Attachment 3.3.3B
Habitat Suitability Criteria

Summary of Habitat Suitability Criteria (HSC) for Target Fish Species and Life Stages on the Lower Bear River

The procedures employed for selecting Habitat Suitability Criteria (HSC) for use in assessing instream habitat in the Bear River, California are described below.

HSC were selected through a collaborative process involving a variety of instream flow specialists, as well as the California Department of Fish and Wildlife (CDFW), U.S. fish & Wildlife Service (FWS), and other relicensing participants. Two collaboration meetings were held, the first on July 20, 2018, with a follow-up meeting on August 20, 2018.

Prior to the HSC meeting, a list of proposed target species and life-stages were discussed with the following selections:

Species	Life-stage	Variables*
Chinook Salmon	Spawning	Depth, MC Velocity, Substrate
(fall run)	Fry	Depth, MC Velocity, Cover
	Juvenile	Depth, MC Velocity, Cover
Steelhead	Spawning	Depth, MC Velocity, Substrate
	Fry	Depth, MC Velocity, Cover
	Juvenile	Depth, MC Velocity, Cover
Hardhead	Juvenile	Depth, MC Velocity
	Adult	Depth, MC Velocity
Sturgeon	Spawning	Depth, MC Velocity, Substrate
(white or green)		

*MC Velocity = Mean Column Velocity

This list was presented and agreed upon by the meeting participants. Candidate HSC curves representing each of these species and life-stages were developed prior to the meeting, then presented and discussed until a final HSC curve was approved by everyone in attendance. The list of candidate HSC was developed from a master list of HSC data, which for salmon and steelhead were filtered to a subset of HSC developed from California streams and rivers and applied in previous instream flow studies. The HSC dataset for Chinook salmon, being very large, was further filtered to represent HSC from medium-sized streams similar to the Bear River (e.g., HSC from large rivers such as the Sacramento River, Klamath River, etc. were dropped from consideration). Candidate HSC for steelhead were drawn from all California studies, but emphasis was focused on data from medium-sized rivers. In general, the consensus-selected HSC for these two species relied heavily on HSC from Clear Creek and the lower Yuba River relicensing studies, as well as Big Sur HSC for steelhead fry and juvenile rearing.

Due to the paucity of HSC data for sturgeon spawning (green or white), all available HSC datasets were presented for discussion; however the consensus HSC for use in the Bear River relied on HSC developed and selected for use on the lower Yuba River. Hardhead HSC previously vetted

and utilized in the Yuba-Bear Drum-Spaulding instream flow study were presented and selected to represent that species in the Bear River.

Specific notes RE selection of individual HSC for each species and life-stage are presented below. Please refer to the tables at the end of this document for the final HSC curve points.

Chinook Salmon

Spawning. Ten candidate HSC datasets were presented to represent spawning by Chinook Salmon, in addition to site-specific data collected at 73 salmon redds in the Bear River study area. Following discussion of the site-specific data and comparison of candidate HSC curves, a consensus HSC curve for spawning velocity was selected that utilized the Clear Creek fall Chinook curve from 0.9 fps to 1.83 fps, then followed the lower Yuba HSC curve to 5.32 fps (see figures). The consensus HSC for spawning depth likewise followed the Clear Creek fall Chinook HSC from 0.4-1.1 ft, then descended to 5 ft based on consensus and discussion regarding the site-specific characteristics of the Bear River study area. HSC representing spawning substrate for Chinook utilized consensus for gravel less than one inch in diameter, then followed the Clear Creek HSC for substrates dominated by gravels 1-3 inches to gravels ranging from 3-5 inches in diameter.

Fry Rearing. Seven candidate HSC datasets were presented to represent rearing by Chinook salmon. The consensus HSC for mean column velocity for Chinook fry was based on the FWS Yuba River HSC, which was largely adopted for the lower Yuba instream flow study, except the consensus HSC was truncated at 1.8 fps. The consensus HSC for fry depth bracketed the FWS Yuba fry curve from 0.0 to 1.5 ft, but then descended proximal to the lower Yuba curve to 4.0 ft. HSC for fry cover suitability was based on the Clear Creek fall Chinook HSC, except for consensus-based decisions for aquatic vegetation, which was rare in the Bear River.

