Appendix M, Folsom Flow and Temperature

Attachment M.1 American River Redd Dewatering

M.1.1 Model Overview

Redd dewatering for salmon and steelhead occurs when the water level (stage) drops below the depth of existing redds or drops low enough to cause lethal conditions for incubating eggs or alevins within the redds. Redd dewatering in a spawning habitat can occur at any time between the start of spawning to the final emergence of alevins from the redds. Fluctuations in flow during this period increase the probability of redd dewatering because higher flows could lead to redd placement in areas that subsequently may be dewatered when flows drop.

The redd dewatering analyses are based on the maximum reduction in flow from the initial flow, or *spawning flow*, that occurs over the duration of an egg cohort. The duration of a cohort in a redd includes egg incubation and alevin development to emergence from the gravel. The change in river stage is tracked for the duration of each cohort. The minimum flow of the egg cohort period is referred to herein as the *dewatering flow*. If flows during the incubation period are all greater than the spawning flow, no dewatering is assumed to occur. The analysis uses CALSIM 3 data, which have a monthly time-step, for the redd dewatering analyses. It assumes a new egg cohort begins each month of the spawning period. Results of the analysis are expressed as the percentage of redds dewatered.

M.1.2 Model Development

M.1.2.1 Methods

The redd dewatering analysis for the lower American River used relationships between flow, river stage, and redd depth distribution developed by Bratovich et al. (2017). Composite redd depth frequency distributions were developed for fall-run Chinook salmon and steelhead by combining results from several redd surveys conducted between 1996 and 2016 (Table M.1-1). The stage versus flow relationship for the river was developed from a combination of field measurements and modeling (Bratovich et al. 2017). For this analysis, CALSIM 3 flow estimates at the Nimbus Dam location were used to estimate stage at the spawning and dewatering flows, and the redd depth frequency distribution was queried to determine the percentage of the redds that occur between those two stages and would therefore be dewatered.

Redd dewatering was estimated for fall-run and steelhead spawning and incubation periods for each year of the CALSIM 3 period of record. Based on ranges provided in Bratovich et al. 2017, fall-run and steelhead were estimated to have 3-month and 2-month incubation periods, respectively. The analysis compared CALSIM 3 flow and the corresponding stage estimates below Nimbus Dam for each spawning month with the minimum flow (and stage) during 2 or 3 months following the spawning month to estimate the percentage of redds dewatered at least once based on the redd depth cumulative frequencies in Table M.1-1. Absolute differences between the alternatives and baseline conditions in the percentage of redds dewatered were used to compare redd dewatering under the alternatives and the baseline. The use of monthly time-step flow estimates like those obtained from CALSIM 3 modeling likely underestimates redd dewatering rates. This potential bias is expected to affect all alternative scenarios equally.

Table M.1-1. Cumulative Proportions of Fall-run Chinook Salmon and Steelhead Redd Depths Used in the Redd Dewatering Analysis for the Lower American River.

Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead
0.00	0.0000	0.0000	2.00	0.7679	0.6481	4.00	0.9928	0.9941
0.01	0.0000	0.0000	2.01	0.7714	0.6532	4.01	0.9929	0.9943
0.02	0.0000	0.0000	2.02	0.7749	0.6582	4.02	0.9930	0.9945
0.03	0.0000	0.0000	2.03	0.7784	0.6632	4.03	0.9932	0.9946
0.04	0.0000	0.0000	2.04	0.7818	0.6682	4.04	0.9933	0.9948
0.05	0.0000	0.0000	2.05	0.7852	0.6731	4.05	0.9934	0.9949
0.06	0.0000	0.0000	2.06	0.7885	0.6780	4.06	0.9935	0.9951
0.07	0.0000	0.0000	2.07	0.7918	0.6828	4.07	0.9937	0.9952
0.08	0.0000	0.0000	2.08	0.7950	0.6876	4.08	0.9938	0.9954
0.09	0.0000	0.0000	2.09	0.7982	0.6923	4.09	0.9939	0.9955
0.10	0.0000	0.0000	2.10	0.8014	0.6970	4.10	0.9940	0.9957
0.11	0.0000	0.0000	2.11	0.8045	0.7016	4.11	0.9941	0.9958
0.12	0.0000	0.0000	2.12	0.8075	0.7062	4.12	0.9942	0.9959
0.13	0.0000	0.0000	2.13	0.8106	0.7108	4.13	0.9943	0.9961
0.14	0.0000	0.0000	2.14	0.8136	0.7153	4.14	0.9944	0.9962
0.15	0.0000	0.0000	2.15	0.8165	0.7197	4.15	0.9945	0.9963
0.16	0.0000	0.0000	2.16	0.8194	0.7242	4.16	0.9946	0.9965
0.17	0.0000	0.0000	2.17	0.8223	0.7285	4.17	0.9947	0.9966
0.18	0.0000	0.0000	2.18	0.8251	0.7328	4.18	0.9948	0.9967
0.19	0.0000	0.0000	2.19	0.8279	0.7371	4.19	0.9949	0.9968
0.20	0.0000	0.0000	2.20	0.8306	0.7413	4.20	0.9950	0.9969
0.21	0.0000	0.0000	2.21	0.8333	0.7455	4.21	0.9951	0.9970

Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead
0.22	0.0000	0.0000	2.22	0.8360	0.7496	4.22	0.9952	0.9972
0.23	0.0000	0.0000	2.23	0.8386	0.7536	4.23	0.9953	0.9973
0.24	0.0000	0.0000	2.24	0.8412	0.7577	4.24	0.9954	0.9974
0.25	0.0000	0.0000	2.25	0.8438	0.7616	4.25	0.9955	0.9975
0.26	0.0000	0.0000	2.26	0.8463	0.7656	4.26	0.9955	0.9976
0.27	0.0000	0.0000	2.27	0.8488	0.7694	4.27	0.9956	0.9977
0.28	0.0000	0.0000	2.28	0.8513	0.7733	4.28	0.9957	0.9978
0.29	0.0000	0.0000	2.29	0.8537	0.7770	4.29	0.9958	0.9979
0.30	0.0011	0.0000	2.30	0.8561	0.7808	4.30	0.9959	0.9980
0.31	0.0022	0.0000	2.31	0.8584	0.7845	4.31	0.9959	0.9981
0.32	0.0034	0.0000	2.32	0.8607	0.7881	4.32	0.9960	0.9981
0.33	0.0046	0.0000	2.33	0.8630	0.7917	4.33	0.9961	0.9982
0.34	0.0059	0.0000	2.34	0.8652	0.7952	4.34	0.9962	0.9983
0.35	0.0072	0.0000	2.35	0.8674	0.7987	4.35	0.9962	0.9984
0.36	0.0086	0.0008	2.36	0.8696	0.8021	4.36	0.9963	0.9985
0.37	0.0100	0.0016	2.37	0.8718	0.8055	4.37	0.9964	0.9986
0.38	0.0114	0.0024	2.38	0.8739	0.8089	4.38	0.9964	0.9986
0.39	0.0130	0.0033	2.39	0.8760	0.8122	4.39	0.9965	0.9987
0.40	0.0145	0.0041	2.40	0.8780	0.8155	4.40	0.9966	0.9988
0.41	0.0162	0.0050	2.41	0.8800	0.8187	4.41	0.9966	0.9989
0.42	0.0179	0.0059	2.42	0.8820	0.8218	4.42	0.9967	0.9990
0.43	0.0196	0.0069	2.43	0.8840	0.8250	4.43	0.9968	0.9990
0.44	0.0214	0.0078	2.44	0.8859	0.8280	4.44	0.9968	0.9991
0.45	0.0233	0.0088	2.45	0.8878	0.8311	4.45	0.9969	0.9992
0.46	0.0252	0.0099	2.46	0.8897	0.8341	4.46	0.9970	0.9992
0.47	0.0272	0.0109	2.47	0.8915	0.8370	4.47	0.9970	0.9993
0.48	0.0293	0.0120	2.48	0.8933	0.8399	4.48	0.9971	0.9994
0.49	0.0314	0.0131	2.49	0.8951	0.8428	4.49	0.9971	0.9994
0.50	0.0336	0.0142	2.50	0.8968	0.8456	4.50	0.9972	0.9995
0.51	0.0358	0.0154	2.51	0.8986	0.8483	4.51	0.9972	0.9996
0.52	0.0381	0.0166	2.52	0.9003	0.8511	4.52	0.9973	0.9996
0.53	0.0405	0.0178	2.53	0.9019	0.8538	4.53	0.9973	0.9997
0.54	0.0430	0.0191	2.54	0.9036	0.8564	4.54	0.9974	0.9997
0.55	0.0455	0.0204	2.55	0.9052	0.8590	4.55	0.9974	0.9998

Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead
0.56	0.0481	0.0217	2.56	0.9068	0.8616	4.56	0.9975	0.9998
0.57	0.0508	0.0231	2.57	0.9084	0.8641	4.57	0.9975	0.9999
0.58	0.0535	0.0245	2.58	0.9099	0.8666	4.58	0.9976	0.9999
0.59	0.0563	0.0259	2.59	0.9114	0.8690	4.59	0.9976	1.0000
0.60	0.0592	0.0274	2.60	0.9129	0.8714	4.60	0.9977	1.0000
0.61	0.0621	0.0289	2.61	0.9144	0.8738	4.61	0.9977	1.0000
0.62	0.0652	0.0304	2.62	0.9159	0.8761	4.62	0.9978	1.0000
0.63	0.0683	0.0320	2.63	0.9173	0.8784	4.63	0.9978	1.0000
0.64	0.0714	0.0336	2.64	0.9187	0.8807	4.64	0.9978	1.0000
0.65	0.0747	0.0352	2.65	0.9201	0.8829	4.65	0.9979	1.0000
0.66	0.0780	0.0369	2.66	0.9214	0.8851	4.66	0.9979	1.0000
0.67	0.0814	0.0387	2.67	0.9228	0.8872	4.67	0.9980	--
0.68	0.0849	0.0404	2.68	0.9241	0.8894	4.68	0.9980	--
0.69	0.0884	0.0423	2.69	0.9254	0.8914	4.69	0.9981	--
0.70	0.0921	0.0441	2.70	0.9267	0.8935	4.70	0.9981	--
0.71	0.0958	0.0460	2.71	0.9279	0.8955	4.71	0.9981	--
0.72	0.0995	0.0480	2.72	0.9291	0.8975	4.72	0.9982	--
0.73	0.1034	0.0500	2.73	0.9304	0.8994	4.73	0.9982	--
0.74	0.1073	0.0520	2.74	0.9315	0.9013	4.74	0.9982	--
0.75	0.1113	0.0541	2.75	0.9327	0.9032	4.75	0.9983	--
0.76	0.1154	0.0562	2.76	0.9339	0.9050	4.76	0.9983	--
0.77	0.1195	0.0584	2.77	0.9350	0.9069	4.77	0.9983	--
0.78	0.1237	0.0606	2.78	0.9361	0.9086	4.78	0.9984	--
0.79	0.1280	0.0629	2.79	0.9372	0.9104	4.79	0.9984	--
0.80	0.1324	0.0652	2.80	0.9383	0.9121	4.80	0.9984	--
0.81	0.1368	0.0676	2.81	0.9394	0.9138	4.81	0.9985	--
0.82	0.1413	0.0700	2.82	0.9404	0.9155	4.82	0.9985	--
0.83	0.1458	0.0725	2.83	0.9414	0.9171	4.83	0.9985	--
0.84	0.1505	0.0750	2.84	0.9424	0.9187	4.84	0.9986	--
0.85	0.1552	0.0776	2.85	0.9434	0.9203	4.85	0.9986	--
0.86	0.1599	0.0802	2.86	0.9444	0.9218	4.86	0.9986	--
0.87	0.1648	0.0829	2.87	0.9454	0.9234	4.87	0.9986	--
0.88	0.1696	0.0856	2.88	0.9463	0.9249	4.88	0.9987	--
0.89	0.1746	0.0884	2.89	0.9472	0.9263	4.89	0.9987	--

Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead
0.90	0.1796	0.0913	2.90	0.9482	0.9278	4.90	0.9987	--
0.91	0.1847	0.0942	2.91	0.9491	0.9292	4.91	0.9988	--
0.92	0.1898	0.0971	2.92	0.9499	0.9306	4.92	0.9988	--
0.93	0.1950	0.1001	2.93	0.9508	0.9320	4.93	0.9988	--
0.94	0.2003	0.1032	2.94	0.9517	0.9333	4.94	0.9988	--
0.95	0.2056	0.1063	2.95	0.9525	0.9346	4.95	0.9989	--
0.96	0.2109	0.1095	2.96	0.9533	0.9359	4.96	0.9989	--
0.97	0.2163	0.1127	2.97	0.9541	0.9372	4.97	0.9989	--
0.98	0.2218	0.1160	2.98	0.9549	0.9384	4.98	0.9989	--
0.99	0.2273	0.1194	2.99	0.9557	0.9397	4.99	0.9989	--
1.00	0.2329	0.1228	3.00	0.0000	0.0000	5.00	0.9990	--
1.01	0.2385	0.1263	3.01	0.0000	0.0000	5.01	0.9990	--
1.02	0.2441	0.1298	3.02	0.0000	0.0000	5.02	0.9990	--
1.03	0.2498	0.1334	3.03	0.0000	0.0000	5.03	0.9990	--
1.04	0.2555	0.1370	3.04	0.0000	0.0000	5.04	0.9991	--
1.05	0.2613	0.1407	3.05	0.0000	0.0000	5.05	0.9991	--
1.06	0.2671	0.1445	3.06	0.0000	0.0000	5.06	0.9991	--
1.07	0.2729	0.1483	3.07	0.0000	0.0000	5.07	0.9991	--
1.08	0.2788	0.1522	3.08	0.0000	0.0000	5.08	0.9991	--
1.09	0.2847	0.1561	3.09	0.0000	0.0000	5.09	0.9992	--
1.10	0.2906	0.1601	3.10	0.0000	0.0000	5.10	0.9992	--
1.11	0.2966	0.1642	3.11	0.0000	0.0000	5.11	0.9992	--
1.12	0.3026	0.1683	3.12	0.0000	0.0000	5.12	0.9992	--
1.13	0.3086	0.1724	3.13	0.0000	0.0000	5.13	0.9992	--
1.14	0.3146	0.1767	3.14	0.0000	0.0000	5.14	0.9992	--
1.15	0.3207	0.1810	3.15	0.0000	0.0000	5.15	0.9993	--
1.16	0.3267	0.1853	3.16	0.0000	0.0000	5.16	0.9993	--
1.17	0.3328	0.1897	3.17	0.0000	0.0000	5.17	0.9993	--
1.18	0.3389	0.1941	3.18	0.0000	0.0000	5.18	0.9993	--
1.19	0.3451	0.1986	3.19	0.0000	0.0000	5.19	0.9993	--
1.20	0.3512	0.2032	3.20	0.0000	0.0000	5.20	0.9993	--
1.21	0.3573	0.2078	3.21	0.0000	0.0000	5.21	0.9994	--
1.22	0.3635	0.2125	3.22	0.0000	0.0000	5.22	0.9994	--
1.23	0.3697	0.2172	3.23	0.0000	0.0000	5.23	0.9994	--

Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead
1.24	0.3758	0.2220	3.24	0.0000	0.0000	5.24	0.9994	--
1.25	0.3820	0.2268	3.25	0.0000	0.0000	5.25	0.9994	--
1.26	0.3881	0.2317	3.26	0.0000	0.0000	5.26	0.9994	--
1.27	0.3943	0.2366	3.27	0.0000	0.0000	5.27	0.9994	--
1.28	0.4005	0.2416	3.28	0.0000	0.0000	5.28	0.9995	--
1.29	0.4066	0.2466	3.29	0.0000	0.0000	5.29	0.9995	--
1.30	0.4128	0.2517	3.30	0.0011	0.0000	5.30	0.9995	--
1.31	0.4190	0.2568	3.31	0.0022	0.0000	5.31	0.9995	--
1.32	0.4251	0.2620	3.32	0.0034	0.0000	5.32	0.9995	--
1.33	0.4312	0.2672	3.33	0.0046	0.0000	5.33	0.9995	--
1.34	0.4373	0.2725	3.34	0.0059	0.0000	5.34	0.9995	--
1.35	0.4435	0.2778	3.35	0.0072	0.0000	5.35	0.9995	--
1.36	0.4496	0.2831	3.36	0.0086	0.0008	5.36	0.9996	--
1.37	0.4556	0.2885	3.37	0.0100	0.0016	5.37	0.9996	--
1.38	0.4617	0.2939	3.38	0.0114	0.0024	5.38	0.9996	--
1.39	0.4677	0.2994	3.39	0.0130	0.0033	5.39	0.9996	--
1.40	0.4738	0.3049	3.40	0.0145	0.0041	5.40	0.9996	--
1.41	0.4798	0.3104	3.41	0.0162	0.0050	5.41	0.9996	--
1.42	0.4857	0.3160	3.42	0.0179	0.0059	5.42	0.9996	--
1.43	0.4917	0.3216	3.43	0.0196	0.0069	5.43	0.9996	--
1.44	0.4976	0.3272	3.44	0.0214	0.0078	5.44	0.9996	--
1.45	0.5035	0.3329	3.45	0.0233	0.0088	5.45	0.9997	--
1.46	0.5094	0.3386	3.46	0.0252	0.0099	5.46	0.9997	--
1.47	0.5153	0.3443	3.47	0.0272	0.0109	5.47	0.9997	--
1.48	0.5211	0.3500	3.48	0.0293	0.0120	5.48	0.9997	--
1.49	0.5269	0.3558	3.49	0.0314	0.0131	5.49	0.9997	--
1.50	0.5326	0.3616	3.50	0.0336	0.0142	5.50	0.9997	--
1.51	0.5384	0.3674	3.51	0.0358	0.0154	5.51	0.9997	--
1.52	0.5441	0.3732	3.52	0.0381	0.0166	5.52	0.9997	--
1.53	0.5497	0.3791	3.53	0.0405	0.0178	5.53	0.9997	--
1.54	0.5554	0.3850	3.54	0.0430	0.0191	5.54	0.9997	--
1.55	0.5609	0.3909	3.55	0.0455	0.0204	5.55	0.9997	--
1.56	0.5665	0.3968	3.56	0.0481	0.0217	5.56	0.9998	--
1.57	0.5720	0.4027	3.57	0.0508	0.0231	5.57	0.9998	--

Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead
1.58	0.5775	0.4086	3.58	0.0535	0.0245	5.58	0.9998	--
1.59	0.5829	0.4145	3.59	0.0563	0.0259	5.59	0.9998	--
1.60	0.5883	0.4205	3.60	0.0592	0.0274	5.60	0.9998	--
1.61	0.5937	0.4264	3.61	0.0621	0.0289	5.61	0.9998	--
1.62	0.5990	0.4324	3.62	0.0652	0.0304	5.62	0.9998	--
1.63	0.6043	0.4383	3.63	0.0683	0.0320	5.63	0.9998	--
1.64	0.6095	0.4443	3.64	0.0714	0.0336	5.64	0.9998	--
1.65	0.6147	0.4502	3.65	0.0747	0.0352	5.65	0.9998	--
1.66	0.6199	0.4562	3.66	0.0780	0.0369	5.66	0.9998	--
1.67	0.6250	0.4622	3.67	0.0814	0.0387	5.67	0.9998	--
1.68	0.6301	0.4681	3.68	0.0849	0.0404	5.68	0.9998	--
1.69	0.6351	0.4740	3.69	0.0884	0.0423	5.69	0.9998	--
1.70	0.6401	0.4800	3.70	0.0921	0.0441	5.70	0.9999	--
1.71	0.6450	0.4859	3.71	0.0958	0.0460	5.71	0.9999	--
1.72	0.6499	0.4918	3.72	0.0995	0.0480	5.72	0.9999	--
1.73	0.6547	0.4977	3.73	0.1034	0.0500	5.73	0.9999	--
1.74	0.6595	0.5036	3.74	0.1073	0.0520	5.74	0.9999	--
1.75	0.6643	0.5095	3.75	0.1113	0.0541	5.75	0.9999	--
1.76	0.6690	0.5154	3.76	0.1154	0.0562	5.76	0.9999	--
1.77	0.6736	0.5212	3.77	0.1195	0.0584	5.77	0.9999	--
1.78	0.6782	0.5270	3.78	0.1237	0.0606	5.78	0.9999	--
1.79	0.6828	0.5328	3.79	0.1280	0.0629	5.79	0.9999	--
1.80	0.6873	0.5386	3.80	0.1324	0.0652	5.80	0.9999	--
1.81	0.6918	0.5444	3.81	0.1368	0.0676	5.81	0.9999	--
1.82	0.6962	0.5501	3.82	0.1413	0.0700	5.82	0.9999	--
1.83	0.7006	0.5558	3.83	0.1458	0.0725	5.83	0.9999	--
1.84	0.7049	0.5615	3.84	0.1505	0.0750	5.84	0.9999	--
1.85	0.7092	0.5672	3.85	0.1552	0.0776	5.85	0.9999	--
1.86	0.7134	0.5728	3.86	0.1599	0.0802	5.86	0.9999	--
1.87	0.7176	0.5784	3.87	0.1648	0.0829	5.87	0.9999	--
1.88	0.7218	0.5840	3.88	0.1696	0.0856	5.88	1.0000	--
1.89	0.7259	0.5895	3.89	0.1746	0.0884	5.89	1.0000	--
1.90	0.7299	0.5950	3.90	0.1796	0.0913	5.90	1.0000	--
1.91	0.7339	0.6005	3.91	0.1847	0.0942	5.91	1.0000	--

Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead	Redd Depth (ft)	Fall-run	Steelhead
1.92	0.7379	0.6059	3.92	0.1898	0.0971	5.92	1.0000	--
1.93	0.7418	0.6113	3.93	0.1950	0.1001	5.93	1.0000	--
1.94	0.7457	0.6167	3.94	0.2003	0.1032	5.94	1.0000	--
1.95	0.7495	0.6220	3.95	0.2056	0.1063	5.95	1.0000	--
1.96	0.7532	0.6273	3.96	0.2109	0.1095	5.96	1.0000	--
1.97	0.7570	0.6326	3.97	0.2163	0.1127	5.97	1.0000	--
1.98	0.7606	0.6378	3.98	0.2218	0.1160	5.98	1.0000	--
1.99	0.7643	0.6429	3.99	0.2273	0.1194	5.99	1.0000	--

M.1.2.2 Assumptions/Uncertainty

This section provides a list of some important uncertainties and assumptions of the redd dewatering analyses used for this analysis.

M.1.2.2.1 Important Uncertainties and Assumptions of the Redd Dewatering Analysis Conducted for this Analysis

1. The use of monthly time-step flow estimates like those obtained from CALSIM III modeling likely underestimates redd dewatering rates because they smooth out short-term flow fluctuations. This potential bias is expected to affect the Project and NAA scenarios equally.

2. An assumption of the redd dewatering analysis is that dewatering of the redd results in 100% mortality of the eggs and alevins it contains. This assumption overestimates mortality. Several studies have demonstrated that the level of mortality is strongly related to the duration of dewatering, the temperature and humidity in the dewatered redd, and the life stages present when the redd is dewatered (Becker et al. 1982; Reiser and White 1983; McMichael et al. 2005). In general, eggs survive dewatering at a much higher rate than the alevins (Becker et al. 1982). Eggs may survive for weeks in a dewatered redd whereas alevins generally survive only a few hours (Becker et al. 1982; Reiser and White 1983). This observation suggests that dewatering of redds early in the spawning period of a population may have a less negative effect than later dewatering because the egg stage would be more prevalent early in the season than the alevin stage. Although the assumption of 100% mortality resulting from redd dewatering overestimates the effects of redd dewatering on the salmon and steelhead populations under the alternative scenarios, the level of overestimation is uncertain. Regardless, this assumption applies to all alternative scenarios equally.

3. The duration of egg and alevin incubation for fall-run Chinook salmon and steelhead is assumed to be the same regardless of the time of year. This ignores water temperature effects on egg and alevin development times, which increases uncertainty in the analysis. Water temperatures in the lower American River are not expected to differ greatly among the alternative scenarios, so any biases resulting from temperature effects are likely to be similar among scenarios.

4. The redd dewatering analyses assume that channel characteristics of the river, such as proportions of mesohabitat types, during the time of field data collection by U.S. Fish and Wildlife Service (1995–1999) 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.

M.1.2.3 Code and Data Repository

Code, input, and output files for this analysis can be found at: [TBD].

M.1.3 Results

M.1.3.1 Steelhead

The results of the redd dewatering analysis for steelhead indicate that redd dewatering is much greater in wet water years the in dry water years for all BA and EIS modeled scenarios (Table M.1-2 and Table M.1-3, Figure M.1-1 and Figure M.1-2). This difference reflects the greater frequency of larger flow fluctuations in wetter years.

Table M.1-2. Mean Percent Steelhead Redds Dewatered for the American River by Water Year Type for January through March Spawning Period, BA Modeled Scenarios

WYT	EXP1	EXP3	NAA	Alt2v1woTUCP	Alt2DeltaVAs	Alt2allwatershedVAs
W	39.6	49.7	49.1	49.1	49.1	48.9
AN	37.6	41.2	38.6	39.5	40.2	39.8
BN	23.6	26.0	20.6	23.2	22.6	21.1
D	18.6	17.1	8.4	10.6	10.5	10.9
C	15.8	6.1	4.6	5.1	6.7	5.8
All	27.6	29.4	25.6	26.8	27.0	26.6

