Technical Memorandum

To: Columbia River CWR Project Team

From: John Palmer, Joe Ebersole, Jenny Wu, and Dylan Laird

Date: November 11, 2018 (*updated July 22, 2020 to reflect updated references*)

Subject: Location of Upstream Extent of 23 CWR Areas Used by Migrating Salmon and Steelhead

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EPA assessed 191 tributaries to the lower 310 miles of the Columbia River and determined that 23 tributaries have sufficently cool temperatures, flow, and accessiblity to provide cold water refugia for migrating adult salmon and steelhead. See *Evaluation of the Potential Cold Water Refugia Created by Tributaries within the Lower/Middle Columbia River based on "NorWeST" Temperature Modeling Project, June 6, 2017 (Appendix 12.2)* and *Screening Approach to Identify the 23 Tributaries That Currently Provide CWR in the Lower Columbia River and Selection of the 12 Primary CWR, July 22, 2020 (Appendix 12.5)*. This Memorandum describes the rationale for estimating how far upstream the majority (>80%) of non-natal salmon or steelhead may travel in these tributaries while temporarily using them as cold water refugia. The distance upstream identified for these 23 tributaries is used in other analyses to determine the volume of cold water refuge (CWR) in each tributary.

The term "upstream extent" is intended to represent the limit on how far the large majority (80-85%) salmon and steelhead will generally go while using the tributary as CWR. It's recognized that for tributaries with sufficient flow and depth, salmon and steelhead are capabable of traveling many miles upstream. Most of the 23 tributaries have their own spawning populations of anadromous fish that generally enter and migrate up these streams in the fall, winter and spring during higher streamflows. In addition, salmon and steelhead may 'stray' into non-natal tributaries, which can include movements of many kilometers upstream into the tributary before returning to the Columbia River and resuming migration. However, this analysis attempts to distinguish CWR use of the lower portion of the tributaries by salmon and steelhead versus straying behavior of fish that may be using the tributary via exploratory movements not related to CWR use. Our focus is instead on the relatively short-term (hours to weeks) behavior of salmon and steelhead destined for other river systems to spawn that use non-natal tributary confluence areas for temporary cold-water refuge during periods of heat stress (e.g.; Goniea et al. 2006, High et al. 2006, Keefer et al. 2009).

Our underlying hypotheses of this assessment is that fish prefer to conserve energy and minimize exposure to predators, particularly during periods of thermal stress when vulnerability may be high (Dauble and Mueller 2000, Goniea et al. 2006). For migratory salmon and steelhead, this is accomplished by minimizing unnecessary energy expenditure (reducing tail beat frequency), minimizing thermal exposure (staying cool in thermal refuges), and minimizing predation risks (orienting toward depth and/or cover). Thus, we assume that salmon and steelhead will be reluctant to spend the energy to go farther upstream in a CWR tributary than necessary, will prefer the coldest, deepest areas, and will minimize use of shallow, exposed areas.

Several factors and sources of information were considered to demark the upstream extent of CWR use for each of the 23 tributaries. Each are discussed below followed by a specific discussion and map for each of the 23 tributaries.