Juvenile Rearing. The FWS Yuba HSC for juvenile Chinook velocity suitability, subsequently adopted for use in the lower Yuba instream flow study (with slight modifications), was likewise selected for use in the Bear River. In contrast to the FWS and Lower Yuba curves, the Bear consensus curve dropped to zero suitability at 3.0 fps. For juvenile depth, the Bear River participants selected a new curve that utilized components of several existing HSC, including the Battle Creek, Stanislaus River, and lower Yuba curves. Use of instream cover by juvenile Chinook was based on the Clear Creek fall Chinook curve, except suitability was downgraded for aquatic vegetation, as for fry.

Steelhead

Spawning. Eight HSC curves for steelhead spawning were presented, along with site-specific redd data previously collected in the lower Yuba River. Following discussion the Clear Creek HSC for spawning velocity was selected to represent the Bear River. The final Bear HSC for spawning depth was also largely based on the Clear Creek HSC from depths of 0.3 to 2.5 ft, but then the curve dropped along the lower Yuba redd data to an intermediate value at 4 ft, then extended to 10 ft. The maximum depth was based in part on the maximum spawning depths observed in Clear Creek. Spawning substrate HSC for steelhead followed the Clear Creek HSC for substrate sizes up to 1-2 inches, then followed the lower Yuba HSC for larger substrates.

Fry Rearing. Seven HSC datasets were presented as candidate curves for steelhead rearing. The consensus HSC from fry velocity suitability was a curve drawn intermediate to the HSC from Clear Creek and the Big Sur River. The fry depth curve was drawn by consensus to bracket both the Clear Creek and the Big Sur River HSC. Instream cover HSC for steelhead fry was largely based on the Clear Creek HSC, with some adjustments for suitability of cobble and boulder substrates based on Big Sur data, and adjustments to aquatic vegetation suitability based on lower Yuba HSC.

Juvenile Rearing. Consensus HSC representing velocity suitability for juvenile steelhead bracketed the Big Sur HSC, except for velocities less than 0.75 fps which were intermediate to HSC from the Big Sur River and Clear Creek. The final HSC for juvenile depth suitability likewise bracketed the Big Sur HSC, with somewhat higher suitability for depths over 3 ft and maximum depth of 6 ft due to higher values represented by the Clear Creek HSC. As noted for steelhead fry, the cover HSC for juvenile steelhead followed the Clear Creek HSC except for cobble/boulder substrate which was adjusted based on HSC data from the Big Sur River.

Sturgeon

Spawning. As noted above, the HSC selected to represent spawning by green or white sturgeon was taken directly from the HSC selected for use in the lower Yuba River instream flow study.

Hardhead

Juvenile and Adult Rearing. As noted above, the HSC selected to represent juvenile and adult rearing by hardhead were taken directly from the HSC selected for use in the Yuba-Bear Drum-Spaulding instream flow study.

Table 3.3.3B-1. Fall-run Chinook salmon spawning habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability	Substrate (in. diameter)	Suitability
0.09	0	0.4	0	<0.1	0
0.1	0.06	0.5	0.39	0.1-1	0
0.15	0.08	0.6	0.59	1-2	0.5
0.22	0.1	0.7	0.76	1-3	1
0.29	0.12	0.8	0.88	2-3	0.8
0.36	0.14	0.9	0.95	2-4	0.6
0.43	0.17	1	0.99	3-4	0.3
0.5	0.21	1.1	1	3-5	0
0.57	0.24	1.5	1	4-5	0
0.64	0.29	3	0.2	4-6	0
0.71	0.33	5	0	6-8	0
0.78	0.38	--	--	8-10	0

