State of California
The Resources Agency
Department of Water Resources

ADDENDUM TO PHASE 2 REPORT EVALUATION OF PROJECT EFFECTS ON INSTREAM FLOWS AND FISH HABITAT SP-F16

Oroville Facilities Relicensing FERC Project No. 2100

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ARNOLD SCHWARZENEGGER
Governor
State of California

MIKE CHRISMAN
Secretary for Resources
The Resources Agency

LESTER A. SNOW
Director
Department of Water Resources

State of California
The Resources Agency
Department of Water Resources

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This report was prepared under the direction of

Terry J. Mills .... Environmental Program Manager I, DWR
Ted Sommer .... Fisheries Biologist, Department of Water Resources
Brad Cavallo............................Environmental Scientist, Department of Water Resources

by

Thomas R. Payne .... Fisheries Biologist, Thomas R. Payne & Associates

Assisted by

Mark Allen .... Fisheries Biologist, Thomas R. Payne & Associates

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1.0 INTRODUCTION

This addendum to the original SP-F16 report serves to describe PHABSIM results for fry and juvenile steelhead trout and Chinook salmon. The results for this component of the analysis were more ambiguous and difficult to interpret than those for adult salmon and steelhead. In an effort to reach agreement on the meaning and applicability of the juvenile salmonid PHABSIM findings, an interagency meeting was held on June 3, 2004. At this meeting it was agreed that, given current channel conditions, the results did not support a clear alternative or ideal discharge level. Rearing habitat indexes for fry and juvenile Chinook salmon and steelhead did not respond clearly or significantly to changes in discharge. Furthermore, results differed markedly depending on how areas having no cover were treated in the model. Although the results appear to be valid (i.e. they correctly represent a simplified version of juvenile fish habitat), the amount of suitable habitat seems relatively insensitive to modeled discharge levels. Based on this interpretation, the group agreed that efforts to improve physical habitat for juvenile salmonids (e.g. increasing habitat complexity with side channels, mid-channel bars, riparian vegetation and/or instream objects) should be given primary consideration, and that any flow changes should be complimentary to these physical habitat enhancements. However, the group did recommend that juvenile salmonid PHABSIM results be used wherever possible to aide in the design and placement of future habitat enhancements.

The remainder of this addendum describes specific results of the juvenile salmonid PHAMSIM analysis. Given the qualifications and caveats described in the preceding paragraph, the reader is advised to proceed cautiously in interpreting these results. Please refer to the full SP-F16 for introductory materials, methods and background for these analyses.

2.0 STUDY RESULTS

2.1 CRITERIA CURVE DEVELOPMENT AND SELECTION FOR REARING

Site-specific micro-habitat data was collected by DWR for spawning Chinook salmon in 1991 (DWR 1991) and in 1995 (Sommer et al. 2001) and spawning steelhead in 2003 (Cavallo et al. 2003). These data were used to develop HSC for instream flow analysis.

2.1.1 Fry and Juvenile Chinook Salmon Rearing

Micro-habitat data was collected at 464 focal positions of fry and juvenile Chinook salmon in the Feather River during 1992. All observations were made within 100 ft of 19 transects previously established for the PHABSIM study. Transects were located in both the upper segment and lower segment, and in pools, riffles, and run/glides, although sampling effort emphasized pool habitats according to a proportional design. HSC were created by DWR for fry (<50mm) and juvenile Chinook salmon depth and mean column velocity data using a 3-point running mean to smooth frequency distributions of the fry habitat use data, and using NPTL for the juvenile habitat use data. Frequency histograms for dominant and subdominant substrate and for cover types were created and normalized to the largest value. The suitability values for substrate were then discarded and all substrate types were given a suitability of 1.0 due to the finding that substrate was not a driving variable determining microhabitat selection of fry and juvenile Chinook salmon (Cavallo et al. 2003). The normalized cover suitability values were also modified by combining the data into two classes: with cover and without cover. The suitability for without cover was calculated as the percentage of fish observed without cover to the total sample size. The suitability of cover present was assigned a value of 1.0 and 0.30 or 0.22 for cover absent for Chinook salmon fry and juveniles, respectively, by DWR.

The DWR criteria were reviewed for the current analysis with a focus on the suitability of instream cover as the critical variable most likely to affect results. In the absence of a cover variable in the habitat index computation, the preference for low velocity and shallow depth by fry and juvenile fish in a large river will only indicate acceptable habitat along the stream margins or out in the main channel when the river is nearly dry and the preferred conditions are prevalent. When a cover variable is used in the computation, habitat index results show physical conditions to be most suitable along the margins where there is the most cover, but the broad expanse of the main channel (where there is little or no cover) will dominate the composite index for any given flow, depending on the exact suitability of abundant cells with no cover. The difference in suitability between any type of cover and no cover, almost regardless of velocity and depth suitability, will dominate the composite habitat index results when a cover variable is included. The typical result even for low no-cover suitability shows continued improvement in the habitat index at ever-lower flows.

