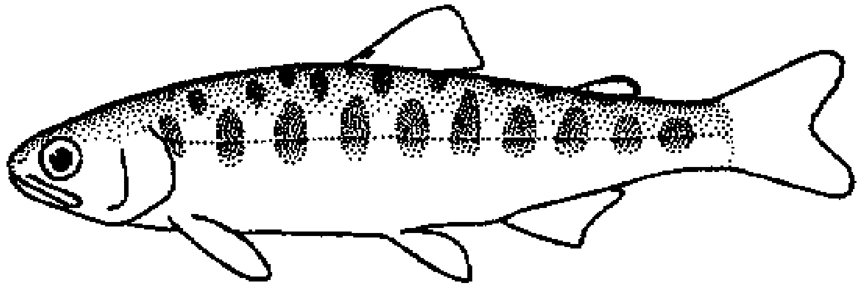
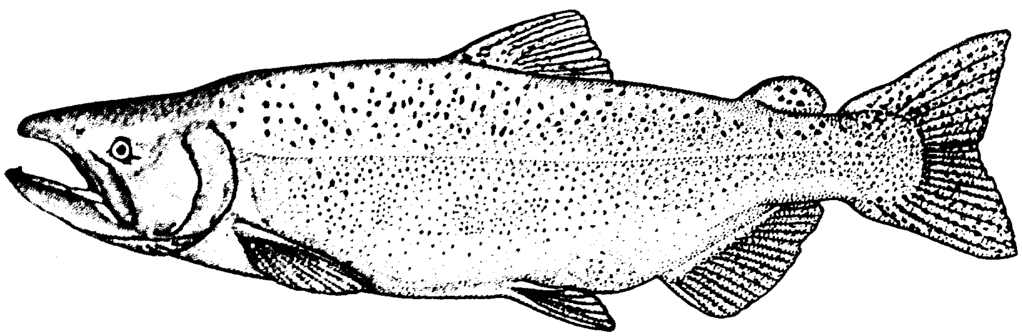
CLEAR CREEK HABITAT SYNTHESIS REPORT





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CVPIA INSTREAM FLOW INVESTIGATIONS CLEAR CREEK SYNTHESIS REPORT

PREFACE

The following is a synthesis of the U. S. Fish and Wildlife Service's investigations on anadromous salmonid spawning and rearing habitat in Clear Creek. These investigations are part of the Central Valley Project Improvement Act (CVPIA) Instream Flow Investigations, an effort which began in October, 2001[1]. Title 34, Section 3406(b)(1)(B) of the CVPIA, P.L. 102-575, requires the Secretary of the Interior to determine instream flow needs for anadromous fish for all Central Valley Project controlled streams and rivers, based on recommendations of the U. S. Fish and Wildlife Service after consultation with the California Department of Fish and Wildlife (CDFW). The purpose of these investigations is to provide scientific data to the U. S. Fish and Wildlife Service CVPIA Program to assist in developing such recommendations for Central Valley rivers.

Written comments or information can be submitted to and raw data in digital format can be obtained from:

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[1] This program is a continuation of a 7-year effort, also titled the Central Valley Project Improvement Act Flow Investigations, which ran from February 1995 through September 2001.

INTRODUCTION

In response to substantial declines in anadromous fish populations, the Central Valley Project Improvement Act (CVPIA) provided for enactment of all reasonable efforts to double sustainable natural production of anadromous fish stocks including the four races of Chinook salmon (fall, late-fall, winter, and spring runs), steelhead, white and green sturgeon, American shad and striped bass. For Clear Creek, the CVPIA Anadromous Fish Restoration Plan calls for a release from Whiskeytown Dam of 200 cfs from October through June and a release of 150 cfs or less from July through September (U. S. Fish and Wildlife Service 2001). Table 1 shows the temporal distribution and Figure 1 shows the spatial distribution of adult and juvenile spring-run, fall-run, and steelhead in Clear Creek. An experiment in 1998 established that flows of 150 cfs would not provide adequate temperatures in all years (Newton and Brown 2004). As a result, actual peak July through September flows, as measured at the Igo gage, have been as high as 250 cfs. In addition, flows have been 200 to 250 cfs in September for spring-run Chinook salmon spawning. In addition, flows up to 250 cfs has gone into October to meet temperature targets as identified in the 2009 Central Valley Project and State Water Project Long-term water operations (OCAP) biological opinion[2].

The Clear Creek study was planned to be a 5-year effort, the goals of which were to determine the relationship between stream flow and physical habitat availability for all life stages of Chinook salmon (fall- and spring-run) and steelhead/rainbow trout. There were four phases to this study based on the life stages to be studied and the number of segments delineated for Clear Creek from downstream of Whiskeytown Reservoir to the confluence with the Sacramento River[3]. Results of the four phases of the study are given in U. S. Fish and Wildlife Service (2007, 2011a, 2011b and 2013). The goal of this report is to synthesize the information in the above four reports in a form that can be used for developing flow recommendations for Clear Creek as related to physical habitat for anadromous salmonids. The intent of this report is to provide a framework for adaptive management of flows in Clear Creek by identifying uncertainties and hypotheses, and providing an experimental approach to use future monitoring data to inform flow management.