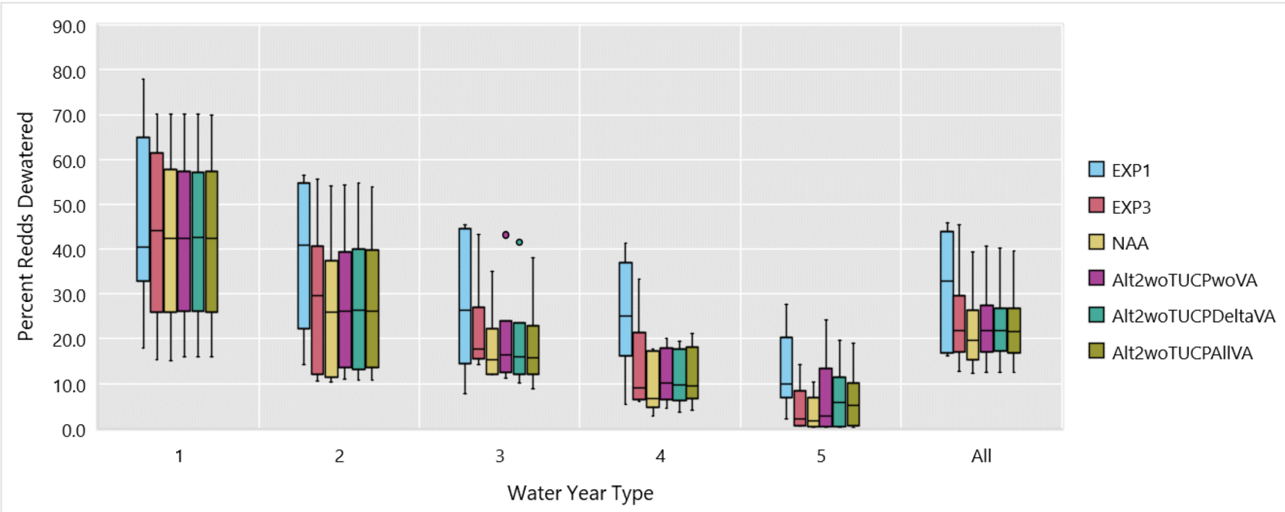

Figure M.1-1. SH_Redds Mean Percent Steelhead Redds Dewatered for the American River by Water Year Type for December through May, BA Modeled Scenarios.

Table M.1-3. Mean Percent Steelhead Redds Dewatered for the American River by Water Year Type for January through March Spawning Period, EIS Modeled Scenarios

WYT	NAA	Alt1	Alt2v1 wTUCP	Alt2v1 woTUCP	Alt2 DeltaVAs	Alt2all watershedVAs	Alt3	Alt4
W	49.1	50.5	49.1	49.1	49.1	48.9	46.6	46.6
AN	38.6	46.9	39.7	39.5	40.2	39.8	33.4	33.4
BN	20.6	36.7	23.4	23.2	22.6	21.1	13.6	13.6
D	8.4	29.2	10.7	10.6	10.5	10.9	9.4	9.4
C	4.6	18.5	8.2	5.1	6.7	5.8	3.6	3.6
All	25.6	37.3	27.4	26.8	27.0	26.6	23.0	23.0

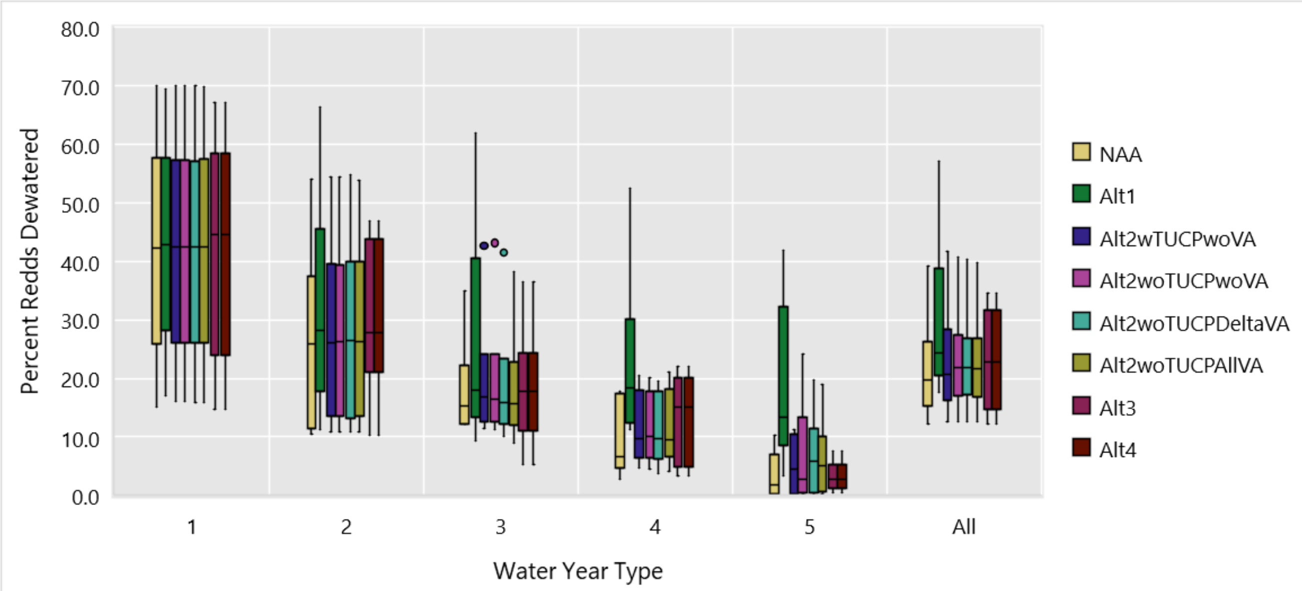

Figure M.1-2. SH_Redds Mean Percent Steelhead Redds Dewatered for the American River by Water Year Type for January through March, EIS Modeled Scenarios.

