

## Memorandum

March 13, 2019

**To:** John Palmer, USEPA Region 10

**From:** Peter Leinenbach, USEPA Region 10

**Subject:** Water temperature estimates of the Columbia River and tributaries in 2040 and 2080.

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**Results** – Water temperature modeling showed that water temperatures in the Columbia River, along with the tributaries that drain the Columbia River, are anticipated to increase in the near future (**Figures 1, 2, and 3**). The modeled tributary response was a function of expected increases of summer air temperatures, along with summer hydrologic reductions, due to anticipated future climate changes within the Columbia basin. Future tributary temperatures are anticipated increasing between 0.6°C and 0.7°C relative to Columbia River temperature (**Figure 4**) and will result in a relatively increased future heat load to the Columbia River mainstem from tributary discharges. In addition, these figures also show that many of the tributaries, despite being relatively cooler than the Columbia River, could become warmer than the applicable water temperature standard in the future and therefore would be less available to function as “Cold Water Refugia” in the future (Section XXXX or Appendix XXXX - that is, reference the Cold Water Refugia section of this TMDL).

**Methods** – Estimates of current and future tributary temperatures were obtained from a Spatial Stream Network (SSN) model developed by the USFS ([www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html](http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html)) (Isaak et al., 2018). This SSN model derived current stream temperatures based on 2002 through 2011 observed stream temperature data. The SSN model was also used to estimate future temperature conditions based on global climate model projections, which were also adjusted for differential stream sensitivity. Specifically, future scenarios were based on global climate model ensemble averages that represent the A1B warming trajectory for 2040’s (2030-2059) and 2080’s (2070-2099).