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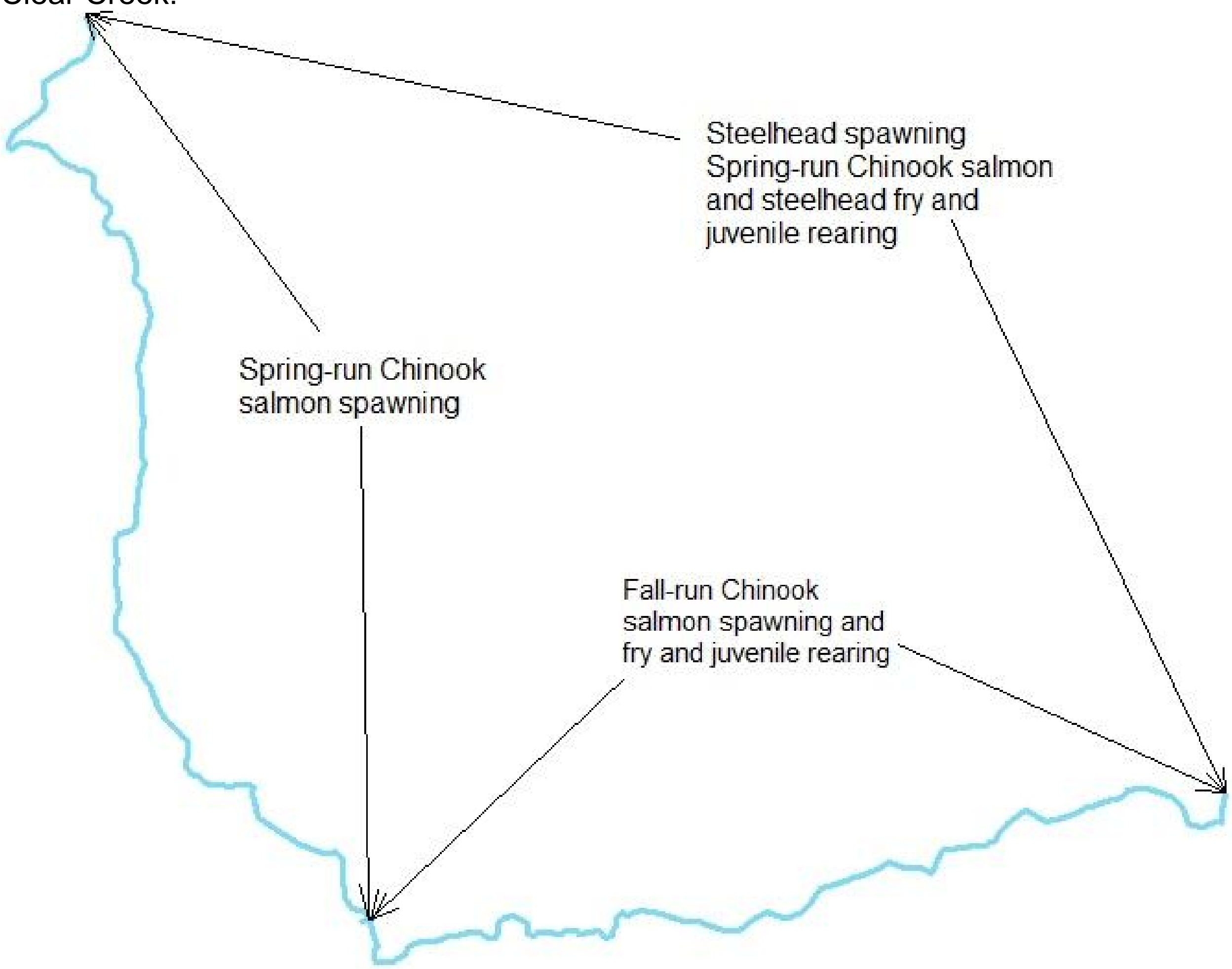
[2] OCAP Reasonable Prudent Alterative Action I.1.5 requires that Reclamation shall manage Whiskeytown releases to meet a daily water temperature of 60°F at the Igo gage from June 1 through September 15 and 56°F at the Igo gage from September 15 to October 31 in order to reduce thermal stress to over-summering steelhead and spring-run during holding, spawning, and embryo incubation.

[3] There are three segments: the Upper Alluvial segment, the Canyon segment, and the Lower Alluvial segment. Spring-run Chinook salmon spawn in the upper two segments and the upper mile of the lower segment, fall-run Chinook salmon spawn primarily in the lower 6.5 miles of the 8.5 mile lower segment, and steelhead/rainbow trout spawn in all three segments.

Table 1. Temporal distribution of adult and juvenile spring-run, fall-run and steelhead in Clear Creek.

Life Stage	Fall-run	Spring-run	Steelhead
Spawning	Oct-Dec	Sep	Dec-Apr
Fry (< 60 mm)	Jan-Apr	Nov-Mar	Feb-June
Juvenile (> 60 mm)	May-Sep	Apr-Aug	Jul-Dec

Figure 1. Spatial distribution of adult and juvenile spring-run, fall-run and steelhead in Clear Creek.



METHODS

The flow-habitat relationships in U. S. Fish and Wildlife Service (2007, 2011a, 2011b and 2013) were summed for the three segments. The total habitat available for spring-run Chinook salmon and steelhead/rainbow trout was then compared to the amount of habitat needed to support an annual escapement of 833 adults for each species. This escapement level is equivalent to a census size of 2,500, which would represent the Central Valley Anadromous Salmonid Recovery Plan abundance target[4] for recovery of the population of these two species/races in Clear Creek, based on reaching a viable status (NMFS 2014). The amount of habitat needed to support an annual escapement of 833 adults was based on the parameters in Table 2. The sources of information for the habitat requirement numbers in Table 2 are the average size of fall-run Chinook salmon redds measured by the Red Bluff Fish and Wildlife Office, and fry and juvenile densities from snorkel survey data collected by the Red Bluff Fish and Wildlife Office. The average recent (2005-2013) fall-run Chinook salmon annual escapement is 7,920, while the 90th percentile value is 14,824 (Azat 2014). The amount of habitat needed to support an annual escapement of 7,920 adult fall-run Chinook salmon was also based on the parameters in Table 2. Alternatively, the AFRP goal of 7,100 fall-run Chinook salmon for Clear Creek may be a more appropriate metric to use, since it is required within the CVPIA legal mandates and language.

RESULTS

The total habitat for the three life stages and species/races of anadromous salmonids in Clear Creek is shown in Figures 2 to 8. With the exception of spring-run Chinook salmon spawning at all flows (based on the original habitat availability estimate) and steelhead spawning at 50 cfs, the amount of habitat present in Clear Creek is greater than the amount of habitat needed to achieve the abundance recovery goal of spring-run Chinook salmon and steelhead in Clear Creek[5]. In contrast, the amount of habitat present in Clear Creek is less than the amounts of habitat needed for 7,920 adult fall-run Chinook salmon (316,800 square feet of spawning habitat,

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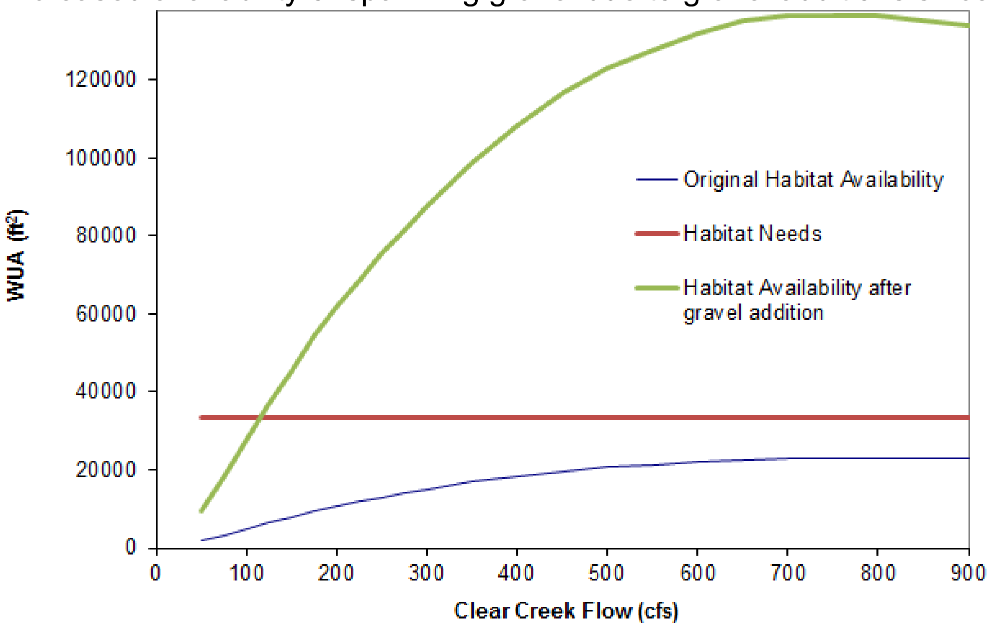
[4] The population size is only one of four criteria that define a low risk of extinction. The other three criteria are no apparent productivity decline, no catastrophic events occurring or apparent within the last 10 years, and low hatchery influence (Lindley et al. 2007, NMFS 2014). Thus, a population with 833 adult fish may not be considered viable if any one of the other criteria is not met.

