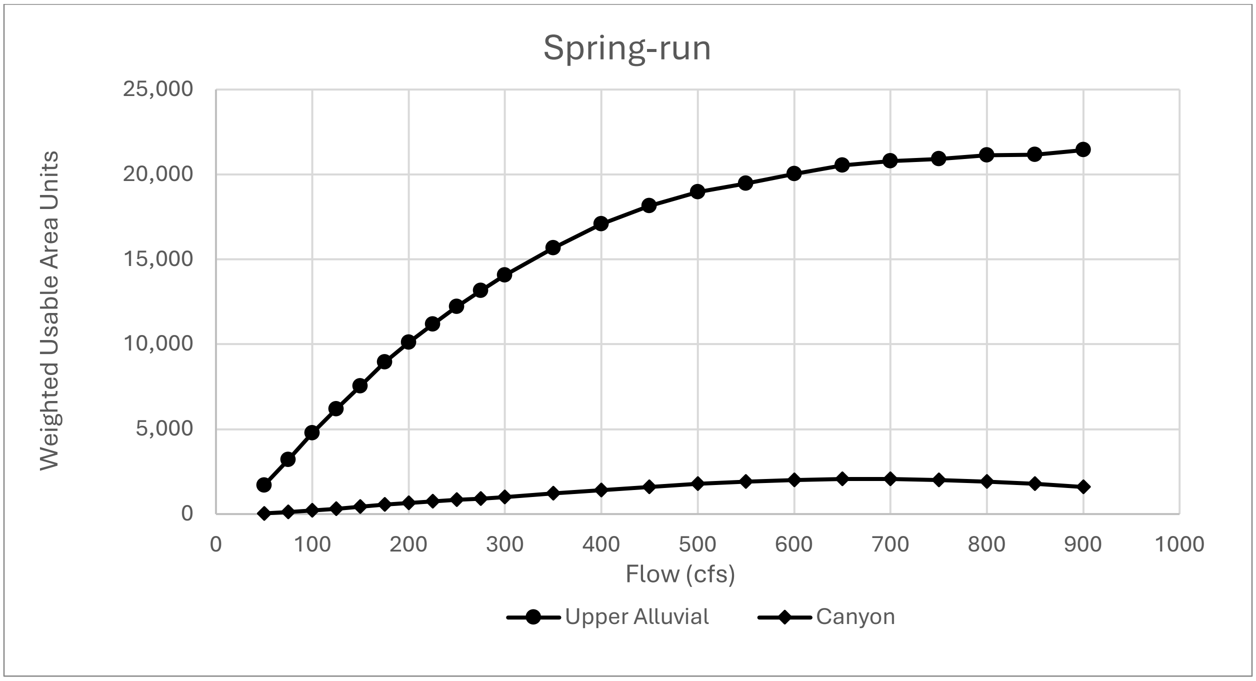

Figure O.1-2. Spawning WUA curves for Spring-Run Salmon in Clear Creek, Upper Alluvial and Canyon Segments.

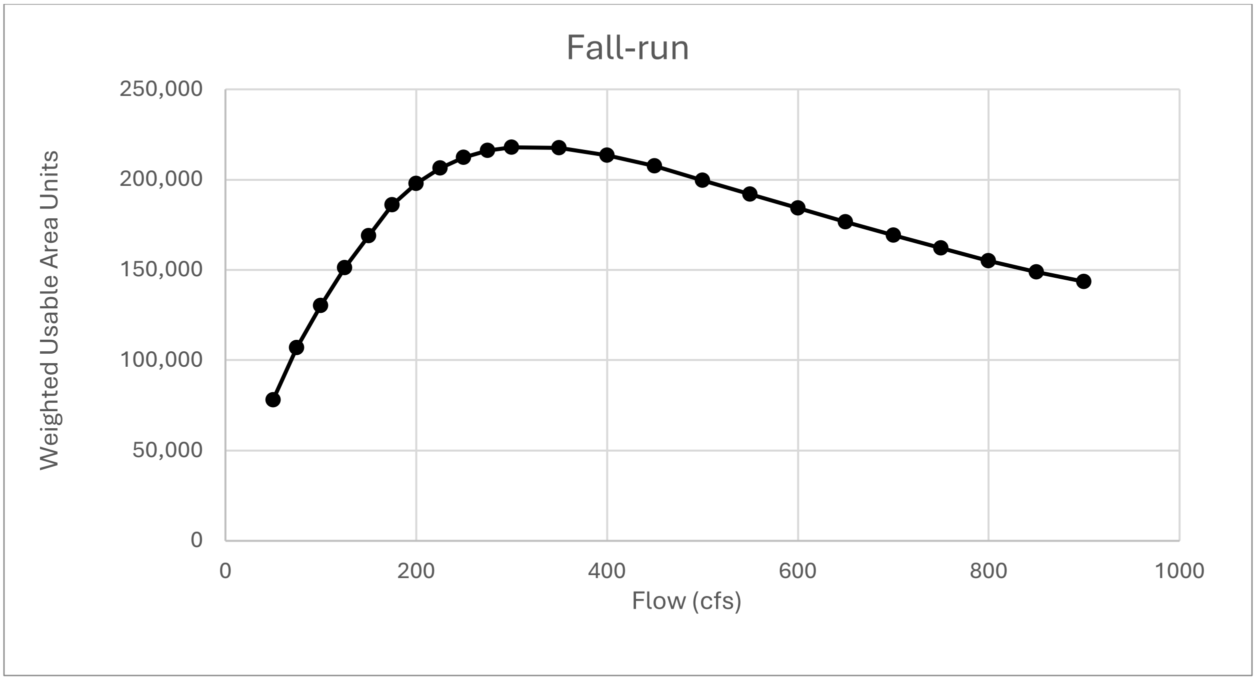

Figure O.1-3. Spawning WUA curve for Fall-Run Salmon in Clear Creek, Lower Alluvial Segment

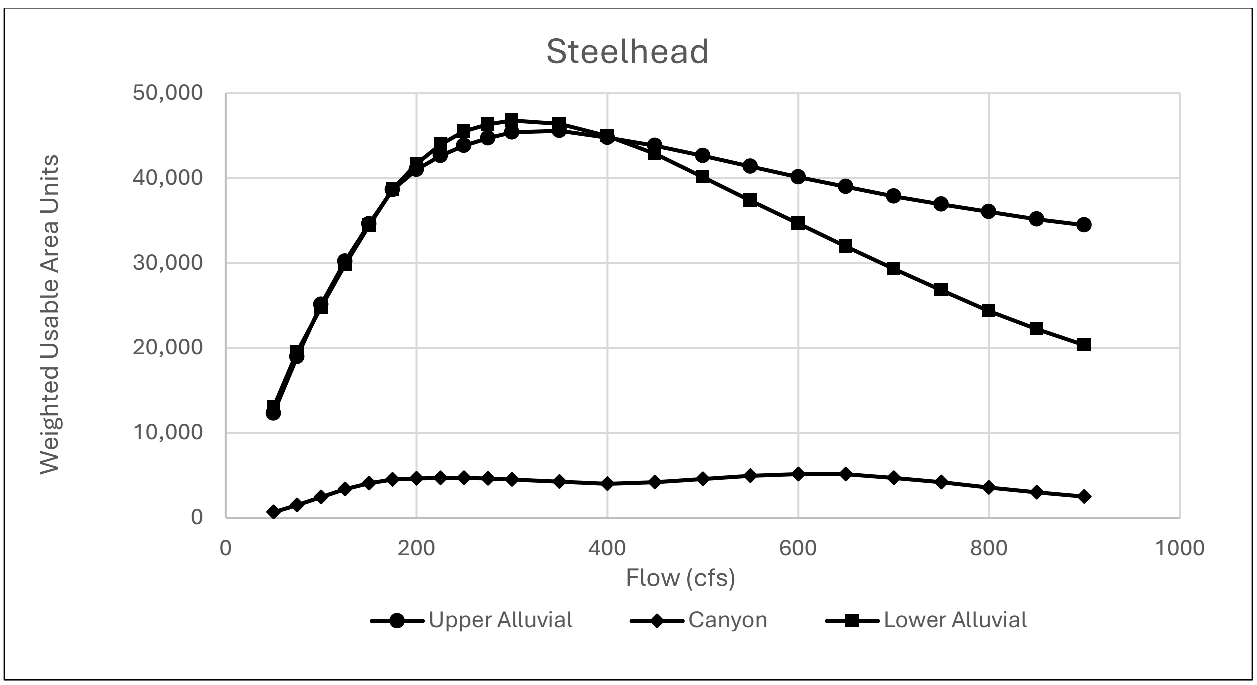

Figure O.1-4. Spawning WUA curves for Steelhead in Clear Creek, Upper Alluvial, Canyon, and Lower Alluvial Segments.

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.

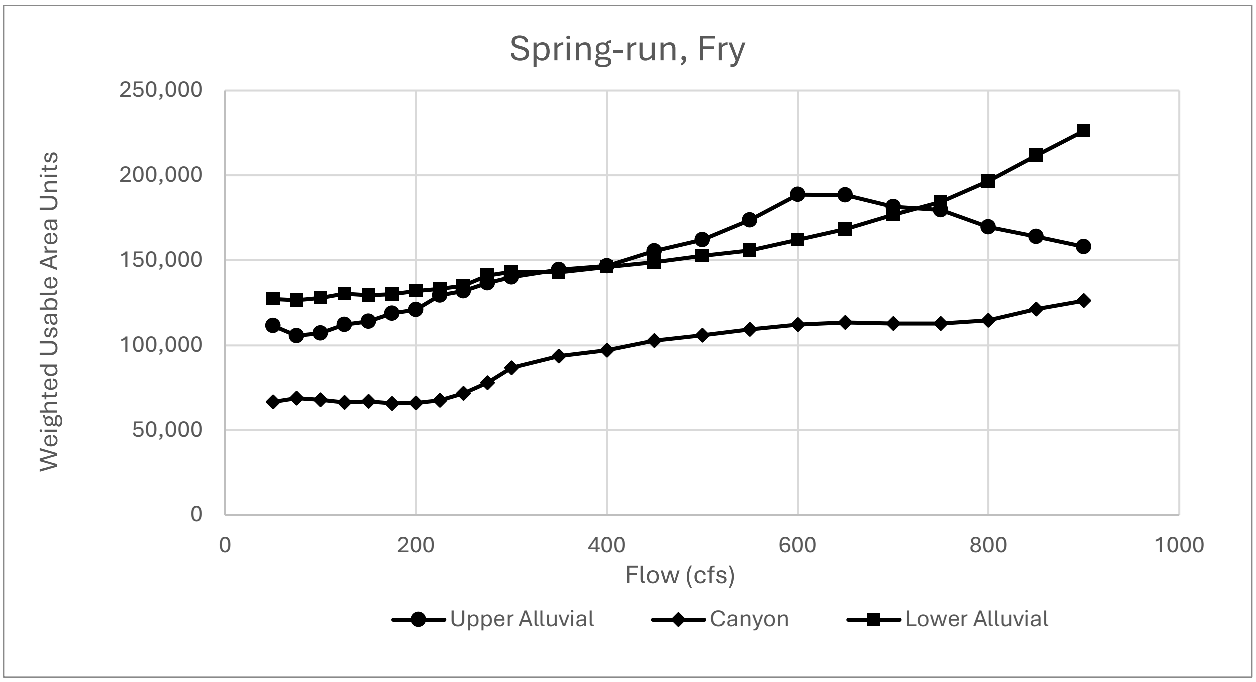

Figure O.1-5. Rearing WUA Curves for Spring-Run Salmon Fry in Clear Creek, Upper Alluvial, Canyon, and Lower Alluvial Segments.