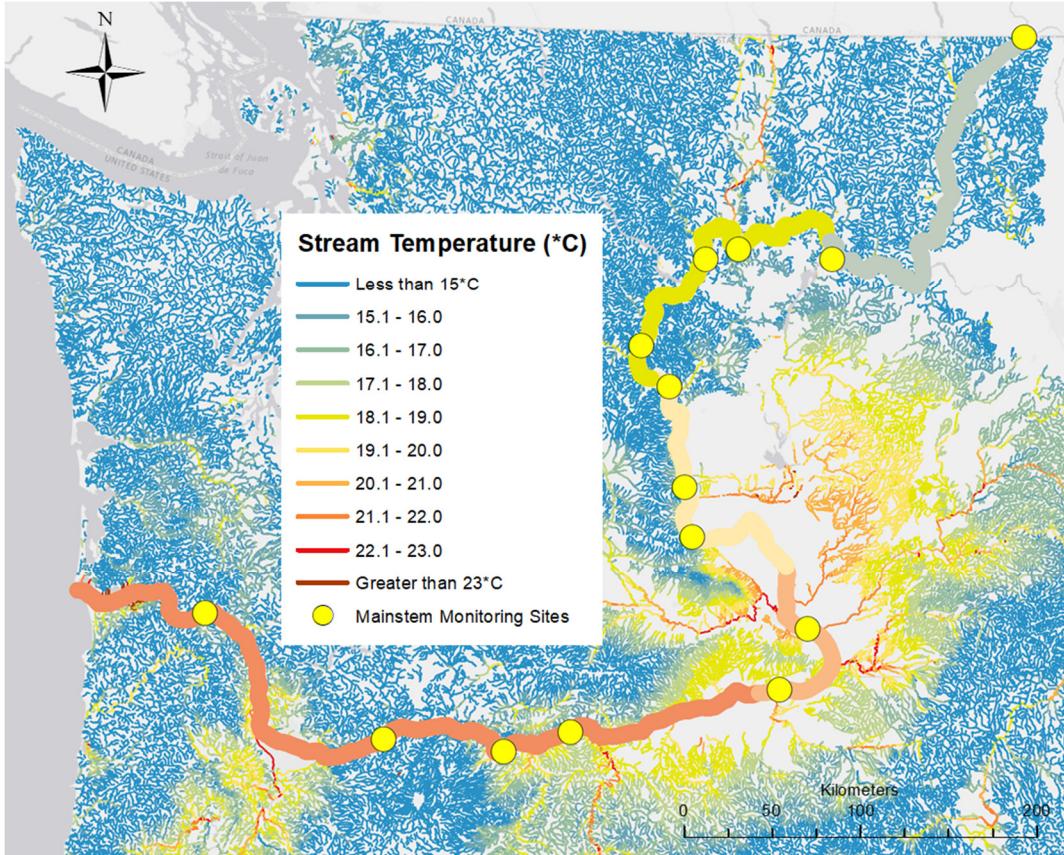
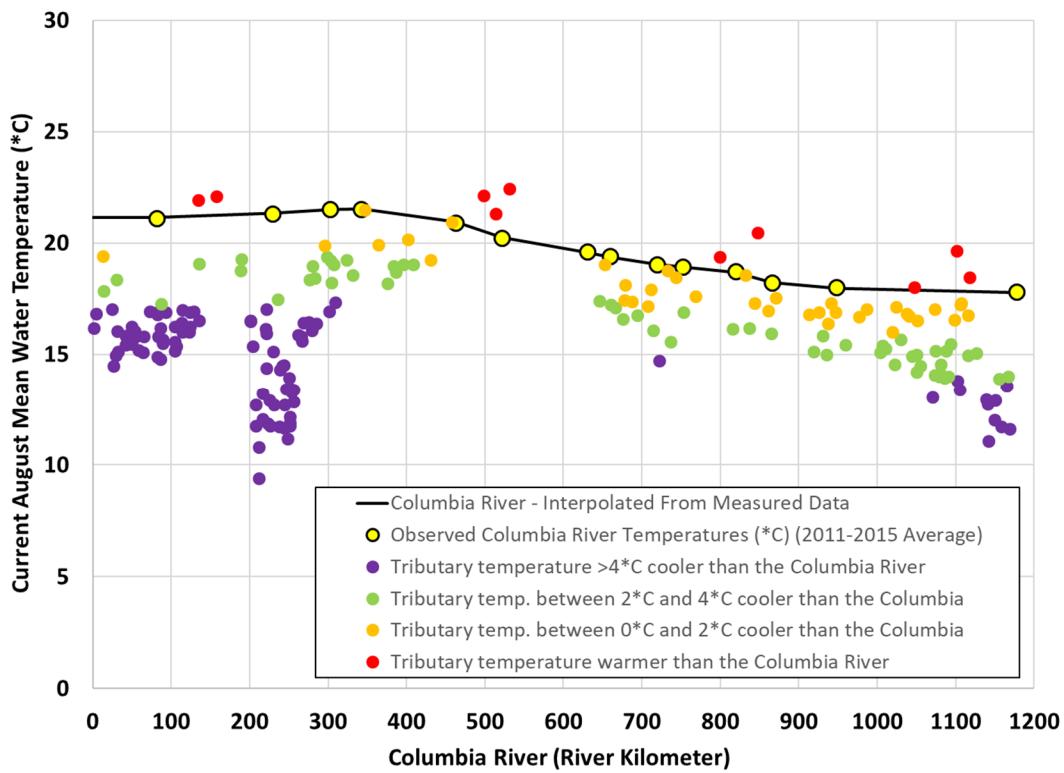
Current mainstem Columbia River temperatures were obtained from the Columbia River Dart website ([www.cbr.washington.edu/dart](http://www.cbr.washington.edu/dart)). Specifically, current Columbia River August stream temperatures were estimated from the available data for the 2011 through 2016 period (i.e., yellow dots in **Figure 1**). River temperatures for areas between these monitoring locations were derived by interpolation (i.e., black line in **Figure 1**). Future Columbia River temperatures were derived from the reported observed range of the decadal temperature change rates along the Columbia River (i.e., 0.2°C to 0.4°C) (see Section 5.4.1 of the Columbia River TMDL). Specifically, the average of the reported decadal change rate, 0.3°C, was applied to current mainstem estimates proportion to length of time associated with each future scenario (e.g., 2040 water temperature increase was estimated as 0.78°C, which was calculated as 2.6 decades in the future times 0.3°C increase per decade, and using similar methods, the 2080 mainstem temperature conditions were estimated to increase 1.98°C above current conditions).