With this consideration in mind, Chinook salmon fry and juvenile cover data from the DWR 1992 and subsequent intermediate scale surveys was separated into four cover types: no cover, object only cover, overhead only cover, and both object and overhead cover. Sample sizes were 427 for fry less than 50 mm in length and 206 for larger juveniles. Resulting frequencies of the four types were normalized to 1.0. In addition, if object and overhead cover was less suitable than either object or overhead separately, it was increased to the higher level (a minor adjustment in all cases). The suitability of the no cover variable resulting from this process was still relatively high, since the no cover sample size was treated as a single bin, while “any cover” was divided into three bins. No cover suitability was therefore further reduced by application of the DWR availability data for the intermediate scale surveys (Cavallo et al. 2003).

Two other options for treatment of the cover variables were devised after preliminary computations of weighted usable area still showed dominance of the no cover suitability value. First, areas of the river channel containing rooted aquatic vegetation were originally treated as no cover instead of as either object cover or overhead cover. In some years of survey by DWR, no Chinook were seen in association with aquatic vegetation, while in other years they were, apparently depending on the depth of water over the top of the vegetation. As a compromise, all transect stations with rooted aquatic vegetation were coded as a fifth category and given an arbitrarily low suitability of 0.10. In addition, a second complete set of suitability criteria were processed through the habitat computer program using the no cover category set to a suitability of zero, as a means of further identifying the influence of the main channel areas having no cover. Table 2.1-1 presents the original suitabilities for the five categories, the adjustment to equalize by cover type, the no cover availability adjustment, and the no cover category.

In 2002, DWR implemented transect sampling for rearing juvenile Chinook and steelhead to address the habitat suitability of deeper water outside of 4 meters from shore. According to the spreadsheet file of observations (Cavallo 2002, pers. comm.), only 6 fish were observed in water between 1 and 2 meters deep, and none were found deeper than 2 meters. The lack of rearing fish in deep water, despite a specific effort to find them, supports the unadjusted use of previous data. Figures 2.1-1 and 2.1-2 show the final Chinook rearing criteria for depth, velocity, and cover variables.

Table 2.1-1. Chinook Salmon Rearing Habitat Suitability Criteria.

	Chinook Salmon Fry <50 mm				
Cover Type	No Cover	Object Cover	Overhead Cover	Obj + Ovh Cover	Aquatic Veg.
Cover Code	1	2	3	4	5
Raw Suitability	0.94	0.31	1.00	0.96	
Adjusted	0.41	0.31	1.00	1.00	

Suitability					
Final Suitability	0.15	0.31	1.00	1.00	0.10
No Cover=0 Option	0.00	0.31	1.00	1.00	0.10
	Chinook Salmon Juvenile 50 mm+				
Cover Type	No Cover	Object Cover	Overhead Cover	Obj + Ovh Cover	Aquatic Veg.
Cover Code	1	2	3	4	5
Raw Suitability	0.99	0.24	0.71	1.00	
Adjusted Suitability	0.50	0.24	0.71	1.00	
Final Suitability	0.28	0.24	0.71	1.00	0.10
No Cover=0 Option	0.00	0.24	0.71	1.00	0.10

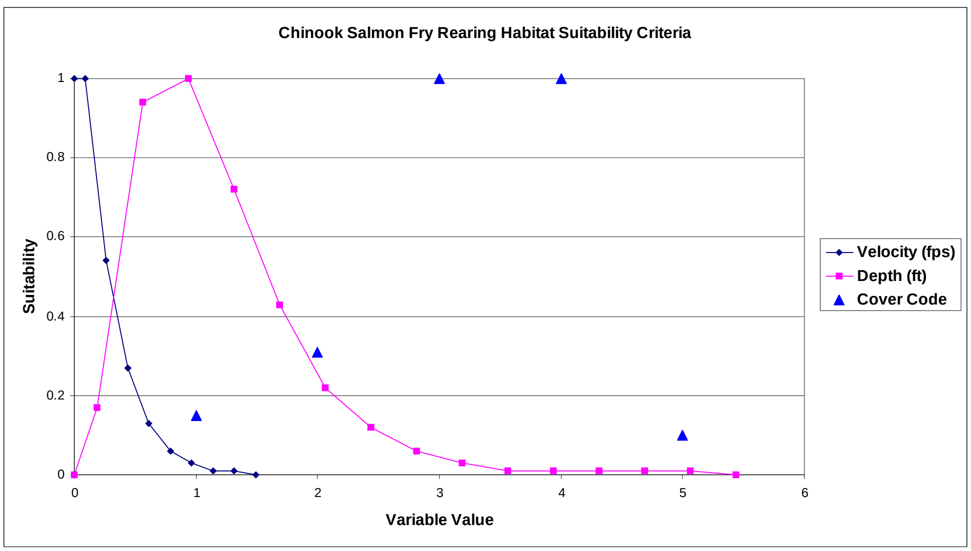

Figure 2.1-1. Chinook Salmon Fry Rearing Habitat Suitability Criteria.