[5] As noted below in the discussion, the amount of spawning habitat for spring-run Chinook salmon spawning may actually be higher with the continual injection and redistribution of spawning gravel.

Table 2. Habitat capacity parameters. Parameters are Clear Creek specific, from U.S. Fish and Wildlife Service Red Bluff staff, personal communication.

Life Stage	Habitat Requirement	Adult Equivalent
Spawning	100 ft^2/redd	2.5 adults/redd
Fry (< 60 mm)	1.45 [6] fry/ft^2	200 fry/adult [7]
Juvenile (> 60 mm)	0.77 [6] juveniles/ft^2	67 juveniles/adult [7]

Figure 2. Spring-run Chinook salmon spawning flow-habitat availability relationship and habitat needs. Original habitat availability is from U.S. Fish and Wildlife Service 2007. Increased habitat availability was calculated by increasing the habitat availability in the upper alluvial and Canyon reaches by, respectively 533% and 2397%, to reflect increased availability of spawning gravel due to gravel additions since 2003.



[6] The values were the 90% exceedance of densities, calculated by dividing fish numbers (from snorkel survey data) by the WUA of each habitat unit in restoration sites 3A and 3B in 2008.

[7] The values are based on assumptions that 75% of fry immediately leave Clear Creek and do not rear in Clear Creek, and that 86% of young of the year fish leave Clear Creek before they become juveniles. These values are based on the percentages of different sizes of fall-run Chinook salmon in Clear Creek screw trap data.

Figure 3. Spring-run Chinook salmon fry rearing flow-habitat availability relationship and habitat needs.

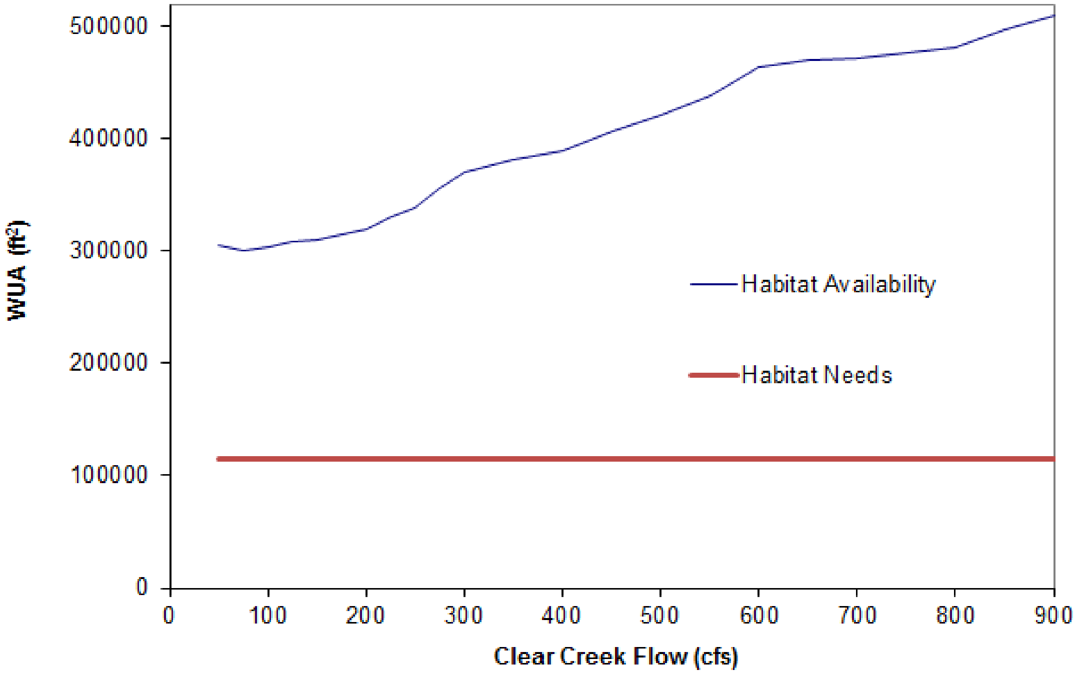


Figure 4. Spring-run Chinook salmon juvenile rearing flow-habitat availability relationship and habitat needs.

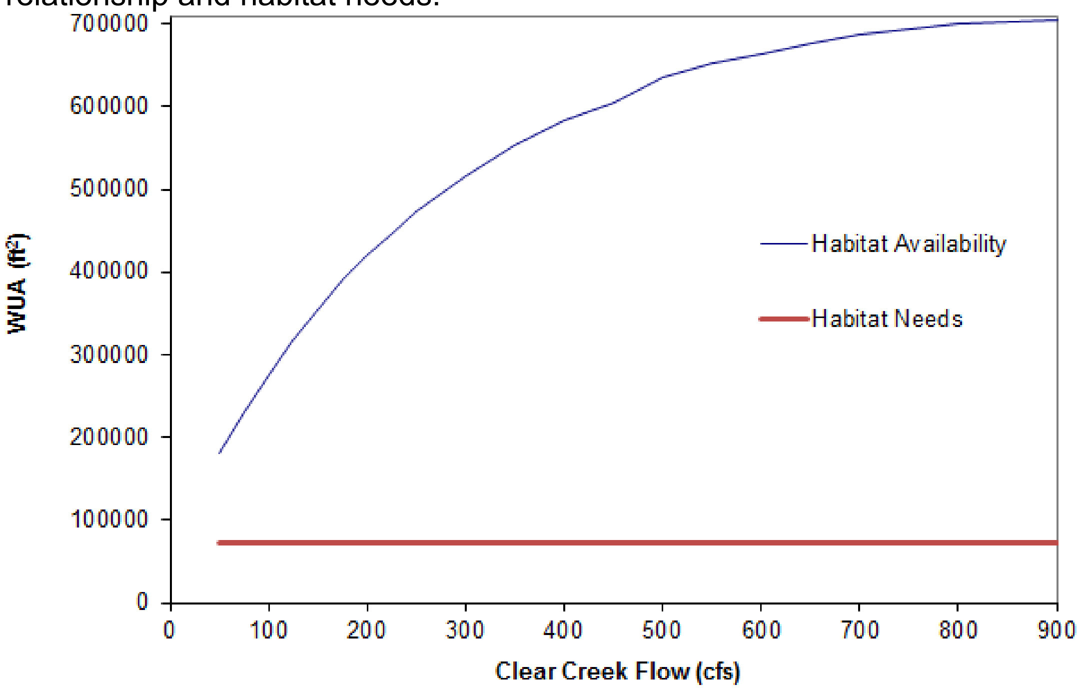


Figure 5. Steelhead/rainbow trout spawning flow-habitat availability relationship and habitat needs.