1) Aerial imagery for each tributary confluence area was assessed to visually identify the first riffle or feature that could serve as either: 1) an impediment to upstream travel in regards to energy expenditure and exposure to predators; or 2) an actual barrier to upstream travel. For lower-gradient tributaries that lacked well-defined riffle-pool structure, we defined the upstream boundary at the first geomorphic feature encountered, including channel braiding, islands, significant channel structures, or tributary junctions. This approach was the initial factor for setting the upstream extent for the 23 tributaries. Where available, additional information as discussed below was used to either confirm or adjust the upstream extent of each tributary.
2) Where available, results from radio telemetry studies and PIT tag information was assessed. Upon request by EPA, NOAA Fisheries conducted an analysis of PIT Tag data from 2011-2015 to determine how many out-of-basin steelhead were detected at interrogation sites within tributaries. Only five of the 23 tributaries, however, have interrogation sites (Abernethy, Wind, Hood, Klickitat, and Deschutes). PIT data from the Deschutes River for steelhead native to other rivers was particularly useful because there are data from various distances upstream, which provide the distribution of out-of-basin steelhead in the river. In the Deschutes River, 83% of the radio-tagged out-of-basin steelhead entering the river stayed below 5 kilometers (3.2 miles), while 7% went as far as Sherars Falls at river kilometer 60 (43 miles) (High et al. 2006). Based on these data, we set the upstream extent for CWR use at 5 kilometers and considered the steelhead going farther upstream as exhibiting temperory straying behavoir. The steelhead distribution in the Deschutes River also: 1) generally confirmed our hypothesis discussed above that fish will generally only use the the lower portion of the tributaries for CWR purposes; and 2) served as a general benchmark (e.g., CWR use 5km or lower) for some of the other CWR tributaries with relatively high flow levels and depth (e.g., Cowlitz, Lewis, White Salmon, and Klickitat). For the other four tributaries with PIT Tag interrogation sites (Abernethy, Wind, Hood, and Klickitat) there were only a few or no out-of-basin steelhead detected. We concluded that the fish detected at these sites were exhibiting straying behavior similar to those traveling to Sherars Falls in the Deschutes River or there was limited CWR use at these sites. Thus, the upstream extent for CWR use in these tributaries was downstream of the PIT Tag interrogation sites.
3) Discussions with local field biologists has to date been limited, but valuable. For one tributary (Wind River), local biologists had knowledge of CWR use based on snorkling and other studies, which helped set the upstream extent in conjunction with field investigation.
4) Field investigation and depth measurements were used to examine and verify features identified from analysis of aerial imagery. Some tributaries (Mill, Abernethy, Washougal, Tanner, Eagle, Wind, Rock, Herman, White Salmon, Little White Salmon, and Klickitat) were visually inspected to confirm or adjust the upstream extent based on aerial photos. Additionally, in six tributaries (Wind, Kalama, Sandy, White Salmon, Eagle Creek, Hood), depth measurements were taken at key locations to confirm or adjust the upstream extent. Depth of 0.8 meters or less was used as an indicator of an impediment to upstream travel based on our assumption that salmon and steelhead will be unlikely to use tributaries less than 0.8m in depth that require extensive movement over very shallow gravel bars (Raleigh 1986).
5) For small, low flow tributaries (20 cfs August mean flow or less) the upstream extent point at or very near the confluence of the Columbia River based on aerial imagery was assumed to be an adequate representation of the upstream extent of CWR use. These streams are very shallow near the tributary

confluence areas during late July throught mid-September and salmon or steelhead traveling upstream will quickly encounter depths less than than 0.8m that require extensive movement over very shallow gravel bars. This applied to: Germany, Bridal Veil, Wahkeena, and Oneonta Creeks.

The following images, reproduced from Google Earth, show each tributary confluence with a marker (yellow pushpin icon) indicating the point of upstream extent of the CWR. Text below each image describes the rationale for each location.

The upstream extent was set at the first structure (foot bridge and abutment), encountered 0.39 miles (0.63 km) upstream from mouth. We assume that the incentive to go more than a few hundred meters into small tributaries like this one is very low.

The upstream extent was set at the first riffle, 0.15 miles (0.24 km) upstream. Stream gradient increases above this point, based on field observations. The upstream extent does not appear to be tidally influenced.

The upstream extent was set at the first riffle, where the gradient increases above the first riffle. This location is consistent with previous site visits. Limited PIT tag information confirms the upstream extent of CWR use is in the lower portion of creek as only a few out-of-basin steelhead have been detected at the PIT tag interrogation site (pink balloon icon) 0.25 miles (0.40 km) upstream of the confluence .

Upstream origin PIT tagged steelhead detected in Lower Columbia Tributaries, July -September, 2010-2015				
Stream	Year	Origin	Detect in stream	Redetected at upstream dam
Abernethy Creek	2014	Hood River	2	0
Abernethy Creek	2015	Klickitat	1	0

The upstream extent was set at the first riffle, 0.20 miles (0.32 km) upstream of the confluence. There appear to be engineered log jams on the east bank of Germany Creek.

The upstream extent was set at the first tributary, 1.75 miles (2.82 km) upstream. The Cowlitz River is a large, deep river with ample CWR volume to support a significant number of fish below the upstream extent point. Lack of geomorphic structure serving as any sort of inhibitor of upstream movement makes determining an upstream extent more challenging for this location. As noted above, the steelhead radio tag information from the Deschutes River indicates CWR use is primarily in the lower 5 km (3.2 miles). Lacking more specific data, we use this as a reference for the Cowlitz and other large rivers. For the Cowlitz River, the CWR volume below this upstream extent point (1.75 mi) is almost twice the volume of CWR available in the lower 3.2 miles of the Deschutes.

The upstream extent was set at the second bend, 0.6 miles (1 km) upstream of the confluence. The Kalama River delta at the confluence is shallow and is tidally influenced. During low tide, salmon and steelhead are unlikely to enter the river because the maximum depth is less than 0.8 meters based on an 8/30/18 site visit.