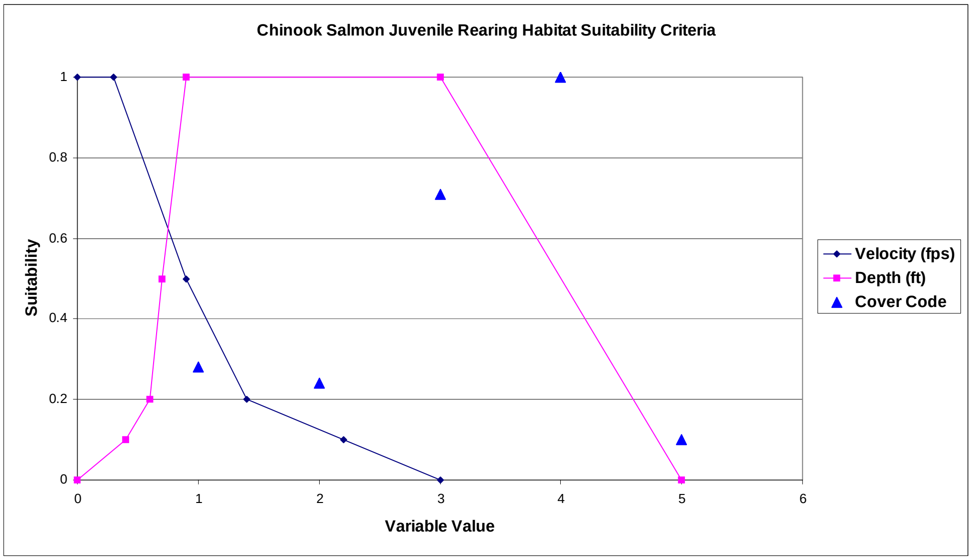

Figure 2.1-2. Chinook Salmon Juvenile Rearing Habitat Suitability Criteria.

2.1.2 Fry and Juvenile Steelhead Trout Rearing

Micro-habitat observations of rearing steelhead fry and juveniles were also made by DWR for several years at the intermediate-scale level. Samples sizes obtained for rearing fry and juveniles were 452 and 527, respectively. Treatment of the data to account for the influence of availability on no cover suitability and for the presence of rooted aquatic vegetation were nearly the same as described for rearing Chinook. The one exception was that when no cover was adjusted for availability, the remaining cover types had to be re-normalized, since the raw no cover suitability was 1.00. Table 2.1-2 presents the original suitabilities for the five variables, the adjustment to equalize by cover type, the no cover availability adjustment and re-normalization, and the no cover variable. Figures 2.1-3 and 2.1-4 show the final steelhead rearing criteria for depth, velocity, and cover variables.

Table 2.1-2. Steelhead Trout Rearing Habitat Suitability Criteria.

	Steelhead Trout Fry <50 mm				
Cover Type	No Cover	Object Cover	Overhead Cover	Obj + Ovh Cover	Aquatic Veg.
Cover Code	1	2	3	4	5
Raw Suitability	1.00	0.90	0.47	0.81	
Adjusted Suitability	0.46	1.00	0.52	1.00	
Final Suitability	0.17	1.00	0.52	1.00	0.10
No Cover=0 Option	0.00	1.00	0.52	1.00	0.10
	Steelhead Trout Juvenile 50 mm+				
Cover Type	No	Object	Overhead	Obj + Ovh	Aquatic

	Cover	Cover	Cover	Cover	Veg.
Cover Code	1	2	3	4	5
Raw Suitability	1.00	0.16	0.47	0.29	
Adjusted Suitability	0.40	0.34	1.00	0.62	
Final Suitability	0.40	0.34	1.00	0.62	0.10
No Cover=0 Option	0.00	0.34	1.00	0.62	0.10