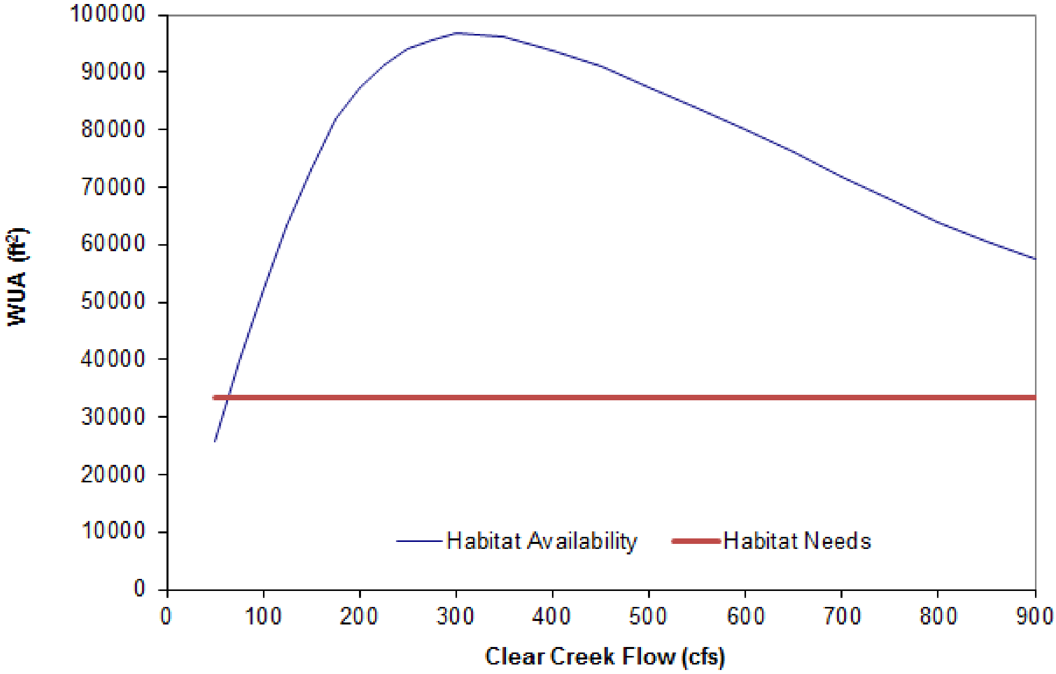


Figure 6. Steelhead/rainbow trout fry rearing flow-habitat availability relationship and habitat needs.

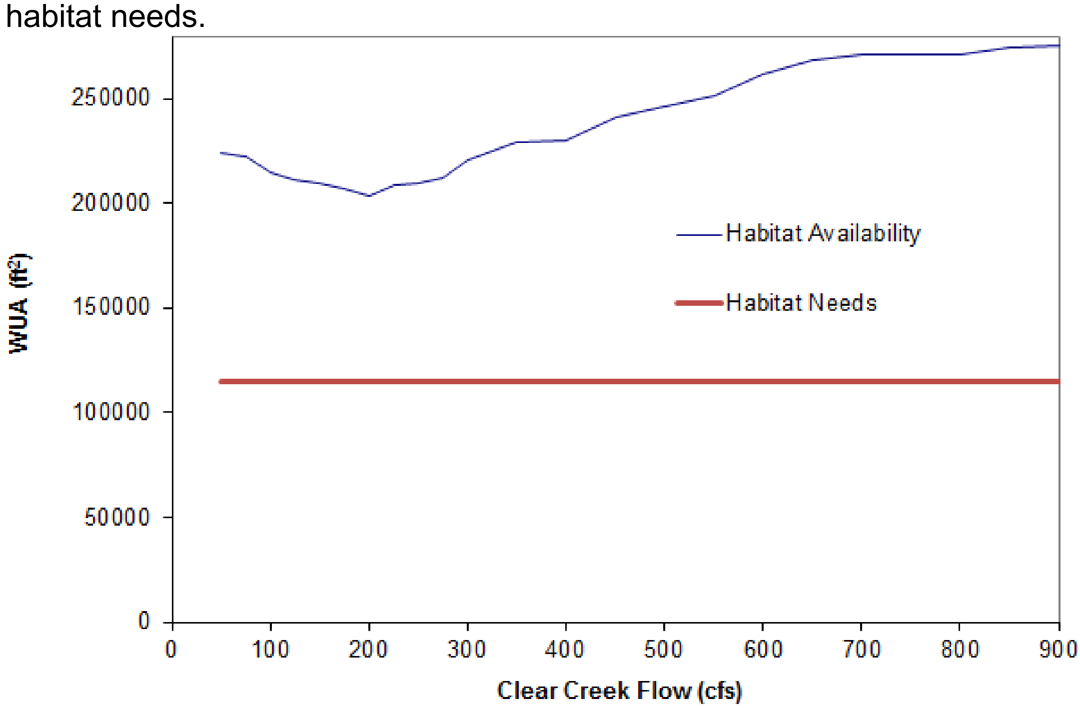


Figure 7. Steelhead/rainbow trout juvenile rearing flow-habitat availability relationship and habitat needs.

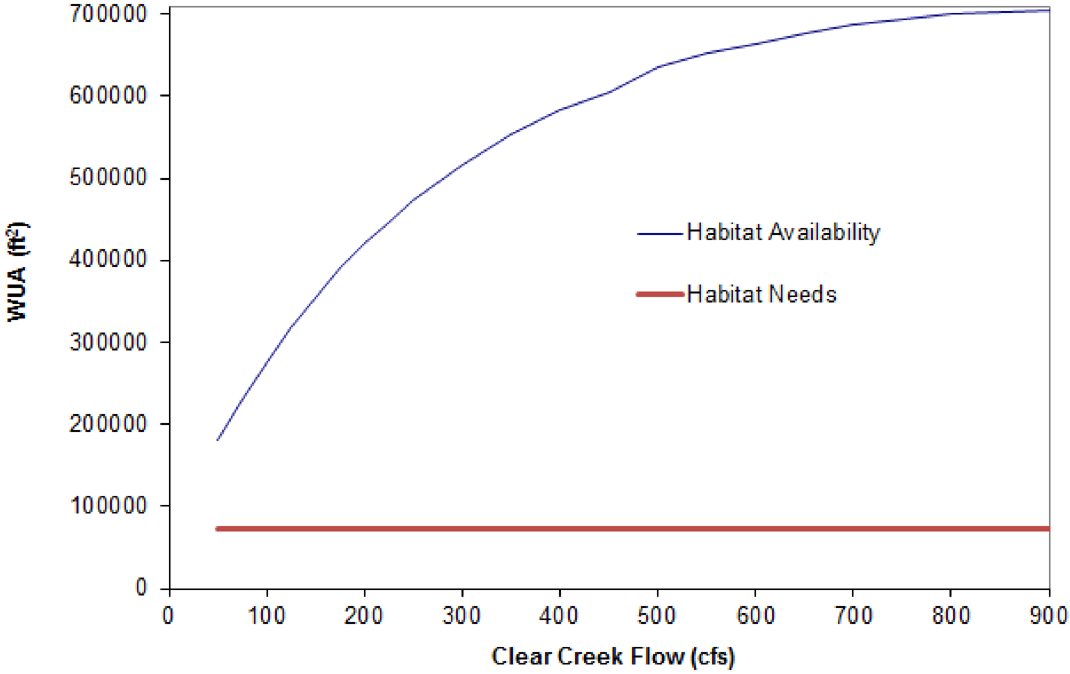
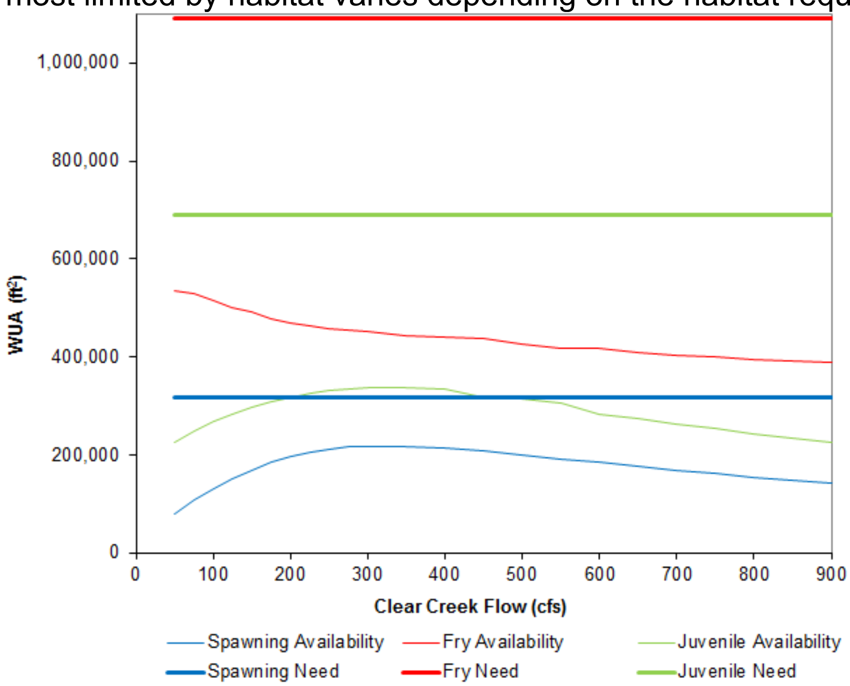


