

Technical Memorandum

To: Columbia River CWR Project Team

From: John Palmer

Date: September 11, 2019

Subject: Volume of Cold Water Refuge Associated with the 23 Tributaries Providing CWR in the Lower Columbia River and Selection of the 12 Primary CWR

This memo summarizes the sources of information used to estimate the volume of cold water refuge (CWR) associated with the 23 tributaries that provide cold water refuge in the Lower Columbia River, as well as the basis for selection of the 12 primary CWR. **Table 1** summarizes the attributes of each of the 23 tributaries, including the volume of CWR that is greater than 2°C colder than the Columbia River and volume of CWR that is 18°C or less. The following is a listing of the EPA technical memorandums to estimate the CWR volumes in Table 1.

- The selection of the 23 tributaries is described in Appendix 3: *EPA Technical Memorandum: Screening Approach to Identify the 23 Tributaries That Currently Provide CWR in the Lower Columbia River, March 29, 2018.*
- The CWR volume estimates for the tributary plumes (except for Herman Creek, Wind River, and Little White Salmon River) are described in Appendix 6: *CORMIX Modeling of Tributary Plumes in the Lower Columbia River, June 23, 2017.*
- The CWR volume estimates for the “coves” (included in the Plume CWR volume in **Table 1** and highlighted in green) for Herman Creek, Wind River and Little White Salmon River/Drano Lake are in Appendices 9, 10, and 12: *Estimated CWR volume for the Wind River and Little White Salmon River/Drano Lake, May 22, 2017; and Supplement to estimated CWR volume in Herman Creek Cove, September 27, 2017; Estimates of plume volumes associated with five tributary/confluence sites using USEPA field data collected in 2016, March 1, 2017.*
- The CWR volume estimates for the stream portion for each of the 23 tributaries are described in Appendix 7: *EPA Memorandum: Estimating the Potential Coldwater refuge volume within tributaries that discharge into the Columbia River, October 26, 2018.* The stream length (SL) used in the above memorandum is based on Appendix 4: *EPA Memorandum: Location of Upstream Extent of 23 CWR areas used by Migrating Salmon and Steelhead, November 1, 2018.*

Table 1 includes the following coloring coding: the 12 primary CWR are highlighted in blue (discussed further below); the difference between the tributary's temperature and the Columbia River temperature highlighted in purple if greater than 4°C, green if between 2 and 4°C, and orange if between 0 and 2°C. Light green highlights those CWR where the "plume" CWR volume are cove areas, which EPA estimated with direct monitoring measurements.

Table 1 Estimated CWR Volumes for Tributary's Providing CWR in the Lower Columbia River