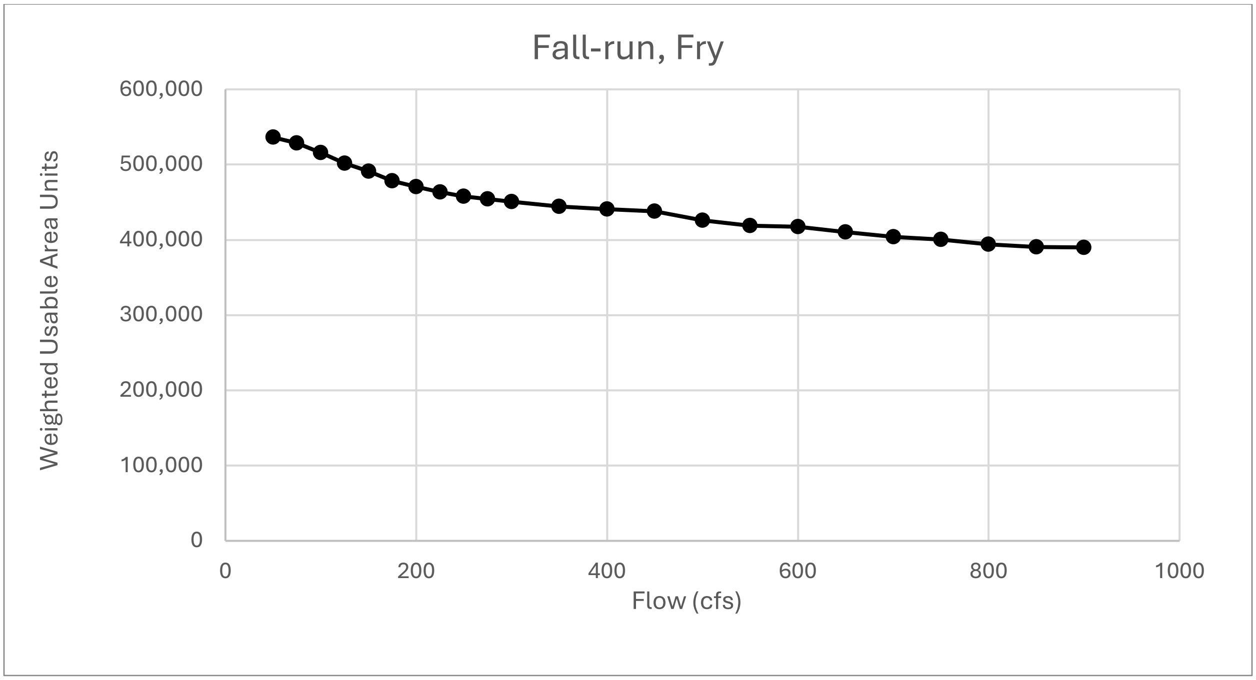

Figure O.1-6. Rearing WUA Curve for Fall-Run Salmon Fry in Clear Creek, Lower Alluvial Segment.

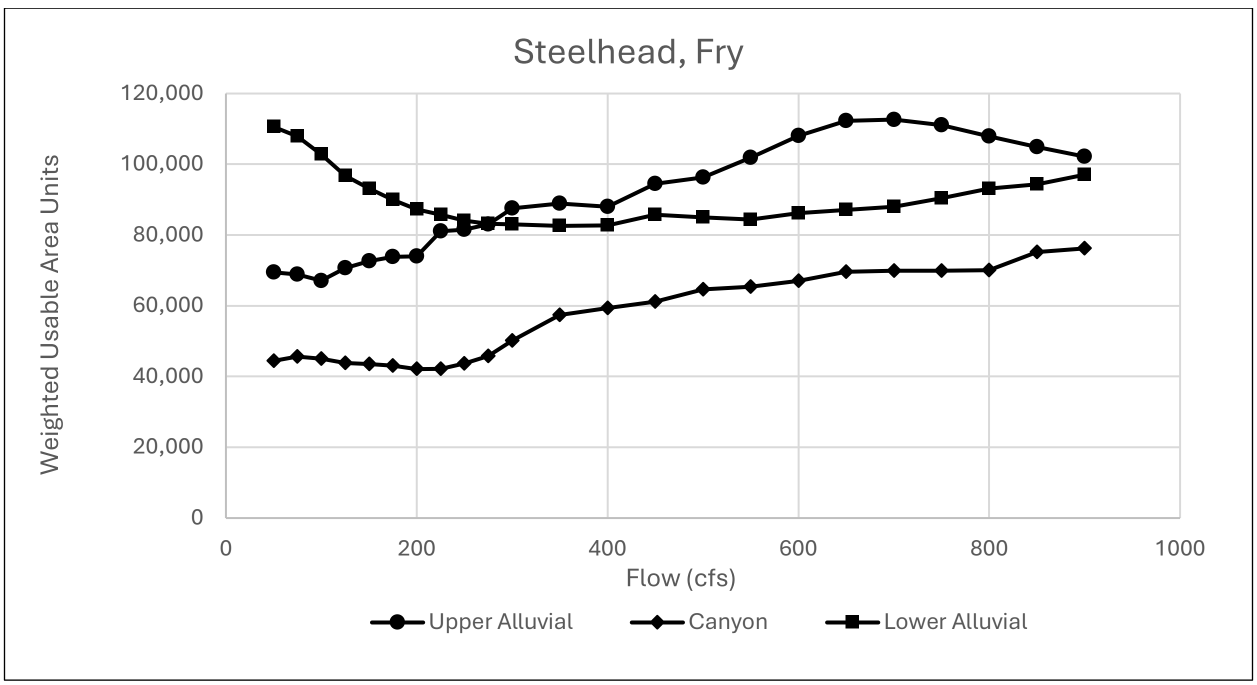

Figure O.1-7. Rearing WUA Curves for Steelhead Fry in Clear Creek, Upper Alluvial, Canyon, and Lower Alluvial Segments.

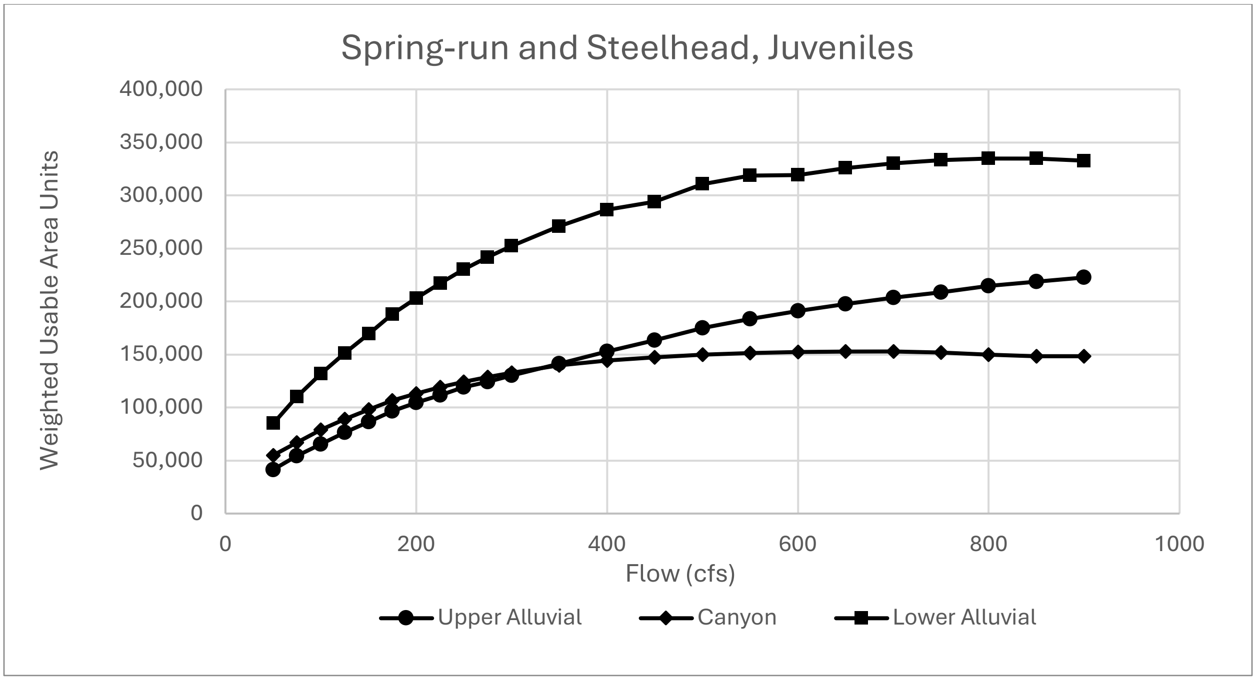

Figure O.1-8. Rearing WUA Curves for Spring-Run Salmon and Steelhead Juveniles in Clear Creek, Upper Alluvial, Canyon, and Lower Alluvial Segments.