Figure 8. Fall-run Chinook salmon flow-habitat availability relationships. The life stage most limited by habitat varies depending on the habitat requirement in Table 2.



1,902,418 square feet of fry rearing habitat, and 689,145 square feet of juvenile rearing habitat[8]). A flow of 200 cfs provides 91%, 88% and 94% of the maximum amount of habitat for, respectively, spawning, fry and juvenile fall-run Chinook salmon. In contrast, flows of 225 to 300 cfs provide the percentages in Table 3 of the maximum amount of habitat for, respectively, spawning, fry and juvenile fall-run Chinook salmon. Since, as discussed above, habitat is not limiting for spring-run Chinook salmon and steelhead, there is no need to balance flow needs between species, and thus only fall-run Chinook salmon habitat requirements need to be addressed. An additional consideration that will need to be addressed by the Clear Creek technical team in developing flow recommendations will be the amount of available water (with the water being of suitable temperatures) on Clear Creek, by water year type.

DISCUSSION

The low amount of spawning habitat available for spring-run Chinook salmon, versus other life stages of spring-run Chinook salmon and all life stages of steelhead/rainbow trout, is due to spring-run Chinook salmon mostly spawning in the upper alluvial and canyon reaches, where there is a limited amount of spawning habitat. The amount of spring-run Chinook salmon spawning habitat available is based in part on the count of spring-run Chinook salmon redds from 2000-2003[9], prior to the addition of spawning gravel to the upper alluvial and canyon reaches. Graham Matthews and Associates (2011) found that there was a 533 percent increase in spring-run Chinook salmon spawning habitat available from 2001 to 2009 in the upper alluvial reach, largely as a result of gravel addition. In addition, spawning mapping data from 2010 to 2013 indicates that there was a 2397 percent increase in spawning habitat available in the Canyon reach due to gravel addition. With a 533 percent increase in the amount of spawning habitat in the upper alluvial reach and a 2397 percent increase in the amount of spawning habitat in the Canyon Reach, there would be enough available spawning habitat for a spring-run Chinook salmon annual escapement of 833 adults for flows greater than 125 cfs[10] (Figure 2).

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[8] While the spawning habitat for spring-run and fall-run do not overlap, there is a partial overlap in spring-run and fall-run fry and juvenile rearing habitat, as it’s been analyzed in this report, since fry and juveniles of both runs rear in the lower alluvial reach.

[9] The multiplier used to extrapolate from the WUA in the study sites to the WUA in each reach was calculated by dividing the number of redds in each reach by the total number of redds in the study sites, using the number of redds in 2000-2003. Saeltzer Dam was removed in the early fall of 2000. Spring-run Chinook salmon were able to spawn in the upper alluvial and Canyon reaches in 2000 because of efforts to clean the Saeltzer Dam fish ladder during the spring and summer of 2000 (S. Gallagher, personal communication).

[10] This assumes that spring-run Chinook salmon would use the injected gravel; they don’t always use it, based on the Red Bluff Fish and Wildlife Office’s reports on the proportion of use of injected spawning gravel relative to naturally occurring gravel.

Table 3. Percentage of maximum available habitat for fall-run Chinook salmon.

Flow (cfs)	Spawning	Fry (< 60 mm)	Juvenile (> 60 mm)
225	95%	86%	96%
250	97%	85%	98%
275	99%	85%	99%
300	100%	84%	100%

This conclusion is supported by the lack of spring-run Chinook salmon redd superposition observed in 2013 when there was an estimated escapement of 659 (S. Gallagher, personal communication). In addition, 16 percent of spring-run Chinook salmon spawn in the lower alluvial reach, which would also increase the total amount of spring-run Chinook spawning habitat available in Clear Creek.

The habitat needs for steelhead/rainbow trout shown in Figures 5 through 7 (33,300 ft^2 for spawning, 114,895 ft^2 for fry rearing and 72,482 ft^2 for juvenile rearing) are likely conservative, given that the habitat capacity parameters are based on Chinook salmon, and steelhead/rainbow trout would be expected to have lower habitat needs than Chinook salmon due to, for example, smaller redds[11]. Given that habitat is not likely to be limiting for spring-run Chinook salmon and steelhead/rainbow trout, instream flow needs for physical habitat should be based on fall-run Chinook salmon. Habitat is much more likely to be limiting for this race due to much higher population levels, as compared to spring-run Chinook salmon and steelhead/rainbow trout. Alternatively, if habitat does become limiting for spring-run Chinook salmon or steelhead/rainbow trout, habitat restoration could be used to meet the habitat needs of these species, while flow is used in part to meet the habitat needs of fall-run Chinook salmon.

For developing flow recommendations for fall-run Chinook salmon, flows in October through December would be based on spawning, while flows in January through April would be based on fry rearing, and flows in May through September would be based on juvenile rearing. The decrease in the number of rearing juveniles during the summer would reduce the need for habitat. If the reduced need for habitat fell below habitat availability, temperature would be the controlling factor of flows in July and August. To avoid dewatering of fall-run Chinook salmon redds (Tables 4 and 5), flows in the range of 200 to 300 cfs in October through December should

[11] There is no available data to assess whether fry and juvenile steelhead/rainbow trout would require less habitat than fry and juvenile Chinook.

Table 4. Percentage of fall-run Chinook salmon redds dewatered, based on equation in Peterson et al. (2014).

