How Will Climate Change Affect the Puyallup Watershed?

Prepared by the University of Washington Climate Impacts Group, July 2015

Climate

Increasing greenhouse gases will lead to warmer temperatures throughout this century for the Pacific Northwest region. Climate modeling studies indicate that the Puyallup watershed will become warmer under all future scenarios, and will also undergo more intense rainfall events under most future scenarios. Although average annual precipitation is not expected to change significantly, summer months are projected to be drier than they were historically.

Water

The Puyallup watershed will undergo shifts in streamflow timing, increased winter flooding, and lower summer streamflows as a result of warmer temperatures and lower snowpack projected for the region (Figure 1)***.*** The overall amount of annual streamflow is not projected to change, however. Flood risk is projected to increase during the fall and winter seasons as warmer temperatures cause more precipitation to fall as rain over a larger portion of the basin area and as more intense extreme rainfall events contribute to higher flows. Likewise, less snowmelt will cause the lowest flows to become lower in the summer months.

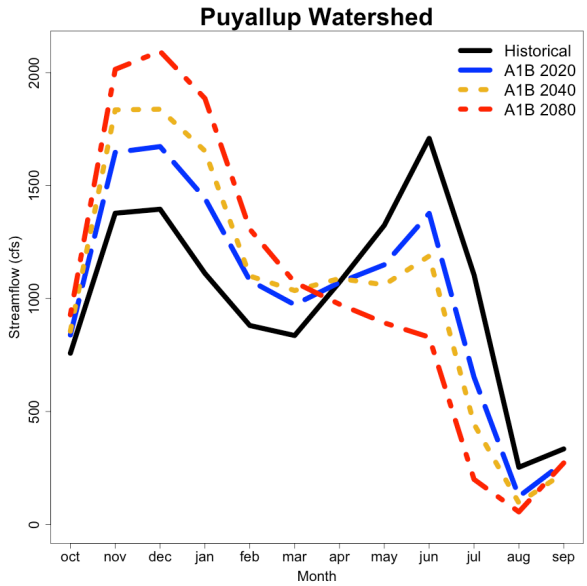

Figure 1. Change in the seasonality of streamflow, showing monthly average runoff for the water-year (Oct-Sep), for the 20th century (1916-2006; black line), the 2020s (2010-2039; blue line), the 2040s (2030-2059; gold line), and the 2080s (2070-2099; red line), all based on a medium (A1B[1]) greenhouse gas scenario. *Source: http://warm.atmos.washington.edu/2860*.[2]

Water Quality and Sediment

The Puyallup watershed is projected to undergo higher water temperatures, increased sediment loading and possibly more frequent landslides. Warmer air temperatures and lower summer streamflow will increase water temperature, while receding snowlines and more winter rainfall enhance erosion, increasing sediment supply in the watershed. Predicting landslide risk is complicated, however projections of higher rainfall, increased soil saturation, and steep slopes in the Puyallup watershed provide the conditions that favor more landslide activity.

Coasts

Commencement Bay will experience sea level rise and increasing ocean acidification. Increased greenhouse gas emissions will exacerbate both of these marine conditions. Local characteristics of the Puget Sound region will influence the extent of sea level rise and ocean acidification in the region. Sea level rise could be amplified by land subsidence occurring as a result of plate tectonics. Ocean acidification could be locally magnified by nutrient rich runoff from the urban and agricultural areas surrounding the Puyallup delta.

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[1] To make projections, climate scientists use greenhouse gas scenarios – "what if" scenarios of plausible future emissions – to drive global climate model simulations of the earth's climate. Wherever possible, scenarios used in this document include both a low and a high emissions scenario of 21st century greenhouse gas emissions.