Table 3.3.3B-1. (continued)

Velocity (fps)	Suitability	Depth (ft)	Suitability	Substrate (in. diameter)	Suitability
0.85	0.43	--	--	8-12	0
0.92	0.48	--	--	>12	0
0.95	0.5	--	--	--	--
0.99	0.53	--	--	--	--
1.06	0.59	--	--	--	--
1.13	0.64	--	--	--	--
1.2	0.7	--	--	--	--
1.27	0.75	--	--	--	--
1.34	0.8	--	--	--	--
1.41	0.84	--	--	--	--
1.48	0.88	--	--	--	--
1.55	0.92	--	--	--	--
1.62	0.95	--	--	--	--
1.69	0.97	--	--	--	--
1.76	0.99	--	--	--	--
1.83	1	--	--	--	--
2.95	1	--	--	--	--
3.25	0.5	--	--	--	--
5.32	0	--	--	--	--

Table 3.3.3B-2. Fall-run Chinook salmon fry rearing habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability	Cover Code	Cover Description	Suitability
0	1	0	0	0.1	none	0.33
0.1	0.99	0.2	0.85	1	cobble	0.33
0.2	0.95	0.4	1	2	boulder	0.33
0.3	0.89	1.5	1	3	fine woody veg (<1")	1
0.4	0.81	3	0.25	3.7	3+ovh	1
0.6	0.65	4	0	4	branches	1
0.7	0.56	--	--	4.7	4+ovh	1
0.8	0.49	--	--	5	log (>1' diam)	1
0.9	0.42	--	--	5.7	5+ovh	1
1.1	0.3	--	--	7	ovh (>2' abv sub)	0.33
1.3	0.22	--	--	8	ucb	1
1.8	0	--	--	9	aq veg	0.2
--	--	--	--	9.7	9+ovh	0.2
--	--	--	--	10	rip-rap	0.33

Table 3.3.3B-3 Fall-run Chinook salmon juvenile rearing habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability	Cover Code	Cover Description	Suitability
0	1	0.2	0	0.1	none	0.33
0.1	1	1.25	1	1	cobble	1
0.2	0.99	1.5	1	2	boulder	0.33
0.3	0.98	2.1	1	3	fine woody veg (<1")	0.33
0.4	0.97	3	0.4	3.7	3+ovh	1
0.5	0.96	7	0	4	branches	1
0.6	0.94	--	--	4.7	4+ovh	1
0.7	0.92	--	--	5	log (>1' diam)	1
0.8	0.89	--	--	5.7	5+ovh	1
0.9	0.87	--	--	7	ovh (>2' abv sub)	0.33
1	0.84	--	--	8	ucb	1
1.1	0.81	--	--	9	aq veg	0.24
1.2	0.78	--	--	9.7	9+ovh	0.24
1.3	0.74	--	--	10	rip-rap	0.33
1.4	0.71	--	--	--	--	--
1.5	0.67	--	--	--	--	--
1.6	0.63	--	--	--	--	--
1.7	0.6	--	--	--	--	--
1.8	0.56	--	--	--	--	--
1.9	0.52	--	--	--	--	--
2	0.48	--	--	--	--	--
2.1	0.45	--	--	--	--	--
2.2	0.41	--	--	--	--	--
3	0	--	--	--	--	--

Table 3.3.3B-4. Steelhead spawning habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability	Substrate (in. diameter)	Suitability
0.6	0	0.3	0	0.1	0
0.61	0.08	1	1	1	0.38
0.7	0.14	2.5	1	1-2	1
0.8	0.25	4	0.3	1-3	0.85
0.9	0.38	10	0	2-4	0.28
1	0.53	--	--	3-5	0.16
1.1	0.66	--	--	4-6	0.05

Table 3.3.3B-4. (continued)