	Spawning Flow				
Dewatering Flow (cfs)	300 cfs	275 cfs	250 cfs	225 cfs	200 cfs
275	1.8%				
250	3.1%	1.9%			
225	5.3%	3.5%	2.0%		
200	8.9%	6.1%	3.9%	2.2%	
175	23%	18%	13%	8.9%	5.3%
150	34%	29%	23%	17%	11%
100	47%	42%	37%	30%	23%
75	61%	57%	53%	47%	41%
50	73%	71%	69%	65%	61%

not be reduced in January. Similarly, flows should not be reduced in October through December, as compared with flows in September, to avoid dewatering spring-run Chinook salmon redds. Finally, flows should not be reduced in December through May, versus flows in October and November, to avoid dewatering steelhead/rainbow trout redds[12]. Given these constraints, a year-round flow of 200 cfs[13] (Figure 9) would balance the habitat needs for the different life stages of fall-run Chinook salmon, with the amount of habitat for all life stages at 88%[14] or greater of the maximum amount of habitat. Alternatively, based on the percentages

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[12] In Clear Creek, 95 percent of steelhead spawn by early April (S. Gallagher, personal communication), and thus 95 percent of steelhead fry would emerge by the end of May.
[13] 200 cfs was selected since it is the flow identified in the CVPIA Anadromous Fish Restoration Plan. 200 cfs is neither a minimum or optimal baseflow, but is one flow that would balance the flow needs for different life stages of fall-run Chinook salmon, while preventing redd dewatering.
[14] 88% of habitat is not a criterion and we are unable to determine whether it is sufficient; rather it is a metric to allow for a comparison between different life stages. The different life stages are addressed to show how the 200 cfs flow was derived from the different optimal flows for each life stage. Consideration of redd dewatering eliminated different flow amounts for each life stage. Given uncertainty associated with the values in Table 2, the limiting life stage cannot be determined. However, with the values in Table 2, fry would be the limiting life stage.

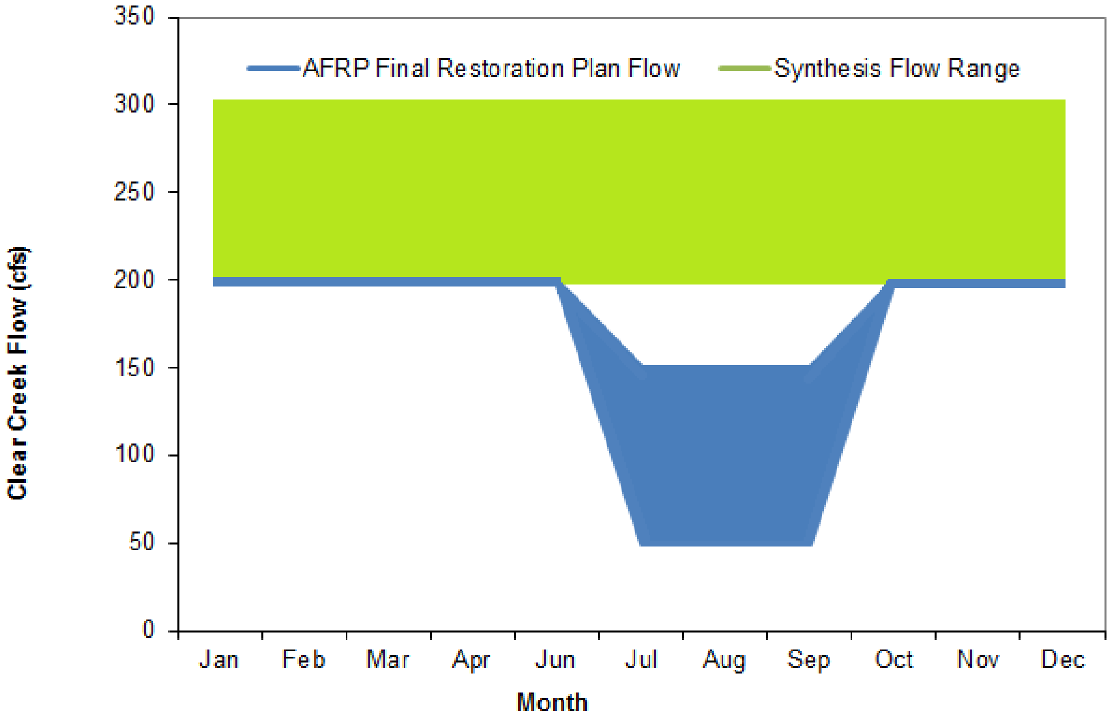
Table 5. Predicted percentages of Clear Creek fall-run Chinook salmon redds dewatered, based on historic data. For 2013 and 2014, the lower end of range is based on a dewatering velocity criterion of 0.1 ft/s, while the upper end of the range is based on a dewatering velocity criterion of 0.25 ft/s.

Year	Spawning Flow (cfs)	Dewatering Flow (cfs)	Percent Redds Dewatered
2009	244	92	19%
2010	284	73	20%
2011	241	65	26%
2013	215	175	5.6-6.3%
2013	215	150	8.6-9.7%
2013	215	125	11-12%
2013	215	100	16-19%
2013	215	75	21-29%
2013	215	50	30-37%
2014	185	175	5.8%
2014	185	150	8.7%
2014	185	125	12-14%
2014	185	100	13%
2014	185	75	19-20%
2014	185	50	25-27%

of WUA for 200 to 300 cfs[15] in Table 3, the highest average WUA for all three life stages is at 300 cfs, since the maximum WUA for spawning and juvenile rearing is at 300 cfs and the maximum WUA for fry rearing is at 50 cfs, but only decreases to 84% of the maximum at 300 cfs. A third alternative approach would be to look at which life stage is limiting; if spawning or juvenile rearing is the limiting life stage, a flow of 300 cfs would be expected to maximize

[15] 225 to 300 cfs were selected to show the effects of incremental changes in flow on habitat availability.

Figure 9. Potential Clear Creek base flow regimes[16].



fall-run Chinook salmon production. As shown in Figure 8, no flow from 50 cfs to 900 cfs would meet the habitat needs for any of the three life stages of fall-run Chinook salmon: spawning, fry rearing, or juvenile rearing. For example, a 200 cfs flow would meet approximately 70% of the spawning need, 40% of the juvenile rearing need, and 30% of the fry rearing need. This implies the following three possibilities: (1) a population at this size exceeded the carrying capacity in Clear Creek, which would not be sustainable, (2) the actual habitat area used by fall-run Chinook salmon was larger than the area estimated from the studies, if the fall-run population had proven sustainable at 7100 adults in Clear Creek, or (3) the actual habitat needs for fall-run were smaller than the calculated needs based on the estimated densities of redd, fry, and juvenile. It also points out the importance of both flows and habitat restoration to achieve the doubling goal for fall-run Chinook salmon in Clear Creek.

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[16] As discussed in the introduction, the synthesis flow range is more typical of recent flow releases. The flow regimes represent potential Clear Creek base flows, and thus do not include pulse flows or channel maintenance flows. The OCAP Biological Opinion also includes flow requirements, but they are not amenable to being illustrated in this fashion, since they are largely based on meeting temperature targets, rather than being specified flows.