The upstream extent was set at Allen Creek, 1.70 miles (2.74 km) upstream from the confluence. Lewis River is a large, deep river with significant CWR volume in the lower reach. As noted above, the steelhead radio tag information from the Deschutes River indicating CWR use is primarily in the lower 5 km (3.2 miles), and serves as a reference for other large rivers. For the Lewis River, the CWR volume downstream of this upstream extent point is comparable the CWR volume of the lower 3.2 miles of the Deschutes.

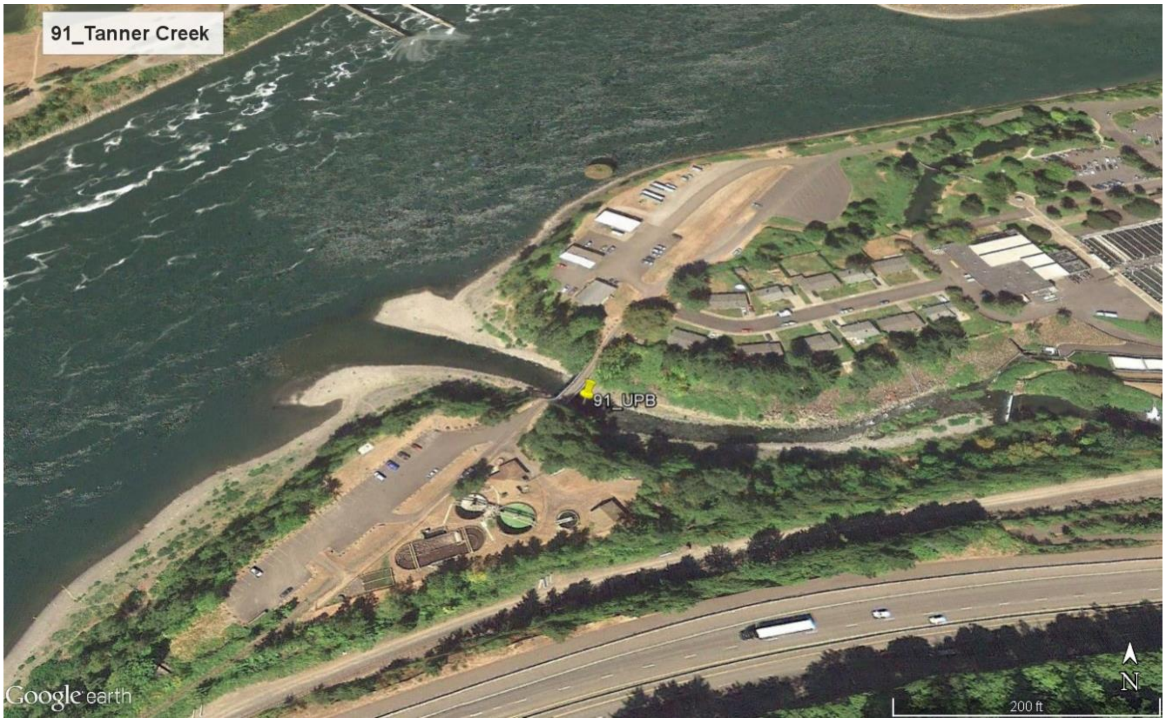
The upstream extent was set where the river channel in the delta was at maximum depth of 0.8 meter based on a site visit conducted on 8/30/18, 0.19 miles (0.3 km) upstream of the interface of the Sandy River and the Columbia River. The lower section of the Sandy River is a shallow delta and is tidally influenced.

The upstream extent was set at the first significant riffle, 0.81 miles (1.10 km) upstream from the confluence.

The upstream extent was set at the stream confluence due to Bridal Veil Creek being a small, shallow tributary.

The upstream extent was set at the stream confluence due to Wahkeena Creek being a small, shallow tributary.

The upstream extent was set at the I-84 overpass, 0.03 miles (0.05 km) upstream. Due to the creek being a low flow tributary, stream depth likely limits CWR use upstream of this point.



The upstream extent was set at the first riffle under the Bonneville bridge, 0.08 miles (0.13 km) upstream. The upstream extent was confirmed during a site visit on 8/17/17 when large numbers of Chinook and steelhead were observed in the pools and runs downstream of this first riffle.

The upstream extent was set at a riffle 0.15 miles (0.24 km) upstream that constrains movement (depth of 0.8 meter or less), based on a site visit conducted on 8/17/17.

The upstream extent was set at the shallow channel above the pool north of WA-14, 0.13 miles (0.21 km) upstream from the confluence.