Velocity (fps)	Suitability	Depth (ft)	Suitability	Substrate (in. diameter)	Suitability
1.2	0.78	--	--	6-8	0
1.3	0.87	--	--	8-10	0
1.4	0.94	--	--	8-12	0
1.5	0.98	--	--	>12	0
1.6	1	--	--	--	--
1.7	1	--	--	--	--
1.8	0.99	--	--	--	--
1.9	0.97	--	--	--	--
2	0.95	--	--	--	--
2.1	0.93	--	--	--	--
2.2	0.9	--	--	--	--
2.3	0.87	--	--	--	--
2.4	0.85	--	--	--	--
2.5	0.82	--	--	--	--
2.6	0.8	--	--	--	--
2.7	0.78	--	--	--	--
2.8	0.76	--	--	--	--
2.9	0.73	--	--	--	--
3	0.7	--	--	--	--
3.1	0.66	--	--	--	--
3.2	0.61	--	--	--	--
3.3	0.56	--	--	--	--
3.4	0.49	--	--	--	--
3.5	0.41	--	--	--	--
3.6	0.33	--	--	--	--
3.7	0.25	--	--	--	--
3.8	0.17	--	--	--	--
3.89	0.11	--	--	--	--
3.9	0	--	--	--	--

Table 3.3.3B-5. Steelhead fry rearing habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability	Cover Code	Cover Description	Suitability
0	1	0	0	0.1	none	0.33
0.1	1	0.1	1	1	cobble	0.75
0.25	1	0.75	1	2	boulder	0.33
1	0.2	2	0.2	3	fine woody veg (<1")	0.66
3.6	0	4	0	3.7	3+ovh	1
--	--	--	--	4	branches	0.66
--	--	--	--	4.7	4+ovh	1
--	--	--	--	5	log (>1' diam)	1

Table 3.3.3B-5. (continued)

Velocity (fps)	Suitability	Depth (ft)	Suitability	Cover Code	Cover Description	Suitability
--	--	--	--	5.7	5+ovh	1
--	--	--	--	7	ovh (>2' abv sub)	0.66
--	--	--	--	8	ucb	1
--	--	--	--	9	aq veg	0.5
--	--	--	--	9.7	5+ovh	0.5
--	--	--	--	10	rip-rap	0.33

Table 3.3.3B-6. Steelhead juvenile rearing habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability	Cover Code	Cover Description	Suitability
0	0.7	0	0	0.1	none	0.31
0.5	1	1	1	1	cobble	0.75
1.5	1	2	1	2	boulder	0.6
3.5	0.1	4	0.2	3	fine woody veg (<1")	0.4
5.6	0	6	0	3.7	3+ovh	1
--	--	--	--	4	branches	1
--	--	--	--	4.7	4+ovh	1
--	--	--	--	5	log (>1' diam)	1
--	--	--	--	5.7	5+ovh	1
--	--	--	--	7	ovh (>2' abv sub)	1
--	--	--	--	8	ucb	1
--	--	--	--	9	aq veg	0.4
--	--	--	--	9.7	5+ovh	0.4
--	--	--	--	10	rip-rap	0.4

Table 3.3.3B-7. Hardhead juvenile habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability
0	1	0.5	0
0.25	1	0.67	1
1.75	0.25	3.67	1
2.6	0	8.71	0.1
--	--	18	0.1

Table 3.3.3B-8. Hardhead adult habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability
0	0.82	0.66	0
0.2	1	2.62	1
0.9	1	18	1
2.13	0.22	--	--
3.5	0	--	--

Table 3.3.3B-9. Sturgeon spawning habitat suitability criteria.

Velocity (fps)	Suitability	Depth (ft)	Suitability	Substrate Category	Suitability
1.6	0	5	0	snags	0
3.6	1	10	1	organics	0
10	1	100	1	hard clay	0
15	0	--	--	silt/fine clay	0
--	--	--	--	sand	0.1
--	--	--	--	gravel	1
--	--	--	--	cobble	1
--	--	--	--	boulder	0.75
--	--	--	--	bedrock	0.4