Given that habitat is likely not limiting for spring-run Chinook salmon and steelhead, a 200 to 300 cfs year round flow will meet the habitat needs of all life stages of these runs/species, to provide the conditions needed to address the abundance recovery goal. Although a year-round constant flow (e.g., 250 cfs) may provide sufficient physical habitat needed for spawning or rearing, it may not be enough for the recovery of the listed species or achieving the doubling goal for fall-run Chinook salmon. Development of a flow regime requires consideration of other parameters such as channel maintenance, floodplain inundation, riparian regeneration, and water temperature. If these factors were not considered in a flow regime, the physical habitat could not be maintained as needed and eventually unable to support the long-term population sustainability. It has been widely accepted that to protect freshwater biodiversity and maintain the valuable goods and services provided by rivers, it is essential to mimic components of natural flow variability, taking into consideration the magnitude, frequency, timing, duration, and rate of change of flow events (Richter et al. 1996, Poff et al. 1997, Richter et al. 1997, Petts 2009). These five critical components of the flow regime regulate ecological processes in river ecosystems. They can be used to characterize the entire range of flows and specific hydrologic phenomena such as floods and low flows. Furthermore, by defining flow regimes in these terms, the ecological consequences of particular human activities that modify one or more components of the flow regime can be considered and addressed explicitly (Dahm et al. 2014, He and Marcinkevage 2014).

Equally important is the consideration of water temperature needs for spawning, egg incubation, and juvenile rearing. High water temperatures can pose lethal or sublethal impacts to salmonids at all life stages, including adult migration, pre-spawn holding, spawning, egg incubation, fry emergence, and juvenile rearing and outmigration (McCullough 1999, Poole and Berman 2001, U.S. Environmental Protection Agency 2003, Poole et al. 2004, Richter and Kolmes 2005, Jonsson and Jonsson 2009, McCullough et al. 2009). In Clear Creek, elevated water temperatures impact both adults and juveniles. The number of spring-run adults in Clear Creek was negatively correlated to water temperature in July, while the number of outmigrating juveniles was negatively correlated to the October water temperature of previous year. The number of steelhead juveniles outmigrating from Clear Creek was negatively impacted by warmer water temperatures in June or August as steelhead juveniles typically spend more than one year for rearing (He and Marcinkevage 2014).

In setting flows, the life history needs at a particular time of the year should be considered. In addition, there is ecological importance in varying flows from year to year. For example, a flow regime could have a flow of 250 cfs in wet years, 225 cfs in normal years and 200 cfs in dry years. This would address the variability seen in unregulated systems due to different water year types. An assumption of this analysis is that flow changes would dewater redds. It would be expected that decreasing flows from 225 or 250 cfs to 200 cfs would dewater redds, but at a much lower magnitude than decreasing flows to 50 cfs. Accretions between Whiskeytown Dam and the lower alluvial reach increase through the fall into winter and may ameliorate redd dewatering. Development of a flow regime for Clear Creek will also require consideration of other parameters, such as water temperatures, riparian regeneration, channel maintenance, pulse flows for upstream and downstream migration, and effects of flows on the spatial distribution of adult fall-run and spring-run Chinook salmon. Another consideration is the possibility of managing flows based upon forecasts and/or projections of water availability in concert with fish needs by life stage and species/run.

Factors causing uncertainty in implementing a revised flow regime in Clear Creek include:

· effects of high flows on the topography, substrate and cover of Clear Creek since data was collected to develop the flow-habitat relationships in Figures 2 to 8
· extrapolation from the study sites used to develop the flow-habitat relationship in Figures 2 to 8 to all of Clear Creek
· uncertainties in the habitat suitability criteria used to develop the flow-habitat relationships in Figures 2 to 8
· the relative effects of habitat for different life stages on overall salmonid productivity[17]
· the number of juveniles that continue to rear through the summer[18]
· the relative contribution to escapement of different life history strategies (fry emigration versus smolt emigration versus yearling emigration)
· uncertainties in the values of the parameters in Table 2

Alternative habitat suitability criteria for spring-run Chinook salmon spawning (U.S. Fish and Wildlife Service 2007, 2010) predicted greater amount of habitat at all flows (Figure 10)[19] than the results in Figure 2, suggesting that that results in Figure 2 are a conservative estimate of habitat capacity for spring-run Chinook salmon spawning. Given that Figure 2 shows that there is not a deficiency in spawning habitat relative to the needs of 833 fish, the alternative criteria would also meet the needs of 833 fish.

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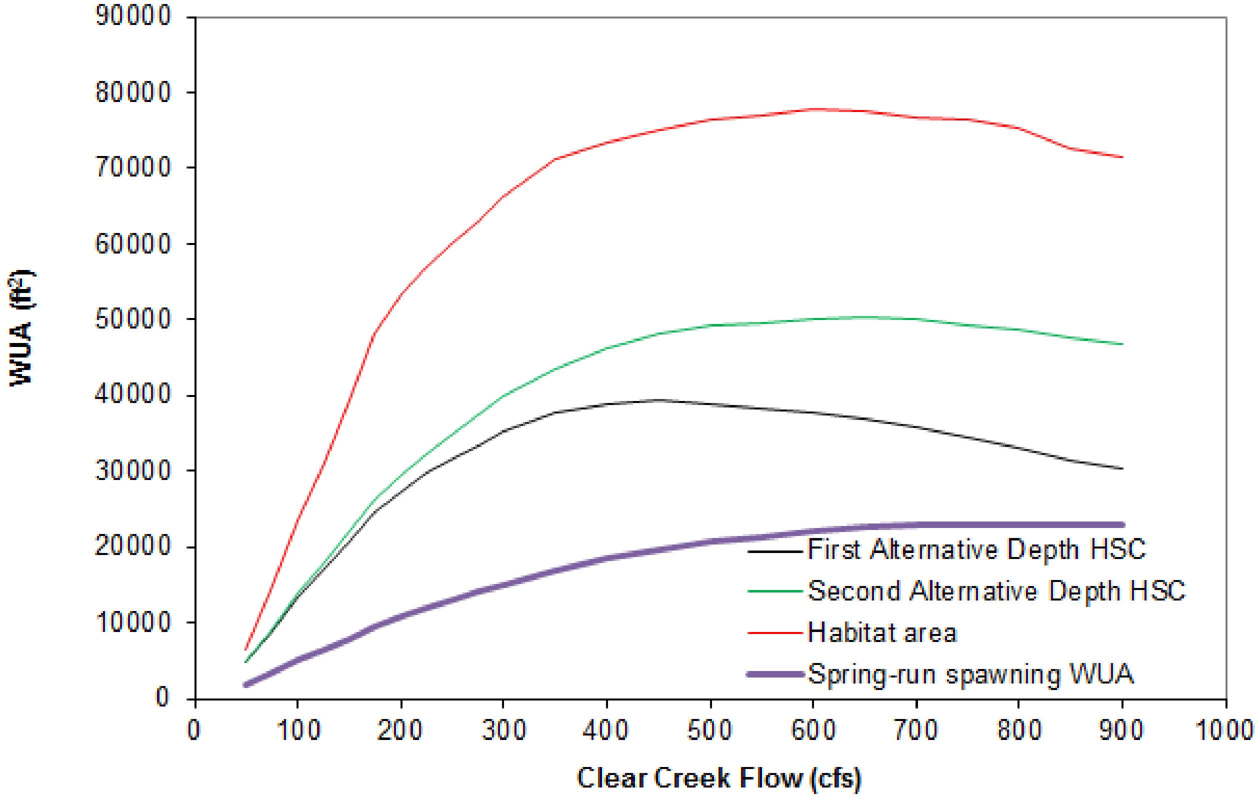
[17] Effects of spawning habitat limitations (redd superposition), resulting in direct mortality of eggs, could have a very different effect than fry or juvenile habitat limitations, where mortality rates could be much less if fry or juveniles respond to habitat limitations by moving out of Clear Creek and rearing in the Sacramento River.
[18] This is based on snorkel survey data showing juveniles numbers declining through the summer, presumably due to juvenile outmigration from Clear Creek.
[19] This information is presented because of the uncertainty in the habitat suitability criteria.