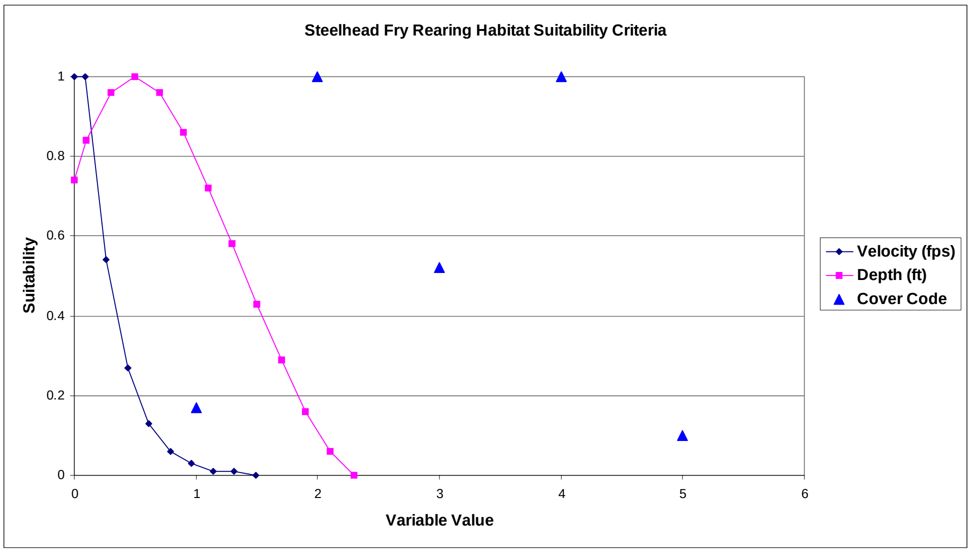

Figure 2.1-3. Steelhead Trout Fry Rearing Habitat Suitability Criteria.

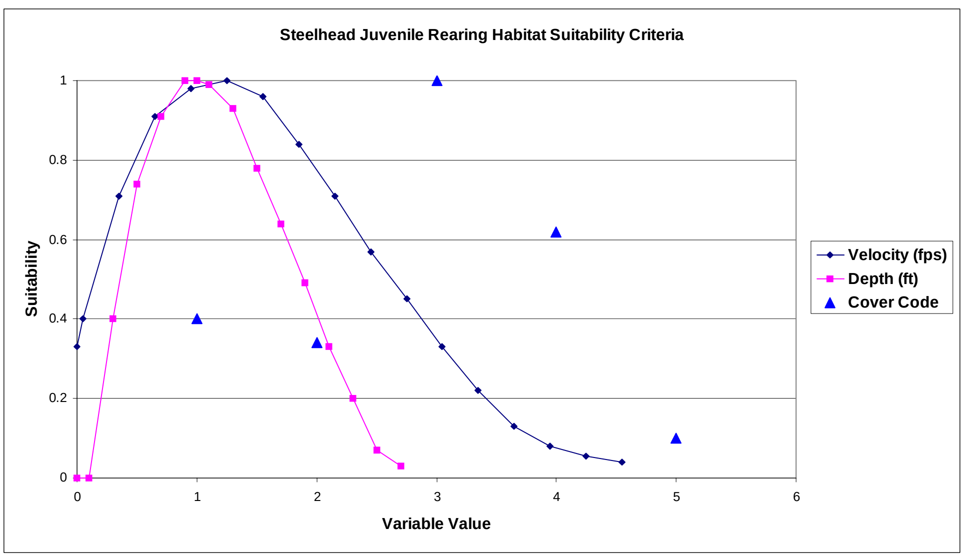

Figure 2.1-4. Steelhead Trout Juvenile Rearing Habitat Suitability Criteria.

2.2 WEIGHTED USABLE AREA HABITAT INDEX COMPUTATION FOR REARING

Following the recalibration and merging of the transect hydraulic data and finalization of the habitat suitability criteria, the two sets of data were combined in the PHABSIM computer model to compute the weighted usable area index to habitat suitability for the two species and life stages in the two reaches. Weighted usable area (WUA), also known as a relative suitability index (RSI – Payne 2003), relates the extent of match between hydraulics and habitat suitability for flows specified in the models. The index is only a relative indicator of suitability, not actual physical area, and, being an index, cannot be directly related to numbers of fish that may occupy the Feather River at the modeled flows. It does provide the capacity to compare various flow regimes, however, for evaluating the suitability of alternatives.

2.2.1 Chinook Salmon Fry Rearing WUA/RSI

Figures 2.2-1 and 2.2-2 show the WUA/RSI for Chinook salmon fry rearing in the upper and lower reaches, respectively, for both the “low suitability” and the “zero suitability” options for the no cover category in the cover code suitability criteria. The differences in the two curves at flows below about 1000 cfs in the upper reach illustrates the influence of the large areal extent of the Feather River where there is no cover. When the no cover suitability is only 0.15, the habitat index rises sharply when the river is nearing zero flow and most of the wetted area becomes shallow and slow. When no cover is assigned a zero suitability, this effect is eliminated and the index slowly rises over the extent of the flows simulated. A WUA/RSI difference for Chinook salmon fry rearing in the lower reach also occurs for the two options, but the rise in the low no cover index at low flows is not as pronounced as in the upper reach. Differences in results for fry must be viewed with caution, since the percent of total wetted area shown as suitable is less than 5 percent in the upper reach and less than 3 percent in the lower reach. Percentages this low tend to be driven by a small number of sample points and are subject to random effects.