The upstream extent was set at the hatchery racks outlet channel and on Herman Creek at the first gravel bar at the bend in the eastern inlet, based on fish observations during a site visit on 8/17/17. The upstream extent on the hatchery outlet channel (96_UPB_A) is 0.13 miles (0.21 km) upstream from Herman Cove, and the upstream extent on Herman Creek is 0.11 miles (0.18 km) upstream from Herman Cove.

The upstream extent was set at an upstream riffle 0.81 miles (1.30 km) upstream presumed to limit movement (0.8-meter depth) based on field observations on 8/17/17. Deeper pools along the channel banks provide accessible refuge below this point. Also, as noted above, discussions with local biologists who have conducted past snorkeling surveys indicate that CWR use by out-of-basin steelhead is limited above this reach. Lack of PIT tag detection of out-of-basin steelhead at the PIT tag site (pink marker) at river mile 2.16 (3.48 km) is consistent with these observations.

Upstream origin PIT tagged steelhead detected in Lower Columbia Tributaries, July -September, 2010-2015				
Stream	Year	Origin	detect at stream	Redetect at upstream dam
Wind River (both sites)	All years		0	0

The upstream extent was set at the hatchery weir, 1.30 miles (2.09 km) upstream.

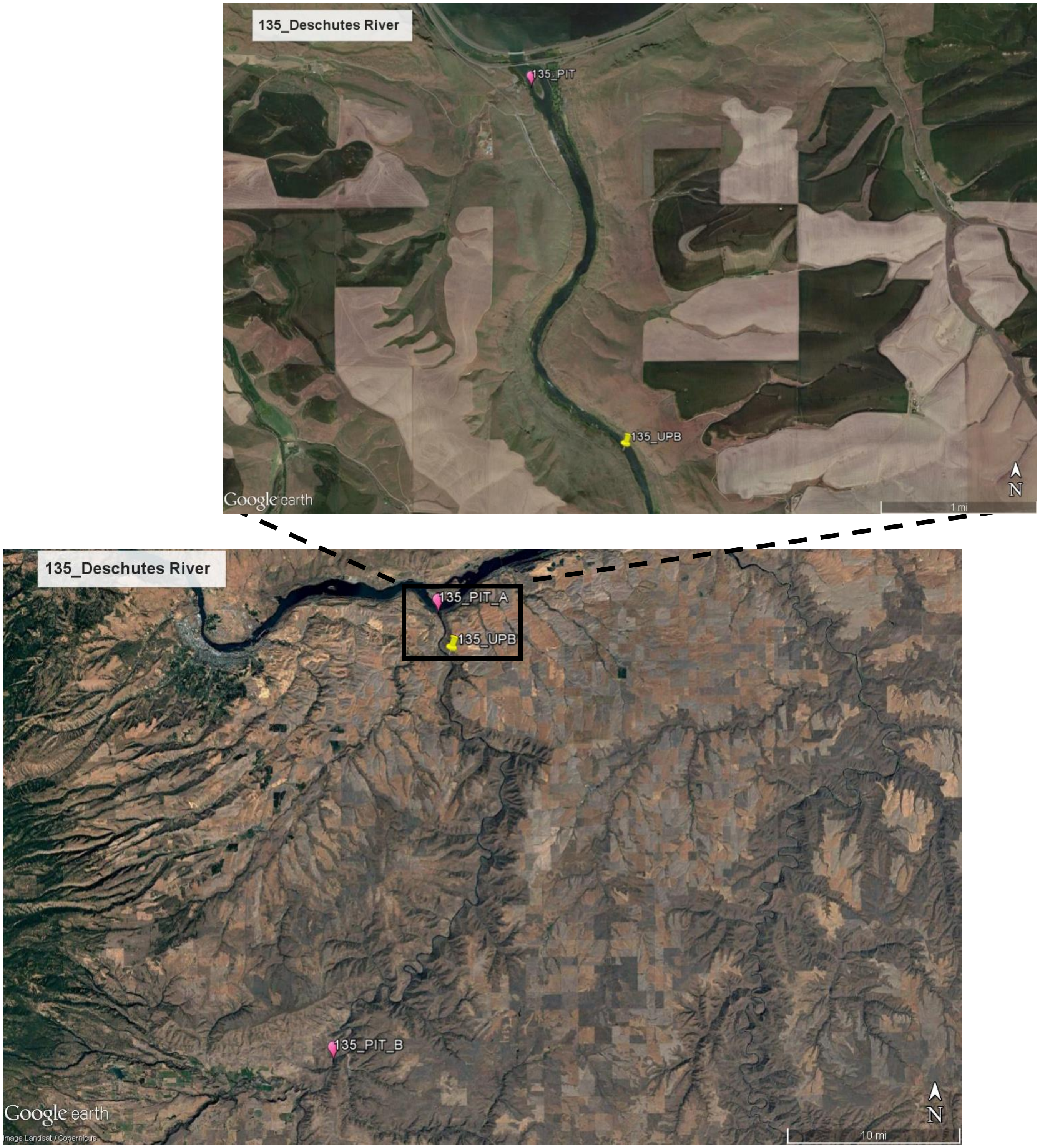
The upstream extent was set 1.29 miles (2.08 km) upstream at the first significant rapids based on field interviews and observation. Sufficient depth and flow is available below this point. Ian Courter and John Plumb confirmed the choice of the first high-gradient section in the gorge based on personal angling experience and that of colleagues, who continue to catch hatchery fish (out of basin steelhead) in the lower White Salmon during periods of warm Columbia River temperatures Almost all of these fish are below the first set of rapids (phone conversation 9/12/17).