Figure 9. Flow-habitat relationships for spring-run Chinook salmon spawning from alternative habitat suitability criteria.



Values in the literature for the parameters in Table 2 vary widely. For example, redd size estimates can be as much as 215 ft^2, including area defended, or as little as 48 ft^2 based on the egg pocket area. The value in Table 2 for redd area was derived from the assumption that adults would build redds side by side on the spawning ground, without any space left between redds. This assumption is most likely invalid as adults do not build redds side by side. In fact, Riebe et al. (2014) found fall-run adults in the Shasta River used, on average, only 18.5% of the entire suitable spawning area to build redds. This redd coverage percentage was observed under the condition of relatively high escapement (6100 adults) in 2009. This implies that one would find one redd in an area of 270 ft^2. However, a redd area of 270 ft^2 is inconsistent with the lack of observed spring-run redd superposition in 2013. Specifically, with a spring-run spawning habitat availability of 61,858 ft^2 in 2013, the redd size would need to be less than 235 ft^2 (61,858 ft^2 x 2.5 adults/redd / 659 adults) for habitat needs to be less than habitat availability[20].

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[20] A lack of redd superposition indicates that habitat needs are less than habitat availability.

Values of fry densities in the literature include 0.01 fish/ft^2 (Early and Brown 2013), 0.03 – 0.05 fish/ft^2 (FISHBIO and Normandeau Associates 2012) and 2.1 fish/ft^2 (Grant and Kramer 1990). The lower values would not be compatible with the habitat availability estimates used in this report, since they are based on total area, rather than weighted usable area. Weighted usable area can be viewed as the equivalent total area with an optimal suitability. Since most of a stream will have suitabilities less than 1, weighted useable area values will typically be much less than total area. Values of juvenile density in the literature include 0.58 fish/ft^2 (Grant and Kramer 1990). The values from Grant and Kramer (1990) are based on a minimum territory size, and densities may be higher than 2.1 fish/ft^2 for schooling fish. Table 6 shows the range of habitat needs based on different values for Table 2 and different potential population levels (833 to 1,666 for spring-run and steelhead and 7,100 to 14,824 for fall-run).

Adaptive management of the flow regime and habitat restoration, coupled with long-term monitoring, is an effective strategy to address these uncertainties. For example, adaptive management could address uncertainties in the habitat suitability criteria used to develop the flow-habitat relationships in Figures 2 to 8 by monitoring year to year variations in biological responses, such as redd superposition rates and juvenile production, to habitat limitations, and relate them to year to year variations in flows and adult escapement (Souchon et al. 2008).

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Table 6. Range of potential habitat needs (ft^2).

Life Stage	Fall-run	Spring-run	Steelhead
Spawning	136,320-1,600,992	15,994-179,928	15,994-179,928
Fry	676,190-296,480,000	77,488-33,320,000	77,488-33,320,000
Juvenile	617,792-1,712,428	72,482-192,452	72,482-192,452

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APPENDIX A
COMMENTS ON REPORT

Redding Electric Utility

TO: U.S. Fish and Wildlife Service Restoration and Monitoring Program

FROM: Elizabeth Hadley, Redding Electric Utility

SUBJECT: **COMMENTS ON THE DRAFT CLEAR CREEK HABITAT SYNTHESIS REPORT**

DATE: December 15, 2014

I. INTRODUCTION

Redding Electric Utility ("Redding") appreciates the opportunity to provide written comments on the Draft Clear Creek Habitat Synthesis Report ("Report") prepared by the U.S Fish and Wildlife Service's ("FWS") Restoration and Monitoring Program in conjunction with the Clear Creek Technical Team ("CCTT"). Since the Report addresses various aspects of restoration efforts on the Lower Clear Creek, it is essential that any recommendations be based on the best scientific data available, and with an understanding of any operational constraints that may be imposed.

The implementation of the Report could affect Redding's 45,000 customers since the City of Redding owns the 3.24 MW hydroelectric generator located at the base of Whiskeytown Dam. This hydroelectric energy is an important renewable resource that helps Redding comply with California's renewable and greenhouse gas mandates.[1] Any changes in the flow at Whiskeytown Dam that decrease the hydroelectric output from Redding's hydroelectric generator could be a significant cost impact to Redding's customers.

II. POWER OPERATIONS AT THE WHISKEYTOWN DAM

The current operational abilities of Redding's hydroelectric generator can run between flow releases of 50-200 cfs. Flows in excess of 200 cfs are diverted through the Bureau of Reclamation's (Reclamation) two release gates which each can handle up to 600 cfs. Concurrent operations of both the hydroelectric generator and Reclamation's gates are potentially detrimental to Redding's hydroelectric generator. At higher flows Redding will curtail its generation, resulting in the need for Redding to procure supplemental renewable power.

Though not discussed in the Report, based on CCTT recommendations Reclamation has been implementing pulse flow events as required by the 2009 National Marine Fisheries Service

[1] SBX 1 2 requires California's electric utilities to procure 33% of their energy from renewable resources by 2020. AB 32 mandates California to reduce its greenhouse gas emissions to 1990 levels by 2020.

Biological Opinion for Reclamation's Operations Criteria and Plan for the Central Valley Project.[2] These events involve releasing water above the base flows to create peaking events to aid restoration efforts on the Lower Clear Creek. Redding has supported these events even though it is necessary to completely bypass Redding's hydroelectric generator during these times. Redding has been appreciative to be able to participate in the scheduling of these events, which provide Redding with the ability to plan routine maintenance outages to coincide.

III. SPECIFIC COMMENTS TO THE REPORT

The Report lacks an assessment of the operational needs and constraints of Whiskeytown Dam and Redding's hydroelectric generator as well as the economic impact on Redding's customers from the loss of power generation and the need to procure supplemental renewable power. Any recommendations developed by the CCTT to change the flows in excess of 200 cfs needs to include such an assessment and a discussion of mitigation for the economic impact to Redding's customers. Further, the Report should include operational constraints in the Discussion, on page 17, second paragraph, exploring the uncertainty in implementing a revised regime in Clear Creek.

IV. CONCLUSION

Redding looks forward to continuing to work with the FWS, CCTT, and Reclamation to develop the operational ability to meet any proposed flow releases in excess of 200 cfs, if such releases prove to be both environmentally and economically viable.

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[2] Action I.1.2 (Page 587) "Reclamation shall annually conduct at least two pulse flows in Clear Creek in May and June of at least 600 cfs for at least three days for each pulse, to attract adult spring-run holding in the Sacramento River mainstem. This may be done in conjunction with channel-maintenance flows."