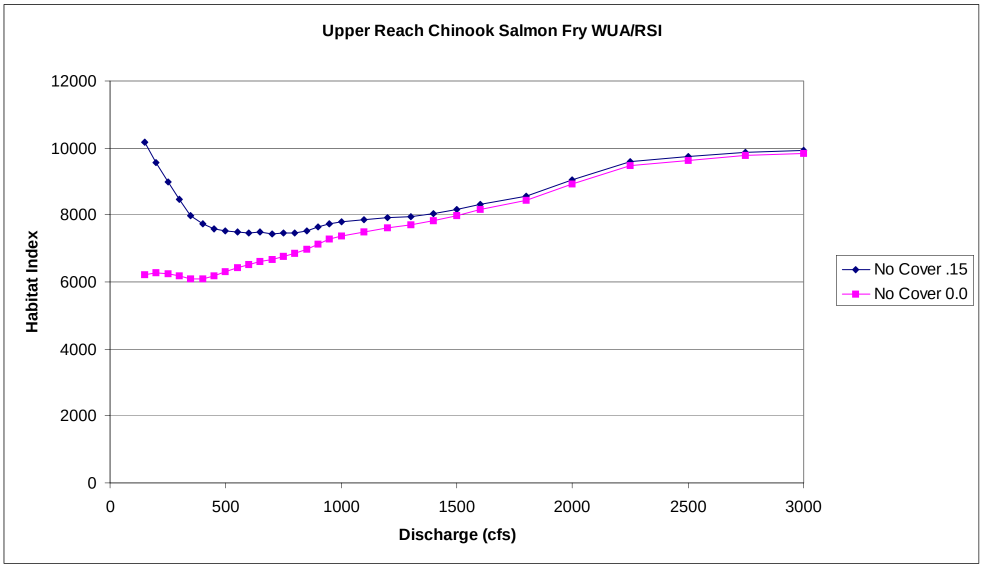

Figure 2.2-1. Upper Reach Chinook Salmon Fry<50mm WUA/RSI

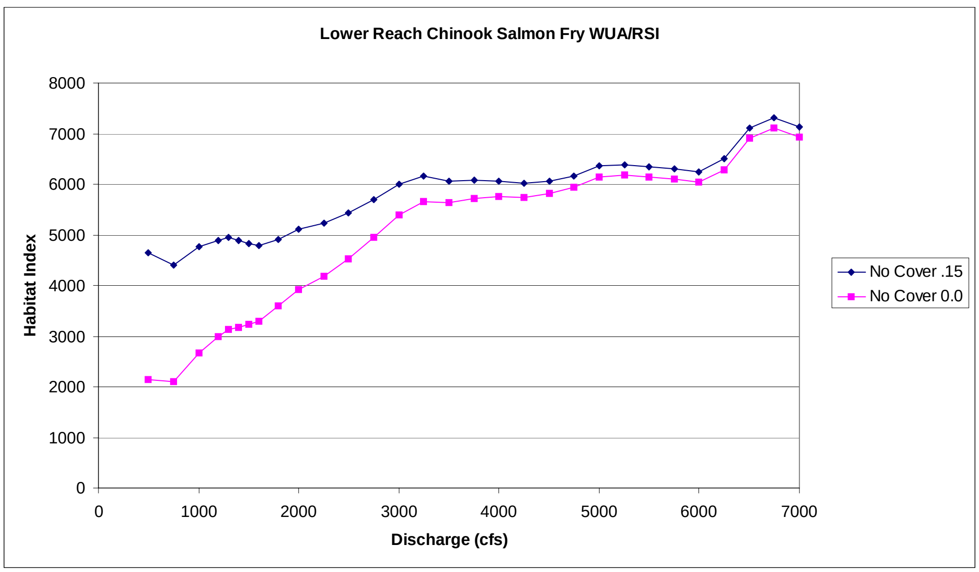

Figure 2.2-2. Lower Reach Chinook Salmon Fry<50mm WUA/RSI

2.2.2 Steelhead Trout Fry Rearing WUA/RSI

Figures 2.2-3 and 2.2-4 show the WUA/RSI for steelhead trout fry rearing in the upper and lower reaches, respectively, for both the low no cover suitability and the zero no cover suitability options in the cover code suitability criteria. Results for steelhead fry are very similar to those for Chinook fry, showing some divergence at the lowest flows between the two cover options in both reaches, with convergence at the highest flows. The WUA/RSI functions display more variability in pattern as flow changes, variously increasing or decreasing over the range of modeled flows. The most likely explanation for this effect is low sample size, where the habitat index magnitude is less than 5 percent of total wetted area. Low magnitude allows the index to be subject to random effects from small patches of area that enter and leave suitability depending on localized conditions.