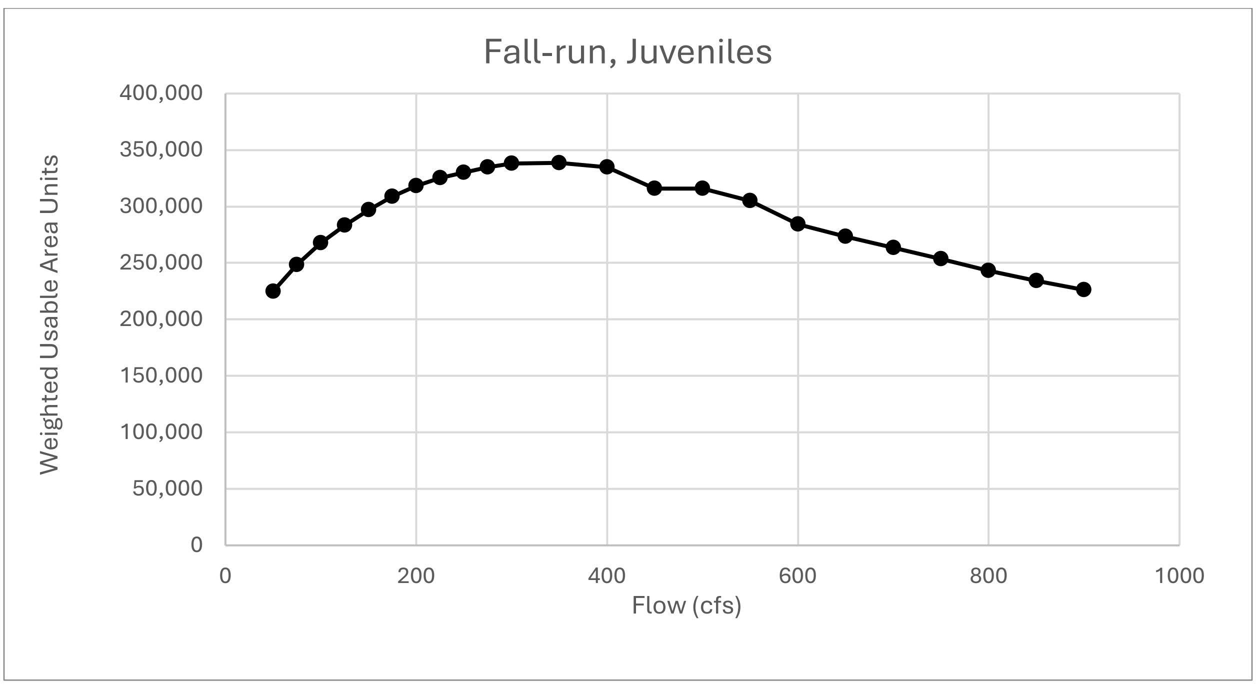

Figure O.1-9. Rearing WUA Curve for Fall-Run Salmon Juveniles in Clear Creek, Lower Alluvial Segment.

In this analysis, spawning and rearing WUA tables in the USFWS reports (USFWS 2007b, 2011a, 2011b, and 2013) 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 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 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	0	0
October	0.8	0	0.3
November	0.2	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	--	0.9
Canyon	0.3	--	0.02
Lower Alluvial Canyon	--	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, 2013) 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, 2013). 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 from Reclamation 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 EXP 1, EXP 2, 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	2,540	5,714	5,752	5,064	5,064	5,064	5,064
AN	2,494	5,875	5,643	5,048	5,048	5,048	5,048
BN	764	4,170	5,459	4,993	4,540	4,561	4,530
Dry	773	3,287	5,719	5,051	5,051	5,051	5,051
Critical	563	2,926	5,069	4,577	4,141	4,215	4,123
All	1,473	4,430	5,567	4,968	4,817	4,832	4,812

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	5,752	1,200	5,064	5,064	5,064	5,064	4,532	5,046
AN	5,643	1,191	5,048	5,048	5,048	5,048	4,525	5,030
BN	5,459	1,134	4,993	4,540	4,561	4,530	4,457	4,766
Dry	5,719	1,200	5,051	5,051	5,051	5,051	4,526	5,033
Critical	5,069	1,017	4,577	4,141	4,215	4,123	4,184	4,516
All	5,567	1,158	4,968	4,817	4,832	4,812	4,461	4,905
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	5,752	-79.13	-11.96	-11.96	-11.96	-11.96	-21.21	-12.28
AN	5,643	-78.89	-10.54	-10.54	-10.54	-10.54	-19.81	-10.87
BN	5,459	-79.23	-8.53	-16.84	-16.44	-17.02	-18.35	-12.68
Dry	5,719	-79.01	-11.68	-11.68	-11.68	-11.68	-20.85	-12.00
Critical	5,069	-79.93	-9.71	-18.30	-16.85	-18.67	-17.46	-10.91
All	5,567	-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 full variation in estimated spawning WUA for spring-run under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the spawning WUA curves from which they are estimated (Figure O.1-2). The box plots in Figure O.1-10 and Figure O.1-11 show very little variation for the NAA, or for any of the BA or EIS modeled scenarios for alternatives. All of the first and third quartile values are identical because identical WUA values regularly repeat. This, in turn, results because a limited number of flow values occur in the CalSim 3 record for the modeled BA and EIS alternatives. The flow values are derived from Whiskeytown Dam releases, which are set to a limited number of levels based on flow release requirements.

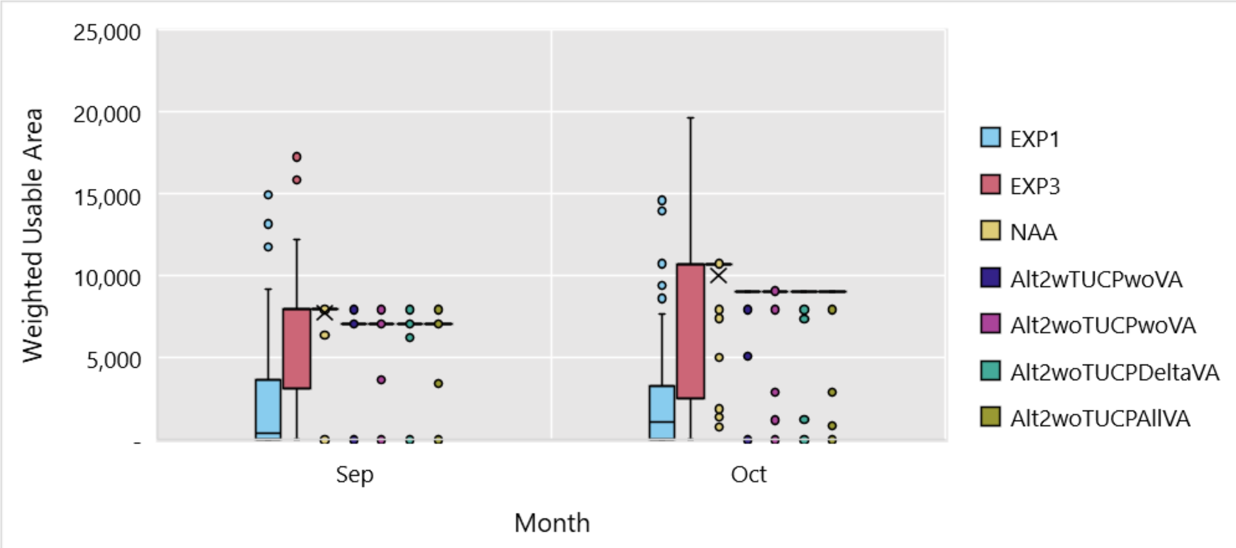

Figure O.1-10. Expected WUA for Spring-run Chinook Spawning in Clear Creek for EXP1, EXP3, NAA, and four phases of Alternative 2

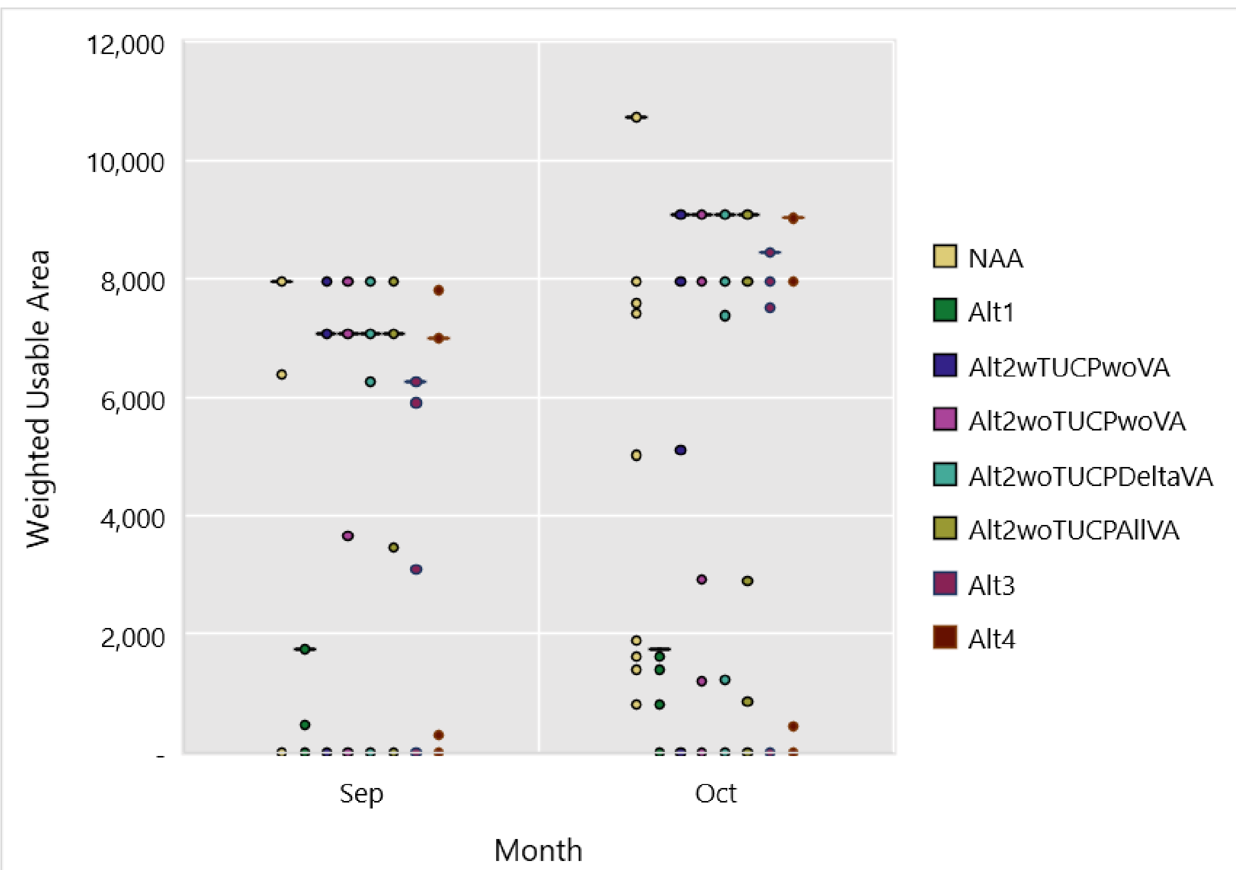

Figure O.1-11. Expected WUA for Spring-run Chinook Spawning in Clear Creek for the NAA and Alternatives 1-4, by Month