The results for steelhead redd dewatering grouped by months indicate that for both BA and EIS modeled scenarios redd dewatering peaks in February and is roughly similar in January and March (Figure M.1-3 and Figure M.1-4).

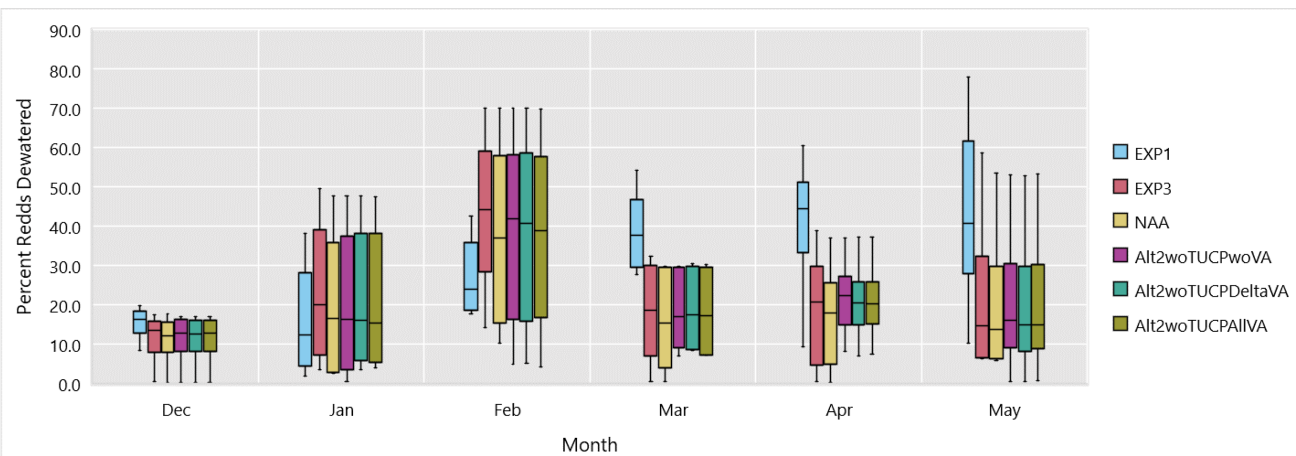

Figure M.1-3. SH_Redds Mean Percent Steelhead Redds Dewatered for the American River by Month, BA modeled scenarios.

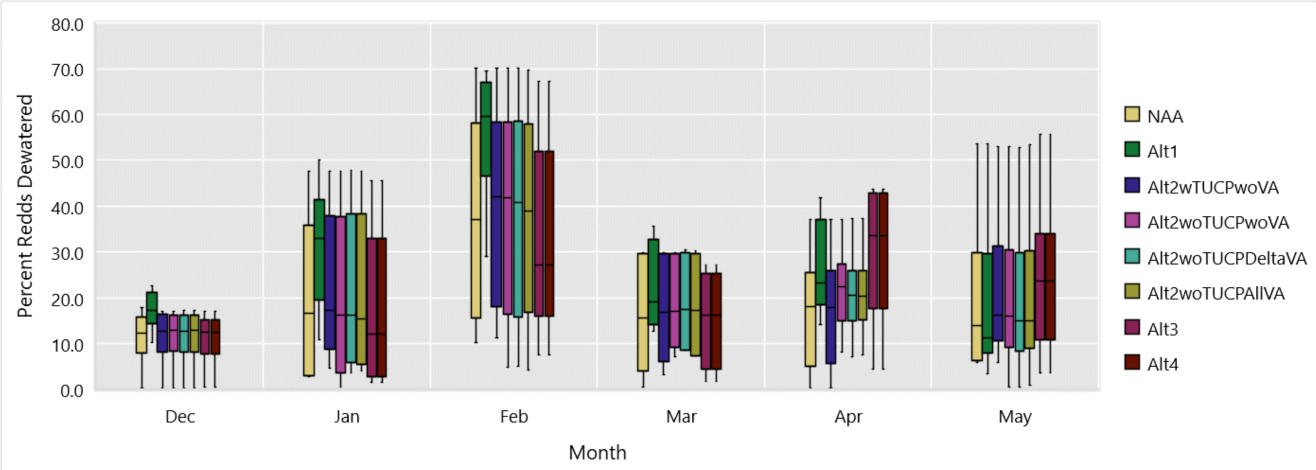

Figure M.1-4. SH_Redds Mean Percent Steelhead Redds Dewatered for the American River by Month, EIS modeled scenatios.

M.1.3.2 Fall-run Chinook

The results of the redd dewatering analysis for fall-run Chinook indicate that redd dewatering is greater in wet and above normal water years than in the drier dry water year types for all the EIS modeled scenarios (Table M.1-4 and Figure M.1-5). As noted above for steelhead, higher levels of flow typically result in more opportunities for redd dewatering.