Note – This memorandum is identical to a 11/20/18 memo to Laurie Mann (R10EPA) except that the temperature range in the figures was changed to a higher display resolution of elevated temperatures.

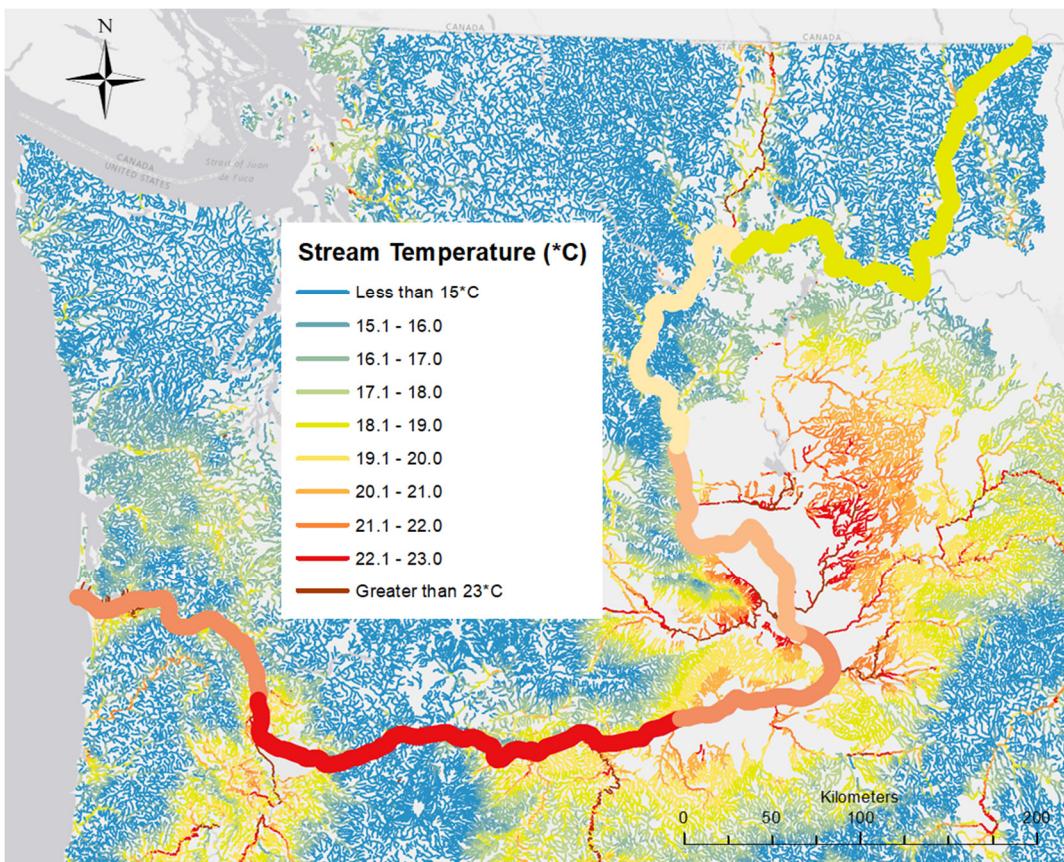
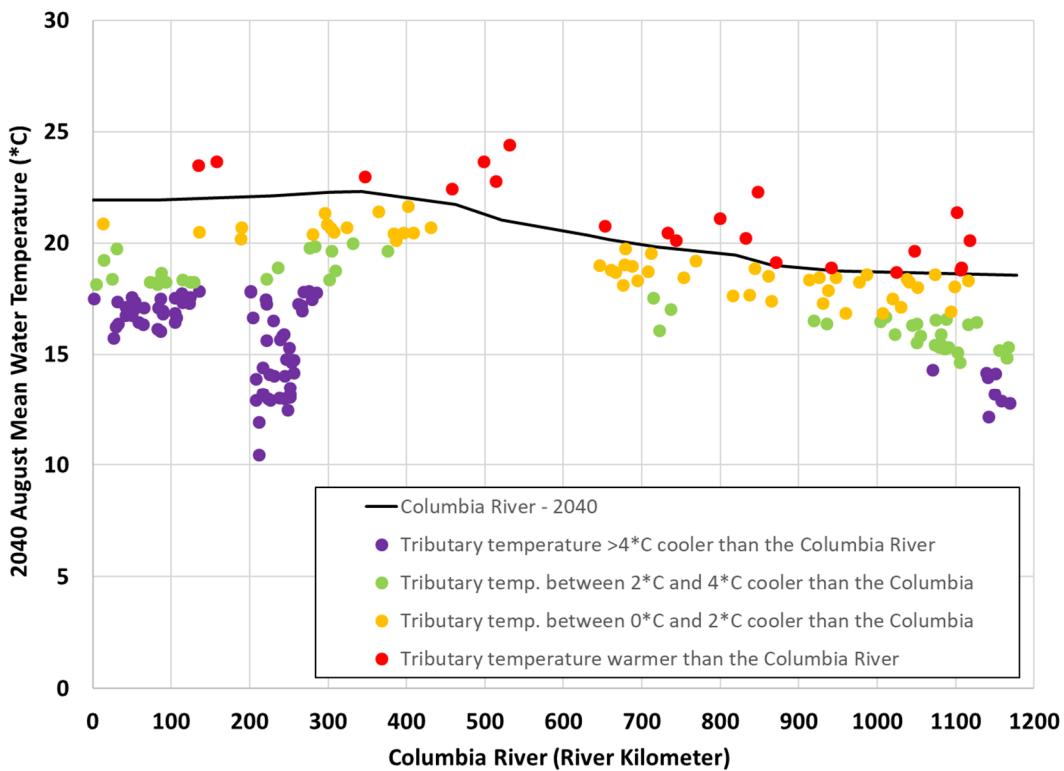
## References