Estimated CWR Volumes for Tributaries Providing CWR in the Columbia River													
Code	Tributary Name	River Mile	Mainstem Temp ¹	Tributary Temp ²	Temp Difference	Tributary Flow ³	Plume CWR Volume (> 2°C Δ) ⁴	Stream CWR Volume (> 2°C Δ) ⁵	Total CWR Volume (> 2°C Δ)	CWR Volume (<18C)	Stream CWR (<18C)	Total CWR Volume (<18C)	
			°C	°C	°C	cfs	m3	m3	m3	m3	m3	m3	
28	Skamokawa Creek	30.9	21.3	16.2	-5.1	23	450	1,033	1,483	48	1,033	1,081	
38	Mill Creek	51.3	21.3	14.5	-6.8	10	110	446	556	41	446	487	
40	Abernethy Creek	51.7	21.3	15.7	-5.6	10	81	806	887	17	806	823	
41	Germany Creek	53.6	21.3	15.4	-5.9	8	72	446	518	18	446	464	
49	Cowlitz River	65.2	21.3	16.0	-5.4	3634	870,000	684,230	1,554,230	130,000	684,230	814,230	
52	Kalama River ⁶	70.5	21.3	16.3	-5.0	314	14,000	27,820	41,820	980	27,820	28,800	
63	Lewis River	84.4	21.3	16.6	-4.8	1291	120,000	493,455	613,455	13,000	493,455	506,455	
77	Sandy River	117.1	21.3	18.8	-2.5	469	9,900	22,015	31,915	0	0	0	
78	Washougal River ⁷	117.6	21.3	19.2	-2.1	107	740	32,563	33,303	0	0	0	
83	Bridal Veil Creek	128.9	21.3	11.7	-9.6	7	120	0	120	54	0	54	
85	Wahkeena Creek	131.7	21.3	13.6	-7.7	15	220	0	220	92	0	92	
86	Oneonta Creek	134.3	21.3	13.1	-8.2	29	820	54	874	280	54	334	
91	Tanner Creek	140.9	21.3	11.7	-9.6	38	1,300	413	1,713	630	413	1,043	
Bonneville Dam													
92	Eagle Creek	142.7	21.2	15.1	-6.1	72	2,100	888	2,988	610	888	1,498	
94	Rock Creek ⁷	146.6	21.2	17.4	-3.8	47	530	1,178	1,708	26	1,178	1,204	
96	Herman Creek	147.5	21.2	12.0	-9.2	45	168,000	1,698	169,698	93,958	1,698	95,656	
100	Wind River	151.1	21.2	14.5	-6.7	293	60,800	44,420	105,220	20,390	44,420	64,810	
112	Little White Salmon River	158.7	21.2	13.3	-7.9	88	1,097,000	4,126	1,101,126	531,524	4,126	535,650	
115	White Salmon River	164.9	21.2	15.7	-5.5	715	72,000	81,529	153,529	14,000	81,529	95,529	
116	Hood River	165.7	21.4	15.5	-5.9	374	28,000	0	28,000	7,500	0	7,500	
125	Klickitat River	176.8	21.4	16.4	-5.0	851	73,000	149,029	222,029	3,300	149,029	152,329	
The Dalles Dam													
135	Deschutes River	200.8	21.4	19.2	-2.2	4772	300,000	580,124	880,124	0	0	0	
John Day Dam													
176	Umatilla River ⁷	284.7	20.9	20.8	-0.1	169	0	46,299	46,299	0	0	0	
							Total Plume Volume	Total Stream	Total CWR Volume	Plume V (<18C)	Stream V (<18C)	Total V (<18C)	
							(M3)	2,819,243	2,172,572	4,991,815	816,468	1,491,571	2,308,039
							Olympic Pools	1,128	869	1,997	327	597	923
Notes													
¹ August Mean (10 year average) from nearest station in DART.													
² August Mean (NorWeST model estimate).													
³ August Mean (EROM model, except USGS gage for 6 tribs: Kalama, Lewis, Washougal, White Salmon, Klickitat, and Deschutes)													
⁴ Plume CWR Volume @ August Mean Trib Temp or measured temp for direct estimate method. Three methods used for Plume CWR Volume: CORMIX model, CORMIX regression, and direct method estimate based monitoring data.													
⁵ Stream CWR Volume based on estimated upstream range of CWR use and stream volume estimate method.													
⁶ Kalama River is tidally influence and appears to be inaccessible during low tides													
⁷ Washougal, Rock and Umatilla only provide intermittent CWR; CWR volume represents volume when rivers are >2C colder than Columbia River.													
EPAR10 CWR Summary and Volume Table.xlsx													

The total CWR volume for all 23 tributaries is nearly 5 million cubic meters, which is approximately 2,000 Olympic-sized swimming pools. The three tributaries with the largest CWR volumes are the Cowlitz River, Little White Salmon River/Drano Lake, and the Deschutes River.

Twelve of the 23 CWR tributaries, which are highlighted in blue in **Table 1**, were determined to be primary CWR tributaries based on CWR volume, known or presumed CWR use by steelhead or salmon, and easy access and depth for cover while in CWR. **Table 2**, which ranks the tributaries by CWR volume, provides information on CWR use and other characteristics which provide the basis for selection of the 12 primary and 11 non-primary CWR.

Eleven CWR tributaries are non-primary CWR because they have small CWR volume (less than 2,000 m³), have substantial periods of time when the tributary is less than 2°C cooler or even warmer than the Columbia River, and/or are shallow and exposed. Additionally, the extent of use by salmon and steelhead in these 11 non-primary CWR tributaries is unknown and likely is minimal due to one or more of the characteristics noted above.

The 12 primary CWR represent 97% of the total CWR volume in the Lower Columbia River and are known or presumed to be used currently by migrating steelhead or salmon for cold water refuge.

Monitoring data contained in Appendix 8 (Washougal River and Rock Creek) and Appendix 12 (Umatilla River) show these tributary's temperatures near the confluence compared to the Columbia River temperature and the intermittent nature of the CWR associated with these tributaries. As noted in Table 2, the Kalama River was observed to be very shallow at the confluence likely creating access limitations, especially during low tides.

The seven tributaries with the smallest CWR volumes in **Table 2** only provide a small area of CWR and fish use in these CWR are unknown. Potentially a few fish may temporarily hold in these small areas. Four of these tributaries are relatively close to the ocean, so migrating steelhead and salmon have only been exposed to warm Columbia River temperatures for a short period in their upstream migration and may be less likely to seek CWR at this time.

Table 2 Selection Factors to Identify 12 Primary CWR

Tributary Name	River Mile	Temp Difference vs Columbia River (Aug Mean) °C	Tributary Flow ³ cfs	Total CWR Volume (>2°C Δ) m3	Documented CWR Use	Comments
Cowlitz River	65	-5.4	3634	1,554,230	Presumed	Presumed CWR use based on observed fishing at the confluence
Little White Salmon River	159	-7.9	88	1,101,126	Yes	Radio-tagged verified CWR use
Deschutes River	201	-2.2	4772	880,124	Yes	Radio-tagged verified CWR use
Lewis River	84	-4.8	1291	613,455	Presumed	Presumed CWR use based on observed fishing at the confluence
Klickitat River	177	-5.0	851	222,029	Yes	Radio-tagged verified CWR use
Herman Creek	147	-9.2	45	169,698	Yes	Radio-tagged verified CWR use
White Salmon River	165	-5.5	715	153,529	Yes	Radio-tagged verified CWR use
Wind River	151	-6.7	293	105,220	Yes	Radio-tagged verified CWR use
Umatilla River	285	-0.1	169	46,299	Unknown	Intermittent CWR; Significant time less than 2C colder than Columbia River or warmer than Columbia River; water quality degradation; aquatic weed growth
Kalama River	71	-5.0	314	41,820	Unknown	Tidally influenced; very shallow (1-2 feet) and exposed at confluence during lower tides creating potential access barrier
Washougal River	118	-2.1	107	33,303	Unknown	Intermittent CWR; Significant time less than 2C colder than Columbia River or warmer than Columbia River; shallow and exposed
Sandy River	117	-2.5	469	31,915	Presumed	Presumed CWR use based on observed fishing at the confluence
Hood River	166	-5.9	374	28,000	Yes	Radio-tagged verified CWR use
Eagle Creek	143	-6.1	72	2,988	Yes	Radio-tagged verified CWR use
Tanner Creek	141	-9.6	38	1,713	Yes	Observed CWR use by Chinook and steelhead from snorkling observation
Rock Creek	147	-3.8	47	1,708	Unknown	Intermittent CWR; Significant time less than 2C colder than Columbia River or warmer than Columbia River; shallow and exposed
Skamokawa Creek	31	-5.1	23	1,483	Unknown	Small CWR; near ocean
Abernethy Creek	52	-5.6	10	887	Unknown	Small CWR; near ocean
Oneonta Creek	134	-8.2	29	874	Unknown	Small CWR
Mill Creek	51	-6.8	10	556	Unknown	Small CWR; near ocean
Germany Creek	54	-5.9	8	518	Unknown	Small CWR; near ocean
Wahkeena Creek	132	-7.7	15	220	Unknown	Small CWR
Bridal Veil Creek	129	-9.6	7	120	Unknown	Small CWR