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 2, 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 except Alt 1 have higher fry rearing WUA values than the NAA (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	37,137	36,563	28,124	29,758	29,753	29,752	29,752
AN	36,206	35,427	27,538	29,108	29,108	29,108	29,108
BN	29,095	29,311	26,952	28,880	28,818	28,803	28,806
Dry	29,007	28,571	26,737	28,809	28,809	28,809	28,809
Critical	22,551	24,348	25,418	26,928	26,920	26,918	26,915
All	31,274	31,226	27,065	28,828	28,814	28,811	28,811

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	28,124	25,959	29,758	29,753	29,752	29,752	29,716	29,838
AN	27,538	25,346	29,108	29,108	29,108	29,108	29,090	29,208
BN	26,952	24,942	28,880	28,818	28,803	28,806	28,842	28,971
Dry	26,737	25,347	28,809	28,809	28,809	28,809	28,764	28,874
Critical	25,418	24,500	26,928	26,920	26,918	26,915	27,116	27,007
All	27,065	25,310	28,828	28,814	28,811	28,811	28,827	28,910

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	28,124	-7.70	5.81	5.79	5.79	5.79	5.66	6.09
AN	27,538	-7.96	5.70	5.70	5.70	5.70	5.64	6.07
BN	26,952	-7.46	7.16	6.92	6.87	6.88	7.01	7.49
Dry	26,737	-5.20	7.75	7.75	7.75	7.75	7.58	8.00
Critical	25,418	-3.61	5.94	5.91	5.90	5.89	6.68	6.25
All	27,065	-6.48	6.51	6.46	6.45	6.45	6.51	6.81

Figure O.1-12 and Figure O.1-13 show the full variation in estimated fry rearing WUA for spring-run under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the fry rearing WUA curves from which they are estimated (Figure O.1-5). The box plots in Figure O.1-12 and Figure O.1-13 show the months of January through March have the highest WUA values on average under all scenarios, with the most variation in EXP1 and EXP3. The first and third quartile values are identical because identical WUA values regularly repeat. This, in turn, results because a limited number of flow values occur in the CalSim 3 record for the modeled BA and EIS alternatives. The flow values are derived from Whiskeytown Dam releases, which are set to a limited number of levels based on flow release requirements.

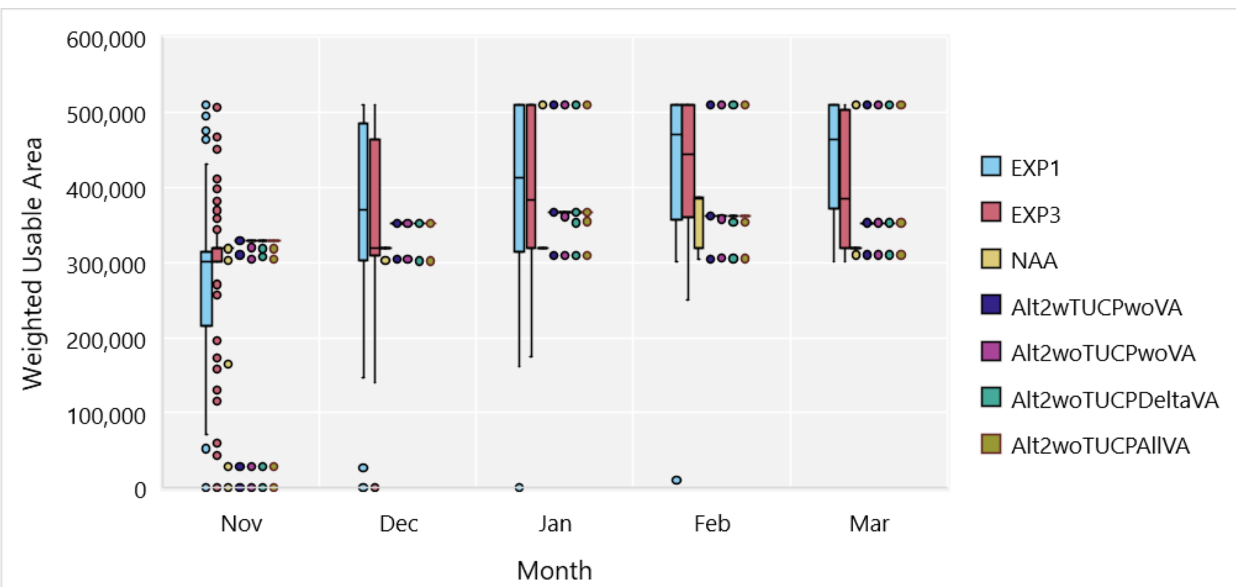

Figure O.1-12. Expected WUA for Spring-run Chinook Fry Rearing in Clear Creek for EXP1, EXP3, NAA, and four phases of Alternative 2 by Month with All Three Segments Combined.

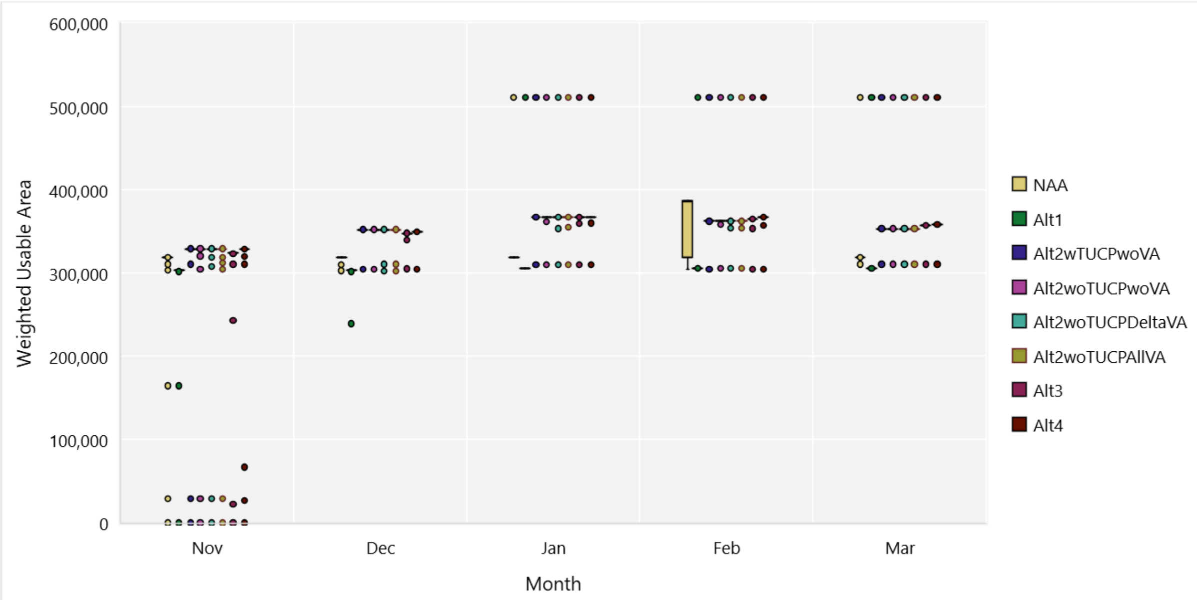

Figure O.1-13. Expected WUA for Spring-run Chinook Fry Rearing in Clear Creek for the NAA and Alternatives 1-4 by Month with All Three Segments Combined.

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 EXP 1, EXP 2, 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 moderately lower juvenile rearing WUA than the NAA (Table O.1-7). Reductions range from 0.3% to 5.2% 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 64.3% 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	38,630	42,247	34,937	34,430	34,430	34,430	34,430
AN	38,497	40,849	34,797	34,325	34,325	34,325	34,325
BN	32,507	34,810	34,797	34,325	34,325	34,325	34,325
Dry	30,253	32,266	34,561	33,884	33,884	33,884	33,884
Critical	26,294	25,935	30,780	29,554	29,416	29,583	29,668
All	33,525	35,707	34,137	33,485	33,463	33,490	33,503

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	34,937	15,380	34,430	34,430	34,430	34,430	34,806	34,516
AN	34,797	15,121	34,325	34,325	34,325	34,325	34,706	34,412
BN	34,797	15,121	34,325	34,325	34,325	34,325	34,706	34,412
Dry	34,561	15,121	33,884	33,884	33,884	33,884	34,230	33,962
Critical	30,780	14,885	29,554	29,416	29,583	29,668	29,165	29,633
All	34,137	15,156	33,485	33,463	33,490	33,503	33,733	33,568
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	34,937	-50.63	-1.31	-1.31	-1.31	-1.31	-0.34	-1.09
AN	34,797	-51.11	-1.23	-1.23	-1.23	-1.23	-0.24	-1.00
BN	34,797	-60.53	-1.45	-1.45	-1.45	-1.45	-0.28	-1.18
Dry	34,561	-64.26	-2.24	-2.24	-2.24	-2.24	-1.09	-1.98
Critical	30,780	-60.45	-4.66	-5.19	-4.55	-4.23	-6.14	-4.36
All	34,137	-56.62	-1.94	-2.01	-1.93	-1.89	-1.20	-1.70

Figure O.1-14 and Figure O.1-15 show the full variation in estimated juvenile rearing WUA for spring-run under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the juvenile rearing WUA curves from which they are estimated (Figure O.1-8). The box plots in Figure O.1-14 and Figure O.1-15 show the months of April and May have the highest WUA values on average under all scenarios. The first and third quartile values are identical because identical WUA values regularly repeat. This, in turn, results because a limited number of flow values occur in the CalSim 3 record for the modeled BA and EIS alternatives. The flow values are derived from Whiskeytown Dam releases, which are set to a limited number of levels based on flow release requirements.

