Research Prospectus for Chas Jones, Ph.D. Hydrology, University of Alaska Fairbanks,

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Warming temperatures have caused permafrost degradation across the Arctic (Hinzman et al., 2005). Permafrost typically is an effective barrier to water transport and recharge, but permafrost degradation can be result in increased hydrologic connectivity, which can be linked to lake drainage (Smith et al., 2005); increased annual river discharge (Peterson et al., 2002); and increased winter river baseflow (Walvoord and Striegl, 2007). Other hydrologic effects associated with a warming climate have been reported by indigenous peoples in Alaska, including thinner river ice and less predictable driftwood flows (Herman-Mercer et al., 2011). These shifts can be very consequential and have serious social impacts for arctic people. During my project, I have collaborated with rural Alaskans to examine how they may be affected by changes to hydrologic processes in interior Alaska.

The title for the first chapter is "Modeling the driftwood harvest in interior Alaska: Integrating local knowledge, hydrology, and climate scenarios." Numerous communities along the Yukon River harvest driftwood from the river to use as a source of fuel. Extensive amounts of driftwood flows down the river during high flow events. In this chapter, I develop a model that uses USGS Gaging station data on the Yukon River to model the amount of driftwood harvested for the village of Tanana, Alaska. In the model, information about historic driftwood harvest dates is integrated with historic river discharge data and interview data to estimate total annual driftwood harvest. Brabets and Walvoord (2009) found various relationships between the Pacific Decadal Oscillation (PDO) index and Yukon River discharge. These relationships provide an opportunity to predict hydrologic patterns based upon the PDO index. My model will be applied to high flow scenarios to assess the sensitivity of the driftwood harvest to future changes in Yukon River hydrology. Preliminary model results estimated that the mean harvest rate decreased by 60% since 1996, when compared to the period of 1977-1995.

My second research chapter is entitled “Modeling the thermal balance between groundwater springs and river ice.” On the Tanana River in Alaska, field observations show that river ice can remain thin or non-existent at very cold temperatures in recurring locations each winter. I hypothesized that this was caused by groundwater upwelling and created a numerical model that estimates how much ice is melted by groundwater upwelling based upon changing atmospheric and hydrologic conditions. Associated field efforts have been used to monitor atmospheric conditions at three locations and to monitor the temperature profile from the groundwater upwelling zone in the sediment, through the river column, and through the ice and snow. Preliminary model results indicate that groundwater upwelling can degrade up to 17 mm/day under spring conditions and that potential ice melt rates may increase by 18% under an altered climate. Additional field data will be collected through the winter of 2012-2013 to validate the model results.

My third research chapter is titled “Using airborne thermal infrared imagery to monitor seasonal changes in groundwater flow into the Tanana River, Alaska.” I hypothesize that airborne thermal infrared imagery can be used to detect groundwater upwelling prior to freeze-up and can be used to indicate that winter groundwater discharge will be the primary control of degraded ice conditions in mid- and late-winter. Airborne thermal infrared and optical imagery was acquired from an altitude of 2500 ft (above ground level) during four periods through 2011-2012 (Nov. 2011; Feb. 2012; Apr. 2012; Oct. 2012). The imagery will be analyzed to determine the degree to which the thermal signature of groundwater discharge can be observed before freeze-up (Banks et al., 1996) and through the winter. Preliminary results support the hypothesis. Remote sensing results will be used in conjunction with the model from chapter two to estimate groundwater discharge rates.

Other data:

- Thermal temperature gradient from river bed through water column, ice, snow, and air.
- Hyporheic water stage, specific conductivity, and temperature in numerous groundwater wells in Bonanza Creek LTER.
- Repeat daily photography though winter
- Water chemistry for river and hyporheic zone (specific conductivity, stable isotope)
- Ice thickness
- Snow depth
- Snow samples for stable isotope analyses
- Repeat ground penetrating radar data (March & April 2012)
- Airborne thermal infrared and optical images
- Sediment hydraulic conductivity (measured)
- Upwelling rate (calculated)
- Ice melt rate (modeled)
- Ice degradation extent (extracted from remote sensing imagery and modeled)