[2] Hamlet, A.F., M.M. Elsner, G.S. Mauger, S-Y. Lee, I. Tohver, and R.A. Norheim. 2013. An overview of the Columbia Basin Climate Change Scenarios Project: Approach, methods, and summary of key results. *Atmosphere-Ocean* 51(4):392-415, doi: 10.1080/07055900.2013.819555: http://warm.atmos.washington.edu/2860/

Observed and Projected[1] Changes

Temperature	
Annual Temp - Observed[3]	Increase in average historical temperature (1895-2014) for nearby stations Buckley 1NE: +1.1°F ± 1.11°F McMillin RSVR: +0.6°F ± 0.98°F
Annual Temp – Projected[4]	Projected increase in average annual temperature (2050s, relative to 1980s): Low emissions (RCP 4.5): +4.2°F (range: 2.8 to 5.7°F) High emissions (RCP 8.5): +5.5°F (range 4.3 to 7.3°F)
Growing Season and Growing Degree Days - Projected [4]	Longer freeze-free period expected. Low emissions (RCP 4.5): +19 days (range: +14 to +23 days) High emissions (RCP 8.5): +25 days (range: +19 to +30 days) Increase in growing degree days (GDD) projected (base 50°F)[5]: Low emissions (RCP 4.5): +863 GDDs (range: +595 to +1140 GDDs) High emissions (RCP 8.5): +1119 GDDs (range: +800 to +1534 GDDs)

Precipitation	
Seasonal Precipitation - Observed[3]	No historical trend in seasonal precipitation; large variations from year-to-year.
Seasonal Precipitation – Projected[4]	Increased wet season precipitation and decreased dry season precipitation (2050s relative to 1980s): *Wet season (Oct – Mar)* Low emissions (RCP 4.5): +8% (range: −3 to +16%) High emissions (RCP 8.5): +9% (range: +2 to +17%) *Dry season (Apr – Sep)* Low emissions (RCP 4.5): -10% (range: −3 to -24%) High emissions (RCP 8.5): -9% (range: +1 to -21%)
Heavy Precipitation - Projected[4]	Increased maximum daily precipitation totals in Puyallup watershed (2050s relative to 1970-1999): Low emissions (RCP 4.5): +16% (range: +4 to +30%) High emissions (RCP 8.5): +20% (range: +1 to +39%) Recent research indicates that heavy precipitation events may be larger than what is projected in the above models.[6]

[3] Menne, M. J., Williams Jr, C. N., & Vose, R. S. (2009). *The US Historical Climatology Network monthly temperature data, version 2*. Bulletin of the American Meteorological Society, 90(7), 993-1007.
[4] Integrated Scenarios of the Future Northwest Environment: https://www.nwclimatescience.org/node/231
[5] Growing degree days are measurements used in agriculture to estimate growing season potential. For the current calculation, a growing degree day is counted for each degree the average temperature for a day moves above 50°F. For example, if the average temperature for the day was 55°F, that would count as 5 growing degree days.
[6] Salathé, EP, AF Hamlet, CF Mass M Stumbaugh, S-Y Lee, R Steed (2014) Estimates of 21st Century Flood Risk in the Pacific Northwest Based on Regional Scale Climate Model Simulations. *J. Hydrometeorology*

Water	
Snow	
Spring Snowpack – Projected[4]	Substantial declines in April 1st snowpack, 2050s relative to 1970-1999, for the Puyallup watershed: Low emissions (RCP 4.5): −52% (range: −59 to −36%) High emissions (RCP 8.5): −58% (range: −76 to −39%)
Streamflow	
Winter – Projected[4]	Increases in winter (October−March), 2050s relative to 1980s: Low emissions (RCP 4.5): +27% (range: +21 to +37%) High emissions (RCP 8.5): +34% (range: +19 to +62%)
Summer – Projected[4	Decreases in summer (April−September), 2050s relative to 1980s: Low emissions (RCP 4.5): −18% (range: −25 to −10%) High emissions (RCP 8.5): −20% (range: −31 to −9%)
Flooding – Projected[2]	Most models indicate increases in volume associated with the 100-year (1% annual probability) flood event, 2040s (2030 – 2059) relative to 1980s for the White River at Buckley[7]: Low emissions (B1): +39% (range: −14 to +85%) Moderate emissions (A1b): +56% (range: +22 to +115%)
Low flows – Projected[2]	Most models indicate decreased volumes associated with the 7Q10 (or 7-day lowest flow in 10 years) low flow event, 2040s (2030 – 2059) relative to 1980s for the White River at Buckley[7]: Low emissions (B1): −13% (range: −26 to +2%) Moderate emissions (A1b): −16% (range: −30 to −2%)