The upstream extent was set at the river mouth. Shallow depth throughout the delta (less than 0.8 meters) is a presumed limitation to upstream travel for CWR use. PIT tag information shows only a few detections of out-of-basin steelhead (10-15 annually) at the interrogation site (pink marker) confirming minimal CWR use in the lower Hood River delta. By comparison, 600-700 out-of-basin steelhead are detected near the mouth of the Deschutes River annually.

Upstream origin PIT tagged steelhead detected in Lower Columbia Tributaries, July -September, 2010-2015				
Stream	Year	Origin	detect at stream	Redetect at upstream dam
Hood River	2012	Deschutes	2	*
Hood River	2012	Klickitat	9	*
Hood River	2012	Snake River	4	2
Hood River	2013	Deschutes	1	1
Hood River	2013	Klickitat	6	*
Hood River	2013	Snake River	7	7
Hood River	2014	John Day	1	1
Hood River	2014	Klickitat	13	*
Hood River	2014	Snake River	3	3
Hood River	2015	John Day	1	1
Hood River	2015	Klickitat	9	2*
Hood River	2015	Okanagan	1	1
Hood River	2015	Snake River	7	6
Hood River	2015	Umatilla	1	1

The upstream extent was set at the first major rapid in the narrow canyon at river mile 1.77 (2.85 km), based on a site visit and field observations conducted on 8/17/17. PIT tag information shows limited out-of-basin steelhead detections at the interrogation site (pink marker), indicating CWR use is limited above this location.

Upstream origin PIT tagged steelhead detected in Lower Columbia Tributaries, July -September, 2010-2015				
Stream	Year	Origin	detect at stream	Redetect at upstream dam
Klicktat	2011	Hood	1	*
Klicktat	2012	Hood	1	*
Klicktat	2012	Snake	2	1
Klicktat	2013	Hood	3	2*
Klicktat	2013	Snake	17	12
Klicktat	2014	Snake River	7	7
Klicktat	2015	Hood	1	0
Klicktat	2015	Snake River	9	5
Klicktat	2015	Umatilla	3	3
Klicktat	2015	Yakima	1	0
* Home stream is below upstream dam				



The upstream extent was set at 5km (3.2 miles) based on High et. al. 2006 (page 526), which states "Of the 591 steelhead upriver steelhead that delayed migration in the Deschutes River, 17% were recorded in the Deschutes River 5 km or more upstream from its mouth and nearly 7% were recorded at a receiver site at Sherars Falls, located 67.9 km upstream." From this statement, 83% of steelhead use the lower 5km as CWR. Pink markers indicate PIT antenna locations. PIT tag information from near the mouth shows extensive CWR use in lower section of the Deschutes River. Also, PIT tag detection of out-of-basin steelhead at Sherars Falls has declined in recent years, which is speculated to be due to the decreased percentage juvenile steelhead that are barged downstream. This supports the hypothesis that those steelhead reaching Sherars Falls are exhibiting straying behavior.

NOAA Steelhead PIT Tag Analysis for the Deschutes:

Near the mouth

DPS	2013	2014	2015
Lower Columbia	9	5	31
Middle Columbia (includes steelhead returning to Deschutes)	174	214	385
Snake River	541	506	540
Upper Columbia	74	54	86

Sherars Falls

DPS	2007	2008	2009	2010	2011	2012	2013	2014	2015
Lower Columbia	1		99	59	42	98	46	No Data	
Middle Columbia	36	47	94	78	73	78	111		31
Snake River	159	121	460	164	73	74	55 (11%)		34 (6%)

The upstream extent was set at the first upstream riffle, 1.03 miles (1.66 km) upstream from the confluence.

Citations

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