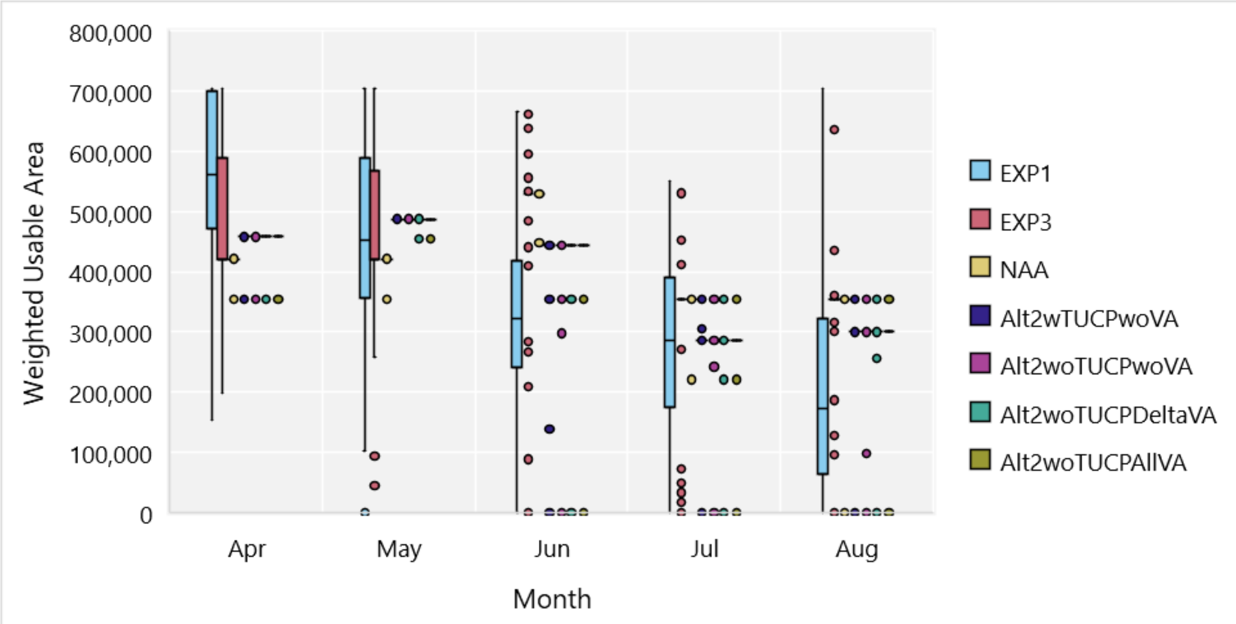

Figure O.1-14. Expected WUA for Spring-run Chinook Juvenile Rearing in Clear Creek for EXP1, EXP3, NAA, and four phases of Alternative by Month with All Three Segments Combined.

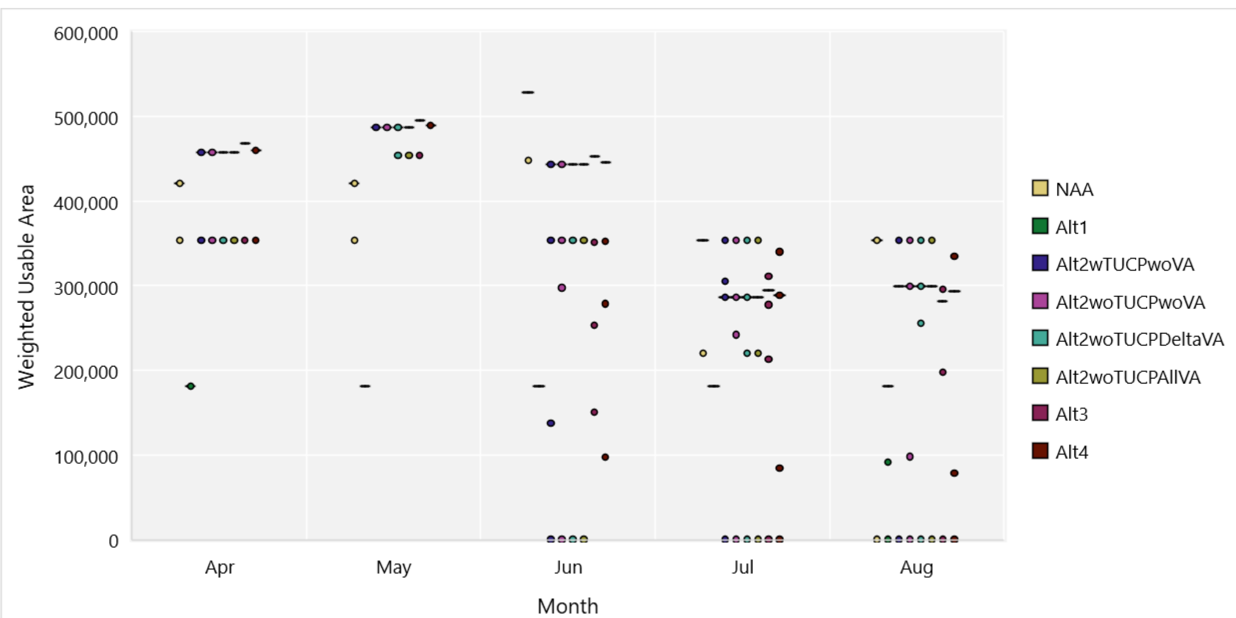

Figure O.1-15. Expected WUA for Spring-run Chinook Juvenile Rearing in Clear Creek for the NAA, and Alternative 1, Alternative 3, Alternative 4, and four phases of Alternative 2.

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 mostly little consistent variation in mean spawning WUA with water year type EXP1, EXP3, the NAA, and the BA and EIS modeled scenarios for alternatives (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. Alt 1 has relatively 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 much higher steelhead spawning WUA values than the NAA. except Alt 1, for which the values are very much lower (ranging from 72.3% to 81.0% lower) (Table O.1-11). The increases in spawning WUA for the other scenarios range from 6.2% to 8.5%).

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	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	35,270	35,662	41,196	43,452	43,452	43,452	43,452	43,452
AN	35,517	36,262	41,305	43,489	43,489	43,489	43,489	43,489
BN	32,763	35,167	40,891	43,611	43,611	43,288	43,295	43,289
Dry	34,675	37,190	39,588	42,470	42,470	42,470	42,470	42,470
Critical	28,227	30,931	36,610	38,610	38,610	38,618	38,618	38,618
All	33,584	35,267	40,037	42,475	42,475	42,418	42,420	42,419

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	41,196	15,690	43,452	43,452	43,452	43,452	43,515	43,451
AN	41,305	14,393	43,489	43,489	43,489	43,489	43,572	43,489
BN	40,891	14,338	43,611	43,288	43,295	43,289	43,688	43,589
Dry	39,588	14,479	42,470	42,470	42,470	42,470	42,512	42,469
Critical	36,610	13,957	38,610	38,618	38,618	38,618	38,594	38,610
All	40,037	14,697	42,475	42,418	42,420	42,419	42,526	42,471
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	41,196	-72.32	6.40	6.40	6.40	6.40	6.58	6.39
AN	41,305	-75.77	6.15	6.15	6.15	6.15	6.38	6.15
BN	40,891	-81.05	8.30	7.31	7.34	7.32	8.54	8.23
Dry	39,588	-72.41	8.31	8.31	8.31	8.31	8.43	8.31
Critical	36,610	-80.25	7.09	7.11	7.11	7.11	7.03	7.09
All	40,037	-75.45	7.26	7.09	7.10	7.09	7.41	7.25

Figure O.1-16 and Figure O.1-17 show the full variation in estimated steelhead spawning WUA under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the spawning WUA curves from which they are estimated (Figure O.1-4). The box plots in Figure O.1-16 and Figure O.1-17 show very little variation for the NAA (except in February), or for any of the BA or EIS modeled scenarios for alternatives. All the first and third quartile values are identical because identical WUA values regularly repeat. This, in turn, results because a limited number of flow values occur in the CalSim 3 record for the modeled BA and ESI alternatives. The flow values are derived from Whiskeytown Dam releases, which are set to a limited number of levels based on flow release requirements.

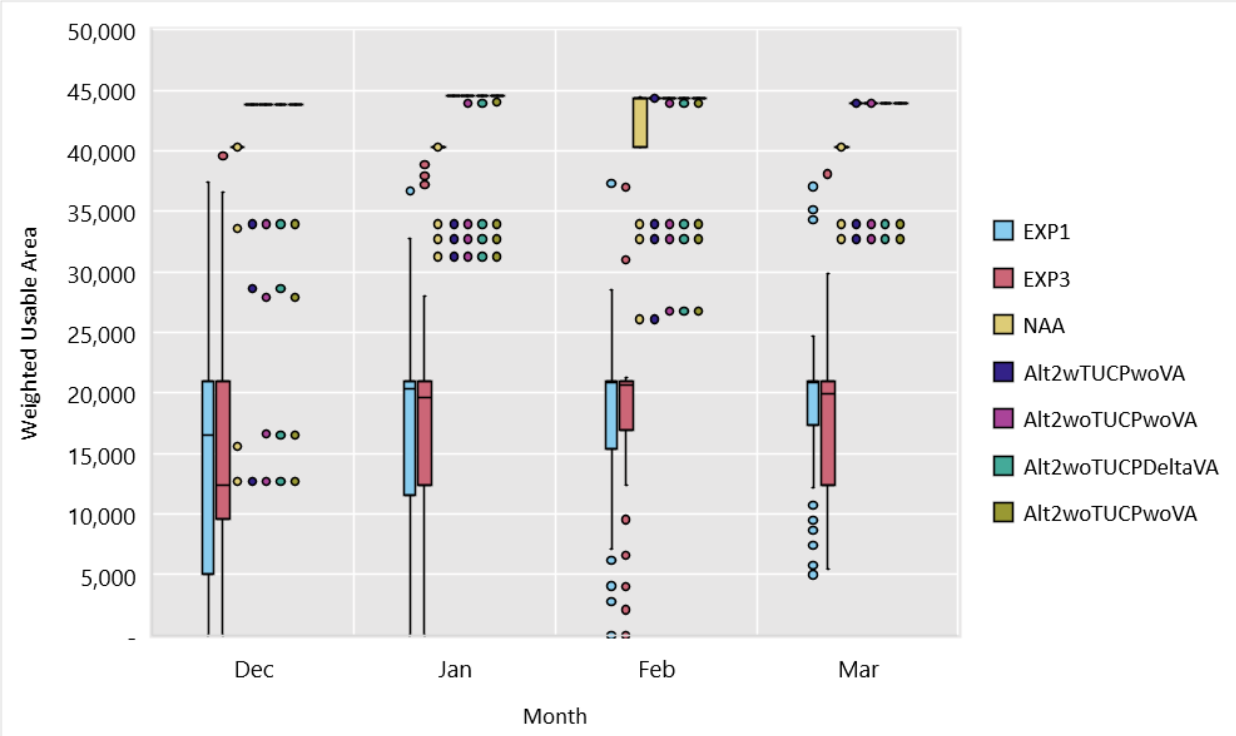

Figure O.1-16. Expected WUA for Steelhead Spawning in Clear Creek for EXP1, EXP3, NAA, and Four Phases of Alternative 2 by Month

