Memorandum June 9, 2020

To: John Palmer, USEPA R10

From: Peter Leinenbach, USEPA R10

Subject: Estimating the potential Cold Water Refugia volume within tributaries that discharge into the Columbia River

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The potential Cold Water Refugia (CWR) volume within tributaries that discharge to the Columbia Basin was estimated through using the following equation:

$$\begin{aligned} &Tributary\ CWR\ Volume\ (m^3) \\ &= Stream\ Length\ (SL)\ providing\ CWR\ habitat\ for\ Columbia\ River\ migratory\ salmonids\ (m) \\ &* Average\ Tributary\ Cross\ Sectional\ Area\ (\bar{A})\ within\ this\ designated\ area\ (m^2) \end{aligned}$$

Where the Stream Length (SL) is the tributary length that potentially provides Colombia River migratory salmonids CWR habitat. SL was estimated as occurring at either the 1) first observed riffle or physical barrier located upstream of the confluence with the Columbia River as observed from imagery[1], or 2) field information, when known. The cross sectional area ($\bar{A}$) was estimated with the following equation:

$$\bar{A} = {Stream\ Discharge\ (m^3/s)} \Big/ {Stream\ Velocity\ (m/s)}$$

Where both stream discharge and stream velocity were obtained from the EROM model reported in the NHDPlus dataset (http://www.horizon-systems.com/NHDPlus/NHDPlusV2_17.php). Specifically, the Q0001E attribute associated with the upstream portion of the SL were used in this calculation. Results of this analysis are presented in **Table 1**.

[1] The wetted right and left banks were digitized in Google Earth, and these KML files were imported into ArcMap as shapefiles through using the Xtools extension for ArcGIS. The two banks were then merged together and then this merged shapefile was converted to centerline through use of the "Collapse Dual Line to Centerline" ArcGIS tool. This collapsed line represents the stream centerline for the tributary. This collapsed line was clipped by the upper and lower extent of salmon migratory distribution and the length of this clipped shapefile was calculated using the Xtools extension.

Table 1. Estimated Potential Riverine Cold Water Refugia Volume

Tributary Code	Tributary Name	Stream Length Providing CWR Habitat (m)	Average August Stream Discharge (m^3/s)	Average August Stream Velocity (m/s)	Potential Riverine CWR Volume (m^3)
28	Skamokawa Creek	317	0.57	0.17	1,033
38	Mill Creek	283	0.29	0.19	446
40	Abernethy Creek	337	0.29	0.12	806
41	Germany Creek	329	0.24	0.18	446
49	Cowlitz River	1,764	102.86	0.27	684,230
52	Kalama River	942	7.48	0.25	27,820
63	Lewis River	2,549	40.12	0.21	493,455
77	Sandy River	300	13.29	0.18	22,015
78	Washougal River	1,232	3.86	0.15	32,536
83	Bridal Veil Creek	0	0.21	0.13	0
85	Wahkeena Creek	0	0.43	0.19	0
86	Oneonta Creek	12	0.83	0.18	54
88	Woodward Creek	0	0.97	0.14	0
89	McCord Creek	0	0.42	0.29	0
90	Moffett Creek	0	0.25	0.30	0
91	Tanner Creek	121	1.07	0.31	413
92	Eagle Creek	137	2.04	0.31	888
94	Rock Creek	237	1.33	0.27	1,178
96	Herman Creek[2]	414	1.28	0.31	1,698
100	Wind River[3]	913	8.30	0.17	44,420
112	Little White Salmon River[4]	562	7.02	0.34	11,661
115	White Salmon River	2,104	19.61	0.51	81,529
116	Hood River	0	10.59	0.31	0
125	Klickitat River	2,846	24.12	0.46	149,029
135	Deschutes River	5,231	97.59	0.88	580,124
176	Umatilla River	1,711	2.46	0.40	10,473

[2] SL for Herman Creek included both channel areas near the mouth of this tributary.

[3] Only areas upstream of the boat ramp at the mouth of the Wind River were included in the SL analysis; these downstream areas were included in the plume field studies discussed previously.

[4] Only areas upstream of the Drano Lake were included in the SL analysis for the Little White Salmon River; Drano Lake areas were included in the plume field studies discussed previously.