Appendix C

Analysis of Weighted Usable Areas for Spawning Salmonids

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The potential effects of flows on the adult spawning life stage of lower Yuba River Chinook salmon were evaluated by examining spawning habitat available to Chinook salmon throughout their spawning season, as expressed by a scaled composite usable area that corresponds to Chinook salmon spawning areas under the monthly flows during the spawning season. The scaled composite usable area (i.e., $\widehat{CWUA}$) was calculated as the sum of the usable areas that correspond to the monthly flows during the spawning season over one reach for spring-run Chinook salmon located above Daguerre Point Dam, and over two reaches for fall-run Chinook salmon located above and below Daguerre Point Dam, divided by the sum of the maximum WUA of each reach in each of the spawning season months.

For example, fall-run Chinook salmon utilize k = 2 distinct reaches within the lower Yuba River, during m = 3 months of a particular year, and the scaled composite weighted usable area (i.e., $\widehat{CWUA}_Y$) is expressed by the following formula:

$$\widehat{CWUA}_Y = \frac{\sum_{m=1}^{3}\sum_{k=1}^{2} WUA_k\left(Q_{m,Y}\right)}{\sum_{m=1}^{3}\sum_{k=1}^{2} \max\left(WUA_k\right)} \qquad \textbf{(1)}$$

where $WUA_k\left(Q_{m,Y}\right)$ is the usable area (WUA) of reach k at the monthly flow $Q_{m,Y}$ obtained from the WUA-flow relationships developed by the most recent IFIM studies completed in the spawning grounds, and $\max\left(WUA_k\right)$ is the maximum weighted usable area of reach k over the flow range for which the WUA-flow relationship was developed.

The following sections describe the precedence of the data and calculations associated with the computation of $\widehat{WUA}_Y$ (**Equation 1**):

Lower Yuba River Salmonid Spawning WUA-Flow Relationships

The present analysis utilized the WUA-flow relationships described in CDFG (1991) to evaluate the habitat available to fall-run Chinook salmon spawning at different lower Yuba River flows. The instream flow incremental methodology study described in CDFG (1991) divided the lower Yuba River into four reaches two of which are located above Daguerre Point Dam and two located below Daguerre Point Dam (**Table C-1**).

Table C-1. Names and River Miles (RM) of the Limits of Lower Yuba River Reaches With WUA-Flow Relationships Developed by CDFG (1991)

Reach *k*	Upstream limit	RM	Downstream limit	RM
1	Englebright Dam	23.9	Terminus of the Narrows	21.5
2	Terminus of the Narrows	21.5	Daguerre Point Dam	11.4
3	Daguerre Point Dam	11.4	Terminus of Feather River Backwater Influence	3.5
4	Terminus of Feather River Backwater Influence	3.5	Feather River Confluence	0

Reach 1, also termed the Narrows reach, consists of 11,400 feet of river with steep-walled canyon topography, dominated by deep pools, and bedrock and large boulder substrate. This reach is believed to be an important site for spring-run Chinook salmon holding during late spring, summer and fall. This reach has never been sampled for fall-run Chinook salmon redds or carcasses. The spawning WUA-flow relationships developed for fall-run Chinook salmon and steelhead at this uppermost reach showed zero WUA values for flows between 100 cfs and 2,500 cfs. The 56,400-foot long Reach 2, known as the Garcia Gravel Pit reach, and the 41,400-foot Reach 3, known as the Daguerre Point Dam reach, are believed to have good spawning potential for Chinook salmon. Both reaches, which have been customarily sampled during the annual fall-run Chinook salmon carcass surveys performed by CDFG and YCWA, consist of repeating segments of long, deep pools, shallow pools, rum/glide, and long low-gradient riffles, with fewer riffles and more pools in Reach 3. Finally, Reach 4, named the Simpson Lane reach, consists of 18,500 feet of river with low gradient and water velocities, characterized by deep pools under the influence of Feather River waters. This reach that has been normally sampled, but never differentiated from Reach 3 during the CDFG and YCWA fall-run Chinook salmon carcass surveys, is believed to have limited potential for Chinook salmon spawning.