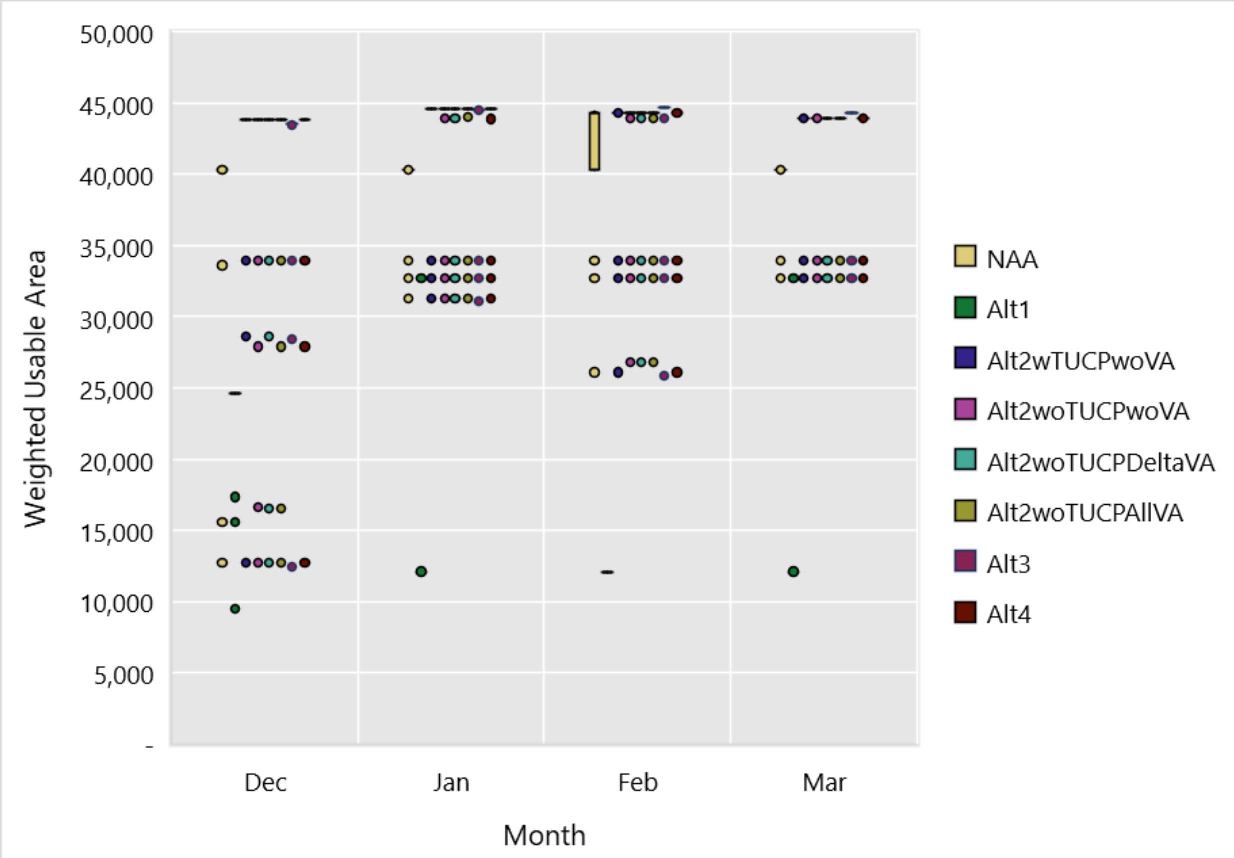

Figure O.1-17. Expected WUA for Steelhead Spawning in Clear Creek for the NAA and Alternatives 1-4 by Month

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 EXP 1, EXP 2, 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 (≤1.0%), except for Alt 1 (Table O.1-13). Under Alt 1, fry rearing WUA ranges from 4.8% to 7.8% 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	20,616	20,299	17,799	17,708	17,708	17,708	17,708
AN	20,591	20,006	17,685	17,599	17,599	17,599	17,599
BN	18,827	17,996	17,619	17,599	17,599	17,599	17,599
Dry	18,681	18,193	17,437	17,564	17,564	17,564	17,564
Critical	17,239	16,917	17,353	17,240	17,267	17,275	17,275
All	19,286	18,797	17,592	17,563	17,568	17,569	17,569

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	17,799	18,788	17,708	17,708	17,708	17,708	17,794	17,822
AN	17,685	18,696	17,599	17,599	17,599	17,599	17,689	17,717
BN	17,619	18,696	17,599	17,599	17,599	17,599	17,689	17,717
Dry	17,437	18,696	17,564	17,564	17,564	17,564	17,639	17,665
Critical	17,353	18,696	17,240	17,267	17,275	17,275	17,382	17,325
All	17,592	18,722	17,563	17,568	17,569	17,569	17,657	17,671
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	17,799	4.80	-0.44	-0.44	-0.44	-0.44	-0.02	0.11
AN	17,685	4.91	-0.42	-0.42	-0.42	-0.42	0.02	0.16
BN	17,619	5.72	-0.11	-0.11	-0.11	-0.11	0.37	0.52
Dry	17,437	6.74	0.68	0.68	0.68	0.68	1.08	1.22
Critical	17,353	7.79	-0.66	-0.50	-0.45	-0.45	0.17	-0.16
All	17,592	5.86	-0.15	-0.13	-0.12	-0.12	0.34	0.41

Figure O.1-18 and Figure O.1-19 show the full variation in estimated fry rearing WUA for steelhead under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the fry rearing WUA curves from which they are estimated (Figure O.1-7). The box plots in Figure O.1-18 and Figure O.1-19 show very little variation across months for NAA, or for any of the BA or EIS modeled scenarios. The NAA and Alt 2 have the lowest WUA across all months on average. The first and third quartile values are identical because identical WUA values regularly repeat. This, in turn, results because a limited number of flow values occur in the CalSim 3 record for the modeled BA and EIS alternatives. The flow values are derived from Whiskeytown Dam releases, which are set to a limited number of levels based on flow release requirements.

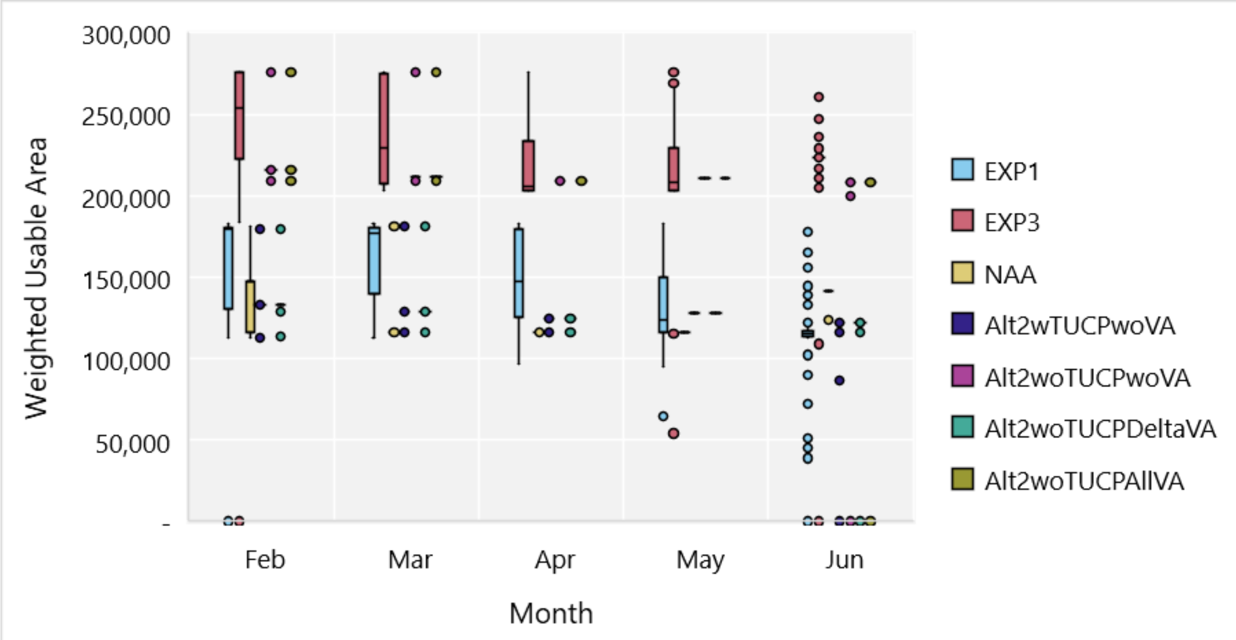

Figure O.1-18. Expected WUA for Steelhead Fry Rearing in Clear Creek for EXP1, EXP3, NAA, and Four Phases of Alternative 2 by Month for Three Segments Combined.

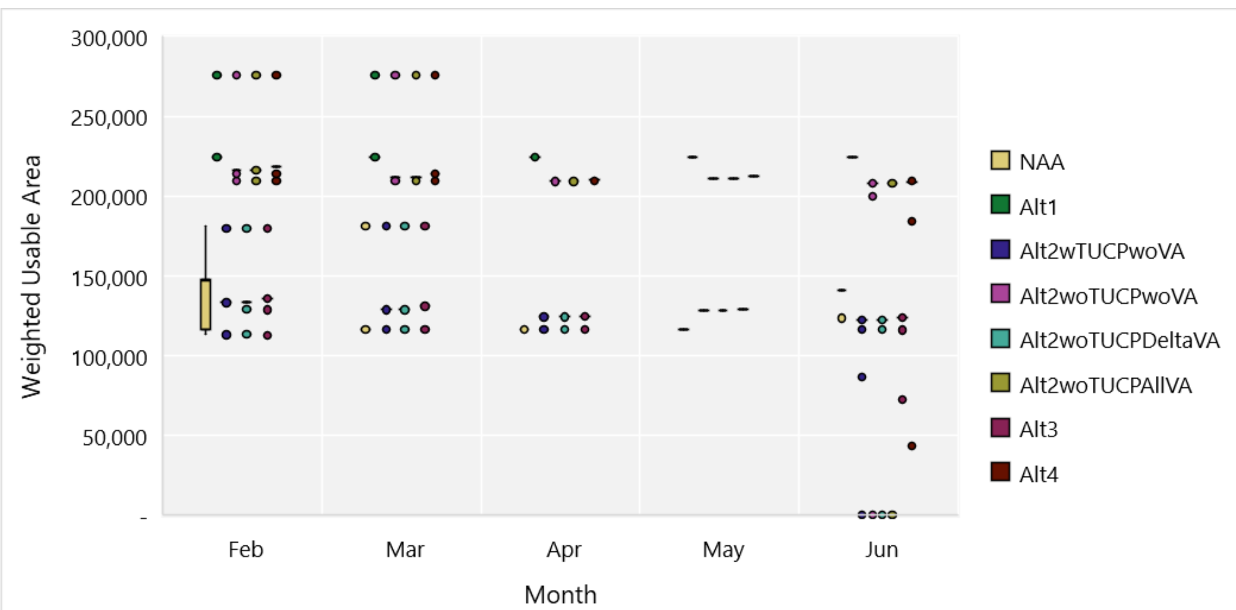

Figure O.1-19. Expected WUA for Steelhead Fry Rearing in Clear Creek for the NAA, and Alternative 1, Alternative 3, Alternative 4, and four phases of Alternative 2 by Month for Three Segments Combined