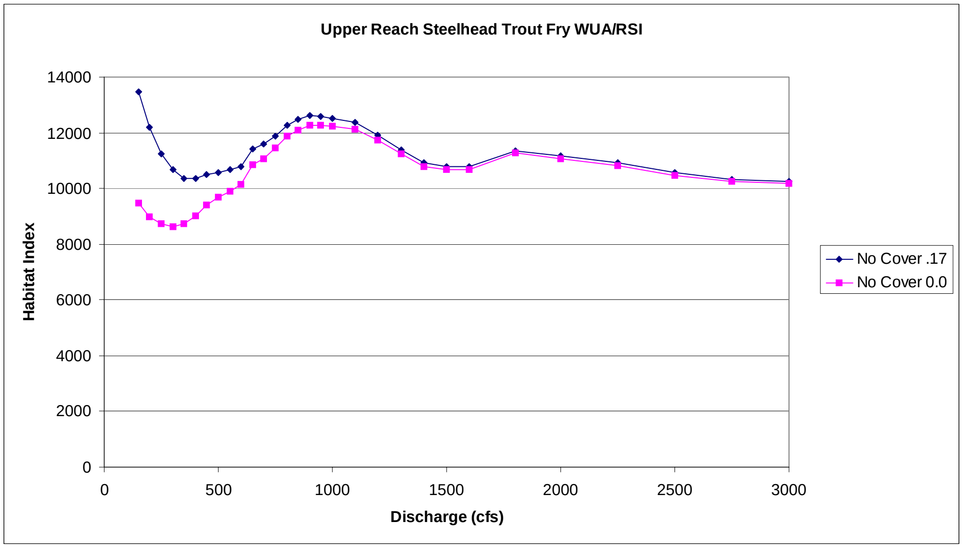

Figure 2.2-3. Upper Reach Steelhead Fry<50mm WUA/RSI.

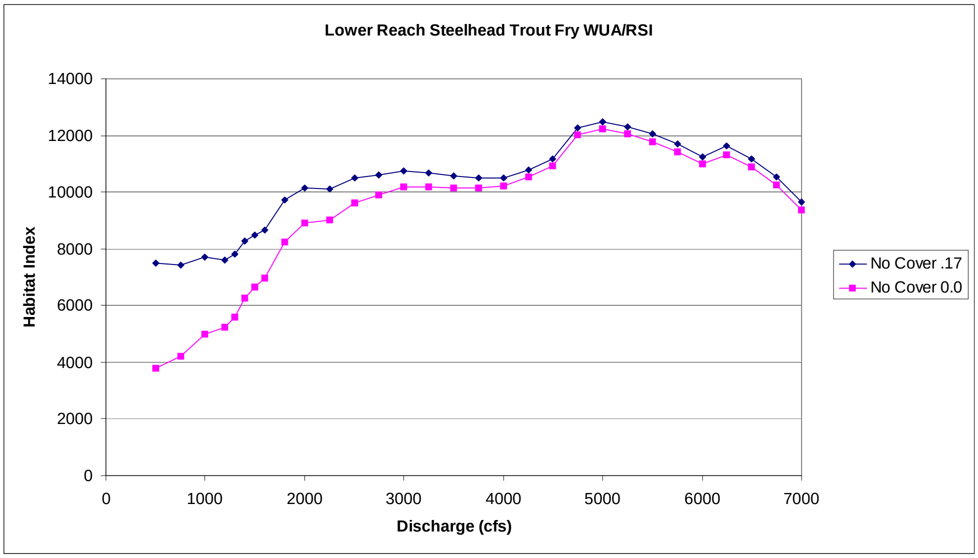

Figure 2.2-4. Lower Reach Steelhead Fry<50mm WUA/RSI

2.2.3 Chinook Salmon Juvenile Rearing WUA/RSI

Figures 2.2-5 and 2.2-6 show the WUA/RSI for Chinook salmon juvenile rearing in the upper and lower reaches, respectively, for both the low no cover suitability and the zero no cover suitability options in the cover code suitability criteria. In both reaches, the low no cover suitability declines over most of the flow range (from low to high flow) and the zero no cover suitability steadily increases, with the greatest divergence at the lowest modeled flow. These differences are greater than for the fry life stage because juveniles are stronger swimmers and can utilize more of the river channel (where there is more area of no cover) and because the suitability difference between low no cover and zero no cover is greater (0.28 and 0.00).