Although CDFG (1991) developed spawning WUA-flow relationships for both fall-run Chinook salmon and steelhead, only the relationships for fall-run Chinook salmon were used in the present analysis (see below). The steelhead WUA-flow relationships were not used because they were not based upon depth, velocity and substrate data collected on lower Yuba River steelhead redds. Instead, CDFG (1991) steelhead WUA-flow relationships were developed from suitability habitat criteria recommended by Bovee (1978). The comparison of Bovee's steelhead HSI curves with HSI curves developed for the species in the lower Feather River, lower American River and Trinity River suggests that Bovee's criteria may not be very adequate for Californian steelhead (**Figure C-1**) (DWR 2003; Hampton 1997; USFWS 2000).

For the computation of $\widehat{WUA}_Y$, the WUA-flow relationships for IFIM reaches located above and below Daguerre Point Dam are used for fall-run Chinook salmon. The WUA-flow relationship for IFIM reaches 1 and 2 are (**Table C-1**) combined by summing WUA values corresponding to flow levels to define the WUA-flow relationships upstream Daguerre Point Dam (**Figure C-2**). In a similar fashion Reaches 3 and 4 summed to define WUA-flow relationships downstream of Daguerre Point Dam (**Figure C-2**).

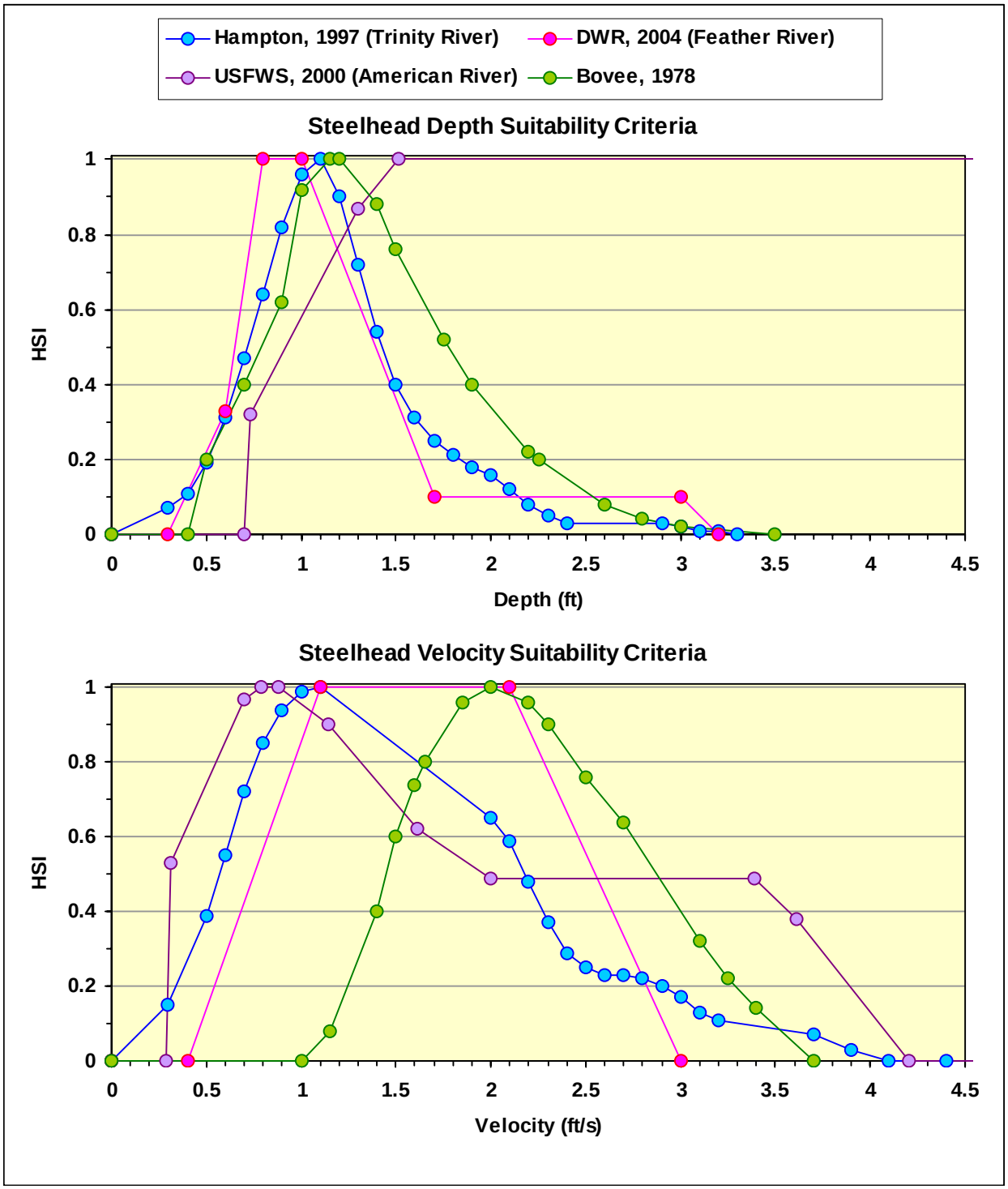

Figure C-1. Comparison of Steelhead Depth and Velocity Habitat Suitability Index (HSI) Curves

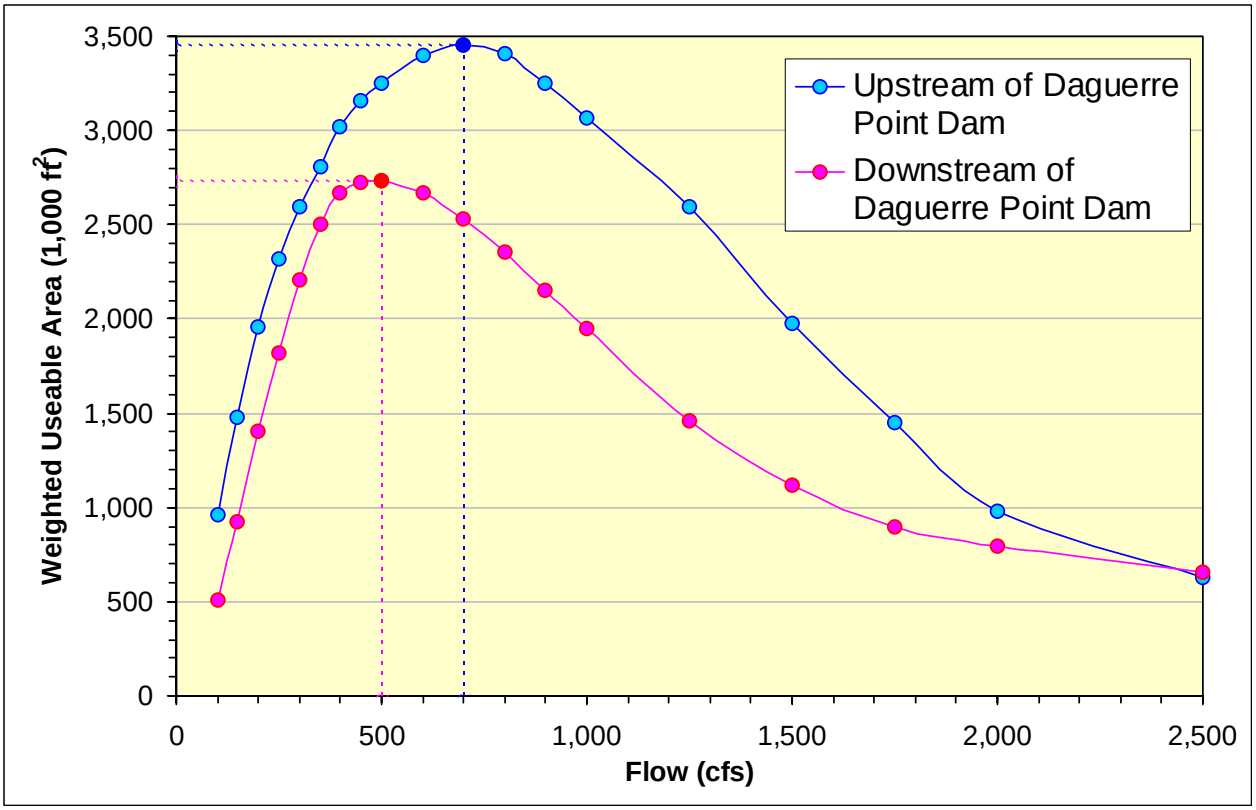

Figure C-2. Relationships Between WUA and Flow for Fall-run Chinook Salmon Spawning in the Lower Yuba River

References

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