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 EXP 1, EXP 2, 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 5.5% to 9.1% lower for the EIS modeled scenarios other than Alt 1, and ranging from 47.8% to 49.2 % 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	27,589	36,405	33,925	31,792	31,784	31,781	31,781
AN	25,911	35,065	33,310	31,466	31,466	31,466	31,466
BN	18,178	29,015	32,859	31,064	30,476	30,340	30,314
Dry	17,090	25,273	33,710	31,520	31,520	31,520	31,520
Critical	14,319	20,703	29,924	27,695	27,203	27,257	27,277
All	21,017	29,703	32,955	30,894	30,708	30,691	30,690

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	33,925	17,329	31,792	31,784	31,781	31,781	31,247	31,609
AN	33,310	17,092	31,466	31,466	31,466	31,466	30,961	31,302
BN	32,859	16,682	31,064	30,476	30,340	30,314	30,346	30,736
Dry	33,710	17,267	31,520	31,520	31,520	31,520	31,009	31,355
Critical	29,924	15,632	27,695	27,203	27,257	27,277	27,347	27,717
All	32,955	16,893	30,894	30,708	30,691	30,690	30,363	30,725

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	33,925	-48.92	-6.29	-6.31	-6.32	-6.32	-7.89	-6.83
AN	33,310	-48.69	-5.54	-5.54	-5.54	-5.54	-7.05	-6.03
BN	32,859	-49.23	-5.46	-7.25	-7.66	-7.74	-7.65	-6.46
Dry	33,710	-48.78	-6.50	-6.50	-6.50	-6.50	-8.01	-6.99
Critical	29,924	-47.76	-7.45	-9.09	-8.91	-8.85	-8.61	-7.38
All	32,955	-48.74	-6.25	-6.82	-6.87	-6.87	-7.86	-6.77

Figure O.1-20 and Figure O.1-21 show the full variation in estimated juvenile rearing WUA for steelhead under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the juvenile rearing WUA curves from which they are estimated (Figure O.1-8). The box plots in Figure O.1-20 and Figure O.1-21 show very little variation in scenarios across months, with the exception of EXP1 and EXP3.

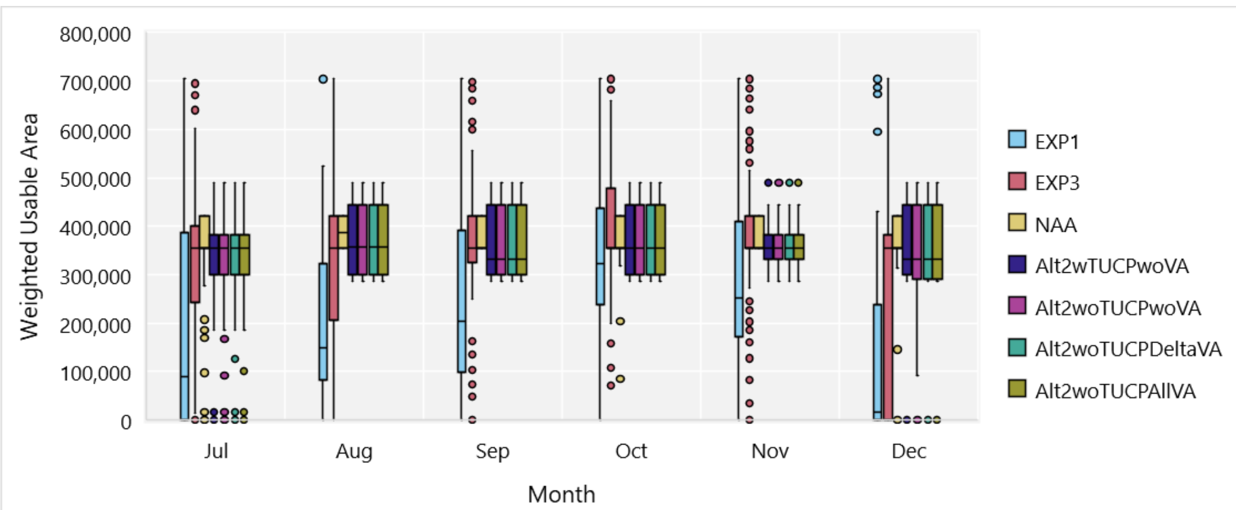

Figure O.1-20. Expected WUA for Steelhead Juvenile Rearing in Clear Creek for EXP1, EXP3, NAA, and Four Phases of Alternative 2 by Month.

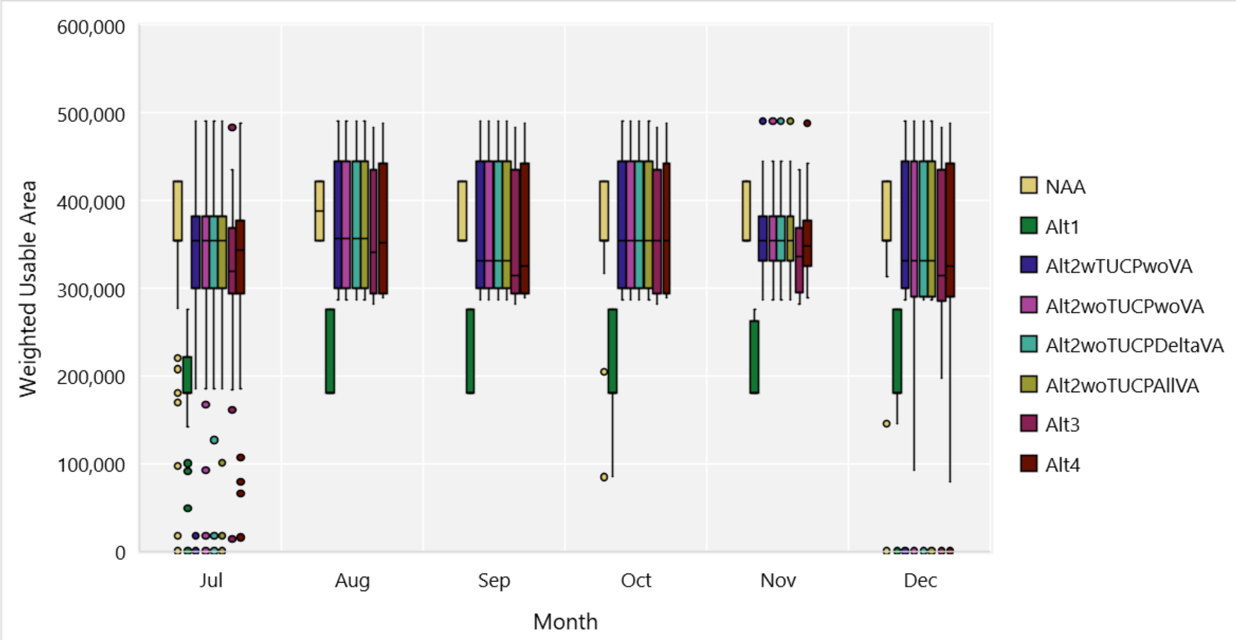

Figure O.1-21. Expected WUA for Steelhead Juvenile Rearing in Clear Creek for the NAA and Alternatives 1-4.

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). The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table O.1-16).

The results for the EIS modeled scenarios mostly show little variation in mean spawning WUA for dry through wet water year types, but WUA is consistently substantially lower under critical water years (Table O.1-16). For the EIS modeled scenarios, most of the scenarios other than Alt 1 have much higher spawning WUA than the NAA, ranging up to 24.7% higher for Alt 3 under critical year types (Table O.1-16). For Alt 1, spawning WUA ranges from 68.1% to 88.6% 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	197,705	114,579	201,120	201,120	201,120	201,120	196,781	201,120
AN	197,705	114,579	201,120	201,120	201,120	201,120	196,781	201,120
BN	192,524	112,033	201,120	197,831	198,023	198,289	196,781	200,941
Dry	197,705	114,579	201,120	201,120	201,120	201,120	196,781	201,120
Critical	136,527	81,290	145,932	142,095	143,601	141,779	154,459	143,347
All	187,596	109,128	192,841	191,674	191,935	191,709	190,432	192,422
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	197,705	-68.64	2.82	2.82	2.82	2.82	-0.76	2.82
AN	197,705	-68.09	2.80	2.80	2.80	2.80	-0.76	2.80
BN	192,524	-88.51	9.45	5.84	6.05	6.34	4.68	9.26
Dry	197,705	-88.63	3.64	3.64	3.64	3.64	-0.99	3.64
Critical	136,527	-76.22	12.98	7.68	9.76	7.25	24.74	9.41
All	187,596	-76.95	5.14	4.00	4.25	4.03	2.78	4.73

Figure O.1-22 shows the full variation in estimated spawning WUA for steelhead under the EIS modeled scenarios. The upper and lower limits of the range in WUA values are determined by the ranges of the spawning WUA curves from which they are estimated (Figure O.1-2). The box plots in Figure O.1-22 show very little variation for the NAA, or for any of the EIS modeled scenarios for alternatives. All of the first and third quartile values are identical because identical WUA values regularly repeat. This, in turn, results because a limited number of flow values occur in the CalSim 3 record for the modeled BA and ESI alternatives. The flow values are derived from Whiskeytown Dam releases, which are set to a limited number of levels based on flow release requirements.