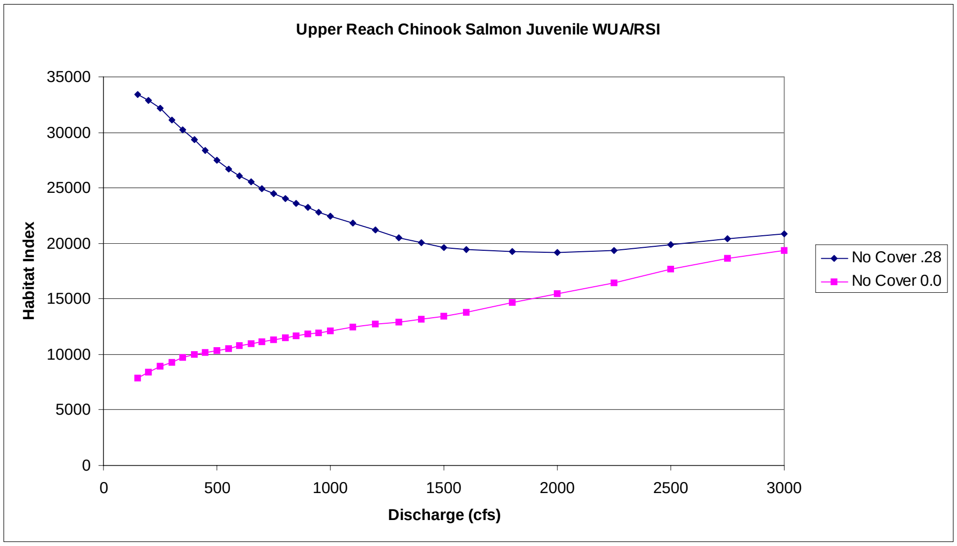

Figure 2.2-5. Upper Reach Chinook Salmon Juvenile 50mm+ WUA/RSI

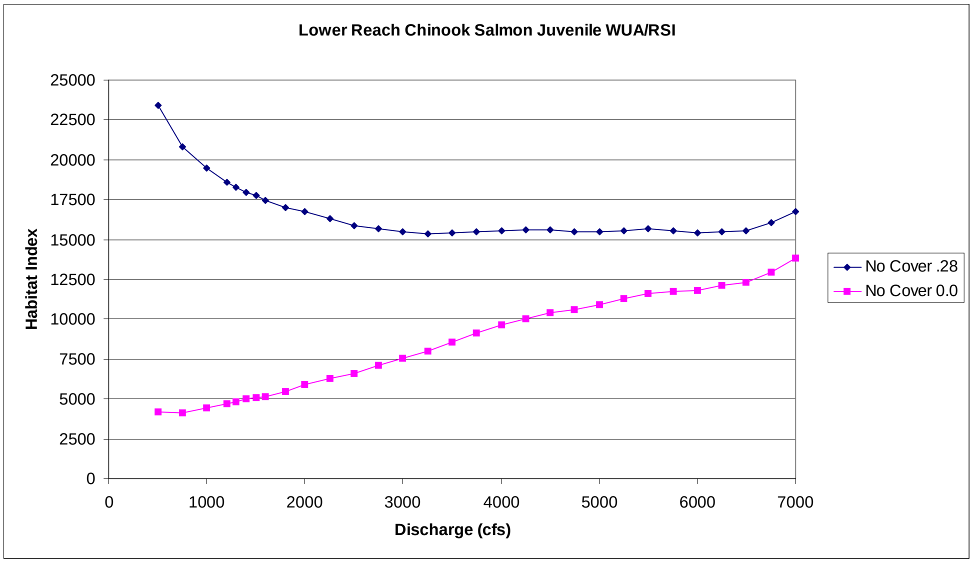

Figure 2.2-6. Lower Reach Chinook Salmon Juvenile 50mm+ WUA/RSI

2.2.4 Steelhead Trout Juvenile Rearing WUA/RSI

Figures 2.2-7 and 2.2-8 show the WUA/RSI for steelhead trout juvenile rearing in the upper and lower reaches, respectively, for both the low no cover suitability and the zero no cover suitability options in the cover code suitability criteria. The pattern of index results for steelhead juveniles is again similar to that of Chinook juveniles, except that the magnitude difference between the two cover options is somewhat greater, particularly in the lower reach. When the no cover suitability is reduced from 0.40 to 0.00, much of the river channel is shown to be unsuitable, even though steelhead juveniles are likely capable of utilizing more than just the stream margins where cover elements are present.