Table M.1-4. Mean Percent Fall-run Chinook Redds Dewatered for the American River by Water Year Type for October through December Spawning Period, EIS Modeled Scenarios

WYT	NAA	Alt1	Alt2v1 wTUCP	Alt2v1 woTUCP	Alt2 DeltaVAs	Alt2all watershedVAs	Alt3	Alt4
W	9.9	14.6	10.8	10.8	11.0	10.9	10.2	10.2
AN	6.1	15.8	6.5	6.5	6.7	6.6	5.8	5.8
BN	4.3	9.3	4.5	4.6	4.7	5.1	4.5	4.5
D	6.9	12.1	6.6	6.6	6.5	7.8	6.6	6.6
C	4.3	8.9	2.8	4.7	4.0	4.3	2.0	2.0
All	6.8	12.4	6.8	7.1	7.1	7.5	6.4	6.4

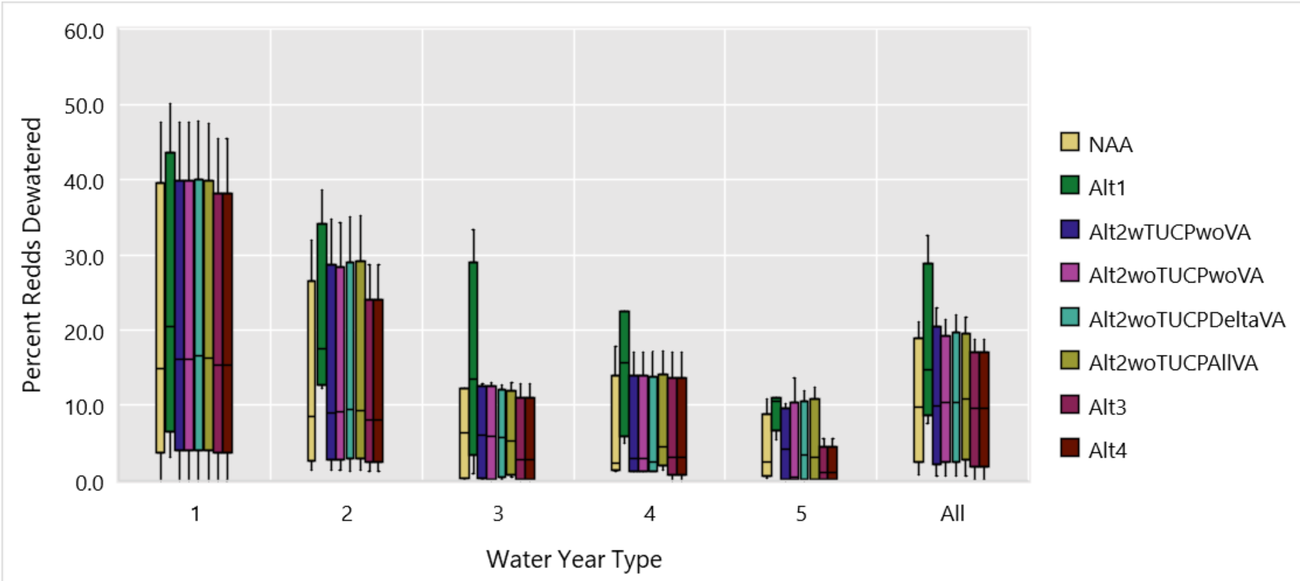

Figure M.1-5. Mean Percent Fall-run Chinook Salmon Redds Dewatered for the American River by Water Year Type for October through January.

The results for fall-run redd dewatering grouped by months indicate that redd dewatering increases from spawning in October to that in December, reflecting the increasingly higher average flow levels over this period (Figure M.1-6).

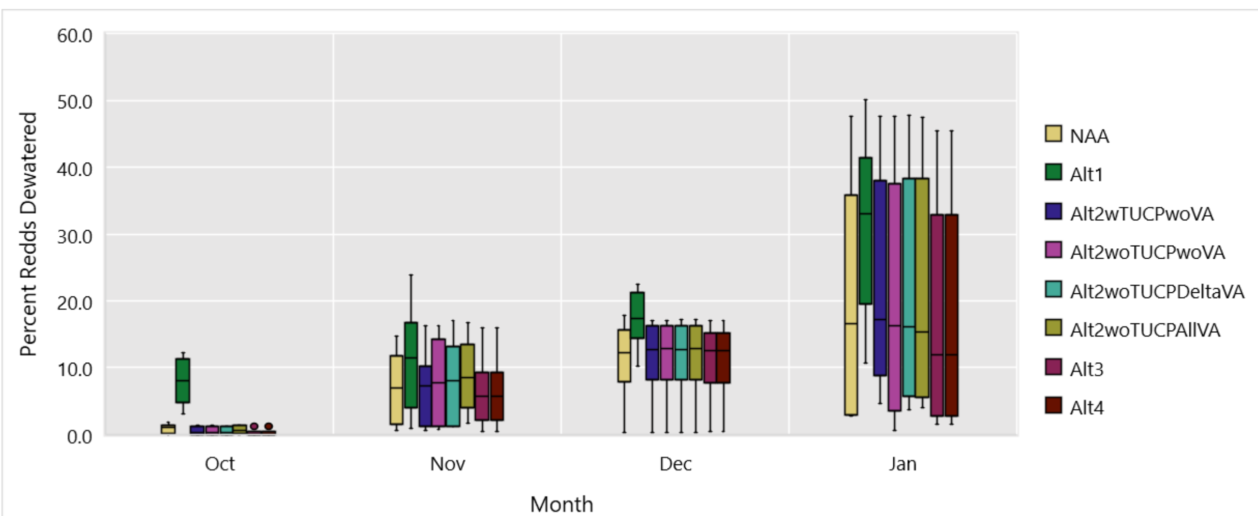

Figure M.1-6. Mean Percent Fall-run Chinook Salmon Redds Dewatered for the American River by Month, EIS modeled scenarios.

M.1.4 References

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