- Isaak, D. J., Luce, C. H., Horan, D. L., Chandler, G. L., Wollrab, S. P., & Nagel, D. E. (2018). Global Warming of Salmon and Trout Rivers in the Northwestern US: Road to Ruin or Path Through Purgatory?. *Transactions of the American Fisheries Society*, 147(3), 566-587.

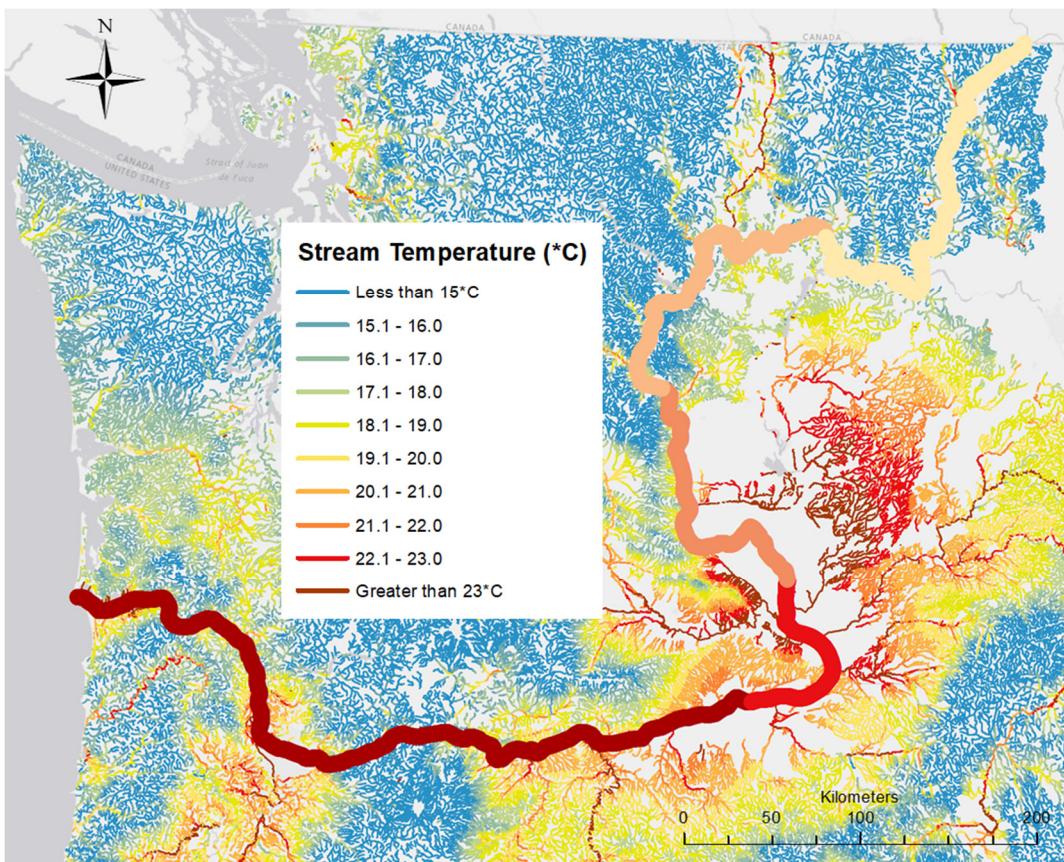
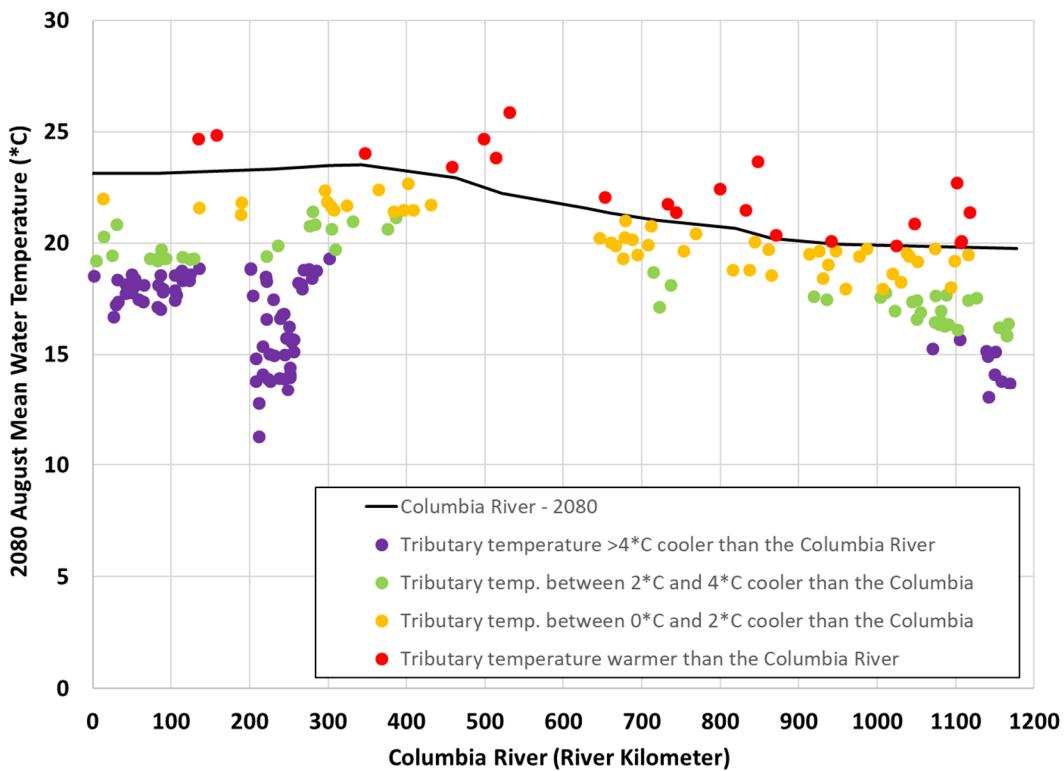
**Figure 1.** Estimated Current August Mean Water Temperature in the Columbia River and tributaries. -



**Figure 2.** Estimated 2040 August Mean Water Temperature in the Columbia River and tributaries. -



**Figure 3.** Estimated 2080 August Mean Water Temperature in the Columbia River and tributaries. -



**Figure 4.** Tributary Temperatures Relative to Mainstem Columbia River Temperatures at their - Respective Confluences at current, 2040 and 2080 conditions. -