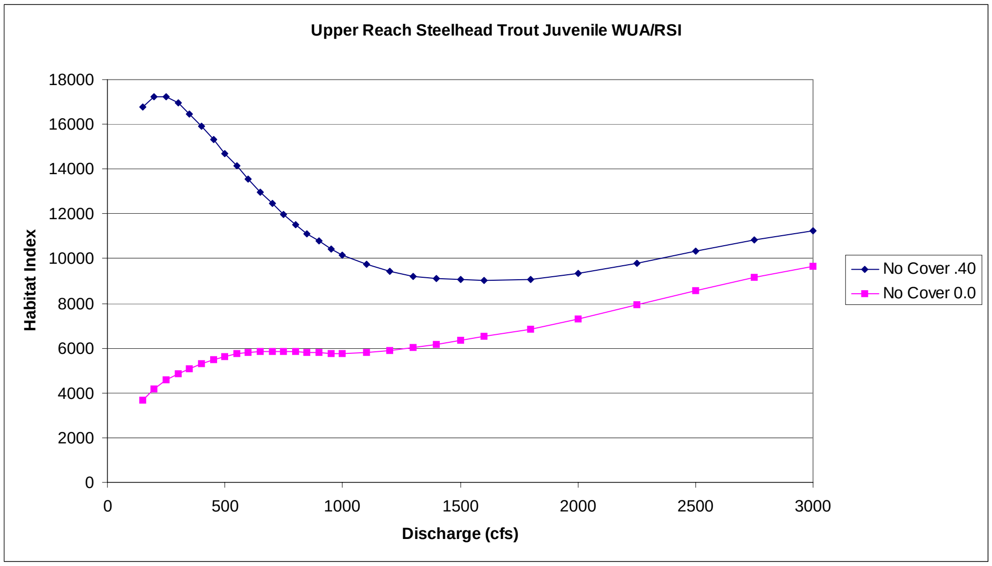

Figure 2.2-7. Upper Reach Steelhead Juvenile 50mm+ WUA/RSI

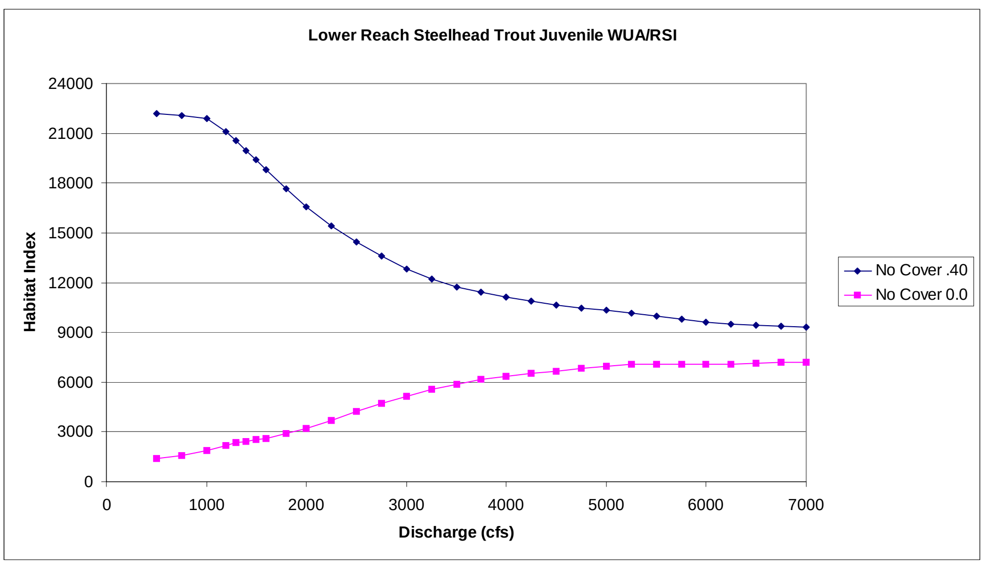

Figure 2.2-8. Lower Reach Steelhead Juvenile 50mm+ WUA/RSI

3.0 DISCUSSION AND CONCLUSIONS

3.1 CHINOOK SALMON AND STEELHEAD FRY AND JUVENILE REARING

The habitat indexes for both Chinook and steelhead fry respond similarly, whether or not the no cover code is given some or no suitability. That is, the fry indices slowly increase along with rising discharge. This response is most likely a result of stream margin inundation where the combinations of cover, low velocity, and shallow depth predominate. As more of this type of area inundates and remains at low velocity, the habitat index rises. No flow level which provides index optimization is readily apparent, nor are particular levels of flow observed to be more biologically suitable, except as consistent with the general trend of higher flows being somewhat better. As has been the case with many other large river instream flow studies, species and life stages typically restricted by their small size and behavior tend to do better as stream margins inundate.

For Chinook salmon and steelhead, differences between model results for fry and juveniles were more pronounced. Juveniles are larger and stronger swimmers than fry and can use more of the main river channel when their physical capacities are not exceeded. The response of the habitat index for no cover areas being somewhat suitable is also typical – at very low flows they can use the open water channel and at high flows they will also use the inundated margins. At intermediate flow levels when the main channel is too deep and fast to be suitable and not much of the margin is inundated, the habitat index shows a slump in response. When the absence of cover is modeled as corresponding to no suitability, the main channel is no longer "suitable" and the juvenile habitat indices respond like those of fry.

Collectively the minor variations in the indices within the total flow range are a result of variability in channel margin areas and not believed to be significant. The fact that changes in habitat suitability indices do not appear to be biologically significant generally supports an interpretation that flow volume in the two reaches is less important as a management action than other possible alternatives such as maintaining water quality or increasing habitat complexity.