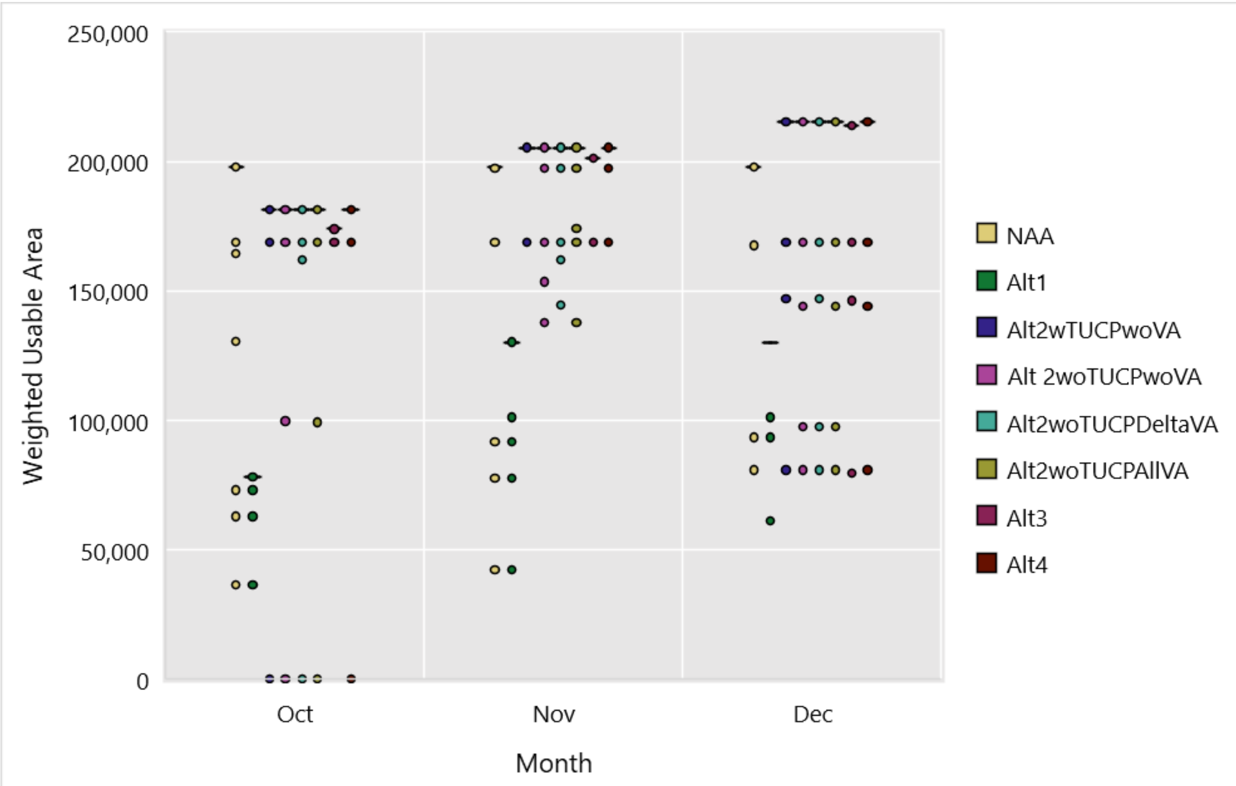

Figure O.1-22. Expected WUA for Fall-run Chinook Salmon Spawning in Clear Creek the NAA and Alternatives 1-4 by Month

O.1.3.3.2 Rearing Weighted Usable Area

Table O.1-17 through 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 both the BA and EIS modeled scenarios mostly show little variation in mean fry rearing WUA among water year types for EXP 1, EXP 2, the NAA, and the EIS modeled scenarios for alternatives, 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 1.3% lower to 2.8% lower (Table O.1-17). For Alt 1, fry rearing WUA greatly increases under all water year types, ranging from 11.4% to 17.6% 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	38,399	44,136	37,731	37,731	37,731	37,731	37,604	37,731
AN	38,724	44,681	38,052	38,052	38,052	38,052	37,920	38,052
BN	38,798	44,681	38,026	38,030	38,030	38,029	37,894	38,030
Dry	39,323	44,681	38,409	38,409	38,409	38,409	38,299	38,409
Critical	40,349	44,680	39,855	39,855	39,855	39,855	39,832	39,855
All	39,050	44,528	38,332	38,332	38,332	38,332	38,224	38,332
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	38,399	16.97	-1.98	-1.98	-1.98	-1.98	-2.35	-1.98
AN	38,724	17.64	-1.99	-1.99	-1.99	-1.99	-2.38	-1.99
BN	38,798	16.69	-2.19	-2.18	-2.18	-2.18	-2.56	-2.18
Dry	39,323	14.36	-2.45	-2.45	-2.45	-2.45	-2.75	-2.45
Critical	40,349	11.43	-1.30	-1.30	-1.30	-1.30	-1.36	-1.30
All	39,050	15.41	-2.02	-2.02	-2.02	-2.02	-2.32	-2.02

Figure O.1-23 shows the full variation in estimated fry rearing WUA for fall-run Chinook salmon under the EIS modeled scenarios. The upper and lower limits of the range in WUA values are determined by the ranges of the fry rearing WUA curves from which they are estimated (Figure O.1-5). The box plot in Figure O.1-23 shows very little variation across months for NAA, or for any of the EIS modeled scenarios. The first and third quartile values are identical because identical WUA values regularly repeat. This, in turn, results because a limited number of flow values occur in the CalSim 3 record for the modeled EIS alternatives. The flow values are derived from Whiskeytown Dam releases, which are set to a limited number of levels based on flow release requirements.

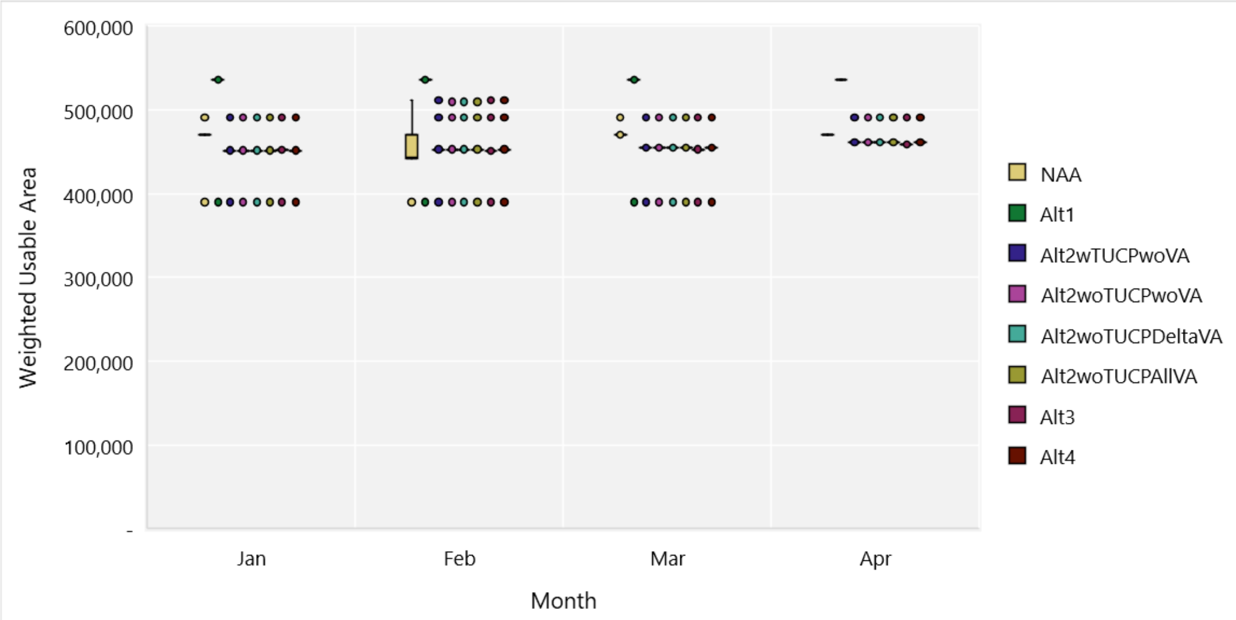

Figure O.1-23. Expected WUA for Fall-run Chinook Salmon Fry Rearing in Clear Creek for the NAA and Alternatives 1-4 by Month for Three Segments Combined

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). (Table O.1-14 and Table O.1-15). For the EIS modeled scenarios, 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	25,782	18,743	24,900	24,900	24,900	24,900	24,755	24,900
AN	25,782	18,743	24,900	24,900	24,900	24,900	24,755	24,900
BN	25,507	18,535	24,900	24,366	24,366	24,366	24,755	24,633
Dry	25,782	18,743	24,900	24,900	24,900	24,900	24,755	24,900
Critical	24,511	17,753	22,302	21,731	22,070	22,038	22,991	22,452
All	25,529	18,547	24,484	24,297	24,351	24,346	24,473	24,460

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	25,782	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
AN	25,782	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
BN	25,507	-27.34	-2.38	-4.47	-4.47	-4.47	-2.95	-3.43
Dry	25,782	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
Critical	24,511	-27.57	-9.01	-11.34	-9.96	-10.09	-6.20	-8.40
All	25,529	-27.35	-4.09	-4.83	-4.61	-4.63	-4.14	-4.19

Figure O.1-24 shows the full variation in estimated juvenile rearing WUA for fall-run Chinook salmon under the EIS modeled scenarios. The upper and lower limits of the range in WUA values are determined by the ranges of the juvenile rearing WUA curves from which they are estimated (Figure O.1-9). The box plot in Figure O.1-24 shows the highest WUA values in May and June for all of the EIS modeled scenarios. The first and third quartile values are identical because identical WUA values regularly repeat. This, in turn, results because a limited number of flow values occur in the CalSim 3 record for the modeled EIS alternatives. The flow values are derived from Whiskeytown Dam releases, which are set to a limited number of levels based on flow release requirements.

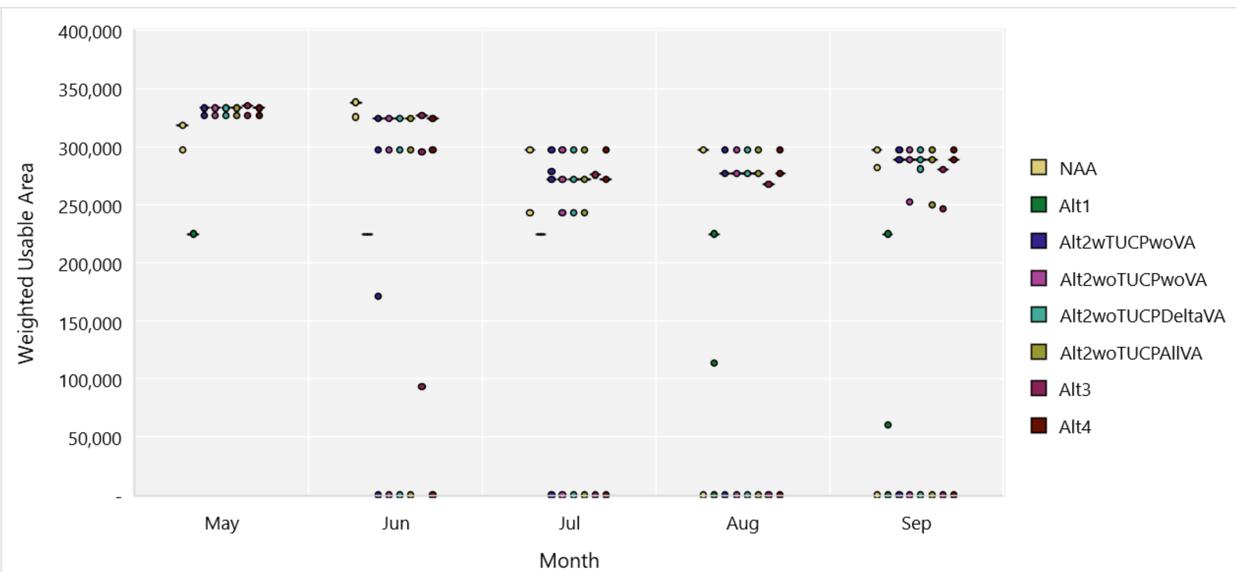

Figure O.1-24. Expected WUA for Fall-run Chinook Salmon Juvenile Rearing in Clear Creek for the NAA and Alternatives 1-4 by Month for Three Segments Combined

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