Water Quality and Sediment	
Stream temperatures – Projected	*Char*[8]*:* Decline in number of river miles within thermal thresholds for char spawning/rearing (mean August stream Temp. <54°F[9]): Historical (1993 – 2011): 726 miles 2040s, Moderate emissions (A1b): 531 miles (−26% loss) 2080s, Moderate emissions (A1b): 412 miles (−43% loss)) *Salmonids*[8]*:* Decline in number of river miles within thermal thresholds for core summer salmonid habitat (mean August stream Temp. <60°F): Historical (1993 – 2011): 988 miles 2040s, Moderate emissions (A1b): 934 miles (−5% loss) 2080s, Moderate emissions (A1b): 868 miles (−12% loss)

[7] Projected extreme statistics are reported here for the White River as a proxy for the Puyallup watershed since it is a major tributary and extreme flow data for the Puyallup is not available.
[8] NorWest Regional Database and Modeled Stream Temperatures: http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html
[9] Note that these thresholds are actually intended for 7-day average stream temperatures, not monthly averages. This means that the projections shown here are optimistic – an overestimate of suitable habitat.

Water Quality and Sediment	
Sediment & Landslides	Since the practice of dredging was halted in the mid-1990s for water quality improvement, the Puyallup watershed has aggraded, raising the channel elevations of the Puyallup, White and Carbon Rivers by 7.5', 6.5' and 2', respectively.[10] Loss of snowpack and glaciers due to warmer temperatures contributes to the exposure of highly mobile sediment sources and increases in flood flows, which triggers faster sediment movement. Geomorphic hazards, like debris flows and landslides, could also increase in response to decreasing snowpack and glaciers.[11] Increasing heavy precipitation may increase erosion rates and also threaten slope stability.

Coasts	
Sea Level – Observed[12]	Historical rise in sea level (Seattle is the closest long-term gauge) Seattle, WA: +9 inches (1899-2014)
Sea Level – Projected[13]	Rising for all scenarios Seattle, WA: +4 to +56 inches (2100, relative to 2000)
Ocean Acidification – Observed[14]	Global increase in ocean acidity since 1750 +26% *(decrease in pH: −0.1)*
Ocean Acidification – Projected[14]	Global increase by 2100 for all scenarios (relative to 1986-2005). There are no projections for ocean acidification specific to Washington State. Low emissions (RCP 4.5): +38 to +41% High emissions (RCP 8.5): +100 to +109%

This document was prepared by the Climate Impacts Group to support interviews planned as part of the ***Integrating Climate Resilience in Puget Sound Floodplain and Working Lands Programs*** project.

For more information on climate change impacts in Washington, see *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers* (2013), available at http://cses.washington.edu/cig/reports.shtml, or contact the Climate Impacts Group (cig@uw.edu, 206-616-5350).

[10] Czuba, J.A., Czuba, C.R., Magirl, C.S., Voss, F. 2010. Channel-Conveyance Capacity, Channel Change, and Sediment Transport in the Lower Puyallup, White, and Carbon Rivers, Western Washington: US Geological Survey Scientific Investigations Report 2010-5240, 104p.

[11] Lee, S-Y., and A.F. Hamlet. 2011. Skagit River Basin Climate Science Report. A summary report prepared for Skagit County and the Envision Skagit Project by the Department of Civil and Environmental Engineering and the Climate Impacts Group, University of Washington, Seattle. September, 2011.

[12] NOAA Sea Level Trends: http://tidesandcurrents.noaa.gov/sltrends/sltrends.html

[13] (NRC) National Research Council 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.* Washington, DC: The National Academies Press

[14] (IPCC) Intergovernmental Panel on Climate Change. 2013. *Working Group 1, Summary for Policymakers.* Available at: http://www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf